SALIENT FEATURES

1. GAUGE (Nominal) 1435 mm

2. ROUTE LENGTH (between dead ends)

Corridors	Total Length (km) Completely Elevated
Phase-II	
Motera Stadium to Mahatma Mandir	22.838
GNLU to GIFT City	5.416
Total Length	**28.254**
Phase-IIA : Koteshwar Road – Airport	6.339
Phase-IIB : Additional Corridor inside GIFT City	6.000
Total Length (Phase II+IIA+IIB)	**40.593**

3. NUMBER OF STATIONS

Corridor Name	Total Stations (All Elevated)
Phase-II	
Motera Stadium to Mahatma Mandir	20
GNLU to GIFT City	2
Total Stations	**22**
Phase-IIA : Koteshwar Road – Airport	2
Phase-IIB : Additional Corridor inside GIFT City	3
Total Stations (Phase II+IIA+IIB)	**27**

Note: Koteshwar Road and GNLU are interchange stations

4. TRAFFIC FORECAST

Daily ridership				
Corridor/Year	**2021**	**2031**	**2041**	**2051**
Motera Stadium to Mahatma Mandir Corridor	99,791	1,58,397	2,27,228	2,86,579
GNLU to GIFT City Corridor	11,798	27,742	36,893	48,018
Koteshwar Road to Airport Corridor	13,349	19,215	24,513	30,504
Total	**1,24,938**	**2,05,354**	**2,88,634**	**3,65,101**
Trip Length	**9.26**	**8.34**	**8.46**	**8.45**

PHPDT				
Corridor/Year	**2021**	**2031**	**2041**	**2051**
Motera Stadium to Mahatma Mandir Corridor	4,121	5,733	7,935	9,950
GNLU to GIFT City Corridor	638	1326	1766	2261
Koteshwar Road to Airport Corridor	801	1062	1328	1668

Note: Moderate Scenario of Traffic Demand Forecast is being used for Station Planning, Rolling Stock and Fare Box calculation.

5. TRAIN OPERATION PLAN

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

Sections	Year	Headway (min)	No. of Rakes for Phase-I and Phase-II	Net No. of Rakes for Phase- II**	Rake Consist	No. of Coaches	Max. PHPDT Demand	PHPDT Capacity Available
Capacity Provided for Motera Stadium to Mahatma Mandir Corridor								
APMC to Shreyash and Koteshwar Road to Mahatma Mandir	2021	10	25	1	3-car	3	4052	4584 (5832*)
Shreyash to Koteshwar Road		5		6	3-car	18	8747	9168 (11664*)
APMC to Shreyash and Koteshwar Road to Mahatma Mandir	2031	8	31	0	3-car	0	5178	5730 (7290*)
Shreyash to Koteshwar Road		4		4	3-car	12	11597	11460 (14580*)
APMC to Shreyash and Koteshwar Road to Mahatma Mandir	2041	6	40	0	3-car	0	7240	7640 (9720*)
Shreyash to Koteshwar Road		3		0	3-car	0	14509	15280 (19440*)
APMC to Shreyash and Koteshwar Road to Mahatma Mandir	2051	5	36	36	3-car	108	9066	9168 (11664*)
Shreyash to Koteshwar Road		2.5	12	12	3-car	36	16968	18336 (23328*)

Capacity Provided for GNLU to GIFT City Corridor								
GNLU to Gift City	2021	10	3	3	3-car	9	638	4584 (5832*)
GNLU to Gift City	2031	10	3	3	3-car	9	1326	4584 (5832*)
GNLU to Gift City	2041	10	3	3	3-car	9	1766	4584 (5832*)
GNLU to Gift City	2051	10	3	3	3-car	9	2261	4584 (5832*)

Capacity Provided for Koteshwar Road to Airport Corridor (Phase-IIA)								
Koteshwar Road to Airport	2021	10	3	3	3-car	9	801	4584 (5832*)
Koteshwar Road to Airport	2031	10	3	3	3-car	9	1062	4584 (5832*)
Koteshwar Road to Airport	2041	10	3	0	3-car	0	1328	4584 (5832*)
Koteshwar Road to Airport	2051	10	3	3	3-car	9	1668	4584 (5832*)

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

*** Net rake requirement for Phase-II has been calculated after subtracting previous DPR requirements from the total requirements*

6. SPEED

Design Speed	90kmph
Maximum operating speed	80kmph
Schedule speed	33kmph

7. TRACTION POWER SUPPLY

a) Voltage — 750v dc

b) SCADA system — Provided

c) Power Demand (MVA)

Power Demand (in MVA)

Corridors	Load	Year			
		2021	**2031**	**2041**	**2051**
Extension of North-South Corridor; Motera Stadium to Mahatma Mandir, 20 Stations (22.84 km)	Traction	3.47	4.34	5.78	6.93
	Auxiliary	6.17	6.42	6.79	7.41
	Sub-total	**9.64**	**10.76**	**12.57**	**14.34**
Spur of North-South Corridor extension; GNLU to Gift City, 3 Stations (5.4 km)	Traction	0.79	0.79	0.79	0.79
	Auxiliary	0.93	0.96	1.02	1.11
	Sub-total	**1.72**	**1.75**	**1.81**	**1.90**
Spur of North-South Corridor extension; Koteshwar Road to Airport, 3 Stations (6.34 km) (Phase-IIA)	Traction	0.92	0.92	0.92	0.92
	Auxiliary	0.93	0.97	1.02	1.12
	Sub-total	**1.85**	**1.89**	**1.94**	**2.04**
	Grand Total	**13.21**	**14.40**	**16.32**	**18.28**

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

Gyaspur Depot of Phase-I will also fulfill the requirements of Phase-II after suitable augmentation and other than that a stabling depot is proposed at Indroda Circle.

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 Fiber 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

i. Viaduct: Precast twin „U" girders on Single pier with pile / Open foundations upto radius 300m and flatter, however, MEGA Co. may opt for any other method of segmental construction, if found technically feasible and economically viable and for sharper curves and location of Points & Crossings I-Girder.
ii. Station structure on columns, independent of viaduct piers.

13. TOTAL ESTIMATED COST (AT DECEMBER 2018 PRICES)

Corridor-wise Details of Capital Cost

S. No./ Corridor	Name of the corridor	Capital Cost (Rs. Crore)	Taxes & Duties (Rs. Crore)	Total (Rs. Crore)
	Phase-II			
1	Motera Stadium to Mahatma Mandir	3529	529	4058
2	GNLU to GIFT City	660	104	764
	Total	**4189**	**633**	**4822**
	Phase-IIA			
3	Koteshwar Road to Airport	790	123	913
	Phase-IIB			
4	Additional corridor inside GIFT City*	579	87	666
	Total (Phase II + IIA + IIB)	**5558**	**843**	**6401**

* - *The corridor inside GIFT city has not been considered in Ridership Study, FIRR and EIRR calculations. The detailed planning of this corridor may be done at later stage as decided by M/s GIFT City Ltd.*

14. TOTAL COMPLETION COST

	Completion Cost including land cost and all taxes & duties but excluding IDC (in Rs. Crore)	Completion Cost including land cost, IDC and all taxes & duties (in Rs. Crore)
Option II (Motera Stadium to Mahatma Mandir and GNLU to GIFT City Corridor)	**5310.17**	**5384.17**

15. FINANCIAL INDICES

a) FIRR (Without PD) : 2.12% (Option-II)
b) FIRR (With PD) : 6.01% (Option-II)
c) EIRR : 18.28% (Option-II)

EXECUTIVE SUMMARY

0.1 INTRODUCTION

0.1.1 Background

Ahmedabad also known as Amdavad in Gujarati pronunciation is the largest city and former capital of Gujarat. It is the administrative headquarters of the Ahmedabad district and the seat of the Gujarat High Court. It is the sixth largest city and seventh largest metropolitan area of India with a population of more than 6.3 million and an extended population of 7.8 million. Ahmedabad is located on the banks of the Sabarmati River. It is located 30 km from the state capital Gandhinagar, which is its twin city.

Ahmedabad has emerged as an important economic and industrial hub in India. It is the second largest producer of cotton in India, and its stock exchange is the country's second oldest. Cricket is a popular sport in Ahmedabad, which houses the 54,000-seat Sardar Patel Stadium. The effects of liberalization of the Indian economy have energized the city's economy towards tertiary sector activities such as commerce, communication and construction. Ahmedabad's increasing population has resulted in an increase in the construction and housing industries resulting in recent development of skyscrapers.

It was ranked third in Forbes's list of fastest growing cities of the decade in 2010. The Times of India chose Ahmedabad as India's best city to live in 2012. Ahmedabad has been selected as one of the hundred Indian cities to be developed as a smart city under Government of India's flagship Smart Cities Mission.

Gandhinagar

Gandhinagar, the Capital of Gujarat, is a systematically 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. Gandhinagar is linked with Ahmedabad on the south by a direct road, having a straight alignment and 91.44m (300.0 ft) wide Right of Way.

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 2008 DMRC was again commissioned by GIDB to prepare DPR for metro connectivity from Gandhinagar to GIFT city & from Gandhinagar 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 1.1) requested to DMRC for updating of earlier DPR submitted by DMRC in 2005, updated DPR was submitted in February 2014 and same was revised and resubmitted in March 2015.

0.1.1 Present Study area

High Powered Committee (HPC) of Government of Gujarat (GoG) decided to further extend APMC – Motera line to Gandhi Nagar (Sachivalya, Akshardham and Mahatma Mandir). It is also decided to connect GIFT City and Airport also. In view of this MEGA vide letter No. Ref. MEGA/MD/DMRC/IC/19, dated 27/01/2016, asked DMRC to submit Terms of Reference (ToR) to take up study of for preparation of Detailed Project Report (DPR) of Ahmedabad Metro Phase – 2 corridors.

0.2 TRAFFIC DEMAND FORECAST

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 Phase-II Corridors in Horizon Years

Daily ridership on the Ahmedabad Phase-II Metro Rail network in 2021 is expected to be 1.4988 lakh passengers. The average trip length will be 15.77 km in year 2021. Corridor wise total daily ridership for the years 2021, 2031, 2041 and 2051 and PHPDT are shown in **Table 0.1.**

Table 0.1 - Corridor wise Daily Ridership and PHPDT

Daily ridership				
Corridor/Year	**2021**	**2031**	**2041**	**2051**
Motera Stadium to Mahatma Mandir Corridor	99,791	1,58,397	2,27,228	2,86,579
GNLU to GIFT City Corridor	11,798	27,742	36,893	48,018
Koteshwar Road to Airport Corridor	13,349	19,215	24,513	30,504
Total	**1,24,938**	**2,05,354**	**2,88,634**	**3,65,101**
Trip Length	**9.26**	**8.34**	**8.46**	**8.45**

PHPDT				
Corridor/Year	**2021**	**2031**	**2041**	**2051**
Motera Stadium to Mahatma Mandir Corridor	4,121	5,733	7,935	9,950
GNLU to GIFT City Corridor	638	1326	1766	2261
Koteshwar Road to Airport Corridor	801	1062	1328	1668

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 45,000 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) **Medium Capacity Metro System**: This metro system has the capacity of PHPDT varying from more than 30,000 and upto 45,000.

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

iv) **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 signalling at road inter-section.

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

vi) Other 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 is 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
Organized 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.

0.3.1 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 4121 on the extension of the North South Corridor from Motera Stadium to Mahatma Mandir (refer Table 0.1), 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 than Light metro. The Mono rail is being adopted only for small lengths and as feeder to Metro worldwide.

Based on MMRDA's experience, following are the demerits of Monorail over Light Capacity Metro:

Technology is not proven.
It has comparatively high maintenance cost due to wear and tear of rubber tyres.
Problems in emergency evacuation thus posing disaster management problems.
Total dependence on Rolling Stock supplier. No indigenous production of Rolling Stock.
Total dependence on manufacturer of spares.
It has poor ride quality as compared to metro.
Rolling Stock cannot be purchased from another manufacturer without changing the guide beams.
Higher Life Cycle Cost

The capital cost of Mono rail is also almost same as that of Light Capacity Metro. MMRDA is now shifting to Metro Rail System on its earlier proposed Monorail Corridor Thane- Bhiwandi – Kalyan after having bad experience of their Wadala – Chembur Monorail Corridor.

Moreover, it is extension of under implementation corridor from APMC to Motera Stadium, therefore it is recommended to adopt same system i.e. Light Capacity Metro System.

Ridership and PHPDT figures in year 2021 of Koteshwar Road to Airport Corridor are 13349 and 801 respectively. Similarly, Ridership and PHPDT figures of GNLU to GIFT City Corridor are 11798 and 638 respectively (refer Table 0.1). These corridors can be managed with the road based transportation system or any other grade separated low capacity transportation system for quite a long time. However, any new mode of transport will require additional full-fledged depot, different type of inventory of rolling stock and separate team of operation and maintenance staff. Moreover, there will not be seamless integration at Koteshwar road and GNLU stations. Hence same mode of transportation i.e. Light Capacity Metro System is examined for these corridors also.

0.4 GEOMETRIC DESIGNING PARAMETERS AND ALIGNMENT DESCRIPTION

This topic deals with geometrical standards adopted for horizontal and vertical alignments, route description, etc. The proposed corridors will be implemented with track on Standard Gauge (SG) 1435mm.

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

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

0.4.1 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.

0.4.2 Route Alignment

Two Corridors have been identified for implementation in Phase-II of Ahmedabad Metro Rail Project as follows: -

Table 0.3

Corridors	Total Length (km) Completely Elevated
Phase-II	
Motera Stadium to Mahatma Mandir	22.838
GNLU to GIFT City	5.416
Total Length	**28.254**
Phase-IIA : Koteshwar Road – Airport	6.339
Phase-IIB : Additional Corridor inside GIFT City	6.000
Total Length (Phase II+IIA+IIB)	**40.593**

0.5 CIVIL ENGINEERING

This chapter deals with civil elevated structure, Geotechnical investigation, construction methods, land requirements, Utility services and Traffic diversion during construction etc.

0.5.1 Elevated Section - Choice of Superstructure

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

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

In case of Ahmedabad Phase-II Metro corridors, it is suggested to use Double U-Girder in the superstructure upto radius 300m keeping in view the open area in the proposed corridor. However, MEGA Co. may opt for any other method of segmental construction, if found technically feasible and economically viable.

Some other merits of Double U-Girder are given below:

- It is an efficient and economical method.
- Its construction permits a reduction of construction time as it may be manufactured while substructure work proceeds and assembled rapidly thereafter.
- This method of construction protects the environment as only space required for foundation and sub-station is required at site. The superstructure is manufactured at a place away from busy areas and placement of superstructure is done at site.
- Girders are easy to stack in the casting yard/stacking yard in more than one layer, thereby saving in requirement of space.
- Interference to the traffic during construction is significantly reduced.

- It contributes towards aesthetically pleasing structures and good finishes.
- The overall labour requirement is less than that for conventional methods.
- Better quality control is possible in the casting yard.
- During construction, the technique shows an exceptionally high record of safety.

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

0.5.2 Geo-Technical Investigations

0.5.2.1 General Geology & Related Characteristics

Physiography

Ahmedabad District is situated in the central part of Gujarat and lies between 22°0' and 23°35' north latitudes and 71° 42' and 72° 50' east longitudes. It falls in the survey of India degree sheet numbers 41N, 41M, 46A and 46B. It is bounded by Mahesana and Gandhinagar in north, Sabarkantha in north east, Kheda in east Gulf of Cambay (Khambat), Bhavnagar in South and Surendranagar in west.

Ahmedabad district as a whole forms a level plain gradually rising towards the north and east where the elevation varies between 17 meters and 100 meters above M.S.L. The southern portion of the district is low lying area with an altitude ranging between 12 meters and 22 meters above MSL. Sabarmati is the principal river of the district. It enters the district in the extreme north-eastern side and flows in southerly direction which ultimately merges along with its tributary i.e. Bhogava in the Gulf of Khambhat. Other river is Bhadar which also flows eastward and merges in the same Gulf.

Geology

The landscape is characterized by a subdued topography comprising a variety of depositional transitional area between the plain and the highland is marked by a pediment zone of undulating topography, characterized by low altitude mounds and hillocks of stabilized Aeolian sands dunes. There are also small alluvial fans and cones of fluvial material brought by the rivers coming from the neighboring highland. The central part of the plain shows mix topography of fluvial plains marked by subdued fossil dunes. The western part is almost a level ground of saline waste land with a thin veneer of sand and silt.

Seismology

For design purpose, the earthquake magnitude of 6.50 on Reactor’s scale can be considered safely as per Annexure A of IS: 1893 (part -1). Also the project area under study and its surroundings are seismically active falls in Seismic Zone – III (Zone factor, Z = 0.16).

Climate

The climate of the district is characterized by hot summer and general dryness except during the southwest monsoon seasons. The year can be divided into four seasons. The period from March to May is the hot season (summer) followed by southwest monsoon from June to September, October and November constitute the post-monsoon or retreating monsoon season. The cold season (winter) starts from December and ends in February. The mean maximum temperature ranges between 28.4°C during January to 41.8°C during May and the mean minimum temperatures vary between 11.7°C during January and 27°C during June. The relative humidity varies between 32 % (March) and 79% (August). The wind velocity varies from 74 km/d (November) and 174.2 km/d (June). The potential Evapo-transpiration varies between 3.2 mm (December) and 7.8 mm/d (June). Long-term average annual rainfall recorded by IMD station at Ahmedabad is 799.6 mm. Most of the rainfall (about 766 mm) is received from south-west monsoon between June to September.

0.5.2.2 Objective of Geotechnical Investigation

The main objectives of Geo-Technical Investigation 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.

0.5.2.3 Recommendation

Type of Foundation: Bored Cast in situ RCC Pile

Depending on the field and laboratory observations of subsoil strata, test results and the type of structures proposed at site, the most feasible soil-foundation system is recommended as normal bored cast in situ R.C.C. piles foundations of 1.0m & 1.2m diameter at different depths with cut-off level of 2.0m to 3.0m depth below existing Ground level.

Recommended Diameter & Depth of Foundation have been given in Table 0.4 below:

Table 0.4 - Diameter & Depth of Foundation

Type of foundation	Diameter of Pile, m	Cut off level, m	Effective Depth, m
Bored Cast in situ RCC Pile	1.00 & 1.20	2.00	20.0 – 30.0

Note: For details, please refer Detailed Geotechnical Report

0.5.3 Land

In order to minimize 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:

0.5.3.1 Land Requirement for following Major Components

MRTS Structure (including Route Alignment), Station Building, Platforms, Entry/Exit Structures, Traffic Integration Facilities, Depots/Stabling Yard, etc.

Receiving/Traction Sub-stations

Radio Towers

Temporary Construction Depots and work sites.

Staff quarters, office complex and operation control centre(OCC)

0.5.3.2 Summary of Land Requirements

Abstract of land requirements for different components of the corridors is given in Tables below.

Table 0.5 - Summary of Permanent Land Requirement (All figures in Sq. m)

Sr.	Description	Phase - II				Phase – IIA		Phase - IIB		Total
		Motera Stadium to Mahatma Mandir		GNLU to GIFT City		Koteshwar Road to Airport		Additional corridor inside GIFT City		
		Govt.	Pvt.	Govt.	Pvt.	Govt.	Pvt.	Govt.	Pvt.	
1	Stations	19694	1763	1335	920	2081	0	4200	0	**29993**
2	Running Section	5378	35	0	0	3893	4540	0	0	**13846**
3	Depot/Stabling Yard	100000	0	0	0	0	0	0	0	**100000**
4	Staff Quarters	15000	0	0	0	0	0	0	0	**15000**
5	Office Complex and OCC	0	0	0	0	0	0	0	0	**0**
6	RSS	3600	0	0	0	3600	0	0	0	**7200**
	Total	**143672**	**1798**	**1335**	**920**	**9574**	**4540**	**4200**	**0**	**166039**

Total = 16.6039 ha
Government = 15.8781 ha
Private = 0.7258 ha

Table 0.6 - Summary of Temporary Land Requirement (All figures in Sq. m)

Sr.	Description	Motera Stadium to Mahatma Mandir	GNLU to GIFT City	Koteshwar Road to Airport	Additional corridor inside GIFT City	OWNER-SHIP
1	Temporary Office/ Site Office	8000	2000	2000	2000	Government
2	Segment Casting Yard	80000	20000	20000	20000	Government
	Total	**88000**	**22000**	**22000**	**22000**	**154000**

Total land required for temporary acquisition is **15.4 ha,** and has been assumed as government land.

0.6 STATION PLANNING

The proposed Metro for MEGA consists of three corridors i.e. from **Motera Stadium to Mahatma Mandir, GNLU to GIFT City** and **Koteshwar Road to Airport** (Phase-IIA). The stretch of the proposed Mahatma Mandir to Airport corridor is 23 km (approx.) from North to South. Along this Corridor, twenty stations have been planned. There are four stations proposed, two stations from GNLU to Gift City and two stations from Koteshwar Road to Airport corridor. The placement of the stations has been done considering Right of way, land availability, location, proximity to the Institutions for better ridership and connectivity, however, position of the entry/exit can be suitably changed as per land availability and ROW.

To attract maximum pedestrian traffic, station locations are finalised at the traffic nodal points.

0.6.1 Station Types

A total of 24 Stations have been planned on these Corridors. All the stations are of elevated type with side platforms except, four which are either island or combination of both. Concourse of all these stations is proposed along the roads with sufficient right of way.

Average inter-station distance is 1.4 km approximately varying from 0.899 km to 4.2 km depending upon the site, operational and traffic constraints.

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

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

11. Following requirements have been taken into account:
    a. Minimum capital cost is incurred consistent with maximizing passenger attraction.
    b. Minimum operating costs are incurred consistent with maintaining efficiency and the safety of passengers.
    c. 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.
    d. Provision of good visibility of platforms, fare collection zones and other areas, thus aiding the supervision of operations and monitoring of efficiency and safety.
    e. Provision of display of passenger information and advertising.

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

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

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

0.7 TRAIN OPERATION PLAN

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.
- Optimization of trains reliability for achieving best possible availability on line.
- A short train consists of 3 coaches.
- Multi-tasking of train operation and maintenance staff.

0.7.2 Stations

List of stations for the Corridor of Ahmedabad Metro are given below: -

Table 0.7 A: Stations - North-South Corridor (APMC to Mahatma Mandir)

S. No	Name of Station	Chainage (m)	Inter – Station Distance (m)	Remarks
	Dead End	-1615.0		
1	APMC	0.0	1615.0	Elevated
2	Jivraj	950.0	950.0	Elevated
3	Rajiv Nagar	1800.0	850.0	Elevated
4	Shreyash	3170.0	1370.0	Elevated
5	Paldi	4524.0	1354.0	Elevated
6	Gandhigram Railway Station	5970.0	1446.0	Elevated
7	Old High Court	7045.0	1075.0	Elevated
8	Ushmanpura	8078.0	1033.0	Elevated
9	Vijay Nagar	9575.0	1497.0	Elevated
10	New Vadaj	10867.0	1292.0	Elevated
11	Ranip	12197.0	1330.0	Elevated
12	Sabarmati Railway Station	12965.0	768.0	Elevated
13	AEC	13906.0	941.0	Elevated
14	Sabarmati	15265.0	1359.0	Elevated
15	Motera Stadium	16661.7	1396.7	Elevated
16	Koteshwar Road	17598.8	937.1	Elevated

S. No	Name of Station	Chainage (m)	Inter – Station Distance (m)	Remarks
17	Vishwakarma College	19017.0	1418.2	Elevated
18	Tapovan Circle	19994.4	977.4	Elevated
19	Narmada Canal	20900.0	905.6	Elevated
20	Koba Circle	22050.6	1150.6	Elevated
21	Juna Koba	23056.4	1005.8	Elevated
22	Koba Gaam	24066.4	1010.0	Elevated
23	GNLU	24977.6	911.1	Elevated
24	Raysan	26413.7	1436.2	Elevated
25	Randesan	27786.9	1373.2	Elevated
26	Dholakuva Circle	28943.2	1156.3	Elevated
27	Infocity	30334.0	1390.8	Elevated
28	Sectror-1	31600.0	1266.0	Elevated
29	Sector-10A	32850.0	1250.0	Elevated
30	Sachivalaya	34041.3	1191.3	Elevated
31	Akshardham	35170.0	1128.7	Elevated
32	Juna Sachivalaya	36069.0	899	Elevated
33	Sector-16	37161.3	1092.3	Elevated
34	Sector-24	38199.0	1037.7	Elevated
35	Mahatma Mandir	39399.6	1200.6	Elevated
	Dead End	39499.6	100.0	

Table 0.7 B: Stations - Koteshwar Road to Airport Corridor (Phase-IIA)

S. No	Name of Station	Chainage (m)	Inter–Station Distance (in m)	Remarks
	Dead End	-405.00		
1	Koteshwar Road	0.00	450.00	Elevated
2	Sardarnagar	4212.19	4212.19	Elevated
3	Airport	5834.17	1621.98	Elevated
	Dead End	5934.17	100.00	

Table 0.7 C: Stations - GNLU to Gift City Corridor

S. No	Name of Station	Chainage (m)	Inter–Station Distance (in m)	Remarks
	Dead End	-405.00		
1	GNLU	0.00	405.00	Elevated
2	PDPU	1749.00	1749.00	Elevated
3	Gift City	4605.86	2856.86	Elevated
	Dead End	5010.86	405.00	

0.7.3 Salient Features

Running of services for 19 hours of the day (5 AM to Midnight) with a station dwell time of 30 seconds,

Make up time of 5-10% with 8-12% coasting.

Scheduled speed for these corridors has been considered as: 33 kmph.

0.7.4 Train Formation

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

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)

The PHPDT capacity provided on the different sections of North South corridor in different years of operation is tabulated below:

Table 0.8 A - PHPDT Capacity (APMC to Mahatma Mandir Corridor)

Sections	Year	Headway (min)	No. of Rakes for Phase-I and Phase-II	Net No. of Rakes for Phase- II**	Rake Consist	No. of Coaches	Max. PHPDT Demand	PHPDT Capacity Available
APMC to Shreyash and Koteshwar Road to Mahatma Mandir	2021	10	25	1	3-car	3	4052	4584 (5832*)
Shreyash to Koteshwar Road		5		6	3-car	18	8747	9168 (11664*)
APMC to Shreyash and Koteshwar Road to Mahatma Mandir	2031	8	31	0	3-car	0	5178	5730 (7290*)
Shreyash to Koteshwar Road		4		4	3-car	12	11597	11460 (14580*)
APMC to Shreyash and Koteshwar Road to Mahatma Mandir	2041[#]	6	40	0	3-car	0	7240	7640 (9720*)
Shreyash to Koteshwar Road		3		0	3-car	0	14509	15280 (19440*)
APMC to Shreyash and Koteshwar Road to Mahatma Mandir	2051[##]	5	36	36	3-car	108	9066	9168 (11664*)
Shreyash to Koteshwar Road		2.5	12	12	3-car	36	16968	18336 (23328*)

 # The provision for number of rake requirement for the year 2043 considered in Phase-I DPR has been considered against year 2041 in Phase-II DPR for calculating the additional rakes required.

The provision of rakes for year 2051 was not available in Phase-I DPR. Hence all the requirements have been considered for Phase-II only.

Table 0.8 B - PHPDT Capacity (Koteshwar Road to Airport Corridor) (Phase-IIA)

Sections	Year	Headway (min)	No. of Rakes for Phase-I and Phase-II	Net No. of Rakes for Phase- II**	Rake Consist	No. of Coaches	Max. PHPDT Demand	PHPDT Capacity Available
Koteshwar Road to Airport	2021	10	3	3	3-car	9	801	4584 (5832*)
Koteshwar Road to Airport	2031	10	3	3	3-car	9	1062	4584 (5832*)
Koteshwar Road to Airport	2041	10	3	0	3-car	0	1328	4584 (5832*)
Koteshwar Road to Airport	2051	10	3	3	3-car	9	1668	4584 (5832*)

Table 0.8 C - PHPDT Capacity (GNLU to Gift City)

Sections	Year	Headway (min)	No. of Rakes for Phase-I and Phase-II	Net No. of Rakes for Phase- II**	Rake Consist	No. of Coaches	Max. PHPDT Demand	PHPDT Capacity Available
GNLU to Gift City	2021	10	3	3	3-car	9	638	4584 (5832*)
GNLU to Gift City	2031	10	3	3	3-car	9	1326	4584 (5832*)
GNLU to Gift City	2041	10	3	3	3-car	9	1766	4584 (5832*)
GNLU to Gift City	2051	10	3	3	3-car	9	2261	4584 (5832*)

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

*** Net rake requirement for Phase-II has been calculated after subtracting previous DPR requirements from the total requirements*

0.7.5 TRAIN FREQUENCY

Table 0.9A - Train Frequency (APMC to Mahatma Mandir Corridor)

Section	2021		2031		2041		2051	
	Peak Hour Head-way	Lean Hour Head-way	Peak Hour Head-way	Lean Hour Head-way	Peak Hour Head-way	Lean Hour Head-way	Peak Hour Head-way	Lean Hour Head-way
APMC to Shreyash and Koteshwar Road to Mahatma Mandir	10 min	16 to 32 min	8 min	12 to 32 min	6 min	10 to 24 min	5 min	8 to 16 min
Shreyash to Koteshwar Road	5 min	8 to 16 min	4 min	6 to 16 min	3 min	5 to 12 min	2.50 min	4 to 8 min

Table 0.9B - Train Frequency (Koteshwar Road to Airport) (Phase-IIA)

Section	2021		2031		2041		2051	
	Peak Hour Head-way	Lean Hour Head-way	Peak Hour Head-way	Lean Hour Head-way	Peak Hour Head-way	Lean Hour Head-way	Peak Hour Head-way	Lean Hour Head-way
Koteshwar Road to Airport	10 min	16 to 32 min	10 min	12 to 32 min	10 min	12 to 24 min	10 min	12 to 24 min

Table 0.9C - Train Frequency (GNLU to Gift City)

Section	2021		2026		2036		2046	
	Peak Hour Head-way	Lean Hour Head-way	Peak Hour Head-way	Lean Hour Head-way	Peak Hour Head-way	Lean Hour Head-way	Peak Hour Head-way	Lean Hour Head-way
GNLU to Gift City	10 min	16 to 32 min	10 min	12 to 32 min	10 min	12 to 24 min	10 min	12 to 24 min

No services are proposed between 00:00 hrs to 5.00 hrs, which are reserved for maintenance of infrastructure and rolling stock.

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 Mass Rapid 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 Table 0.10.

Table 0.10 - 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 to 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 car is envisaged.

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

Table 0.11 shows the carrying capacity of Medium Rail Vehicles.

Table 0.11 - 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 0.12, referring to the experiences in Delhi Metro. The average passenger weight has been taken as 65 kg.

Table 0.12 - 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	15.574	

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)
	1.2 m/s^2 (with AW2 load)
Max. Deceleration:	1.1 m/s^2 (with AW3 load)
	1.1 m/s^2 (with AW2 load)
	>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 DEPOT

0.9.1 Depot- cum- Workshop

It is proposed to use one depot- cum- workshop with following functions at Gyaspur Depot for Phase-II in addition to fulfilling the requirements for Phase-I:

(i) Major overhauls of all the trains.
(ii) All minor schedules and repairs.
(iii) Lifting for replacement of heavy equipment and testing thereafter.
(iv) Repair of heavy equipments.

Another depot at Indroda Circle is planned with only stabling facilities at present.

The Depot planning is based on following assumptions:

(i) Enough space should be available for establishment of a Depot- Cum- workshop for the additional trains required for Phase-II.

(ii) All inspection lines, workshop lines, stabling lines are designed to accommodate two train sets of 3- Car each and space earmarked for future provision.

(iii) All Stabling lines are designed to accommodate two trains of 3- Car each.

(iv) All stabling lines are planned in the proposed depot-cum-workshop assuming adequate space availability. In case of space constraints, if any, stabling facilities may need to be created at terminal stations or elsewhere (preferably as close to depot as possible) to cater to the required stabling facilities.

(v) In case of space constraint for depot two storeyed Stabling lines can also be planned.

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

Layout of Stabling-shed, Inspection-shed, minor repairs and heavy repair overhauling workshop and cleaning of Rolling Stock.

Operational and functional safety requirements.

Ancillary buildings for other maintenance facilities.

Electrical & Mechanical Services, power supply and distribution system.

Water Supplies, Drainage & Sewerage.

0.9.2 Maintenance Philosophy

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

Labour intensive procedures are kept to the minimum. Automation with state of the art machinery to ensure quality with reliability.

Increase in the periodic maintenance intervals with predictive maintenance based on condition monitoring.

Multi skilling of the Maintenance staff to ensure quality and productivity in their performance.

Periodic review of maintenance practices to update replacement cycle of critical components based on experience.

Energy conservation is given due attention.

0.10 POWER SUPPLY ARRANGEMENTS

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

(i) Specific energy consumption of rolling stock at Pantograph/ Current Collector – 60KWh/1000 GTKM as per MOUD guideline for 750 V dc system.

(ii) Elevated/at –grade station auxiliary load – initially 250 kW, which will increase to 300 kW in the year 2051.

Keeping in view of the train operation plan and demand of auxiliary and traction power, power requirements projected for the year 2021, 2031, 2041 and 2051 are summarized in table 0.13 below:-

Table 0.13 - Power Demand Estimation (MVA)

Corridors	Load	Year			
		2021	**2031**	**2041**	**2051**
Extension of North-South Corridor; Motera Stadium to Mahatma Mandir, 20 Stations (22.84 km)	Traction	3.47	4.34	5.78	6.93
	Auxiliary	6.17	6.42	6.79	7.41
	Sub-total	**9.64**	**10.76**	**12.57**	**14.34**
Spur of North-South Corridor extension; GNLU to Gift City, 3 Stations (5.4 km)	Traction	0.79	0.79	0.79	0.79
	Auxiliary	0.93	0.96	1.02	1.11
	Sub-total	**1.72**	**1.75**	**1.81**	**1.90**
Spur of North-South Corridor extension; Koteshwar Road to Airport, 3 Stations (6.34 km) (Phase-IIA)	Traction	0.92	0.92	0.92	0.92
	Auxiliary	0.93	0.97	1.02	1.12
	Sub-total	**1.85**	**1.89**	**1.94**	**2.04**
	Grand Total	**13.21**	**14.40**	**16.32**	**18.28**

0.10.1 Need for High Reliability of Power Supply

The proposed Ahmedabad metro system is being designed to handle about 16,000 passengers per direction during peak hours when trains are expected to run at 2.0 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 signage's, disruption of operation of lifts and escalators is likely to cause confusion, anxiety and ire in commuters, whose tolerance level are low on account of stress. Effect on signal and communication may affect train operation and passenger safety as well. Therefore, uninterrupted power supply is mandatory for efficient metro operations.

To ensure reliability of power supply, it is essential that both the sources of Supply and connected transmission & distribution networks are reliable and have adequate redundancies built in. Therefore, it is desirable to obtain power supply at high grid voltage of 220 kV, 132 kV or 66 kV from stable grid sub-stations and further transmission & distribution is done by the Metro Authority itself.

0.10.2 Sources of Power Supply

The high voltage power supply network of Ahmedabad city was studied in brief. The city has 220 kV, 132 kV and 66 kV network to cater to various types of demand in vicinity of the proposed corridors. A meeting was held on 19.04.2017 with M/s Torrent Power & MEGA official, and various sub-stations sites had been inspected to finalize the Input Power Supply sources & Supply Voltage.

Keeping in view the reliability requirements, Two Receiving Sub-stations (RSS) are proposed to be set up for extension of North-South Corridor Motera Stadium to Mahatma Mandir and its two Spurs Koteshwar Road to Airport & GNLU to Gift City. This is an economical solution without compromising reliability. Based on the discussions in meeting with M/s Torrent Power & MEGA, it is proposed to avail power supply for traction as well as auxiliary services from the following grid sub-stations at 132 kV voltage through cable feeders: -

Table 0.14 - Sources of Power Supply

S. No.	Corridor	Grid sub-station of Power Supply Authority (Input voltage)	Location of RSS of Metro Authority	Approx. length of cables
1.	Extension of North-South Corridor; Motera Stadium to Mahatma Mandir and its spur; GNLU to Gift City	One no. 132 kV bays from 132 kV Gandhi Nagar Substation	Near Infocity Station	5.0 km
		One no. 132 kV bays from 132 kV IT Park Substation		2.6 km
2.	Spur of North-South Corridor extension; Koteshwar Road to Airport (Phase –IIA)	Two no. 132 kV bays from 132 Airport Substation ______Or________	Near Airport Station	0.5 km
		Two Nos 66 kV bays from **proposed** Bhat 220/66 kV Grid Sub-station (GETCO).	Near Koba Circle	3.5 km

M/s Torrent Power MoM, dated:-19.04.2017 have assured that reliable power supply from their 132 kV Sub-station will be provided. A letter bearing No. DMRC/DPR/AM/10/Part-IV, dated 04.05.17 has been sent to M/s GETCO for the sake of confirmation of power supply at 220/66 kV Bhat Grid Substation. 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. The summary of expected power demand at various sources is given in table 0.15.

Table 0.15 – Power Demand projections for various sources (in MVA)

Corridor	Input Source	Peak demand - Normal		Peak demand** - Emergency	
		Year (2021)	Year (2051)	Year (2021)	Year (2051)
Extension of North-South Corridor; Motera Stadium to Mahatma Mandir and its spur Koteshwar Road to Airport & GNLU to Gift City	**RSS Near Infocity Station**				
	Traction	2.59	4.32	5.18	8.64
	Auxiliary	4.02	4.82	8.03	9.64
	Sub-total (A)	**6.61**	**9.14**	**13.21**	**18.38**
	RSS Near Airport Station/ Koba Circle Station				
	Traction	2.59	4.32	5.18	8.64
	Auxiliary	4.02	4.82	8.03	9.64
	Sub-total (B)	**6.61**	**9.14**	**13.21**	**18.38**

****In case of failure of other source of power

The 132 kV, 66 kV power supply will be stepped down to 33 kV level at the RSS's of metro authority. The 33 kV power will be distributed along the alignment through separate 33 kV Ring main cable network for feeding traction as well as auxiliary loads. These cables will be laid in dedicated ducts/cable brackets along the viaduct.

0.10.3 Various Options of Traction System

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

25 kV & 2x25 kV AC Overhead Catenary system.
750 V dc third rail system.
1500 V dc Overhead Catenary system

A sub- committee set up by "Ministry of Urban Development" on Traction system for metro railway has studies various aspects of merits and demerits of various traction system.

In view of the merits and demerits, DMRC recommends 25 kV AC Traction power supply. This is 95% available indigenously. However due to the low PHPDT of the network, lesser network lengths and aesthetics use of 750V DC system as used in Ahmedabad Metro by MEGA for Phase-1, is also suitable and justified. The DC suppliers are located outside India with 95% import content. As the Train Maintenance depot is common for Phase-1 & Phase-2, it is technically necessary to have a common traction system and hence 750 V dc 3rd rail traction system is optimum & recommended. Final decision may be taken by the client in this regard.

0.10.4 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 & depot is envisaged from reliability and safety considerations (figure below).

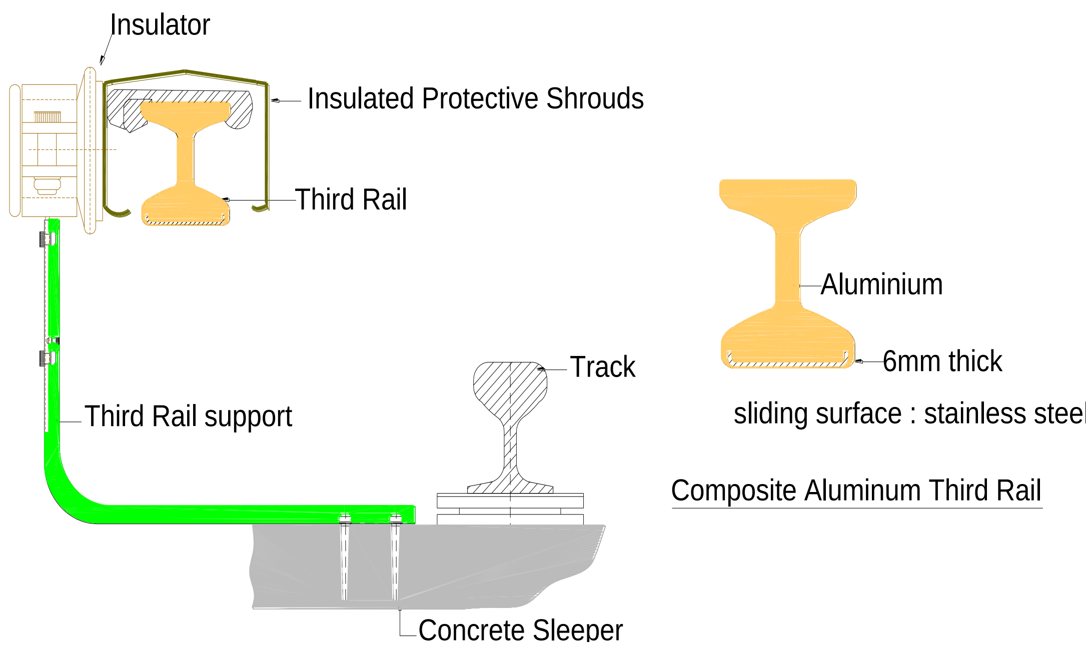


Figure 0.1

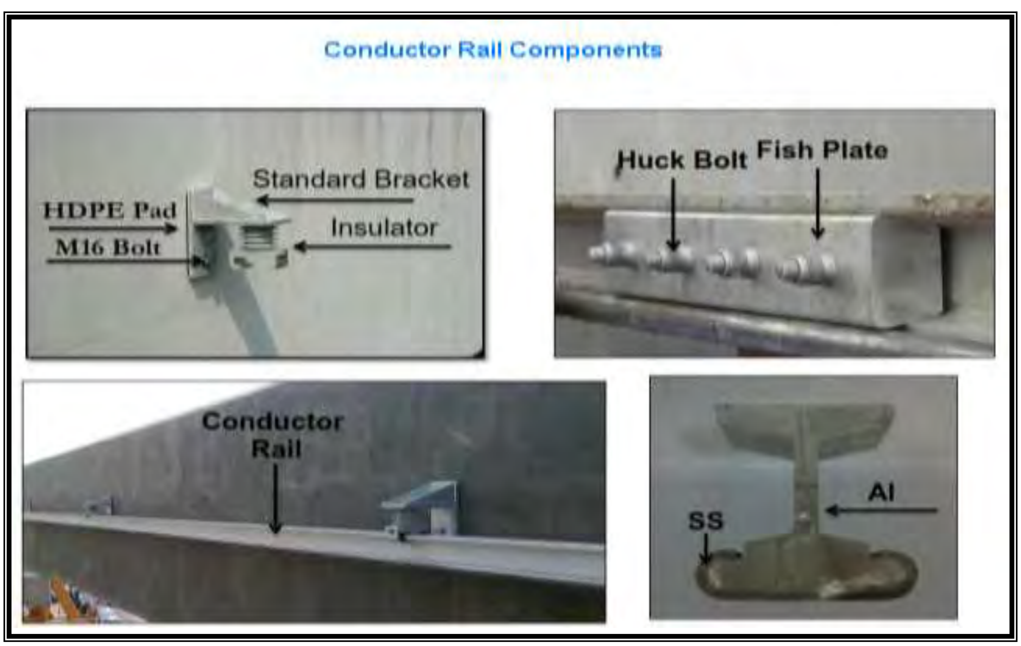


Fig. 0.2 750V dc Third Rail Current Collection System

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 m-ohm/km respectively. The life of composite and steel third rail is expected to be 25-30 years.

0.10.5 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 or Ground level inside a room. The typical layouts for TSS & ASS are given below. The requirement comes to 11 TSSs for extension of North-South Corridor; Motera Stadium to Mahatma Mandir, 2 TSSs for its first Spur; Koteshwar Road to Airport & 2 TSSs for its second Spur; GNLU to Gift City.

0.11 SIGNALLING AND TRAIN CONTROL SYSTEM

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

This Chapter provides the main design features of the signaling and train control system for the operation of Ahmedabad Phase-II metro corridor from Motera Stadium to Mahatma Mandir and their two extensions from Koteshwar Road to Ahmedabad Airport and from GNLU to Gift City corridors taking into account the proven and advance system being used worldwide.

0.11.1 Signalling

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

The proposed signalling system design for metro line corridor is as under:

Continuous Automatic Train Control System (CATC)
Automatic Train Operation (ATO) System
Radio based Automatic Train Control (ATC) System
Automatic Train Protection (ATP) System
On board Equipment
Cab Signalling
Fall-Back Block System
Interlocking device
Track side Radio equipment
Track Vacancy Detection System
Electric Point Machine

Track side Signals
Centralized Traffic Control System
Power Supply of signalling
Cable for signalling
Half Height Integrated Platform Gate (PG)

The requirements of the Ahmedabad Metro Corridor planned to be achieved by adopting following basic principles of signalling System: -

The Train Control and Monitoring shall be ensured from Centralized Traffic Control System located at Operation Control Centre (OCC). OCC equipment shall be connected to station equipment room through optical fiber network.
Computer Based Interlocking System shall be designed on failsafe philosophy. In case of failure of any equipment, the equipment shall fail on safe side or more restrictive state. In such case the signalling System shall authorized movement of train in normal and degraded operations.
Track side equipment shall be connected through Electronic Interlocking (to Station Equipment Room) by secure links to ensure safe movement of train.
Provide high level of safety with trains running at shorter headways ensuring continuous safe train separation.
Eliminate accidents due to driver passing Signal at Danger by continuous speed monitoring and automatic application of brake in case of disregard of signal / warning by the driver.
Provide safety and enforce speed limit on the sections having permanent and temporary speed restrictions.
Improve capacity with safer and smoother operations. Driver will have continuous display of Target Speed in his cab enabling him to optimize the speed potential of the track section. It provides signal / speed status in the cab even in bad weather.
Increased productivity of rolling stock by increasing line capacity and train speeds, and enabling train to arrive at its destination sooner. Hence more trips will be possible with the same number of rolling stock.
Improve maintenance of Signalling and Telecommunication equipment by monitoring System status of trackside and train borne equipment and enabling preventive maintenance.
To avoid any accident at platform, Integrated Passenger Gate shall be provided, which will be a barrier between the track and platform accessible to passengers. Signalling and Rolling Stock interfaces shall be provided for Passenger Gate System.
Signalling & Train Control System on the line shall be designed to meet the required headway during peak hours.

0.12 TELECOMMUNICATION & AUTOMATIC FARE COLLECTION SYSTEMS

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

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

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

The proposed Telecom system will cater to the following requirements:

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

0.12.1 Automatic Fare Collection

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

AFC system proves to be cheaper than semi-automatic (Manual System) in long run due to reduced manpower cost of ticketing staff, reduced maintenance in comparison to paper ticket machines, overall less cost of recyclable tickets (Smart Card / Token) in comparison to paper tickets and prevention of leakage of revenue. Seamless ticketing is now being thought of for Ahmedabad Metro Rail. This system is recommended to be adopted as this will enable the commuters to travel hassle free by different modes of transport viz. Metro, suburban trains, buses, water transport (whenever introduced) and even taxies without purchasing multiple tickets for each mode separately.

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

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

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

B) Automatic fare collection systems have the following advantages:

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

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

As per Metro Rail Policy 2017, it is mandatory to involve PPP in some form for implementation/ Operation & Maintenance, Fare Collection, etc. It has been proposed that AFC component for all 22 stations of Phase-II may be given on PPP basis in this project. The cost of above may be funded by engaging concessionaire on similar lines as of Kochi Metro, Nagpur Metro for the supply, installation, Testing, commissioning, operation & Maintenance of AFC gates and Allied services etc.

0.12.2 Choice of Control Gates

Retractable Flap Type/Paddle Type Control Gates are proposed which offer high throughput, require less maintenance and are latest in modern systems.

0.12.3 Ticket Vending Machine (TVM)

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

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

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

0.12.4 Ticket Reader/Add Value Machines

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

0.12.5 Recharge Card Terminal Machine (RCTM)

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

0.13 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

0.14 ENVIRONMENT AND SOCIAL IMPACT ASSESSMENT

The objective of the Environment and Social Impact Assessment study is to facilitate the Metro-Link Express for Gandhinagar and Ahmedabad (**MEGA**) evaluate the environmental impacts of its proposed activity. MEGA proposes to apply for loan to seek financial support from multilateral funding agencies. Thus, the objective of the study is to conduct Environmental Impact Assessment as per requirement of multilateral funding agencies. The scope of EIA includes the impacts resulting from pre-construction, during construction and operation phases of the proposed metro alignments in Ahmedabad. In addition, it is proposed to establish environmental baseline and safeguard measures for protection of environment for sustainable development during project cycles.

The proposed project does not pass through any Wildlife Sanctuary, National Park, or any other environmentally sensitive or protected areas. The proposed project comprises three alignments viz., between Motera Stadium – Mahatma Mandir, GNLU – Gift City and Koteshwar Road – Airport (Phase-IIA) metro corridors. The alignments are proposed mostly on the center of the road. Although, the proposed project will bring in many benefits to the area, there is potential for environmental impacts on the ambient environment.

Requirement of Environmental Clearance

As per provisions of the EIA Notification, 14 September 2006 as amended up to 1December 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, 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.

Requirement of 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 refers, in principle agreement, 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 alignment is not passing through any forest land and no diversion of forest land is involved in the proposed project, no forest clearance is required for this project.

0.15 SECURITY MEASURES FOR A METRO SYSTEM

Metro is emerging as the most favored 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 human casualties poses greater threat to its security. Security is a relatively new challenge in the context of public transport. It addresses problems caused intentionally. Security differs from safety which addresses problems caused accidentally. Security problems or threats are caused by people whose actions aim to undermine or disturb the public transport system and/or to harm passengers or staff. These threats range from daily operational security problems such as disorder, vandalism and assault to the terrorist threat.

0.15.1 Necessity of Security

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

0.16 DISASTER MANAGEMENT MEASURES

"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 even may 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.

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 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 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.

0.17 MULTI MODAL TRAFFIC INTEGRATION AT METRO STATIONS

0.17.1 Introduction

Ridership of a Mass rapid Transit system is directly or indirectly dependent on the accessibility of the trip generating and trip attracting areas within catchment zone. Importance of Last mile connectivity becomes crucial. A well connected, integrated network of footpath, cycle and bus feeder system acts as complimentary modes to generate ridership of Metro

Ahmedabad Gandhinagar Metro is a proposed rail rapid transit system connecting the city of Ahmedabad, Gandhinagar and the very ambitious GIFT city of Gujarat. The metro would be constructed in two phases and has two corridors Phase I consists of 40 km network comprising of East West Corridor and North South Corridor (Gyaspur to Motera-Phase I). Phase II consists of 34 km network that comprises of extension of North South Corridor, (Motera to Gandhinagar - Phase II) and two segment connectivity to GIFT City & Airport. This report consists of last mile connectivity only for Phase II of the planned metro.

Currently, due to unavailability of planned services, a user would tend to take metro only by accessing it by a car, auto or cabs, in case the place of origin of the user is situated within 500 to 800 mts from metro station, he/she will tend to walk to metro or take any shared services if available. Due to these consequences, with time a user would start depending on private vehicles more than public services available. To do otherwise strategic planning and design for services is required.

An on ground assessment of Phase II station area was conducted to identify potential local area access plan network consisting of footpath, cycling network, and feeder bus network.

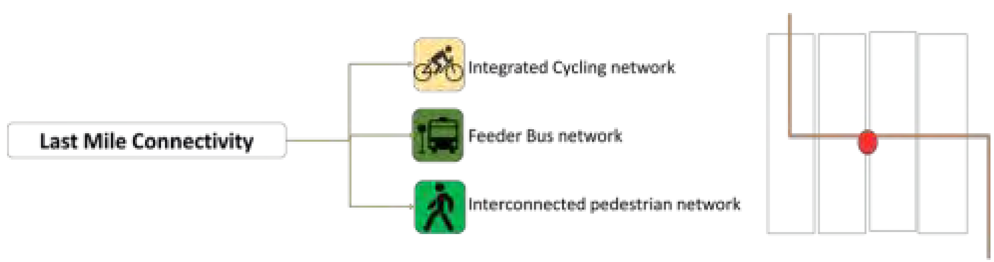


Figure 0.3 Parameters of Last mile connectivity

0.17.2 Benefits of Last Mile Connectivity

Improved accessibility to metro stations
Provision of last mile connectivity
Promotes use of sustainable public transport
Focuses on improving station area integration and connectivity
Long term impact on low pollution

Long term impact on traffic solutions
Improve reliability on public transport systems

0.18 COST ESTIMATES

Project Cost estimates for Ahmedabad Metro Phase-II corridors have been prepared covering civil, electrical, signaling and telecommunication works, rolling stock, environmental protection, rehabilitation, considering 750 V dc third rail traction system etc. at December 2018 price level.

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

(i) Route km. Length of alignment
(ii) No. of units of that item and
(iii) Item being an independent entity.

All items related with alignment, permanent way, 750 V dc third rail current collection system, signaling and telecommunication, have been estimated on rate per route km basis. The cost of elevated stations includes civil work for station structures, architectural finishes, platform, roofing, etc. Provisions for electrical and mechanical works, air conditioning, lifts, escalators, etc. have been worked out separately. These rates do not include cost of permanent way, 750 V dc third rail current collection system, power supply, signaling and telecommunication, automatic fare collection (AFC) installations, for which separate provisions have been made in the cost estimates. Similarly, for other items like Rolling stock, Traction & Power, etc. costs have been summed up separately. In remaining items, viz. land, utility diversions, rehabilitation, etc. the costs have been assessed on the basis of each item taken as an independent entity.

In order to arrive at realistic cost of various items, costs have been assessed on the basis of rates considered in DPR of Delhi Metro Phase-IV network. Taxes & Duties such as Customs Duty, CGST, SGST and IGST wherever applicable, have been worked out on the basis of prevailing rates and included in the cost estimates separately.

The overall Capital Cost for **Motera Stadium to Mahatma Mandir Metro Corridor** of Ahmedabad Phase-II at December 2018 price level works out to **Rs.3529 Crores** excluding applicable Taxes & Duties of **Rs. 529 Crores**.

Capital Cost for **GNLU to GIFT City Metro Corridor** at December 2018 price level works out to **Rs.660 Crores** excluding applicable Taxes & Duties of **Rs. 104 Crores**.

Capital Cost for **Koteshwar Road to Airport Metro Corridor** (Phase-IIA) at December 2018 price level works out to **Rs.790 Crores** excluding applicable Taxes & Duties of **Rs. 123 Crores**.

Capital Cost for additional corridor inside **GIFT City** (Phase-IIB) at December 2018 price level works out to **Rs.579 Crores** excluding applicable Taxes & Duties of **Rs. 87 crores**. All the above costs are tabulated hereunder.

Table 0.16 – Corridor-wise Details of Capital Cost (at December 2018 level)

Sr. No.	Name of the corridor	Capital Cost (Rs. Crore)	Taxes & Duties (Rs. Crore)	Total (Rs. Crore)
Phase-II				
1	Motera Stadium to Mahatma Mandir	3529	529	4058
2	GNLU to GIFT City	660	104	764
	Total	**4189**	**633**	**4822**
Phase-IIA				
3	Koteshwar Road to Airport	790	123	913
Phase-IIB				
4	Additional corridor in GIFT City	579	87	666
	Total (Phase – II + IIA + IIB)	**5558**	**843**	**6401**

0.19 FINANCING OPTIONS, FARE STRUCTURE, FINANCIAL VIABILITY AND NON FARE BOX REVENUE

The Phase-II of Ahmedabad Metro Rail Project from Motera Stadium to Mahatma Mandir (Corridor 1), Koteshwar Road to Ahmedabad Airport (Corridor 2) and GNLU to GIFT City (Corridor 3) is proposed to be constructed from September 2019 to March 2024. The route length of the metro system and estimated cost at December-2018 price level without central taxes, with central taxes and with all taxes were worked out under the three options as given in table 0.17 as under:

Table 0.17 Cost Details

Cost Details (at December 2018 Price Level)					
Corridor	**Name of Corridor**	**Distance (km)**	**Estimated cost without taxes (Rs/Crore)**	**Estimated cost with Central taxes & land cost (Rs/Crore)**	**Estimated cost with all taxes & land cost (Rs/Crore)**
Option I – Considering Corridor I, II & III					
I	Motera Stadium to Mahatma Mandir Corridor	22.838	3529.00	3814.00	4058.00
II	GNLU to GIFT City Corridor	5.416	660.00	716.00	764.00
III	Koteshwar Road to Ahmedabad Airport (Phase-IIA)	6.339	790.00	857.00	913.00
Total		**34.593**	**4979.00**	**5387.00**	**5735.00**
Option II – Corridor I & II					
I	Motera Stadium to Mahatma Mandir Corridor	22.838	3529.00	3814.00	4058.00
II	GNLU to GIFT City	5.416	660.00	716.00	764.00

Cost Details (at December 2018 Price Level)					
Corridor	**Name of Corridor**	**Distance (km)**	**Estimated cost without taxes (Rs/Crore)**	**Estimated cost with Central taxes & land cost (Rs/Crore)**	**Estimated cost with all taxes & land cost (Rs/Crore)**
	Corridor				
	Total	**28.254**	**4189.00**	**4530.00**	**4822.00**
Option III – Corridor I					
I	Motera Stadium to Mahatma Mandir Corridor	22.838	3529.00	3814.00	4058.00
Total		**22.838**	**3529.00**	**3814.00**	**4058.00**

The estimated cost at December-2018 price level includes an amount of Rs. 7.40 Crore for corridor 1, Rs. 1.11 crore for corridor 2, Rs. 1.11 crore for corridor 3 and Rs. 1.11 for corridor 4 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 personnel have not taken in to account in the FIRR calculation since providing required security at metro stations shall be the responsibility of state police. The financial viability has been worked out for Option II only.

0.19.1 Investment Cost

For the purpose of calculating the Financial Internal Rate of Return (FIRR), the completion cost with all taxes has been calculated by taking escalation factor @5.00% per annum. It has been assumed that the Government of Gujarat will provide the land worth Rs. 262.48 crore under option II either free of cost or it shall provide Interest Free Subordinate Debt. The taxes and duties consist of Custom Duty (CD), Central Goods and Service Tax (CGST), State Goods and Service Tax (SGST), Integrated Goods and Service Tax (IGST). It is understood that Phase-II of Ahmedabad metro project is eligible for availing concessional project import duty under chapter 98.01 of the Custom Tariff Act. The effective CD works out to 24.077% {Basic CD @ 5%, IGST (CGST & SGST) @ 18% and cess} on the imported portions. Post-GST, the GST rate on construction of original works of metro project has been considered @ 6% each for CGST and SGST while the GST rate has been considered @ 18% for supply of indigenously manufactured items and services. The above taxes and duties have been considered for working out the estimated taxes and duties. The Interest Free Subordinate Debt is normally repayable in 5 equal instalments (31-35 years) after repayment of Multilateral/Overseas Development Assistance Loan.

It is assumed that the construction work will start from 01.09.2019 and is expected to be completed on 31.03.2024 with Revenue Opening Date (ROD) as 01.04.2024. The total completion costs duly escalated and shown in the table 19.2 have been taken as the initial investment. The cash flow of investments under option II is placed in the table 0.18.

Table 0.18 Year –wise Investment for Option II

Figures in Rs. Crore

Financial Year	Estimated Cost including cost of land and all taxes & duties at December 2018 Price Level	Completion Cost including cost of land cost and all taxes & duties
2019-20	482.2	482.16
2020-21	964.4	1008.73
2021-22	1205.5	1316.44
2022-23	1446.6	1646.34
2023-24	723.3	856.5
Total	**4822**	**5310.17**

0.19.2 Fare Structure

The 4th Fare Fixation Committee has recommended 6 fare slabs to DMRC. The fare recommended to DMRC from October 2017 has been assumed to be taken as the base for all the corridors of Phase-II of Ahmedabad Metro project. The same has been escalated by using @ 12.00% once in every two years considering the increase in the Consumer Price Index (CPI) and input costs of operation. The fare structure for the FY 2022-23 is shown in table 0.19.

Table 0.19 Fare Structure in 2022-23 (All options except corridor IV)

Distance (km)	Fare (Rs.)	
	DMRC Fare from October 2017	Proposed Fare in 2022-23
0-2	10	10
2-5	20	30
5-12	30	40
12-21	40	50
21-32	50	70
>32	60	80

0.19.3 Financial Internal Rate of Return (FIRR)

The Financial Internal Rate of Return (FIRR) obtained for 30 years life cycle business model including construction period without additional PD Income and with additional PD Income from 20 Hectare Land under option II is tabulated in Table 0.20.

Table 0.20 FIRR

Alternative	FIRR without Additional PD Income	FIRR with Additional PD Income
Option II	2.12%	6.01%

0.19.4 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)/Chennai Metro Rail Corporation/Mumbai Metro Rail Corporation
(ii) Design-Build-Finance-Operate-Transfer (DBFOT), and
(iii) Public Private Partnership (PPP)

SPV Model: - The corridors are a standalone one and a separate SPV with the name Metro Link Express for Gandhinagar and Ahmedabad (MEGA) Company Ltd, A SPV of GoI and GoG is already in existence for execution of Phase I Metro project. The funding pattern under this model (SPV) for option II is placed in table 0.21.

Table 0.21 Funding pattern under SPV model (with all taxes)

(Rs./Crore)

Particulars	With Taxes & Duties	
	Amount (Rs./Crore)	% of contribution
Equity By GOI	757.11	15.28%
Equity By GOG	757.11	15.28%
SD for Total Taxes by GOG (2/3rd)	468.06	9.44%
SD for Total Taxes by GOI (1/3rd)	234.03	4.72%
Loan from bilateral/ multilateral agencies	2739.38	55.28%
Sub-Total	**4955.69**	**100.00%**
Subordinate Debt for Land Including R&R cost by GoG	262.48	
Sub-Total	**5218.17**	
Concessionaire Fund for PPP Component (AFC for Stations)	92.00	
Sub-Total	**5310.17**	
IDC for Loan to be borne by GoG	74	
Grand Total	**5384.17**	

DBFOT Model: - In this model, the private firm will be responsible for financing, designing, building, operating and maintaining of the entire project. The contribution of Government of Gujarat will be limited to cost of land only. Such a project become eligible for Viability Gap Funding (VGF) up to 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.

0.19.5 Recommendations

The FIRR without and with Additional PD Income from 20 Hectare land is 2.12% and 6.01% under option II.

As per Metro Rail Policy 2017, issued by the Ministry of Housing and Urban Affairs, (MOH&UA), GOI, apart from financial viability, the economic and social viability of the project is also required to be assessed. The Economic Internal Rate of Return (EIRR) for any metro rail project proposal should be 14% and above for consideration of its approval. Accordingly, the metro corridors under option II discussed above are recommended for implementation provided the required EIRR works out to 14% or above. The Metro Link for Gandhinagar to Ahmedabad (MEGA) may explore the possibility for generation of fund from TOD development, Value Capture Financing, Increase in Floor Area Ratio (FAR), Imposition of Green Cess etc to make the system self-sustainable.

0.20 ECONOMIC APPRAISALS

Economic appraisal aims to represent a complete view of contribution of upcoming Metro system benefiting the society in form of money value. Thus calculating Economic Internal Rate of Return measures viability of the project. This part of study quantifies benefits by saving of time, saving in cost of public and private transport, saving in fuel consumption, increasing safety of passengers, reduction in traffic congestion and reduction in air pollution.

Metro corridors in phase-I and phase-II with corridor-I (East-West Corridor: Thaltej Gam to Vastral Gam), corridor-II (North-South Corridor: APMC to Motera Stadium) and corridor-II extension (Motera Stadium to Mahatma Mandir) are proposed to be operational from 2022. However, start of construction is considered from 2019 and economic benefits are estimated from this year (2019) onward for coming 30 years. Therefore, 2048 is considered as horizon year for the project.

0.20.1 Option Evaluation

An option collating with financial Analysis for operation of two corridors – Motera Stadium to Mahatma Mandir and GNLU to GIFT City has been evaluated for second phase of metro project. Summary Table for this is as follows.

Table 0.22 - Summary of Estimated EIRR for all Options

Corridor	Name of Corridor	Distance (km)	Calculated EIRR
I	Motera Stadium to Mahatma Mandir Corridor	22.838	
II	GNLU to GIFT City Corridor	5.416	
Total		**28.254**	**18.28%**

The years of construction is assumed as 2019 to 2023 for two phases of Metro with two corridors and extension. Estimated total cost is subtracted from total benefit to arrive at net benefit. The cash flow is prepared in discounting process to evaluate internal rate of return. The result proves this project to be economically viable. While calculating the Net Present Value 12% discount rate is considered as per ADB. EIRR for Metro system in Ahmedabad for Option -II is estimated using shadow prices is 18.28%.

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 0.26

Table 0.23 - 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 Public Investment Board	D +3months
6	Sanction of Project by Government of India	D +6months
7	Appoint General Consultant	D +9months
8	Tendering, Execution of works and Procurement of equipments, coaches and installations	D +45months
9	Testing and Commissioning	D +46moths
10	Revenue Operation	D +46months

0.22 CONCLUSIONS & RECOMMENDATIONS

The 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) Motera Stadium to Mahatma Mandir (22.838km) and (ii) GNLU to GIFT City (5.416km) at a completion cost of **5310.17 Crores** (including Cost of Land and all taxes & duties) to be made operational as recommended in implementation chapter. In addition to this, Rs. 74 Crore IDC for Loan is to be borne by GoG.

While the Financial Internal Rate of Return (FIRR) for the project has been assessed as 2.12% without PD income for Option II and the Economic Internal Rate of Return (EIRR) for same option works out to 18.28%. Therefore, it is recommended for implementation. The FIRR of the corridors with additional PD Income from 20 Hectare Land is 6.01% for Option II.

Implementation of Option II consisting of following corridors is recommended on Part PPP model.

Motera Stadium to Mahatma Mandir (22.838km)
GNLU to GIFT City (5.416km)
AFC component for all stations of Phase-II as PPP model

0.23 TRANSIT ORIENTED DEVELOPMENT (TOD) & VALUE CAPTURE FINANCE (VCF)

New Metro Rail Policy 2017 emphasizes that “Transit Oriented Development (TOD)” with proposed intermodal integration, universal accessibility, adequate walkways and pathways for Non-Motorized Transport (NMT), stations for public bike sharing, commensurate parking lots for cycles and personal vehicles, as well as adequate arrangement for receiving and dispatch of feeder buses at all metro stations. The commitment by the State Government to adhere the guidelines issued by the central government w.r.t. TOD and adoption of VCF framework should be an integral part of the project proposal. The commitment should inter alia include commitment of transfer of the financial benefits accruing in the influence zone of the metro alignment on account of the TOD policies and VCF framework directly to the Special Purpose Vehicle (SPV)/agency implementing the metro rail project. The project report should specify the proposed quantum of such benefits being transferred to the project. This requirement would form a mandatory part of all metro rail project proposals.

Commercial/property development at stations and on other urban land has been used as a key instrument for maximizing revenues in metro rail/ railway systems in cities around the world. Notable examples are Hong Kong and Tokyo. Metro rail implementing agencies should endeavor to maximize revenue through commercial development at stations and on land allocated for this purpose.

Ordinarily, own sources of revenue in ULBs can be classified into three categories, (a) taxes levied by the municipality, (b) user charges levied for provision of civic services, and (c) fees and fines levied for performance of regulatory and other statutory functions. Octroi, which was one of the main sources of own income of the ULBs has been abolished, resulting in a serious dent on ULBs’ resources. On the other hand, property tax, which is at present the main source of own resources is underused and has issues related to its narrow tax base, exemptions, etc. Furthermore, the State Governments are increasingly fixing the rate for services being provided by ULBs, even though these functions are mandated to be performed by ULBs under the 74th Constitutional

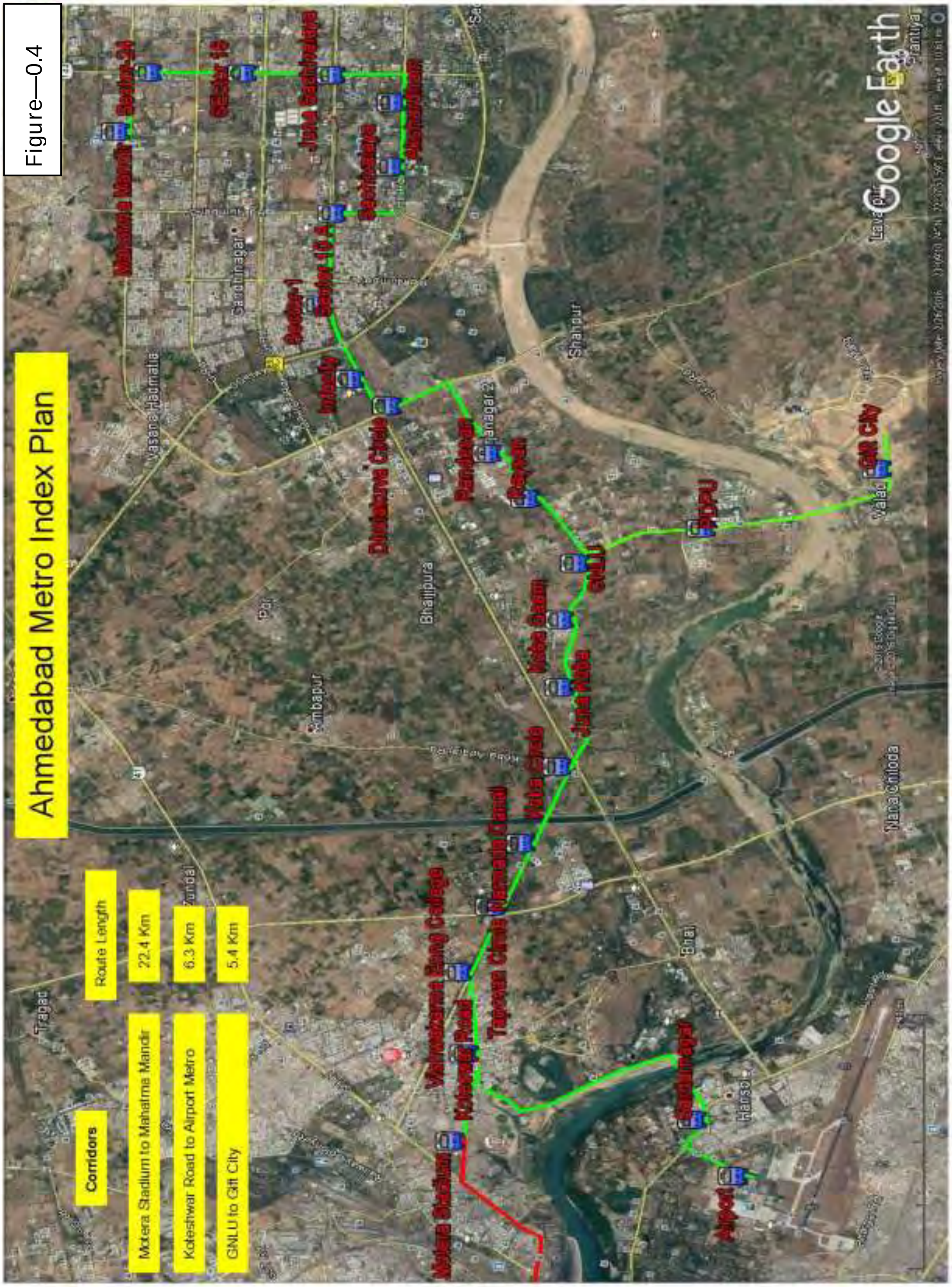
Amendment. Overall, this has led to increased dependency on State Governments and reduction in efforts made by ULBs to mobilize resources.

Land is the most fundamental asset that is owned and managed by the States/ULBs and is a resource to generate revenues. Traditionally, States/ULBs have relied on direct sale of lands to raise funds, which is a less efficient form of resource mobilization, as compared to value capture. It is not that States/ULBs have not used Value Capture methods to raise resources. In fact, States/ ULBs are using different Value Capture methods, especially in urban areas, such as impact fee, betterment charges, etc. For example, the Mumbai Metropolitan Region Development Authority (MMRDA) and City and Industrial Development Corporation Limited (CIDCO) of Maharashtra have used different Value Capture methods to finance infrastructure development in the urbanizing areas. Similarly, Haryana and Gujarat have successfully used land pooling schemes, where owners agree to exchange their lands for infrastructure services.

While States/ULBs have been developing and using some of the Value Capture Finance (VCF) methods, the Central Government Ministries/Departments have not yet systematically used VCF methods as a revenue generation tool. One reason is that land is a State subject and VCF Policies have to be made by the concerned State Governments. A promising way is to link the location and construction of the projects by the Central Government Ministries and their agencies with the existing VCF Policy of the generated within the area of influence of the projects. Alternatively, the State VCF Policy could be revised whenever new projects are being planned in order to capture full value being generated due to proposed investment in projects.

There is an increasing focus on creation of infrastructure by Ministries/Departments of Government of India and their agencies. For example, the Ministry of Ports is constructing a series of projects as part of the Sagarmala program. Moreover, the Delhi-Mumbai Industrial Corridor (DMIC) is being developed by the Department of Industrial Policy and Promotion (DIPP) and the Metro Rail projects by the Ministry of Urban Development (MoUD). All these projects have an area of influence in which they lead to increase in value of lands and buildings, creating opportunities for using value capture methods to mop up additional resources.

Figure—0.4


Ahmedabad Metro Index Plan
Corridors
Route Length
Motera Stadium to Mahatma Mandir
22.4 Km
Koteshwar Road to Airport Metro
6.3 Km
GNLU to Gift City
5.4 Km
Google Earth

Chapter – 1

INTRODUCTION

1.1 BACKGROUND

Ahmedabad also known as Amdavad in Gujarati pronunciation is the largest city and former capital of Gujarat. It is the administrative headquarters of the Ahmedabad district and the seat of the Gujarat High Court. It is the sixth largest city and seventh largest metropolitan area of India with a population of more than 6.3 million and an extended population of 7.8 million. Ahmedabad is located on the banks of the Sabarmati River. It is located 30 km from the state capital Gandhinagar, which is its twin city.

Ahmedabad has emerged as an important economic and industrial hub in India. It is the second largest producer of cotton in India, and its stock exchange is the country's second oldest. Cricket is a popular sport in Ahmedabad, which houses the 54,000-seat Sardar Patel Stadium. The effects of liberalization of the Indian economy have energized the city's economy towards tertiary sector activities such as commerce, communication and construction. Ahmedabad's increasing population has resulted in an increase in the construction and housing industries resulting in recent development of skyscrapers.

It was ranked third in Forbes's list of fastest growing cities of the decade in 2010. The Times of India chose Ahmedabad as India's best city to live in 2012. Ahmedabad has been selected as one of the hundred Indian cities to be developed as a smart city under Government of India's flagship Smart Cities Mission.

In 1960, Bombay state was split in two different states, Gujarat and Maharashtra. Ahmedabad became capital of Gujarat, and a new capital Gandhinagar has been built on land which was once part of Pethapur state. The new capital Gandhinagar was planned by Chief Architect H.K. Mewada, educated at Cornell University, and his assistant Prakash M Apte. Both Mewada, and Apte had worked as trainees under legendary architect Le Corbusier in the Chandigarh Project in the 1950s. Gandhinagar's streets are numbered, and have cross streets named for letters of the Gujarati alphabet (e.g., "k", "kh", "g", "gh", "ch", "chh", "j"). All streets cross every kilometre, and at every crossing traffic circles decrease the speed of traffic. Gandhinagar has developed in four distinct phases:

> **Phase 1:** After the Gandhinagar's infrastructure was completed in 1970, and until 1980, it was known as 'Gandhian City,' since it was based on Gandhi's concepts and principles.

Phase 2: Between 1980 and 1990, a time of low pollution, it was known as 'Unpolluted City'.

Phase 3: After 1990, many trees were planted, and the city became the 'Green City.'

Phase 4: In 2002, Gujarat's Chief Minister, Narendra Modi, proposed a new, triple focus for the city: it should be green, it should use solar energy, and It should be cosmopolitan.

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. Gandhi Nagar is linked with Ahmedabad on the south by a direct road, having a straight alignment and 91.44m (300.0 ft) wide Right of Way.

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.

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, Centre for Environment Planning and Technology (CEPT) University, 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 2009 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 1.1) desired for DMRC to update the earlier DPR submitted by DMRC in 2005. Accordingly, DMRC submitted the updated and revised DPR to MEGA in March 2015.

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 through DMRC. CRRI, on behalf of DMRC undertook this study and estimated demand along the proposed metro corridor of Airport-Koba-GIFT.

Two metro corridors: East-West (Thaltej to Vastral) and North-South (APMC to Motera Stadium) identified for Metro Phase I and is shown in the Figure below. These corridors are under implementation and expected to be commissioned in the year 2018.

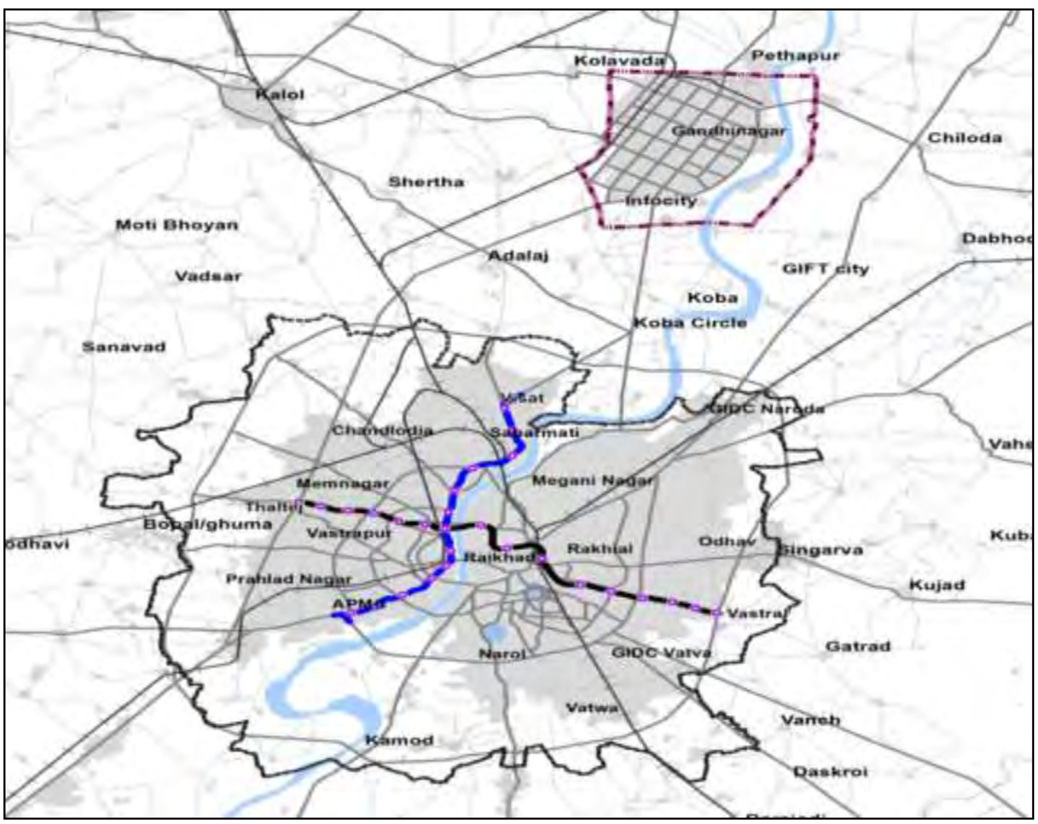


Fig.1.1 Proposed Metro Corridors – Phase I

1.3 PRESENT STUDY

High Powered Committee (HPC) of Government of Gujarat (GoG) decided to further extend APMC – Motera line to Gandhi Nagar (Sachivalya, Akshardham and Mahatma Mandir). It is also decided to connect GIFT City and Airport also. In view of this MEGA vide letter No. Ref. MEGA/MD/DMRC/IC/19, dated 27/01/2016 (**Annexure 1.2**), asked DMRC to submit Terms of Reference (ToR) to take up study of for preparation of Detailed Project Report (DPR) of Ahmedabad Metro Phase – 2 corridors.

1.3.1 Scope of services

The services to be rendered under the proposed detailed study will include:

(i) Traffic & Transportation surveys for estimation of Transport Demand and projection of sectional and station traffic loads for various horizon years.

(ii) Preparation of alternative routes on Google/available standard maps duly verifying at site regarding the actual location. Also, prepare the comparative study for Underground and Elevated options for the finalized route.

(iii) Multi modal Traffic integration, planning for feeder bus service, public bike sharing and pedestrianisation in the influence area of stations.

(iv) Field Surveys and preparation of topographical survey plans for route alignments and assessment of land requirement for facilities like station areas, Electric sub stations (TSS and RSS) Maintenance Depot and Construction Depots. The topography surveys for adequate width for the viaduct and stations to accommodate any future minor modifications in the alignment and the locations of stations.

(v) Field Surveys for identification of major above- ground utilities along the proposed Metro routes requiring diversion/relocation. Details of underground utilities shall be supplied by State Govt. through the concerned utility agencies. The responsibility to collect the utility data from the respective agencies lies with DMRC. However, necessary co-operation/co-ordinance will be extended by MEGA to carry out the same.

(vi) Preparation of Geometric design of the route alignments covering horizontal and vertical profile including viaduct and station GAD along the tentative pier configuration has to be prepared to assess the approximate land acquisition required along the viaduct alignment and station location.

(vii) Location of stations and general layout plans for stations and integration areas.

(viii) EIA studies and preparation of EMP for negative impacts, if any.

(ix) Geo-technical investigations along the corridor at the interval of 1km for elevated corridor and 500 meters for underground corridor and up to the required depth. However, the interval may be modified based on the availability of the site.

(x) Technology Selection – Broad details of Traction and Signalling system, rolling stock, track, etc.

(xi) Conceptual Plan for utilization of existing Phase-I depot for arriving at the total depot requirement for the purpose of the rolling stock maintenance. Also, report on interface with the proposal system of Phase-I to be mentioned.

(xii) Creation of disable friendly features to ensure accessibility to persons with disabilities.

(xiii) Security measures to ensure security for metro system.

(xiv) Disaster management features for metro system.

(xv) Implementation Schedule.

(xvi) Estimation of construction costs, operation and maintenance costs. The basis, for the assumption for arriving at the cost has to be submitted.

(xvii) Study on the Fare Structure.

(xviii) Financial and Economic analysis for the project.

(xix) Evolving a Funding Plan and Institutional arrangement for the Project.

(xx) Preparation and submission of Detailed Project Report.

1.4 STUDY AREA

Introduction

The basis for secondary data collection is that it helps to fill the gaps that have not been able to be collected through primary surveys. Also, this data is required for establishing trends and development patterns of the city. Collection of relevant secondary data like demographic and land use data for every ward, accident data of last five years, bus route details, fleet details, speed and delay of car along the proposed metro corridors, fare structure of every mode of transport etc. as per the scope of work entrusted to the consultant was completed. The following section would provide an overview of the data collected through various sources.

a. City Profile

The study area boundary primarily comprises of area within four administrative boundaries namely 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

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.

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.

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

Gujarat International Finance Tech-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.

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 11existing 4 proposed SEZ. Part of the Changodar SIR also forms a part of the study area.

Based on the above mentioned areas, the study area defined includes areas as given in the following table.

Table 1.1 Study Area Boundary

Area Boundary	Area (km2)	Name	No of Zones	Population
GUDA	388	Urban Area (Gandhinagar Municipal Area , Adalaj) and 39 Villages of GUDA	80	4,37,111
AMC	466	Ahmedabad Municipal Corporation	285	55,89,944
AUDA (Urban + Rural) Or Area adjoining AMC)	272.44	Urban areas (Bopal, , Singarva , Chiloda and Out growth – Kathwada and Guma) 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)	44	2,21,698
Outside AUDA	19.98	2 villages (Changodar ,Moraiya)	4	14,656
Grand Total	1146.41		413	62,63,409

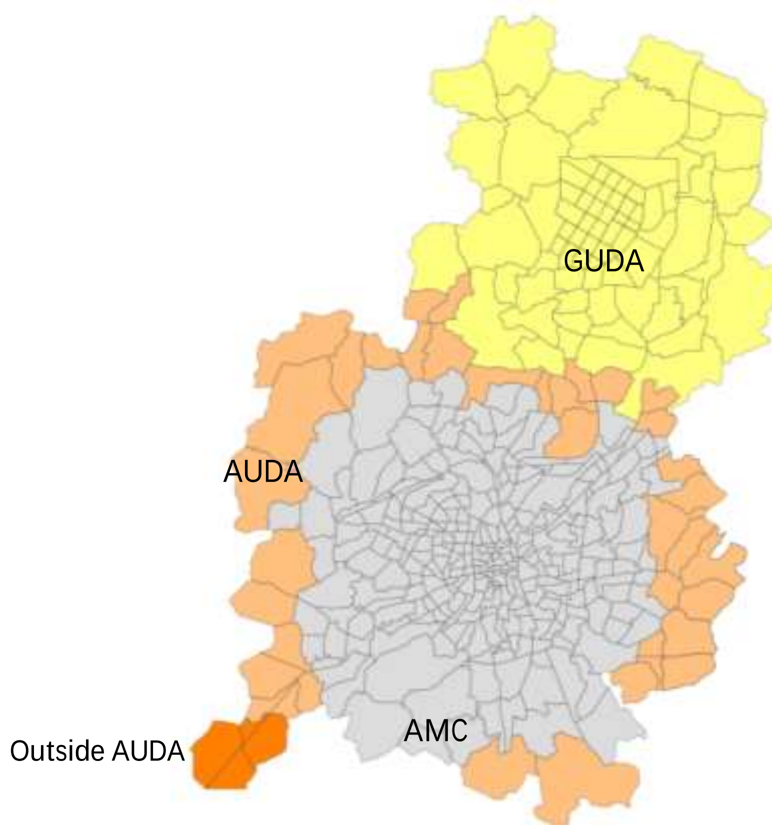


Fig. 1.2 Study Area

b. Demographic Details

As per Census of India 2011, the study area consisting of four administrative boundaries has a population of 6.3 million.

Table 1.2 Demographic Profile of the study area

Areas	Population			Area	Density (Person / Ha)			Annual Growth Rate (%)	
	1991	2001	2011	(in Ha)	1991	2001	2011	1991-01	2001-11
GUDA	2,78,558	3,81,183	4,37,111 (6.98%)	38800	7	10	11	3.19	1.38
AMC	34,21,044	45,17,194	55,89,944 (89.25%)	46683	73	97	120	2.82	2.15
AUDA (AMC Adjoining area)	1,20,065	1,50,335	2,21,698 (3.54%)	27244	4	6	8	2.27	3.96
Outside AUDA	6,075	6,938	14,656 (0.23%)	2001	3	3	4	1.34	7.77
Total	**38,25,742**	**50,55,650**	**62,63,409**	**114728**					

The population within the AMC boundary is highest consisting of 89.25% of study area population in the census year 2011, followed by 6.98% of population within the GUDA boundary, 3.54% population within AUDA (urban and rural/AMC Adjoining area) and a very negligible share of 0.23% population outside AUDA area.

Population within areas outside AUDA and AUDA (AMC Adjoining area) have witnessed the highest growth in the decade 2001-11. On the other hand, urban boundaries consisting of AMC and GUDA have witnessed a moderate growth of 2.15% and 1.38%.

Population Projection

Futuristic population growth has been collected from various sources. As per GUDA development plan-2024, by 2031 the region would have a population of 10 lakhs from 4.9 lakhs in 2021. Introduction of GIFT city and urbanization of the GNA area and current villages would add to it.

Table 1.3

Jurisdiction	2021	2031
GNA	2,40,620	3,35,678
GUDA villages	2,50,885	2,81,326
GIFT		3,38,000
Total GUDA	**4,91,505**	**9,55,004**

Source: Guda Development Plan, 2024

As per greater Ahmedabad development plan, by 2031 the region that consists of two major urban areas Ahmedabad, Gandhinagar, economic hub of GIFT, 131 other villages and few other small towns and settlements would be 125 lakhs. It is also mentioned that urban areas of Ahmedabad i.e. AMC boundary and urban area of Gandhinagar i.e. GNA boundary together will house 60% of the population projected.

Table 1.4 Projected Population of Greater Ahmedabad

Jurisdiction	2011	2031
Greater Ahmedabad	81,12,000	1,25,00,000
AMC + GNA	60%	60%
AMC + GNA	48,67,200	75,00,000
AMC	-	71,64,322
GNA	-	3,35,678

Source: Greater Ahmedabad Development Plan and Integrated Mobility Plan of Greater Ahmedabad

Socio Economic Characteristics

As per Ahmedabad Metro DPR, 2015, 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.

Projected employment generation for GIFT shows that, by 2020 this economic hub would cater to 1.75 lakh jobs which would subsequently increase to lakh in 2025 and 5 lakh in the year 2030

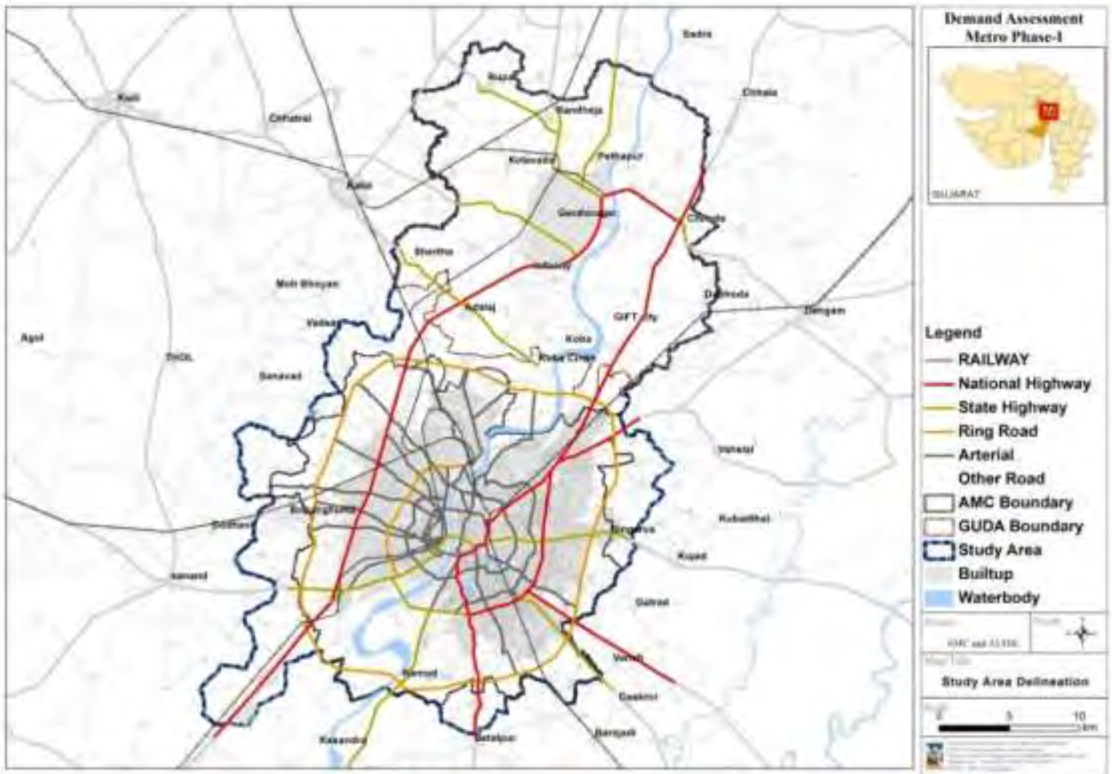
Table 1.5 Projected Employment of GIFT 2030

Year	Employment (lakh)
2020	1.75
2025	3
2030	5

Data Source: MEGA Office, 2017

c. Road Network

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.



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

Fig. 1.3 Figure 5 Existing Road Network in Study area

Table 1.6 Road Network Composition

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*

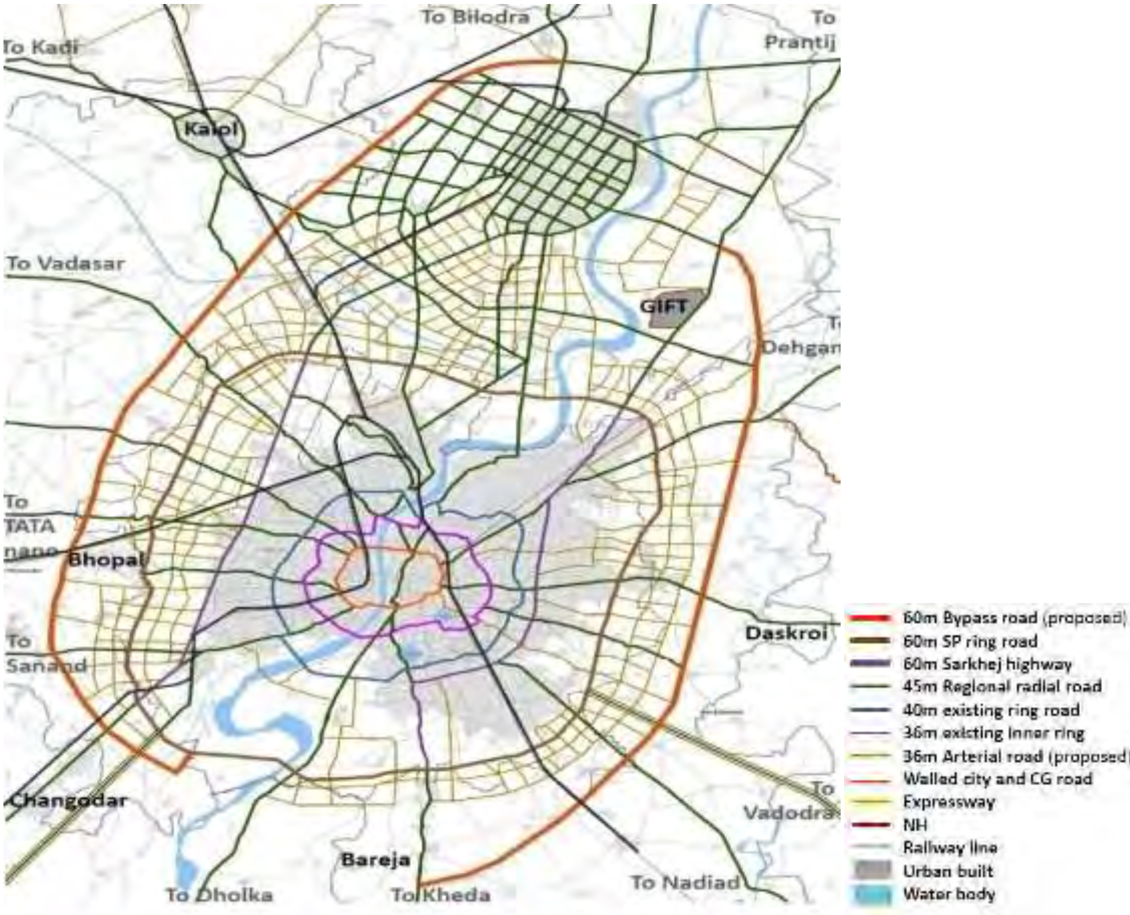


Fig. 1.4 Network Characteristics

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

1.5 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
Chapter-8	Rolling Stock
Chapter-9	Depot
Chapter-10	Power Supply Arrangements
Chapter-11	Signalling

CHAPTER NO.	DESCRIPTION
Chapter-12	Telecommunication & Automatic Fare Collection
Chapter-13	Disabled Friendly Features
Chapter-14	Environmental & Social Impact Assessment
Chapter-15	Security Measures for a Metro System
Chapter-16	Disaster Management Measures
Chapter-17	Multi Modal Transport Integration at Metro Stations
Chapter-18	Cost Estimates
Chapter-19	Financing Options, Fare Structure And Financial Viability
Chapter-20	Economic Appraisal
Chapter-21	Implementation Plan
Chapter-22	Conclusion

Annexure 1.1

GOVT OF GUJARAT

Dr. Ma jula 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

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

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

Annexure 1.2

I. P. Gautam, IAS (Retd.)
Managing Director

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

Ref.MEGA/MD/DMRC-IC/

Outward No. G/66/19
Date : 27/01/2016

January 27, 2016

To,
Shri S.D. Sharma,
Director (Business Development),
Delhi Metro Rail Corporation Ltd.,
25, Ashoka Road,(Nr. Patel Chowk Metro Station)
New Delhi - 110001

Sub:- Preparation of DPR for Ahmedabad Metro Project Phase-2 connecting Airport, Gandhinagar and GIFT City.

Dear Sir,

Please recall our discussion on 20th Jan., 2016 regarding above cited subject. As DMRC had prepared the DPR for Phase-1 in Feb. 2014 which was approved by Government of India and the construction work is in progress. The High Powered Committee of State Government has decided to further extend the connectivity from APMC – Motera line to Gandhinagar (Sachivalaya, Akshardham and Mahatma Mandir). It is further decided to connect the GIFT city and Airport also.

As you are aware that connectivity of Gandhinagar had already been discussed in details during the preparation of DPR of Phase-1 and Tentative alignment was also drawn for the purpose of Gandhinnagar connectivity.

In view of above, it is requested to send the detailed proposal including financial quote at the earliest. We are expecting that the preparation of DPR for Phase 2 should be completed within 5 – 6 months time.

Thanking you,

Yours faithfully,

I.P. Gautam
Managing Director

c.c. to:

(1) Managing Director, Delhi Metro Rail Corporation Ltd., Metro Bhavan, 13, fire Brigade Lane, Barakhamba road, New Delhi – 110001 for information and necessary action.

(2) Managing Director, Gujarat Urban Development Company Ltd., Block No.6, 5th Floor, Udyog Bhavan, Sector-11, Gandhinagar for information

Regd. Office : Block 1, First Floor, Karmayogi Bhavan, Sector-10/A, Gandhinagar - 382010
Ph.: +91-79-65721786, 23220071 E-mail : md@gujaratmetrorail.com
Web.: www.gujaratmetrorail.com CIN : U60200GJ2010SGC059407

Chapter – 2

TRAFFIC DEMAND FORECAST

2.1 INTRODUCTION

2.1.1 Study Background

Ahmedabad Metro is a proposed Metro Rapid Transit System connecting the city of Ahmedabad, Gandhinagar and the very ambitious Gujarat International Finance Tech-City (GIFT City). The proposed Metro Rapid Transit network is envisaged to consist of two major corridors and two segment connectivity:

(i) Corridor I – East West Corridor (Phase I)
(ii) Corridor II – North South Corridor (Phase I)
(iii) Corridor II (extn) – Motera to Gandhinagar
(iv) Segment connectivity – GIFT City & Airport

2.1.2 Scope of Work

The traffic & transportation aspect of this work involves collection of socioeconomic, land use, traffic & travel data from secondary sources as well as conducting primary traffic & travel surveys. The scope can be divided into two segments:

1. Updating of passenger forecasting of Ahmedabad Metro Phase I corridors.
2. The second segment mainly comprises of traffic data collection for the proposed metro corridors (total length is 34 km approx.):

   Extension of connectivity from APMC – Motera line to Gandhinagar
   Connection of GIFT city and Airport and realistic assessment of traffic on the proposed network.

I. The consultant has to assess:

Baseline total and assigned traffic onto the system across horizon years;
Metro ridership and passenger km across horizon years;
PHPDT (peak sectional load) across horizon years;
Corridor wise ridership across horizon years;
Different station loadings (boarding, alighting numbers) across horizon years;
Unidirectional station boarding and alighting in the peak hour giving sectional load in peak hour.
Base network, traffic and travel characteristics amidst a multi model setup; and
The dynamics of traffic shift to the proposed system in wake of competing modes across horizon years.

II. For estimating the passenger traffic, the study should consider:

Passenger trips that would resort to the project corridor due to the new metro system linkages. This procedure should measure the relationship between the strength of a stimulus and the proportion of cases exhibiting a certain response to the stimulus (passengers resorting to the metro).

The modal shift to the newly introduced system on to the existing network (Probabilistic Model) from each competing mode once the metro system is installed.

Unidirectional station boarding & alighting of daily and days section load.

Determination of total trips on date (vehicular and walk) and in horizon years.

Existing modal split on date for various modes

Modal split after metro in place i.e. corridor N-S & E-W corridor of Phase-I and these corridors or any other corridor, identified by DMRC:

- Total passenger km (PKM) on metro corridor wise.
- Average trip length for each metro corridor separately and also combined.
- Fare structure to be mentioned clearly in the report.
- Station to station of metro OD to be provided.
- Complete OD matrix of all trips, private trips and public trips to be provided.

Traffic that may accrue at major interchange points and mid-block locations due to introduction of the new facility.

III. The study shall be based on analysis of:

Review of the existing travel pattern

Review of network usage pattern by different modes

Review of existing transport facilities (all competing modes)

Review of the zoning system ? Network plan and the specified project corridor

Hourly classified volume counts ? Origin Destination (O-D) matrices – consolidated and mode-wise

Existing public transport network and their specific movement along the project corridor

Competing transport modes

Average Trip Lengths for various categories of vehicles

IV. The traffic and travel data collated is to be used to formalise the 4 stage travel demand model for the baseline and projected scenarios (maximum 2), that inter alia includes:-

Trip Generation Model

Trip Attraction Model

Trip Assignment Model

Peak and off peak period system load forecast

Trip distribution model suiting either growth factor models/system models

V. The consultant has to model and estimate the “generalized cost of travel” for the proposed metro system. Also, the consultants need to formulate discrete logit model using primary data collated as part of the study. The foresaid models will help gauge the extent of traffic diversion / attraction across competing modes for the project corridor (in wake of travel time and travel cost savings once the proposed system is in place). Fare differentials with competing modes and their relative impact on metro ridership is to be gauged using direct and cross price elasticity measures. Such models shall be spatially and logically validated using the assignment exercise with changes to TTM and related cost impedance factors. Statistical analysis and discrete choice model estimation should be carried out using the stated preference survey data segmented by vehicle type, highway used, trip purpose and time of day (AM peak, PM peak and off-peak periods).

VI. Consultants need to support their travel forecast using estimates arrived at from using Time series/ Panel data pertaining to key traffic generation (population, motorization rates, households etc.) and traffic attraction parameters (land-use based parameters). Back-testing of trip end data has to be accomplished by the consultants.

VII. Preparation of alternative routes on Google/available standard maps duly verifying at site regarding the actual location. Also, prepare the comparative study for Underground and Elevated options for the finalized route.

VIII. Multi-Modal Traffic integration, planning for feeder bus service, public bike sharing and pedestrianisation in the influence area of stations.

IX. Updating the demand forecast report will include both Phase-I & Phase-II ridership.

2.1.3 Study Approach

The work flow plan is designed to archive the desired goal. It comprises of the following milestones. The **first stage** entails understanding of the study including its scopes and objectives. Identification of primary survey locations is also an essential task of this stage.

In the **second stage** reconnaissance survey of the study area will be followed by primary survey at various locations in Ahmedabad and Gandhinagar.

The **third stage** of the study entails tabulation, verification and consistency check for the data. The prime task in **stage four** is digitization of collected primary data.

In the **fifth stage** traffic and travel data will be analysed. The exploratory data analysis, presentation of key results and inference of the analysis will be executed in **stage six**.

All the primary and secondary collected data will be assimilated in **stage seven**.

The **eighth stage** comprises of projections for the horizon years, travel demand modelling for the existing situation and travel demand forecast for future and two projected scenarios.

The draft and final report will be presented in the **final stage**.

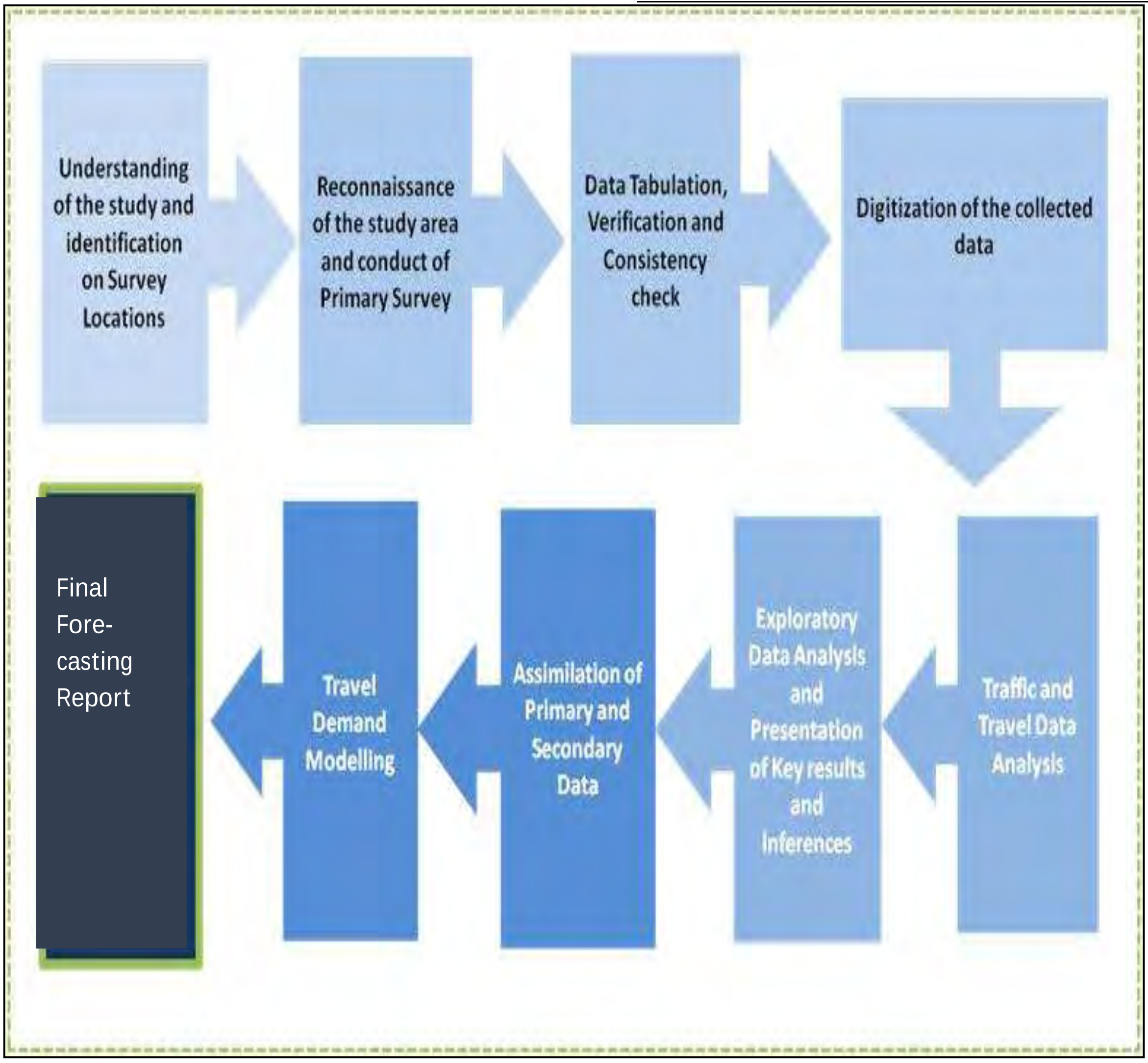
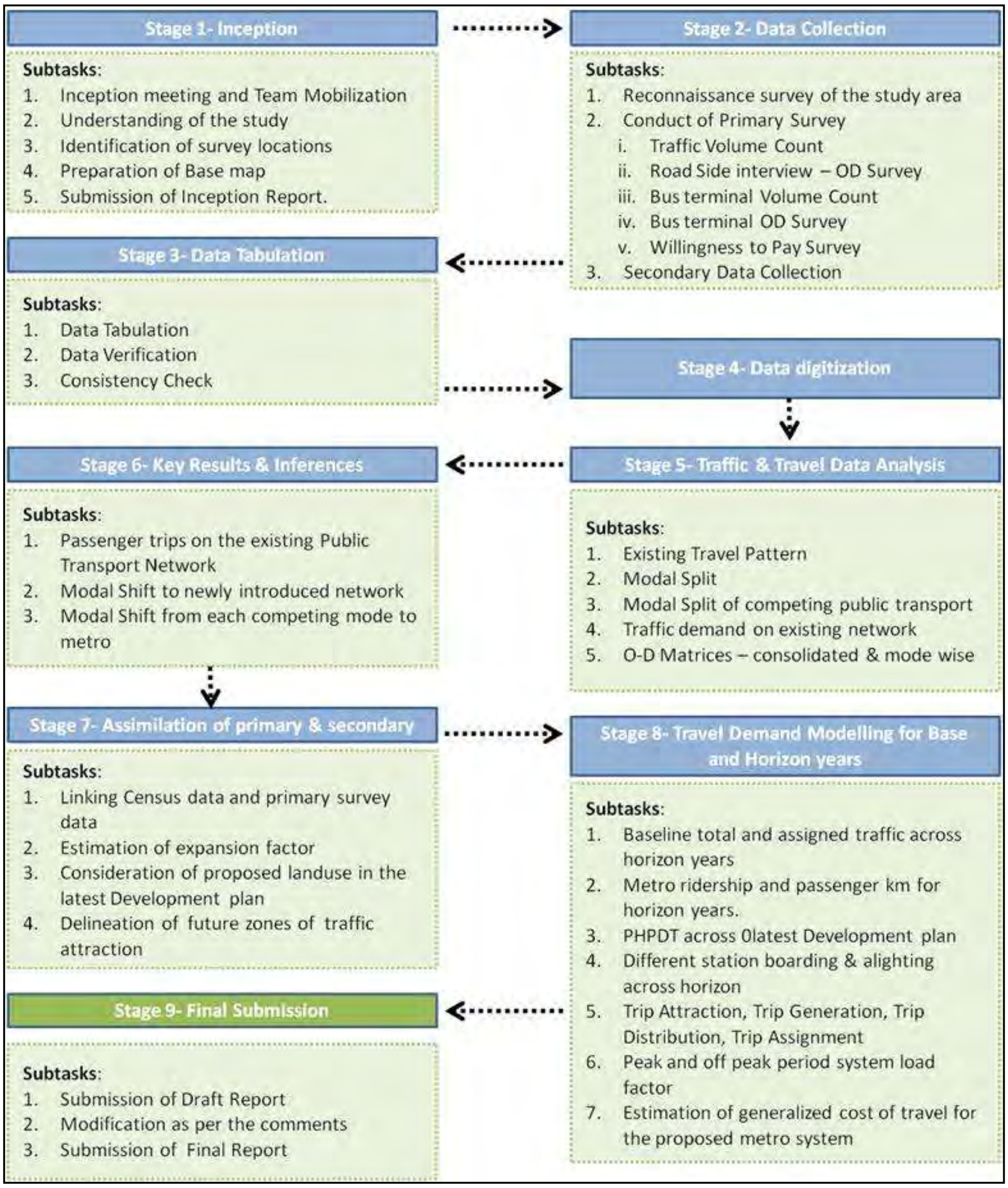


Figure 2.1 Study Approach

2.1.4 Study Methodology

The scope and principal study objectives have been derived from the Terms of Reference (TOR) section of the Request for Proposal (RFP). The said scope of work has been derived through the following study methodology as mentioned below:

Figure 2.2 Study Methodology



A) Stage 1: Data Collection

The second stage of the study included a reconnaissance survey. It was undertaken to identify and finalize the primary survey points on the network. The primary surveys were then undertaken at selected locations.

(i) Traffic Volume Surveys and Occupancy Surveys

Classified traffic volume count were conducted at the 48 identified locations, which include Screen line, Mid Block and Cordon points on the major travel corridors. This data otherwise was also required to expand the O-D Survey sample to the total population of traffic in O-D location. The TVC and the Occupancy Survey data were analyzed to obtain:

Average Daily Traffic (ADT)
Hourly variation and Peak Hour flows

Directional distribution by hour of the day

Traffic composition

The classified traffic count surveys were conducted as per the provisions of IRC Guidelines (IRC 9-1972).

(ii) Road Side OD Surveys

Road side Origin – Destination (OD) surveys were undertaken for establishing the travel pattern of the commuters in the city. Origin destination survey of the commuters was conducted at 26 locations in the city. The surveys were conducted on working days using systematized sampling method/s. Commuters were surveyed for their trip origin, destination, trip length, time, cost, purpose, mode of travel etc. The enumerators selected for OD surveys were fully trained in the use of standard interview sheets. It is also necessary to estimate the number of passengers travelling in passenger vehicles. This was achieved by enumerating number of passengers travelling by interviewed passenger vehicles.

(iii) Bus Terminal Volume Count

Volume count survey at six bus terminals and four major bus stops was carried out for 24 hours on a working day. The survey was conducted to determine to establish the boarding/ alighting pattern along with assessment passengers using that particular terminal.

(iv) Passenger Terminal OD Surveys

Passenger Terminal OD Surveys was carried out at the identified bus train terminals and major bus stops. These passengers were surveyed in order to establish the travelling pattern of the passengers which were using the terminal facilities. Details like trip origin, destination, length, time taken, cost of the trip, propose etc. were collected from the passengers captured through random sampling.

(v) Willing to Pay Survey

Willing to pay survey will be conducted at ten locations. These locations are five of the major bus terminals and five of the outer cordon points. The commuters will be interviewed with the details like trip purpose, monthly way, willing to pay for the metro facility, their affordable choice of fare.

(vi) Speed and Delay Surveys

Speed and Delay surveys were undertaken along the proposed metro corridors during peak and off peak time period. This provided an understanding about the speed profile of the vehicles along the proposed metro corridors.

Other than the primary data collection required, secondary data was also collected from various authorities in the city and the same has been elaborated in subsequent sections below.

B) Stage -3: Data Tabulation

After collection of the all primary and secondary data, the work of tabulation, verification and consistency check was carried out.

C) Stage -4: Digitization of All Primary Data

All collected, verified and corrected data was then digitized and refined for the ease of analysis under this stage.

D) Stage -5: Traffic and Travel Data Analysis

The digitized and refined data was further analyzed to assess existing travel pattern, traffic composition, modal share of competing public transport, traffic demand on existing network. Further consolidated and mode wise OD matrices were generated from the data collected.

E) Stage -6: Key Results and Inferences

Analysis of all the travel and traffic data led to the results and inferences related to the city's travel pattern. This also included appreciation of travel pattern of public transport users of the city. Modal shift to newly introduce network and modal shift from each of the competing mode to metro was estimated in this stage.

F) Stage -7: Assimilation of Primary and Secondary Data

In this stage collected primary and secondary data were assimilated. The data of Census was linked to primary data, estimation of expansion factor depending on collected data samples was carried out. The proposed land use plan for the city in the recent Development Plan was also considered to mark the future points of major traffic attraction.

G) Stage -8: Travel Demand Modeling for Base and Horizon Years

This stage of the study was very essential, where the analyzed data concluded to the desired study results with the aid of travel demand modeling software. Baseline total and assigned traffic across the horizon years was assessed. Forecasting of metro ridership and passenger km for horizon years was undertaken at this stage. PHPDT, taking into consideration the latest Development plan, was assessed. Boarding/ alighting pattern of the passengers for various metro stations on the alignment was forecasted. Peak and off peak period system load factor was also determined.

H) Stage -9: Final Submission

This stage comprised of the Draft report submission with inclusion of all the foresaid stages. The Draft report was corrected and altered as per the comments.

2.2 STUDY AREA APPRECIATION

2.2.1 Introduction

The basis for secondary data collection is that it helps to fill the gaps that have not been able to be collected through primary surveys. Also, this data is required for establishing trends and development patterns of the city. Collection of relevant secondary data like demographic and land use data for every ward, accident data of last five years, bus route details, fleet details, speed and delay of car along the proposed metro corridors, fare structure of every mode of transport etc. as per the scope of work entrusted to the consultant was completed. The following section would provide an overview of the data collected through various sources.

2.2.2 City Profile

The study area boundary primarily comprises of area within four administrative boundaries namely Ahmedabad Municipal Corporation (AMC), Gandhinagar Urban Development Area (GUDA), urban outgrowth areas of Ahmedabad i.e. Kathwada, Singarva, Bopal, Guma and41 villages between AMC & GUDA and adjoining areas are also considered on the basis of contiguous built up and interaction with 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.

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.

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

Gujarat International Finance Tech-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.

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 11existing 4 proposed SEZ. Part of the Changodar SIR also forms a part of the study area.

Based on the above mentioned areas, the study area defined includes areas as given in the following table.

Table 2.1 Study Area Boundary

Area Boundary	Area (km2)	Name	No of Zones	Population
GUDA	388	Urban Area (Gandhinagar Municipal Area , Adalaj) and 39 Villages of GUDA	80	4,37,111
AMC	466	Ahmedabad Municipal Corporation	285	55,89,944
AUDA (Urban + Rural) Or Area adjoining AMC)	272.44	Urban areas (Bopal, Singarva , Chiloda and Out growth – Kathwada and Guma) 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)	44	2,21,698
Outside AUDA	19.98	2 villages (Changodar ,Moraiya)	4	14,656
Grand Total	**1146.41**		**413**	**62,63,409**

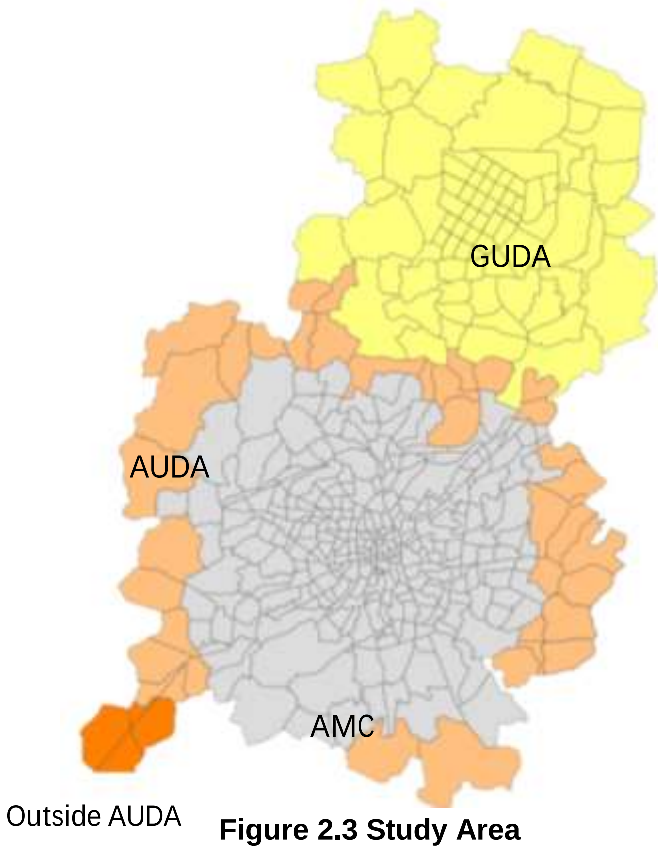


Figure 2.3 Study Area

2.2.3 Demographic Details

As per Census of India 2011, the study area consisting of four administrative boundaries has a population of 6.3 million.

Table 2.2 Demographic Profile of the study area

Areas	Population			Area (in Ha)	Density (Person / Ha)			Annual Growth Rate (%)	
	1991	2001	2011		1991	2001	2011	1991-01	2001-11
GUDA	2,78,558	3,81,183	4,37,111 (6.98%)	38800	7	10	11	3.19	1.38
AMC	34,21,044	45,17,194	55,89,944 (89.25%)	46683	73	97	120	2.82	2.15
AUDA (AMC Adjoining area)	1,20,065	1,50,335	2,21,698 (3.54%)	27244	4	6	8	2.27	3.96
Outside AUDA	6,075	6,938	14,656 (0.23%)	2001	3	3	4	1.34	7.77
Total	**38,25,742**	**50,55,650**	**62,63,409**	**114728**					

The population within the AMC boundary is highest consisting of 89.25% of study area population in the census year 2011, followed by 6.98% of population within the GUDA boundary, 3.54% population within AUDA (urban and rural/AMC Adjoining area) and a very negligible share of 0.23% population outside AUDA area.

Population within areas outside AUDA and AUDA (AMC Adjoining area) have witnessed the highest growth in the decade 2001-11. On the other hand, urban boundaries consisting of AMC and GUDA have witnessed a moderate growth of 2.15% and 1.38%.

Population Projection

Futuristic population growth has been collected from various sources. As per GUDA development plan-2024, by 2031 the region would have a population of 10 lakhs from 4.9 lakhs in 2021. Introduction of GIFT city and urbanization of the GNA area and current villages would add to it.

Table 2.3

Jurisdiction	2021	2031
GNA	2,40,620	3,35,678
GUDA villages	2,50,885	2,81,326
GIFT City		3,38,000
Total GUDA	4,91,505	9,55,004

Source: GUDA Development Plan, 2024

As per greater Ahmedabad development plan, by 2031 the region that consists of two major urban areas Ahmedabad, Gandhinagar, economic hub of GUFT, 131 other villages and few other small towns and settlements would be 125 lakhs. It is also mentioned that urban areas of Ahmedabad i.e. AMC boundary and urban area of Gandhinagar i.e. GNA boundary together will house 60% of the population projected.

Table 2.4 Projected Population of Greater Ahmedabad

Jurisdiction	2011	2031
Greater Ahmedabad	81,12,000	1,25,00,000
AMC + GNA	60%	60%

Jurisdiction	2011	2031
AMC + GNA	48,67,200	75,00,000
AMC	-	71,64,322
GNA	-	3,35,678

Source: Greater Ahmedabad Development Plan and Integrated mobility Plan of Greater Ahmedabad

Socio Economic Characteristics

As per Ahmedabad Metro DPR, 2015, 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.

Projected employment generation for GIFT shows that, by 2020 this economic hub would cater to 1.75 lakh jobs which would subsequently increase to lakh in 2025 and 5 lakhs in the year 2030

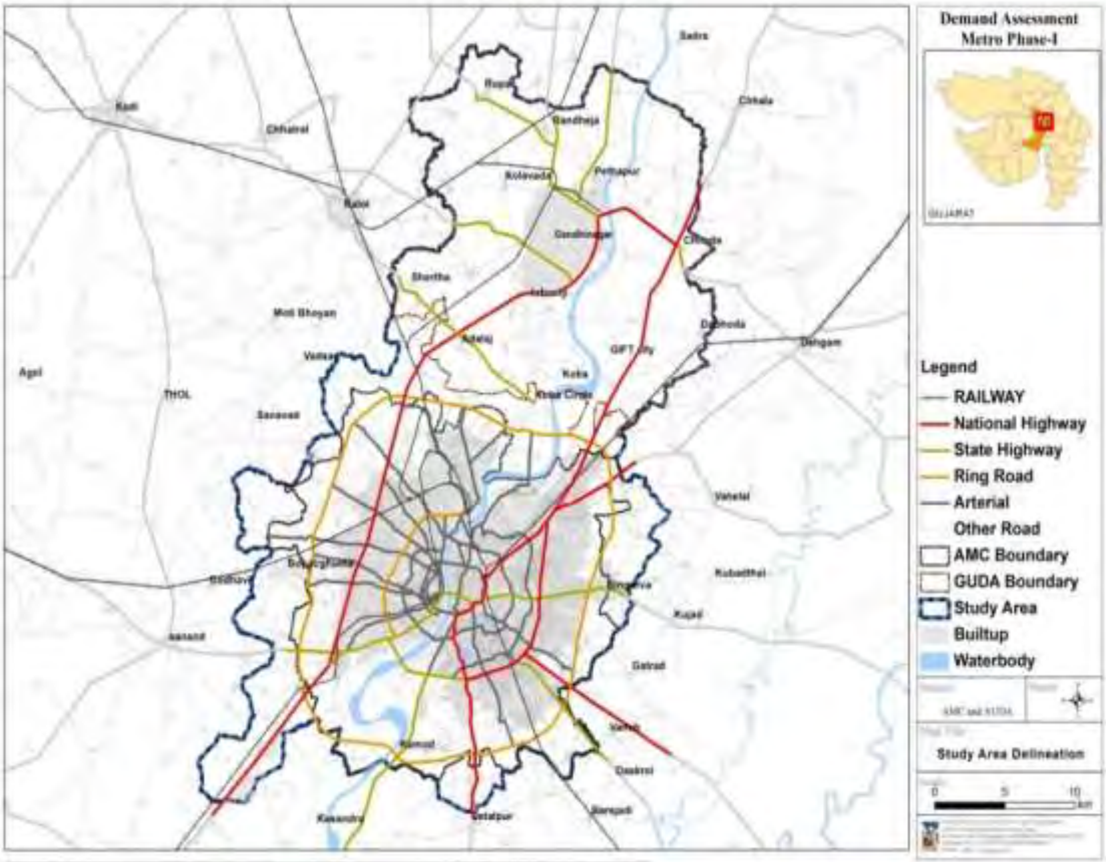
Table 2.5 Projected Employment of GIFT 2030

Year	Employment (lakh)
2020	1.75
2025	3
2030	5

Data Source: MEGA Office, 2017

2.2.4 Road Network

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.



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

Figure 2.4 Figure 5 Existing Road Network in Study area

Table 2.6 Road Network Composition

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%

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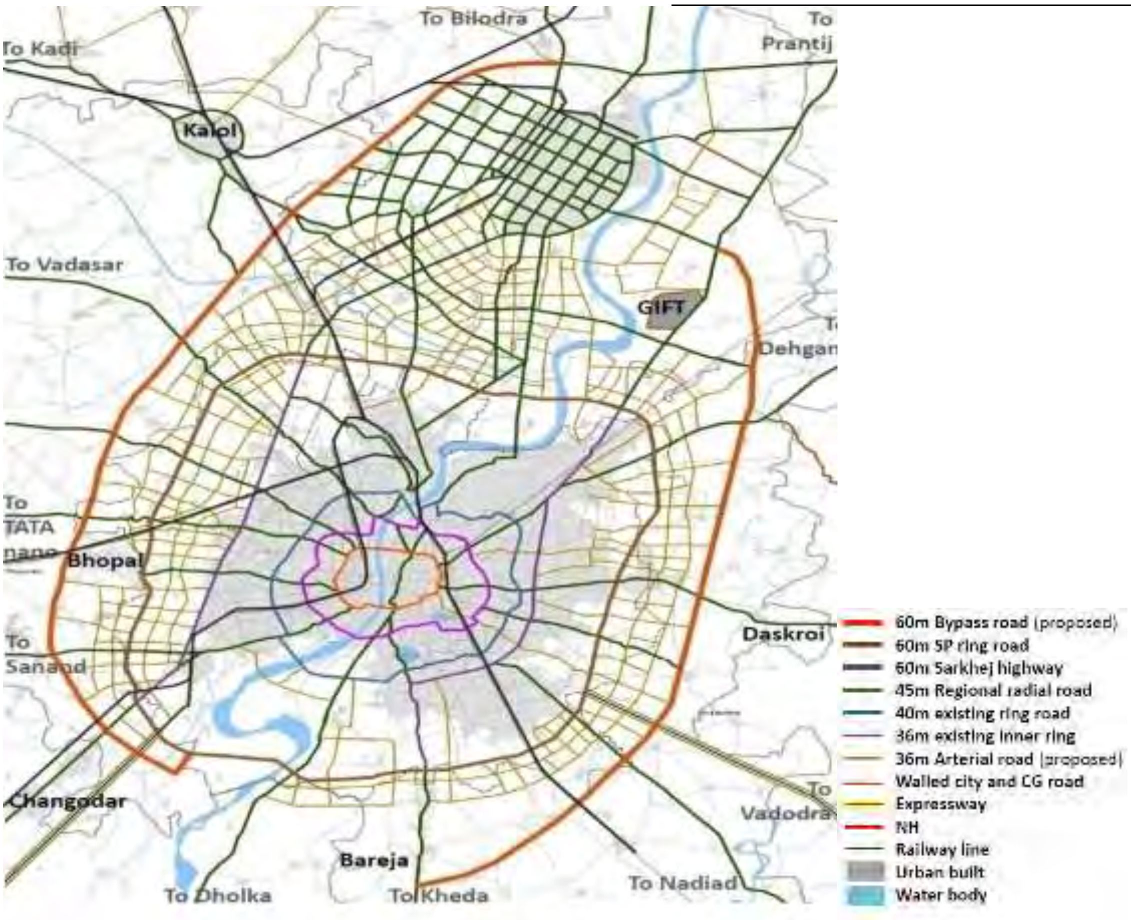


Figure 2.5 Network Characteristics

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

As per MOUD report Sustainable Urban Transport Project, India**,** the Road network hierarchy given in Ahmedabad is as follows:

Table 2.7 Road Network Hierarchy

Type	Road length (km)	% of network
Ring road & Radial road (Arterial and Collector)	347	14.2
Sub-Arterial and Collector	923	37.9
Other Roads	1166	47.9
Total	2436	100

Source: MOUD Report for Sustainable Urban Transport Project, India

2.2.5 Mode wise vehicle registration data

The total number of vehicles registered in Ahmedabad have witnessed a growth of 6.3% from 18,47,587 in 2005 to 35,75,437 in 2016. Gandhinagar on the other hand have registered a growth rate of 12.7% which is double than Ahmedabad.

A mode wise comparison shows that, at Ahmedabad growth rate of three-wheeler is highest (8.8%) followed by four-wheeler and two-wheeler at 8.3% and 6.5% respectively. On the other hand growth rate of four-wheeler is highest in Gandhinagar at 13.6% followed by 11.7% two wheeler.

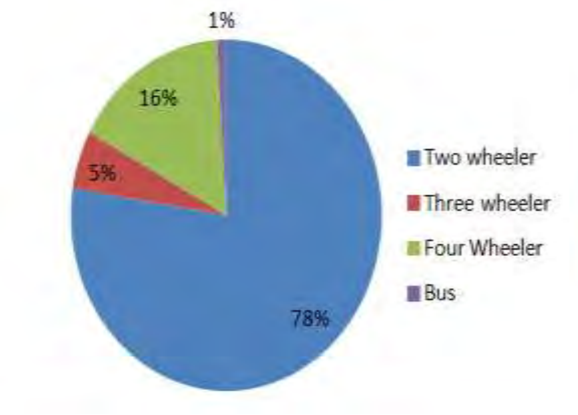
An average growth rate of car in the study area is highest at 10.9 %. This growth trend shows highlights the fact that Ahmedabad Gandhinagar region is highly dependent on private mode of transport for commuting.

Table 2.8 Vehicles Registered in Study Area 2005-06 to 2015-16

Type of Vehicles	Ahmedabad		Gandhinagar	
	2005-06	2015-16	2010-11	2015-16
Two wheeler	14,50,250	27,11,554	1,29,476	3,92,416
Three wheeler	80,278	1,85,910	3,656	NA
Four Wheeler	2,94,045	6,51,155	30,867	1,10,426
Bus	23,014	26,818	8,908	NA
Total	**18,47,587**	**35,75,437**	**1,72,907**	**5,02,842**

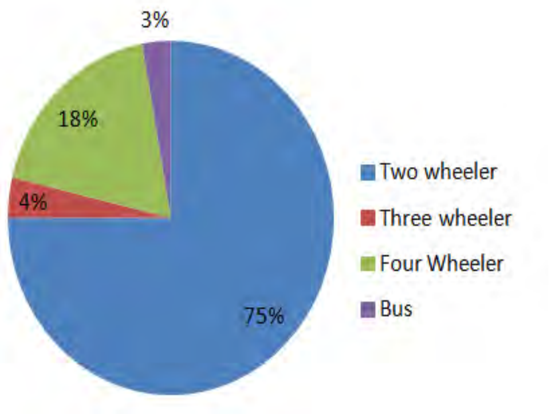
Source: RTO Ahmedabad & Gandhinagar, 2017

Fig.**2**.6 Vehicles Registered in Ahmedabad



Source: RTO Ahmedabad, 25.01.2017

Fig.**2**.7 Vehicles Registered in Gandhinagar



Source: RTO Gandhinagar, 17.02.2017

Table 2.9 Details of registered vehicles in Ahmedabad from 2005 - 2016

Type of Vehicles	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16
Motor Cycle/Scooters	1218028	1316718	1427598	1527479	1609687	1709441	1853263	1998776	2125451	2273565	2419444
Moped	232222	237811	242490	247176	249001	266503	269817	271070	272025	276680	292110
Auto rikshaws	69075	88271	101293	108761	115807	126074	138615	149962	158768	166337	174693
Jeep	21087	21753	22385	23706	25052	30065	30225	30473	30748	30817	30848
Three whellers M/Car	11203	11205	11205	11205	11208	11210	11214	11217	11217	11217	11217
Four whellers M/Car	264525	279693	298919	320650	345712	371945	416314	462163	502391	552026	605057
Taxi	8433	8844	9255	9532	9835	10349	10885	11482	12399	14061	15250
Maxi-Cab	1587	1827	2118	2441	2981	3398	3903	4454	5013	5315	5695
Contract Carriages	3526	3610	3703	3830	3976	4129	4428	4984	5400	5723	6308
Stage Carriages	19488	19838	20060	20140	20220	20254	20358	20491	20491	20491	20510
School Bus	399	466	496	538	589	649	684	702	709	956	1038
Private Service Vehicle	878	920	958	1007	1049	1087	1101	1108	1109	1226	1238
Police Van	813	819	821	822	837	840	840	842	842	842	842
Truck/Lorries	29632	30321	31196	31957	32493	33100	34275	36222	37285	38476	40139
Tankers	3037	3071	3105	3138	3202	3298	3381	3393	3412	3490	3490
Tempo	27037	30109	34197	37485	40353	44182	48444	52583	55888	59298	62596
Other light Vehicle	17077	17558	18549	19978	21374	23367	26638	30360	34290	36973	40120
Transport-Trailors	18682	19385	20200	21244	22157	23263	24155	24755	24906	24991	25135
Non-Transport-Trailors	752	752	752	752	757	763	966	1847	2760	3091	3645
Tractors	33527	35009	36556	38180	40076	41867	44409	48350	49622	52678	54797
Ambulance Van	930	947	981	1002	1043	1070	1098	1144	1194	1241	1311
Others	4892	5463	5977	6822	7674	8636	9535	10273	10882	11128	11388
TOTAL	**1986219**	**2133779**	**2292069**	**2437126**	**2564575**	**2735004**	**2954123**	**3176546**	**3366802**	**3590622**	**3826871**

Source: RTO Ahmedabad, 25.01.2017

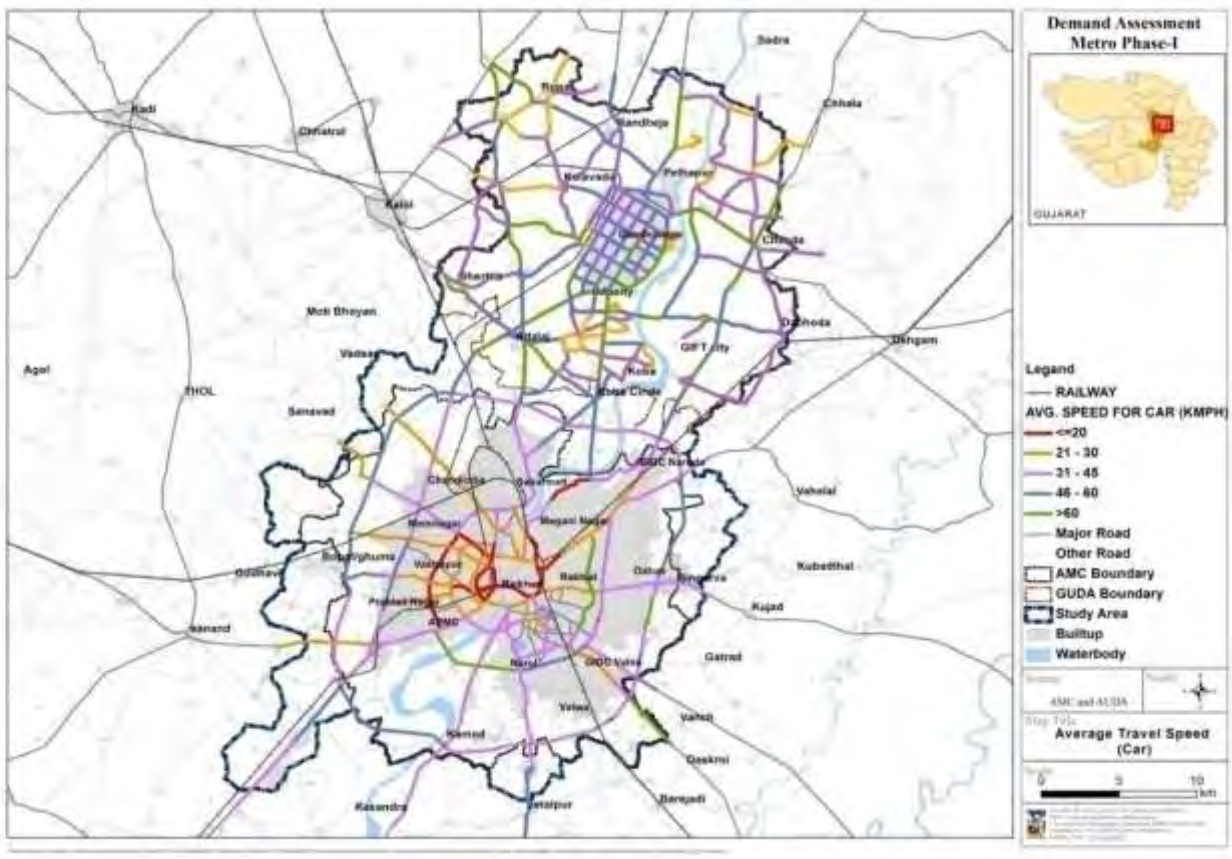
Table 2.10 Details of registered vehicles in Gandhinagar from 2005 - 2016

Type of Vehicles	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16
Two wheeler	18489	21287	22702	25059	27322	28189	24111	27896	27744	28527	30103
Four wheeler	5659	5901	6045	6390	6562	6824	9983	9485	8214	9275	10880
Tractor	764	749	849	950	978	998	0	4	0	1739	1167
Passenger vehicles	107	169	110	113	113	130	44	2443	1972	2495	2463
Goods	648	1202	1312	1361	1434	1567	0	1992	2261	2065	2193
Special vehicle	0	2	1	3	5	6	0	1	0	0	0
Other Vehicle	150	214	412	402	445	460	57	134	95	91	131
TOTAL	**25817**	**29524**	**31431**	**34278**	**36859**	**38174**	**34195**	**41955**	**40286**	**44192**	**46937**

Source: RTO Gandhinagar, 17.02.2017

2.2.6 Speed and Delay Data from Secondary Sources

Travel speed which is a product of speed and delay surveys, was also extracted from previous studies as given in Ahmedabad Metro DPR Phase I-2015. Mean travel speed as recorded was 25kmph along corridors.



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

Figure2.8 Speeds on Major Roads in Study area

As recorded the average travel speed along major roads in Gandhinagar was found to be relatively higher (> at 50 kmph than travel speed along major roads of Ahmedabad which was 25 kmph

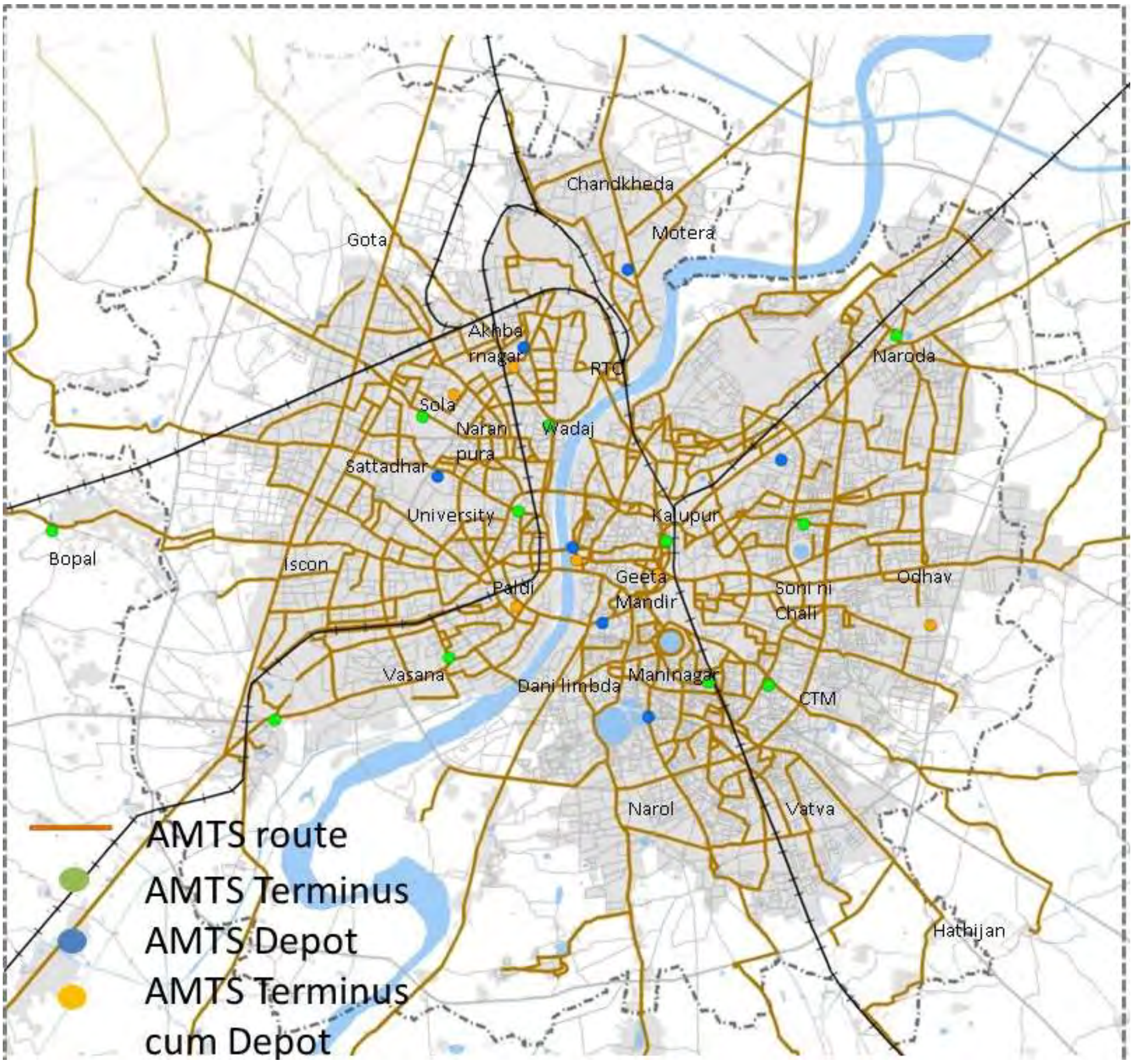
2.2.7 Public Transport

Passenger trips within the study area consisting of Ahmedabad and Gandhinagar Region is highly dependent on bus and auto which is an intermediate mode of transport. There are three public bus services being operated in the region. The services are namely Ahmedabad Municipal Transport Service (AMTS) City Bus Services, Bus Rapid Transit System -JANMARG and Vallabhipur Transportation Co-Operative Society Pvt. Ltd. (VTCOS).

Ahmedabad is a city that is connected with 631 km network of Bus routes comprising of Bus Rapid Transit System -JANMARG and Ahmedabad Municipal Transport Service (AMTS) City Bus Services. 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 operated by Vallabhipur Transportation Co-Operative Society Pvt. Ltd. (VTCOS), a private bus service operator.

Ahmedabad Municipal Transport Service (AMTS)

AMTS have been providing bus services in Ahmedabad since 1947. It is a system that consists of 201 routes and covers 549 kms of route length. Coverage area of AMTS is spread over 88% of developed AMC area. As per AMTS data 2012, it caters to 11% of trips within the city i.e. 0.9 million passengers per day.



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

Figure 2.9 AMTS Route network

The observed speed of AMTS is approximately 17km/hr, and most of the routes (70%) pass through walled city area, hence the city center 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. Currently AMTS has 7 bus depots, 11 bus terminals and 3 bus terminal cum depots.

Table 2.11 Bus Terminal Profile

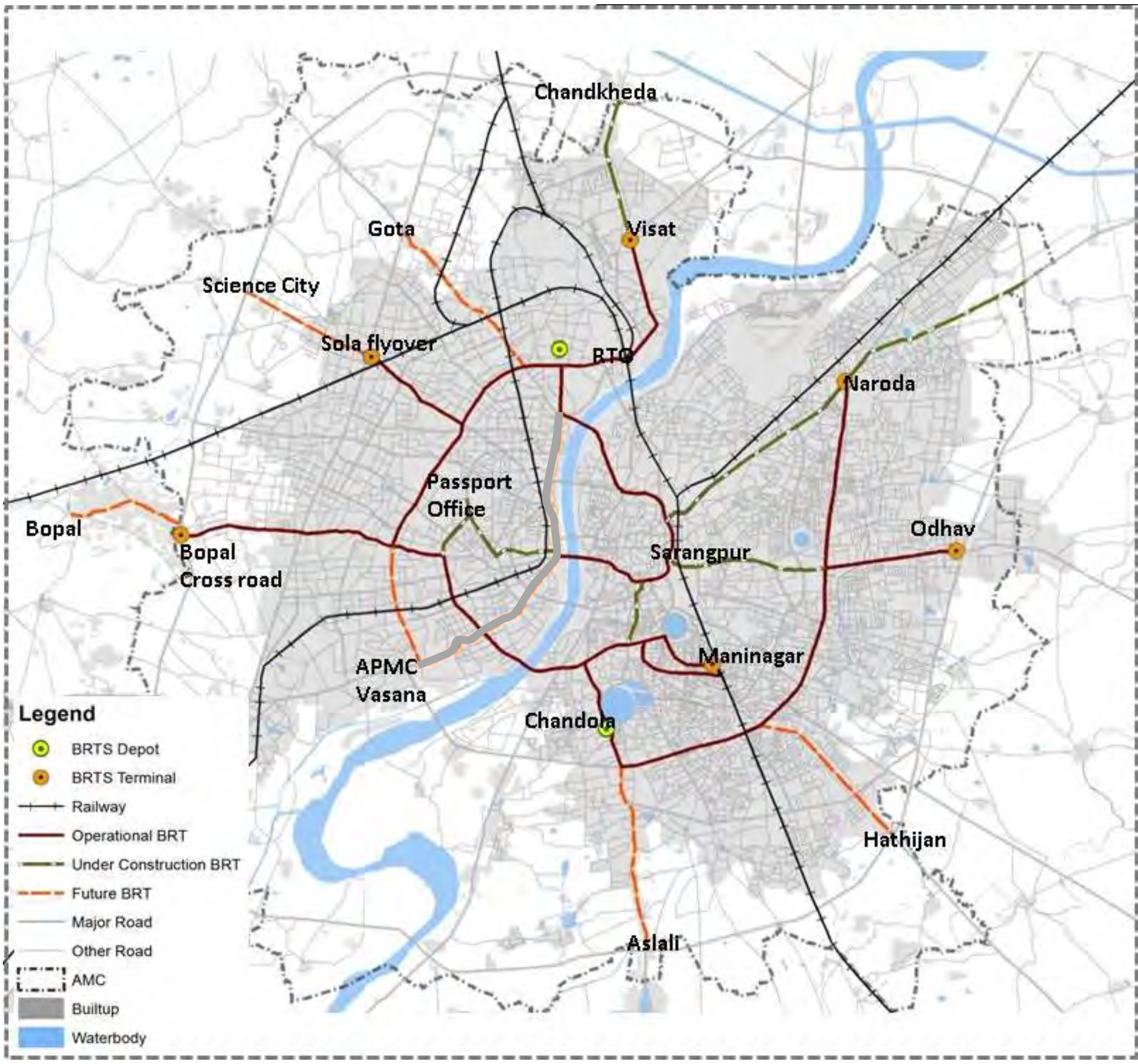
Terminals	No of Routes	Daily bus trips (Up& Down)	Average bus trip/Route
Bapunagar	7	111	8
Bopal	3	35	6
Bhuyangdev Sola	10	146	7
Hatkeshwar	7	99	7
Kalupur Terminus	17	256	8
Lal Darwaza	79	1461	9
Manin nagar terminus	28	389	7
Naroda Terminus	13	179	7
Nava Wadaj	14	245	9
Navrangpura	13	174	7
Paldi	18	294	8
Vasna Terminus	20	287	7
Wadaj Old Terminal	10	144	7
Sarkhej	8	106	7
Total	**247**	**3926**	

Source: AMTS Bus Info, Extracted 10.02.17

It was found that LAL Darwaza Bus terminus which is located at the old city of Ahmedabad is the major terminal catering to 30% of the routes i.e. AMTS 79 routes followed by Manin nagar Bus Terminus which caters to 13% of the routes.

BUS Rapid Transit System (BRTS) – "Janmarg"

Janmarg BRTS services commenced in the year 2009 as the first closed system BRTS in India. Currently the BRT system operates on 13 route with a network length of 82 kms. The BRT attracts a 1.30 lakh passenger daily. The 13 operational routes operate with peak headways of 2.5 to 3 minutes. Due to the dedicated corridors and Bus priority system at major intersections, the peak hour operational speeds of BRT buses are 25kmph which is more than AMTS buses. 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.



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

Figure 2.10 BRTS Route network

Table 2.12 Comparison table of BRTS and AMTS

Parameters	BRTS	AMTS
Year of start	2009	1947
Network Length	82	549
No of Routes	13	212
Fleet size	230	1036
Operational hours	6 am to 11 pm	7 am to 11 pm
Daily ridership	1,30,407	9,50,000 (approx..)
Fleet Utilisation	92.61	70.27
Operational Speed	25 kmph	17 kmph

Source: AJL and AMTS Office, 2017

A comparison of physical performance of city bus services shows that BRTS fleet utilisation is 92.61 which is better than AMTS at 70.27

Table 2.13 Fare Structure of City Buses

Stage	Kms	AMTS Fare (Rs)	BRTS Fare (Rs)
1	2	3	4
2	4	7	9
3	6	9	12
4	8	11	15
5	10	12	16
6	12	13	18
7	14	13	18
8	16	15	20
9	18	15	20
10	20	17	23
11	22	17	25
12	24	18	26
13	26	18	26
14-16	32	20	29
17-19	38	22	32
20-22	44	23	33
23-25	50	25	36

Source: AJL and AMTS Office, 2017

Since inception, fare for BRTS Bus service is 1.5 times greater than that of AMTS Bus services.

Vallabhipur Transportation Co-Operative Society Pvt. Ltd. (VTCOS) City Bus Service
VTCOS is the city bus service in Gandhinagar, operated by a private organisation. It has been operating city buses in Gandhinagar since 2009, with 11 buses in the first Phase. Currently VTCOS operates 45 buses in GUDA and GNA area. These buses operate on 9 routes and run on Compressed Natural Gas (CNG). The nine routes of VTCOS are

i. Kh-1 to Akshardham
ii. Akshardham to Pathikashram,
iii. Ch-0 to Gh-7
iv. Ch-0 to Sector 19/20
v. Adalaj to Chiloda
vi. Pethapur to Gh-1
vii. VasaniaMahadev to Pathikashram
viii. Vavol to Sector 21
ix. 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 found to be more than 100%.

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

Figure 2.11 City Bus Services in Gandhinagar

2.2.8 Introduction to Proposed Metro Corridors

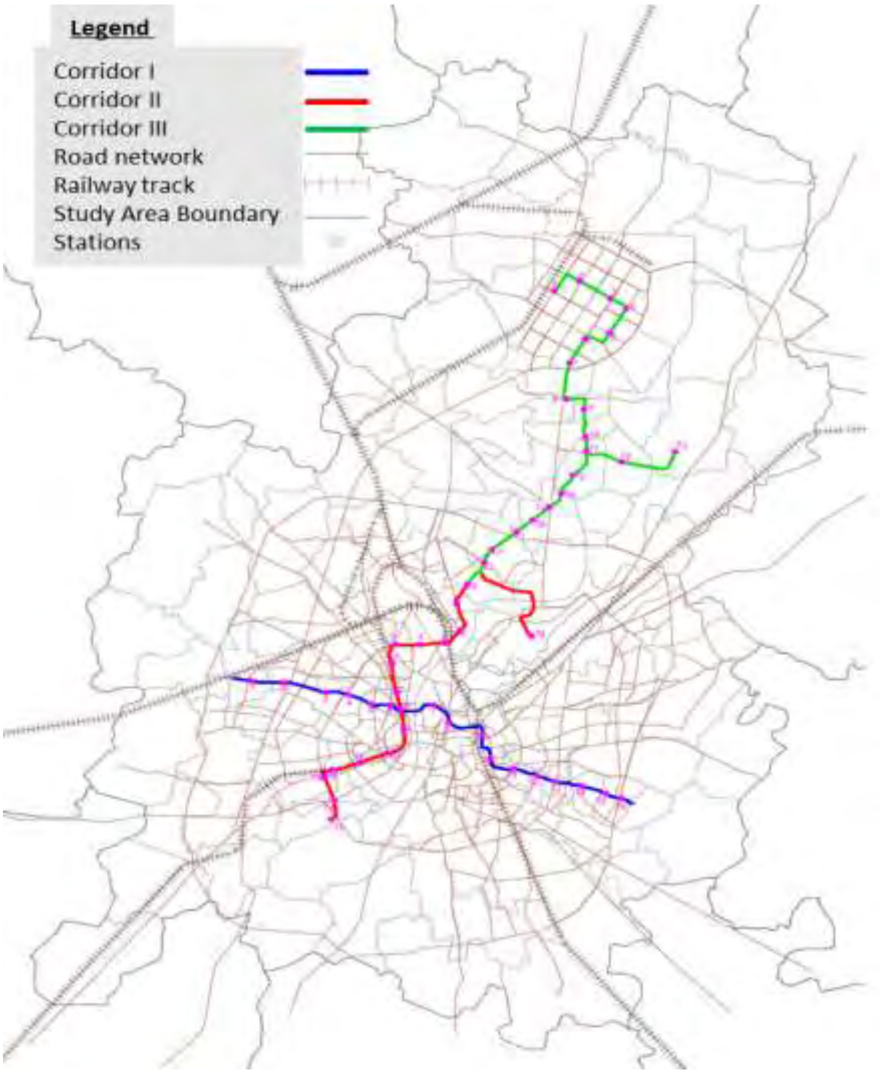
Ahmedabad Metro is a proposed Metro Rapid Transit System connecting the city of Ahmedabad, Gandhinagar and the very ambitious Gujarat International Finance Tech-city (GIFT). Office for MEGA Metro (Metro-Link Express for Gandhinagar and Ahmedabad) is responsible to build and operate this network. It will provide rapid mass transit connectivity for the twin cities. Along with existing BRTS and AMTS service, metro would boost the public transport commuters for the region and hence help in de-congesting city roads. The proposed Metro Rapid Transit network as illustrated in figure 1.is planned to consist of two major corridors and two segment connectivity as :

i. Corridor I – East West Corridor (Phase I)
ii. Corridor II – North South Corridor (Phase I)
iii. Corridor II (extn) – Motera to Gandhinagar
iv. Segment connectivity – GIFT City & Airport

Table 2.14 Corridor Profile

Phase	Route	No. of Stations	Route Length (Km)
Phase I (2019)	Corridor I – East West Corridor	17	20.74
	Corridor II – North South Corridor	15	18.52
Phase II	Corridor II (extn) – Motera to Gandhinagar	20	22.838
	Segment connectivity – GIFT City	2	5.416
Phase IIA	Segment connectivity – Airport	2	6.339

As given in table 2.14 Corridor II with extension, the 41.36 km North South corridor is the longest corridor and is being planned in two phases, where link1 (Phase-I) from Gyaspur to Motera is 18.52 km and link2 (Phase-II) from Motera to Gandhinagar is 22.838 km.



Source: DMRC, 2017

Figure 2.12 Proposed MEGA Route Map 2017

2.3 ANALYSIS OF EXISTING TRAFFIC AND TRAVEL PATTERN

On ground primary study conducted includes reconnaissance survey on the proposed metro corridor and supporting traffic surveys as mentioned below:

1. Classified Traffic Volume Count Survey
2. Origin Destination Survey and Occupancy Survey
3. Bus Terminal Volume Count Survey
4. Bus Terminal Passenger OD Survey
5. Speed and Delay Survey
6. Willing to Pay Survey

Table 2.15 Description of Type of Surveys

Sl. No.	Types of Survey	Type of Survey Location	No of Locations
1	Traffic Volume Count (24 hrs for 1 day)	Mid Block	26
		Screen Line	10
		Cordon	12
2	Road Side Interview – OD Survey (16 hrs for 1 day)	Mid-Block	14
		Screen Line	6
		Cordon	6
3	Bus Terminal Volume Count (24 hrs for 1 day)		10
4	Bus Terminal - OD Survey (16 hrs for 1 day)		10
5	Willing to Pay Survey (16 hrs for 1 day)		10

The locations are given in the below Table 2.16

Location ID	TVC & OD Locations	City
C1	Indroda circle, Info city Bus station	Gandhinagar
C2	Gandhinagar circle	Gandhinagar
C3	Gandhinagar Bijapur road, near charedi	Gandhinagar
C4	Mahatma mandir road, Sector 13	Gandhinagar
C5	Gandhinagar Bypass road	Gandhinagar
C6	PDPU road to GIFT City, near intersection	GIFT
C7	Zundal	Motera
C8	NH 59 and Sardar patel ring road intersection	Ahmedabad
C9	Kolavada Gandhinagar road	Gandhinagar
C10	Vastral road and Sardar patel ring road intersection	Ahmedabad
C11	Jawaharlal Nehru Rd, near Sanklit nagar	Ahmedabad
C12	Chanlodia road and SG Hwy intersection	Ahmedabad
S1	Rd 5, Swami narayan gurukul Vidyalaya	Gandhinagar
S2	Railway crossing near Road 7 and KH road intersection	Gandhinagar
S3	Saraspura road and kalupur Bridge railway crossing	Ahmedabad
S4	Gandhi bridge, Adwait ashram	Ahmedabad
S5	Swami vivekananda road bridge	Ahmedabad
S6	Bhagtacharya Road bridge	Ahmedabad
S7	Thaltej road Railway crossing	Ahmedabad
S8	Gandhinagar ahmedabad road and Airport Road	Ahmedabad
S9	Power house, sabarmati railway station	Ahmedabad
S10	Koba circle	Koba
M1	Koteshwar Bhatt Road, Motera to Airport	Motera
M2	Road 5, Near sector 24	Ahmedabad
M3	Road 5, Near Harshithanagar, Sec 23	Gandhinagar
M4	Road 5, Near sector 22	Gandhinagar
M5	Road 5, Near sector 21	Gandhinagar

Location ID	TVC & OD Locations	City
M6	CH Road, sector 10B	Gandhinagar
M7	CHH Road, near Sector 10	Gandhinagar
M8	Road 3, Near sector 10	Gandhinagar
M9	CH Road, CH 7 Bus stop	Gandhinagar
M10	CH Road , sector 1C	Gandhinagar
M11	Motera Stadium road	Motera
M12	Drive In road, Nilmani Society	Ahmedabad
M13	Drive In road, Professor's colony	Ahmedabad
M14	Sp Stadium road and commersix road junction	Ahmedabad
M15	Akhbar nagar circle	Ahmedabad
M16	Narol sarkhoj Road, near ice factory road	Ahmedabad
M17	Dr Jivraj mehta Marg	Ahmedabad
M18	Manubhai jadhani marg, near jain nagar	Ahmedabad
M19	Kasturba Gandhi rd and mirzapur road junction	Ahmedabad
M20	BRTS Corridor , Ramnagar	Ahmedabad
M21	Wadaj	Ahmedabad
M22	Anjali	Ahmedabad
M23	Vastral Road, near Madhav nagar tekra	Ahmedabad
M24	Amraivadi road , near janta nagar	Ahmedabad
M25	Amraivadi road,	Ahmedabad
M26	Rajpur gomtipur road, Masjid e Ammar	Ahmedabad

The survey locations as identified is given in figure 2.13

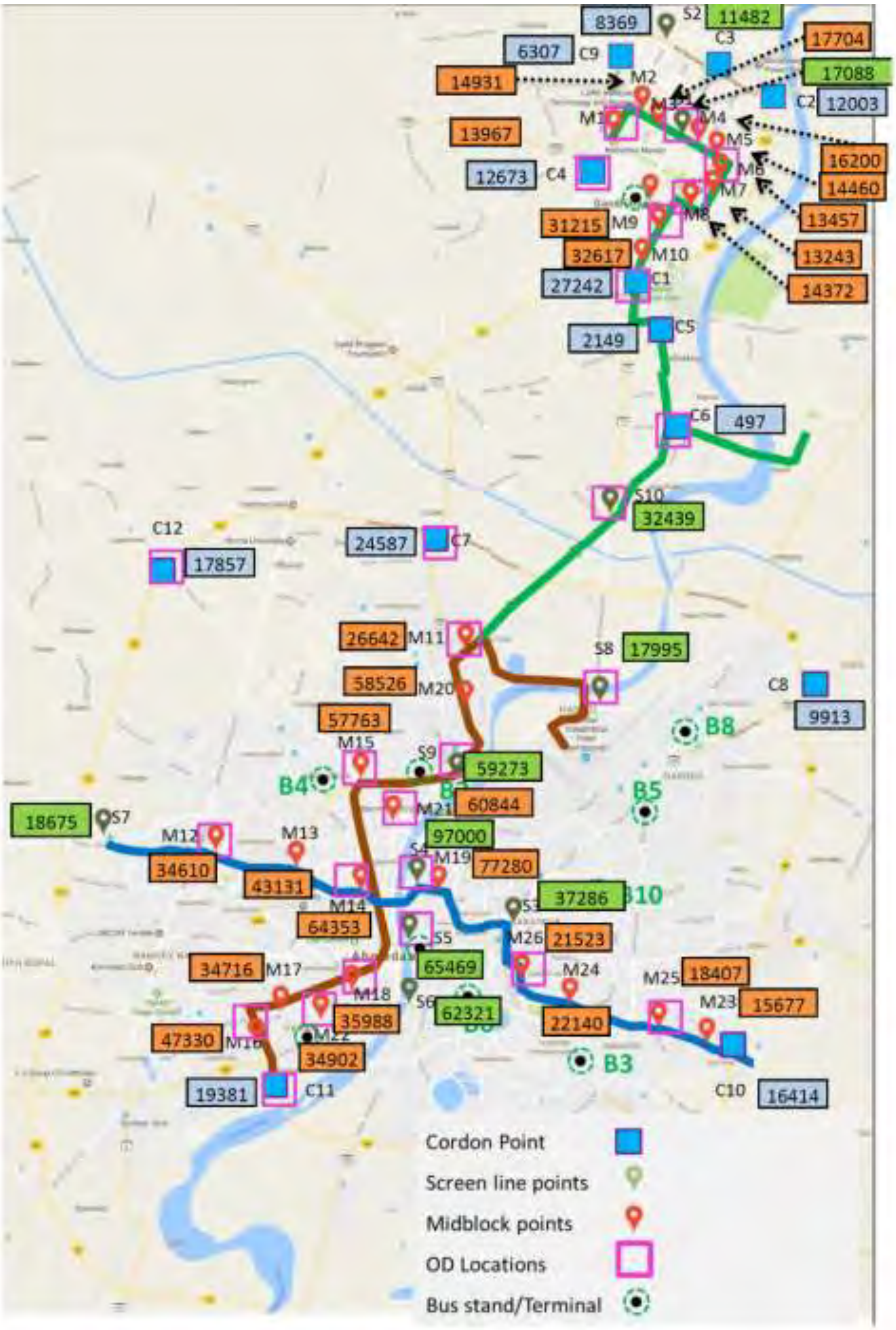
Source: IMaCS, 2017

Figure 2.13 Primary Survey Location Map, 2017

2.3.1 Classified Traffic Volume Count

Classified traffic volume count survey was conducted at the 48 identified locations, which includes Screen line, Mid-Block and Cordon points. This data is required to expand the O-D Survey data to the total volume at respective O-D location. The TVC and the Occupancy Survey data assessment is done to obtain Average Daily Traffic (ADT) , Hourly variation and Peak Hour flows , Directional distribution by hour of the day and modal split.

From assessment of traffic volume, it was observed that Screen line 4 which is located at the Gandhi bridge has the highest traffic volume of 106833 (97000 PCU's) whereas the lowest traffic volume was observed at Cordon point 6 located at PDPU road, which is a link to the GIFT City. Observed passenger traffic volume at all locations is shown in figure 3 below:



Source: Primary Study, IMacS, 2017

Figure 2.14 Passenger Traffic Volume (in PCU)

Table 2.17 Location wise Total Passenger, Vehicles and PCU

Location	Total Passenger	Total Vehicles	Total PCU's	Location	Total Passenger	Total Vehicles	Total PCU's
C1	58269	31833	27242	**M3**	36362	20971	17704
C2	24104	14012	12003	**M4**	33946	19053	16200
C3	17452	9815	8369	**M5**	29365	17019	14460
C4	24744	15000	12673	**M6**	26468	15469	13457
C5	5576	2425	2149	**M7**	29060	15063	13243
C6	924	691	497	**M8**	32299	16544	14372
C7	49975	28138	24587	**M9**	64209	36504	31215
C8	18260	11172	9913	**M10**	68236	38200	32617
C9	12708	6607	6307	**M11**	59426	30718	26642
C10	30527	19237	16414	**M12**	68139	39914	34610
C11	37856	21616	19381	**M13**	89506	49541	43131
C12	36055	20281	17857	**M14**	134720	74172	64353
S1	37123	20169	17088	**M15**	119553	63091	57763
S2	23017	13603	11482	**M16**	87911	51053	47330
S3	76792	42980	37286	**M17**	70195	37838	34716
S4	208105	106827	97000	**M18**	72020	38212	35988
S5	131698	75325	65469	**M19**	170237	87740	77280
S6	126360	71171	62321	**M20**	122375	66463	58526
S7	36786	21488	18675	**M21**	128640	66917	60844
S8	34792	19823	17995	**M22**	67530	39,993	34902
S9	118735	64922	59273	**M23**	28749	17973	15677
S10	71488	35966	32439	**M24**	40934	24463	22140
M1	26977	16532	13967	**M25**	32069	20537	18407
M2	31538	17531	14931	**M26**	40846	24034	21523

Table 2.18 Location wise directional traffic volume (No of Passenger Vehicles)

Location	Direction	Two Wheeler	Auto Rickshaw (Passenger)	Car/ Van	Other shared IPT	Mini Bus_Public	Mini Bus_Regional	Standard Bus_Public	Standard Bus_Regional	Cycle	Cycle Rickshaw	Direction Total	Total
C1	Dir 1	10,434	1,500	3,458	0	2	3	70	66	36	7	15,576	31,833
	Dir 2	11,412	1,408	3,283	0	1	2	53	70	19	9	16,257	
C2	Dir 1	4,655	92	2,456	74	3	4	23	28	35	1	7,371	14,012
	Dir 2	4,139	149	2,188	70	4	5	28	20	36	2	6,641	
C3	Dir 1	3,375	47	1,606	37	3	4	25	29	35	1	5,162	9,815
	Dir 2	2,997	89	1,432	38	4	5	19	31	36	2	4,653	
C4	Dir 1	5,558	499	1,770	37	3	3	22	28	35	1	7,956	15,000
	Dir 2	4,944	380	1,581	34	4	5	23	35	36	2	7,044	
C5	Dir 1	806	34	374	27	2	8	9	18	33	6	1,317	2,425
	Dir 2	603	52	338	31	2	2	21	11	43	5	1,108	
C6	Dir 1	177	26	144	0	0	0	1	0	0	0	348	691
	Dir 2	167	34	142	0	0	0	0	0	0	0	343	
C7	Dir 1	8,834	1,458	3,029	0	6	36	90	64	146	20	13,683	28,138
	Dir 2	9,034	1,875	3,227	0	10	40	72	74	119	4	14,455	
C8	Dir 1	3,288	727	1,149	133	6	1	6	19	25	7	5,361	11,172
	Dir 2	3,588	791	1,245	141	1	4	2	11	20	8	5,811	
C9	Dir 1	979	198	1,817	42	0	2	24	19	0	0	3,081	6,607
	Dir 2	1,098	256	2,107	24	0	0	37	4	0	0	3,526	
C10	Dir 1	6,026	929	2,121	0	0	3	9	7	65	0	9,160	19,237
	Dir 2	6,612	1,026	2,328	0	1	1	11	5	93	0	10,077	
C11	Dir 1	6,323	1,405	2,213	254	3	3	86	35	25	13	10,360	21,616
	Dir 2	6,905	1,531	2,410	275	1	5	69	22	22	16	11,256	
C12	Dir 1	6,049	1,257	2,152	0	2	14	64	55	31	8	9,632	20,281
	Dir 2	6,790	1,455	2,237	0	3	18	45	57	40	4	10,649	

Location	Direction	Two Wheeler	Auto Rickshaw (Passenger)	Car/ Van	Other shared IPT	Mini Bus_Public	Mini Bus_Regional	Standard Bus_Public	Standard Bus_Regional	Cycle	Cycle Rickshaw	Direction Total	Total
S1	Dir 1	7,504	653	2,376	44	3	2	44	52	38	1	10,717	20,169
	Dir 2	6,664	467	2,127	42	4	5	58	46	37	2	9,452	
S2	Dir 1	5,052	444	1,606	37	3	2	45	21	35	1	7,246	13,603
	Dir 2	4,492	315	1,432	38	4	5	23	10	36	2	6,357	
S3	Dir 1	14,813	2,367	3,802	503	0	21	130	56	288	156	22,136	42,980
	Dir 2	14,126	2,426	3,949	120	5	16	115	56	30	1	20,844	
S4	Dir 1	29,229	6,042	16,928	1,314	1	38	335	140	78	34	54,139	1,06,827
	Dir 2	28,306	5,963	16,518	1,286	10	43	318	137	77	30	52,688	
S5	Dir 1	26,590	3,860	7,203	845	6	42	260	59	169	55	39,089	75,325
	Dir 2	24,121	4,334	6,661	659	4	45	106	100	135	71	36,236	
S6	Dir 1	23,281	4,423	7,522	391	2	29	118	141	76	29	36,012	71,171
	Dir 2	22,717	4,331	7,337	378	6	31	115	133	74	37	35,159	
S7	Dir 1	6,297	980	2,783	0	3	21	24	40	85	0	10,233	21,488
	Dir 2	6,901	1,081	3,043	0	4	16	36	51	123	0	11,255	
S8	Dir 1	6,312	1,590	1,998	346	0	0	43	21	33	33	10,376	19,823
	Dir 2	5,380	1,604	1,879	419	0	0	21	32	54	58	9,447	
S9	Dir 1	19,065	4,248	8,457	894	11	24	211	144	121	38	33,213	64,922
	Dir 2	17,330	5,098	7,485	1,278	6	15	176	147	143	31	31,709	
S10	Dir 1	13,243	2,637	4,866	503	0	24	137	107	13	19	21,549	35,966
	Dir 2	8,329	1,982	3,384	462	0	21	91	95	20	33	14,417	
M1	Dir 1	5,747	521	1,816	37	3	3	47	37	35	1	8,247	16,532
	Dir 2	5,877	417	1,861	33	4	5	35	15	36	2	8,285	
M2	Dir 1	6,486	574	2,059	37	3	3	50	46	35	1	9,294	17,531
	Dir 2	5,773	410	1,840	34	4	5	78	55	36	2	8,237	
M3	Dir 1	7,812	685	2,483	44	3	2	52	37	38	1	11,157	20,971
	Dir 2	6,944	495	2,216	42	4	5	45	24	37	2	9,814	

Location	Direction	Two Wheeler	Auto Rickshaw (Passenger)	Car/ Van	Other shared IPT	Mini Bus_Public	Mini Bus_Regional	Standard Bus_Public	Standard Bus_Regional	Cycle	Cycle Rickshaw	Direction Total	Total
M4	Dir 1	6,900	366	2,687	22	2	9	84	30	34	6	10,140	19,053
	Dir 2	5,826	533	2,438	26	2	2	18	9	53	6	8,913	
M5	Dir 1	6,160	334	2,394	22	2	9	35	25	34	6	9,021	17,019
	Dir 2	5,190	489	2,181	23	2	2	44	9	52	6	7,998	
M6	Dir 1	4,964	307	2,777	18	2	12	36	41	33	6	8,196	15,469
	Dir 2	4,180	459	2,522	20	2	2	36	3	44	5	7,273	
M7	Dir 1	4,788	304	2,682	21	2	9	63	56	34	6	7,965	15,063
	Dir 2	4,038	444	2,434	24	2	2	53	43	52	6	7,098	
M8	Dir 1	5,266	875	1,814	0	1	3	71	43	37	8	8,118	16,544
	Dir 2	5,748	817	1,721	0	1	2	64	43	20	10	8,426	
M9	Dir 1	11,972	1,750	3,960	0	2	3	88	46	37	9	17,867	36,504
	Dir 2	13,069	1,643	3,764	0	1	2	80	48	20	10	18,637	
M10	Dir 1	12,553	1,793	4,112	0	3	3	86	47	32	8	18,637	38,200
	Dir 2	13,766	1,702	3,943	0	1	2	80	47	12	10	19,563	
M11	Dir 1	11,512	1,840	2,306	238	3	4	89	94	4	39	16,129	30,718
	Dir 2	10,411	1,826	1,848	258	2	1	94	86	17	46	14,589	
M12	Dir 1	11,770	2,443	4,185	0	2	21	76	66	382	12	18,957	39,914
	Dir 2	13,186	2,831	4,362	0	3	25	59	72	413	6	20,957	
M13	Dir 1	17,415	3,244	5,393	79	13	29	137	83	16	2	26,411	49,541
	Dir 2	15,276	2,845	4,720	70	6	21	112	64	15	1	23,130	
M14	Dir 1	24,616	4,470	5,716	618	5	26	280	57	126	176	36,090	74,172
	Dir 2	26,332	4,333	6,501	330	7	19	186	63	134	177	38,082	
M15	Dir 1	16,610	3,787	9,246	751	1	34	208	101	62	32	30,832	63,091
	Dir 2	16,084	3,743	11,254	742	10	35	202	102	58	29	32,259	
M16	Dir 1	12,701	9,881	2,023	7	4	18	93	103	158	53	25,041	51,053
	Dir 2	14,953	4,395	6,342	0	8	17	67	66	126	38	26,012	

Location	Direction	Two Wheeler	Auto Rickshaw (Passenger)	Car/ Van	Other shared IPT	Mini Bus_Public	Mini Bus_Regional	Standard Bus_Public	Standard Bus_Regional	Cycle	Cycle Rickshaw	Direction Total	Total
M17	Dir 1	10,228	3,796	4,303	21	6	41	123	112	183	96	18,909	37,838
	Dir 2	10,344	3,650	4,473	5	5	42	103	97	132	78	18,929	
M18	Dir 1	9,072	3,235	5,994	599	2	6	120	109	145	118	19,400	38,212
	Dir 2	8,992	2,906	5,851	574	3	1	154	101	115	115	18,812	
M19	Dir 1	29,022	4,442	13,307	1,057	0	37	363	137	360	118	48,843	87,740
	Dir 2	25,844	3,949	7,364	948	6	33	212	128	305	108	38,897	
M20	Dir 1	23,308	4,672	5,856	613	7	23	147	121	57	110	34,914	66,463
	Dir 2	21,067	4,620	4,696	650	4	16	185	118	67	126	31,549	
M21	Dir 1	18,273	3,781	10,582	821	1	34	217	101	62	32	33,904	66,917
	Dir 2	17,700	3,734	10,322	811	10	35	212	102	58	29	33,013	
M22	Dir 1	12,792	2,559	4,326	10	1	22	52	49	36	41	19,888	39,993
	Dir 2	12,937	2,466	4,492	3	1	27	48	50	40	41	20,105	
M23	Dir 1	5,376	1,017	1,916	148	2	6	9	5	35	12	8,526	17,973
	Dir 2	6,049	1,175	2,000	145	3	12	12	2	43	6	9,447	
M24	Dir 1	9,081	2,530	3,202	377	1	34	43	11	14	3	15,296	24,463
	Dir 2	5,285	1,616	2,007	208	10	8	20	10	3	0	9,167	
M25	Dir 1	6,112	1,637	2,426	174	3	15	15	4	16	25	10,427	20,537
	Dir 2	5,983	1,602	2,237	222	2	13	23	5	4	19	10,110	
M26	Dir 1	7,512	1,706	2,973	209	8	15	44	21	125	66	12,679	24,034
	Dir 2	6,788	1,697	2,383	221	3	16	31	16	125	75	11,355	

Table 2.19 Peak Hour

Period	Time
Morning peak	8:00am – 11:00am
Evening peak	5:00pm- 8:00pm

The peak period was observed from 8 am to 11 am and evening peak period was observed from 5 pm to 8 pm.

Table 2.20 Location wise Peak hour factor

Location		Peak Traffic	Total	Peak hr Factor
C1	Veh	2,652	31,833	8.3%
	PCU	2,162	27,242	7.9%
C2	Veh	1,159	14,012	8.3%
	PCU	984	12,003	8.2%
C3	Veh	812	9,815	8.3%
	PCU	679	8,369	8.1%
C4	Veh	1,261	15,000	8.4%
	PCU	1,059	12,673	8.4%
C5	Veh	340	2,425	14.0%
	PCU	276	2,149	12.8%
C6	Veh	53	558	9.5%
	PCU	48	497	9.6%
C7	Veh	2,243	28,138	8.0%
	PCU	1,951	24,587	7.9%
C8	Veh	1,116	11,176	10.0%
	PCU	989	9,913	10.0%
C9	Veh	533	6,607	8.1%
	PCU	517	6,307	8.2%
C10	Veh	1,583	19,237	8.2%
	PCU	1,291	16,414	7.9%
C11	Veh	2,157	21,623	10.0%
	PCU	1,922	19,381	9.9%
C12	Veh	1,945	20,281	9.6%
	PCU	1,687	17,857	9.4%
S1	Veh	1,703	20,169	8.4%
	PCU	1,439	17,088	8.4%
S2	Veh	1,148	13,603	8.4%
	PCU	965	11,482	8.4%
S3	Veh	3,874	42,980	9.0%
	PCU	3,393	37,286	9.1%
S4	Veh	8,152	1,06,833	7.6%
	PCU	7,363	97,000	7.6%
S5	Veh	7,639	75,333	10.1%
	PCU	6,558	65,469	10.0%

Location		Peak Traffic	Total	Peak hr Factor
S6	Veh	6,469	71,174	9.1%
	PCU	5,599	62,321	9.0%
S7	Veh	1,732	21,488	8.1%
	PCU	1,467	18,675	7.9%
S8	Veh	1,768	19,827	8.9%
	PCU	1,557	17,995	8.7%
S9	Veh	4,924	64,922	7.6%
	PCU	4,458	59,273	7.5%
S10	Veh	3,251	35,970	9.0%
	PCU	2,849	32,439	8.8%
M1	Veh	1,399	16,532	8.5%
	PCU	1,185	13,967	8.5%
M2	Veh	1,468	17,531	8.4%
	PCU	1,234	14,931	8.3%
M3	Veh	1,763	20,971	8.4%
	PCU	1,475	17,704	8.3%
M4	Veh	1,808	19,053	9.5%
	PCU	1,496	16,200	9.2%
M5	Veh	1,615	17,019	9.5%
	PCU	1,333	14,460	9.2%
M6	Veh	1,448	15,469	9.4%
	PCU	1,239	13,457	9.2%
M7	Veh	1,398	15,063	9.3%
	PCU	1,201	13,243	9.1%
M8	Veh	1,364	16,544	8.2%
	PCU	1,125	14,372	7.8%
M9	Veh	3,031	36,504	8.3%
	PCU	2,471	31,215	7.9%
M10	Veh	3,028	38,200	7.9%
	PCU	2,568	32,617	7.9%
M11	Veh	2,988	30,719	9.7%
	PCU	2,547	26,642	9.6%
M12	Veh	3,802	39,914	9.5%
	PCU	3,262	34,610	9.4%
M13	Veh	4,511	49,541	9.1%
	PCU	3,905	43,131	9.1%
M14	Veh	5,951	74,180	8.0%
	PCU	5,208	64,353	8.1%
M15	Veh	4,777	63,095	7.6%
	PCU	4,400	57,763	7.6%
M16	Veh	4,243	51,064	8.3%
	PCU	3,967	47,330	8.4%
M17	Veh	3,088	37,854	8.2%

Location		Peak Traffic	Total	Peak hr Factor
	PCU	2,832	34,716	8.2%
	Veh	3,301	38,224	8.6%
M18	PCU	3,029	35,988	8.4%
	Veh	7,811	87,746	8.9%
M19	PCU	6,836	77,280	8.8%
	Veh	6,487	66,474	9.8%
M20	PCU	5,647	58,526	9.6%
	Veh	5,100	66,921	7.6%
M21	PCU	4,612	60,844	7.6%
	Veh	3,273	40,012	8.2%
M22	PCU	2,869	34,902	8.2%
	Veh	1,720	17,973	9.6%
M23	PCU	1,478	15,677	9.4%
	Veh	2,017	24,486	8.2%
M24	PCU	1,815	22,140	8.2%
	Veh	1,698	20,539	8.3%
M25	PCU	1,485	18,407	8.1%
	Veh	2,359	24,069	9.8%
M26	PCU	2,117	21,523	9.8%

Vehicular Composition

Vehicular composition (fig.10) recorded during the traffic volume study shows that majority of the traffic is contributed by private vehicles of which 62% is two-wheeler and 25% is four-wheeler, followed by 11% Intermediate Public transport modes and 1% by bus.

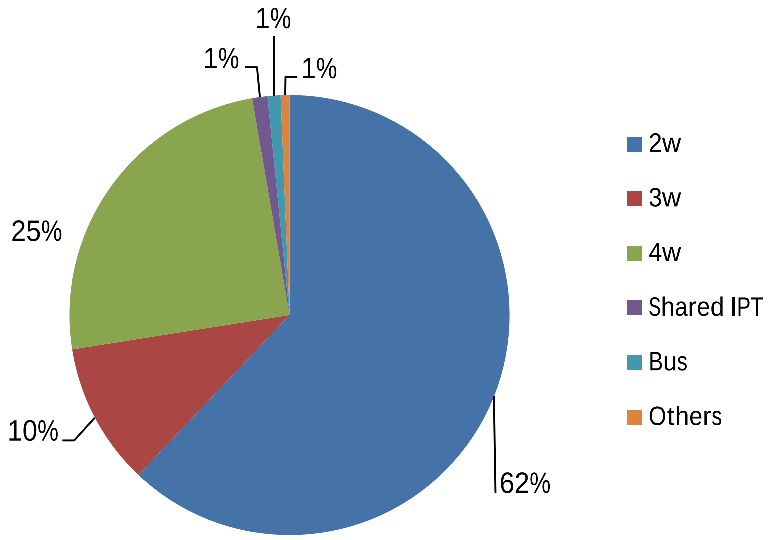


Figure 2.15 Vehicular Composition

Table 2.21 Location wise Vehicular Composition (Passenger Vehicle)

Code		Two Wheeler	Auto Rickshaw (Passenger)	Car/ Van	Other shared IPT	Mini Bus	Standard Bus	Slow Vehicles	Total Vehicles
C1	Veh	21846	2908	6741	0	8	259	71	31833
	%	68.63	9.14	21.18	0.00	0.03	0.81	0.22	100
C2	Veh	8794	241	4644	144	16	99	74	14012
	%	62.76	1.72	33.14	1.03	0.11	0.71	0.53	100
C3	Veh	6372	136	3038	75	16	104	74	9815
	%	64.92	1.39	30.95	0.76	0.16	1.06	0.75	100
C4	Veh	10502	879	3351	71	15	108	74	15000
	%	70.01	5.86	22.34	0.47	0.10	0.72	0.49	100
C5	Veh	1409	86	712	58	14	59	87	2425
	%	58.10	3.55	29.36	2.39	0.58	2.43	3.59	100
C6	Veh	344	60	286	0	0	1	0	691
	%	49.78	8.68	41.39	0.00	0.00	0.14	0.00	100
C7	Veh	17868	3333	6256	0	92	300	289	28138
	%	63.50	11.85	22.23	0.00	0.33	1.07	1.03	100
C8	Veh	6876	1518	2394	274	12	38	60	11172
	%	61.55	13.59	21.43	2.45	0.11	0.34	0.54	100
C9	Veh	2077	454	3924	66	2	84	0	6607
	%	31.44	6.87	59.39	1.00	0.03	1.27	0.00	100
C10	Veh	12638	1955	4449	0	5	32	158	19237
	%	65.70	10.16	23.13	0.00	0.03	0.17	0.82	100
C11	Veh	13228	2936	4623	529	12	212	76	21616
	%	61.20	13.58	21.39	2.45	0.06	0.98	0.35	100
C12	Veh	12839	2712	4389	0	37	221	83	20281
	%	63.31	13.37	21.64	0.00	0.18	1.09	0.41	100
S1	Veh	14168	1120	4503	86	14	200	78	20169
	%	70.25	5.55	22.33	0.43	0.07	0.99	0.39	100
S2	Veh	9544	759	3038	75	14	99	74	13603
	%	70.16	5.58	22.33	0.55	0.10	0.73	0.54	100
S3	Veh	28939	4793	7751	623	42	357	475	42980
	%	67.33	11.15	18.03	1.45	0.10	0.83	1.11	100
S4	Veh	57535	12005	33446	2600	92	930	219	106827
	%	53.86	11.24	31.31	2.43	0.09	0.87	0.21	100
S5	Veh	50711	8194	13864	1504	97	525	430	75325
	%	67.32	10.88	18.41	2.00	0.13	0.70	0.57	100
S6	Veh	45998	8754	14859	769	68	507	216	71171
	%	64.63	12.30	20.88	1.08	0.10	0.71	0.30	100
S7	Veh	13198	2061	5826	0	44	151	208	21488
	%	61.42	9.59	27.11	0.00	0.20	0.70	0.97	100
S8	Veh	11692	3194	3877	765	0	117	178	19823
	%	58.98	16.11	19.56	3.86	0.00	0.59	0.90	100
S9	Veh	36395	9346	15942	2172	56	678	333	64922

Code		Two Wheeler	Auto Rickshaw (Passenger)	Car/ Van	Other shared IPT	Mini Bus	Standard Bus	Slow Vehicles	Total Vehicles
	%	56.06	14.40	24.56	3.35	0.09	1.04	0.51	100
S10	Veh	21572	4619	8250	965	45	430	85	35966
	%	59.98	12.84	22.94	2.68	0.13	1.20	0.24	100
M1	Veh	11624	938	3677	70	15	134	74	16532
	%	70.31	5.67	22.24	0.42	0.09	0.81	0.45	100
M2	Veh	12259	984	3899	71	15	229	74	17531
	%	69.93	5.61	22.24	0.40	0.09	1.31	0.42	100
M3	Veh	14756	1180	4699	86	14	158	78	20971
	%	70.36	5.63	22.41	0.41	0.07	0.75	0.37	100
M4	Veh	12726	899	5125	48	15	141	99	19053
	%	66.79	4.72	26.90	0.25	0.08	0.74	0.52	100
M5	Veh	11350	823	4575	45	15	113	98	17019
	%	66.69	4.84	26.88	0.26	0.09	0.66	0.58	100
M6	Veh	9144	766	5299	38	18	116	88	15469
	%	59.11	4.95	34.26	0.25	0.12	0.75	0.57	100
M7	Veh	8826	748	5116	45	15	215	98	15063
	%	58.59	4.97	33.96	0.30	0.10	1.43	0.65	100
M8	Veh	11014	1692	3535	0	7	221	75	16544
	%	66.57	10.23	21.37	0.00	0.04	1.34	0.45	100
M9	Veh	25041	3393	7724	0	8	262	76	36504
	%	68.60	9.29	21.16	0.00	0.02	0.72	0.21	100
M10	Veh	26319	3495	8055	0	9	260	62	38200
	%	68.90	9.15	21.09	0.00	0.02	0.68	0.16	100
M11	Veh	21923	3666	4154	496	10	363	106	30718
	%	71.37	11.93	13.52	1.61	0.03	1.18	0.35	100
M12	Veh	24956	5274	8547	0	51	273	813	39914
	%	62.52	13.21	21.41	0.00	0.13	0.68	2.04	100
M13	Veh	32691	6089	10113	149	69	396	34	49541
	%	65.99	12.29	20.41	0.30	0.14	0.80	0.07	100
M14	Veh	50948	8803	12217	948	57	586	613	74172
	%	68.69	11.87	16.47	1.28	0.08	0.79	0.83	100
M15	Veh	32694	7530	20500	1493	80	613	181	63091
	%	51.82	11.94	32.49	2.37	0.13	0.97	0.29	100
M16	Veh	27654	14276	8365	7	47	329	375	51053
	%	54.17	27.96	16.38	0.01	0.09	0.64	0.73	100
M17	Veh	20572	7446	8776	26	94	435	489	37838
	%	54.37	19.68	23.19	0.07	0.25	1.15	1.29	100
M18	Veh	18064	6141	11845	1173	12	484	493	38212
	%	47.27	16.07	31.00	3.07	0.03	1.27	1.29	100
M19	Veh	54866	8391	20671	2005	76	840	891	87740
	%	62.53	9.56	23.56	2.29	0.09	0.96	1.02	100
M20	Veh	44375	9292	10552	1263	50	571	360	66463

Code		Two Wheeler	Auto Rickshaw (Passenger)	Car/ Van	Other shared IPT	Mini Bus	Standard Bus	Slow Vehicles	Total Vehicles
	%	66.77	13.98	15.88	1.90	0.08	0.86	0.54	100
M21	Veh	35973	7515	20904	1632	80	632	181	66917
	%	53.76	11.23	31.24	2.44	0.12	0.94	0.27	100
M22	Veh	25729	5025	8818	13	51	199	158	39993
	%	64.33	12.56	22.05	0.03	0.13	0.50	0.40	100
M23	Veh	11425	2192	3916	293	23	28	96	17973
	%	63.57	12.20	21.79	1.63	0.13	0.16	0.53	100
M24	Veh	14366	4146	5209	585	53	84	20	24463
	%	58.73	16.95	21.29	2.39	0.22	0.34	0.08	100
M25	Veh	12095	3239	4663	396	33	47	64	20537
	%	58.89	15.77	22.71	1.93	0.16	0.23	0.31	100
M26	Veh	14300	3403	5356	430	42	112	391	24034
	%	59.50	14.16	22.29	1.79	0.17	0.47	1.63	100

2.3.2 Traffic Area Zoning

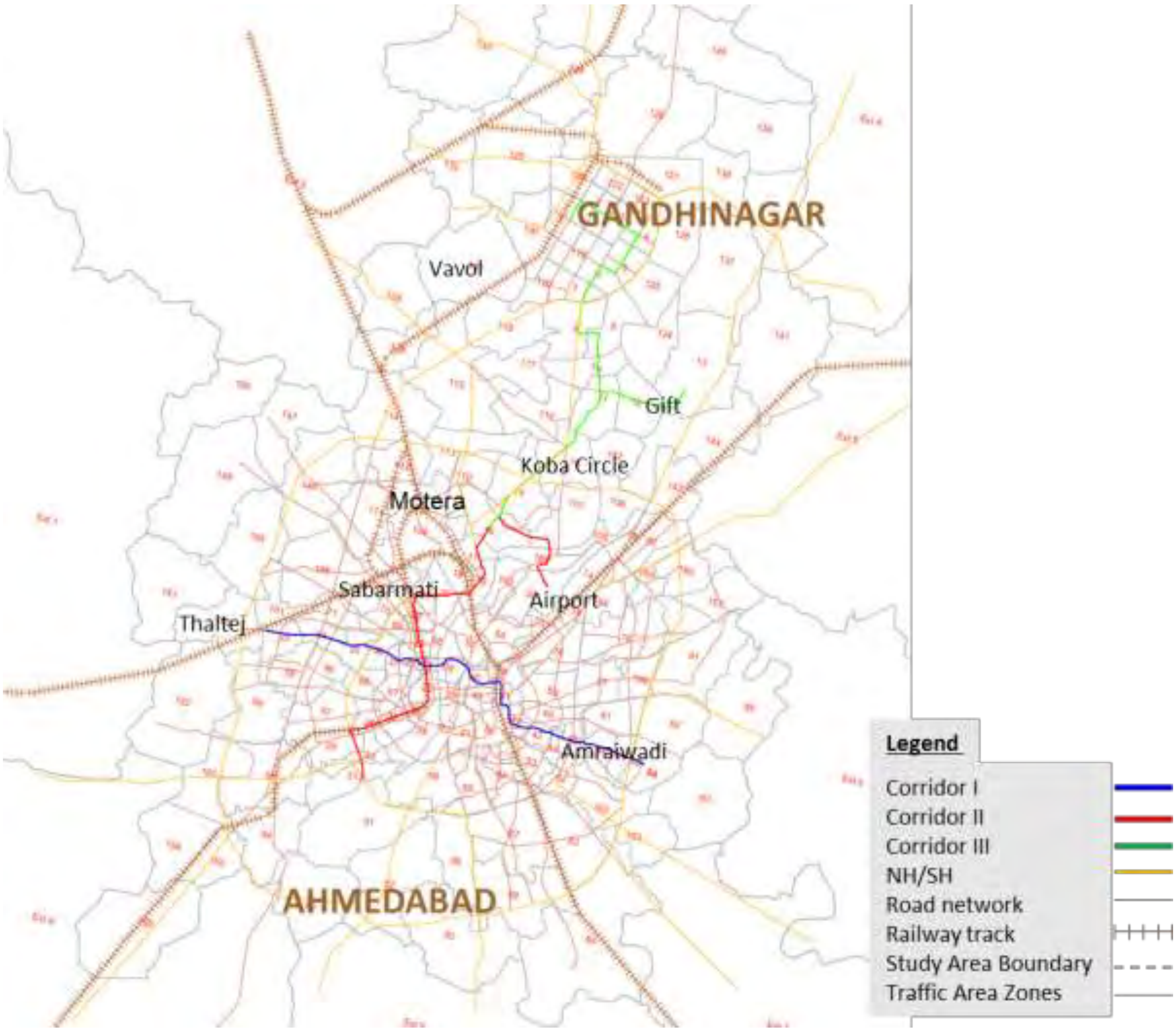
For the purpose of origin destination surveys, traffic demand modelling, estimating travel pattern and updating loading and unloading at stations, 179 traffic area zones were created(figure10) within the study area boundary that comprises of GUDA, AUDA, AMC and other areas beyond AUDA.

Table 2.22 Zoning distribution

Zones	Areas	No of Zones
Internal Zones	Ahmedabad	124
	Gandhinagar	46
External Zones		9
Total		**179**

Source: IMaCS, 2017

As shown in table 2.22, there are 124 Zones within Ahmedabad region, 46 TAZ within Gandhinagar region and 9 external zones



Source: IMaCS, 2017

Figure 2.16 Traffic Area Zone Map

2.3.3 Origin destination survey analysis

OD Survey for the study area was conducted at 26 locations (14 midblock location, 6 screenline and 6 cordon points). TVC Surveys at the respective locations were conducted on the same day as OD surveys, such that the OD samples can be expanded accordingly. Vehicles captured during the OD for surveys are given below in table **2**.23.

Table 2.23 Vehicles Captured at OD Locations

Mode Type	Corridor 1	Corridor 2	Corridor 3
2 Wheeler	56.32%	50.34%	42.59%
Auto	14.40%	16.42%	11.02%
4 Wheeler	27.51%	30.72%	44.03%
Shared Vehicle	1.76%	2.52%	2.36%

Source: IMaCS, 2017

(a) Vehicular Occupancy

Vehicular occupancy as recorded during OD survey was found to be 1.46 for two wheelers, 1.34 for four wheelers, and 1.64 for Auto and 24.25 for Buses. (Table 2.24).

Table 2.24 Average Vehicle Occupancy

Occupancy	Two Wheeler	Auto Rickshaw (Passenger)	Car/ Van	Other shared IPT	Bus
	1.46	*1.64*	*1.34*	*1.61*	*24.25*

Source: IMaCS, 2017

(b) Trip Purpose

On an average predominant trip purpose for the study area are recorded to be 50% work trips followed by 16.23% commercial trips, 15.3% education trips, 8.85% Social/Recreational/Religious trips and 9.56% other trips.

Predominant trips captured were work related. Next most significant trips were for shopping and education purpose. The table below shows the distribution:

Table 2.25 Distribution of trips by purpose

Purpose	Along Corridor 1	Along Corridor 2	Along Corridor 3	Overall Study Area
Work	58.61%	41.53%	49.93%	50.02%
Commercial	15.13%	19.20%	14.36%	16.23%
Education	15.10%	17.09%	13.81%	15.33%
Social/Recreational/Religious	5.50%	12.72%	8.32%	8.85%
Others	5.66%	9.45%	13.58%	9.56%

Source: IMaCS, 2017

(c) Trip length Frequency Distribution

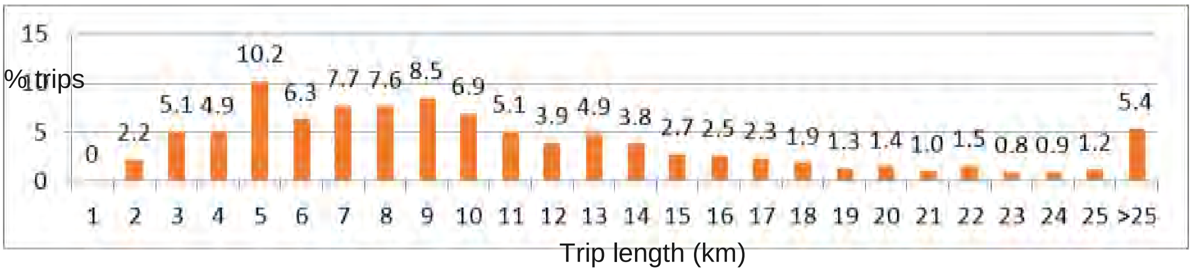
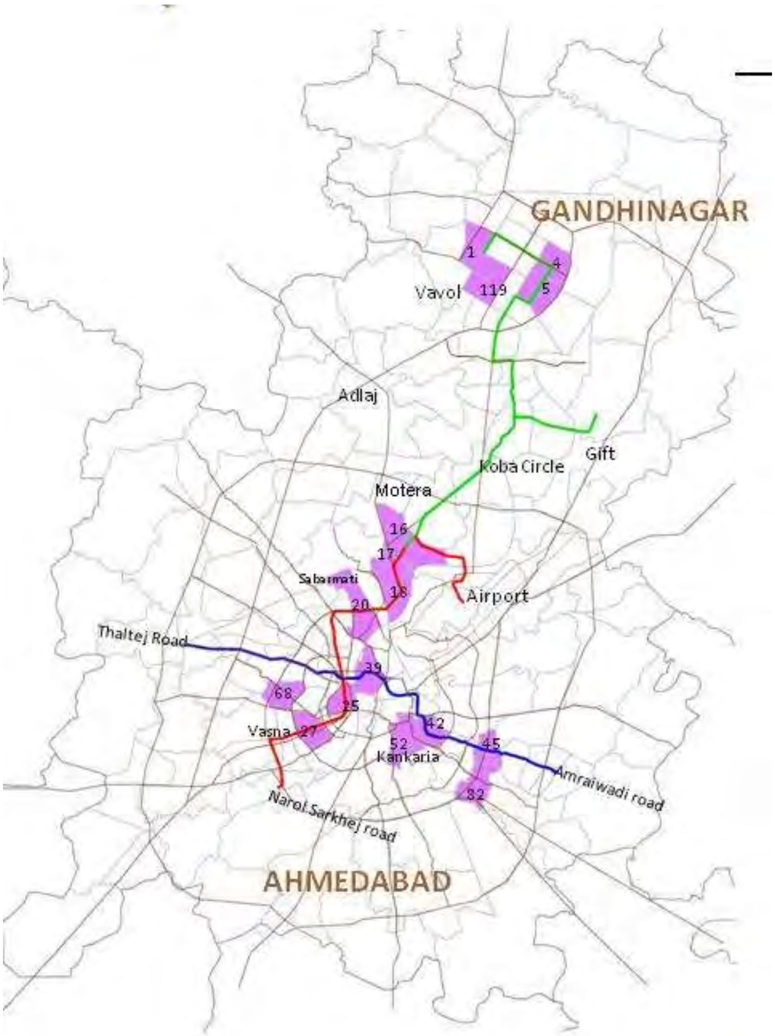


Figure 2.17 Trip length Frequency Distribution

Source: Imacs, 2017

(d) Major Trip Generating areas

From the OD survey and assessment, 10 major areas of trip generation and trip attraction as observed are highlighted below in fig11.



Source: Imacs,2017

Figure 2.18 Major Trip Generating and Trip Attracting Areas

Table 2.26 Major Trip Generating and Attracting Zones

City	Zone no	Areas
Gandhinagar	1	Mahatma Mandir, Govt college, Police Bhawan, LDRP , Dadi Kutir
	4,5	Secretariat , Akshardham, Central university, Police Bhawan
	119	Pathika Ashram
Ahmedabad	16	Motera, Chand khera, Hospital, BSNL Office , Gujarat housing board
	17, 18	Sabarmati Ashram, Railway station, Power house
	20	Nawa vadaj Bus terminal , commercial areas
	25	Gandhigram Railway station, Gujarat college
	27, 39, 42, 52, 45, 82	Residential Area
	68	Gujarat University, LD College of engineering , IIM, Vastrapur

Source:Imacs,2017

These locations are tentative and may change after calibration of trips on cube.

Base year trip distribution

Table 2.27

Modes	I-I	I-E	E-I	E-E
Four wheeler	96.7	1.71	1.4	0.11
Auto + other IPT	96.8	1.27	1.92	0.01
Four Wheeler	96.4	1.5	1.98	0.11
Bus	97.8	1.46	0.69	0.05

Source:Imacs,2017

2.3.4 Passenger Terminal Survey (Origin Destination Survey)

A) Terminal Survey locations

Bus Passenger OD Surveys were conducted at 10 Bus terminal and Bus-Stops within the study area. The survey Locations are:

i. Pathika circle Bus Stop
ii. GSRTC Bus Stop, Ahmedabad
iii. Hatkeshwar Bus stand
iv. New Wadaj Bus stand
v. VTCOS Bus stand, Gandhinagar
vi. RTO Circle
vii. Lal Darwaza terminal
viii. Naroda terminal
ix. Vasna Bus terminal
x. Bapunagar terminal

B) Access/Dispersal Trips by different Modes

It was observed that 45% of access dispersal trips were walk trips, followed by 28% auto trips as shown in figure 2.19

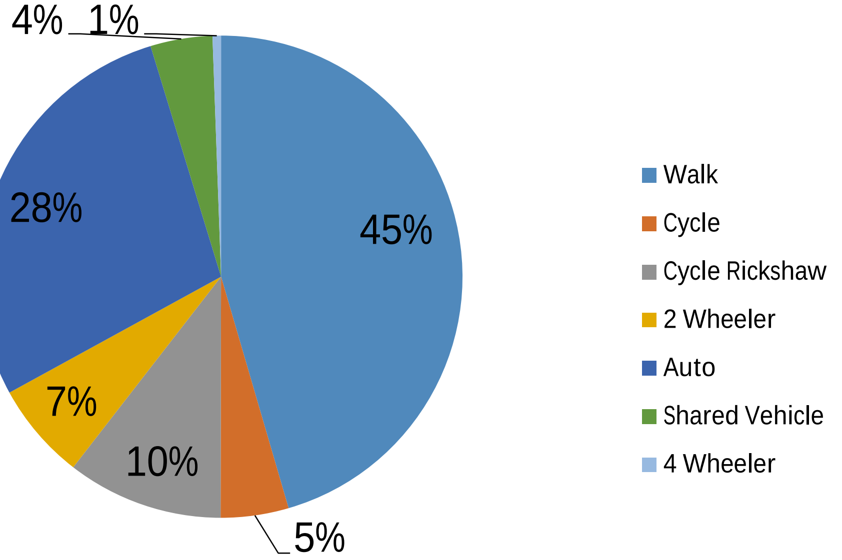


Figure 2.19 Modal Split for Access Dispersal trips

The location wise trip distribution by modes is presented on the table below:

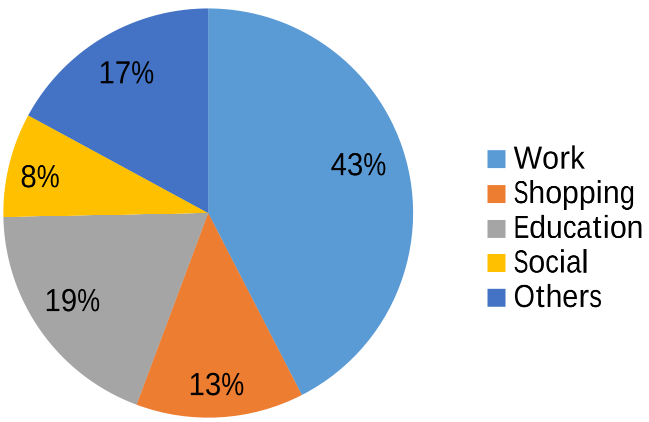
Table 2.28 Distribution of access dispersal trips by modes

Mode	Pathika	GSRTC	Hatkesh war	New Wadaj	Sector 6 Gandhinagar	RTO Circle	Lal Darwaja	Naroda	Vasna	Bapunagar
Walk	54.20%	51.70%	66.74%	52.32%	30.88%	14.33 %	33.33%	53.21%	57.83 %	40.30%
Cycle	7.25%	6.55%	7.37%	1.32%	2.21%	9.06%	8.06%	2.14%	0.00%	1.49%
Cycle Rickshaw	9.16%	9.95%	4.24%	3.97%	18.38%	19.59 %	19.89%	2.94%	10.54 %	5.97%
2 Wheeler	7.63%	8.50%	8.26%	6.95%	9.56%	7.02%	7.26%	4.81%	1.51%	3.73%
Auto	20.23%	22.09%	13.17%	33.77%	33.82%	30.41 %	17.20%	35.83%	28.61 %	47.51%
Shared Vehicle	1.15%	0.97%	0.22%	0.66%	5.15%	19.59 %	13.44%	0.00%	0.30%	0.00%
4 Wheeler	0.38%	0.24%	0.00%	0.99%	0.00%	0.00%	0.81%	1.07%	1.20%	1.00%
	100%	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*	*100%*

Source: IMaCS, 2017

C) Access Dispersal Trip Purpose

Distribution of trips by purpose shows that peope use buses predominantly for work trips followed by education and others. On average 43% trips are for work, 19% for education, 13 % for commercial, 8 % for recreational and 17 % for others



Source: Imacs,2017

Figure 2.20 Distribution of Bus trips by Purpose

It can be inferred from table 26, that 62% trips are daily trips, whereas 21% trips are occasional trips and remaining 17% trips may or may not be daily.

Table 2.29 Trip Frequency

Daily trips	62%
Occasional trips	21%
Others trips	17

Source: Imacs,2017

It was observed that recreational trips and commercial trips are comparatively more by private vehicles than buses. The location wise trip distribution by purpose is presented on the table below;

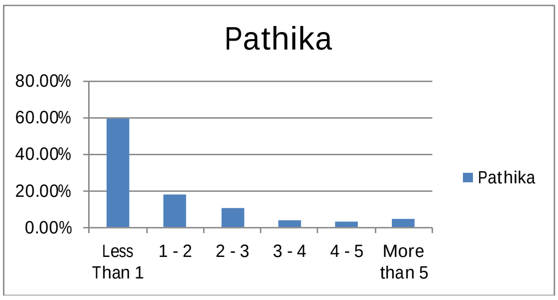
Table 2.30 Distribution of Trips by Purpose

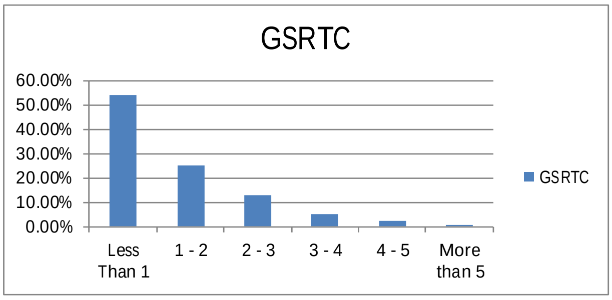
Purpose	Pathika	GSRTC	Hatkeshwar	New Wadaj	Sector 6 Gandhinagar	RTO Circle	Lal Darwaja	Naroda	Vasna	Bapunagar
Work	45.80%	42.23%	35.71%	43.71%	51.47%	42.11%	36.02%	38.50%	44.58%	44.28%
Shopping	13.74%	16.02%	18.75%	9.27%	1.47%	23.39%	15.05%	22.99%	4.82%	6.97%
Education	24.43%	23.79%	23.66%	13.25%	8.82%	24.56%	37.63%	8.02%	14.46%	11.44%
Social	4.58%	4.37%	16.96%	5.30%	2.94%	8.19%	3.76%	24.06%	3.61%	8.46%
Others	11.45%	13.59%	4.91%	28.48%	35.29%	1.75%	7.53%	6.42%	32.53%	28.86%

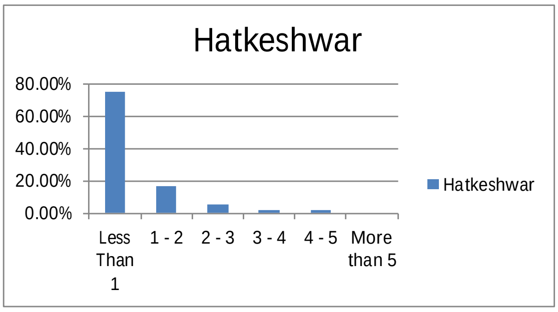
Source: IMaCS, 2017

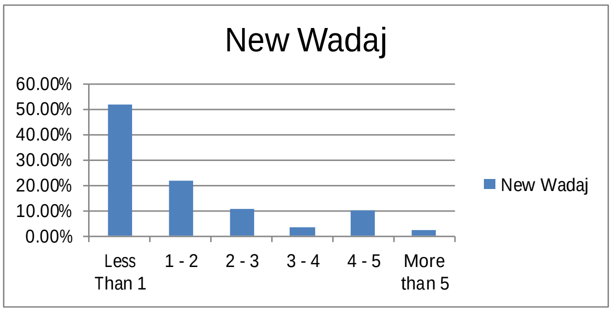
D) Access / Dispersal Trip Length Frequency Distribution

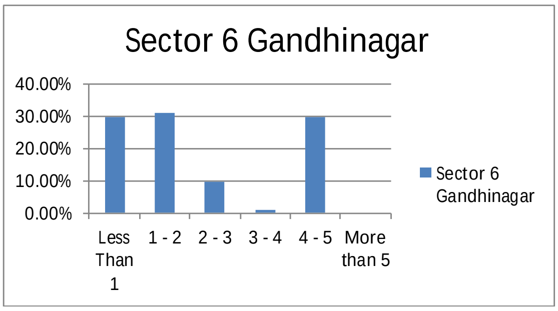
Majority of the access dispersal trips are within 1km from the bus stand or terminal. The figures below show the access/dispersal trip distance distribution for the bus terminals.

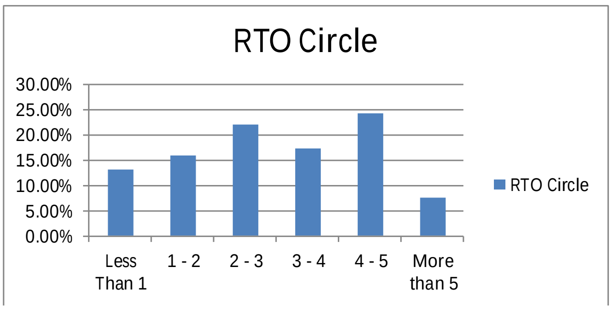


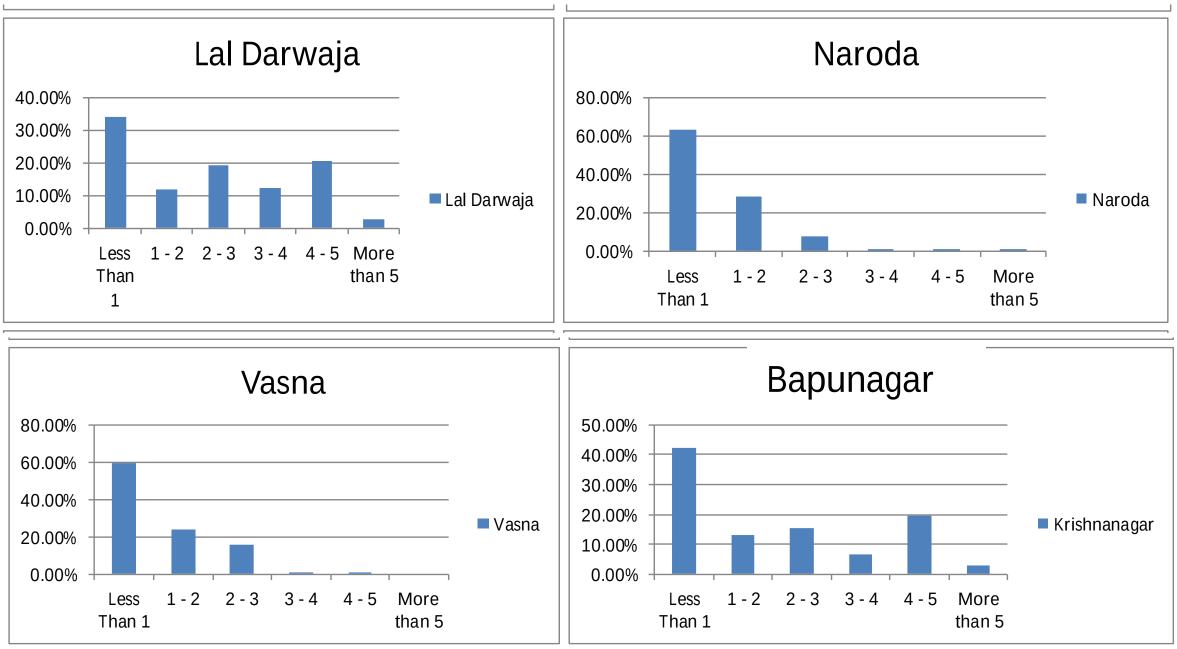










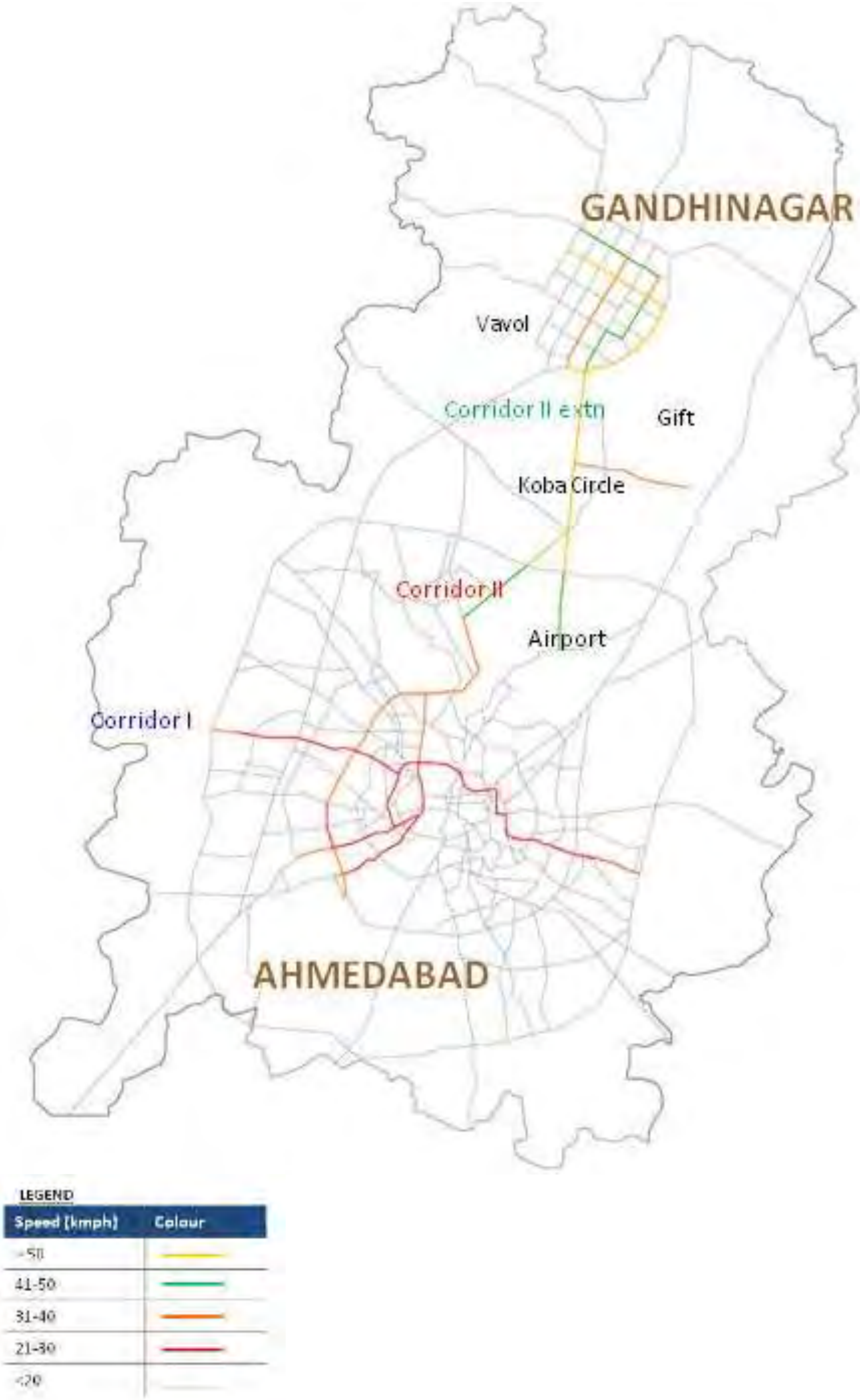


Source: Imacs,2017

Figure 2.21 Access and Dispersal Trip Distribution by Trip length

2.3.5 Speed and Delay Survey

Speed and delay survey was conducted on 10 corridors for two shift. It was observed that traffic moving along corridor III has highest travel speed i.e. above 50 kmph. Traffic moving along Corridor II has travel speed within 30-40 kmph aound AUDA border and 21-30 kmph within core Ahmedabad city. And travel speed along Corridor I has the least travel speed of 21 – 30 kmph. The speed and delay map, as generated is given below in figure 2.22.



Source: IMaCS, 2017

Figure 2.22 Speed and Delay Map

2.4 Ridership Estimation for Revised Alignment

Planning Period

The base year of the study is considered as 2017. Demand forecasting on the network was undertaken till 2051. In order to estimate the demand on the metro corridor, all relevant data has been collated for the base year 2017 and secondary sources available. The horizon years considered is as follows:

1. 2017 – Estimation of Phase I metro corridor ridership
2. 2021 – Operation of Phase I metro corridor and estimation of Phase II corridor ridership
3. 2031 – Operation of both Phase I and Phase II corridor
4. 2041 – Operation of both Phase I and Phase II corridor
5. 2051 – Operation of all both Phase I and Phase II corridor

Analytical Framework for Model Development

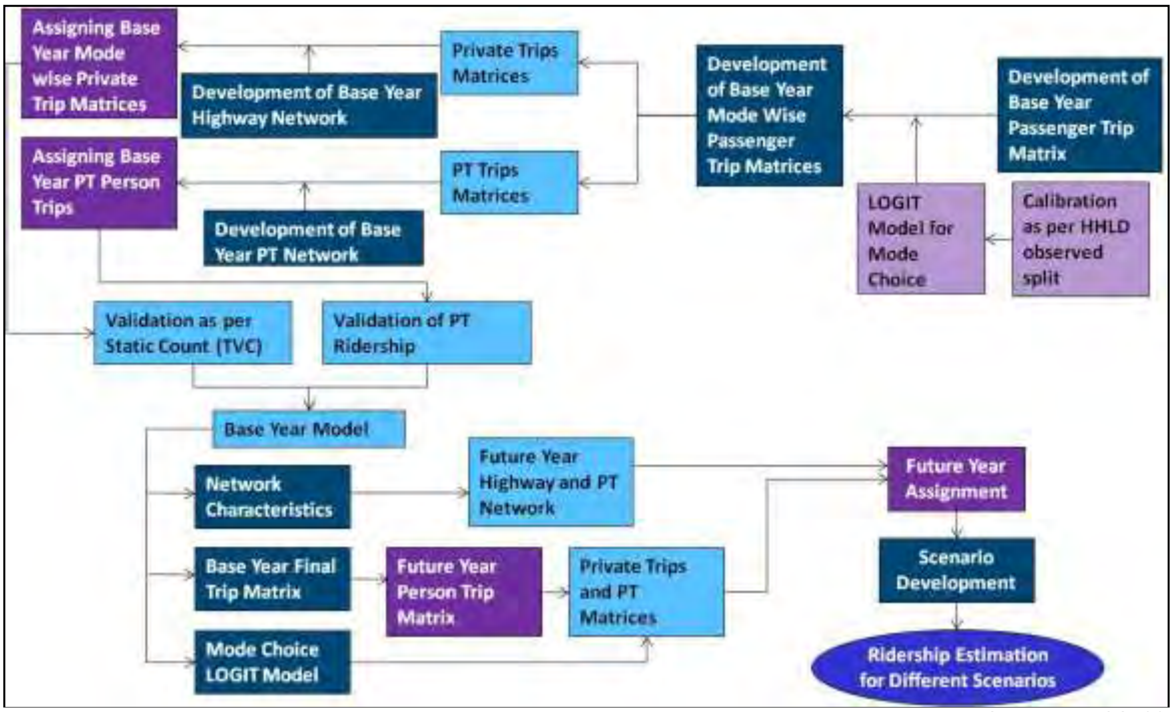
The figure below discusses the analytical framework towards the model built up. Worldwide accepted CUBE Voyager software has been utilized to develop the ridership estimation model. A complete three fold analytical approach was adopted. The assignment technique adopted helped to ascertain the ridership at the proposed metro corridors. This assignment technique involved:

Network Development: The network development stage involves both the highway and transit network throughout the entire study area. Base year network is the existing road network. Once the base year mode-wise matrices are developed and assigned to the base year network, the network characteristics have been calibrated and validated with respect to the ground conditions. Further future year network has been developed for both the highway and public transport (PT) incorporating the additional future proposed road networks and future phases PT routes including proposed metro routes with the base year validated network.

Matrix Development: Base year passenger trip matrix has been developed from the zone-wise population-employment database and calibrated. This calibrated passenger trip matrix was utilised to develop base year mode-wise passenger trip matrices as per the existing modal share. Once these base year passenger trip matrices have been assigned to the base year highway as well as transit network, the assigned passenger trips have been validated comparing to the existing database. These base year mode-wise passenger trips matrices further forecasted for future year with estimated future PCTR and modal shift from other modes to proposed metro as per the Logit Model.

Trip Assignment: Trip assignment has been conducted for both the highway assignment and PT assignment. Base year assigned trips has been validated in comparison with existing database to validate the model. Further future year assignment was undertaken to estimate the ridership for horizon years.

Figure 2.23 Analytical Framework for Ridership Estimation Model



Source: IMaCS, 2017

Cube Inputs

A trip had two direct dependent variables i.e. people and their purpose of trips. Thus, population projection is the crux of any demand assessment. For estimating ridership of Ahmedabad Gandhinagar metro, population was considered for four horizon years. Population growth was considered from various sources as Development Plan of GUDA and Greater Ahmedabad, Revised development Plan Ahmedabad, Employment phasing of GIFT city and other related studies undertaken.

Population projected

Population projection has been considered from various sources as Development Plan of GUDA and Greater Ahmedabad, Revised development Plan Ahmedabad, Employment phasing of GIFT city and other related studies.

Table 2.31 Projected Population

Census Year	Population	CAGR	Source
2001	5055650	2.83%	Census 2001
2011	6263409	2.17%	Census 2011
2017	6910675	1.65%	Ahmedabad metro DPR I
2021	7853584	2.29%	Development Plan of GUDA and Greater Ahmedabad, Revised development Plan Ahmedabad, Employment phasing of GIFT city
2031	8641875	0.96%	Development Plan of GUDA and Greater Ahmedabad, Employment phasing of GIFT city
2041	9427065	0.87%	IMaCS Projection
2051	10030912	0.45%	IMaCS Projection

Source: IMaCS,2017

Table 2.32 Population, Employment and Person Trips Forecast

Parameters	2017	2021	2031	2041	2051
Population	7024877	7853584	8794696	9590495	10030912
Employment	2893598	3305276	3794379	4352888	4714529
Trips	5268658	5968724	6859863	7672396	8526275
PCTR	0.75	0.76	0.78	0.80	0.85

Source: IMaCS, 2017

Modal Split

Mode share of person trips was considered from OD survey conducted in the year 2017 by IMaCS. According to the achieved modal split, it was found that only 13% daily trips are by public transport bus, majority of trips consists of 53% two wheeler trips, 11% auto trips, 21% four wheeler trips and only 1% trips are based on other IPT modes.

Table 2.33 Modal Split (%) of Motorized Trips for 2017

Mode	Modal Split (%)	Person Trips
Two Wheeler	53.3	2,808,195
IPT (Auto + Others)	12.8	674,388
Four wheeler	21.5	1,132,761
Bus	12.4	653,314

Source: IMaCS, 2017

A cube model requires four major input category i.e. Demand data, Zone to zone trip matrix, transport supply data and model calibration data. Network development is based on existing road network, route network of AMTS, BRTS routes, VTCOS routes, route network of proposed metro.

Table 2.34 Data Inputs

Type of data	Details
Demand Data	Existing demand – from DPR Phase I Socio-economic data – population, employment data existing and proposed, student enrolment existing and proposed
Trip Matrix	TVC and OD Survey , 2017
Supply Data	Road network – physical attributes, network speeds and delay
	Public Transport network – stops, corridors, routes, service details
Model calibration Data	Travel speeds on major network (DPR Phase I and Study 2017) Classified volume counts, vehicle occupancy surveys
Network Development	Existing road network, Route network of AMTS , BRTS routes, VTCOS routes , Route network of proposed metro

Source: IMaCS, 2017

Public Transport Fares

For the model input was considered from three sources i.e. AMTS bus fare collected from AMTS office in 2017, BRTS bus fare collected from AJL data in 2017. Metro fare was assumed from current operational Delhi metro fares. It was also assumed that public transport fares will increase annually at a rate of 5%.

Table 2.35 Public Transport Fare

Fare Slab (km)	2017 Fare (Rs)			2021 Fare (Rs)			2031 Fare (Rs)			2041 Fare (Rs)			2051 Fare (Rs)		
	AMTS	BRTS	METRO	AMTS	BRTS	METRO	AMTS	BRTS	METRO	AMTS	BRTS	METRO	AMTS	BRTS	METRO
0-2	3	4	8	4	5	10	6	8	16	10	13	26	16	21	42
2-4	7	9	10	9	11	12	14	19	20	23	30	32	37	50	53
4-6	9	12	12	11	15	15	18	24	24	29	39	39	47	64	63
6-8	11	15	15	13	18	18	22	29	30	35	48	48	58	78	79
8-10	12	16	15	15	20	18	24	32	30	39	52	48	63	85	79
10-12	13	18	16	16	21	19	26	35	32	42	57	52	68	92	84
12-14	13	18	18	16	21	22	26	35	36	42	57	58	68	92	95
14-16	15	20	18	18	25	22	30	40	36	48	65	58	79	106	95
16-18	15	20	19	18	25	23	30	40	38	48	65	61	79	106	100
18-20	17	23	21	21	28	26	34	45	42	55	74	68	89	121	110
20-22	17	25	22	21	30	27	34	49	44	55	79	71	89	129	116
22-24	18	26	22	22	32	27	36	52	44	58	85	71	95	138	116
24-26	18	26	23	22	32	28	36	52	46	58	85	74	95	139	121
26-32	20	29	27	24	35	33	40	57	53	65	94	87	105	152	142
32-38	22	32	28	27	39	34	44	63	55	71	103	90	116	168	147
38-44	23	33	30	28	41	36	46	66	59	74	108	97	121	175	158
44-50	25	36	34	30	44	41	49	72	67	81	117	110	131	190	179

Source: IMaCS, 2017

Assessment of Shift

To assess the probability of shift from different existing motorized modes to new introduced metro, mode-wise Binary Logit Model has been developed. According to this model, probability equation of mode used is as follows:

$$\textbf{Pr (Existing Mode)} = \frac{1}{1 + e^{\gamma\,(U(Metro) - U(EM))}}$$

Where, U (Metro) = Deterministic component of utility of Metro and U (EM) = Deterministic component of utility of Existing Mode.

γ= Constant factor estimated from regression analysis of willing to shift to Metro and Cost Difference from existing mode

These utility functions are:

U(EM) = αWT(EM) + βTT(EM) + γTC(EM) + φTR(EM) + ηDC(EM)

and U(Metro) = αWT(Metro) + βTT(Metro) + γTC(Metro) + φTR(Metro) + ηDC(Metro)

where, WT = Waiting Time

TT = Travel Time

TC = Travel Cost

TR = Transfer Cost

DC = Discomfort Cost

For simplifying the calculation of the Logit Model equation, all the above factors have been converted to generalized cost (Rs./km) for utility function. Estimated generalized cost for utility function for optimistic scenario is given below:

Table 2.36

Modes	Travel Cost/ Operating Cost (INR/km)	Travel Time Cost (INR/km)	Waiting Time Cost (INR/km)	Safety/ Discomfort Cost (Rs./km)	Average Occupancy	Mode Wise Generalized Cost (INR)
Car	3.05	3.53	2.38	5.00	1.34	11.58
Auto (IPT)	2.40	3.37	7.15	6.50	1.64	16.48
Two Wheeler	1.38	2.46	0.53	10.00	1.46	13.83
Bus/ Tempo	1.65	2.60	8.09	7.00	24.25	17.13
Metro	1.75	1.34	2.46	0.00		6.45

Scenario Building

The process of estimation of ridership involves development of various scenarios of growth. **Scenario building** is a process of analyzing possible future events by considering alternative possible outcomes. Thus, the scenario analysis, which is a main method of projections, does not try to show one exact picture of the future. Instead, it presents consciously several alternative future developments. Consequently, a scope of possible future outcomes is observable. Not only are the outcomes observable, also the development paths leading to the outcomes.

The development factors and program are taken from the Development Plan of GUDA and Greater Ahmedabad, Revised development Plan Ahmedabad, Employment phasing of GIFT city, Ahmedabad metro DPR Phase-I and other relevant studies. The various scenarios that have been evaluated are as follows:

Moderate Scenario – with Population Growth Trend and incremental PCTR and

Optimistic Scenario – with Population Growth Trend, incremental PCTR and higher shift.

Moderate Scenario

This scenario considers an increase in propensity to travel due to the introduction of a new transport system. Historically, it has been seen that a new system introduction is followed by increased number of trips due to the ease in travel. This leads to increased PCTR. The increase in PCTR has been calculated based on the historic data.

Table 2.37 Shift from Different Modes to Metro – Moderate Scenario

Year	Two Wheeler	IPT (Auto + Others)	Four Wheeler	Bus
2017	8.07%	10.16%	3.26%	11.48%
2021	9.68%	11.81%	4.63%	7.61%
2031	11.28%	10.57%	6.42%	1.15%
2041	13.55%	6.96%	8.22%	1.01%
2051	14.62%	3.67%	9.55%	0.69%

Source: IMaCS, 2017

Table 2.38 Per Capita Trip Rate (PCTR)

Year	Motorized	Source
2017	0.75	IMaCS Calculation
2021	0.76	Ahmedabad metro DPR phase I, 2015
2031	0.78	Ahmedabad metro DPR phase I, 2015
2041	0.80	IMaCS Calculation
2051	0.85	IMaCS Calculation

Source: IMaCS, 2017

As per Ahmedabad metro DPR Phase-I, conducted in 2015, the PCTR was estimated to be 0.76 in 2021, and 0.78 in 2031. Assuming the similar growth rates PCTR for future years have been estimated.

Table 2.39 Modal Split (%) with Metro for Different Horizon Years – Moderate Scenario

Year	Metro	Two Wheeler	IPT (Auto + Others)	Four wheeler	Bus	Total
2017	7.72	49.00	11.50	20.80	10.98	100
2021	8.61	48.50	11.20	20.60	11.09	100
2031	8.94	48.00	11.00	20.40	11.66	100
2041	10.12	47.20	10.70	20.10	11.88	100
2051	10.60	46.85	10.50	19.90	12.15	100

Source: IMaCS, 2017

The increased PCTR and induction of new mode facility as metro would result in 10.60% of mode share by metro reducing all other existing mode share in 2051.

Table 2.40 Forecasted Person Trips – Moderate Scenario

Year	Metro	Two Wheeler	IPT (Auto + Others)	Four Wheeler	Bus	Total
2017	406,937	2,581,642	605,896	1,095,881	578,302	5,268,658
2021	514,063	2,894,831	668,497	1,229,557	661,776	5,968,724
2031	612,940	3,292,734	754,585	1,399,412	800,192	6,859,862
2041	776,543	3,621,371	820,946	1,542,152	911,384	7,672,396
2051	904,175	3,994,560	895,259	1,696,729	1,035,553	8,526,275

Source: IMaCS, 2017

Optimistic Scenario

City Bus System consisting of BRTS and AMTS buses form the background of public transport for Ahmedabad and Gandhinagar city. They are preferred due various advantages like cost, accessibility and frequency etc. With the introduction of the Metro system, the routes of the City Bus could be modified such that the parallel bus routes will be converted to feeder to Metro System rather than competing with it. It is envisaged that due to introduction of metro, public transport ridership would improve to 23.36% in 2051. The PCTR considered for this scenario is same as the moderate Scenario.

Table 2.41 Shift from Different Modes to Metro – Optimistic Scenario

Year	Two Wheeler	IPT (Auto + Others)	Four Wheeler	Bus
2017	9.2%	10.2%	3.3%	11.5%
2021	10.8%	11.8%	4.7%	6.3%

Year	Two Wheeler	IPT (Auto + Others)	Four Wheeler	Bus
2031	12.4%	10.6%	6.5%	3.4%
2041	14.7%	7.0%	8.3%	3.0%
2051	15.7%	3.7%	9.6%	2.8%

Source: IMaCS, 2017

Table 2.42 Modal Split (%) with Metro for Different Horizon Years – Optimistic Scenario

Year	Metro	Two Wheeler	IPT (Auto + Others)	Four Wheeler	Bus	Total
2017	8.33	48.40	11.50	20.79	10.98	100
2021	9.07	47.90	11.20	20.59	11.24	100
2031	9.82	47.40	11.00	20.39	11.39	100
2041	10.96	46.60	10.70	20.09	11.65	100
2051	11.48	46.25	10.50	19.89	11.88	100

Source: IMaCS, 2017

Table 2.43 Forecasted Person Trips– Optimistic Scenario

Year	Metro	Two Wheeler	IPT (Auto + Others)	Four Wheeler	Bus	Total
2017	439,064	2,550,030	605,896	1,095,354	578,314	5,268,658
2021	541,119	2,859,019	668,497	1,228,960	671,129	5,968,724
2031	673,369	3,251,575	754,585	1,398,726	781,608	6,859,862
2041	841,254	3,575,336	820,946	1,541,384	893,475	7,672,396
2051	978,491	3,943,402	895,259	1,695,876	1,013,247	8,526,275

Source: IMaCS, 2017

Ridership Estimation

This section highlights the assignment details especially for public transport along with overall network loading based upon our model results. Public transport network loading represents the metro ridership separately. This is presented at aggregate level for the entire network as well as for different metro lines/ corridors. The assignment has been conducted for the daily level and further peak hour factor as 12.79% has been applied to estimate the peak hour passenger per direction (PHPDT). This peak hour factor has been adopted from the primary survey database.

Estimation of Aggregated Ridership

Forecasted mode-wise passenger trip matrices assigned to the entire network for horizon years and assigned public transport trips have been obtained for entire network level to estimate the aggregated daily ridership on the proposed metro corridors.

The traffic forecast is presented below for projected scenarios in two different approaches:

First, the ridership for the phase-II corridors and the corridor which is partly extended from Phase-I to phase-II are presented which gives a clear understanding of phase-II traffic forecast separately. It is the north south corridor of Ahmedabad metro that is being planned in two phases. Thus a phase wise segregated ridership of this corridor gives a better judgment of the extended part. Tables in this category includes

a. Summary of traffic distribution in the north south corridor segregated in Phase-I part and phase-II part and Other Two Links of Phase-II (table 4-14, & 4-15)

b. Disaggregate distribution of total passenger using Phase II stations (table 4-16, 4-17, 4-18 & 4-19)

In the second approach, ridership is presented for all corridors of the metro system without segregating stations of Phase I and Phase II. Tables in this approach includes

a. Metro ridership summary corridor wise for scenarios (table 4-20, & 4-21)
b. Corridor wise directional boarding and alighting at stations (table 4-22, & 4-57)

Sectional Loading: It is the loading of passengers between two consequent stations of a corridor, thus it is presented in table showing corridor wise directional boarding and alighting at stations

PHPDT: per hour per direction traffic is an assessment of corridor that shows the maximum load a corridor takes in an hour of the day.

The tables below give distribution of passengers in the two parts of north south corridor i.e. for Phase I part (APMC to Motera segment) and Phase II part (Motera to Mahatma Mandir).

Table 2.44 Summary of Traffic Distribution in the North South Corridor (APMC to Mahatma Mandir) and Other Two Links of Phase-II for Moderate Scenario

Target Year	Metro Routes Operational	Route Length (km)	Daily Ridership (Passengers)	PHPDT (Passengers)	Interchange Passengers	Daily Passenger Kilometers (km)	Average Trip Length (km)
2021	APMC to Mahatma Mandir	41.36	273,013	8,747	91,964	1,648,421	6.04
	Motera to Mahatma Mandir	22.838	99,791	4,121		1,050,899	10.53
	GNLU to Gift City	5.416	11,798	638		48,680	4.13
	Koteshwar road to Airport	6.339	13,349	801		57,244	4.29
	Combined	**53.115**	**397,951**			**2,805,244**	**7.05**
2031	APMC to Mahatma Mandir	41.36	355,327	11,597	155,257	2,167,525	6.10
	Motera to Mahatma Mandir	22.838	158,397	5,733		1,511,450	9.54
	GNLU to Gift City	5.416	27,742	1,326		118,093	4.26
	Koteshwar road to Airport	6.339	19,215	1,062		82,365	4.29
	Combined	**53.115**	**560,681**			**3,879,433**	**6.92**
2041	APMC to Mahatma Mandir	41.36	442,211	14,509	210,155	2,765,155	6.25
	Motera to Mahatma Mandir	22.838	227,228	7,935		2,181,127	9.60
	GNLU to Gift City	5.416	36,893	1,766		156,555	4.24
	Koteshwar road to Airport	6.339	24,513	1,328		104,999	4.28
	Combined	**53.115**	**730,845**			**5,207,836**	**7.13**
2051	APMC to Mahatma Mandir	41.36	512,550	16,968	261,422	3,248,255	6.34
	Motera to Mahatma Mandir	22.838	286,579	9,950		2,749,724	9.59
	GNLU to Gift City	5.416	48,018	2,261		203,694	4.24
	Koteshwar road to Airport	6.339	30,504	1,668		130,514	4.28
	Combined	**53.115**	**877,651**			**6,332,187**	**7.21**

Note: APMC to Motera segment (Phase-I), Motera to Mahatma Mandir (Phase- II)

Table 2.45 Summary of Traffic Distribution in the North South Corridor (APMC to Mahatma Mandir) and Other Two Links of Phase-II for Optimistic Scenario

Target Year	Metro Routes Operational	Route Length (km)	Daily Ridership (Passengers)	PHPDT (Passengers)	Interchange Passengers	Daily Passenger Kilometers (km)	Average Trip Length (km)
2021	APMC to Mahatma Mandir	41.36	273,013	9,207	77,183	1,648,421	6.04
	Motera to Mahatma Mandir	22.838	99,791	4,338		1,050,899	10.53
	GNLU to Gift City	5.416	12,419	671		51,243	4.13
	Koteshwar road to Airport	6.339	14,051	843		60,257	4.29
	Combined	**53.115**	**399,274**			**2,810,819**	**7.04**
2031	APMC to Mahatma Mandir	41.36	390,358	12,740	170,563	2,381,211	6.10
	Motera to Mahatma Mandir	22.838	174,013	6,298		1,660,465	9.54
	GNLU to Gift City	5.416	30,477	1,457		129,736	4.26
	Koteshwar road to Airport	6.339	21,109	1,166		90,486	4.29
	Combined	**53.115**	**615,957**			**4,261,897**	**6.92**
2041	APMC to Mahatma Mandir	41.36	479,062	15,718	227,668	2,995,583	6.25
	Motera to Mahatma Mandir	22.838	246,164	8,596		2,362,885	9.60
	GNLU to Gift City	5.416	39,967	1,913		169,601	4.24
	Koteshwar road to Airport	6.339	26,555	1,439		113,750	4.28
	Combined	**53.115**	**791,749**			**5,641,818**	**7.13**
2051	APMC to Mahatma Mandir	41.36	554,678	18,362	282,909	3,515,246	6.34
	Motera to Mahatma Mandir	22.838	310,134	10,768		2,975,741	9.60
	GNLU to Gift City	5.416	51,965	2,447		220,437	4.24
	Koteshwar road to Airport	6.339	33,011	1,806		141,241	4.28
	Combined	**53.115**	**949,788**			**6,852,665**	**7.21**

Note: APMC to Motera segment (Phase- I), Motera to Mahatma Mandir (Phase-II)

Ridership estimation was conducted for the entire planned metro corridors of Ahmadabad Gandhinagar metro that consists of two corridors namely East west corridor and across region and two corridors as segment connecting GIFT city and Airport for four horizon years i.e. 2021, 2031, 2041 and 2051. The estimation was done

The corridor wise ridership summary for the entire metro with two corridors namely East west corridor, North south corridor and two corridors as segment connecting GIFT city and Airport are given in table (2.50, 2.51).

As mentioned earlier, the sum of ridership at segment APMC to Motera (Phase I stations) and Motera to Mahatma Mandir (Phase II stations) is more than the sum of Corridor Ahmedabad metro because there is a certain number of interchange passengers that travel from phase I to Phase II and vice versa. However, the distribution of passengers boarding and alighting at stations aggregate of travelling both direction (up and down) is given in the table (2.46, 2.47, 2.48, 2.49) below.

Table 2.46 Disaggregate Distribution of Daily Passenger Boarding-Alighting in Phase-II (Moderate Scenario)

Stations	2021			2031			2041			2051		
	Boarding	Alighting		Boarding	Alighting		Boarding	Alighting		Boarding	Alighting	
		Within phase-II corridor	From Phase-I to Phase-II		Within phase-II corridor	From Phase-I to Phase-II		Within phase-II corridor	From Phase-I to Phase-II		Within phase-II corridor	From Phase-I to Phase-II
	A	B	C	A	B	C	A	B	C	A	B	C
Motera Stadium	4575	489	1935	8002	710	2261	9492	922	2618	10485	1076	2863
Koteshwar Road	10173	1301	3911	11283	1672	4124	13826	2305	5210	17578	3036	6577
Vishwakarma College	3191	440	1194	3143	711	1487	3722	913	1703	4111	1054	1857
Tapovan Circle	4884	1297	3219	8327	2450	4992	13295	4030	7512	16537	5247	9222
Narmada Canal	1183	228	438	2877	437	680	4999	837	1166	6033	1055	1383
Koba Circle	3830	689	1291	6960	1239	1882	11325	2203	3041	14759	2976	3891
Juna Koba	433	94	178	902	143	215	1569	275	367	1891	346	435
Koba Gaam	879	173	316	1267	338	482	1638	470	597	2135	638	765
GNLU	3753	1523	2457	6759	2271	2928	8934	3234	3615	11390	4366	4616
Raysan	1377	312	483	1755	488	569	2610	774	806	3408	1051	1031
Randesan	1645	443	623	2382	867	864	3854	1579	1443	4992	2145	1845
Dholakuva Circle	3497	1251	1649	4588	2238	2357	7384	3851	3706	9626	5230	4737
Infocity	1456	662	716	2323	833	720	3462	1313	1011	4196	1646	1193
Sector - 1	2608	731	730	3988	1240	999	5963	1958	1400	7836	2648	1791
Sector 10A	2409	2458	2225	3248	3662	2722	4995	5818	3808	6572	7859	4877
Sachivalaya	628	3359	3093	787	4885	3786	1181	7674	5272	1511	10356	6739
Akshardham	4205	2175	2099	5576	3300	2710	8422	5352	3881	10451	7086	4856
Juna Sachivalaya	3557	1407	1229	4211	2021	1498	6254	3177	2067	8198	4282	2658
Sector - 16	2808	2070	1758	3797	3609	2633	6058	6006	3862	7338	7681	4664
Sector - 24	5534	4258	3630	6798	6569	4721	10577	10757	6816	13405	14527	8764
Mahatma Mandir	6205	1389	1579	8406	2443	2236	13015	4142	3332	16604	5618	4268
PDPU	2185	634	614	4471	1814	1101	5996	2466	1423	7823	3321	1812

Stations	2021			2031			2041			2051		
	Boarding	Alighting		Boarding	Alighting		Boarding	Alighting		Boarding	Alighting	
		Within phase-II corridor	From Phase-I to Phase-II		Within phase-II corridor	From Phase-I to Phase-II		Within phase-II corridor	From Phase-I to Phase-II		Within phase-II corridor	From Phase-I to Phase-II
	A	B	C	A	B	C	A	B	C	A	B	C
Gift City	3237	2555	3231	11104	5648	5914	14575	7925	7417	18706	10754	9523
Sardarnagar	7842	1386	3339	10435	2244	5596	13069	3156	7174	16459	4015	8798
Airport	257	172	447	268	213	545	318	268	633	353	314	692
Total	**82352**	**31498**	**42383**	**123658**	**52044**	**58021**	**176533**	**81406**	**79879**	**222398**	**108325**	**99858**
Total Passenger at Phase-II Stations = A + C	**124735**			**181680**			**256413**			**322256**		

Table 2.47 Disaggregate Distribution of Daily Passenger Boarding-Alighting in Phase-II (Optimistic Scenario)

Stations	2021			2031			2041			2051		
	Boarding	Alighting		Boarding	Alighting		Boarding	Alighting		Boarding	Alighting	
		Within phase-II corridor	From Phase-I to Phase-II		Within phase-II corridor	From Phase-I to Phase-II		Within phase-II corridor	From Phase-I to Phase-II		Within phase-II corridor	From Phase-I to Phase-II
	A	B	C	A	B	C	A	B	C	A	B	C
Motera Stadium	4815	515	2037	8791	780	2484	10283	999	2837	11346	1164	3099
Koteshwar Road	10709	1370	4117	12396	1837	4530	14978	2497	5644	19023	3285	7117
Vishwakarma College	3359	463	1256	3452	781	1633	4032	989	1845	4449	1141	2010
Tapovan Circle	5141	1366	3388	9147	2692	5484	14403	4366	8138	17896	5678	9980
Narmada Canal	1245	240	461	3161	480	747	5416	907	1264	6529	1142	1496
Koba Circle	4032	725	1359	7646	1361	2067	12269	2386	3294	15972	3221	4211
Juna Koba	456	99	187	991	157	236	1700	298	398	2046	374	471
Koba Gaam	926	182	332	1392	371	530	1775	509	647	2311	690	828
GNLU	3951	1604	2587	7426	2495	3217	9679	3504	3917	12326	4724	4995
Raysan	1450	329	508	1929	536	625	2827	838	873	3688	1137	1116

Stations	2021			2031			2041			2051		
	Boarding	Alighting		Boarding	Alighting		Boarding	Alighting		Boarding	Alighting	
		Within phase-II corridor	From Phase-I to Phase-II		Within phase-II corridor	From Phase-I to Phase-II		Within phase-II corridor	From Phase-I to Phase-II		Within phase-II corridor	From Phase-I to Phase-II
	A	B	C	A	B	C	A	B	C	A	B	C
Randesan	1732	466	656	2617	952	949	4175	1711	1563	5402	2321	1997
Dholakuva Circle	3681	1317	1736	5040	2459	2590	8000	4172	4015	10417	5660	5126
Infocity	1532	696	753	2552	915	791	3751	1422	1095	4540	1781	1291
Sector - 1	2745	770	768	4381	1363	1097	6459	2121	1517	8480	2865	1939
Sector 10A	2536	2588	2342	3568	4023	2990	5411	6303	4126	7112	8505	5278
Sachivalaya	661	3536	3256	865	5367	4159	1279	8314	5711	1635	11208	7293
Akshardham	4426	2289	2210	6126	3626	2977	9124	5798	4204	11310	7668	5255
Juna Sachivalaya	3745	1482	1294	4626	2221	1646	6775	3442	2239	8872	4634	2876
Sector - 16	2956	2179	1850	4171	3965	2893	6563	6506	4184	7942	8312	5048
Sector - 24	5825	4482	3821	7468	7216	5186	11458	11653	7384	14506	15721	9484
Mahatma Mandir	6531	1462	1662	9235	2684	2457	14099	4487	3609	17969	6080	4619
PDPU	2300	668	646	4912	1993	1210	6496	2672	1541	8466	3594	1961
Gift City	3408	2690	3401	12199	6205	6497	15790	8585	8035	20244	11638	10306
Sardarnagar	8255	1459	3515	11464	2465	6147	14157	3419	7772	17812	4345	9521
Airport	270	181	470	295	234	598	345	290	686	382	340	749
Total	**86686**	**33156**	**44614**	**135849**	**57175**	**63741**	**191244**	**88190**	**86536**	**240677**	**117227**	**108065**
Total Passenger at Phase-II Stations = A + C	**131300**			**199590**			**277781**			**348742**		

Table 2.48 Disaggregate Distribution of Peak Hour Passenger Boarding-Alighting in Phase-II (Moderate Scenario)

Stations	2021			2031			2041			2051		
	Boarding	Alighting		Boarding	Alighting		Boarding	Alighting		Boarding	Alighting	
		Within phase-II corridor	From Phase-I to Phase-II		Within phase-II corridor	From Phase-I to Phase-II		Within phase-II corridor	From Phase-I to Phase-II		Within phase-II corridor	From Phase-I to Phase-II
	A	B	C	A	B	C	A	B	C	A	B	C
Motera Stadium	457	49	194	800	71	226	949	92	262	1048	108	286
Koteshwar Road	1017	130	391	1128	167	412	1383	231	521	1758	304	658
Vishwakarma College	319	44	119	314	71	149	372	91	170	411	105	186
Tapovan Circle	488	130	322	833	245	499	1330	403	751	1654	525	922
Narmada Canal	118	23	44	288	44	68	500	84	117	603	106	138
Koba Circle	383	69	129	696	124	188	1132	220	304	1476	298	389
Juna Koba	43	9	18	90	14	21	157	28	37	189	35	44
Koba Gaam	88	17	32	127	34	48	164	47	60	214	64	77
GNLU	375	152	246	676	227	293	893	323	362	1139	437	462
Raysan	138	31	48	176	49	57	261	77	81	341	105	103
Randesan	165	44	62	238	87	86	385	158	144	499	214	185
Dholakuva Circle	350	125	165	459	224	236	738	385	371	963	523	474
Infocity	146	66	72	232	83	72	346	131	101	420	165	119
Sector - 1	261	73	73	399	124	100	596	196	140	784	265	179
Sector 10A	241	246	223	325	366	272	500	582	381	657	786	488
Sachivalaya	63	336	309	79	489	379	118	767	527	151	1036	674
Akshardham	420	217	210	558	330	271	842	535	388	1045	709	486
Juna Sachivalaya	356	141	123	421	202	150	625	318	207	820	428	266
Sector - 16	281	207	176	380	361	263	606	601	386	734	768	466
Sector - 24	553	426	363	680	657	472	1058	1076	682	1340	1453	876
Mahatma Mandir	620	139	158	841	244	224	1301	414	333	1660	562	427
PDPU	219	63	61	447	181	110	600	247	142	782	332	181

Stations	2021			2031			2041			2051		
	Boarding	Alighting		Boarding	Alighting		Boarding	Alighting		Boarding	Alighting	
		Within phase-II corridor	From Phase-I to Phase-II		Within phase-II corridor	From Phase-I to Phase-II		Within phase-II corridor	From Phase-I to Phase-II		Within phase-II corridor	From Phase-I to Phase-II
	A	B	C	A	B	C	A	B	C	A	B	C
Gift City	324	256	323	1110	565	591	1458	792	742	1871	1075	952
Sardarnagar	784	139	334	1044	224	560	1307	316	717	1646	402	880
Airport	26	17	45	27	21	54	32	27	63	35	31	69
Total	**8235**	**3150**	**4238**	**12366**	**5204**	**5802**	**17653**	**8141**	**7988**	**22240**	**10833**	**9986**
Total Passenger at Phase-II Stations = A + C	**12473**			**18168**			**25641**			**32226**		

Table 2.49 Disaggregate Distribution of Peak Hour Passenger Boarding-Alighting in Phase-II (Optimistic Scenario)

Stations	2021			2031			2041			2051		
	Boarding	Alighting		Boarding	Alighting		Boarding	Alighting		Boarding	Alighting	
		Within phase-II corridor	From Phase-I to Phase-II		Within phase-II corridor	From Phase-I to Phase-II		Within phase-II corridor	From Phase-I to Phase-II		Within phase-II corridor	From Phase-I to Phase-II
	A	B	C	A	B	C	A	B	C	A	B	C
Motera Stadium	482	51	204	879	78	248	1028	100	284	1135	116	310
Koteshwar Road	1071	137	412	1240	184	453	1498	250	564	1902	329	712
Vishwakarma College	336	46	126	345	78	163	403	99	185	445	114	201
Tapovan Circle	514	137	339	915	269	548	1440	437	814	1790	568	998
Narmada Canal	124	24	46	316	48	75	542	91	126	653	114	150
Koba Circle	403	73	136	765	136	207	1227	239	329	1597	322	421
Juna Koba	46	10	19	99	16	24	170	30	40	205	37	47
Koba Gaam	93	18	33	139	37	53	178	51	65	231	69	83
GNLU	395	160	259	743	250	322	968	350	392	1233	472	500

Stations	2021			2031			2041			2051		
	Boarding	Alighting		Boarding	Alighting		Boarding	Alighting		Boarding	Alighting	
		Within phase-II corridor	From Phase-I to Phase-II		Within phase-II corridor	From Phase-I to Phase-II		Within phase-II corridor	From Phase-I to Phase-II		Within phase-II corridor	From Phase-I to Phase-II
	A	B	C	A	B	C	A	B	C	A	B	C
Raysan	145	33	51	193	54	62	283	84	87	369	114	112
Randesan	173	47	66	262	95	95	418	171	156	540	232	200
Dholakuva Circle	368	132	174	504	246	259	800	417	401	1042	566	513
Infocity	153	70	75	255	92	79	375	142	109	454	178	129
Sector - 1	274	77	77	438	136	110	646	212	152	848	287	194
Sector 10A	254	259	234	357	402	299	541	630	413	711	851	528
Sachivalaya	66	354	326	87	537	416	128	831	571	164	1121	729
Akshardham	443	229	221	613	363	298	912	580	420	1131	767	526
Juna Sachivalaya	374	148	129	463	222	165	677	344	224	887	463	288
Sector - 16	296	218	185	417	396	289	656	651	418	794	831	505
Sector - 24	583	448	382	747	722	519	1146	1165	738	1451	1572	948
Mahatma Mandir	653	146	166	924	268	246	1410	449	361	1797	608	462
PDPU	230	67	65	491	199	121	650	267	154	847	359	196
Gift City	341	269	340	1220	620	650	1579	858	803	2024	1164	1031
Sardarnagar	825	146	352	1146	246	615	1416	342	777	1781	435	952
Airport	27	18	47	29	23	60	34	29	69	38	34	75
Total	**8669**	**3316**	**4461**	**13585**	**5717**	**6374**	**19124**	**8819**	**8654**	**24068**	**11723**	**10807**
Total Passenger at Phase-II Stations = A + C	**13130**			**19959**			**27778**			**34874**		

Table 2.50 Metro Ridership Summary (Corridor Wise) for Moderate Scenario

Target Year	Metro Routes Operational	Route Length (km)	Daily Ridership (Passengers)	PHPDT (Passengers)	Daily Passenger Kilometers (km)	Average Trip Length/ Passenger Lead (km)
2017	Thaltej Gaam to Vastral Gaam	20.21	282,775	7,597	1,653,359	5.85
	APMC to Motera	18.52	192,461	5,768	1,045,451	5.43
	Combined	**38.73**	**475,236**		**2,698,810**	**5.68**
2021	Thaltej Gaam to Vastral Gaam	20.21	339,633	9,127	2,757,452	8.12
	APMC to Mahatma Mandir	41.36	305,987	8,747	1,995,666	6.52
	GNLU to Gift City	5.416	11,798	638	48,680	4.13
	Koteshwar road to Airport	6.339	13,349	801	57,244	4.29
	Combined	**73.325**	**670,767**		**4,859,042**	**7.24**
2031	Thaltej Gaam to Vastral Gaam	20.21	413,277	10,809	2,386,326	5.77
	APMC to Mahatma Mandir	41.36	405,424	11,597	3,725,133	9.19
	GNLU to Gift City	5.416	27,742	1,326	118,093	4.26
	Koteshwar road to Airport	6.339	19,215	1,062	82,365	4.29
	Combined	**73.325**	**865,658**		**6,311,917**	**7.29**
2041	Thaltej Gaam to Vastral Gaam	20.21	513,280	13,265	3,020,372	5.88
	APMC to Mahatma Mandir	41.36	520,690	14,509	5,005,565	9.61
	GNLU to Gift City	5.416	36,893	1,766	156,555	4.24
	Koteshwar road to Airport	6.339	24,513	1,328	104,999	4.28
	Combined	**73.325**	**1,095,375**		**8,287,491**	**7.57**
2051	Thaltej Gaam to Vastral Gaam	20.21	584,860.55	15,106	3,470,489	5.93
	APMC to Mahatma Mandir	41.36	616,229	16,968	6,069,708	9.85
	GNLU to Gift City	5.416	48,018	2,261	203,694	4.24
	Koteshwar road to Airport	6.339	30,504	1,668	130,514	4.28
	Combined	**73.325**	**1,279,612**		**9,874,404**	**7.72**

Table 2.51 Metro Ridership Summary (Corridor Wise) for Optimistic Scenario

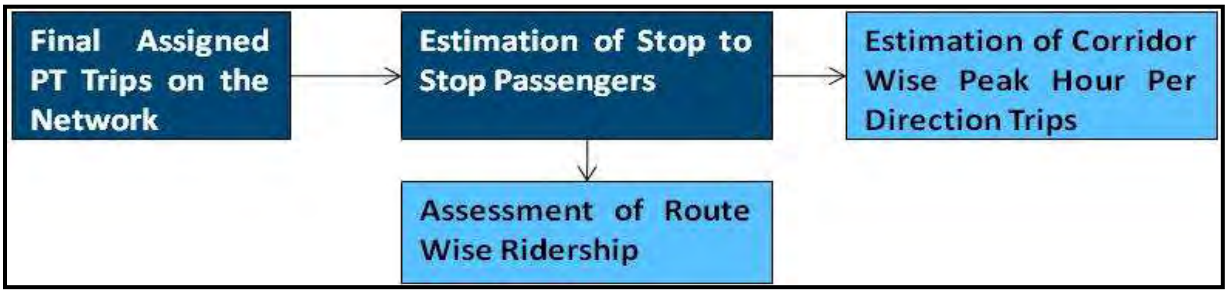
Target Year	Metro Routes Operational	Route Length (km)	Daily Ridership (Passengers)	PHPDT (Passengers)	Daily Passenger Kilometers (km)	Average Trip Length/ Passenger Lead (km)
2017	Thaltej Gaam to Vastral Gaam	20.21	305,099	8,197	1,783,886	5.85
	APMC to Motera	18.52	207,656	6,224	1,127,988	5.43
	Combined	**38.73**	**512,755**		**2,911,874**	**5.68**
2021	Thaltej Gaam to Vastral Gaam	20.21	357,508	9,607	2,902,584	8.12
	APMC to Mahatma Mandir	41.36	322,092	9,207	2,100,696	6.52
	GNLU to Gift City	5.416	12,419	671	51,243	4.13
	Koteshwar road to Airport	6.339	14,051	843	60,257	4.29
	Combined	**73.325**	**706,070**		**5,114,780**	**7.24**

Target Year	Metro Routes Operational	Route Length (km)	Daily Ridership (Passengers)	PHPDT (Passengers)	Daily Passenger Kilometers (km)	Average Trip Length/ Passenger Lead (km)
2031	Thaltej Gaam to Vastral Gaam	20.21	454,022	11,875	2,621,589	5.77
	APMC to Mahatma Mandir	41.36	445,394	12,740	4,092,386	9.19
	GNLU to Gift City	5.416	30,477	1,457	129,736	4.26
	Koteshwar road to Airport	6.339	21,109	1,166	90,486	4.29
	Combined	**73.325**	**951,002**		**6,934,196**	**7.29**
2041	Thaltej Gaam to Vastral Gaam	20.21	556,053	14,370	3,272,065	5.88
	APMC to Mahatma Mandir	41.36	564,081	15,718	5,422,691	9.61
	GNLU to Gift City	5.416	39,967	1,913	169,601	4.24
	Koteshwar road to Airport	6.339	26,555	1,439	113,750	4.28
	Combined	**73.325**	**1,186,656**		**8,978,106**	**7.57**
2051	Thaltej Gaam to Vastral Gaam	20.21	632,932	16,347	3,755,740	5.93
	APMC to Mahatma Mandir	41.36	666,879	18,362	6,568,610	9.85
	GNLU to Gift City	5.416	51,965	2,447	220,437	4.24
	Koteshwar road to Airport	6.339	33,011	1,806	141,241	4.28
	Combined	**73.325**	**1,384,788**		**10,686,028**	**7.72**

Estimation of Line-wise Ridership

From the ridership assignment model stop to stop passengers has been estimated with the CUBE Voyager Public Transport Assignment technique. The route wise stop to stop passengers obtained from the model have been utilized to estimate the line loading for different scenarios within the horizon year. Applying the peak hour factor (10%) PHPDT has also been arrived for each line.

Figure 2.24 Framework for Assessment of Route-wise Ridership



A trip length frequency distribution of estimated trips is given in table

Line Loading of Phase I – 2017 Moderate Scenario

Table 2.52 Station wise Daily Boarding-Alighting on Corridor-I - 2017 (Moderate Scenario)

Thaltej Gaam to Vaastral Gaam			Station Name	Vastral Gam to Thaltej Gaam		
Boarding	Alighting	Sectional Load		Boarding	Alighting	Sectional Load
16,113	0	0	Thaltej gaam	0	11,419	11,419

Thaltej Gaam to Vaastral Gaam			Station Name	Vastral Gam to Thaltej Gaam		
Boarding	**Alighting**	**Sectional Load**		**Boarding**	**Alighting**	**Sectional Load**
12,682	2,443	16,113	Thaltej	1,979	12,669	22,109
9,925	2,766	26,352	Doordarshan Kendra	2,058	11,243	31,294
3,625	1,544	33,511	Gurukul Road	917	5,389	35,766
6,060	4,169	35,592	Gujarat University	2,301	11,273	44,738
1,394	679	37,483	Commerce Six road	613	1,650	45,775
6,509	4,905	38,199	Stadium	4,037	11,397	53,135
28,652	12,954	39,802	Old high court	16,542	36,466	73,059
5,125	1,974	55,500	Shahpur	3,842	4,536	73,753
19,918	8,262	58,651	Ghee kanta	14,125	16,347	75,975
11,174	31,598	70,306	Kalupur rly stn	32,373	16,179	59,781
2,590	10,889	49,882	Kankaria east	9,978	3,702	53,506
2,595	8,796	41,583	Apparel park	10,656	2,900	45,750
2,631	15,499	35,382	Amraiwadi	16,748	3,724	32,726
1,474	12,229	22,514	Rabari	17,965	1,460	16,222
386	1,862	11,759	Vastral	5,012	157	11,368
799	499	10,283	Nirant Cross road	1,608	611	10,371
0	10,583	10,583	Vastral gam	10,371	0	0
1,31,651	**1,31,651**		**Total**	**1,51,124**	**1,51,124**	

Table 2.53 Station wise Daily Boarding-Alighting on Corridor-II - 2017 (Moderate Scenario)

APMC to Motera			Station Name	Motera to APMC		
Boarding	**Alighting**	**Sectional Load**		**Boarding**	**Alighting**	**Sectional Load**
16,383	0	0	APMC	0	9,350	9,350
16,732	2,354	16,383	Jivraj	2,053	10,275	17,572
3,563	1,780	30,760	Rajiv nagar	594	7,013	23,991
4,238	1,560	32,543	Shreyash	841	6,006	29,156
12,015	5,432	35,222	Paldi	4,476	11,840	36,520
4,030	7,551	41,806	Gandhigram rly stn	2,391	13,191	47,320
18,392	22,634	38,284	Old high court	20,836	30,175	56,660
539	1,324	34,042	Ushmanpura	820	1,843	57,682
4,588	4,244	33,258	Vijay nagar	8,646	4,563	53,599
3,068	7,888	33,601	New vadaj	15,245	2,723	41,078
847	3,686	28,781	Ranip	4,817	1,086	37,347
2,107	7,622	25,942	Sabarmati Rly stn	10,025	2,792	30,114
164	1,712	20,427	AEC	1,630	309	28,793
2,352	7,199	18,878	Sabarmati	10,790	2,277	20,281
0	14,032	14,032	Motera stadium	20,281	0	0
89,018	**89,018**		**Total**	**1,03,444**	**1,03,444**	

Line Loading of Phase II – 2021 Moderate Scenario

Table 2.54 Station wise Daily Boarding-Alighting on Corridor-I - 2021 (Moderate Scenario)

Thaltej Gaam to Vaastral Gaam			Station Name	Vastral Gaam to thaltej Gaam		
Boarding	Alighting	Sectional Load		Boarding	Alighting	Sectional Load
19,652	0	0	Thaltej gaam	0	13,665	13,665
14,982	2,401	19,652	Thaltej	1,944	14,803	26,523
9,384	2,342	32,234	Doordarshan Kendra	1,633	11,199	36,089
4,328	1,477	39,276	Gurukul Road	854.33	6,440	41,675
6,518	3,672	42,127	Gujarat University	1,884	13,015	52,806
1,893	692	44,974	Commerce Six road	630.11	2,329	54,505
6,218	4,085	46,175	Stadium	3,147	10,382	61,740
50,028	21,542	48,308	Old high court	27,597	57,126	91,268
5,364	3,899	76,793	Shahpur	5,804	4,758	90,221
17,238	12,078	78,258	Ghee kanta	15,049	15,701	90,873
12,553	37,265	83,418	Kalupur rly stn	38,763	17,626	69,736
2,841	12,493	58,706	Kankaria east	11,343	4,037	62,429
2,737	10,068	49,055	Apparel park	12,178	3,066	53,317
2,820	18,118	41,724	Amraiwadi	19,322	4,039	38,034
1,511	14,141	26,426	Rabari	20,849	1,568	18,752
356	2,148	13,796	Vastral	5,831	162.6	13,085
696	584	12,004	Nirant Cross road	1,905	597.85	11,777
0	12,116	12,116	Vastral Gaam	11,777	0	0
1,59,121	**1,59,121**		**Total**	**1,80,512**	**1,80,512**	

Table 2.55 Station wise Daily Boarding-Alighting on Corridor-II - 2021 (Moderate Scenario)

Motera to Mahatma Mandir			Station Name	Mahatma Mandir to motera		
Boarding	Alighting	Sectional load		Boarding	Alighting	Sectional load
19,422	0	0	APMC	0	11,453	11,454
21,119	2,324	19,422	Jivraj	2,045	13,868	23,277
4,155	1,848	38,217	Rajiv nagar	576	8,120	30,821
4,904	1,627	40,524	Shreyash	835	6,952	36,937
17,863	5,357	43,800	Paldi	4,295	18,605	51,248
4,580	6,037	56,306	Gandhigram rly stn	1,796	16,376	65,828
38,683	33,355	54,849	Old high court	32,411	53,488	86,906
994	2,470	60,178	Ushmanpura	1,853	2,418	87,471
6,372	7,042	58,702	Vijay nagar	12,448	5,872	80,895
5,035	9,358	58,033	New vadaj	17,353	3,830	67,372
1,235	4,070	53,710	Ranip	5,292	1,430	63,510
3,411	7,227	50,874	Sabarmati Rly stn	10,874	3,537	56,173
345	1,829	47,059	AEC	1,737	511	54,948

Motera to Mahatma Mandir			Station Name	Mahatma Mandir to motera		
Boarding	**Alighting**	**Sectional load**		**Boarding**	**Alighting**	**Sectional load**
933	4,124	45,575	Sabarmati	5,171	1,078	50,854
760	1,935	42,383	Motera Stadium	3,814	489	47,529
2,886	7,822	41,208	Koteshwar Road	14,414	1,762	34,876
562	1,326	36,272	Vishwakarma College	2,629	307	32,554
998	3,604	35,508	Tapovan Circle	3,886	912	29,579
264	529	32,901	Narmada Canal	918	137	28,798
940	1,552	32,637	Koba Circle	2,890	429	26,337
88	223	32,025	Juna Koba	345	49	26,040
200	392	31,890	Koba Gaam	679	97	25,458
2,108	7,562	31,698	GNLU	5,940	2,326	21,844
332	632	26,244	Raysan	1,046	163	20,961
437	825	25,944	Randesan	1,208	240	19,993
934	2,286	25,556	Dholakuva Circle	2,564	614	18,044
430	1,050	24,203	Infocity	1,025	327	17,346
848	1,090	23,584	Sector - 1	1,760	371	15,957
1,073	3,398	23,342	Sector 10A	1,335	1,285	15,907
227	4,919	21,017	Sachivalaya	401	1,533	17,039
963	3,323	16,325	Akshardham	3,242	951	14,748
739	2,132	13,964	Juna Sachivalaya	2,819	505	12,434
451	3,251	12,571	Sector - 16	2,357	577	10,655
309	7,113	9,772	Sector - 24	5,225	775	6,205
0	2,968	2,968	Mahatma Mandir	6,205	0	0
144,600	**144,600**		**Total**	**161,388**	**161,387**	
GNLU to GIFT City			**Station Name**	**GIFT City to GNLU**		
Boarding	**Alighting**	**Sectional load**		**Boarding**	**Alighting**	**Sectional load**
6,376	0	0	GNLU	0	4,764	4763
426	1,015	6,376	PDPU	1,759	233	3237
0	5,787	5,787	Gift City	3,237	0	0
6,802	6,802		**Total**	4,996	4,997	
Koteshwar Road to Airport			**Station Name**	**Airport to Koteshwar Road**		
Boarding	**Alighting**	**Sectional load**		**Boarding**	**Alighting**	**Sectional load**
5,250	0	0	Koteshwar Road	0	8,005	8005
72	4,704	5249	Sardarnagar	7,770	21	256
0	618	618	Airport	257	0	0
5,322	**5,322**		**Total**	**8,027**	**8,026**	

Line Loading – 2031 Moderate Scenario

Table 2.56 Station wise Daily Boarding-Alighting on Corridor-I - 2031 (Moderate Scenario)

Thaltej Gaam to Vaastral Gaam				Vastral Gaam to Thaltej Gaam		
Boarding	Alighting	Sectional Load	Station Name	Boarding	Alighting	Sectional Load
25,138	0	0	Thaltej gaam	0	22,205	22,205
18,977	3,088	25,138	Thaltej	2,938	19,206	38,473
11,954	2,288	41,027	Doordarshan Kendra	2,515	10,736	46,695
5,252	896	50,693	Gurukul Road	1,136	3,931	49,489
10,793	5,063	55,050	Gujarat University	2,422	20,978	68,045
2,935	1,177	60,780	Commerce Six road	1,032	3,837	70,850
10,045	4,740	62,538	Stadium	3,546	15,344	82,649
70,012	40,031	67,842	Old high court	49,376	74,817	108,090
5,552	5,489	97,822	Shahpur	7,580	4,268	104,779
11,995	13,818	97,885	Ghee kanta	17,070	9,837	97,546
11,653	43,998	96,062	Kalupur rly stn	39,123	18,111	76,534
2,809	11,805	63,717	Kankaria east	11,412	3,735	68,856
2,838	10,488	54,721	Apparel park	12,615	3,156	59,397
2,917	18,770	47,071	Amraiwadi	18,937	4,357	44,817
1,947	16,715	31,218	Rabari	25,347	1,869	21,339
376	3,526	16,451	Vastral	6,334	267	15,272
761	629	13,301	Nirant Cross road	2,015	667	13,924
0	13,433	13,433	Vastral gam	13,924	0	0
195,956	**195,956**		**Total**	**217,321**	**217,321**	

Table 2.57 Station wise Daily Boarding-Alighting on Corridor-II - 2031 (Moderate Scenario)

Motera to Mahatma Mandir			Station Name	Mahatma Mandir to motera		
Boarding	Alighting	Sectional load		Boarding	Alighting	Sectional load
21,537	0	0	APMC	0	13,874	13,874
28,181	2,331	21,537	Jivraj	2,408	17,105	28,570
4,052	1,723	47,386	Rajiv nagar	539	7,536	35,567
5,086	1,697	49,715	Shreyash	798	7,373	42,142
18,734	4,031	53,104	Paldi	3,334	17,979	56,787
6,034	5,228	67,808	Gandhigram rly stn	1,462	19,179	74,503
63,169	46,105	68,614	Old high court	43,204	84,668	115,967
1,328	3,308	85,677	Ushmanpura	2,884	2,263	115,346
6,222	10,108	83,698	Vijay nagar	14,420	6,601	107,527
5,850	11,360	79,812	New vadaj	18,584	4,798	93,740
1,626	4,786	74,302	Ranip	5,986	1,860	89,615
4,084	11,607	71,142	Sabarmati Rly stn	16,130	4,077	77,562
615	2,722	63,620	AEC	2,628	889	75,822

Motera to Mahatma Mandir			Station Name	Mahatma Mandir to motera		
Boarding	**Alighting**	**Sectional load**		**Boarding**	**Alighting**	**Sectional load**
1,307	4,799	61,513	Sabarmati	5,802	1,594	71,615
1,568	2,261	58,021	Motera Stadium	6,434	710	65,890
3,978	10,497	57,329	Koteshwar Road	16,896	2,784	51,778
663	1,687	50,810	Vishwakarma College	2,479	510	49,809
1,916	5,633	49,786	Tapovan Circle	6,411	1,809	45,207
731	843	46,069	Narmada Canal	2,146	274	43,335
1,926	2,345	45,957	Koba Circle	5,034	775	39,076
214	283	45,537	Juna Koba	688	75	38,462
336	630	45,469	Koba Gaam	931	190	37,722
5,720	12,391	45,175	GNLU	13,485	4,157	28,393
441	849	38,505	Raysan	1,315	208	27,286
649	1,371	38,097	Randesan	1,733	360	25,914
1,271	3,664	37,375	Dholakuva Circle	3,316	931	23,529
718	1,199	34,981	Infocity	1,605	354	22,278
1,356	1,701	34,500	Sector - 1	2,632	538	20,183
1,555	4,708	34,155	Sector 10A	1,692	1,676	20,167
298	6,808	31,003	Sachivalaya	489	1,863	21,540
1,406	4,774	24,493	Akshardham	4,170	1,237	18,607
977	2,885	21,125	Juna Sachivalaya	3,235	635	16,007
665	5,375	19,217	Sector - 16	3,132	867	13,743
418	10,245	14,507	Sector - 24	6,380	1,044	8,406
0	4,679	4,679	Mahatma Mandir	8,406	0	0
194,631	**194,633**		**Total**	**210,788**	**210,793**	

GNLU to GIFT City			Station Name	GIFT City to GNLU		
Boarding	**Alighting**	**Sectional load**		**Boarding**	**Alighting**	**Sectional load**
12,167	0	0	GNLU	0	13,265	13,265
1,301	1,906	12,167	PDPU	3,170	1,009	11,104
0	11,562	11,562	Gift City	11,104	0	0
13,468	**13,468**		**Total**	**14,274**	**14,274**	

Koteshwar Road to Airport			Station Name	Airport to Koteshwar Road		
Boarding	**Alighting**	**Sectional load**		**Boarding**	**Alighting**	**Sectional load**
8,511	0	0	Koteshwar Road	0	10,618	10,618
67	7,820	8,511	Sardarnagar	10,368	19	268
0	758	758	Airport	268	0	0
8,578	**8,578**		**Total**	**10,636**	**10,637**	

Line Loading – 2041 Moderate Scenario

Table 2.58 Station wise Daily Boarding-Alighting on Corridor-I - 2041 (Moderate Scenario)

Thaltej Gaam to Vaastral Gaam				Vastral Gaam to Thaltej Gaam		
Boarding	**Alighting**	**Sectional Load**	**Station Name**	**Boarding**	**Alighting**	**Sectional Load**
33,846	0	0	Thaltej gaam	0	28,632	28,632
22,858	4,170	33,846	Thaltej	3,883	23,169	47,917
14,183	2,780	52,534	Doordarshan Kendra	2,999	12,783	57,702
8,402	1,439	63,938	Gurukul Road	1,805	6,282	62,178
12,797	6,213	70,901	Gujarat University	2,930	24,854	84,102
3,478	1,442	77,485	Commerce Six road	1,234	4,537	87,405
11,910	5,777	79,521	Stadium	4,216	18,163	101,352
87,156	51,002	85,654	Old high court	61,133	92,429	132,647
6,575	6,607	121,808	Shahpur	9,036	5,025	128,636
14,178	16,562	121,776	Ghee kanta	20,299	11,589	119,926
14,156	52,437	119,391	Kalupur rly stn	46,116	21,865	95,675
3,485	13,964	81,110	Kankaria east	13,418	4,571	86,827
3,558	12,366	70,631	Apparel park	14,777	3,882	75,933
3,914	22,091	61,823	Amraiwadi	22,110	5,661	59,484
2,934	22,179	43,647	Rabari	32,332	2,804	29,957
551	4,121	24,401	Vastral	7,377	380	22,960
1,403	725	20,831	Nirant Cross road	2,318	1,272	21,913
0	21,509	21,509	Vastral gam	21,913	0	0
245,383	**245,383**		**Total**	**267,896**	**267,896**	

Table 2.59 Station wise Daily Boarding-Alightingon Corridor-II - 2041 (Moderate Scenario)

Motera to Mahatma Mandir			Station Name	Mahatma Mandir to motera		
Boarding	**Alighting**	**Sectional load**		**Boarding**	**Alighting**	**Sectional load**
25,900	0	0	APMC	0	16,759	16,759
35,142	2,797	25,900	Jivraj	2,912	21,132	34,979
4,904	2,039	58,246	Rajiv nagar	639	9,052	43,392
6,070	2,000	61,111	Shreyash	934	8,823	51,280
22,426	4,752	65,181	Paldi	3,894	21,542	68,928
7,209	6,140	82,855	Gandhigram rly stn	1,702	22,884	90,110
81,820	55,407	83,923	Old high court	51,651	106,627	145,086
1,638	3,908	110,337	Ushmanpura	3,388	2,737	144,435
7,894	11,983	108,067	Vijay nagar	16,957	8,158	135,635
7,478	13,509	103,979	New vadaj	21,707	6,065	119,994
2,068	5,623	97,948	Ranip	6,992	2,307	115,310
5,278	13,612	94,393	Sabarmati Rly stn	18,788	5,139	101,660
800	3,185	86,059	AEC	3,057	1,122	99,725

Motera to Mahatma Mandir			Station Name	Mahatma Mandir to motera		
Boarding	Alighting	Sectional load		Boarding	Alighting	Sectional load
1,758	5,552	83,674	Sabarmati	6,678	2,079	95,127
2,088	2,618	79,880	Motera Stadium	7,404	922	88,644
5,519	13,295	79,349	Koteshwar Road	20,248	4,006	72,403
899	1,927	71,573	Vishwakarma College	2,823	689	70,269
3,430	8,435	70,545	Tapovan Circle	9,865	3,107	63,510
1,405	1,464	65,540	Narmada Canal	3,594	540	60,455
3,432	3,841	65,481	Koba Circle	7,893	1,402	53,965
410	498	65,072	Juna Koba	1,159	144	52,950
476	802	64,984	Koba Gaam	1,162	265	52,053
8,473	15,861	64,658	GNLU	16,951	6,138	41,239
735	1,234	57,270	Raysan	1,875	346	39,710
1,157	2,335	56,771	Randesan	2,697	688	37,700
2,228	5,909	55,594	Dholakuva Circle	5,156	1,649	34,193
1,159	1,752	51,913	Infocity	2,303	572	32,461
2,187	2,490	51,320	Sector - 1	3,775	868	29,554
2,571	6,878	51,017	Sector 10A	2,424	2,749	29,879
478	9,950	46,711	Sachivalaya	703	2,996	32,172
2,304	7,183	37,239	Akshardham	6,118	2,050	28,104
1,575	4,210	32,361	Juna Sachivalaya	4,679	1,034	24,460
1,144	8,392	29,726	Sector - 16	4,914	1,477	21,022
757	15,761	22,478	Sector - 24	9,820	1,812	13,015
0	7,474	7,474	Mahatma Mandir	13,015	0	0
252,812	**252,816**		**Total**	**267,877**	**267,880**	
GNLU to GIFT City			**Station Name**	**GIFT City to GNLU**		
Boarding	**Alighting**	**Sectional load**		**Boarding**	**Alighting**	**Sectional load**
16,322	0	0	GNLU	0	17,663	17,663
1,643	2,623	16,322	PDPU	4,353	1,266	14,575
0	15,341	15,341	Gift City	14,575	0	0
17,965	**17,964**		**Total**	**18,928**	**18,929**	
Koteshwar Road to Airport			**Station Name**	**Airport to Koteshwar Road**		
Boarding	**Alighting**	**Sectional load**		**Boarding**	**Alighting**	**Sectional load**
11,126	0	0	Koteshwar Road	0	13,281	13,281
81	10,306	11,126	Sardarnagar	12,987	24	318
0	901	901	Airport	318	0	0
11,207	**11,207**		**Total**	**13,305**	**13,305**	

Line Loading – 2051 Moderate Scenario

Table 2.60 Station wise Daily Boarding-Alightingon Corridor-I - 2051 (Moderate Scenario)

Thaltej Gaam to Vaastral Gaam				Vastral Gaam to Thaltej Gaam		
Boarding	**Alighting**	**Sectional Load**	**Station Name**	**Boarding**	**Alighting**	**Sectional Load**
39,063	0	0	Thaltej gaam	0	33,657	33,657
27,099	4,871	39,063	Thaltej	4,686	26,683	55,653
15,542	3,130	61,291	Doordarshan Kendra	3,373	14,136	66,417
9,289	1,598	73,702	Gurukul Road	2,004	6,989	71,402
14,425	6,879	81,394	Gujarat University	3,311	27,652	95,743
3,829	1,596	88,940	Commerce Six road	1,354	5,025	99,413
13,645	6,397	91,173	Stadium	4,833	20,112	114,692
100,256	59,319	98,422	Old high court	69,952	106,318	151,059
7,213	7,367	139,360	Shahpur	9,985	5,511	146,585
15,694	18,474	139,206	Ghee kanta	22,694	12,748	136,639
16,295	58,411	136,425	Kalupur rly stn	52,669	23,941	107,911
3,943	15,572	94,309	Kankaria east	14,762	5,043	98,192
4,060	13,768	82,680	Apparel park	16,263	4,290	86,219
4,643	24,449	72,972	Amraiwadi	24,336	6,332	68,215
3,595	26,734	53,166	Rabari	37,105	3,360	34,470
659	4,581	30,027	Vastral	8,101	424	26,794
1,774	804	26,105	Nirant Cross road	2,535	1,615	25,875
0	27,075	27,075	Vastral gam	25,875	0	0
281,025	**281,025**		**Total**	**303,836**	**303,836**	

Table 2.61 Station wise Daily Boarding-Alighting on Corridor-II - 2051 (Moderate Scenario)

Motera to Mahatma Mandir				Mahatma Mandir to motera		
Boarding	**Alighting**	**Sectional load**	**Station Name**	**Boarding**	**Alighting**	**Sectional load**
28,701	0	0	APMC	0	18,773	18,773
39,619	3,087	28,701	Jivraj	3,208	24,207	39,773
5,462	2,223	65,233	Rajiv nagar	702	10,150	49,221
6,725	2,177	68,471	Shreyash	1,020	9,845	58,046
24,937	5,168	73,019	Paldi	4,256	24,145	77,935
8,033	6,656	92,788	Gandhigram rly stn	1,851	25,761	101,845
97,749	60,918	94,165	Old high court	57,177	125,009	169,677
1,891	4,269	130,995	Ushmanpura	3,689	3,147	169,135
9,895	13,483	128,618	Vijay nagar	19,701	9,635	159,069
9,743	16,013	125,030	New vadaj	26,025	7,526	140,570
2,422	6,180	118,760	Ranip	7,598	2,644	135,616
6,391	14,990	115,002	Sabarmati Rly stn	20,672	6,022	120,966
954	3,489	106,403	AEC	3,311	1,303	118,957

Motera to Mahatma Mandir				Mahatma Mandir to motera		
Boarding	Alighting	Sectional load	Station Name	Boarding	Alighting	Sectional load
2,114	6,124	103,868	Sabarmati	7,312	2,427	114,073
2,506	2,863	99,858	Motera Stadium	7,979	1,076	107,170
7,559	16,400	99,500	Koteshwar Road	25,029	5,229	87,370
1,075	2,112	90,659	Vishwakarma College	3,036	799	85,134
4,633	10,388	89,623	Tapovan Circle	11,904	4,081	77,311
1,822	1,754	83,868	Narmada Canal	4,211	684	73,783
4,807	4,955	83,935	Koba Circle	9,952	1,913	65,744
533	600	83,787	Juna Koba	1,358	181	64,567
667	1,043	83,720	Koba Gaam	1,469	360	63,458
11,526	20,578	83,344	GNLU	20,872	8,293	50,879
1,020	1,614	74,293	Raysan	2,388	468	48,959
1,579	3,065	73,699	Randesan	3,413	925	46,471
3,062	7,753	72,213	Dholakuva Circle	6,564	2,213	42,120
1,473	2,130	67,521	Infocity	2,723	709	40,105
3,002	3,278	66,864	Sector - 1	4,835	1,161	36,432
3,468	9,079	66,588	Sector 10A	3,104	3,657	36,985
633	13,124	60,977	Sachivalaya	878	3,972	40,080
2,967	9,266	48,487	Akshardham	7,484	2,676	35,271
2,137	5,569	42,188	Juna Sachivalaya	6,062	1,371	30,580
1,455	10,477	38,755	Sector - 16	5,883	1,868	26,565
1,012	20,858	29,733	Sector - 24	12,393	2,433	16,604
0	9,886	9,887	Mahatma Mandir	16,604	0	0
301,572	301,569		**TOTAL**	314,663	314,663	

GNLU to GIFT City			Station Name	GIFT City to GNLU		
Boarding	Alighting	Sectional load		Boarding	Alighting	Sectional load
21,489	0	0	GNLU	0	22,609	22,609
2,219	3,432	21,489	PDPU	5,603	1,701	18,706
0	20,277	20,277	Gift City	18,706	0	0
23,708	**23,709**		**TOTAL**	**24,309**	**24,310**	

Koteshwar Road to Airport			Station Name	Airport to Koteshwar Road		
Boarding	Alighting	Sectional load		Boarding	Alighting	Sectional load
13,692	0	0	Koteshwar Road	0	16,685	16,685
98	12,784	13,692	Sardarnagar	16,361	29	353
0	1,006	1,006	Airport	353	0	0
339,067	**339,067**		**Total**	**355,685**	**355,685**	

Line Loading – 2017 Optimistic Scenario

Table 2.62 Station wise Daily Boarding-Alighting on Corridor-I - 2017 (Optimistic Scenario)

Thaltej Gaam to Vaastral Gaam				Vastral Gaam to Thaltej		
Boarding	**Alighting**	**Sectional Load**	**Station Name**	**Boarding**	**Alighting**	**Sectional Load**
17,385	0	0	Thaltej gaam	0	12,320	12,320
13,683	2,636	17,385	Thaltej	2,136	13,669	23,854
10,708	2,984	28,433	Doordarshan Kendra	2,220	12,131	33,764
3,911	1,666	36,157	Gurukul Road	989	5,814	38,589
6,539	4,498	38,402	Gujarat University	2,483	12,163	48,270
1,504	732	40,442	Commerce Six road	661	1,780	49,389
7,023	5,293	41,214	Stadium	4,356	12,297	57,330
30,914	13,977	42,944	Old high court	17,848	39,345	78,826
5,529	2,130	59,882	Shahpur	4,145	4,895	79,575
21,490	8,915	63,281	Ghee kanta	15,240	17,638	81,973
12,056	34,093	75,857	Kalupur rly stn	34,929	17,456	64,500
2,795	11,749	53,820	Kankaria east	10,765	3,995	57,729
2,800	9,490	44,866	Apparel park	11,497	3,129	49,361
2,839	16,722	38,176	Amraiwadi	18,070	4,018	35,310
1,590	13,194	24,292	Rabari	19,383	1,576	17,502
416	2,009	12,688	Vastral	5,407	170	12,265
863	538	11,095	Nirant Cross road	1,735	659	11,189
0	11,419	11,419	Vastral Gaam	11,189	0	0
1,42,045	**1,42,045**		**Total**	**1,63,054**	**1,63,054**	

Table 2.63 Station wise Daily Boarding-Alighting on Corridor-II - 2017 (Optimistic Scenario)

APMC to Motera				Motera to APMC		
Boarding	**Alighting**	**Sectional Load**	**Station Name**	**Boarding**	**Alighting**	**Sectional Load**
17,676	0	0	APMC	0	10,088	10,088
18,053	2,540	17,676	Jivraj	2,215	11,087	18,960
3,844	1,920	33,189	Rajiv nagar	641	7,566	25,885
4,573	1,683	35,113	Shreyash	907	6,480	31,458
12,964	5,861	38,003	Paldi	4,829	12,775	39,404
4,348	8,147	45,106	Gandhigram rly stn	2,580	14,232	51,056
19,844	24,421	41,307	Old high court	22,480	32,557	61,133
582	1,428	36,729	Ushmanpura	885	1,988	62,237
4,950	4,579	35,883	Vijay nagar	9,329	4,923	57,831
3,310	8,511	36,254	New vadaj	16,448	2,938	44,321
914	3,977	31,053	Ranip	5,198	1,172	40,295
2,273	8,224	27,990	Sabarmati Rly stn	10,816	3,012	32,492
177	1,848	22,039	AEC	1,758	333	31,067

APMC to Motera				Motera to APMC		
Boarding	Alighting	Sectional Load	Station Name	Boarding	Alighting	Sectional Load
2,538	7,767	20,368	Sabarmati	11,642	2,457	21,882
0	15,139	15,139	Motera stadium	21,882	0	0
96,045	**96,045**		**Total**	**1,11,611**	**1,11,611**	

Line Loading – 2021 Optimistic Scenario

Table 2.64 Station wise Daily Boarding-Alighting on Corridor-I - 2021 (Optimistic Scenario)

Thaltej Gaam to Vaastral Gaam				Vastral Gaam to Thaltej Gaam		
Boarding	Alighting	Sectional Load	Station Name	Boarding	Alighting	Sectional Load
20,687	0	0	Thaltej gaam	0	14,384	14,384
15,771	2,527	20,687	Thaltej	2,047	15,582	27,919
9,878	2,465	33,931	Doordarshan Kendra	1,719	11,788	37,988
4,556	1,555	41,344	Gurukul Road	899	6,779	43,868
6,861	3,865	44,345	Gujarat University	1,983	13,700	55,585
1,992	729	47,341	Commerce Six road	663	2,451	57,373
6,545	4,300	48,605	Stadium	3,313	10,929	64,989
52,660	22,676	50,850	Old high court	29,050	60,132	96,072
5,646	4,105	80,834	Shahpur	6,110	5,008	94,970
18,145	12,713	82,376	Ghee kanta	15,841	16,527	95,656
13,214	39,226	87,808	Kalupur rly stn	40,803	18,553	73,406
2,991	13,150	61,796	Kankaria east	11,940	4,249	65,714
2,881	10,598	51,636	Apparel park	12,819	3,227	56,123
2,968	19,072	43,920	Amraiwadi	20,339	4,252	40,035
1,591	14,885	27,816	Rabari	21,946	1,650	19,739
375	2,261	14,522	Vastral	6,137	171	13,773
733	615	12,635	Nirant Cross road	2,005	629	12,397
0	12,753	12,753	Vastral Gaam	12,397	0	0
1,67,495	**1,67,495**		**Total**	**1,90,013**	**1,90,013**	

Table 2.65 Station wise Daily Boarding-Alighting on Corridor-II - 2021 (Optimistic Scenario)

Motera to Mahatma Mandir				Mahatma Mandir to motera		
Boarding	Alighting	Sectional load	Station Name	Boarding	Alighting	Sectional load
20,444	0	0	APMC	0	12,056	12,056
22,230	2,447	20,444	Jivraj	2,152	14,598	24,502
4,374	1,945	40,228	Rajiv nagar	606	8,547	32,443
5,162	1,713	42,656	Shreyash	879	7,317	38,881
18,803	5,639	46,105	Paldi	4,521	19,585	53,945
4,821	6,355	59,269	Gandhigram rly stn	1,891	17,238	69,293
40,720	35,110	57,735	Old high court	34,117	56,303	91,480
1,047	2,600	63,345	Ushmanpura	1,950	2,546	92,075
6,708	7,412	61,792	Vijay nagar	13,103	6,181	85,152

Motera to Mahatma Mandir				Mahatma Mandir to motera		
Boarding	**Alighting**	**Sectional load**	**Station Name**	**Boarding**	**Alighting**	**Sectional load**
5,300	9,850	61,087	New vadaj	18,266	4,031	70,918
1,299	4,285	56,537	Ranip	5,571	1,506	66,853
3,591	7,607	53,552	Sabarmati Rly stn	11,447	3,724	59,130
363	1,925	49,536	AEC	1,828	538	57,839
982	4,341	47,973	Sabarmati	5,443	1,134	53,530
800	2,037	44,614	Motera Stadium	4,015	515	50,030
3,038	8,233	43,377	Koteshwar Road	15,173	1,854	36,712
591	1,396	38,182	Vishwakarma College	2,768	323	34,267
1,051	3,794	37,377	Tapovan Circle	4,091	960	31,136
278	557	34,633	Narmada Canal	967	144	30,313
990	1,633	34,355	Koba Circle	3,042	451	27,723
93	235	33,711	Juna Koba	363	52	27,411
211	413	33,569	Koba Gaam	715	102	26,798
2,219	7,960	33,367	GNLU	6,252	2,448	22,993
349	665	27,626	Raysan	1,101	172	22,064
460	869	27,310	Randesan	1,271	253	21,046
983	2,407	26,901	Dholakuva Circle	2,698	646	18,993
453	1,105	25,478	Infocity	1,079	345	18,259
892	1,147	24,826	Sector - 1	1,853	391	16,797
1,130	3,577	24,571	Sector 10A	1,406	1,353	16,744
238	5,178	22,123	Sachivalaya	422	1,614	17,936
1,014	3,498	17,184	Akshardham	3,412	1,001	15,525
778	2,244	14,699	Juna Sachivalaya	2,967	531	13089
475	3,422	13,233	Sector - 16	2,481	607	11215
326	7,487	10,286	Sector - 24	5,500	816	6531
0	3,124	3,124	Mahatma Mandir	6,531	0	0
152,213	**152,210**		**Total**	**169,881**	**169,882**	
GNLU to GIFT City			**Station Name**	**GIFT City to GNLU**		
Boarding	**Alighting**	**Sectional load**		**Boarding**	**Alighting**	**Sectional load**
6,711	0	0	GNLU	0	5,014	5014
449	1,069	6,711	PDPU	1,851	245	3408
0	6,091	6,091	Gift City	3,408	0	0
7,160	**7,160**		**Total**	**5,259**	**5,259**	
Koteshwar Road to Airport			**Station Name**	**Airport to Koteshwar Road**		
Boarding	**Alighting**	**Sectional load**		**Boarding**	**Alighting**	**Sectional load**
5,526	0	0	Koteshwar Road	0	8,427	0
76	4,952	5,526	Sardarnagar	8,179	22	270
0	651	651	Airport	270	0	8426.57
5,602	**5,603**		**Total**	**8,449**	**8,449**	

Line Loading – 2031 Optimistic Scenario

Table 2.66 Station wise Daily Boarding-Alighting on Corridor-I - 2031 (Optimistic Scenario)

Thaltej Gaam to Vaastral Gaam				Vastral Gaam to Thaltej Gaam		
Boarding	**Alighting**	**Sectional Load**	**Station Name**	**Boarding**	**Alighting**	**Sectional Load**
27,616	0	0	Thaltej gaam	0	24,394	24,394
20,848	3,393	27,616	Thaltej	3,227	21,099	42,266
13,133	2,514	45,071	Doordarshan Kendra	2,763	11,795	51,298
5,770	984	55,690	Gurukul Road	1,248	4,318	54,368
11,857	5,562	60,477	Gujarat University	2,661	23,046	74,754
3,224	1,293	66,772	Commerce Six road	1,134	4,215	77,835
11,035	5,208	68,703	Stadium	3,895	16,857	90,797
76,914	43,978	74,530	Old high court	54,244	82,193	118,746
6,099	6,031	107,467	Shahpur	8,327	4,689	115,108
13,178	15,180	107,536	Ghee kanta	18,753	10,807	107,162
12,802	48,336	105,533	Kalupur rly stn	42,980	19,897	84,079
3,086	12,969	69,999	Kankaria east	12,537	4,103	75,645
3,118	11,522	60,116	Apparel park	13,859	3,467	65,253
3,205	20,621	51,712	Amraiwadi	20,804	4,787	49,235
2,139	18,362	34,296	Rabari	27,846	2,053	23,442
413	3,874	18,073	Vastral	6,958	294	16,778
836	691	14,612	Nirant Cross road	2,213	733	15,297
0	14,757	14,757	Vastral gam	15,297	0	0
215,275	**215,275**		**Total**	**238,747**	**238,747**	

Table 2.67 Station wise Daily Boarding-Alighting on Corridor -II - 2031 (Optimistic Scenario)

Motera to Mahatma Mandir				Mahatma Mandir to motera		
Boarding	**Alighting**	**Sectional Load**	**Station Name**	**Boarding**	**Alighting**	**Sectional Load**
23,660	0	0	APMC	0	15,242	15,242
30,959	2,561	23,660	Jivraj	2,646	18,791	31,387
4,452	1,893	52,058	Rajiv nagar	592	8,279	39,073
5,587	1,864	54,617	Shreyash	877	8,100	46,297
20,581	4,428	58,340	Paldi	3,663	19,751	62,385
6,629	5,744	74,493	Gandhigram rly stn	1,606	21,070	81,848
69,396	50,651	75,378	Old high court	47,463	93,015	127,400
1,459	3,634	94,124	Ushmanpura	3,169	2,486	126,717
6,836	11,105	91,949	Vijay nagar	15,842	7,252	118,128

Motera to Mahatma Mandir				Mahatma Mandir to motera		
Boarding	Alighting	Sectional Load	Station Name	Boarding	Alighting	Sectional Load
6,427	12,480	87,680	New vadaj	20,417	5,271	102,982
1,787	5,258	81,627	Ranip	6,576	2,044	98,450
4,487	12,751	78,156	Sabarmati Rly stn	17,720	4,479	85,208
676	2,991	69,892	AEC	2,887	977	83,297
1,436	5,272	67,577	Sabarmati	6,374	1,751	78,675
1,723	2,484	63,741	Motera Stadium	7,068	780	72,386
4,371	11,532	62,980	Koteshwar Road	18,562	3,058	56,882
729	1,854	55,819	Vishwakarma College	2,724	560	54,719
2,105	6,189	54,694	Tapovan Circle	7,043	1,987	49,664
803	926	50,610	Narmada Canal	2,357	301	47,607
2,116	2,577	50,487	Koba Circle	5,530	852	42,929
235	311	50,027	Juna Koba	756	82	42,254
369	692	49,952	Koba Gaam	1,022	209	41,441
6,284	13,612	49,629	GNLU	14,815	4,566	31,193
484	932	42,301	Raysan	1,444	228	29,977
713	1,506	41,853	Randesan	1,904	396	28,469
1,397	4,026	41,060	Dholakuva Circle	3,643	1,023	25,848
789	1,317	38,431	Infocity	1,763	389	24,474
1,490	1,869	37,902	Sector - 1	2,891	591	22,173
1,709	5,172	37,523	Sector 10A	1,859	1,841	22,155
328	7,480	34,060	Sachivalaya	537	2,046	23,664
1,545	5,244	26,908	Akshardham	4,581	1,359	20,442
1,073	3,170	23,208	Juna Sachivalaya	3,553	697	17,585
730	5,905	21,111	Sector - 16	3,440	953	15,098
459	11,255	15,937	Sector - 24	7,010	1,147	9,235
0	5,141	5,141	Mahatma Mandir	9,235	0	0
213,824	**213,826**		**Total**	**231,569**	**231,573**	

GNLU to GIFT City			Station Name	GIFT City to GNLU		
Boarding	Alighting	Sectional load		Boarding	Alighting	Sectional load
13,366	0	0	GNLU	0	14,573	14,573
1,430	2,094	13,366	PDPU	3,482	1,109	12,199
0	12,702	12,702	Gift City	12,199	0	0
14,796	**14,796**		**Total**	**15,681**	**15,682**	

Koteshwar Road to Airport			Station Name	Airport to Koteshwar Road		
Boarding	Alighting	Sectional load		Boarding	Alighting	Sectional load
9,350	0	0	Koteshwar Road	0	11,665	11,665
73	8,591	9,350	Sardarnagar	11,391	21	295
0	832	832	Airport	295	0	0
9,423	**9,423**		**Total**	**11,686**	**11,686**	

Line Loading – 2041 Optimistic Scenario

Table 2.68 Station wise Daily Boarding-Alighting on Corridor-I – 2041 (Optimistic Scenario)

Thaltej Gaam to Vaastral Gaam				Vastral Gaam to Thaltej Gaam		
Boarding	**Alighting**	**Sectional Load**	**Station Name**	**Boarding**	**Alighting**	**Sectional Load**
36,667	0	0	Thaltej gaam	0	31,018	31,018
24,762	4,517	36,667	Thaltej	4,207	25,099	51,910
15,365	3,011	56,912	Doordarshan Kendra	3,249	13,848	62,510
9,103	1,559	69,266	Gurukul Road	1,956	6,805	67,360
13,864	6,731	76,809	Gujarat University	3,175	26,926	91,111
3,768	1,562	83,942	Commerce Six road	1,337	4,915	94,688
12,903	6,259	86,147	Stadium	4,567	19,676	109,798
94,418	55,252	92,792	Old high court	66,228	100,131	143,701
7,123	7,158	131,958	Shahpur	9,789	5,444	139,356
15,359	17,942	131,923	Ghee kanta	21,991	12,554	129,920
15,335	56,807	129,340	Kalupur rly stn	49,959	23,687	103,647
3,775	15,127	87,868	Kankaria east	14,536	4,952	94,063
3,855	13,396	76,516	Apparel park	16,008	4,206	82,260
4,240	23,931	66,975	Amraiwadi	23,952	6,132	64,441
3,178	24,028	47,284	Rabari	35,026	3,038	32,453
597	4,464	26,435	Vastral	7,992	412	24,873
1,520	785	22,567	Nirant Cross road	2,512	1,378	23,740
0	23,302	23,302	Vastral gam	23,740	0	0
265,832	**265,832**		**Total**	**290,221**	**290,221**	

Table 2.69 Station wise Daily Boarding-Alighting on Corridor-II-2041 (Optimistic Scenario)

Motera to Mahatma Mandir				Mahatma Mandir to Motera		
Boarding	**Alighting**	**Sectional Load**	**Station Name**	**Boarding**	**Alighting**	**Sectional Load**
28,058	0	0	APMC	0	18,156	18,156
38,071	3,030	28,058	Jivraj	3,155	22,893	37,894
5,313	2,209	63,099	Rajiv nagar	692	9,806	47,008
6,576	2,167	66,204	Shreyash	1,012	9,558	55,554
24,295	5,148	70,613	Paldi	4,219	23,337	74,672
7,810	6,652	89,759	Gandhigram rly stn	1,844	24,791	97,620
88,639	60,025	90,917	Old high court	55,956	115,513	157,176
1,775	4,233	119,531	Ushmanpura	3,670	2,965	156,471
8,552	12,981	117,072	Vijay nagar	18,370	8,838	146,938
8,101	14,635	112,643	New vadaj	23,515	6,570	129,993
2,241	6,092	106,110	Ranip	7,574	2,500	124,919
5,717	14,746	102,258	Sabarmati Rly stn	20,354	5,567	110,132
867	3,451	93,230	AEC	3,311	1,215	108,036
1,904	6,014	90,646	Sabarmati	7,234	2,252	103,054
2,262	2,837	86,536	Motera Stadium	8,021	999	96,031
5,979	14,403	85,961	Koteshwar Road	21,935	4,340	78,436
974	2,087	77,537	Vishwakarma College	3,059	747	76,124

Motera to Mahatma Mandir				Mahatma Mandir to Motera		
Boarding	**Alighting**	**Sectional Load**	**Station Name**	**Boarding**	**Alighting**	**Sectional Load**
3,716	9,138	76,424	Tapovan Circle	10,687	3,365	68,803
1,522	1,586	71,002	Narmada Canal	3,894	585	65,493
3,718	4,161	70,938	Koba Circle	8,550	1,519	58,462
445	540	70,495	Juna Koba	1,255	156	57,363
516	869	70,399	Koba Gaam	1,259	287	56,390
9,179	17,183	70,047	GNLU	18,364	6,649	44,675
796	1,336	62,043	Raysan	2,031	375	43,019
1,253	2,529	61,502	Randesan	2,922	745	40,842
2,414	6,401	60,227	Dholakuva Circle	5,586	1,786	37,042
1,255	1,898	56,239	Infocity	2,495	619	35,166
2,369	2,697	55,596	Sector - 1	4,090	941	32,016
2,785	7,451	55,269	Sector 10A	2,626	2,978	32,369
518	10,779	50,603	Sachivalaya	762	3,246	34,853
2,496	7,781	40,342	Akshardham	6,627	2,221	30,447
1,707	4,561	35,057	Juna Sachivalaya	5,068	1,120	26,498
1,239	9,091	32,203	Sector - 16	5,324	1,600	22,774
820	17,074	24,351	Sector - 24	10,638	1,963	14,099
0	8,096	8,096	Mahatma Mandir	14,099	0	0
273,882	**273,881**		**Total**	**290,198**	**290,202**	
GNLU to GIFT City			**Station Name**	**GIFT City to GNLU**		
Boarding	**Alighting**	**Sectional load**		**Boarding**	**Alighting**	**Sectional load**
17,682	0	0	GNLU	0	19,135	19,135
1,779	2,842	17,682	PDPU	4,716	1,371	15,790
0	16,620	16,620	Gift City	15,790	0	0
19,461	**19,462**		**Total**	**20,506**	**20,506**	
Koteshwar Road to Airport			**Station Name**	**Airport to Koteshwar Road**		
Boarding	**Alighting**	**Sectional load**		**Boarding**	**Alighting**	**Sectional load**
12,053	0	0	Koteshwar Road	0	14,388	14,388
88	11,165	12,053	Sardarnagar	14,070	26	345
0	976	976	Airport	345	0	0
12,141	**12,141**		**Total**	**14,415**	**14,414**	

Line Loading – 2051 Optimistic Scenario

Table 2.70 Station wise Daily Boarding-Alighting on Corridor-I – 2051 (Optimistic Scenario)

Thaltej Gaam to Vaastral Gaam				Vastral Gaam to Thaltej Gaam		
Boarding	**Alighting**	**Sectional Load**	**Station Name**	**Boarding**	**Alighting**	**Sectional Load**
42,274	0	0	Thaltej gaam	0	36,423	36,423
29,327	5,271	42,274	Thaltej	5,071	28,876	60,227
16,819	3,388	66,329	Doordarshan Kendra	3,650	15,298	71,876
10,053	1,730	79,760	Gurukul Road	2,169	7,564	77,270
15,611	7,444	88,084	Gujarat University	3,583	29,925	103,613

Thaltej Gaam to Vaastral Gaam				Vastral Gaam to Thaltej Gaam		
Boarding	**Alighting**	**Sectional Load**	**Station Name**	**Boarding**	**Alighting**	**Sectional Load**
4,144	1,727	96,251	Commerce Six road	1,466	5,438	107,585
14,767	6,922	98,667	Stadium	5,230	21,765	124,119
108,497	64,194	106,512	Old high court	75,701	115,057	163,474
7,805	7,972	150,814	Shahpur	10,805	5,964	158,633
16,983	19,992	150,647	Ghee kanta	24,559	13,796	147,869
17,634	63,212	147,639	Kalupur rly stn	56,998	25,909	116,780
4,267	16,852	102,060	Kankaria east	15,975	5,457	106,263
4,394	14,900	89,476	Apparel park	17,600	4,643	93,306
5,025	26,459	78,970	Amraiwadi	26,336	6,852	73,822
3,890	28,931	57,536	Rabari	40,154	3,636	37,304
713	4,957	32,495	Vastral	8,766	459	28,997
1,920	870	28,251	Nirant Cross road	2,743	1,748	28,002
0	29,301	29,301	Vastral gam	28,002	0	0
304,123	**304,123**		**Total**	**328,809**	**328,809**	

Table 2.71 Station wise Daily Boarding-Alighting on Corridor-II - 2051 (Optimistic Scenario)

Motera to Mahatma Mandir			Station Name	Mahatma Mandir to motera		
Boarding	**Alighting**	**Sectional Load**		**Boarding**	**Alighting**	**Sectional Load**
31,059	0	0	APMC	0	20,316	20,316
42,876	3,341	31,059	Jivraj	3,471	26,197	43,042
5,910	2,406	70,595	Rajiv nagar	759	10,984	53,267
7,278	2,356	74,099	Shreyash	1,104	10,654	62,817
26,986	5,592	79,021	Paldi	4,606	26,130	84,341
8,693	7,203	100,415	Gandhigram rly stn	2,003	27,879	110,216
105,783	65,925	101,905	Old high court	61,876	135,284	183,624
2,047	4,620	141,762	Ushmanpura	3,992	3,405	183,037
10,708	14,591	139,190	Vijay nagar	21,320	10,427	172,144
10,544	17,329	135,307	New vadaj	28,164	8,145	152,125
2,621	6,688	128,522	Ranip	8,223	2,861	146,763
6,916	16,222	124,455	Sabarmati Rly stn	22,371	6,517	130,909
1,032	3,776	115,148	AEC	3,584	1,410	128,735
2,287	6,627	112,405	Sabarmati	7,913	2,627	123,449
2,712	3,099	108,066	Motera Stadium	8,634	1,164	115,979
8,180	17,748	107,679	Koteshwar Road	27,086	5,659	94,552
1,164	2,285	98,111	Vishwakarma College	3,286	865	92,131
5,014	11,242	96,989	Tapovan Circle	12,882	4,417	83,666
1,972	1,899	90,761	Narmada Canal	4,558	740	79,848
5,202	5,362	90,834	Koba Circle	10,771	2,070	71,148
576	649	90,674	Juna Koba	1,470	196	69,874
721	1,129	90,601	Koba Gaam	1,589	389	68,674
12,474	22,269	90,194	GNLU	22,587	8,974	55,061

Motera to Mahatma Mandir			Station Name	Mahatma Mandir to motera		
Boarding	Alighting	Sectional Load		Boarding	Alighting	Sectional Load
1,104	1,746	80,399	Raysan	2,584	506	52,983
1,708	3,316	79,756	Randesan	3,694	1,001	50,291
3,313	8,391	78,148	Dholakuva Circle	7,104	2,395	45,582
1,594	2,305	73,070	Infocity	2,947	767	43,402
3,248	3,547	72,360	Sector - 1	5,232	1,257	39,427
3,753	9,825	72,061	Sector 10A	3,359	3,958	40,026
685	14,203	65,989	Sachivalaya	950	4,298	43,374
3,211	10,028	52,472	Akshardham	8,099	2,896	38,171
2,312	6,027	45,655	Juna Sachivalaya	6,560	1,483	33,094
1,575	11,339	41,940	Sector - 16	6,367	2,021	28,748
1,095	22,572	32,176	Sector - 24	13,412	2,633	17,969
0	10,699	10,699	Mahatma Mandir	17,969	0	0
326,353	**326,356**		**Total**	**340,526**	**340,525**	
GNLU to GIFT City			**Station Name**	**GIFT City to GNLU**		
Boarding	**Alighting**	**Sectional load**		**Boarding**	**Alighting**	**Sectional load**
23,256	0	0	GNLU	0	24,467	24,467
2,402	3,714	23,256	PDPU	6,064	1,840	20,244
0	21,944	21,944	Gift City	20,244	0	0
25,658	**25,658**		**Total**	**26,308**	**26,307**	
Koteshwar Road to Airport			**Station Name**	**Airport to Koteshwar Road**		
Boarding	**Alighting**	**Sectional load**		**Boarding**	**Alighting**	**Sectional load**
14,817	0	0	Koteshwar Road	0	18,056	18,056
107	13,835	14,817	Sardarnagar	17,706	31	382
0	1,089	1,089	Airport	382	0	0
14,924	**14,924**		**Total**	**18,088**	**18,087**	

Peak hour Line Loading – 2017 Moderate Scenario

Table 2.72 Station wise Peak hour Boarding-Alighting on Corridor-I - 2017 (Moderate Scenario)

Thaltej Gaam to Vaastral Gaam			Station Name	Vastral Gaam to Thaltej Gaam		
Boarding	Alighting	Sectional Load		Boarding	Alighting	Sectional Load
1,611	0	0	Thaltej gaam	0	1,142	1,142
1,268	244	1,611	Thaltej	198	1,267	2,211
992	277	2,635	Doordarshan Kendra	206	1,124	3,129
362	154	3,351	Gurukul Road	92	539	3,577
606	417	3,559	Gujarat University	230	1,127	4,474
139	68	3,748	Commerce Six road	61	165	4,578
651	491	3,820	Stadium	404	1,140	5,313
2,865	1,295	3,980	Old high court	1,654	3,647	7,306
512	197	5,550	Shahpur	384	454	7,375
1,992	826	5,865	Ghee kanta	1,413	1,635	7,597

Thaltej Gaam to Vaastral Gaam			Station Name	Vastral Gaam to Thaltej Gaam		
Boarding	Alighting	Sectional Load		Boarding	Alighting	Sectional Load
1,117	3,160	7,031	Kalupur rly stn	3,237	1,618	5,978
259	1,089	4,988	Kankaria east	998	370	5,351
260	880	4,158	Apparel park	1,066	290	4,575
263	1,550	3,538	Amraiwadi	1,675	372	3,273
147	1,223	2,251	Rabari	1,796	146	1,622
39	186	1,176	Vastral	501	16	1,137
80	50	1,028	Nirant Cross road	161	61	1,037
0	1,058	1,058	Vastral gam	1,037	0	0
13,165	**13,165**		**Total**	**15,112**	**15,112**	
			PHPDT			**7,597**

Table 2.73 Station wise Peak hour Boarding-Alighting on Corridor-II - 2017 (Moderate Scenario)

APMC to Motera			Station Name	Motera to APMC		
Boarding	Alighting	Sectional Load		Boarding	Alighting	Sectional Load
1,638	0	0	APMC	0	935	935
1,673	235	1,638	Jivraj	205	1,028	1,757
356	178	3,076	Rajiv nagar	59	701	2,399
424	156	3,254	Shreyash	84	601	2,916
1,202	543	3,522	Paldi	448	1,184	3,652
403	755	4,181	Gandhigram rly stn	239	1,319	4,732
1,839	2,263	3,828	Old high court	2,084	3,017	5,666
54	132	3,404	Ushmanpura	82	184	5,768
459	424	3,326	Vijay nagar	865	456	5,360
307	789	3,360	New vadaj	1,524	272	4,108
85	369	2,878	Ranip	482	109	3,735
211	762	2,594	Sabarmati Rly stn	1,002	279	3,011
16	171	2,043	AEC	163	31	2,879
235	720	1,888	Sabarmati	1,079	228	2,028
0	1,403	1,403	Motera stadium	2,028	0	0
8,902	**8,902**		**Total**	**10,344**	**10,344**	
			PHPDT			**5768**

Peak hour Line Loading – 2021 Moderate Scenario

Table 2.74 Station wise Peak hour Boarding-Alighting on Corridor-I - 2021 (Moderate Scenario)

Thaltej Gaam to Vaastral Gaam				Vastral Gaam to Thaltej Gaam		
Boarding	Alighting	Sectional Load	Station Name	Boarding	Alighting	Sectional Load
1,965	0	0	Thaltej gaam	0	1,366	1,366
1,498	240	1,965	Thaltej	194	1,480	2,652
938	234	3,223	Doordarshan Kendra	163	1,120	3,609
433	148	3,928	Gurukul Road	85	644	4,167

Thaltej Gaam to Vaastral Gaam				Vastral Gaam to Thaltej Gaam		
Boarding	**Alighting**	**Sectional Load**	**Station Name**	**Boarding**	**Alighting**	**Sectional Load**
652	367	4,213	Gujarat University	188	1,301	5,281
189	69	4,497	Commerce Six road	63	233	5,450
622	409	4,617	Stadium	315	1,038	6,174
5,003	2,154	4,831	Old high court	2,760	5,713	9,127
536	390	7,679	Shahpur	580	476	9,022
1,724	1,208	7,826	Ghee kanta	1,505	1,570	9,087
1,255	3,726	8,342	Kalupur rly stn	3,876	1,763	6,974
284	1,249	5,871	Kankaria east	1,134	404	6,243
274	1,007	4,906	Apparel park	1,218	307	5,332
282	1,812	4,172	Amraiwadi	1,932	404	3,803
151	1,414	2,643	Rabari	2,085	157	1,875
36	215	1,380	Vastral	583	16	1,308
70	58	1,200	Nirant Cross road	191	60	1,178
0	1,212	1,212	Vastral gam	1,178	0	0
15,912	**15,912**		**Total**	**18,051**	**18,051**	
			PHPDT			**9,127**

Table 2.75 Station wise Peak hour Boarding-Alighting on Corridor-II - 2021 (Moderate Scenario)

Motera to Mahatma Mandir				Mahatma Mandir to Motera		
Boarding	**Alighting**	**Sectional Load**	**Station Name**	**Boarding**	**Alighting**	**Sectional Load**
1,942	0	0	APMC	0	1,145	1,145
2,112	232	1,942	Jivraj	204	1,387	2,328
415	185	3,822	Rajiv nagar	58	812	3,082
490	163	4,052	Shreyash	83	695	3,694
1,786	536	4,380	Paldi	429	1,861	5,125
458	604	5,631	Gandhigram rly stn	180	1,638	6,583
3,868	3,335	5,485	Old high court	3,241	5,349	8,691
99	247	6,018	Ushmanpura	185	242	8,747
637	704	5,870	Vijay nagar	1,245	587	8,090
503	936	5,803	New vadaj	1,735	383	6,737
123	407	5,371	Ranip	529	143	6,351
341	723	5,087	Sabarmati Rly stn	1,087	354	5,617
34	183	4,706	AEC	174	51	5,495
93	412	4,557	Sabarmati	517	108	5,085
76	194	4,238	Motera Stadium	381	49	4,753
289	782	4,121	Koteshwar Road	1,441	176	3,488
56	133	3,627	Vishwakarma College	263	31	3,255
100	360	3,551	Tapovan Circle	389	91	2,958
26	53	3,290	Narmada Canal	92	14	2,880
94	155	3,264	Koba Circle	289	43	2,634
9	22	3,203	Juna Koba	35	5	2,604
20	39	3,189	Koba Gaam	68	10	2,546

Motera to Mahatma Mandir				Mahatma Mandir to Motera		
Boarding	**Alighting**	**Sectional Load**	**Station Name**	**Boarding**	**Alighting**	**Sectional Load**
211	756	3,170	GNLU	594	233	2,184
33	63	2,624	Raysan	105	16	2,096
44	83	2,594	Randesan	121	24	1,999
93	229	2,556	Dholakuva Circle	256	61	1,804
43	105	2,420	Infocity	103	33	1,735
85	109	2,358	Sector - 1	176	37	1,596
107	340	2,334	Sector 10A	134	129	1,591
23	492	2,102	Sachivalaya	40	153	1,704
96	332	1,632	Akshardham	324	95	1,475
74	213	1,396	Juna Sachivalaya	282	50	1,243
45	325	1,257	Sector - 16	236	58	1,065
31	711	977	Sector - 24	522	77	620
0	297	297	Mahatma Mandir	620	0	0
14,456	**14,460**		**Total**	**16,138**	**16,140**	
			PHPDT			**8747**
GNLU to GIFT City			**Station Name**	**GIFT City to GNLU**		
Boarding	**Alighting**	**Sectional load**		**Boarding**	**Alighting**	**Sectional load**
638	0	0	GNLU	0	476	476
43	102	638	PDPU	176	23	324
0	579	579	Gift City	324	0	0
681	681		**Total**	500	499	
			PHDT			**638**
Koteshwar Road to Airport			**Station Name**	**Airport to Koteshwar Road**		
Boarding	**Alighting**	**Sectional load**		**Boarding**	**Alighting**	**Sectional load**
525	0	0	Koteshwar Road	0	801	801
7	470	525	Sardarnagar	777	2	26
0	62	62	Airport	26	0	0
532	**532**		**Total**	**803**	**803**	
			PHDT			**801**

Peak hour Line Loading - 2031 Moderate Scenario

Table 2.76 Station wise Peak hour Boarding-Alighting on Corridor-I - 2031 (Moderate Scenario)

Thaltej Gaam to Vaastral Gaam				Vastral Gaam to Thaltej Gaam		
Boarding	**Alighting**	**Sectional Load**	**Station Name**	**Boarding**	**Alighting**	**Sectional Load**
2,514	0	0	Thaltej gaam	0	2,221	2,221
1,898	309	2,514	Thaltej	294	1,921	3,847
1,195	229	4,103	Doordarshan Kendra	251	1,074	4,669
525	90	5,069	Gurukul Road	114	393	4,949
1,079	506	5,505	Gujarat University	242	2,098	6,805
294	118	6,078	Commerce Six road	103	384	7,085

Thaltej Gaam to Vaastral Gaam				Vastral Gaam to Thaltej Gaam		
Boarding	**Alighting**	**Sectional Load**	**Station Name**	**Boarding**	**Alighting**	**Sectional Load**
1,004	474	6,254	Stadium	355	1,534	8,265
7,001	4,003	6,784	Old high court	4,938	7,482	10,809
555	549	9,782	Shahpur	758	427	10,478
1,200	1,382	9,789	Ghee kanta	1,707	984	9,755
1,165	4,400	9,606	Kalupur rly stn	3,912	1,811	7,653
281	1,180	6,372	Kankaria east	1,141	373	6,886
284	1,049	5,472	Apparel park	1,262	316	5,940
292	1,877	4,707	Amraiwadi	1,894	436	4,482
195	1,671	3,122	Rabari	2,535	187	2,134
38	353	1,645	Vastral	633	27	1,527
76	63	1,330	Nirant Cross road	201	67	1,392
0	1,343	1,343	Vastral gam	1,392	0	0
19,596	**19,596**		**Total**	**21,732**	**21,732**	
			PHPDT			**10,809**

Table 2.77 Station wise Peak hour Boarding-Alighting on Corridor-II - 2031 (Moderate Scenario)

Motera to Mahatma Mandir			Station Name	Mahatma Mandir to motera		
Boarding	**Alighting**	**Sectional Load**		**Boarding**	**Alighting**	**Sectional Load**
2,154	0	0	APMC	0	1,387	1,387
2,818	233	2,154	Jivraj	241	1,710	2,857
405	172	4,739	Rajiv nagar	54	754	3,557
509	170	4,972	Shreyash	80	737	4,214
1,873	403	5,310	Paldi	333	1,798	5,679
603	523	6,781	Gandhigram rly stn	146	1,918	7,450
6,317	4,611	6,861	Old high court	4,320	8,467	11,597
133	331	8,568	Ushmanpura	288	226	11,535
622	1,011	8,370	Vijay nagar	1,442	660	10,753
585	1,136	7,981	New vadaj	1,858	480	9,374
163	479	7,430	Ranip	599	186	8,961
408	1,161	7,114	Sabarmati Rly stn	1,613	408	7,756
62	272	6,362	AEC	263	89	7,582
131	480	6,151	Sabarmati	580	159	7,161
157	226	5,802	Motera Stadium	643	71	6,589
398	1,050	5,733	Koteshwar Road	1,690	278	5,178
66	169	5,081	Vishwakarma College	248	51	4,981
192	563	4,979	Tapovan Circle	641	181	4,521
73	84	4,607	Narmada Canal	215	27	4,333
193	235	4,596	Koba Circle	503	78	3,908
21	28	4,554	Juna Koba	69	7	3,846
34	63	4,547	Koba Gaam	93	19	3,772
572	1,239	4,518	GNLU	1,349	416	2,839
44	85	3,850	Raysan	131	21	2,729
65	137	3,810	Randesan	173	36	2,591
127	366	3,737	Dholakuva Circle	332	93	2,353

Motera to Mahatma Mandir			Station Name	Mahatma Mandir to motera		
Boarding	Alighting	Sectional Load		Boarding	Alighting	Sectional Load
72	120	3,498	Infocity	161	35	2,228
136	170	3,450	Sector - 1	263	54	2,018
156	471	3,416	Sector 10A	169	168	2,017
30	681	3,100	Sachivalaya	49	186	2,154
141	477	2,449	Akshardham	417	124	1,861
98	289	2,113	Juna Sachivalaya	323	63	1,601
66	537	1,922	Sector - 16	313	87	1,374
42	1,025	1,451	Sector - 24	638	104	841
0	468	468	Mahatma Mandir	841	0	0
19,466	**19,465**		**Total**	**21,078**	**21,078**	
			PHPDT			**11,597**
GNLU to GIFT City			**Station Name**	**GIFT City to GNLU**		
Boarding	**Alighting**	**Sectional load**		**Boarding**	**Alighting**	**Sectional load**
1,217	0	0	GNLU	0	1,326	1,326
130	191	1,217	PDPU	317	101	1,110
0	1,156	1,156	Gift City	1,110	0	0
1,347	**1,347**		**Total**	**1,427**	**1,427**	
			PHPDT			**1,326**
Koteshwar Road to Airport			**Station Name**	**Airport to Koteshwar Road**		
Boarding	**Alighting**	**Sectional load**		**Boarding**	**Alighting**	**Sectional load**
851	0	0	Koteshwar Road	0	1,062	1,062
7	782	851	Sardarnagar	1,037	2	27
0	76	76	Airport	27	0	0
858	**858**		**Total**	**1,064**	**1,064**	
			PHPDT			**1,062**

Peak hour Line Loading– 2041 Moderate Scenario

Table 2.78 Station wise Peak hour Boarding-Alighting on Corridor-I - 2041 (Moderate Scenario)

Thaltej Gaam to Vaastral Gaam			Station Name	Vastral Gaam to Thaltej Gaam		
Boarding	Alighting	Sectional Load		Boarding	Alighting	Sectional Load
3,385	0	0	Thaltej gaam	0	2,863	2,863
2,286	417	3,385	Thaltej	388	2,317	4,792
1,418	278	5,253	Doordarshan Kendra	300	1,278	5,770
840	144	6,394	Gurukul Road	181	628	6,218
1,280	621	7,090	Gujarat University	293	2,485	8,410
348	144	7,749	Commerce Six road	123	454	8,740
1,191	578	7,952	Stadium	422	1,816	10,135
8,716	5,100	8,565	Old high court	6,113	9,243	13,265
657	661	12,181	Shahpur	904	502	12,864
1,418	1,656	12,178	Ghee kanta	2,030	1,159	11,993
1,416	5,244	11,939	Kalupur rly stn	4,612	2,186	9,567
348	1,396	8,111	Kankaria east	1,342	457	8,683
356	1,237	7,063	Apparel park	1,478	388	7,593

Thaltej Gaam to Vaastral Gaam			Station Name	Vastral Gaam to Thaltej Gaam		
Boarding	Alighting	Sectional Load		Boarding	Alighting	Sectional Load
391	2,209	6,182	Amraiwadi	2,211	566	5,948
293	2,218	4,365	Rabari	3,233	280	2,996
55	412	2,440	Vastral	738	38	2,296
140	73	2,083	Nirant Cross road	232	127	2,191
0	2,151	2,151	Vastral gam	2,191	0	0
24,538	**24,538**		**Total**	**26,790**	**26,790**	
			PHPDT			**13,265**

Table 2.79 Station wise Peak hour Boarding-Alighting on Corridor-II - 2041 (Moderate Scenario)

Motera to Mahatma Mandir			Station Name	Mahatma Mandir to motera		
Boarding	Alighting	Sectional Load		Boarding	Alighting	Sectional Load
2,590	0	0	APMC	0	1,676	1,676
3,514	280	2,590	Jivraj	291	2,113	3,498
490	204	5,825	Rajiv nagar	64	905	4,339
607	200	6,111	Shreyash	93	882	5,128
2,243	475	6,518	Paldi	389	2,154	6,893
721	614	8,286	Gandhigram rly stn	170	2,288	9,011
8,182	5,541	8,392	Old high court	5,165	10,663	14,509
164	391	11,034	Ushmanpura	339	274	14,443
789	1,198	10,807	Vijay nagar	1,696	816	13,564
748	1,351	10,398	New vadaj	2,171	606	11,999
207	562	9,795	Ranip	699	231	11,531
528	1,361	9,439	Sabarmati Rly stn	1,879	514	10,166
80	319	8,606	AEC	306	112	9,973
176	555	8,367	Sabarmati	668	208	9,513
209	262	7,988	Motera Stadium	740	92	8,864
552	1,329	7,935	Koteshwar Road	2,025	401	7,240
90	193	7,157	Vishwakarma College	282	69	7,027
343	844	7,055	Tapovan Circle	987	311	6,351
140	146	6,554	Narmada Canal	359	54	6,046
343	384	6,548	Koba Circle	789	140	5,396
41	50	6,507	Juna Koba	116	14	5,295
48	80	6,498	Koba Gaam	116	26	5,205
847	1,586	6,466	GNLU	1,695	614	4,124
73	123	5,727	Raysan	187	35	3,971
116	233	5,677	Randesan	270	69	3,770
223	591	5,559	Dholakuva Circle	516	165	3,419
116	175	5,191	Infocity	230	57	3,246
219	249	5,132	Sector - 1	378	87	2,955
257	688	5,102	Sector 10A	242	275	2,988
48	995	4,671	Sachivalaya	70	300	3,217
230	718	3,724	Akshardham	612	205	2,810

158	421	3,236	Juna Sachivalaya	468	103	2,446
114	839	2,973	Sector - 16	491	148	2,102
76	1,576	2,248	Sector - 24	982	181	1,301
0	747	747	Mahatma Mandir	1,301	0	0
25,282	**25,280**		**Total**	**26,786**	**26,788**	
			PHPDT			**14,509**
GNLU to GIFT City			**Station Name**	**GIFT City to GNLU**		
Boarding	**Alighting**	**Sectional load**		**Boarding**	**Alighting**	**Sectional load**
1,632	0	0	GNLU	0	1,766	1,766
164	262	1,632	PDPU	435	127	1,458
0	1,534	1,534	Gift City	1,458	0	0
1,796	**1,796**		**Total**	**1,893**	**1,893**	
			PHPDT			**1,766**
Koteshwar Road to Airport			**Station Name**	**Airport to Koteshwar Road**		
Boarding	**Alighting**	**Sectional load**		**Boarding**	**Alighting**	**Sectional load**
1,113	0	0	Koteshwar Road	0	1,328	1,328
8	1,031	1,113	Sardarnagar	1,299	2	32
0	90	90	Airport	32	0	0
1,121	**1,121**		**Total**	**1,331**	**1,330**	
			PHPDT			**1,328**

Peak hour Line Loading– 2051 Moderate Scenario

Table 2.80 Station wise Peak hour Boarding-Alighting on Corridor-I - 2051 (Moderate Scenario)

Thaltej Gaam to Vaastral Gaam				**Vastral Gaam to Thaltej Gaam**		
Boarding	**Alighting**	**Sectional Load**	**Station Name**	**Boarding**	**Alighting**	**Sectional Load**
3,906	0	0	Thaltej gaam	0	3,366	3,366
2,710	487	3,906	Thaltej	469	2,668	5,565
1,554	313	6,129	Doordarshan Kendra	337	1,414	6,642
929	160	7,370	Gurukul Road	200	699	7,140
1,443	688	8,139	Gujarat University	331	2,765	9,574
383	160	8,894	Commerce Six road	135	502	9,941
1,365	640	9,117	Stadium	483	2,011	11,469
10,026	5,932	9,842	Old high court	6,995	10,632	15,106
721	737	13,936	Shahpur	998	551	14,658
1,569	1,847	13,921	Ghee kanta	2,269	1,275	13,664
1,629	5,841	13,643	Kalupur rly stn	5,267	2,394	10,791
394	1,557	9,431	Kankaria east	1,476	504	9,819
406	1,377	8,268	Apparel park	1,626	429	8,622
464	2,445	7,297	Amraiwadi	2,434	633	6,822
359	2,673	5,317	Rabari	3,710	336	3,447
66	458	3,003	Vastral	810	42	2,679
177	80	2,611	Nirant Cross road	253	162	2,588
0	2,708	2,708	Vastral gam	2,588	0	0

Thaltej Gaam to Vaastral Gaam				Vastral Gaam to Thaltej Gaam		
Boarding	**Alighting**	**Sectional Load**	**Station Name**	**Boarding**	**Alighting**	**Sectional Load**
28,102	**28,102**		**Total**	**30,384**	**30,384**	
			PHPDT			**15,106**

Table 2.81 Station wise Peak hour Boarding-Alighting on Corridor-II - 2051 (Moderate Scenario)

Motera to Mahatma Mandir			Station Name	Mahatma Mandir to motera		
Boarding	**Alighting**	**Sectional Load**		**Boarding**	**Alighting**	**Sectional Load**
2,870	0	0	APMC	0	1,877	1,877
3,962	309	2,870	Jivraj	321	2,421	3,977
546	222	6,523	Rajiv nagar	70	1,015	4,922
673	218	6,847	Shreyash	102	984	5,805
2,494	517	7,302	Paldi	426	2,415	7,793
803	666	9,279	Gandhigram rly stn	185	2,576	10,185
9,775	6,092	9,416	Old high court	5,718	12,501	16,968
189	427	13,100	Ushmanpura	369	315	16,913
989	1,348	12,862	Vijay nagar	1,970	964	15,907
974	1,601	12,503	New vadaj	2,602	753	14,057
242	618	11,876	Ranip	760	264	13,562
639	1,499	11,500	Sabarmati Rly stn	2,067	602	12,097
95	349	10,640	AEC	331	130	11,896
211	612	10,387	Sabarmati	731	243	11,407
251	286	9,986	Motera Stadium	798	108	10,717
756	1,640	9,950	Koteshwar Road	2,503	523	8,737
108	211	9,066	Vishwakarma College	304	80	8,513
463	1,039	8,962	Tapovan Circle	1,190	408	7,731
182	175	8,387	Narmada Canal	421	68	7,378
481	495	8,394	Koba Circle	995	191	6,574
53	60	8,379	Juna Koba	136	18	6,457
67	104	8,372	Koba Gaam	147	36	6,346
1,153	2,058	8,334	GNLU	2,087	829	5,088
102	161	7,429	Raysan	239	47	4,896
158	306	7,370	Randesan	341	93	4,647
306	775	7,221	Dholakuva Circle	656	221	4,212
147	213	6,752	Infocity	272	71	4,011
300	328	6,686	Sector - 1	483	116	3,643
347	908	6,659	Sector 10A	310	366	3,699
63	1,312	6,098	Sachivalaya	88	397	4,008
297	927	4,849	Akshardham	748	268	3,527
214	557	4,219	Juna Sachivalaya	606	137	3,058
145	1,048	3,876	Sector - 16	588	187	2,656
101	2,086	2,973	Sector - 24	1,239	243	1,660
0	989	989	Mahatma Mandir	1,660	0	0

30,156	**30,156**		**Total**	**31,463**	**31,467**	
			PHPDT			**16,968**
GNLU to GIFT City			**Station Name**	**GIFT City to GNLU**		
Boarding	**Alighting**	**Sectional load**		**Boarding**	**Alighting**	**Sectional load**
2,149	0	0	GNLU	0	2,261	2,261
222	343	2,149	PDPU	560	170	1,871
0	2,028	2,028	Gift City	1,871	0	0
2,371	**2,371**		**Total**	**2,431**	**2,431**	
			PHPDT			**2,261**
Koteshwar Road to Airport			**Station Name**	**Airport to Koteshwar Road**		
Boarding	**Alighting**	**Sectional load**		**Boarding**	**Alighting**	**Sectional load**
1,369	0	0	Koteshwar Road	0	1,668	1,668
10	1,278	1,369	Sardarnagar	1,636	3	35
0	101	101	Airport	35	0	0
1,379	**1,379**		**Total**	**1,671**	**1,671**	
			PHPDT			**1,668**

Peak hour Line Loading – 2017 Optimistic Scenario

Table 2.82 Station wise Peak hour Boarding-Alighting on Corridor-I - 2017 (Optimistic Scenario)

Thaltej Gaam to Vaastral Gaam				**Vastral Gaam to Thaltej Gaam**		
Boarding	**Alighting**	**Sectional Load**	**Station Name**	**Boarding**	**Alighting**	**Sectional Load**
1,739	0	0	Thaltej gaam	0	1,232	1,232
1,368	264	1,739	Thaltej	214	1,367	2,385
1,071	298	2,843	Doordarshan Kendra	222	1,213	3,376
391	167	3,616	Gurukul Road	99	581	3,859
654	450	3,840	Gujarat University	248	1,216	4,827
150	73	4,044	Commerce Six road	66	178	4,939
702	529	4,121	Stadium	436	1,230	5,733
3,091	1,398	4,294	Old high court	1,785	3,935	7,883
553	213	5,988	Shahpur	415	489	7,958
2,149	891	6,328	Ghee kanta	1,524	1,764	8,197
1,206	3,409	7,586	Kalupur rly stn	3,493	1,746	6,450
279	1,175	5,382	Kankaria east	1,077	399	5,773
280	949	4,487	Apparel park	1,150	313	4,936
284	1,672	3,818	Amraiwadi	1,807	402	3,531
159	1,319	2,429	Rabari	1,938	158	1,750
42	201	1,269	Vastral	541	17	1,227
86	54	1,110	Nirant Cross road	173	66	1,119
0	1,142	1,142	Vastral gam	1,119	0	0
14,204	**14,204**		**Total**	**16,305**	**16,305**	
			PHPDT			**8,197**

Table 2.83 Station wise Peak hour Boarding-Alighting on Corridor-II - 2017 (Optimistic Scenario)

APMC to Motera			Station Name	Motera to APMC		
Boarding	Alighting	Sectional Load		Boarding	Alighting	Sectional Load
1,768	0	0	APMC	0	1,009	1,009
1,805	254	1,768	Jivraj	222	1,109	1,896
384	192	3,319	Rajiv nagar	64	757	2,589
457	168	3,511	Shreyash	91	648	3,146
1,296	586	3,800	Paldi	483	1,278	3,940
435	815	4,511	Gandhigram rly stn	258	1,423	5,106
1,984	2,442	4,131	Old high court	2,248	3,256	6,113
58	143	3,673	Ushmanpura	88	199	6,224
495	458	3,588	Vijay nagar	933	492	5,783
331	851	3,625	New vadaj	1,645	294	4,432
91	398	3,105	Ranip	520	117	4,030
227	822	2,799	Sabarmati Rly stn	1,082	301	3,249
18	185	2,204	AEC	176	33	3,107
254	777	2,037	Sabarmati	1,164	246	2,188
0	1,514	1,514	Motera stadium	2,188	0	0
9,605	**9,605**		**Total**	**11,161**	**11,161**	
			PHPDT			**6,224**

Peak hour Line Loading – 2021 Optimistic Scenario

Table 2.84 Station wise Peak hour Boarding-Alighting on Corridor-I - 2021 (Optimistic Scenario)

Thaltej Gaam to Vaastral Gaam				Vastral Gaam to Thaltej Gaam		
Boarding	Alighting	Sectional Load	Station Name	Boarding	Alighting	Sectional Load
2,069	0	0	Thaltej gaam	0	1,438	1,438
1,577	253	2,069	Thaltej	205	1,558	2,792
988	247	3,393	Doordarshan Kendra	172	1,179	3,799
456	155	4,134	Gurukul Road	90	678	4,387
686	386	4,435	Gujarat University	198	1,370	5,559
199	73	4,734	Commerce Six road	66	245	5,737
655	430	4,861	Stadium	331	1,093	6,499
5,266	2,268	5,085	Old high court	2,905	6,013	9,607
565	410	8,083	Shahpur	611	501	9,497
1,815	1,271	8,238	Ghee kanta	1,584	1,653	9,566
1,321	3,923	8,781	Kalupur rly stn	4,080	1,855	7,341
299	1,315	6,180	Kankaria east	1,194	425	6,571
288	1,060	5,164	Apparel park	1,282	323	5,612
297	1,907	4,392	Amraiwadi	2,034	425	4,004
159	1,489	2,782	Rabari	2,195	165	1,974
38	226	1,452	Vastral	614	17	1,377
73	61	1,264	Nirant Cross road	201	63	1,240
0	1,275	1,275	Vastral gam	1,240	0	0
16,750	**16,750**		**Total**	**19,001**	**19,001**	
			PHPDT			**9,607**

Table 2.85 Station wise Peak hour Boarding-Alighting on Corridor-II - 2021 (Optimistic Scenario)

Motera to Mahatma Mandir			Station Name	Mahatma Mandir to motera		
Boarding	**Alighting**	**Sectional Load**		**Boarding**	**Alighting**	**Sectional Load**
2,044	0	0	APMC	0	1,206	1,206
2,223	245	2,044	Jivraj	215	1,460	2,450
437	195	4,023	Rajiv nagar	61	855	3,244
516	171	4,266	Shreyash	88	732	3,888
1,880	564	4,610	Paldi	452	1,958	5,395
482	636	5,927	Gandhigram rly stn	189	1,724	6,929
4,072	3,511	5,774	Old high court	3,412	5,630	9,148
105	260	6,334	Ushmanpura	195	255	9,207
671	741	6,179	Vijay nagar	1,310	618	8,515
530	985	6,109	New vadaj	1,827	403	7,092
130	428	5,654	Ranip	557	151	6,685
359	761	5,355	Sabarmati Rly stn	1,145	372	5,913
36	192	4,954	AEC	183	54	5,784
98	434	4,797	Sabarmati	544	113	5,353
80	204	4,461	Motera Stadium	402	51	5,003
304	823	4,338	Koteshwar Road	1,517	185	3,671
59	140	3,818	Vishwakarma College	277	32	3,427
105	379	3,738	Tapovan Circle	409	96	3,114
28	56	3,463	Narmada Canal	97	14	3,031
99	163	3,435	Koba Circle	304	45	2,772
9	24	3,371	Juna Koba	36	5	2,741
21	41	3,357	Koba Gaam	71	10	2,680
222	796	3,337	GNLU	625	245	2,299
35	67	2,763	Raysan	110	17	2,206
46	87	2,731	Randesan	127	25	2,105
98	241	2,690	Dholakuva Circle	270	65	1,899
45	111	2,548	Infocity	108	34	1,826
89	115	2,483	Sector - 1	185	39	1,680
113	358	2,457	Sector 10A	141	135	1,674
24	518	2,212	Sachivalaya	42	161	1,794
101	350	1,718	Akshardham	341	100	1,552
78	224	1,470	Juna Sachivalaya	297	53	1,309
47	342	1,323	Sector - 16	248	61	1,122
33	749	1,029	Sector - 24	550	82	653
0	312	312	Mahatma Mandir	653	0	0
15,219	**15,223**		**Total**	**16,988**	**16,986**	
			PHPDT			**9,207**
GNLU to GIFT City				**GIFT City to GNLU**		

Boarding	Alighting	Sectional load	Station Name	Boarding	Alighting	Sectional load
671	0	0	GNLU	0	501	501
45	107	671	PDPU	185	24	341
0	609	609	Gift City	341	0	0
716	**716**		**Total**	**526**	**525**	
			PHPDT			**671**
Koteshwar Road to Airport			**Station Name**	**Airport to Koteshwar Road**		
Boarding	**Alighting**	**Sectional load**		**Boarding**	**Alighting**	**Sectional load**
553	0	0	Koteshwar Road	0	843	843
8	495	553	Sardarnagar	818	2	27
0	65	65	Airport	27	0	0
561	**560**		**Total**	**845**	**845**	
			PHPDT			**843**

Peak hour Line Loading – 2031 Optimistic Scenario

Table 2.861 Station wise Peak hour Boarding-Alighting on Corridor-I - 2031(Optimistic Scenario)

Thaltej Gaam to Vaastral Gaam			Station Name	Vastral Gaam to Thaltej Gaam		
Boarding	**Alighting**	**Sectional Load**		**Boarding**	**Alighting**	**Sectional Load**
2,762	0	0	Thaltej gaam	0	2,439	2,439
2,085	339	2,762	Thaltej	323	2,110	4,227
1,313	251	4,507	Doordarshan Kendra	276	1,179	5,130
577	98	5,569	Gurukul Road	125	432	5,437
1,186	556	6,048	Gujarat University	266	2,305	7,475
322	129	6,677	Commerce Six road	113	422	7,784
1,104	521	6,870	Stadium	390	1,686	9,080
7,691	4,398	7,453	Old high court	5,424	8,219	11,875
610	603	10,747	Shahpur	833	469	11,511
1,318	1,518	10,754	Ghee kanta	1,875	1,081	10,716
1,280	4,834	10,553	Kalupur rly stn	4,298	1,990	8,408
309	1,297	7,000	Kankaria east	1,254	410	7,564
312	1,152	6,012	Apparel park	1,386	347	6,525
320	2,062	5,171	Amraiwadi	2,080	479	4,924
214	1,836	3,430	Rabari	2,785	205	2,344
41	387	1,807	Vastral	696	29	1,678
84	69	1,461	Nirant Cross road	221	73	1,530
0	1,476	1,476	Vastral gam	1,530	0	0
21,527	**21,527**		**Total**	**23,875**	**23,875**	
			PHPDT			**11,875**

Table 2.87 Station wise Peak hour Boarding-Alighting on Corridor-II - 2031 (Optimistic Scenario)

Motera to Mahatma Mandir			Station Name	Mahatma Mandir to motera		
Boarding	**Alighting**	**Sectional Load**		**Boarding**	**Alighting**	**Sectional Load**
2,366	0	0	APMC	0	1,524	1,524

Motera to Mahatma Mandir			Station Name	Mahatma Mandir to motera		
Boarding	Alighting	Sectional Load		Boarding	Alighting	Sectional Load
3,096	256	2,366	Jivraj	265	1,879	3,139
445	189	5,206	Rajiv nagar	59	828	3,907
559	186	5,462	Shreyash	88	810	4,630
2,058	443	5,834	Paldi	366	1,975	6,238
663	574	7,449	Gandhigram rly stn	161	2,107	8,185
6,940	5,065	7,538	Old high court	4,746	9,302	12,740
146	363	9,412	Ushmanpura	317	249	12,672
684	1,111	9,195	Vijay nagar	1,584	725	11,813
643	1,248	8,768	New vadaj	2,042	527	10,298
179	526	8,163	Ranip	658	204	9,845
449	1,275	7,816	Sabarmati Rly stn	1,772	448	8,521
68	299	6,989	AEC	289	98	8,330
144	527	6,758	Sabarmati	637	175	7,867
172	248	6,374	Motera Stadium	707	78	7,239
437	1,153	6,298	Koteshwar Road	1,856	306	5,688
73	185	5,582	Vishwakarma College	272	56	5,472
210	619	5,469	Tapovan Circle	704	199	4,966
80	93	5,061	Narmada Canal	236	30	4,761
212	258	5,049	Koba Circle	553	85	4,293
24	31	5,003	Juna Koba	76	8	4,225
37	69	4,995	Koba Gaam	102	21	4,144
628	1,361	4,963	GNLU	1,481	457	3,119
48	93	4,230	Raysan	144	23	2,998
71	151	4,185	Randesan	190	40	2,847
140	403	4,106	Dholakuva Circle	364	102	2,585
79	132	3,843	Infocity	176	39	2,447
149	187	3,790	Sector - 1	289	59	2,217
171	517	3,752	Sector 10A	186	184	2,216
33	748	3,406	Sachivalaya	54	205	2,366
154	524	2,691	Akshardham	458	136	2,044
107	317	2,321	Juna Sachivalaya	355	70	1,759
73	590	2,111	Sector - 16	344	95	1,510
46	1,126	1,594	Sector - 24	701	115	924
0	514	514	Mahatma Mandir	924	0	0
21,384	**21,381**		**Total**	**23,156**	**23,159**	
			PHPDT			**12,740**

GNLU to GIFT City			Station Name	GIFT City to GNLU		
Boarding	Alighting	Sectional load		Boarding	Alighting	Sectional load
1,337	0	0	GNLU	0	1,457	1,457
143	209	1,337	PDPU	348	111	1,220
0	1,270	1,270	Gift City	1,220	0	0
1,480	**1,479**		**Total**	**1,568**	**1,568**	

Motera to Mahatma Mandir			Station Name	Mahatma Mandir to motera		
Boarding	Alighting	Sectional Load		Boarding	Alighting	Sectional Load
			PHPDT			**1,457**
Koteshwar Road to Airport			**Station Name**	**Airport to Koteshwar Road**		
Boarding	**Alighting**	**Sectional load**		**Boarding**	**Alighting**	**Sectional load**
935	0	0	Koteshwar Road	0	1,166	1,166
7	859	935	Sardarnagar	1,139	2	29
0	83	83	Airport	29	0	0
942	**942**		**Total**	**1,168**	**1,168**	
			PHPDT			**1,166**

Peak hour Line Loading – 2041 Optimistic Scenario

Table 2.88 Station wise Peak hour Boarding-Alighting on Corridor-I – 2041 (Optimistic Scenario)

Thaltej Gaam to Vaastral Gaam				Vastral Gaam to Thaltej Gaam		
Boarding	**Alighting**	**Sectional Load**	**Station Name**	**Boarding**	**Alighting**	**Sectional Load**
3,667	0	0	Thaltej gaam	0	3,102	3,102
2,476	452	3,667	Thaltej	421	2,510	5,191
1,537	301	5,691	Doordarshan Kendra	325	1,385	6,251
910	156	6,927	Gurukul Road	196	681	6,736
1,386	673	7,681	Gujarat University	317	2,693	9,111
377	156	8,394	Commerce Six road	134	491	9,469
1,290	626	8,615	Stadium	457	1,968	10,980
9,442	5,525	9,279	Old high court	6,623	10,013	14,370
712	716	13,196	Shahpur	979	544	13,936
1,536	1,794	13,192	Ghee kanta	2,199	1,255	12,992
1,534	5,681	12,934	Kalupur rly stn	4,996	2,369	10,365
377	1,513	8,787	Kankaria east	1,454	495	9,406
385	1,340	7,652	Apparel park	1,601	421	8,226
424	2,393	6,697	Amraiwadi	2,395	613	6,444
318	2,403	4,728	Rabari	3,503	304	3,245
60	446	2,643	Vastral	799	41	2,487
152	79	2,257	Nirant Cross road	251	138	2,374
0	2,330	2,330	Vastral gam	2,374	0	0
26,583	**26,583**		**Total**	**29,022**	**29,022**	
			PHPDT			**14,370**

Table 2.89 Station wise Peak hour Boarding-Alighting on Corridor-II - 2041 (Optimistic Scenario)

Motera to Mahatma Mandir			Station Name	Mahatma Mandir to motera		
Boarding	**Alighting**	**Sectional Load**		**Boarding**	**Alighting**	**Sectional Load**
2,806	0	0	APMC	0	1,816	1,816
3,807	303	2,806	Jivraj	316	2,289	3,789
531	221	6,310	Rajiv nagar	69	981	4,701

Motera to Mahatma Mandir			Station Name	Mahatma Mandir to motera		
Boarding	Alighting	Sectional Load		Boarding	Alighting	Sectional Load
658	217	6,620	Shreyash	101	956	5,555
2,429	515	7,061	Paldi	422	2,334	7,467
781	665	8,976	Gandhigram rly stn	184	2,479	9,762
8,864	6,002	9,092	Old high court	5,596	11,551	15,718
177	423	11,953	Ushmanpura	367	296	15,647
855	1,298	11,707	Vijay nagar	1,837	884	14,694
810	1,463	11,264	New vadaj	2,352	657	12,999
224	609	10,611	Ranip	757	250	12,492
572	1,475	10,226	Sabarmati Rly stn	2,035	557	11,013
87	345	9,323	AEC	331	122	10,804
190	601	9,065	Sabarmati	723	225	10,305
226	284	8,654	Motera Stadium	802	100	9,603
598	1,440	8,596	Koteshwar Road	2,194	434	7,844
97	209	7,754	Vishwakarma College	306	75	7,612
372	914	7,642	Tapovan Circle	1,069	337	6,880
152	159	7,100	Narmada Canal	389	58	6,549
372	416	7,094	Koba Circle	855	152	5,846
44	54	7,049	Juna Koba	126	16	5,736
52	87	7,040	Koba Gaam	126	29	5,639
918	1,718	7,005	GNLU	1,836	665	4,468
80	134	6,204	Raysan	203	37	4,302
125	253	6,150	Randesan	292	74	4,084
241	640	6,023	Dholakuva Circle	559	179	3,704
126	190	5,624	Infocity	250	62	3,517
237	270	5,560	Sector - 1	409	94	3,202
279	745	5,527	Sector 10A	263	298	3,237
52	1,078	5,060	Sachivalaya	76	325	3,485
250	778	4,034	Akshardham	663	222	3,045
171	456	3,506	Juna Sachivalaya	507	112	2,650
124	909	3,220	Sector - 16	532	160	2,277
82	1,707	2,435	Sector - 24	1,064	196	1,410
0	810	810	Mahatma Mandir	1,410	0	0
27,389	**27,388**		**Total**	**29,021**	**29,022**	
			PHPDT			**15,718**

GNLU to GIFT City			Station Name	GIFT City to GNLU		
Boarding	Alighting	Sectional load		Boarding	Alighting	Sectional load
1,768	0	0	GNLU	0	1,913	1,913
178	284	1,768	PDPU	472	137	1,579
0	1,662	1,662	Gift City	1,579	0	0
1,946	**1,946**		**Total**	**2,051**	**2,050**	
			PHPDT			**1,913**

Koteshwar Road to Airport			Station Name	Airport to Koteshwar Road		
Boarding	Alighting	Sectional load		Boarding	Alighting	Sectional load
1,205	0	0	Koteshwar Road	0	1,439	1,439
9	1,116	1,205	Sardarnagar	1,407	3	34
0	98	98	Airport	34	0	0
1,214	**1,214**		**Total**	**1,441**	**1,442**	
			PHPDT			**1,439**

Peak hour Line Loading – 2051 Optimistic Scenario

Table 2.90 Station wise Peak hour Boarding-Alighting on Corridor-I – 2051 (Optimistic Scenario)

Thaltej Gaam to Vaastral Gaam				Vastral Gaam to Thaltej Gaam		
Boarding	Alighting	Sectional Load	Station Name	Boarding	Alighting	Sectional Load
4,227	0	0	Thaltej gaam	0	3,642	3,642
2,933	527	4,227	Thaltej	507	2,888	6,023
1,682	339	6,633	Doordarshan Kendra	365	1,530	7,188
1,005	173	7,976	Gurukul Road	217	756	7,727
1,561	744	8,808	Gujarat University	358	2,992	10,361
414	173	9,625	Commerce Six road	147	544	10,758
1,477	692	9,867	Stadium	523	2,176	12,412
10,850	6,419	10,651	Old high court	7,570	11,506	16,347
781	797	15,081	Shahpur	1,081	596	15,863
1,698	1,999	15,065	Ghee kanta	2,456	1,380	14,787
1,763	6,321	14,764	Kalupur rly stn	5,700	2,591	11,678
427	1,685	10,206	Kankaria east	1,597	546	10,626
439	1,490	8,948	Apparel park	1,760	464	9,331
502	2,646	7,897	Amraiwadi	2,634	685	7,382
389	2,893	5,754	Rabari	4,015	364	3,730
71	496	3,249	Vastral	877	46	2,900
192	87	2,825	Nirant Cross road	274	175	2,800
0	2,930	2,930	Vastral gam	2,800	0	0
30,412	**30,412**		**Total**	**32,881**	**32,881**	
			PHPDT			**16,347**

Table 2.91 Station wise Peak hour Boarding-Alighting on Corridor-II - 2051 (Optimistic Scenario)

Motera to Mahatma Mandir			Station Name	Mahatma Mandir to motera		
Boarding	Alighting	Sectional Load		Boarding	Alighting	Sectional Load
3,106	0	0	APMC	0	2,032	2,032
4,288	334	3,106	Jivraj	347	2,620	4,304
591	241	7,059	Rajiv nagar	76	1,098	5,327
728	236	7,410	Shreyash	110	1,065	6,282
2,699	559	7,902	Paldi	461	2,613	8,434

869	720	10,041	Gandhigram rly stn	200	2,788	11,022
10,578	6,593	10,190	Old high court	6,188	13,528	18,362
205	462	14,176	Ushmanpura	399	341	18,304
1,071	1,459	13,919	Vijay nagar	2,132	1,043	17,214
1,054	1,733	13,531	New vadaj	2,816	814	15,212
262	669	12,852	Ranip	822	286	14,676
692	1,622	12,445	Sabarmati Rly stn	2,237	652	13,091
103	378	11,515	AEC	358	141	12,874
229	663	11,241	Sabarmati	791	263	12,345
271	310	10,807	Motera Stadium	863	116	11,598
818	1,775	10,768	Koteshwar Road	2,709	566	9,455
116	229	9,811	Vishwakarma College	329	87	9,213
501	1,124	9,699	Tapovan Circle	1,288	442	8,367
197	190	9,076	Narmada Canal	456	74	7,985
520	536	9,083	Koba Circle	1,077	207	7,115
58	65	9,067	Juna Koba	147	20	6,987
72	113	9,060	Koba Gaam	159	39	6,867
1,247	2,227	9,019	GNLU	2,259	897	5,506
110	175	8,040	Raysan	258	51	5,298
171	332	7,976	Randesan	369	100	5,029
331	839	7,815	Dholakuva Circle	710	239	4,558
159	230	7,307	Infocity	295	77	4,340
325	355	7,236	Sector - 1	523	126	3,943
375	983	7,206	Sector 10A	336	396	4,003
69	1,420	6,599	Sachivalaya	95	430	4,337
321	1,003	5,247	Akshardham	810	290	3,817
231	603	4,565	Juna Sachivalaya	656	148	3,309
157	1,134	4,194	Sector - 16	637	202	2,875
109	2,257	3,218	Sector - 24	1,341	263	1,797
0	1,070	1,070	Mahatma Mandir	1,797	0	0
32,633	**32,639**		**Total**	**34,051**	**34,054**	
			PHPDT			**18,362**

GNLU to GIFT City				**GIFT City to GNLU**		
Boarding	**Alighting**	**Sectional load**	**Station Name**	**Boarding**	**Alighting**	**Sectional load**
2,326	0	0	GNLU	0	2,447	2,447
240	371	2,326	PDPU	606	184	2,024
0	2,194	2,194	Gift City	2,024	0	0
2,566	**2,565**		**Total**	**2,630**	**2,631**	
			PHPDT			**2,447**

Koteshwar Road to Airport				**Airport to Koteshwar Road**		
Boarding	**Alighting**	**Sectional load**	**Station Name**	**Boarding**	**Alighting**	**Sectional load**
1,482	0	0	Koteshwar Road	0	1,806	1,806
11	1,383	1,482	Sardarnagar	1,771	3	38
0	109	109	Airport	38	0	0
1,493	**1,492**		**Total**	**1,809**	**1,809**	

			PHPDT			**1,806**

The total number of trips distribution with respect to trip length for moderate and optimistic scenarios is given below:

Table 2.92 Trip Length Frequency Distribution (TLFD) of Estimated Passenger Trips in Ahmedabad Metro

Trip length (km)	Moderate Scenario				Optimistic Scenario			
	Trips 2021	Trips 2031	Trips 2041	Trips 2051	Trips 2021	Trips 2031	Trips 2041	Trips 2051
0 - 2	4,482	6,386	7,768	8,635	4,718	7,016	8,415	9,345
2 - 4	21,312	25,414	31,521	35,641	22,434	27,920	34,147	38,570
4 - 6	43,993	49,909	60,793	68,127	46,309	54,830	65,859	73,726
6 - 8	58,288	58,471	71,208	80,302	61,356	64,235	77,142	86,903
8 - 10	66,369	79,004	95,855	108,298	69,862	86,794	103,843	117,199
10 - 12	64,458	71,902	87,133	98,988	67,850	78,990	94,394	107,124
12 - 14	49,520	57,111	69,599	79,203	52,126	62,741	75,398	85,713
14 - 16	45,790	52,354	64,146	74,249	48,200	57,515	69,492	80,351
16 - 18	32,615	42,445	53,992	63,317	34,332	46,629	58,491	68,521
18 - 20	22,156	28,295	36,850	43,721	23,322	31,084	39,922	47,315
20 - 22	19,540	23,517	31,391	37,886	20,569	25,835	34,007	41,000
22 - 24	15,806	21,689	29,690	36,147	16,638	23,827	32,164	39,118
24 - 26	11,664	16,326	22,433	27,588	12,278	17,935	24,302	29,856
26 - 28	9,842	13,750	19,202	23,694	10,360	15,106	20,802	25,642
28 - 30	9,250	12,804	17,565	21,754	9,737	14,066	19,029	23,542
30 - 32	7,722	10,907	15,130	18,790	8,129	11,982	16,391	20,334
32 - 34	6,855	9,502	13,077	16,303	7,216	10,439	14,166	17,644
34 - 36	5,483	7,882	11,106	13,912	5,772	8,659	12,032	15,055
36 - 38	5,118	6,818	9,627	11,939	5,388	7,490	10,430	12,921
38 - 40	3,946	5,358	7,869	9,811	4,153	5,887	8,525	10,618
40 - 42	3,186	4,246	6,259	7,847	3,353	4,664	6,781	8,492
42 - 44	2,337	3,121	4,749	5,917	2,460	3,429	5,145	6,403
44 - 46	1,665	2,172	3,416	4,260	1,753	2,387	3,700	4,610
46 - 48	1,050	1,416	2,307	2,910	1,106	1,556	2,499	3,149
>48	1,615	2,141	3,856	4,936	1,699	2,353	4,177	5,342

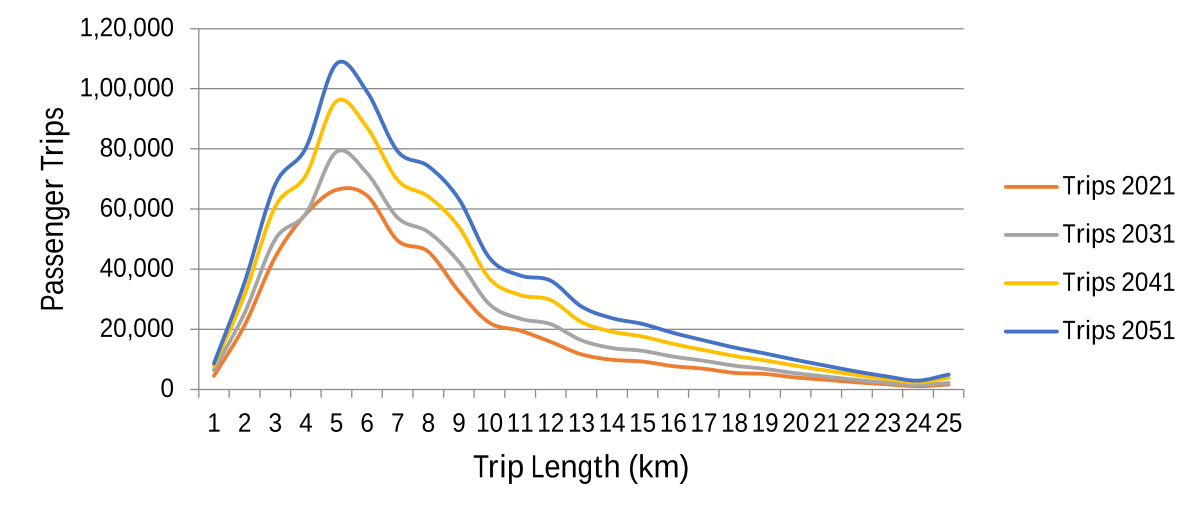


Figure 2.25 Trip Length Frequency Distribution for Moderate Scenario

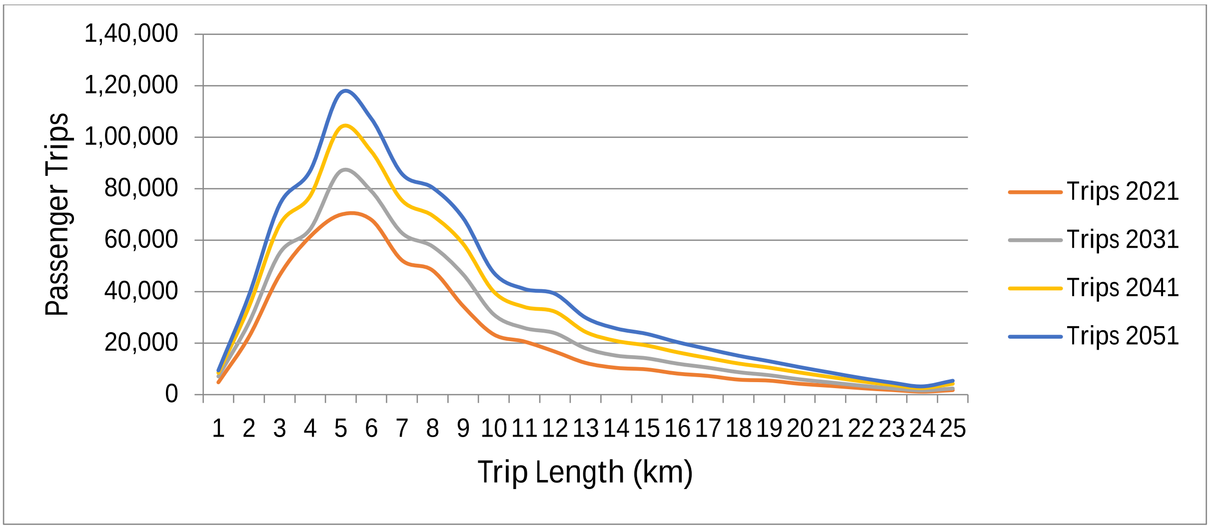


Figure 2.26 Trip Length Frequency Distribution for Optimistic Scenario

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) **Medium Capacity Metro System**: This metro system has the capacity of PHPDT varying from more than 30,000 and upto 45,000.

iv) **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 signalling at road inter-section.

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

vi) **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)	9.0	15.0
Width (m)	2.5	2.5	3.0
Height (m)	3.7	3.5	5.2
Number of doors	3	2	2
Wheel arrangement	2-2-2	2	2-2

System	LRT (Light Rail Transit) (elevated)	AGT (Automated Guide way Transit)	Straddle type Monorail
Weight (tare) (ton)	44	10.5	27.9
Axle load (max)	10tf	9tf	11tf
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 %
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	17	45
standing	90	33	60
total	150 (30m)	60 (L=9m)	105 (L=15m)
4 car seat	120	162	180
standing	180	198	240
total	300 (30m+30m)	360 (6 car L=54m)	420 (L=60m)
8 car seat	240	324	360
standing	360	396	480
total	600 (30m+30m+30m+30m)	720 (12 car L=108m)	840 (L=120m)

System	LRT (Light Rail Transit) (elevated)	AGT (Automated Guide way Transit)	Straddle type Monorail
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 surrounding and harmony with urban landscape			
Effect on ambient surrounding	Its noise proof 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

System	LRT (Light Rail Transit) (elevated)	AGT (Automated Guide way Transit)	Straddle type Monorail
			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)	14.0	24.0	18 (articulated type)
Width (m)	2.6	3.0	2.0
Height (m)	4.3	4.2	3.5
Number of doors	2	4	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 load	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

System	Urban Maglev (HSST)	Metro/Subway	Bus Rapid transit
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			
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	It has less maintenance of track.	It requires maintenance of roads.

System	Urban Maglev (HSST)	Metro/Subway	Bus Rapid transit
	movement.		
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 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 is 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.

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 4,75,236 passengers. The average trip length will be 5.68km in year 2021. Corridor wise total daily ridership figures of phase II for the years 2021, 2031, 2041and 2051 and PHPDT are shown in **Table 3.2.**

Table 3.2 - Proposed Ahmedabad Metro Phase II Ridership Summary

Moderate Scenario

Target Year	Metro Routes Operational	Route Length (km)	Daily Ridership (Passengers)	PHPDT (Passengers)	Interchange Passengers	Daily Passenger Kilometers (km)	Average Trip Length (km)
2021	APMC to Motera	41.33	273,013	8,747	91,964	1,648,421	6.04
	Motera to Mahatma Mandir	22.84	99,791	4,121		1,050,899	10.53
	GNLU to Gift City	5.416	11,798	638		48,680	4.13
	Koteshwar road to Airport (2A)	6.339	13,349	801		57,244	4.29
	Phase 2 Corridors	**34.59**	**124938**			**1,156,823**	**9.26**
2031	APMC to Motera	18.49	355,327	11,597	155,257	2,167,525	6.1
	Motera to Mahatma Mandir	22.84	158,397	5,733		1,511,450	9.54
	GNLU to Gift City	5.416	27,742	1,326		118,093	4.26
	Koteshwar road to Airport (2A)	6.339	19,215	1,062		82,365	4.29
	Phase 2 Corridors	**34.59**	**205,354**			**1,711,908**	**8.34**
2041	APMC to Motera	18.49	442,211	14,509	210,155	2,765,155	6.25
	Motera to Mahatma Mandir	22.84	227,228	7,935		2,181,127	9.6
	GNLU to Gift City	5.416	36,893	1,766		156,555	4.24
	Koteshwar road to Airport (2A)	6.339	24,513	1,328		104,999	4.28
	Phase 2 Corridors	**34.59**	**288,634**			**2,442,681**	**8.46**
2051	APMC to Motera	18.49	512,550	16,968	261,422	3,248,255	6.34
	Motera to Mahatma Mandir	22.84	286,579	9,950		2,749,724	9.59
	GNLU to Gift City	5.416	48,018	2,261		203,694	4.24
	Koteshwar road to Airport (2A)	6.339	30,504	1,668		130,514	4.28
	Phase 2 Corridors	**34.59**	**365,101**			**3,083,932**	**8.45**

Note: APMC to Motera Stadium segment of APMC to Mahatma Mandir Corridor is Phase-I. It's extension from Motera Stadium to Mahatma Mandir, Koteshwar Road to Airport and fro GNLU to GIFT City Corridors are phase II Corridors.

3.4 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 4121 on the extension of the North South Corridor from Motera Stadium to Mahatma Mandir, 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 than Light metro. The Mono rail is being adopted only for small lengths and as feeder to Metro worldwide.

Based on MMRDA's experience, following are the demerits of Monorail over Light Capacity Metro:

- Technology is not proven.
- It has comparatively high maintenance cost due to wear and tear of rubber tyres.
- Problems in emergency evacuation thus posing disaster management problems.
- Total dependence on Rolling Stock supplier. No indigenous production of Rolling Stock. Total dependence on manufacturer of spares.
- It has poor ride quality as compared to metro.
- Rolling Stock cannot be purchased from another manufacturer without changing the guide beams.
- Higher Life Cycle Cost

The capital cost of Mono rail is also almost same as that of Light Capacity Metro. MMRDA is now shifting to Metro Rail System on its earlier proposed Monorail corridor Thane- Bhiwandi – Kalyan after having bad experience of their Wadala – Chembur Monorail Corridor.

Moreover it is extension of under implementation corridor from APMC to Motera Stadium, therefore it is recommended to adopt same system i.e. Light Capacity Metro System.

Ridership and PHPDT figures in year 2021 of Koteshwar Road to Airport Corridor are 13349 and 801 respectively. Similarly Ridership and PHPDT figures of GNLU to GIFT City Corridor are 11798 and 638 respectively. These corridors can be managed with the road based transportation system or any other grade separated low capacity transportation system for quite a long time. However any new mode of transport will require additional full-fledged depot, different type of inventory of rolling stock and separate team of operation and maintenance staff. Moreover there will not be seamless integration at Koteshwar Road and GNLU stations. Hence same mode of transportation i.e. Light Capacity Metro System is examined for these corridors also.

Chapter - 4

GEOMETRIC DESIGNING PARAMETERS AND ALIGNMENT DESCRIPTION

4.1 GENERAL

The proposed corridors will be implemented with track on Standard Gauge (SG) 1435mm.

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

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

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. Minimum radius of 125m has been used at one location having speed potential upto 40 km/h. For maximum permissible speed on curve with various radii, Table 4.2 may be referred.

4.2.2 Horizontal Curves

Table 4.1

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

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

* not used in this corridor.

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

The track centre on the elevated section is kept as 4.7 m uniform throughout the corridor to standardize the superstructure.

(b) Gradients

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

(c) Vertical Curves

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

(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 operational 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 Permitted Speed, Cant & Minimum Track Spacing on Curves

RADIUS (m)	CANT (mm)	MAXIMUM PERMISSIBLE SPEED (kmph)	MINIMUM DISTANCE BETWEEN ADJACENT TRACKS (mm)
			ELEVATED & AT-GRADE
3000	15	80	3650
2800	15	80	3650
2400	20	80	3650
2000	20	80	3650
1600	25	80	3650
1500	30	80	3650
1200	35	80	3650
1000	45	80	3700
800	55	80	3700
600	70	80	3750
500	85	80	3750
450	95	80	3800
400	105	80	3800
350	110	75	3800
300	110	70	3850
200	110	55	3950
150	110	45	4050
150*	0	30	4050
120	110	40	4150
120*	0	25	4150

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

Notes:

a) The track spacing shown in the table above is without any column/structure between two tracks and is with equal cant both for outer and inner tracks.

b) Track spacing shown in the table above 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 for Motera Stadium to Mahatma Mandir, Koteshwar Road to Airport and GNLU to GIFT City corridors are close to 1.14 km, 2.92 km and 2.30 km respectively.

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 Ahmedabad Metro Rail Project Phase-II network. The normal ballasted track in Stabling Yard /Depot (except inside the Workshops, inspection lines and washing plant lines). The ballastless track is recommended on Viaducts as the regular cleaning and replacement of ballast at such locations will not be possible.

For the stabling yard/depots, ballasted track is recommended as ballastless track on formation is not suitable due to settlement of formations. Ballastless track in stabling yard/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 Stabling Yard/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.

4.6 BALLASTLESS TRACK IN STABLING YARD/DEPOT

The ballast less track in Stabling Yard/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

Sr. No.	Description	Turn-out Type
1	Main Line	1 in 9
2	Depot/ Stabling 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

Three Corridors have been identified for implementation in Phase-II of Ahmedabad Metro Rail Project are as follows:-

Table 4. 4

Sr. No.	Corridors	Total Length (km)
i)	Motera Stadium to Mahatma Mandir	22.838
ii)	GNLU to GIFT City	5.416
	Total Length	**28.254**
iii)	Koteshwar Road – Airport (Phase-IIA)	6.339
	Total Length (II + IIA)	**34.593**

4.11 MOTERA STADIUM TO MAHATMA MANDIR CORRIDOR

The features of Motera Stadium to Mahatma Mandir Corridor along with the details of route alignment have been described below:-

4.11.1 References

(a) Chainages

Since this corridor is extension on N-S corridor under implementation, thus Chainage at Motera Stadium end is '16661.70 m' and it increases towards Mahatma Mandir.

(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 Motera Stadium to Mahatma Mandir has been named as 'Up line' and 'Down line' is converse of it.

4.11.2 Features of the Corridor

First station on this Corridor is named as Koteshwar Road and last station is Mahatma Mandir.

Total length of the corridor from dead end to dead end is 22.838 km. The entire corridor proposed is elevated.

Twenty stations have been proposed on the corridor. Names of stations are Koteshwar Road, Vishwakarma College, Tapovan Circle, Narmada Canal, Koba Circle, Juna Koba, Koba Gaam, GNLU, Raysan, Randesan, Dholakuva Circle, Infocity, Sector - 1, Sector 10A, Sachivalaya, Akshardham, Juna Sachivalaya, Sector - 16, Sector – 24 and Mahatma Mandir. Attempt has been made to locate stations at about a kilometer apart. However due to various considerations such as ridership, accessibility, availability of land, design considerations etc; a few stations could not be located at one km. distance apart. The maximum and minimum inter station distances are 1436.18 m and 899 m respectively. No separate depot is proposed for Phase-II corridors. Gyaspur depot will be augmented to serve these corridors also and a stabling depot is proposed at Indroda Circle.

This corridor runs in South to North direction. It connects Koba Circle, GNLU, Infocity, Sachivalaya, Akshardham, Mahatma Mandir and Gandhinager Railway Station.

Width of median in Gandhinagar area varies from 1 m – 1.3 m (approx.) whereas 2.8 m wide median is required for construction of elevated corridor along the road median. Thus the width of both the carriageway will decrease by approx. 0.9 m and hence it is proposed to widen the road by approx. 0.9 m on both sides.

Alignment between Koba Circle and Dholakuva is along the proposed road in the green field area. No land is considered for running section in this area as the alignment is along the proposed road and land for this road will be acquired by GUDA.

4.11.3 Station Locations

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

All stations will be two level stations. The concourse comprising of passenger facilities and station facilities will be at lower level and the platforms on the higher level. Concourse of all these stations is proposed along the roads with sufficient Right of way. Three types of the stations have been conceptualized, for detailed information Chapter-6 on station Planning may be referred.

4.11.4 Terminals

As this corridor is extension of N-S corridor already under implementation, thus this corridor there is only one terminal station:

Mahatma Mandir Terminal

This Station is proposed on the road median. Scissors crossovers are proposed at the front end of the station for train reversals.

4.11.5 Scissors Crossovers

Scissors Crossovers will be provided at the terminal station viz. Mahatma Mandir. In between, crossovers are proposed at Koteshwar Road Station and GNLU Station.

4.11.6 Depot

No separate depot is proposed for Phase-II corridors. It is proposed to augment Gyaspur depot of North-South corridor under implementation for Phase-II corridors also and a stabling depot is proposed at Indroda Circle.

4.11.7 Description of Alignment

Horizontal Alignment:

This corridor is extension of APMC to Motera Stadium corridor under implementation. The first station of this extension is Koteshwar Road at Chainage 17598.8 m; initially alignment runs on the left side of the road and from chainage 18160m it aligns onto the road median; it continues along the road median. Koteshwar Road Station is also interchange station between this corridor and Koteshwar Road to Airport corridor. From chainage 18525m to 18550m, it crosses Motera Gam Ni Bhagod chowk, where it is not on road median. From ch. 18845 m it again aligns along the road median and continues along it. Next station is Vishwakarma College at chainage 19017m.There after also the alignment continues along the road median; it crosses Tapovan Circle from ch. 19750m to 19850m. Next station on this corridor is named as Tapovan Circle which is at chainage 19994.45 m and is just after Tapovan Circle; It continues along the road median. Next station is Narmada Canal at ch. 20900m. This station is on straight alignment. Next station on this corridor is Koba Circle at ch. 22050.63m just before Koba Circle. After crossing Koba Circle, the alignment goes off the road and runs on the agricultural land. Now the alignment comes along the proposed road. Next station is Juna Koba at ch. 23056.45 m. The alignment continues to run over the proposed road. Next station is Koba Gaam at ch. 24066.45 m. The next station on this corridor is GNLU at ch. 24977.57 m. This station is also an interchange station between this corridor and GNLU to GIFT City corridor. Alignment continues on proposed road and next two proposed stations are Raysan and Randesan at ch. 26413.75 m and 27786.89 m respectively. The alignment turns left from ch. 28424.869m with curve of radius 125 m and comes along the median of GIFT city road. Next station is Dholakuva Circle at ch. 28943.26 m, this station is followed by Dholakuva Circle. From Dholakuva Circle the alignment turns right and comes along the median of Gandhinagar-Ahmedabad Road. Next station is Infocity at ch. 30334.00, it is proposed before Indroda Circle. Alignment continues along the road median, next station is Sector-1 at ch. 31600.00 m, this station is followed by Nyay Circle CH-2. Alignment turns right from ch. 32405.148m near Kishan Circle with a curve of radius 125m and aligns onto the median on Rd No. 3. A station is proposed just after the turn at ch. 32850.00m, it is named as Sector 10A and it is near St. Xaviers School. From CH-3 Circle, the alignment turns left and it passes over the parking shed of Birsa Munda Bhavan. It comes along the median of CHH Road, crosses Panchamrut Circle/ CH-4A Circle from ch. 33810m – 33825m and this circle is followed by a station named Sachivalaya at ch. 34041.258m. It continues along CHH Road and crosses Punit Circle/CH-4B Circle from ch. 34860m – 34890m. After Punit Circle there is a station proposed at ch. 35170.00m, which is named as Akshardham. From ch. 35261.247, near CH-5/Punit Circle, it turns left with a curve of 125m and aligns along the median of Rd No.-5. Next station on this corridor is Juna Sachivalaya at ch. 36069.00m, after this station it crosses Prerna Circle from ch. 36180m – 36200m. It continues further along the road median and crosses Ravishanker Maharaj Circle from ch. 36995m – 37015m. This junction is followed by station named Sector-16, proposed at ch. 37161.347m. It continues further and crosses Seva Circle. Next station is Sector-24 at ch. 38199.01 m. After this station, alignment turns left from ch. 38458.44m near Kh-5 Circle with a curve of 125m and aligns along the median of KH road. It continues along the median of road and last station of this corridor is Mahatma Mandir at ch. 39399.64m.

Curvature:

There are many sharp turns and curves along the road. This necessitates provision of curves for metro alignment also. The radius of curves is kept as low as 125 m to reduce the property acquisition. Total 20 Nos. of curves have been provided in the entire length of Motera Stadium to Mahatma Mandir Corridor. The details of curves and abstracts of horizontal curves are indicated in Table 4.5 and 4.6 respectively.

Table 4.5 Details of Horizontal Curves

Curve No.	Hand of Arc	Radius (m)	Arc Length (m)	Transition Length (m)		Included Angle			Tangent (m)	Straight Length (m)
				L1	L2	D	M	S		249.887
1	Left	300	58.874	55	55	11	14	38	29.532	601.334
2	Right	800	35.335	35	35	02	31	50	17.671	0
3	Left	800	39.941	35	35	02	51	38	19.975	108.134
4	Right	5000	186.806	20	20	02	08	26	93.414	153.302
5	Right	300	66.164	55	55	12	38	11	33.217	3936.05
6	Left	1010	345.057	30	30	19	34	28	174.227	1215.784
7	Left	800	42.483	35	35	03	02	33	21.246	0
8	Right	800	65.033	35	35	04	39	27	32.534	0
9	Left	1990.997	548.626	20	20	15	47	17	276.062	68.125
10	Left	1575	406.781	25	25	14	47	52	204.529	974.532
11	Left	1500	35.777	30	30	01	21	59	17.889	979.994
12	Right	2500	438.967	30	30	10	03	37	220.049	57.882
13	Left	125	159.538	55	55	73	07	36	92.709	574.131
14	Right	125	159.851	55	55	73	16	13	92.952	1103.428
15	Right	600	48.898	45	45	04	40	09	24.462	125.77
16	Right	1350	328.704	30	30	13	57	02	165.169	1109.96
17	Right	125	141.425	55	55	64	49	28	79.365	511.231
18	Left	125	141.374	55	55	64	48	04	79.329	1842.068
19	Left	125	141.499	55	55	64	51	30	79.417	2945.695
20	Left	125	141.29	55	55	64	45	44	79.27	774.63

Table 4.6 Abstract of Horizontal Curves

S. No.	Radius (m)	Nos. Occurrences	Curved Length with TL(m)	% w. r. t. total curved length
1	>125m - 500m	8	1890.015	36.68%
2	>500m - 1020m	6	1006.747	19.54%
3	>1020m - 1500m	2	484.481	9.40%
4	>1500m - 2500m	3	1544.374	29.97%
5	>2500m - 5000m	1	226.806	4.40%
6	>5000m	0	0	0.00%
	Total	**20**	**5152.423**	**100.00%**

Vertical Alignment:

Vertical alignment has been designed with consideration of 5.5 m clear head room on the road. Minimum height difference from existing road level and proposed rail levels is about 13.5 m at station locations and 8.5m other than station locations. Efforts have been made to maintain minimum radius of vertical curves of 2500 m. However it is not possible to maintain this at certain locations due to space constraints or overlapping with the transition length of Horizontal curves. At such locations minimum vertical curve radius is 1500 m. Length of vertical curve provided is more than 20 m. Overlap between transition curves and vertical curves are strictly avoided. All proposed stations are kept on level gradient. The maximum gradient used is not steeper than 1.739%. Detailed description of vertical alignment is as follows:

The proposed rail levels are given in **Table 4.7** and abstracts of gradients are given in **Table 4.8.**

Table 4.7: Proposed Gradients of Rail Track (Vertical Curve Details)

S. No.	Chainage		Length	Rail Level		Gradient	Remarks
	From	To		From	To		
1	17000.000	17329.108	329.108	70.485	72.200	0.521%	RISE
2	17329.108	18279.108	950.000	72.200	72.200	0.000%	LEVEL
3	18279.108	18809.108	530.000	72.200	74.500	0.434%	RISE
4	18809.108	19139.108	330.000	74.500	74.500	0.000%	LEVEL
5	19139.108	19539.108	400.000	74.500	72.000	-0.625%	FALL
6	19539.108	19869.108	330.000	72.000	76.500	1.364%	RISE
7	19869.108	20119.108	250.000	76.500	76.500	0.000%	LEVEL
8	20119.108	20499.108	380.000	76.500	73.200	-0.868%	FALL
9	20499.108	20729.108	230.000	73.200	77.200	1.739%	RISE
10	20729.108	21020.000	290.892	77.200	77.200	0.000%	LEVEL
11	21020.000	21379.108	359.108	77.200	79.000	0.501%	RISE
12	21379.108	21650.000	270.892	79.000	74.500	-1.661%	FALL
13	21650.000	21930.000	280.000	74.500	76.500	0.714%	RISE
14	21930.000	22170.000	240.000	76.500	76.500	0.000%	LEVEL
15	22170.000	22570.000	400.000	76.500	73.500	-0.750%	FALL
16	22570.000	22930.000	360.000	73.500	77.500	1.111%	RISE
17	22930.000	23175.000	245.000	77.500	77.500	0.000%	LEVEL
18	23175.000	23580.000	405.000	77.500	74.000	-0.864%	FALL
19	23580.000	23940.000	360.000	74.000	78.000	1.111%	RISE
20	23940.000	24190.000	250.000	78.000	78.000	0.000%	LEVEL
21	24190.000	24512.910	322.910	78.000	76.000	-0.619%	FALL
22	24512.910	24779.108	266.198	76.000	79.200	1.202%	RISE
23	24779.108	25219.108	440.000	79.200	79.200	0.000%	LEVEL

S. No.	Chainage		Length	Rail Level		Gradient	Remarks
	From	To		From	To		
24	25219.108	25619.108	400.000	79.200	76.000	-0.800%	FALL
25	25619.108	26019.108	400.000	76.000	77.500	0.375%	RISE
26	26019.108	26290.000	270.892	77.500	81.500	1.477%	RISE
27	26290.000	26530.000	240.000	81.500	81.500	0.000%	LEVEL
28	26530.000	26840.108	310.108	81.500	78.500	-0.967%	FALL
29	26840.108	27239.108	399.000	78.500	80.000	0.376%	RISE
30	27239.108	27659.108	420.000	80.000	83.500	0.833%	RISE
31	27659.108	27939.108	280.000	83.500	83.500	0.000%	LEVEL
32	27939.108	28250.000	310.892	83.500	77.500	-1.930%	FALL
33	28250.000	28600.000	350.000	77.500	82.750	1.500%	RISE
34	28600.000	29369.108	769.108	82.750	82.750	0.000%	LEVEL
35	29369.108	29769.108	400.000	82.750	80.500	-0.563%	FALL
36	29769.108	30210.000	440.892	80.500	85.000	1.021%	RISE
37	30210.000	30450.000	240.000	85.000	85.000	0.000%	LEVEL
38	30450.000	30711.266	261.266	85.000	82.000	-1.148%	FALL
39	30711.266	31459.108	747.842	82.000	89.000	0.936%	RISE
40	31459.108	31720.000	260.892	89.000	89.000	0.000%	LEVEL
41	31720.000	32259.108	539.108	89.000	84.500	-0.835%	FALL
42	32259.108	32730.000	470.892	84.500	88.500	0.849%	RISE
43	32730.000	32970.000	240.000	88.500	88.500	0.000%	LEVEL
44	32970.000	33269.108	299.108	88.500	86.000	-0.836%	FALL
45	33269.108	33599.108	330.000	86.000	85.000	-0.303%	FALL
46	33599.108	33919.108	320.000	85.000	89.500	1.406%	RISE
47	33919.108	34169.108	250.000	89.500	89.500	0.000%	LEVEL
48	34169.108	34569.108	400.000	89.500	86.000	-0.875%	FALL
49	34569.108	35050.000	480.892	86.000	90.500	0.936%	RISE
50	35050.000	35360.000	310.000	90.500	90.500	0.000%	LEVEL
51	35360.000	35589.108	229.108	90.500	87.000	-1.528%	FALL
52	35589.108	35950.000	360.892	87.000	90.500	0.970%	RISE
53	35950.000	36190.000	240.000	90.500	90.500	0.000%	LEVEL
54	36190.000	36489.108	299.108	90.500	87.000	-1.170%	FALL
55	36489.108	37039.108	550.000	87.000	90.500	0.636%	RISE
56	37039.108	37289.108	250.000	90.500	90.500	0.000%	LEVEL
57	37289.108	37689.108	400.000	90.500	87.500	-0.750%	FALL
58	37689.108	38079.108	390.000	87.500	91.500	1.026%	RISE
59	38079.108	38319.108	240.000	91.500	91.500	0.000%	LEVEL
60	38319.108	38769.108	450.000	91.500	87.000	-1.000%	FALL
61	38769.108	39159.108	390.000	87.000	90.200	0.821%	RISE
62	39159.108	39484.360	325.252	90.200	90.200	0.000%	LEVEL

Table 4.8: Abstract of Gradients

S. N.	Description	Nos. Occurrences	Length (m)	% w. r. t. total Alignment length
1	Level	20	6641.144	29.54%
2	> 0% to = 1%	27	11153.968	49.61%
3	> 1% to = 2%	15	4689.248	20.86%
4	> 2% to = 3%	0	0.000	0.00%
5	> 3% to = 4%	0	0.000	0.00%
	Total	**62**	**22484.360**	**100.00%**

4.12 KOTESHWAR ROAD TO AIRPORT CORRIDOR

The features of **Koteshwar Road to Airport Corridor** along with the details of route alignment have been described below:-

4.12.1 References

(a) Chainages

Chainage of Koteshwar Road proposed station (first station) is taken as 0.0 for reference and dead end chainage of this station as (-) 405 m. Chainage increases towards Airport.

(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 Koteshwar Road to Airport has been named as 'Down line' and 'up line' is converse of it.

4.12.2 Features of the Corridor

First station on this Corridor is named as Koteshwar Road and last station is Airport.

Total length of the corridor from dead end to dead end is 6.339 km. The entire corridor proposed is elevated.

Three stations have been proposed on the corridor. Names of stations are Koteshwar Road, Sardarnagar and Airport. Attempt has been made to locate stations at about a kilometer apart. However due to various considerations such as ridership, accessibility, availability of land, design considerations etc; stations could not be located at one km distance apart. The maximum and minimum inter station distances are 4212.19 m and 1621.98 m respectively.

This corridor runs in North-West to South-East direction. It connects North-South Corridor and Airport.

4.12.3 Station Locations

Stations have been located so as to serve major passenger destinations and to enable convenient integration with other modes of transport such as Railway Stations, Bus Terminals, etc. Effort has also been made to propose station locations, such that inter station distances are as uniform as possible however due to various constrains this could not be possible.

All stations will be two level stations. The concourse comprising of passenger facilities and station facilities will be at lower level and the platforms on the higher level. Concourse of all these stations is proposed along the roads with sufficient Right of way. Three types of the stations have been conceptualized, for detailed information Chapter-6 on station Planning may be referred.

4.12.4 Terminals

Koteshwar Road Terminal

This Station is also an interchange station between this corridor and Motera Stadium to Mahatma Mandir Corridor. Scissors crossovers are proposed at the rear end of the station.

Airport Terminal

This Station is proposed on the road median. Scissors crossovers are proposed at the front end of the station.

4.12.5 Scissors Crossovers

Scissors Crossovers will be provided at the terminal stations viz. Koteshwar Road and Airport. Crossover is proposed at Koteshwar Road Station.

4.12.6 Description of Alignment

Horizontal Alignment:

The first station of this corridor is Koteshwar Road at Chainage 0.00 m, this station provides passenger interchange between this corridor and Motera Stadium to Mahatma Mandir corridor; initially alignment runs on the left side of the road, from chainage 160.991m it turns left with a curve of 150m and comes onto the Asharam Ashram road; from ch. 830.565 m it turns left with a curve of 125 m and goes off the road. From ch. 1350.695 m alignment turns left with a curve of 300 m and it runs on the bank of Sabarmati River; from ch. 3300 m to 3670 m it crosses Sabarmati River and after this it comes along the road. Second station on this corridor is Sardarnagar at ch. 4212.19m on Airport Road. Thereafter the alignment moves along the road median; from ch. 4602.682m to 4875 m it goes away from road median and comes onto International Airport Road. Last station is named as Airport and it is at ch. 5834.17 m.

Curvature:

There are many sharp turns and curves along the road. This necessitates provision of curves for metro alignment also. The radius of curves is kept as low as 125 m to reduce the property acquisition. Total 15 Nos. of curves have been provided in the entire length of Koteshwar Road to Airport Corridor. The details of curves and abstracts of horizontal curves are indicated in Table 4.9 and 4.10 respectively.

Table 4.9 Details of Horizontal Curves

Curve No.	Hand of Arc	Radius (m)	Arc Length (m)	Transition Length (m)		Included Angle			Tangent (m)	Straight Length (m)
				L1	L2	D	M	S		249.887
1	Right	302.1	59.671	55	55	11	19	01	29.933	5.12
2	Left	150	130.647	55	55	49	54	11	69.792	0
3	Right	2500	43.038	20	20	00	59	10	21.52	0
4	Left	450	45.822	45	45	05	50	03	22.931	35.276
5	Left	125	69.726	55	55	31	57	35	35.796	46.094
6	Right	125	60.237	55	55	27	36	38	30.715	124.073
7	Left	300	198.557	55	55	37	55	17	103.068	1449.991
8	Right	125	207.25	55	55	94	59	46	136.405	310.393
9	Left	200	68.881	55	55	19	43	58	34.785	0
10	Right	450	135.87	45	45	17	17	58	68.456	140.955
11	Right	125	80.31	55	55	36	48	41	41.596	129.781
12	Left	125	192.617	55	55	88	17	21	121.322	109.642
13	Right	1500	49.677	25	25	01	53	51	24.841	128.946
14	Right	1020	47.761	30	30	02	40	58	23.885	55.706
15	Left	300	53.542	55	55	10	13	32	26.842	352.648

Table 4.10 Abstract of Horizontal Curves

S. No.	Radius (m)	Nos. Occurrences	Curved Length with TL(m)	% w. r. t. total curved length
1	>125m - 500m	12	2583.13	89.89%
2	>500m - 1020m	1	107.761	3.75%
3	>1020m - 1500m	1	99.677	3.47%
4	>1500m - 2500m	1	83.038	2.89%
5	>2500m - 5000m	0	0	0.00%
6	>5000m	0	0	0.00%
	Total	**15**	**2873.606**	**100.00%**

Vertical Alignment:

Vertical alignment has been designed with consideration of 5.5 m clear head room on the road. Minimum height difference from existing road level and proposed rail levels is about 13.5 m at station locations and 8.5m other than station locations. Efforts have been made to maintain minimum radius of vertical curves of 2500 m. However it is not possible to maintain this at certain locations due to space constraints or overlapping with the transition length of Horizontal curves. At such locations minimum vertical curve radius is 1500 m. Length of vertical curve provided is more than 20 m. Overlap between transition curves and vertical curves are strictly avoided. All proposed stations are kept on level gradient. The maximum gradient used is not steeper than 2.647%. Detailed description of vertical alignment is as follows:

The proposed rail levels are given in **Table 4.11** and abstracts of gradients are given in **Table 4.12.**

Table 4.11: Proposed Gradients of Rail Track (Vertical Curve Details)

S. No.	Chainage		Length	Rail Level		Gradient	Remarks
	From	To		From	To		
1	-405.000	245.826	650.826	72.200	72.200	0.000%	LEVEL
2	245.826	617.948	372.122	72.200	67.000	-1.397%	FALL
3	617.948	1033.337	415.389	67.000	66.000	-0.241%	FALL
4	1033.337	1450.000	416.663	66.000	60.500	-1.320%	FALL
5	1450.000	1860.000	410.000	60.500	57.500	-0.732%	FALL
6	1860.000	2260.000	400.000	57.500	55.000	-0.625%	FALL
7	2260.000	2660.000	400.000	55.000	56.500	0.375%	RISE
8	2660.000	3060.000	400.000	56.500	55.400	-0.275%	FALL
9	3060.000	3460.000	400.000	55.400	59.000	0.900%	RISE
10	3460.000	3700.000	240.000	59.000	62.000	1.250%	RISE
11	3700.000	4040.000	340.000	62.000	71.000	2.647%	RISE
12	4040.000	4377.746	337.746	71.000	71.000	0.000%	LEVEL
13	4377.746	4780.000	402.254	71.000	65.500	-1.367%	FALL
14	4780.000	5180.000	400.000	65.500	66.000	0.125%	RISE
15	5180.000	5600.000	420.000	66.000	68.000	0.476%	RISE
16	5600.000	5923.220	323.220	68.000	68.000	0.000%	LEVEL

Table 4.12: Abstract of Gradients

S. No.	Description	Nos. Occurrences	Length (m)	% w. r. t. Total Alignment length
1	Level	3	1311.792	20.73%
2	> 0% to = 1%	8	3245.389	51.28%
3	> 1% to = 2%	4	1431.039	22.61%
4	> 2% to = 3%	1	340.000	5.37%
5	> 3% to = 4%	0	0.000	0.00%
	Total	**16**	**6328.22**	**100.00%**

4.13 GNLU TO GIFT CITY CORRIDOR

The features of **GNLU to GIFT City Corridor** along with the details of route alignment have been described below:-

4.13.1 References

(a) Chainages

Chainage of GNLU proposed station (first station) is taken as 0.0 for reference and dead end chainage of this station as (-) 405 m. Chainage increases towards GIFT City.

(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 GNLU to GIFT City has been named as ‘Down line’ and ‘up line’ is converse of it.

4.13.2 Features of the Corridor

First station on this Corridor is named as GNLU and last station is GIFT City.

Total length of the corridor from dead end to dead end is 5.416 km. The entire corridor proposed is elevated.

Three stations have been proposed on the corridor. Names of stations are GNLU, PDPU and GIFT City. Attempt has been made to locate stations at about a kilometer apart. However due to various considerations such as ridership, accessibility, availability of land, design considerations etc; stations could not be located at one km distance apart. The maximum and minimum inter station distances are 2856.86 m and 1749.00 m respectively.

This corridor runs in West to East direction. It connects GIFT City and North-South Corridor.

4.13.3 Station Locations

Stations have been located so as to serve major passenger destinations and to enable convenient integration with other modes of transport such as Railway Stations, Bus Terminals, etc. Effort has also been made to propose station locations, such that inter station distances are as uniform as possible however due to various constrains this could not be possible.

All stations will be two level stations. The concourse comprising of passenger facilities and station facilities will be at lower level and the platforms on the higher level. Concourse of all these stations is proposed along the roads with sufficient Right of way. Three types of the stations have been conceptualized, for detailed information Chapter-6 on station Planning may be referred.

4.13.4 Terminals

GNLU Terminal

This Station is also an interchange station between this corridor and Motera Stadium to Mahatma Mandir Corridor. Scissors crossovers are proposed at the rear end of the station.

GIFT City Terminal

This Station is proposed on the road median. Scissors crossovers are proposed at the front end of the station.

4.13.5 Scissors Crossovers

Scissors Crossovers will be provided at the terminal stations viz. GNLU and GIFT City. Crossover is proposed at GNLU Station.

4.13.6 Description of Alignment

Horizontal Alignment:

The first station of this corridor is GNLU at Chainage 0.00 m, this station provides passenger interchange between this corridor and Motera Stadium to Mahatma Mandir corridor; initially alignment runs on the right side of the proposed road, from chainage 283.569m it turns right with a curve of 200m and comes onto Pandit Deendayal Petroleum University (PDPU) road; it moves on the right side of the road continues along the road. Next station is PDPU at chainage 1749 m. There after also the alignment continues along right side of PDPU road; from ch. 2835.073 it turns slightly left with a curve of 1010m to go off the road. It goes over the Sabarmati River running parallel to Signature Bridge (on its left side) and turns left from ch. 4191.759m and comes onto the road median. Last station of this corridor is named as GIFT City which is at chainage 4605.86 m.

Curvature:

There are many sharp turns and curves along the road. This necessitates provision of curves for metro alignment also. The radius of curves is kept as low as 125 m to reduce the property acquisition. Total 12 Nos. of curves have been provided in the entire length of GNLU to GIFT City Corridor. The details of curves and abstracts of horizontal curves are indicated in Table 4.13 and 4.14 respectively.

Table 4.13 Details of Horizontal Curves

Curve No.	Hand of Arc	Radius (m)	Arc Length (m)	Transition Length (m)		Included Angle			Tangent (m)	Straight Length (m)
				L1	L2	D	M	S		185.418
1	Left	2009	483.151	20	20	13	46	45	242.747	0
2	Right	200	215.026	55	55	61	36	01	119.225	219.569
3	Left	1010	61.312	30	30	03	28	41	30.665	40.013
4	Right	600	44.895	40	40	04	17	13	22.458	17.03
5	Right	250	31.247	55	55	07	09	41	15.644	106.104
6	Left	1500	84.867	25	25	03	14	30	42.445	0
7	Right	450	30.556	45	45	03	53	26	15.284	190.334
8	Left	750	159.213	35	35	12	09	46	79.907	192.748
9	Right	750	92.687	35	35	07	04	50	46.402	78.36

Curve No.	Hand of Arc	Radius (m)	Arc Length (m)	Transition Length (m)		Included Angle			Tangent (m)	Straight Length (m)
				L1	L2	D	M	S		185.418
10	Left	600	33.384	40	40	03	11	16	16.696	214.159
11	Left	1010	114.511	30	30	06	29	45	57.317	1182.175
12	Left	125	104.105	55	55	47	43	05	55.286	604.997

Table 4.14 Abstract of Horizontal Curves

S. No.	Radius (m)	Nos. Occurrences	Curved Length with TL(m)	% w. r. t. total curved length
1	>125m - 500m	4	800.934	33.58%
2	>500m - 1020m	6	926.002	38.83%
3	>1020m - 1500m	1	134.867	5.65%
4	>1500m - 2500m	1	523.151	21.94%
5	>2500m - 5000m	0	0	0.00%
6	>5000m	0	0	0.00%
	Total	**12**	**2384.954**	**100.00%**

Vertical Alignment:

Vertical alignment has been designed with consideration of 5.5 m clear head room on the road. Minimum height difference from existing road level and proposed rail levels is about 13.5 m at station locations and 8.5m other than station locations. Efforts have been made to maintain minimum radius of vertical curves of 2500 m. However it is not possible to maintain this at certain locations due to space constraints or overlapping with the transition length of Horizontal curves. At such locations minimum vertical curve radius is 1500 m. Length of vertical curve provided is more than 20 m. Overlap between transition curves and vertical curves are strictly avoided. All proposed stations are kept on level gradient. The maximum gradient used is not steeper than 1.071%. Detailed description of vertical alignment is as follows:

The proposed rail levels are given in **Table 4.15** and abstracts of gradients are given in **Table 4.16.**

Table 4.15: Proposed Gradients of Rail Track (Vertical Curve Details)

S. No.	Chainage		Length	Rail Level		Gradient	Remarks
	From	To		From	To		
1	-405.000	400.000	805.000	79.200	79.200	0.000%	LEVEL
2	400.000	800.000	400.000	79.200	76.800	-0.600%	FALL
3	800.000	1222.038	422.038	76.800	76.000	-0.190%	FALL
4	1222.038	1593.910	371.872	76.000	77.500	0.403%	RISE
5	1593.910	1920.000	326.090	77.500	77.500	0.000%	LEVEL
6	1920.000	2340.000	420.000	77.500	73.000	-1.071%	FALL

S. No.	Chainage		Length	Rail Level		Gradient	Remarks
	From	To		From	To		
7	2340.000	2740.000	400.000	73.000	72.000	-0.250%	FALL
8	2740.000	3140.000	400.000	72.000	70.500	-0.375%	FALL
9	3140.000	3540.000	400.000	70.500	70.000	-0.125%	FALL
10	3540.000	3940.000	400.000	70.000	71.000	0.250%	RISE
11	3940.000	4300.000	360.000	71.000	73.500	0.694%	RISE
12	4300.000	5010.861	710.861	73.500	73.500	0.000%	LEVEL

Table 4.15: Abstract of Gradients

S. No.	Description	Nos. Occurrences	Length (m)	% w. r. t. Total Alignment length
1	Level	3	1841.951	34.01%
2	> 0% to = 1%	8	3153.910	58.23%
3	> 1% to = 2%	1	420.000	7.75%
4	> 2% to = 3%	0	0.000	0.00%
5	> 3% to = 4%	0	0.000	0.00%
	Total	**12**	**5415.861**	**100.00%**

Chapter – 5

CIVIL ENGINEERING

5.1 GENERAL

This chapter deals with civil elevated structure, Geotechnical investigation, construction methods, land requirements, Utility services and Traffic diversion during construction etc.

5.2 CIVIL STRUCTURES

5.2.1 Elevated Section - Choice of Superstructure

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

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

In case of Ahmedabad Phase-II Metro corridors, it is suggested to use Double U-Girder in the superstructure upto radius 300m keeping in view the open area in the proposed corridor. However, MEGA Co. may opt for any other method of segmental construction, if found technically feasible and economically viable.

Some other merits of Double U-Girder are given below:

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

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

5.2.2 Pre-Cast Construction

5.2.2.1 Casting of U-Girder

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

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

5.2.2.2 Erection of U-Girder

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

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

5.2.3 Structural System of Viaduct

5.2.3.1 Superstructure

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

Normally two U-Girders having a soffit width of about 3.5 m (approx) each, accommodates two tracks situated at 4.7 m center to center (c/c). The U-Girder superstructure for almost all the simply supported standard spans will be constructed by precast pre-stressed construction.

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

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

5.2.3.2 Substructure

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

To prevent the direct collision of vehicle to pier, a Jersey Shaped crash barrier of 1.0 m height above existing road level has been provided all around the pier. A gap of 25 mm has also been provided in between the crash barrier and outer face of pier. The shape of upper part of pier has been so dimensioned that a required clearance of 5.5 m is always available on road side beyond vertical plane drawn on outer face of crash barrier. In such a situation, the minimum height of rail above the existing road is about 8.5 m.

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

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

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

5.2.4 Construction of Stations

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

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

5.2.5 Grade of Concrete

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

i)	Piles	-	M -35
ii)	Pile cap and open foundation	-	M -35
iii)	Piers	-	M -40/M-50

iv)	All precast element for viaduct and station	-	M -45/M-50
v)	Cantilever piers and portals	-	M -45/M-50/M -60
vi)	Other miscellaneous structure	-	M -30

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

5.2.6 Reinforcement and pre-stressed Steel

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

5.2.7 Road width required during construction

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

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

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

5.3 GEO-TECHNICAL INVESTIGATIONS

5.3.1 General Geology & Related Characteristics:

Physiography:

Ahmedabad District is situated in the central part of Gujarat and lies between 22°0' and 23°35' north latitudes and 71° 42' and 72° 50' east longitudes. It falls in the survey of India degree sheet numbers 41N, 41M, 46A and 46B. It is bounded by Mahesana and Gandhinagar in north, Sabarkantha in north east, Kheda in east Gulf of Cambay (Khambat), Bhavnagar in South and Surendranagar in west. Ahmedabad district as a whole forms a level plain gradually rising towards the north and east where the elevation varies between 17 meters and 100 meters above M.S.L. The southern portion of the district is low lying area with an altitude ranging between 12 meters and 22 meters above MSL. Sabarmati is the principal river of the district. It enters the district in the extreme north-eastern side and flows in southerly direction which ultimately merges along with its tributary i.e. Bhogava in the Gulf of Khambhat. Other river is Bhadar which also flows eastward and merges in the same Gulf.

Geology:

The landscape is characterized by a subdued topography comprising a variety of depositional transitional area between the plain and the highland is marked by a pediment zone of undulating topography, characterized by low altitude mounds and hillocks of stabilized Aeolian sands dunes. There are also small alluvial fans and cones of fluvial material brought by the rivers coming from the neighboring highland. The central part of the plain shows mix topography of fluvial plains marked by subdued fossil dunes. The western part is almost a level ground of saline waste land with a thin veneer of sand and silt.

The area is almost entirely occupied by the sediments of Quaternary era. Only in the south-western part of the Ahmedabad district basalt flows of the Deccan volcanic of Upper Cretaceous to Eocene age are exposed. The Quaternary sediments include oontlc to sandy limestone with intercalated grit and sandstone (Miliolite Formation) and minor isolated outcrops of variegated clay, siltstone and marl (Vend formation) of Pleistocene age. Sediments of Holocene age comprise Rann Clay Formation (tidal flat deposits] and Mahuva Formation (Shoal spit/bar, tidal flat and tidal marsh deposits) deposited by marine agencies, Katpur Formation (Flood plain and deltaic deposits) and larahi Formation (channel/fill and flood plane deposits) by fluvial agencies, Akhaj Formation (sand sheet and sand dune, stabilized) and Jantral formation (sand sheet and sand dunes unstabilized) by Aeolian agencies and Nalsarobar Formation deposited by lacustrine agencies.

Geomorphologically the district can be divided into two zones, the major portion of it forms a flat planar topography except for a few rocky features in the extreme southern portion.

Flat Alluvial Peneplain - It includes the low-lying land of Dholka and Dhandhuka taluka (falling below 20 m) contour characterized by marshy land, which is believed to be under sea in the past. Water logging is common in these tracts at high tides during monsoon. This barren low land is termed as “The Bhal” area and characterized by high coastal salinity. The spreading of alluvial bed of Sabarmati River from end to end of the district is an important natural feature being observed. Below the city, on the left bank of the river and also midway between it and the Khari River is few small rises. But everywhere else, the surface of the ground is unbroken on every side, except the north, with groves of various trees. Along the Right Bank of Sabarmati river, the prominent characteristics of Dascroi pass into Dholka. However towards west and south-west they pass into fertile but absolutely flat and monotonous black soil of the Bhal. The area from Dholka to Bavliari creek along the coast is characterized by salty and marshy land. Along the western border, the land passes into a reddish form.

Low hills - A series of low hills are present few kilometers west of Rampur in the western Dhandhuka taluka. The hills around Ninana in the most westerly part of Dhandhuka are covered with fragments of quartz and limestone. Some hills are located around Vasai and Miroli in the southern section of the district, also near Thaltej and Gota of Dascroi taluka in the north, and Chandisar in Dholka and Vastrapur in the City Taluka. The Deccan trap and the limestone formations occupying the western part of the Dandhuka taluka. Rocky soils are found in Dhandhuka taluka is known as Kaner tract which is shallow, light in texture.

Seismology:

For design purpose, the earthquake magnitude of 6.50 on Reactor‟s scale can be considered safely as per Annexure A of IS: 1893 (part -1). Also the project area under study and its surroundings are seismically active falls in Seismic Zone – III (Zone factor, Z = 0.16).

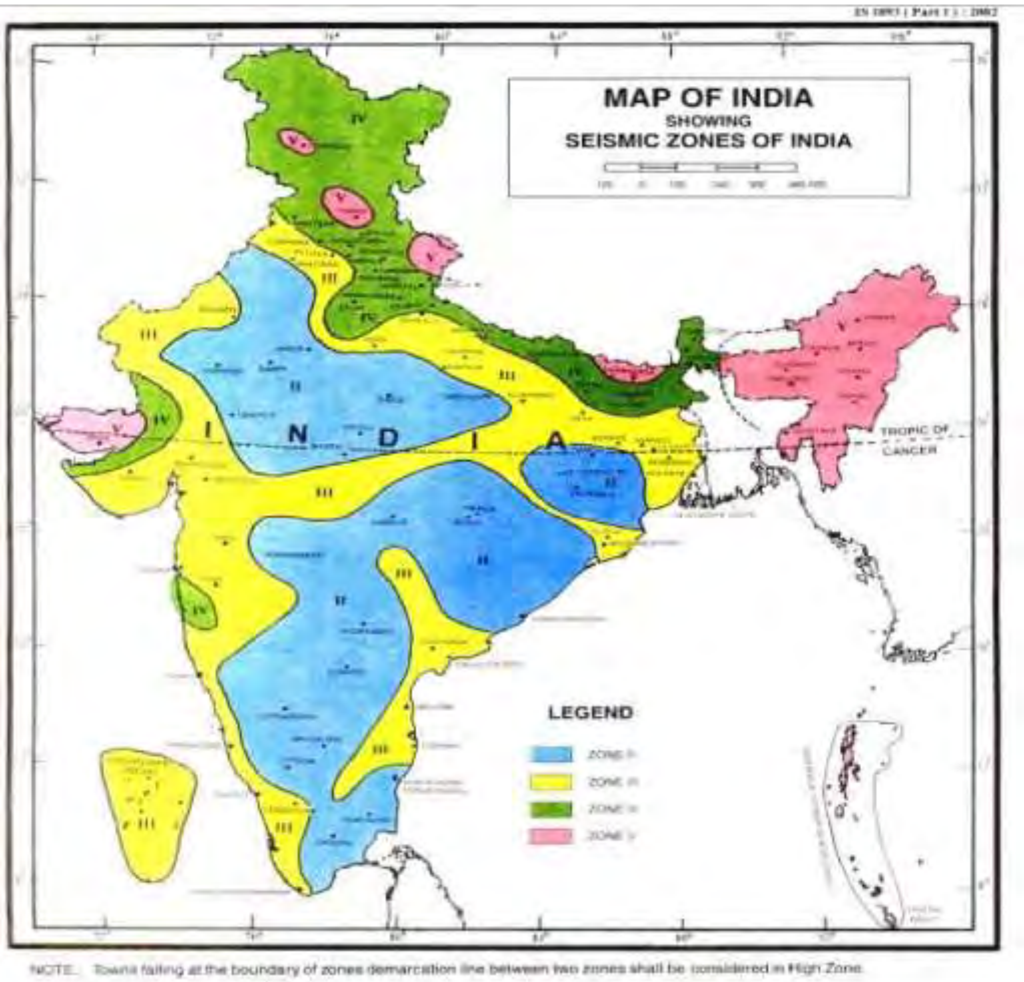


Figure 5.1: Seismic zones of India

Climate

The climate of the district is characterized by hot summer and general dryness except during the southwest monsoon seasons. The year can be divided into four seasons. The period from March to May is the hot season (summer) followed by southwest monsoon from June to September, October and November constitute the post-monsoon or retreating monsoon season. The cold season (winter) starts from December and ends in February. The mean maximum temperature ranges between 28.4ºC during January to 41.8ºC during May and the mean minimum temperatures vary between 11.7ºC during January and 27ºC during June. The relative humidity varies between 32 % (March) and 79% (August). The wind velocity varies from 74 km/d (November) and 174.2 km/d (June). The potential Evapo-transpiration varies between 3.2 mm (December) and 7.8 mm/d (June). Long-term average annual rainfall recorded by IMD station at Ahmedabad is 799.6 mm. Most of the rainfall (about 766 mm) is received from south-west monsoon between June to September.

Climatological data of Ahmedabad IMD station which is nearest is given in the table below.

Climatological data of Ahmedabad IMD station

Month	Max Temp (°C)	Mini Temp (°C)	Humidity (%)	Wind Spd. Kmpd	Sunshine (Hours)	Solar Rad. (MJ/m2/d)	Evapotran spiration (mm/d)	Rainf all (mm)
January	28.4	11.7	43.0	100.1	9.6	17.5	3.4	2.6
February	31.3	13.8	36.0	101.8	10.2	20.5	4.2	1.1
March	36.0	18.8	32.0	108.7	9.3	21.7	5.3	1.0
April	39.9	23.4	34.5	120.8	10.0	24.5	6.6	0.9
May	41.8	26.2	42.5	158.7	10.6	25.9	7.8	6.0
June	38.4	27.0	59.5	174.2	8.8	23.2	6.7	108.7
July	33.3	25.7	76.0	150.1	4.6	16.8	4.4	265.3
August	31.9	24.8	79.0	124.2	4.3	16.0	3.9	219.8
September	33.4	24.1	71.0	103.5	6.7	18.5	4.4	171.9
October	35.8	20.9	50.5	74.2	9.5	20.3	4.4	10.8
November	33.2	16.5	43.0	79.4	9.7	18.1	3.6	8.9
December	29.8	13.0	45.0	91.4	9.5	16.7	3.2	2.6
Total	-	-	-	-	-	-	-	**799.6**
Average	**34.4**	**20.5**	**51.0**	**115.6**	**8.6**	**20.0**	**4.8**	-

5.3.2 Objective of Geotechnical Investigation

The main objectives of Geo-Technical Investigation 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.

5.3.3 Methodology of Investigation

The investigation were planned to obtain the subsurface stratification in the proposed project area and collect soil samples for laboratory testing to determine the engineering properties such as shear strength, along with basic engineering classification of the subsurface stratum to arrive at the foundation design parameters.

For Geotechnical investigation work, boring / drilling rigs were installed at the specified borehole locations. Stability of rig was ensured by making the ground level. Boring has been advanced by shell and auger method in soil and sampling carried out at regular interval in the bore hole.

The rig deployed was suitable for and had arrangement for boring, conducting Standard Penetration Test (SPT), collection of Undisturbed Soil Sample (UDS) and Disturbed Soil Samples (DS).

5.3.3.1 Standard Penetration Tests (SPT)

Standard Penetration Tests (SPT) were conducted in the bore holes at every 1.50 m interval & at change of strata as per specifications. The bores were cleaned up to the desired depths. Standard split spoon sampler attached to lower end of „A" drill rods was driven in the bore holes by means of standard hammer of 63.50 Kg falling freely from a height of 75 cm. The sampler was driven 45 cm as per specifications & the numbers of blows required for each 15 cm penetration were recorded. The numbers of blows for the first 15 cm penetration were not taken into account. This was considered as seating drive. The numbers of blows for next 30 cm penetration were designated as SPT „N" value. Wherever the total penetration was less than 45 cm, the number of blows & the depth penetrated is incorporated in respective bore logs. Disturbed soil samples obtained from standard split spoon sampler for all the above standard penetration tests were collected in polythene bags of suitable size. These samples were properly sealed, labelled, recorded and carefully transported to the laboratory for testing.

5.3.3.2 Undisturbed Sampling in Boreholes

Undisturbed soil samples were collected from the bore holes immediately followed by SPT test, as per sampling specifications, in thin walled sampling tubes of 100 mm dia and 450 mm length fitted to an adopter with ball and socket arrangement. These sampling tubes after retrieval from the bore holes were properly waxed and sealed at both ends. These were carefully labeled and transported to the laboratory for testing. Undisturbed soil samples wherever slipped during lifting, were duly marked in the field bore logs as well as in the soil profile.

5.3.3.3 Disturbed Sampling in Boreholes

Disturbed soil samples were also collected from the bore holes at suitable depths/intervals to supplement the boring records. These samples were collected in polythene bags of suitable size. These samples were properly sealed, labeled, recorded & carefully transported to the laboratory for testing.

5.3.3.4 Laboratory Investigation

The following laboratory tests were conducted on the selected samples recovered from various bore hole / test locations: -

a) Sieve Analysis
b) Hydrometer Analysis
c) Specific Gravity
d) Moisture Content
e) Dry Density
f) Atterberg Limits
g) Direct Shear Test
h) Triaxial Shear Tests
i) Chemical Analysis of Soil Samples
j) Chemical Analysis of Water Samples

All the above laboratory tests were carried out as per relevant Indian Standards. All the soil samples were identified and classified as per IS: 1498-1970.

5.3.3.5 Field Investigations

Detailed field investigations have been carried out during October 2016 to December 2016 along all three corridors proposed.

5.3.4 Details of Bore Holes

Total of 40 boreholes were drilled up to a depth of 30.45 m below existing ground level. The details of these boreholes are shown in the table 5.1(A)-5.1(D) below.

Table 5.1 A - Borehole Details (Motera Stadium to Mahatma Mandir Corridor)

BH No	R.L.	Co-ordinates		Depth of BH below GL (m)	Depth of Water Table
		X	Y		
1	76.156	257575.279	2571355.377	30.0	Not Met
2	77.132	258056.337	2572120.892	30.0	Not Met
3	77.542	258944.143	2571634.524	30.0	Not Met
4	76.692	259803.224	2577740.078	30.0	Not Met
5	76.842	260757.456	2570587.151	30.0	Not Met
6	75.739	260484.939	2569825.635	30.0	Not Met
7	75.09	259873.560	2568814.946	30.0	Not Met
8	75.114	259222.411	2568994.640	30.0	Not Met
9	75.911	258780.998	2568652.714	30.0	Not Met
10	71.432	258295.208	2567469.203	30.0	Not Met
11	70.199	258182.511	2566384.552	30.0	Not Met
12	67.431	258858.117	2566125.052	30.0	Not Met
13	69.871	259007.881	2565392.140	30.0	Not Met
14	69.239	259043.796	2564565.117	30.0	Not Met
15	68.777	259129.790	2564107.247	30.0	Not Met
16	67.152	259194.293	2563137.893	30.0	Not Met
17	66.846	258705.762	2561906.368	30.0	Not Met
18	64.993	257944.891	2560844.118	30.0	Not Met

BH No	R.L.	Co-ordinates		Depth of BH below GL (m)	Depth of Water Table
		X	Y		
19	62.146	257342.838	2560197.153	30.0	12.10
20	61.871	256581.268	2559538.770	30.0	25.85
21	61.866	255789.208	2558807.490	30.0	25.80
22	60.497	254983.496	2558110.836	30.0	25.70
23	59.351	254521.651	2557261.941	30.0	13.50
24	58.742	254329.992	2556844.363	30.0	13.70
25	58.271	254072.270	2556551.633	30.0	9.90

Table 5.1 B - Borehole Details (Koteshwar Road to Airport Corridor)

BH No	R.L.	Co-ordinates		Depth of BH below GL (m)	Depth of Water Table
		X	Y		
1	47.964	254911.513	2555799.088	30.0	Not Met
2	45.248	255908.416	2555798.053	30.0	6.45
3	54.992	256291.000	2554747.00	30.0	17.45
4	54.429	256075.772	2554185.301	30.0	18.10
5	54.319	256271.225	2553826.614	30.0	18.20

Table 5.1 C - Borehole Details (GNLU to GIFT City Corridor)

BH No	R.L.	Co-ordinates		Depth of BH below GL (m)	Depth of Water Table
		X	Y		
1	66.721	259291.779	2563042.753	30.0	20.50
2	65.943	260165.601	2562916.555	30.0	18.00
3	62.491	261105.000	2562558.000	30.0	Not Met
4	58.127	261619.047	2562313.006	30.0	Not Met
5	60.121	262541.218	2562226.514	30.0	Not Met
6	60.432	262776.519	2562400.599	30.0	Not Met

Table 5.1 D - Borehole Details (Stabling Yard near Indroda Circle)

BH No	R.L.	Co-ordinates		Depth of BH below GL (m)	Depth of Water Table
		X	Y		
1	70.986	258459.160	2567075.365	30.0	Not Met
2	70.791	258331.835	2566945.346	30.0	Not Met
3	71.119	258491.335	2566813.346	30.0	Not Met
4	70.669	258305.548	2566674.509	30.0	Not Met

5.3.5 Water Table

At most of the locations, water table was not encountered. At locations where it was encountered, its depth varies from 6.45 m to 25.85 m (below ground).

5.3.6 Recommendation

Type of Foundation: Bored Cast in situ RCC Pile
Depending on the field and laboratory observations of subsoil strata, test results and the type of structures proposed at site, the most feasible soil-foundation system is recommended as normal bored cast in situ R.C.C. piles foundations of 1.0m & 1.2m diameter at different depths with cut-off level of 2.0m to 3.0m depth below existing Ground level.

Recommended Diameter & Depth of Foundation have been given in Table 5.2 below:

Table 5.2 - Diameter & Depth of Foundation

Type of foundation	Diameter of Pile, m	Cut off level, m	Effective Depth, m
Bored Cast in situ RCC Pile	1.00 & 1.20	2.00	20.0 – 30.0

Note: For details, please refer Detailed Geotechnical Report

5.4 LAND

In order to minimize 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:

5.4.1 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)

5.4.2 Land required for elevated stretches

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

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

In view of the constraints on space on ground floor, it is proposed to provide the concourse area exactly below the Station Building at mezzanine level. All the stations are of elevated type with side platforms except, four which are either island or combination of both. Normally, the width required for stations is 21 m. The staircases giving access to concourse area from ground have been proposed as per site conditions and constraints. Nevertheless it is not possible to find open space at all the locations therefore acquisition of certain private structures is inevitable.

5.4.3 Land for Traffic integration

As indicated in station planning para certain land is required for traffic integration at 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.

5.4.4 Land for Depot

No main depot is proposed for Phase-II corridors. It is proposed to have a Stabling Yard in land identified by MEGA near Indroda Circle and to augment Gyaspur depot of North-South Corridor under implementation for serving Phase-II corridors. Hence an area of 10 ha govt. land has been earmarked for Stabling Yard.

5.4.5 Land for Traction and Receiving Substation and Radio Towers

Two RSS, one near Airport Station/Koba Circle Station and other near Infocity Station are proposed to be located for Phase-II Corridors. Hence, an area of 7,200m^2 (Government) has been earmarked. Exact location will be decided at the time of implementation of the project. No additional land proposed for locating radio towers. These will be accommodated in the land already acquired. Land required for RSS will be as tabulated below.

Table 5.3 - Details of Land Required for RSS

S. No.	Name of Corridor	Area (m^2)	Ownership
1.	Motera Stadium to Mahatma Mandir	3600	Government
2.	GNLU to GIFT City	---	---
3.	Koteshwar Road to Airport (Phase-IIA)	3600	Government
	Total	**7200**	

5.4.6 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/footpath of the road. However, at curved portions, the alignment could not be kept in the centre of the road and land acquisition at such locations is inevitable in spite of introduction of sharper curves.

To the extent possible the Entry and Exit points of stations were planned out of ROW of Road. Details of land permanently required for stations and running sections on all the three corridors are indicated in **Table 5.4 (A) - (B) and Table 5.5 (A) – (C).** The areas identified for acquisition are shown in figures placed at the end of the chapter.

Table 5.4 (A) - Motera Stadium – Mahatma Mandir Corridor Running Section

S. NO.	PLOT NO.	AREA (m^2)	REMARKS
1	RS-1	1682	Govt.
2	RS-2	1386	Govt.
3	RS-3	35	Pvt.
4	RS-4	820	Govt.
5	RS-5	666	Govt.
6	RS-6	824	Govt.
		TOTAL = 5413 m^2	
		GOVT. = 5378 m^2	
		PVT. = 35 m^2	

Table 5.4 (B) - Koteshwar Road – Airport Metro Corridor (Phase-IIA) Running Section

S.NO.	PLOT NO.	AREA (m^2)	REMARKS
1	RS-1	1575	Pvt.
2	RS-2	2965	Pvt.
3	RS-3	3893	Govt.
		TOTAL = 8433 m^2	
		GOVT. = 3893 m^2	
		PVT. = 4540 m^2	

Table 5.5 (A) - Motera Stadium – Mahatma Mandir Metro Corridor Land Required for Stations

S.NO.	PLOT NO.	AREA (m^2)	REMARKS
1	KR-1	1320	Pvt.
2	KR-2	443	Pvt.
3	VC-1	460	Govt.
4	VC-2	460	Govt.
5	TC-1	460	Govt.
6	TC-2	460	Govt.
7	NC-1	460	Govt.
8	NC-2	460	Govt.
9	KC-1	460	Govt.
10	KC-2	460	Govt.
11	JK-1	460	Govt.
12	JK-2	460	Govt.
13	KG-1	460	Govt.
14	KG-2	460	Govt.
15	G-1	1530	Govt.
16	G-2	1530	Govt.
17	RAY-1	460	Govt.
18	RAY-2	460	Govt.
19	RAN-1	460	Govt.
20	RAN-2	460	Govt.
21	`DC-1	460	Govt.
22	DC-2	460	Govt.

S.NO.	PLOT NO.	AREA (m^2)	REMARKS
23	INFO-1	460	Govt.
24	INFO-2	460	Govt.
25	SEC.1-1	460	Govt.
26	SEC.1-2	460	Govt.
27	SEC.10A-1	450	Govt.
28	SEC.10A-2	460	Govt.
29	SACHI-1	460	Govt.
30	SACHI-2	460	Govt.
31	AKSH-1	460	Govt.
32	AKSH-2	460	Govt.
33	JS-1	502	Govt.
34	JS-2	474	Govt.
35	SEC.16-1	539	Govt.
36	SEC.16-2	450	Govt.
37	SEC.24-1	454	Govt.
38	SEC.24-2	385	Govt.
39	MM-1	495	Govt.
40	MM-2	465	Govt.
		TOTAL = 21457 m^2	
		GOVT. = 19694 m^2	
		PVT. = 1763 m^2	

Table 5.5 (B) - Koteshwar Road – Airport Metro Corridor (Phase-IIA)
Land Required for Stations

S.NO.	PLOT NO.	AREA (m^2)	REMARKS
1	SN-1	460	Govt.
2	SN-2	460	Govt.
3	AIR-1	497	Govt.
4	AIR-2	664	Govt.
		TOTAL = 2081 m^2	
		GOVT. = 2081 m^2	
		PVT. = 0 m^2	

Table 5.5 (C) - GNLU – GIFT City Metro Corridor
Land Required for Stations

S.NO.	PLOT NO.	AREA (m^2)	REMARKS
1	PDPU-1	460	Pvt.
2	PDPU-2	460	Pvt.
3	GC-1	460	Govt.
4	GC-2	875	Govt.
		TOTAL = 2255 m^2	
		GOVT. = 1335 m^2	
		PVT. = 920 m^2	

5.4.7 Land for Staff quarters, office complex and operation control centre (OCC)

A large number of officers and staff will be required to be deployed permanently to take care of project implementation and post construction operational activities. Moreover Metro Office Complex and Metro Operation Control Centre (OCC) will also be required. Metro Office Complex and OCC will be same for all the metro lines, therefore no separate office complex is proposed for phase-II corridors. It is proposed to keep the provision of **1.5 ha** of government land for staff quarters. Exact location of land has not been identified at this stage. It may be decided at the time of project implementation.

5.4.8 Temporary office accommodation

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

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

Table 5.6 Details of Temporary Land office accommodation

S. No.	Corridor	AREA (m^2)	OWNER-SHIP
1	Motera Stadium to Mahatma Mandir	8000	Government
2	GNLU to GIFT City	2000	Government
	Total	**10000**	
3	Koteshwar Road – Airport (Phase-IIA)	2000	Government
4	Additional Corridor inside GIFT City (Phase-IIB)	2000	Government
	Total (II + IIA + IIB)	**14000**	

5.4.9 Segment Casting Yard

Pre-cast girders are required for construction of elevated structures for which a large open area is required for setting up of casting yard. As far as possible, this area should be close to the site, easily accessible and away from habitation. Considering the various factors, it is proposed to setup seven casting yards (four for Motera Stadium to Mahatma Mandir corridor, one for Koteshwar Road to Airport corridor, one for GNLU to GIFT City corridor and one for additional corridor inside GIFT City) for the proposed corridors. Accordingly a provision of **14 ha** land has been proposed on temporary basis considering 2.0 ha of land for each casting yard for a period of four years.

5.4.10 Summary of Land Requirements

Abstract of land requirements for different components of these corridors is given in Tables below.

Table 5.7 - Summary of Permanent Land Requirement (All figures in Sq. m)

Sr.	Description	Phase - II				Phase – IIA		Phase - IIB		Total
		Motera Stadium to Mahatma Mandir		GNLU to GIFT City		Koteshwar Road to Airport		Additional corridor inside GIFT City		
		Govt.	Pvt.	Govt.	Pvt.	Govt.	Pvt.	Govt.	Pvt.	
1	Stations	19694	1763	1335	920	2081	0	4200	0	**29993**
2	Running Section	5378	35	0	0	3893	4540	0	0	**13846**
3	Depot/Stabling Yard	100000	0	0	0	0	0	0	0	**100000**
4	Staff Quarters	15000	0	0	0	0	0	0	0	**15000**
5	Office Complex and OCC	0	0	0	0	0	0	0	0	**0**
6	RSS	3600	0	0	0	3600	0	0	0	**7200**
	Total	**143672**	**1798**	**1335**	**920**	**9574**	**4540**	**4200**	**0**	**166039**

Total = 16.6039 ha
Government = 15.8781 ha
Private = 0.7258 ha

Table 5.8 - Summary of Temporary Land Requirement (All figures in Sq. m)

Sr.	Description	Phase - II		Phase – IIA	Phase - IIB	OWNER-SHIP
		Motera Stadium to Mahatma Mandir	GNLU to GIFT City	Koteshwar Road to Airport	Additional corridor inside GIFT City	
1	Temporary Office/ Site Office	8000	2000	2000	2000	Government
2	Segment Casting Yard	80000	20000	20000	20000	Government
	Total	**88000**	**22000**	**22000**	**22000**	**154000**

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

5.5 UTILITY DIVERSIONS

5.5.1 Introduction

Besides the details of various aspects e.g. transport demand analysis, route alignment, station locations, system design, viaduct structure, geo-technical investigations etc. 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.

5.5.2 Utility and Services

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. may be existing along the proposed alignment. These utility services are essential and have to be maintained in working order during different stages of construction, by temporary/permanent diversions or by supporting in position. Since these may affect construction and project implementation time schedule/costs, for which necessary planning/action needs to be initiated in advance. Meticulous planning therefore will have to be taken in tackling the issue of protection/diversion of these utility services. Accordingly, the following engineering items have been studied and described below:

i) Existing utilities and planning for their diversion during construction, if necessary.

5.5.3 Diversion of Underground Utilities

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

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

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

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

5.5.4 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.

5.5.5 Aboveground Utilities

Above ground utilities namely street light poles, traffic signal posts, telecommunication posts, junction boxes, etc. are also required to be shifted and relocated suitably during construction of elevated viaduct. Since these will be interfering with the proposed alignment. Approximate numbers of affected lamp/ telecom/elect posts & boxes etc. are indicated in the Table 5.9 below

.

Table 5.9 - Affected Aboveground Services (All three corridors)

Section	LP	MH	EP
Ahmedabad Metro Phase - II Corridor	678	145	55

LP - Lamp Post, MH – Manhole, EP – Electric Pole

5.6 ISSUES RELATED TO INTERFACE WITH EXTERNAL AGENCIES

In order to complete the work timely and successfully, for all the corridors under Ahmedabad Metro Phase-II Project network, interface with external agencies on different issues shall have to be conducted as per details given in **Table 5.10.**

Table 5.10 - Interface with External Agencies

S. No.	Name of Agency	Issue
1	AMC / Forest Department	Removal of trees under the area of proposed corridors.
2	AUDA /AMC/ R&B/GUDA	Clearance of ROW & Bridges for Metro wherever encroached/occupied.
3	Ahmedabad Traffic Police	Alignment of various corridors under Phase-II network shall pass on/along the roads.

4	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.

5.7 TRAFFIC DIVERSION

5.7.1 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:

- For elevated section wherever it is passing along the road, the requirement would be mainly along the central verge.
- 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.

5.7.2 Traffic Diversion Plans

Only temporary diversion plans will be required during construction of the Metro corridors under Ahmedabad Metro Rail Project Phase-II network. At the onset, all encroachments from road ROW will have to be removed. These encroachments vary from „on-street" parking to informal activities.

Keeping in view 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.

Figure 5.2

SCALE- NTS

TYPICAL CROSS SECTION OF THE VIADUCT WITH DOUBLE U GIRDER

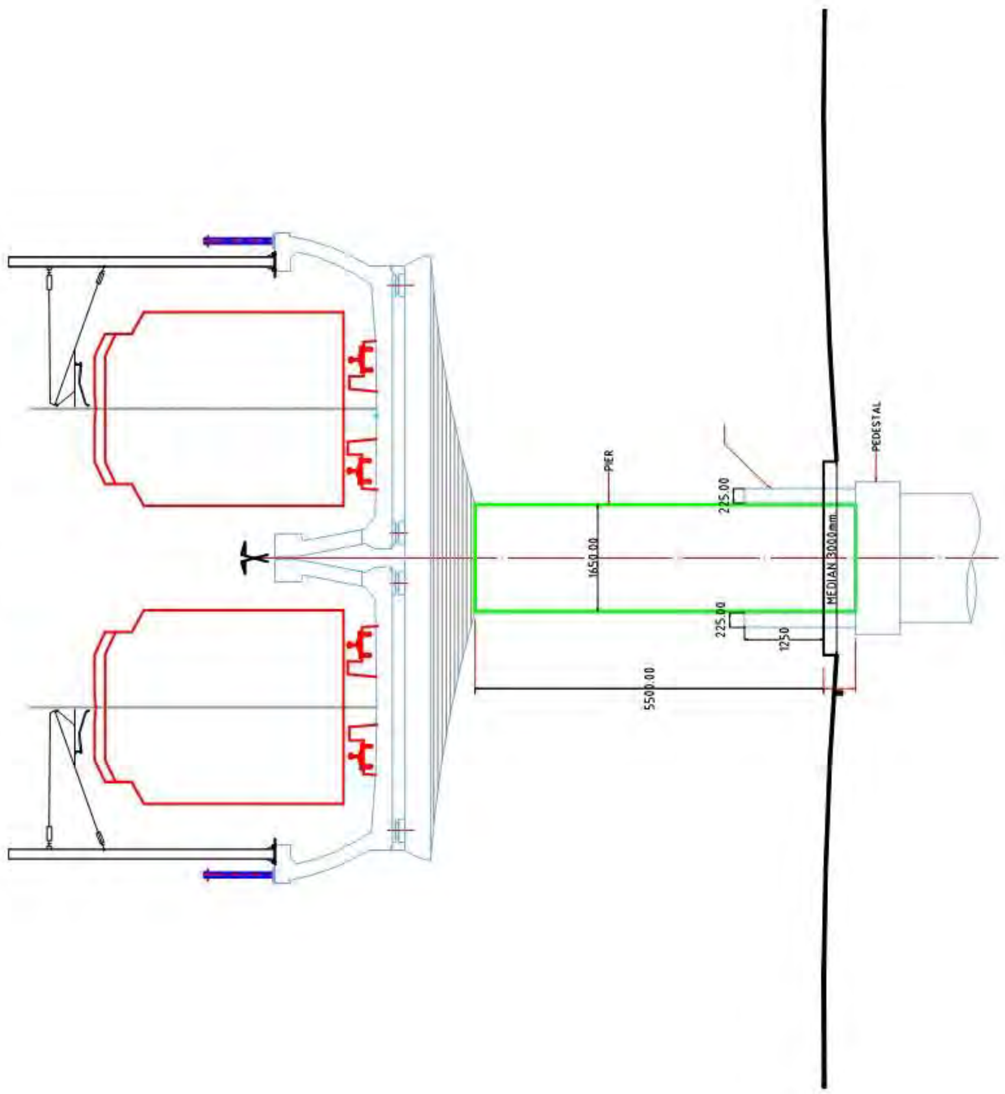
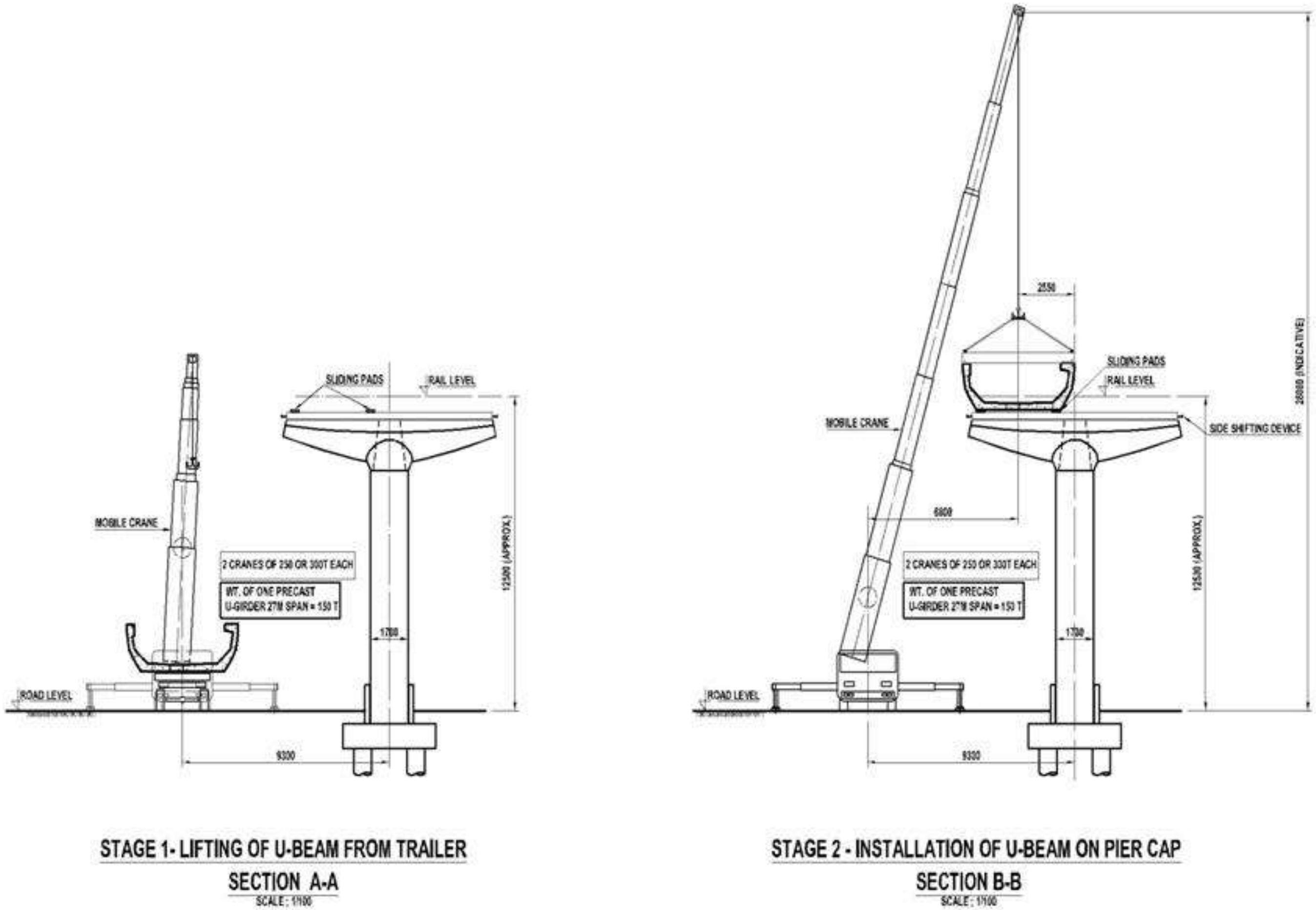
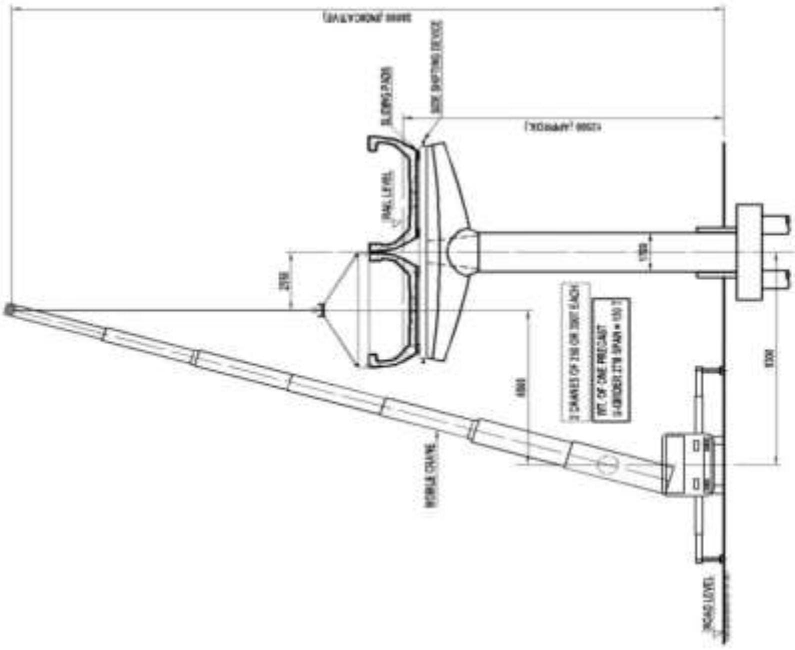


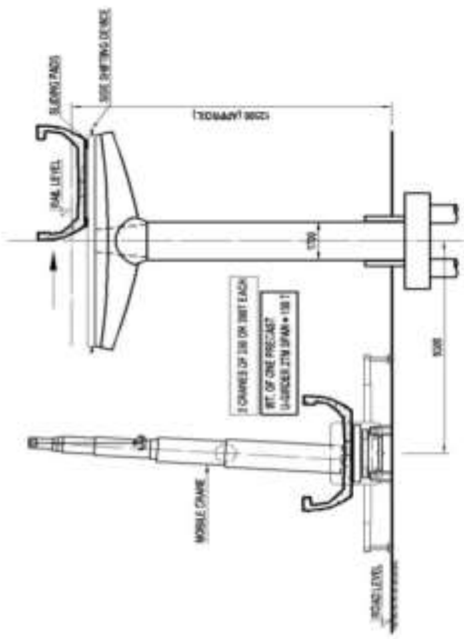
Figure 5.3(a): Erection of Girder using Crane



NOTES:
- METHOD OF ERECTION BY CRANE IS INDICATIVE ONLY AND TO BE DECIDED BY CONTRACTOR. HOWEVER CONTRACTOR MAY PROPOSE ANY OTHER METHOD OF ERECTION.

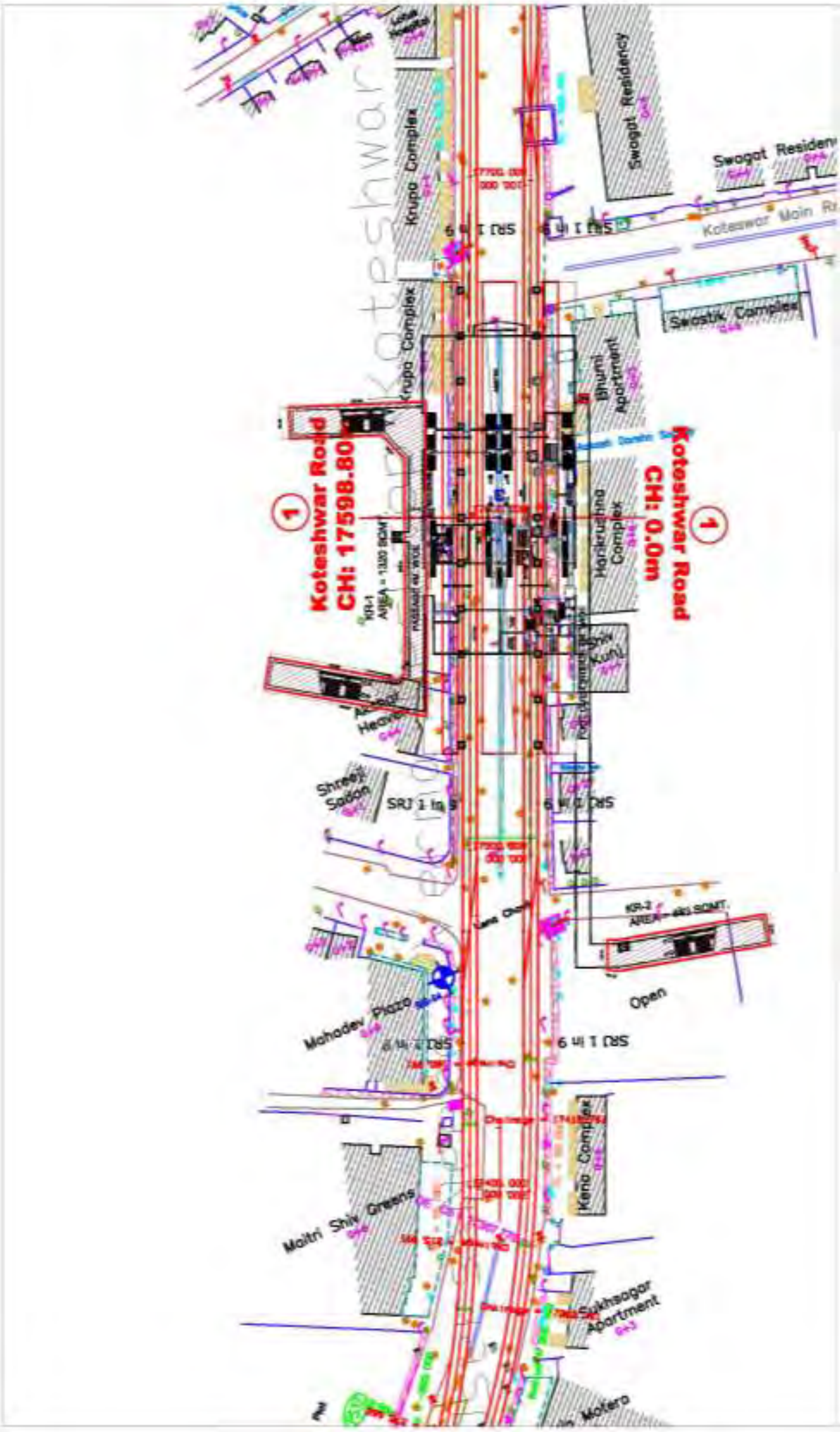


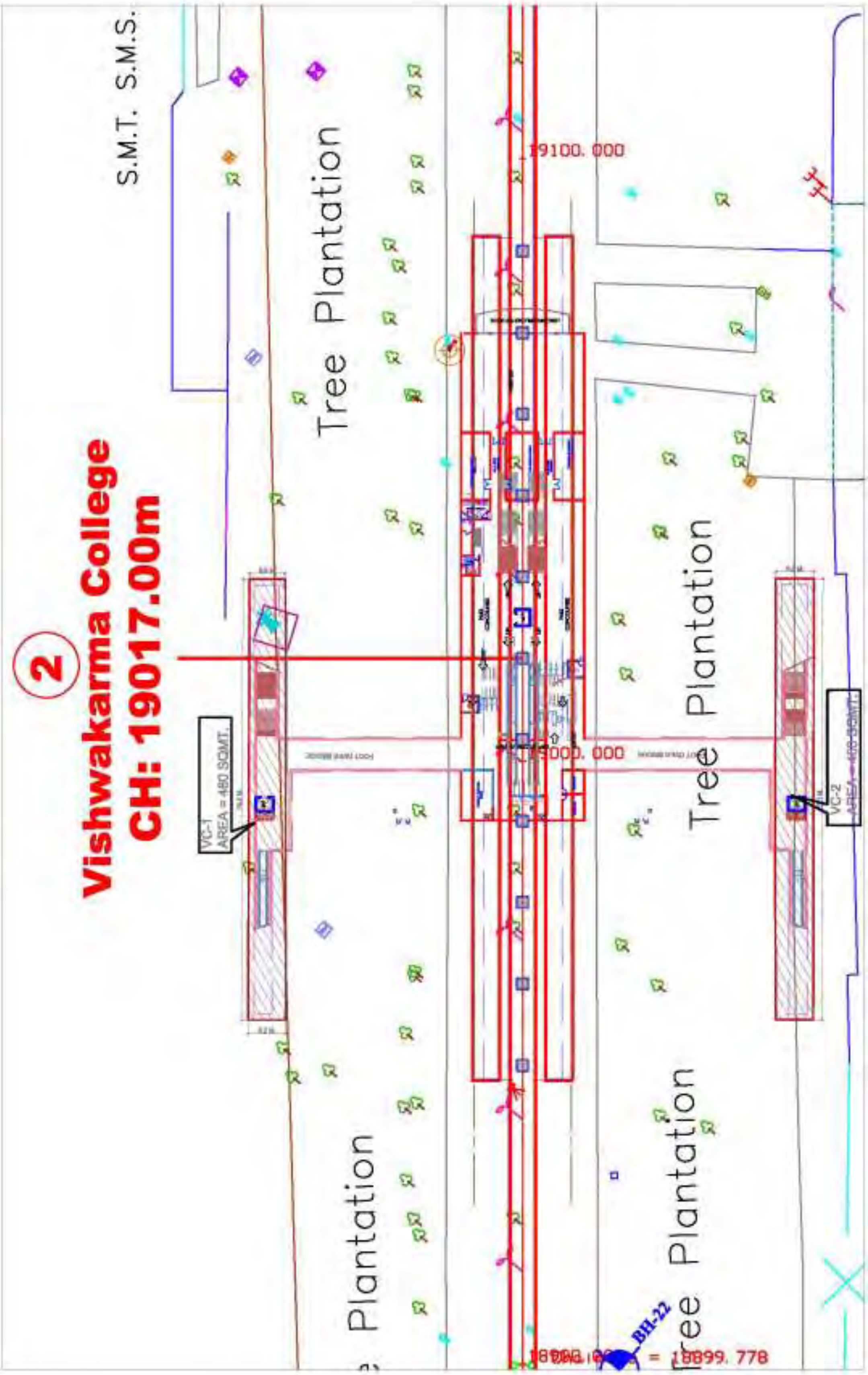
STAGE 4 - LIFTING AND INSTALLATION OF OTHER U-GIRDER
SECTION D-D



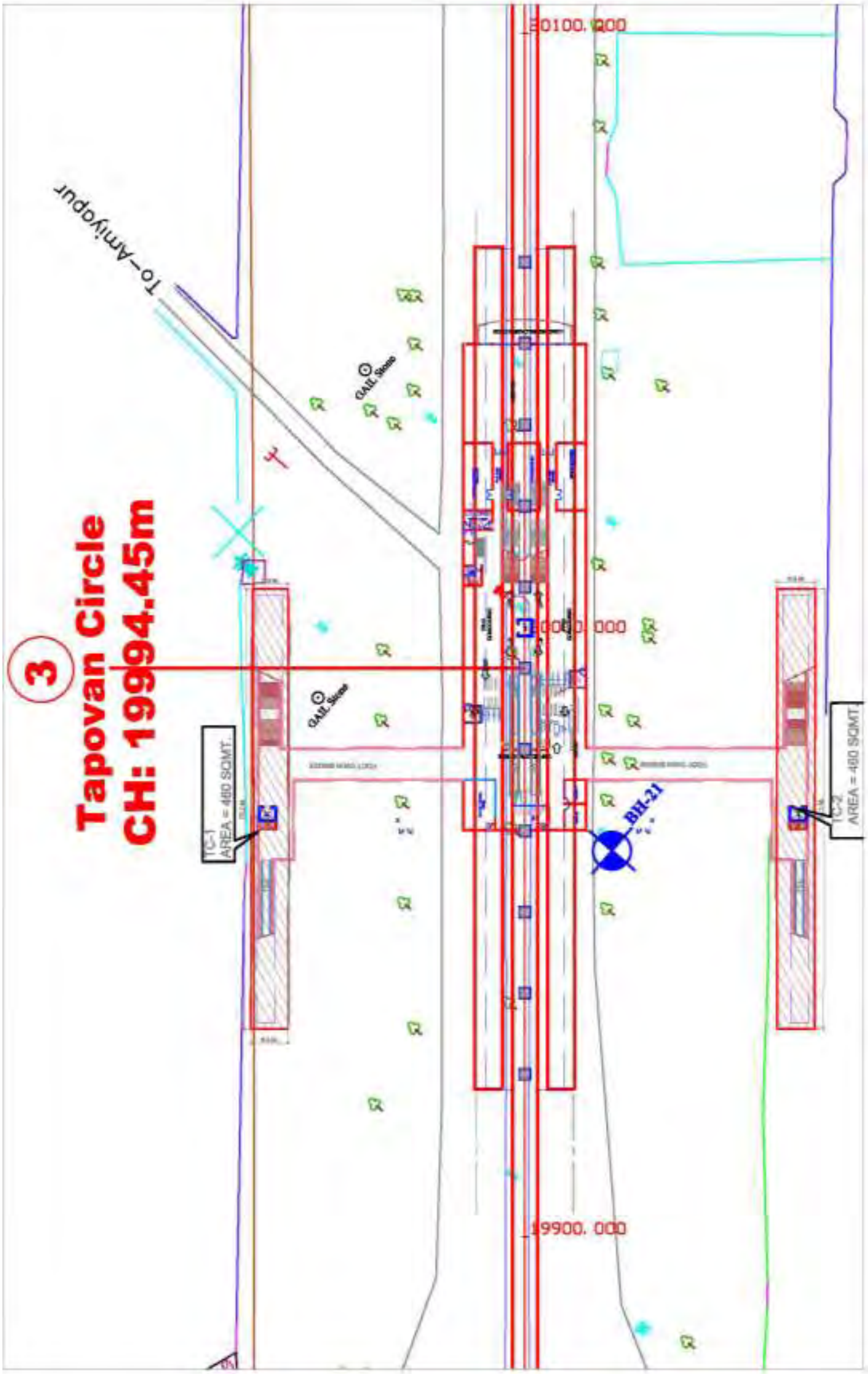
STAGE 3 - SIDE SHIFTING OF U-GIRDER
SECTION C-C

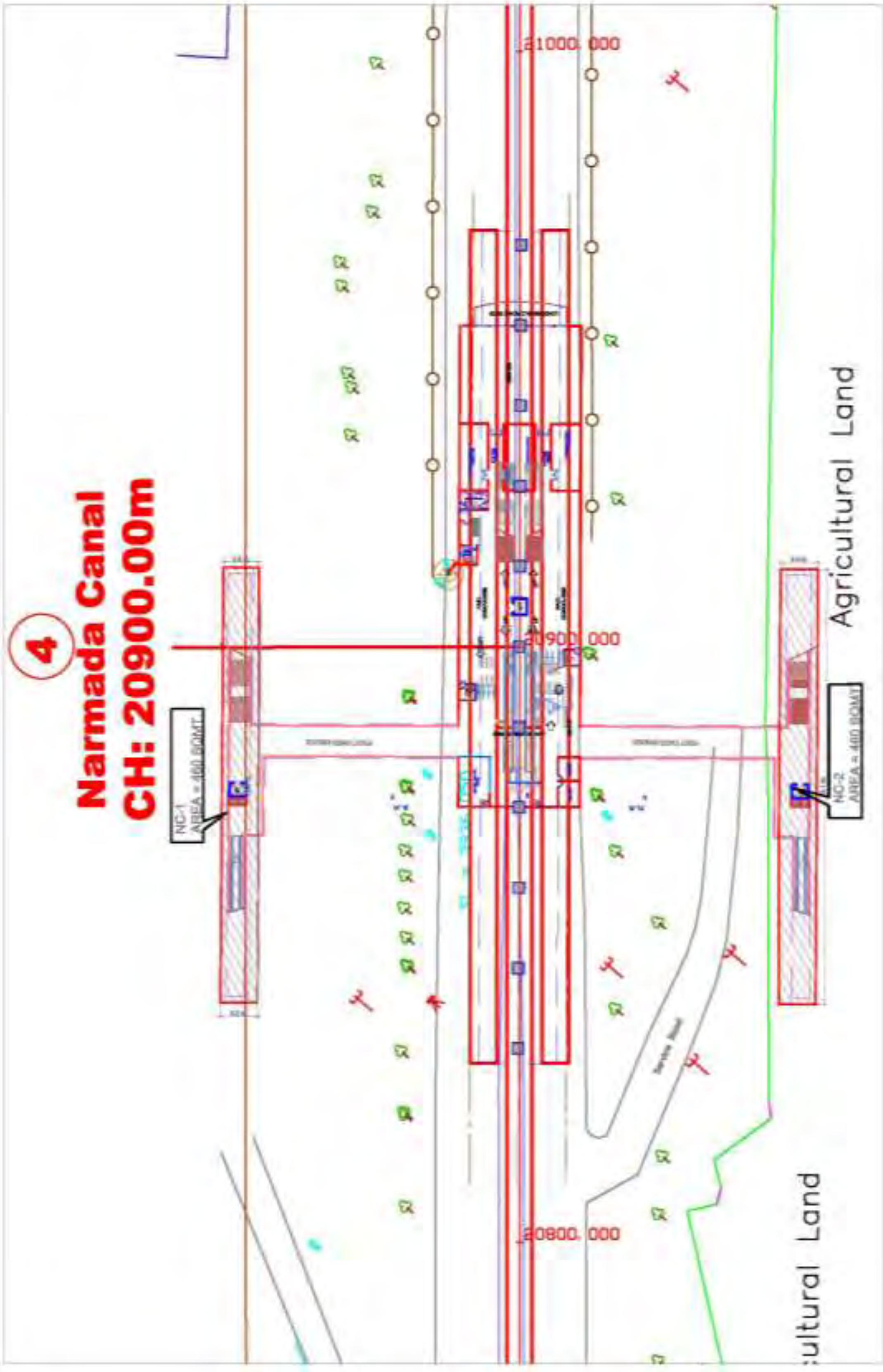
NOTES:
- METHOD OF ERECTION BY CRANE IS INDICATIVE ONLY AND TO BE DECIDED BY CONTRACTOR. HOWEVER CONTRACTOR MAY PROPOSE ANY OTHER METHOD OF ERECTION.

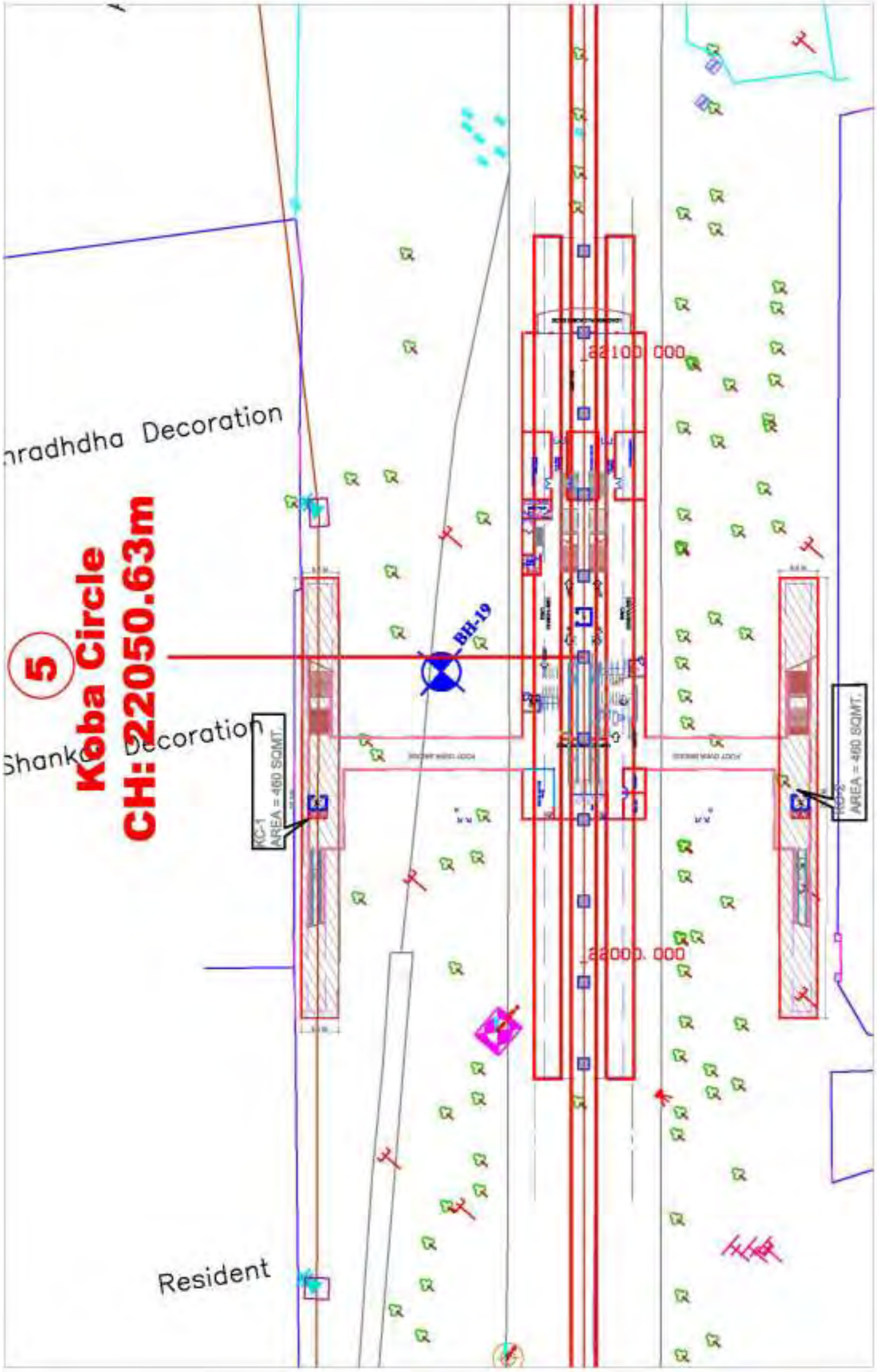


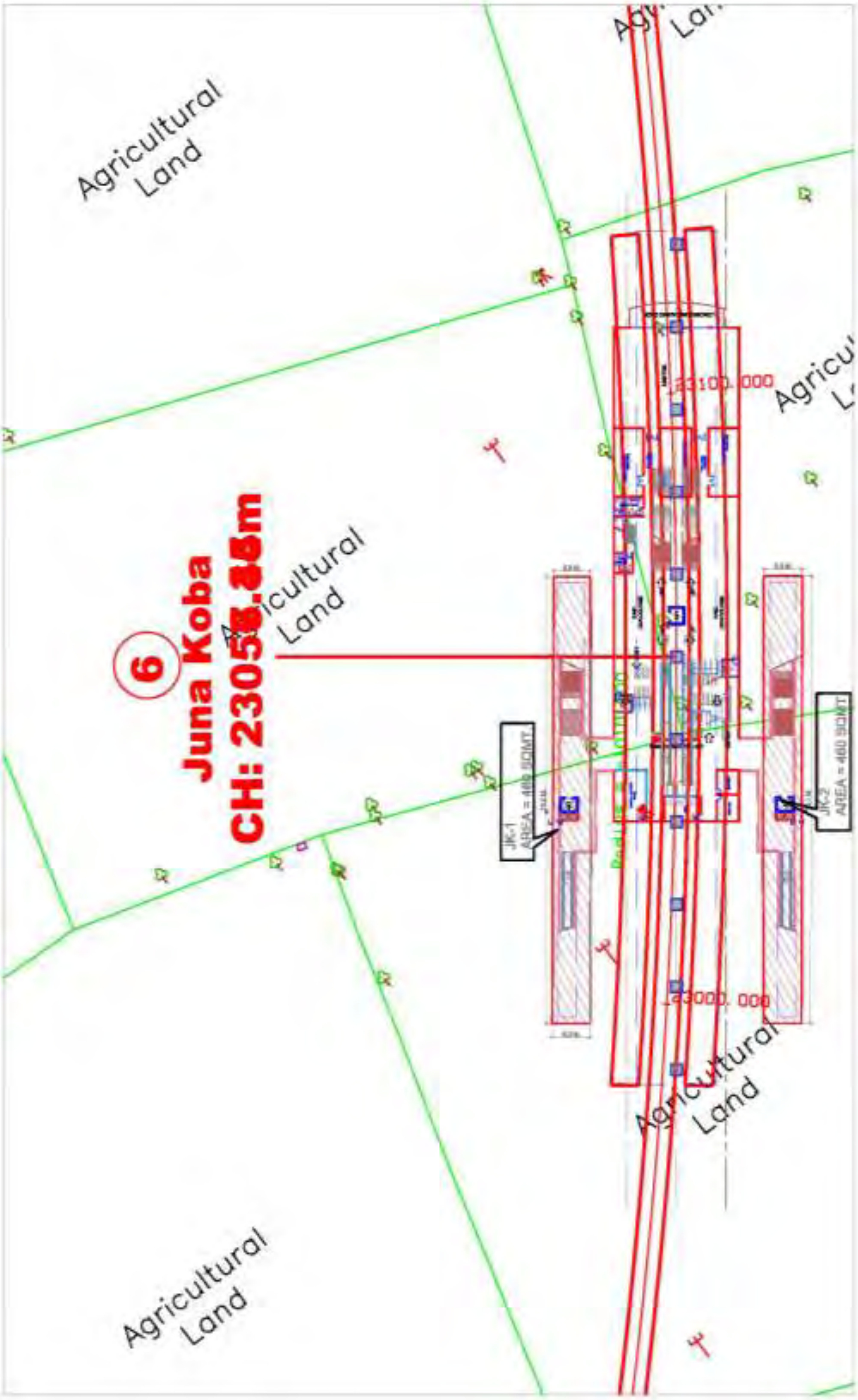


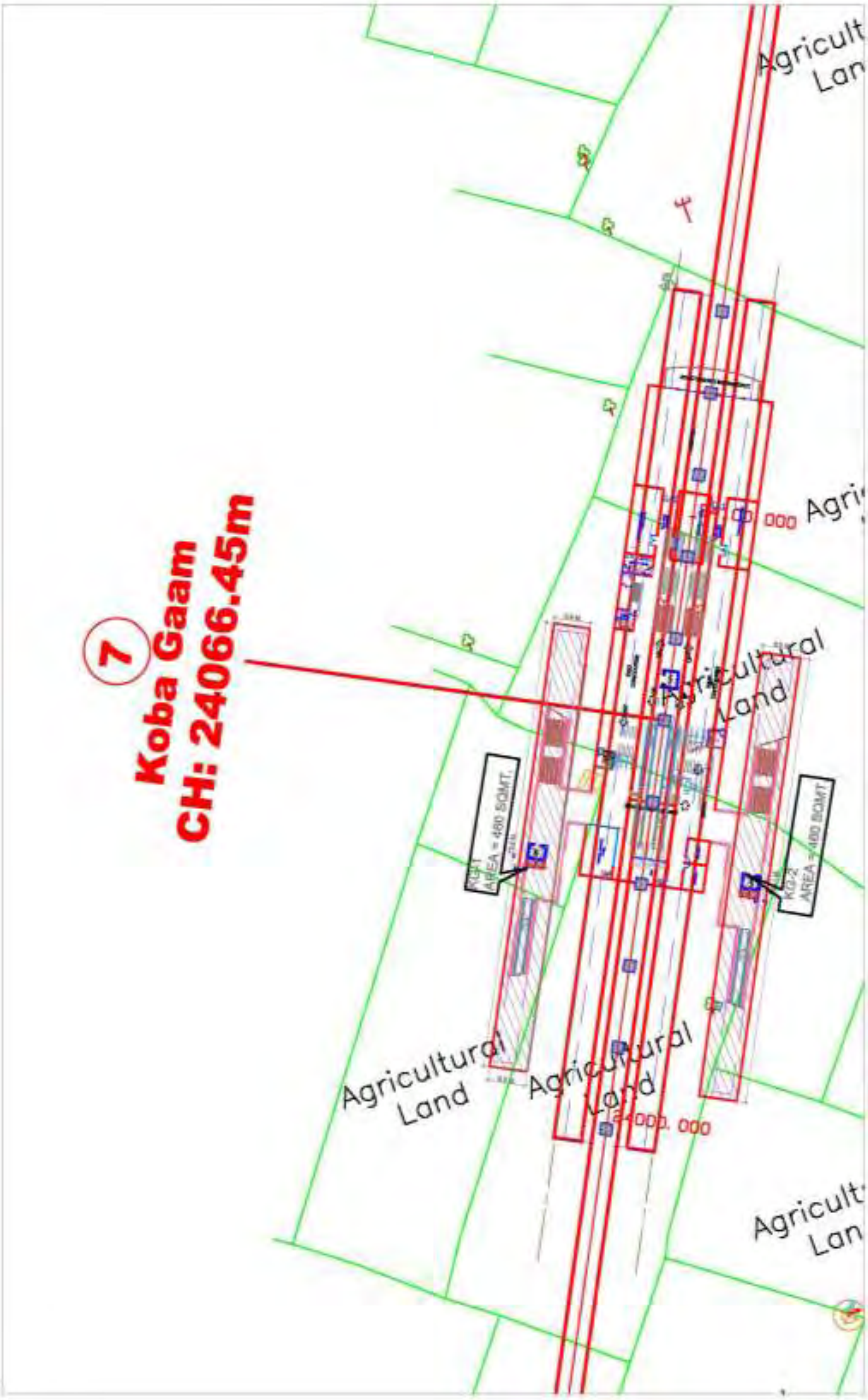
2
Vishwakarma College
CH: 19017.00m
S.M.T. S.M.S.
Tree Plantation
Tree Plantation
Plantation
Tree Plantation
19100.000
19000.000
VC-1
AREA = 480 SQMT.
VC-2
AREA = 480 SQMT.
BH-22
= 18899.778

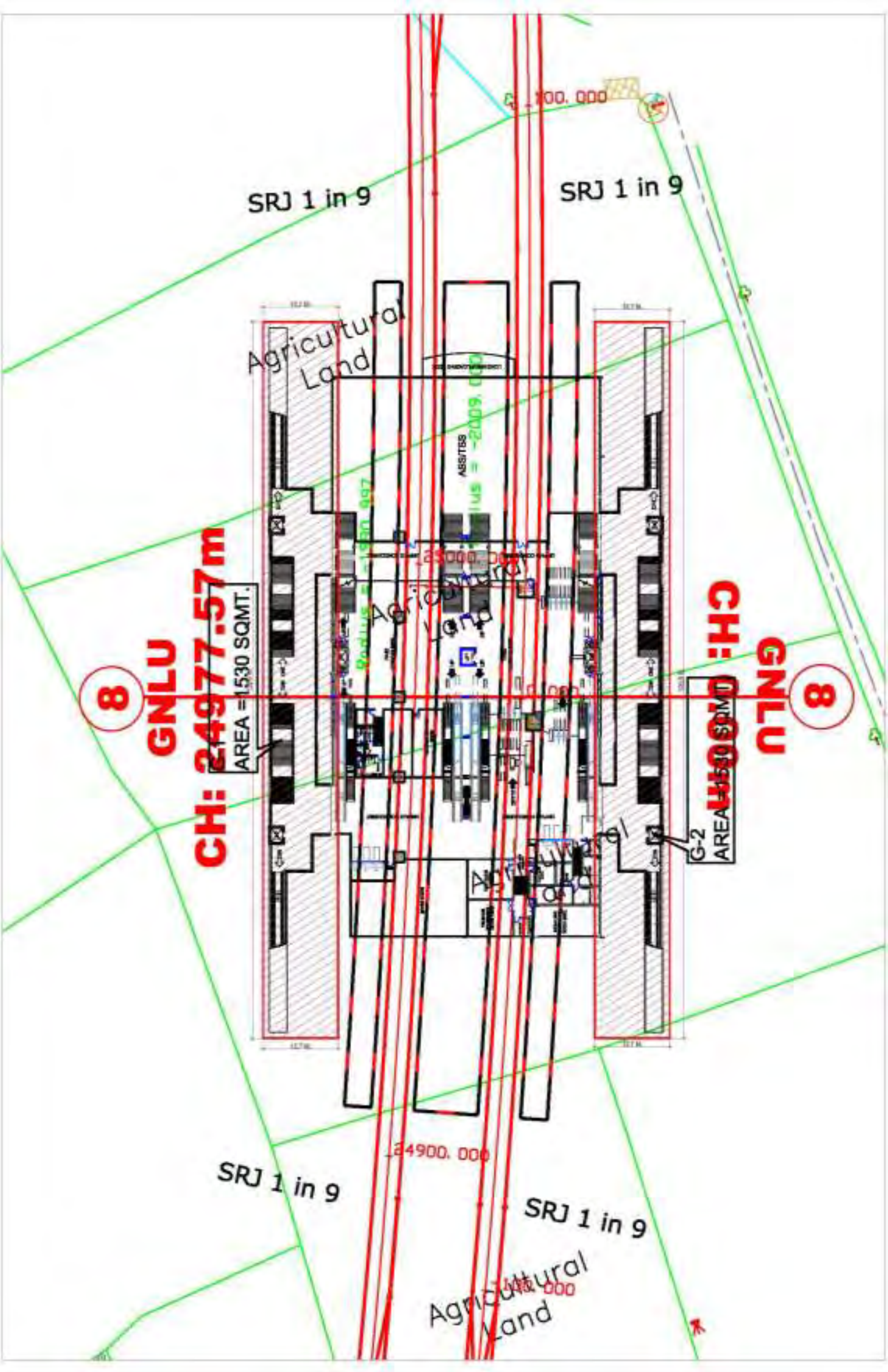

3
Tapovan Circle
CH: 19994.45m
To-Amiyapur
GAIL Stone
GAIL Stone
TC-1
AREA = 480 SQMT.
TC-2
AREA = 480 SQMT.
BH-21
20100.000
19900.000

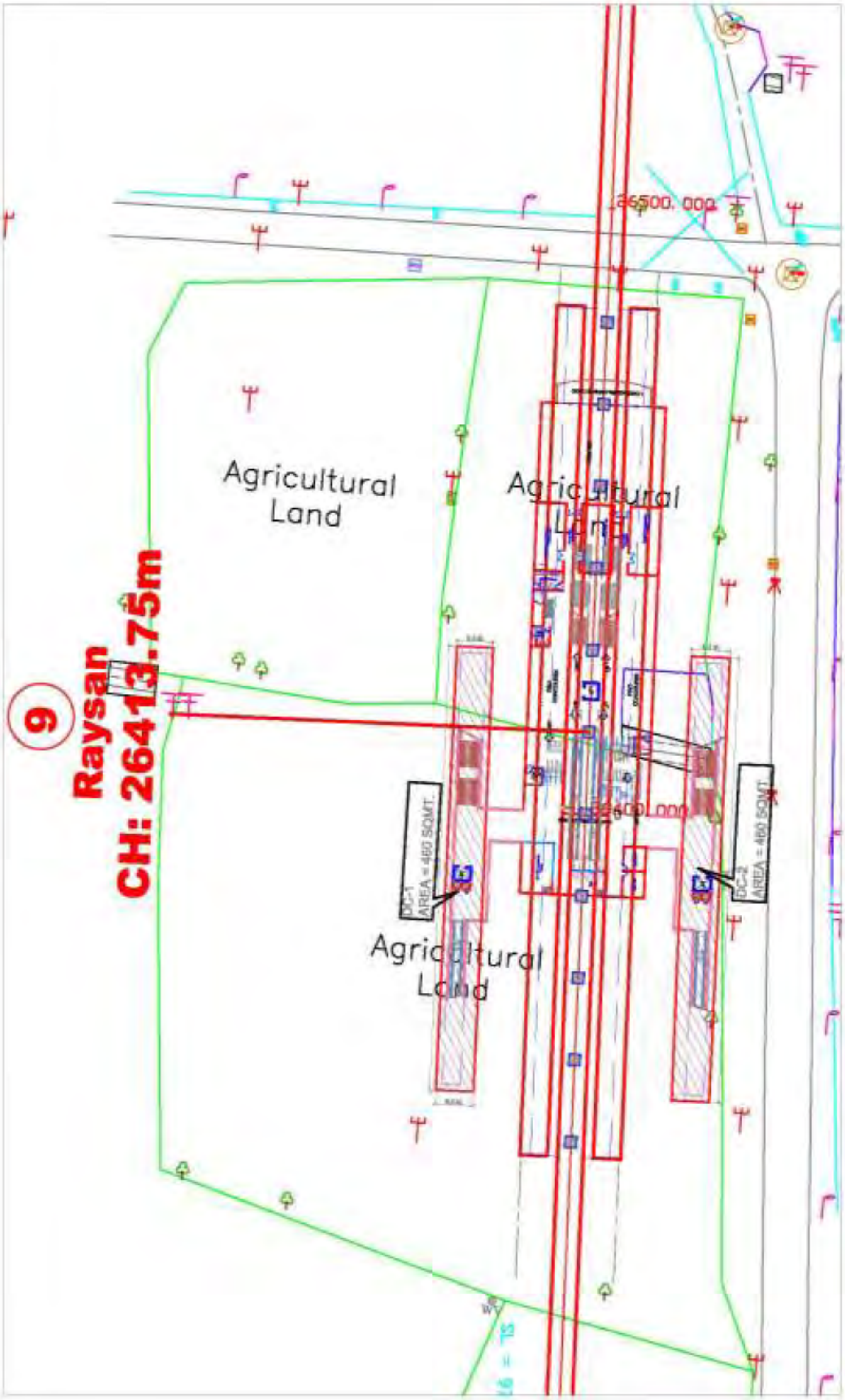

4
Narmada Canal
CH: 20900.00m
21000.000
20900.000
20800.000
NC-1
AREA = 460.50SQMT
NC-2
AREA = 460.50SQMT
Agricultural Land
cultural Land

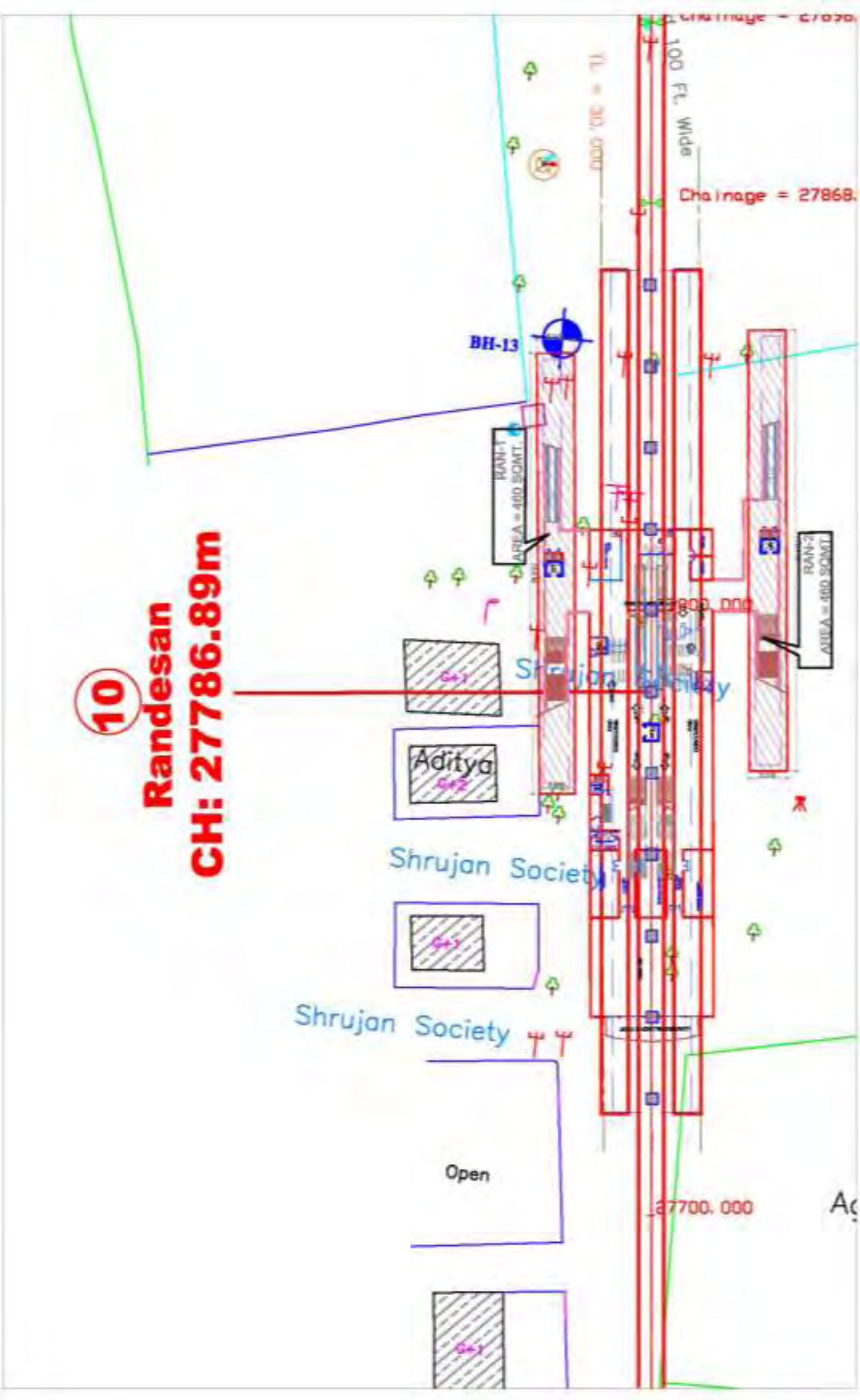

5
Koba Circle
CH: 22050.63m
Decoration
Resident
BH-19
22100.000
22000.000
KC-1
AREA = 460 SQMT.

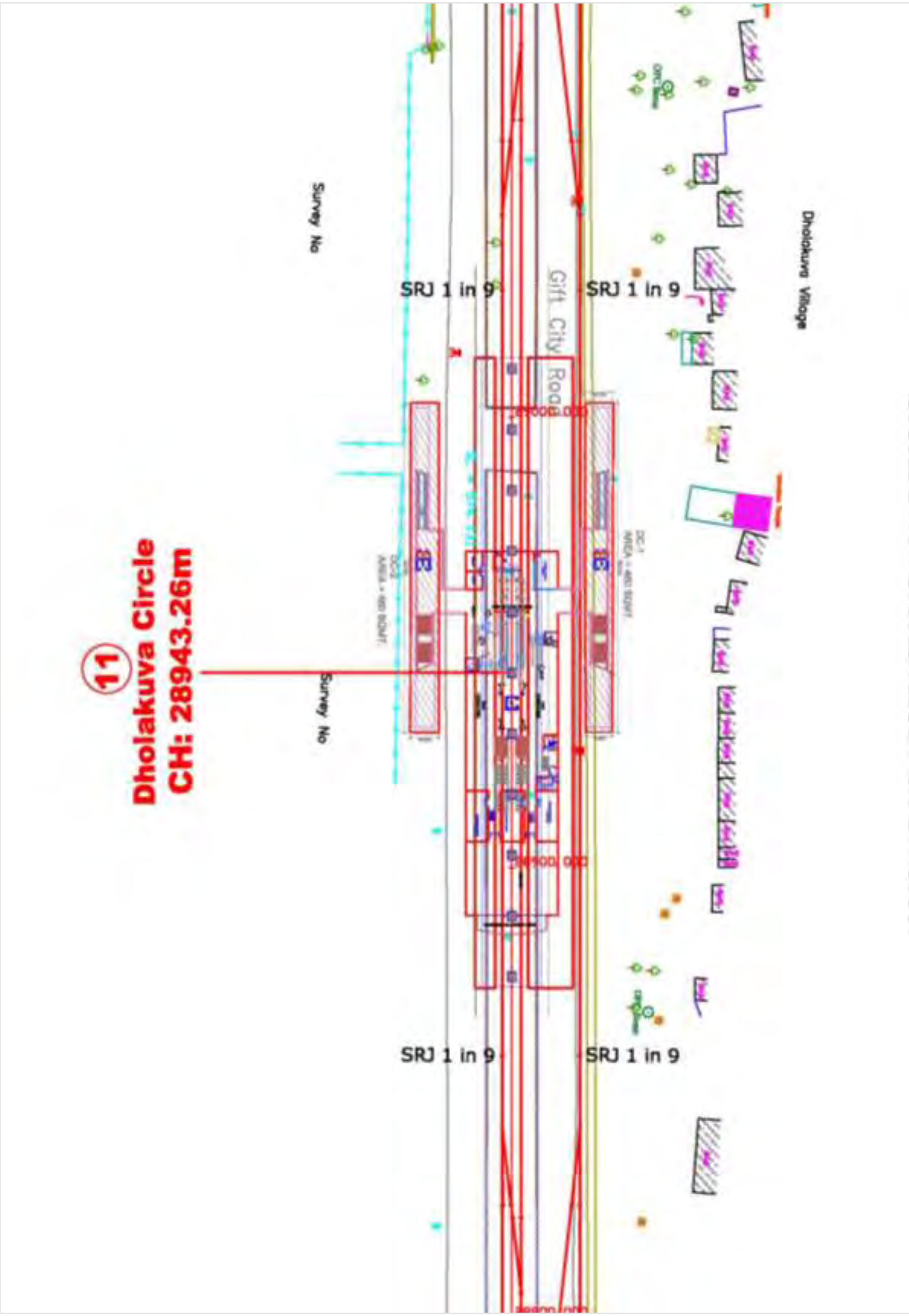

Agricultural Land
Agricultural Land
Agricultural Land
Agricultural Land
6
Juna Koba
23100.000
23000.000
JK-1 AREA = 460 SQMT
JK-2 AREA = 460 SQMT

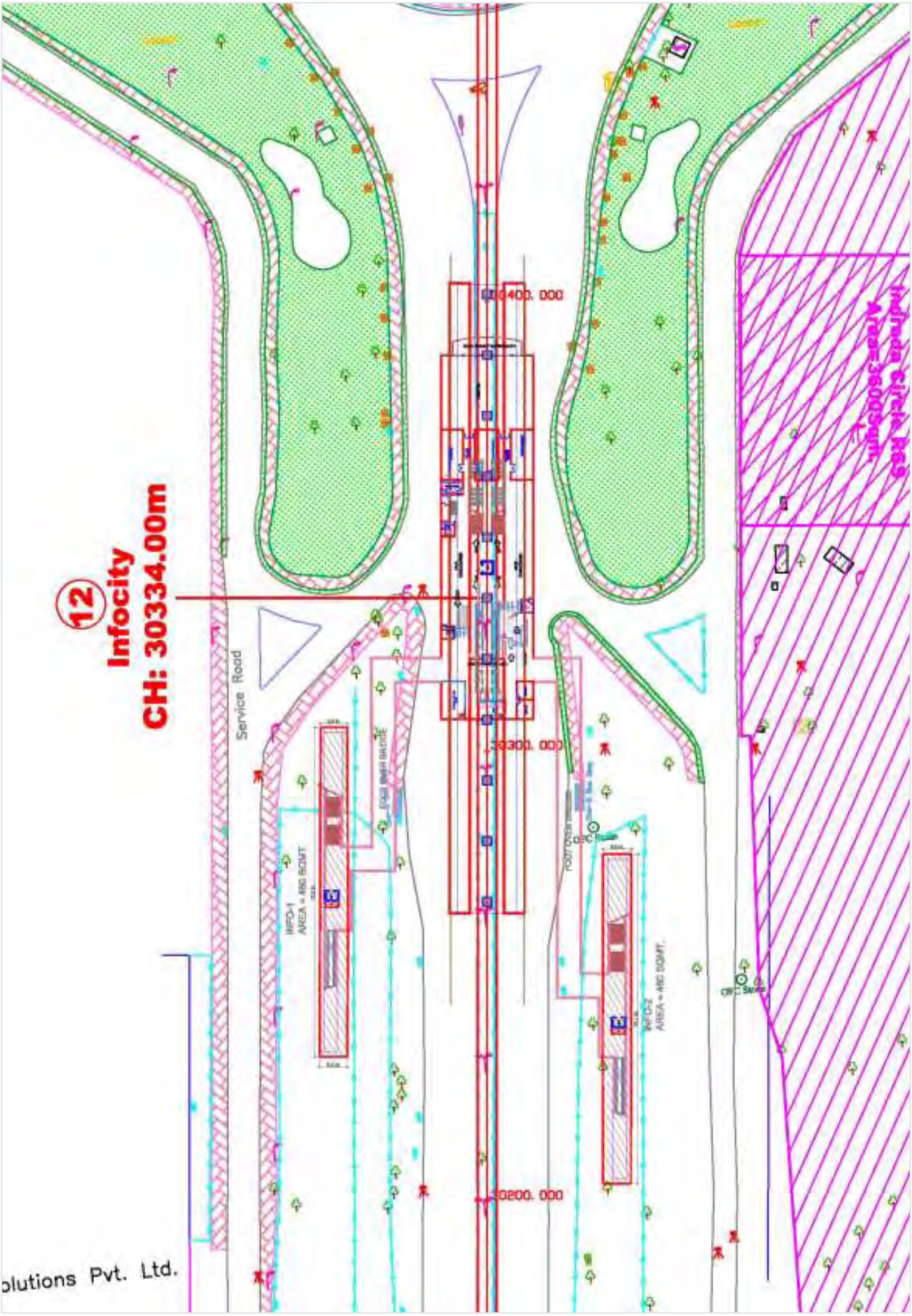

7
Koba Gaam
CH: 24066.45m
Agricultural Land
Agricultural Land
Agricultural Land
24000. 000

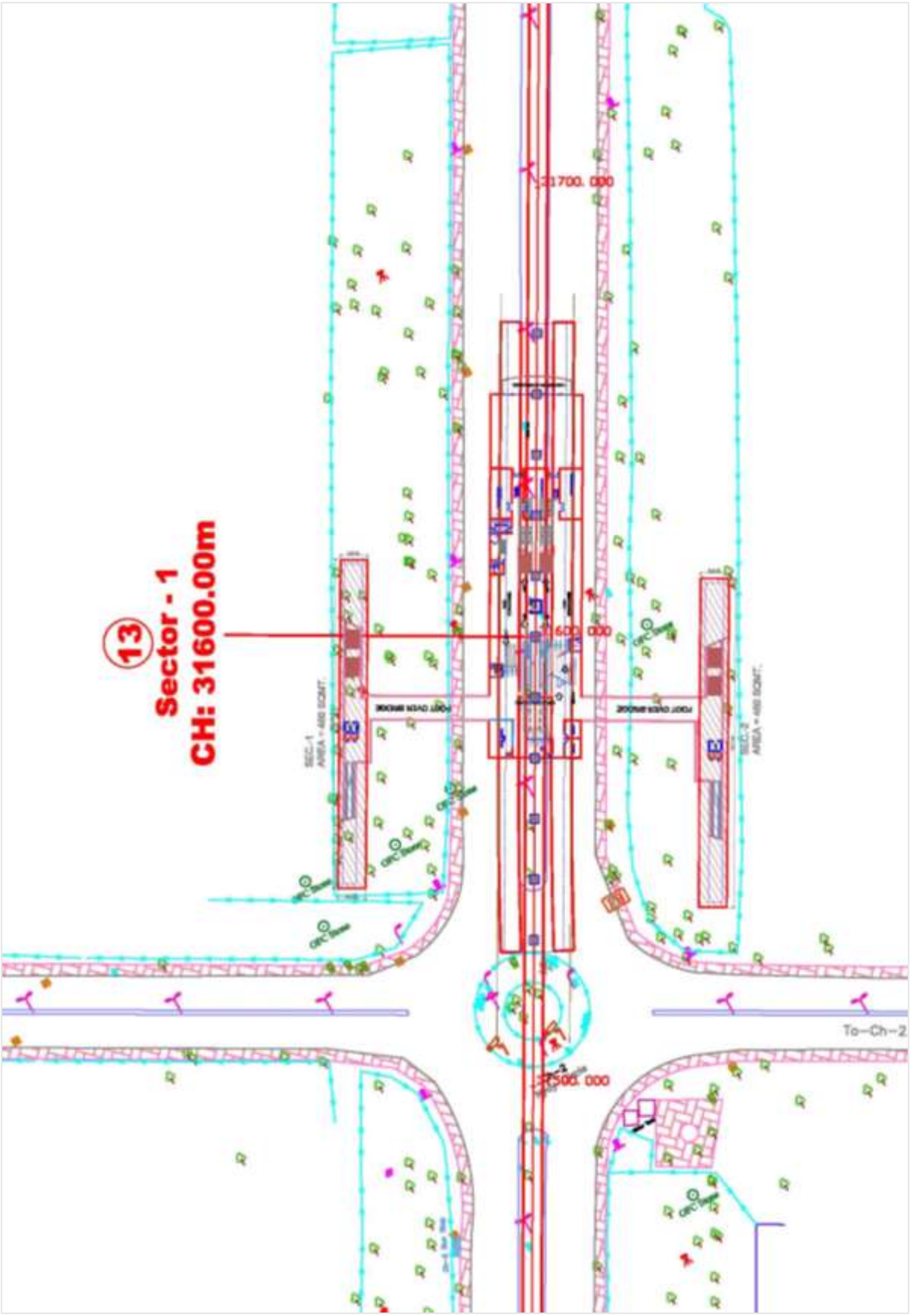

SRJ 1 in 9
SRJ 1 in 9
Agricultural Land
GNLU
CH: 24977.57m
AREA =1530 SQMT.
8
GNLU
8
AREA =1530 SQMT.
G-2
Agricultural Land
Agricultural Land
Agricultural Land
ASS/TSS
24900. 000
SRJ 1 in 9
SRJ 1 in 9

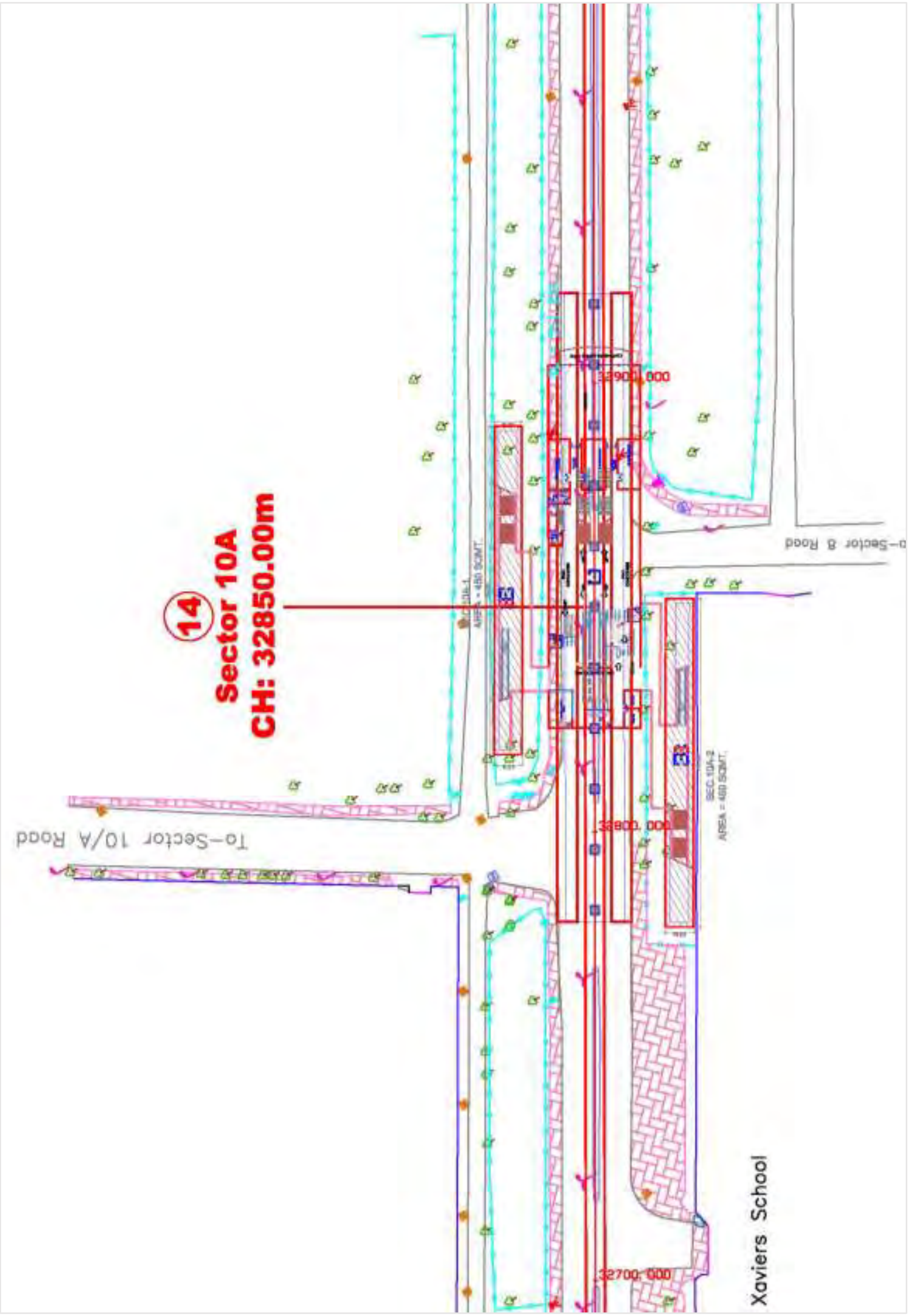

Agricultural Land
Agricultural Land
Agricultural Land
9
Raysan
CH: 26413.75m
26500.000
DC-1
AREA = 460 SQMT
DC-2
AREA = 460 SQMT

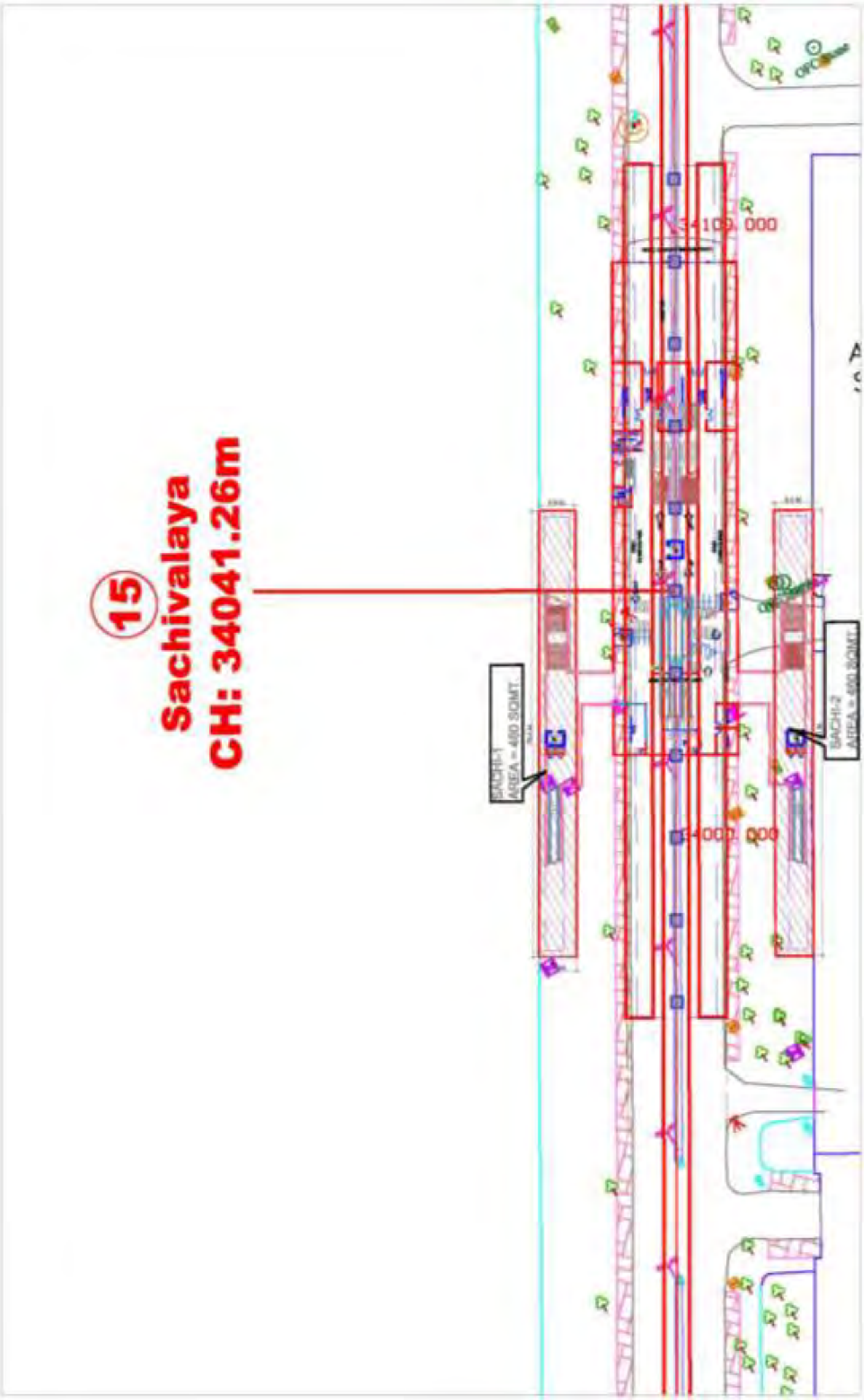

10
Randesan
CH: 27786.89m
BH-13
Chainage = 27868.
100 Ft. Wide
RAN-1
RAN-2
Shrujan Society
Shrujan Society
Aditya
Open
27700.000

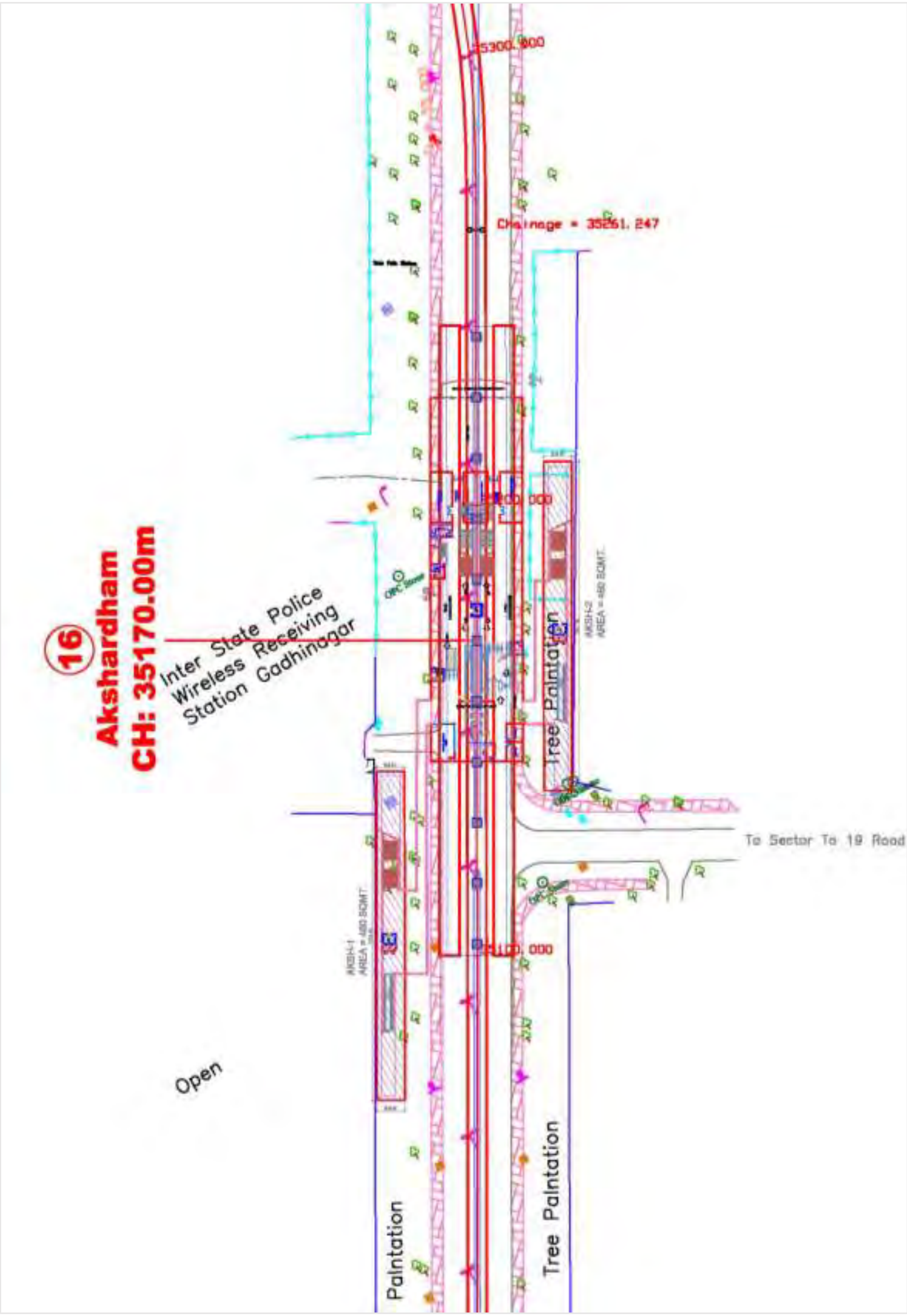

11
Dholakuva Circle
CH: 28943.26m
SRJ 1 in 9
SRJ 1 in 9
SRJ 1 in 9
SRJ 1 in 9
Survey No
Survey No
Gift City Road
Dholakuva Village

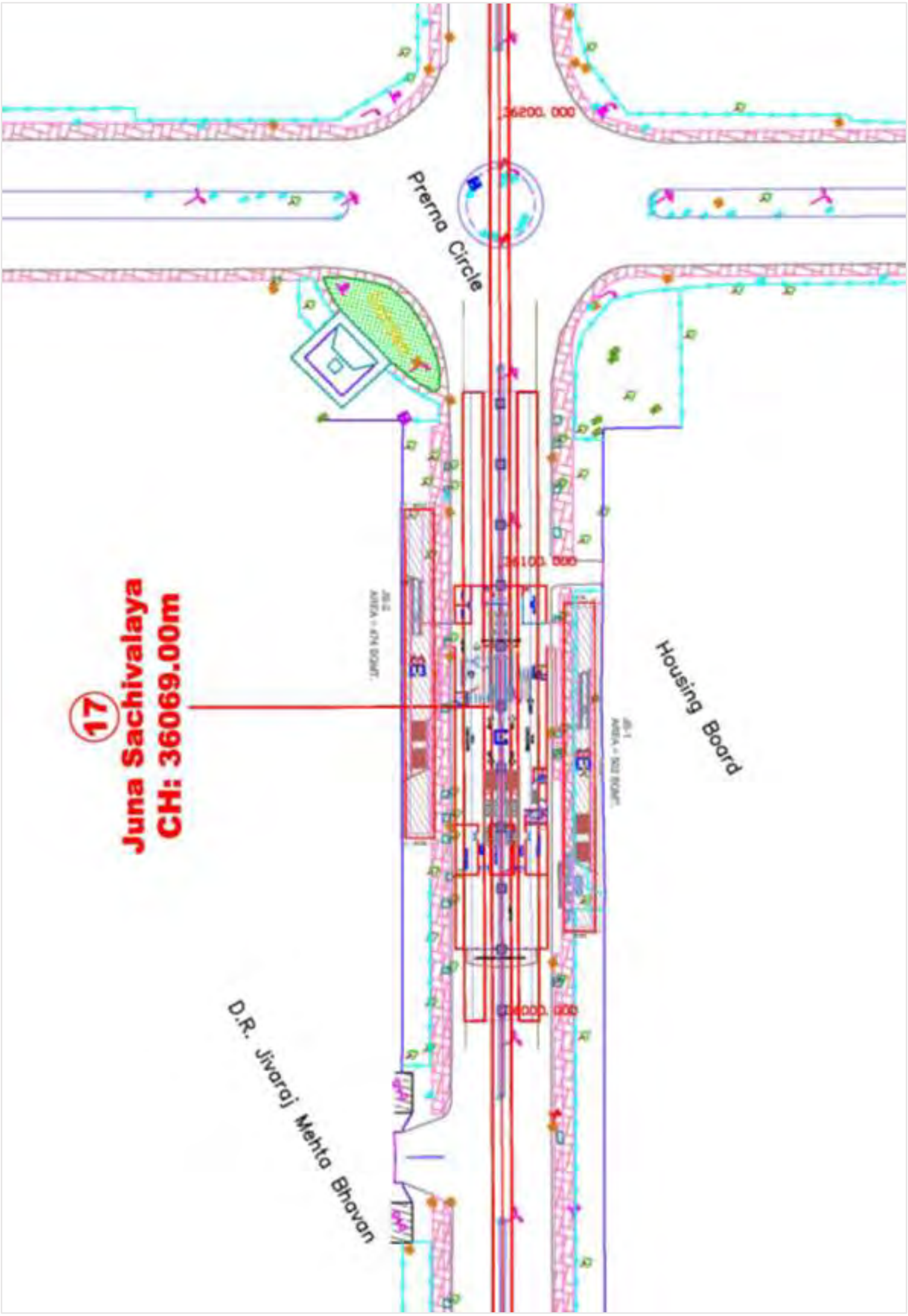

12
Infocity
CH: 30334.00m
Service Road
30400. 000
30300. 000
30200. 000
Indroda Circle R&B
Area=3600sqm.
olutions Pvt. Ltd.

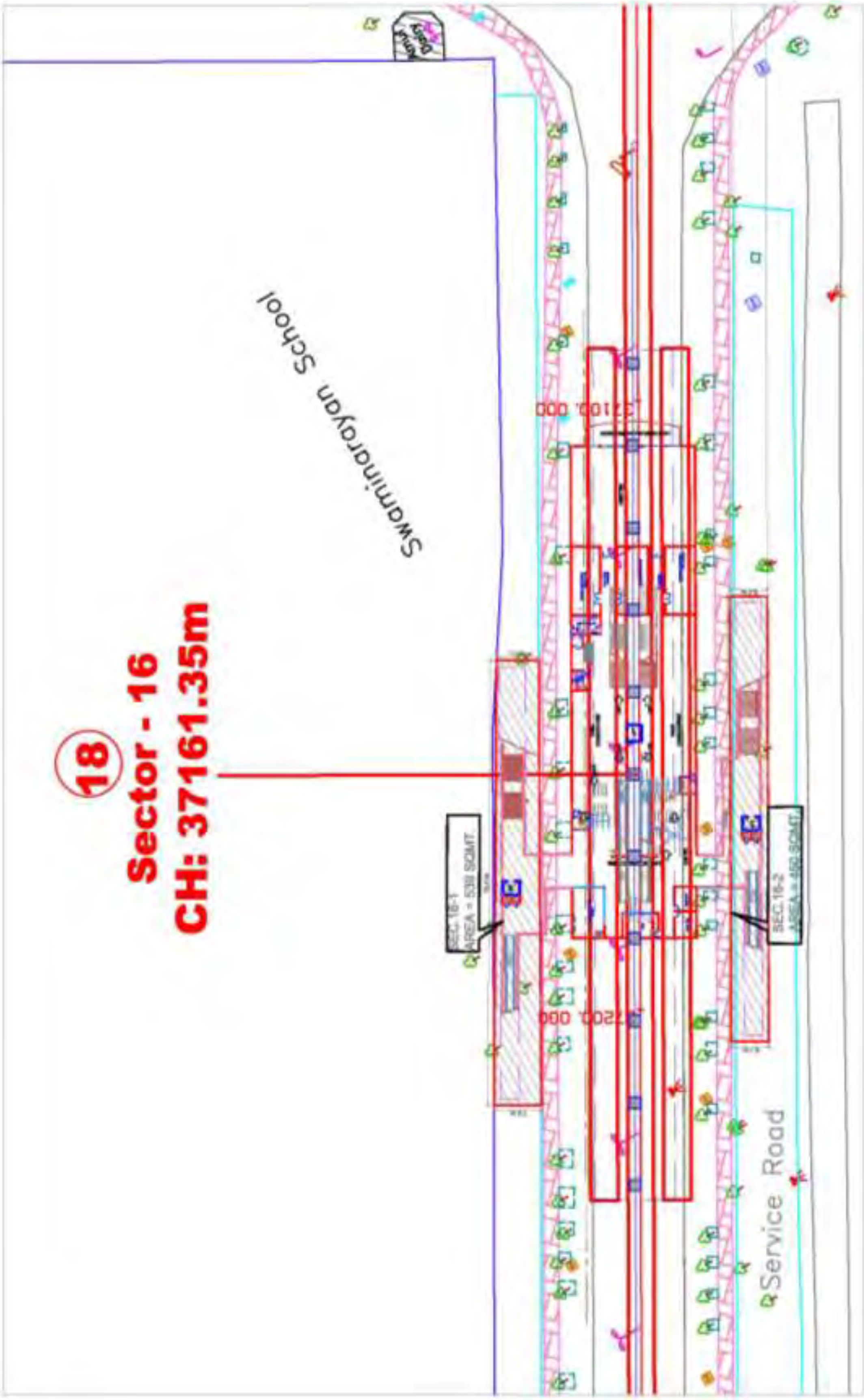

13
Sector - 1
CH: 31600.00m
31700. 000
31600. 000
31500. 000
To-Ch-2

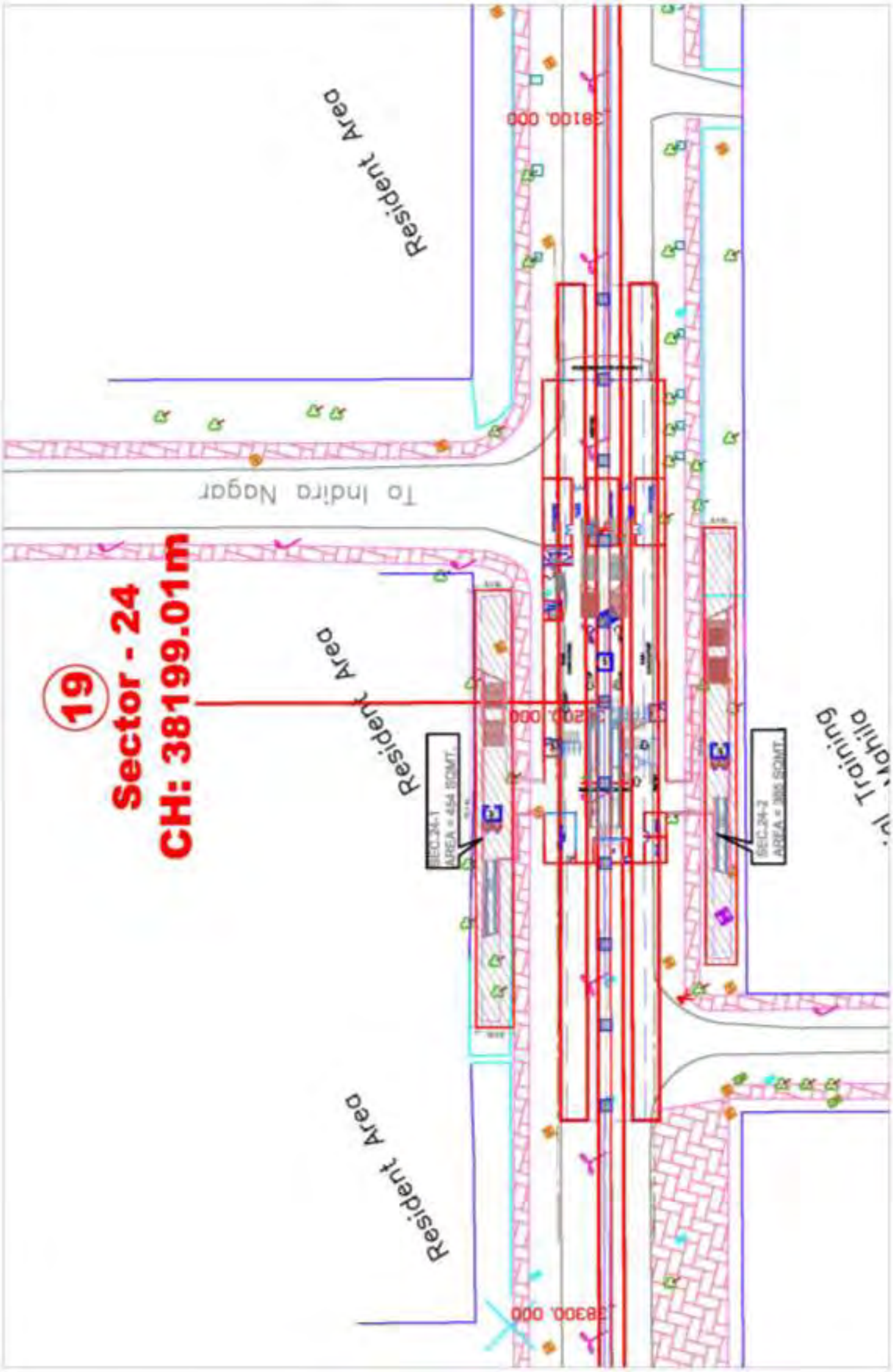

14
Sector 10A
CH: 32850.00m
To-Sector 10/A Road
o-Sector 8 Road
Xaviers School
32900.000
32800.000
32700.000

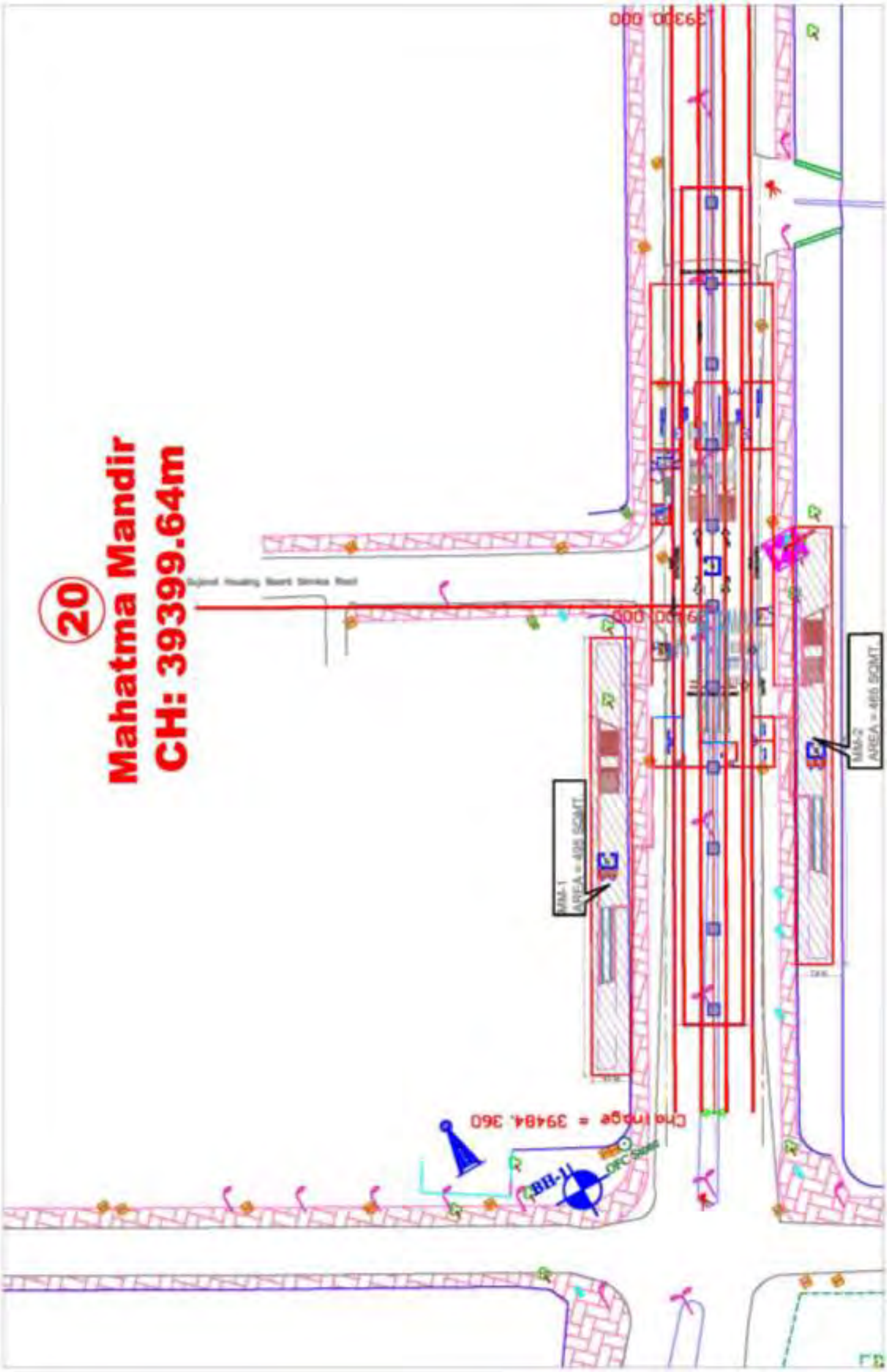

15
Sachivalaya
CH: 34041.26m
34100.000
34000.000
SACHI-1
AREA = 480 SQMT.
SACHI-2
AREA = 480 SQMT.

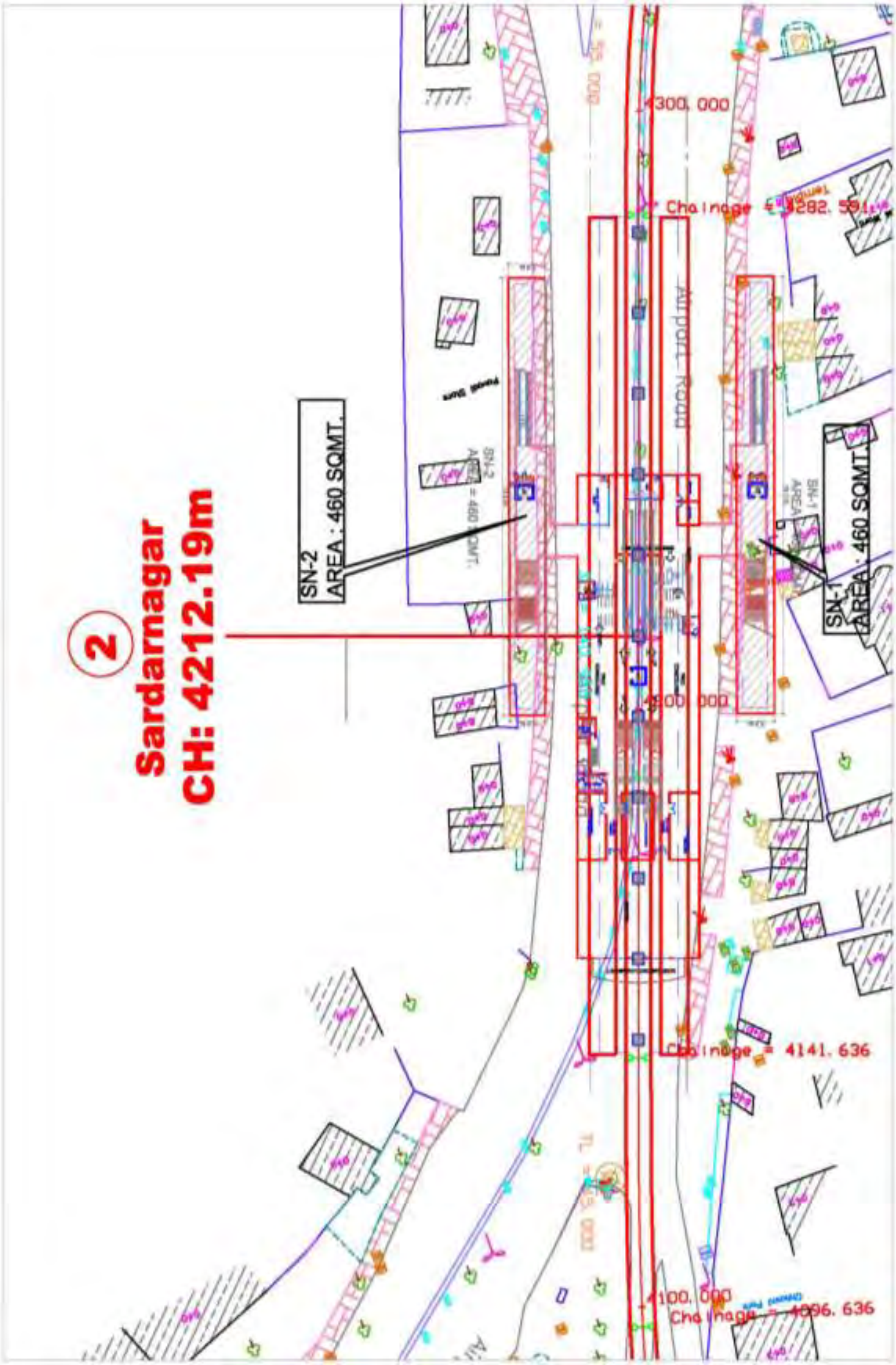

16
Akshardham
CH: 35170.00m
Inter State Police
Wireless Receiving
Station Gadhinagar
Chainage = 35261.247
35300.000
To Sector To 19 Road
Tree Palntation
Palntation
Tree Palntation
Open

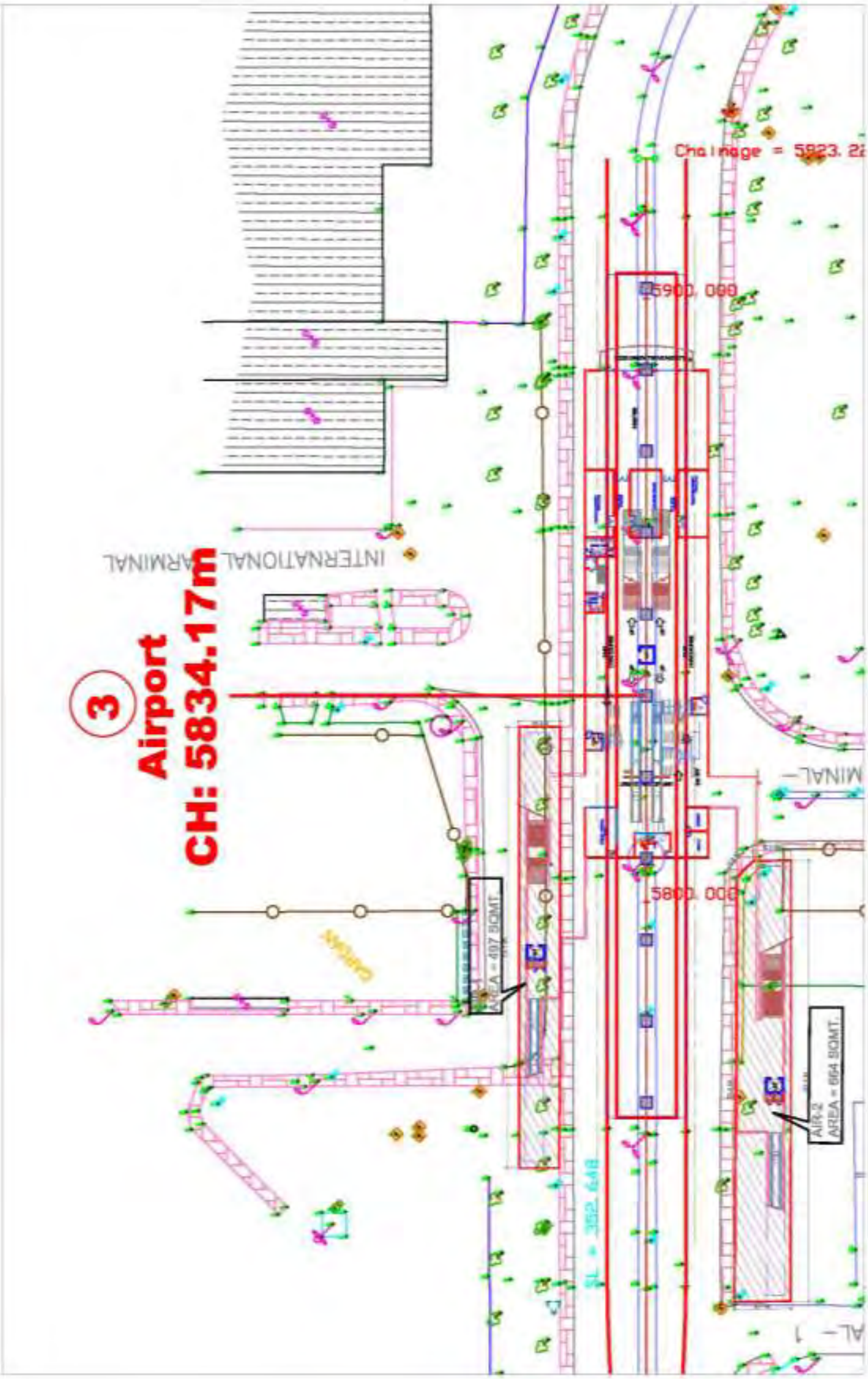

36200.000
Prerna Circle
36100.000
17
Juna Sachivalaya
CH: 36069.00m
Housing Board
36000.000
D.R. Jivaraj Mehta Bhovan

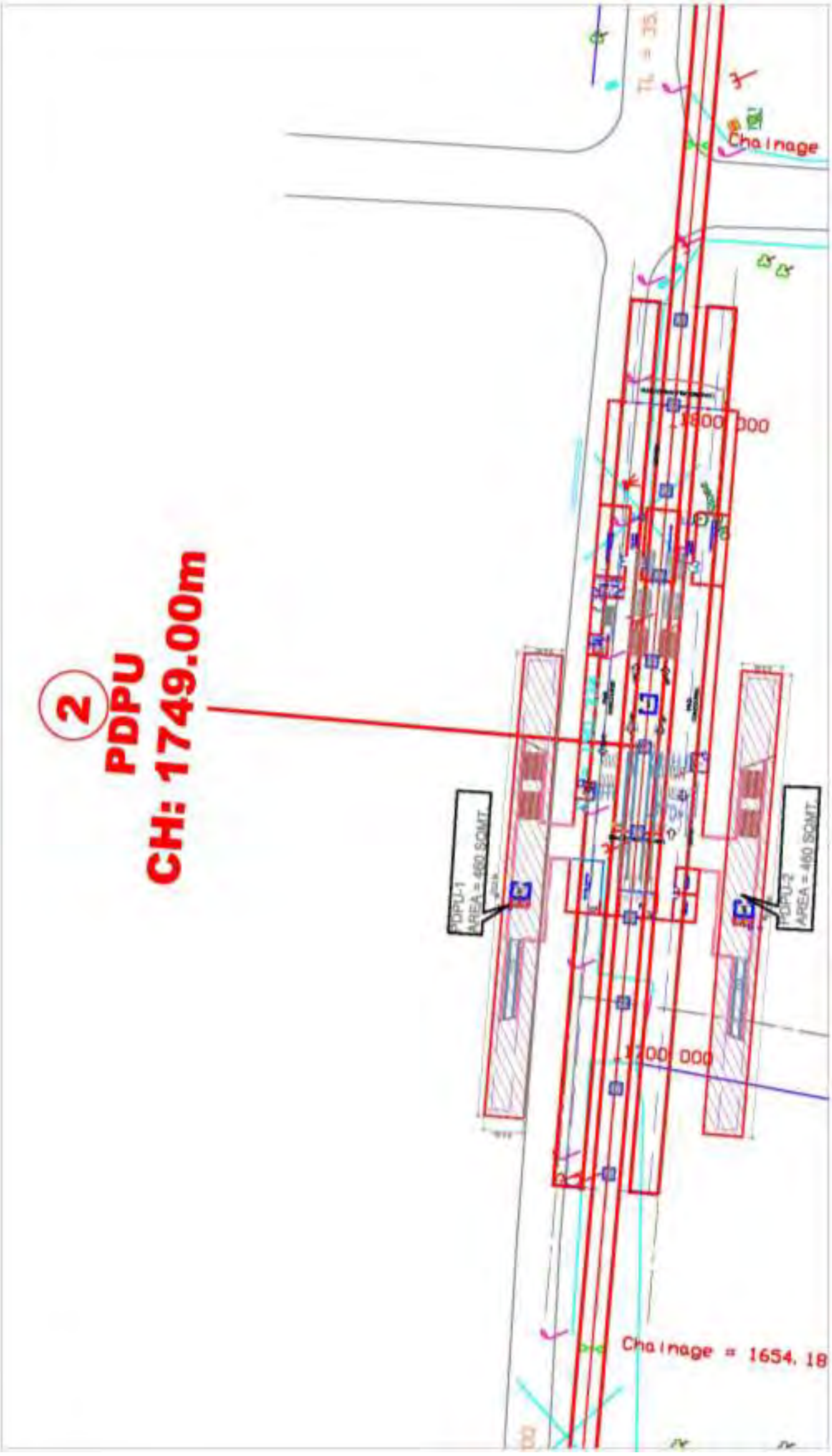

18
Sector - 16
CH: 37161.35m
Swaminarayan School
Service Road

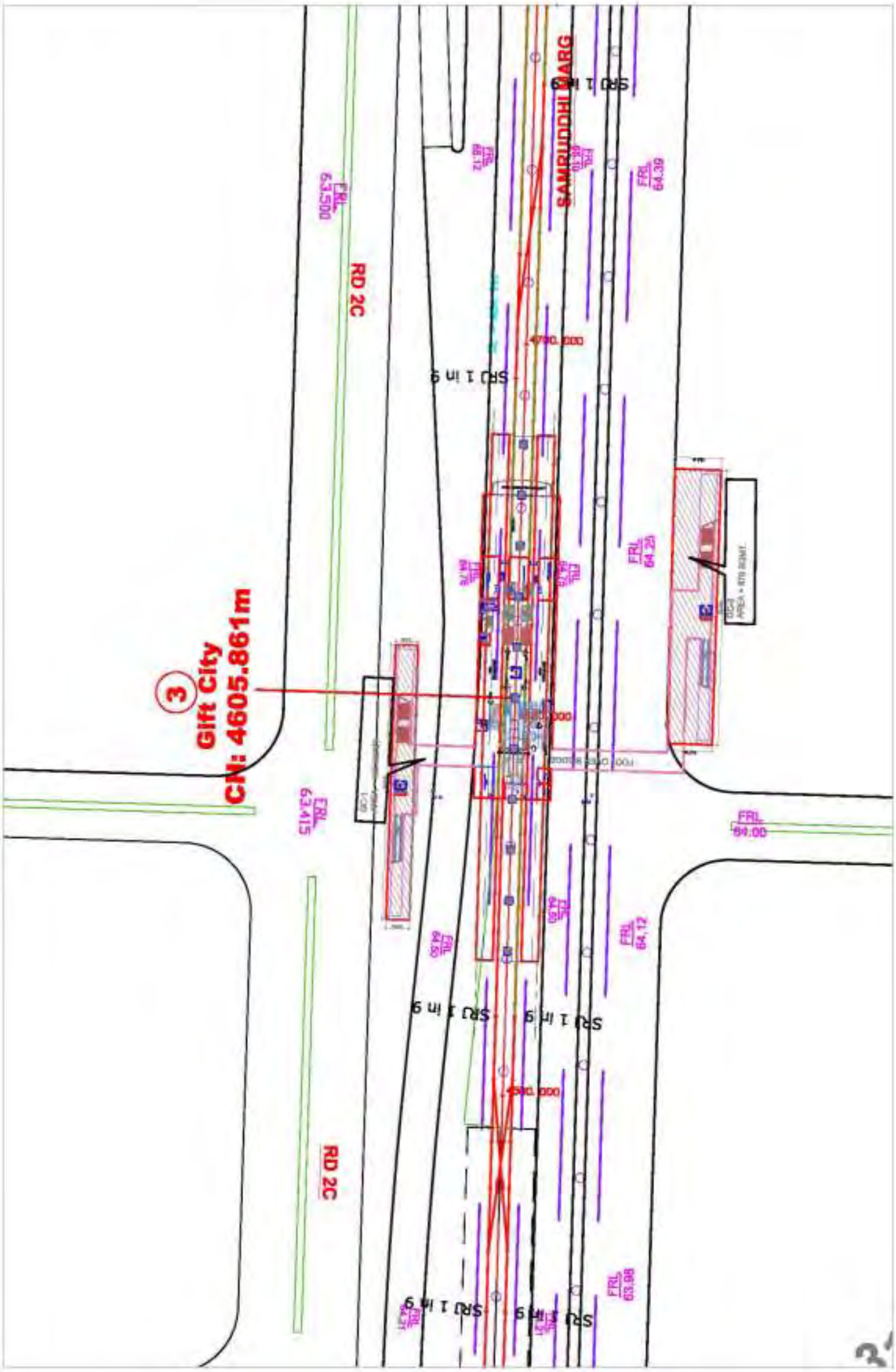

19
Sector - 24
CH: 38199.01m
Resident Area
Resident Area
Resident Area
To Indira Nagar
38100.000
38200.000
38300.000


20
Mahatma Mandir
CH: 39399.64m
Chainage = 39484.360
BH-11


2
Sardarnagar
CH: 4212.19m
SN-2
AREA : 460 SQMT.
SN-1
AREA : 460 SQMT.
Airport Road
4300.000
4200.000
Chainage = 4141.636
4100.000


3
Airport
CH: 5834.17m
5900.000
5800.000


2
PDPU
CH: 1749.00m
PDPU-1
AREA = 460 SQMT.
PDPU-2
AREA = 460 SQMT.
Chainage
Chainage = 1654.18



3
Gift City
CH: 4605.861m
SAMRUDDHI MARG
RD 2C
RD 2C
SRJ 1 in 9
FRL 63.500
FRL 63.415
FRL 64.39
FRL 64.29
FRL 64.12
FRL 63.98
FRL 64.00

Chapter – 6

STATION PLANNING

6.1 GENERAL

The proposed Metro for MEGA phase II consists of two corridors from **Koteshwar Road to Mahatma Mandir and GNLU to GIFT city.** Corridor from **Koteshwar Road to Airport** is planned as Phase-IIA**.**

The stretch of the proposed Mahatma Mandir to Airport corridor is 23 km from north to south. Along this Corridor, twenty stations have been planned. There are four stations proposed, two stations from GNLU to Gift City and two stations from Koteshwar Road to Airport corridor. The placement of the stations has been done considering Right of way, land availability, location, proximity to the Institutions for better ridership and connectivity, however, position of the entry/exit can be suitably changed as per land availability and ROW.

To attract maximum pedestrian traffic, station locations are finalised at the traffic nodal points.

6.2 STATION TYPES

A total of 24 Stations have been planned on these Corridors. All the stations are of elevated type with side platforms except, four which are either island or combination of both. Concourse of all these stations is proposed along the roads with sufficient Right of way.

Average inter-station distance is 1.4 km approximately varying from 0.899 km to 4.2 km depending upon the site, operational and traffic constraints. The sequence of stations with their respective chainages, location and platform characteristics is presented in **Table 6.1.**

Table 6.1: Sequence of Stations with Chain-ages, Location & Platform Characteristics

PASSENGER AMENITY REQUIREMENTS IN STATIONS AS PER YEAR 2051									
CORRIDOR 1. Koteshwar Road to Mahatma Mandir									
MORNING PEAK									
S. No.	**Station**	**Peak Hour Boarding**	**Peak Hour Alighting**	**Peak Hour Sectional Load**	**Peak Minute Boarding**	**Peak Minute Alighting**	**TOM Required**	**Head way**	**Platform Width**
1	Koteshwar Road	932	2,022	12,267	19	40	2	3	3.5
2	Vishwakarma college	133	260	11,177	3	5	2	3	3.5
3	Tapovan Circle	571	1,281	11,049	11	26	2	3	3.5
4	Narmada Canal	225	216	10,340	4	4	2	3	3.5
5	Koba Circle	593	611	10,348	12	12	2	3	3.5
6	Juna Koba	66	74	10,330	1	1	2	3	3.5
7	Koba Gaam	82	129	10,322	2	3	2	3	3.5
8	GNLU	1,421	2,537	10,275	28	51	2	3	3.5
9	Raysan	126	199	9,159	3	4	2	3	3.5
10	Randesan	195	378	9,086	4	8	2	3	3.5
11	Dhola Kuva Circle	378	956	8,903	8	19	2	3	3.5
12	Infocity	182	263	8,325	4	5	2	3	3.5
13	Sector 1	370	404	8,244	7	8	2	3	3.5
14	Sector 10A	428	1,119	8,210	9	22	2	3	3.5
15	Sachivalaya	78	1,618	7,518	2	32	2	3	3.5
16	Akshardham	366	1,142	5,978	7	23	2	3	3.5
17	JUNA Sachivalaya	263	687	5,201	5	14	2	3	3.5
18	Sector 16	179	1,292	4,778	4	26	2	3	3.5
19	Sector 24	125	2,572	3,666	2	51	2	3	3.5
20	Mahatma Mandir	0	1,219	1,219	0	24	2	3	3.5

PASSENGER AMENITY REQUIREMENTS IN STATION AS PER YEAR 2051									
CORRIDOR 1. Mahatma Mandir to Koteshwar Road									
EVENING PEAK									
S. No.	**Station**	**Peak Hour Boarding**	**Peak Hour Alighting**	**Peak Hour Sectional Load**	**Peak Minute Boarding**	**Peak Minute Alighting**	**TOM Required**	**Head way**	**Platform Width**
1	Mahatma Mandir	2047.1	0	0	41	0	2	3	3.5
2	Sector 24	1527.9	300	1,933	31	6	2	3	3.5
3	Sector 16	725.4	230	3,093	15	5	2	3	3.5
4	JUNA Sachivalaya	747.4	169	3,561	15	3	2	3	3.5
5	Akshardham	922.7	330	4,107	18	7	2	3	3.5

PASSENGER AMENITY REQUIREMENTS IN STATION AS PER YEAR 2051									
CORRIDOR 1. Mahatma Mandir to Koteshwar Road									
EVENING PEAK									
6	Sachivalaya	108.2	490	4,667	2	10	2	3	3.5
7	Sector 10A	382.7	451	4,307	8	9	2	3	3.5
8	Sector 1	596.0	143	4,242	12	3	2	3	3.5
9	Infocity	335.7	87	4,670	7	2	2	3	3.5
10	Dhola Kuva Circle	809.3	273	4,904	16	5	2	3	3.5
11	Randesan	420.8	114	5,411	8	2	2	3	3.5
12	Raysan	294.4	58	5,701	6	1	2	3	3.5
13	GNLU	2573.2	1,022	5,924	51	20	2	3	3.5
14	Koba Gaam	181.1	44	7,389	4	1	2	3	3.5
15	Juna Koba	167.5	22	7,518	3	0	2	3	3.5
16	Koba Circle	1227.0	236	7,655	25	5	2	3	3.5
17	Narmada Canal	519.2	84	8,591	10	2	2	3	3.5
18	Tapovan Circle	1467.6	503	9,002	29	10	2	3	3.5
19	Vishwakarma college	374.3	99	9,913	7	2	2	3	3.5
20	Koteshwar Road	3085.8	645	10,173	62	13	3	3	3.1

CORRIDOR 1. Koteshwar Road to Mahatma Mandir				
S. No.	Station	AFC Gates required		
		Ent	Rev	Ex
1	Koteshwar Road	2	1	2
2	Vishwakarma college	1	1	1
3	Tapovan Circle	1	1	1
4	Narmada Canal	1	1	1
5	Koba Circle	1	1	1
6	Juna Koba	1	1	1
7	Koba Gaam	1	1	1
8	GNLU	2	1	2
9	Raysan	1	1	1
10	Randesan	1	1	1
11	Dhola Kuva Circle	1	1	1
12	Infocity	1	1	1
13	Sector 1	1	1	1
14	Sector 10A	1	1	1
15	Sachivalaya	1	1	1
16	Akshardham	1	1	1
17	JUNA Sachivalaya	1	1	1
18	Sector 16	1	1	1
19	Sector 24	2	1	2
20	Mahatma Mandir	1	1	1

PASSENGER AMENITY REQUIREMENTS IN STATION AS PER YEAR 2051									
CORRIDOR 2. GNLU to Gift City									
MORNING PEAK									
S. No.	Station	Peak Hour Boarding	Peak Hour Alighting	Peak Hour Sectional Load	Peak Minute Boarding	Peak Minute Alighting	TOM Required	Head way	Platform Width
1	GNLU	2,649	0	0	53	0	2	3	3.5
2	PDPU	274	423	2,502	5	8	2	3	3.5
3	Gift City	0	2,500	2,361	0	50	2	3	3.5

PASSENGER AMENITY REQUIREMENTS IN STATION AS PER YEAR 2051									
CORRIDOR 2. Gift City to GNLU									
EVENING PEAK									
S. No.	Station	Peak Hour Boarding	Peak Hour Alighting	Peak Hour Sectional Load	Peak Minute Boarding	Peak Minute Alighting	TOM Required	Head way	Platform Width
1	Gift City	2306	0	0	46	0	2	3	3.5
2	PDPU	691	210	2,178	14	4	2	3	3.5
3	GNLU	0	2,787	2,633	0	56	3	3	3.5

CORRIDOR 2. GNLU to Gift City				
S. No.	Station	AFC Gates required		
		Ent	Rev	Ex
1	GNLU	2	1	2
2	PDPU	1	1	1
3	Gift City	2	1	2

PASSENGER AMENITY REQUIREMENTS IN STATION AS PER YEAR 2051									
CORRIDOR 3. Koteshwar Road to Airport (Phase-IIA)									
MORNING PEAK									
S. No.	**Station**	**Peak Hour Boarding**	**Peak Hour Alighting**	**Peak Hour Sectional Load**	**Peak Minute Boarding**	**Peak Minute Alighting**	**TOM Required**	**Head way**	**Platform Width**
1	Koteshwar road	1,688	0	0	34	0	2	3	3.5
2	Sardarnagar	12	1,576	1,688	0	32	2	3	3.5
3	Airport	0	124	124	0	2	2	3	3.5

PASSENGER AMENITY REQUIREMENTS IN STATION AS PER YEAR 2051									
CORRIDOR 3. Airport to Koteshwar Road (Phase-IIA)									
EVENING PEAK									
S. No.	**Station**	**Peak Hour Boarding**	**Peak Hour Alighting**	**Peak Hour Sectional Load**	**Peak Minute Boarding**	**Peak Minute Alighting**	**TOM Required**	**Head way**	**Platform Width**
1	Airport	41	0	0	1	0	2	3	3.5
2	Sardarnagar	1905	3	44	38	0	2	3	3.5
3	Koteshwar road	0	1,943	2,057	0	39	2	3	3.5

CORRIDOR 3. Koteshwar to Airport (Phase-IIA)				
S. No.	**Station**	**AFC Gates required**		
		Ent	**Rev**	**Ex**
1	Koteshwar road	1	1	1
2	Sardarnagar	1	1	1
3	Airport	1	1	1

1. Koteshwar Road Station

Chainage	17598.800m.
Inter-Station Distance	0.0 m.
Rail Level	72.20 m
Platform Height from Ground	13.47 m
Location	Located on Montera stadium Road.
Entry / Exit Stairs	Entry Exit stairs proposed on footpath besides main carriageway.
Catchment Area	Vishwakarma Engineering college, Sardar Patel stadium,Martial Art Authority of India. At south side Mahengiba Nagar.

2. Vishwakarma Engineering College station

Chainage	19017.00 m.
Inter-Station Distance	1418.20 m.
Rail Level	74.50 m
Platform Depth from Ground	13.48 m
Location	Located on junction of Montera stadium Road and KOBA road.
Entry / Exit Stairs	Entry Exit stairs will come on green area along the main carriageway
Catchment Area	Vishwakarma Engineering college.Housing at both side of road.

3. Tapovan Circle station

Chainage	19994.45 m.
Inter-Station Distance	977.45 m.
Rail Level	76.50 m
Platform Depth from Ground	13.49 m
Location	Located on KOBA road besides the Amiyapur Village.
Entry / Exit Stairs	Entry Exit stairs proposed at green area along the KOBA Road.
Catchment Area	Sardar Patel Ring Road, Amiyapur Village, Parshwanath Atlantis Society and other housing.

4. Narmada Canal station

Chainage	20900.0 m.
Inter-Station Distance	905.55 m.
Rail Level	77.20 m
Platform Depth from Ground	14.97 m
Location	Located on KOBA road besides the Narmada Canal at the north side.
Entry / Exit Stairs	Entry Exit stairs will come on green area of Agricultural land along the KOBA road.
Catchment Area	SUGADH road, Parshwanath Atlantis Society and other housing.

5. KOBA Circle station

Chainage	22050.63 m.
Inter-Station Distance	1150.63 m.
Rail Level	76.50 m
Platform Depth from Ground	13.63 m
Location	Located on KOBA Road besides KOBA circle at the north side of the station.
Entry / Exit Stairs	Entry Exit stairs will come on green area of Agricultural land along the KOBA road.
Catchment Area	Sugadh Farm at the west side.Koba Circle at the north side.Santoshi Maa Temple at the east side of the station.

6. Juna Koba station

Chainage	23057.34 m.
Inter-Station Distance	1006.71 m.
Rail Level	77.50 m
Platform Depth from Ground	14.40 m
Location	Located on Future Road parallel to the Ahmedabad-Gandhi Nagar Highway, which will be constructed on the present Agricultural Land.
Entry / Exit Stairs	Entry Exit stairs will be constructed on the green area (and beside the future TP road parallel to koba Gandhinagar highway) .
Catchment Area	Koba Village, Ahmedabad-Gandhi Nagar Highway, Gujrat Police Academy Karai.

7. Koba Gaam station

Chainage	24066.45 m.
Inter-Station Distance	1009.11 m.
Rail Level	78.00 m
Platform Depth from Ground	13.66 m
Location	Located on Future Road parallel to the Ahmedabad-Gandhi Nagar Highway, which will be constructed on the present Agricultural Land.
Entry / Exit Stairs	Entry Exit stairs will be constructed on the green area (and beside the future TP road parallel to koba Gandhinagar highway)
Catchment Area	Kumbheswar Temple at the east side, Koba Village at the north side of the station.

8. GNLU station

Chainage	24977.57 m.
Inter-Station Distance	911.12 m.
Rail Level	79.20 m
Platform Depth from Ground	13.49 m
Location	Located near to the Mind Space IT SEZ Road over the future proposed road.
Entry / Exit Stairs	Entry Exit stairs will be constructed on the green area(and beside the future TP road parallel to koba Gandhinagar highway) .
Catchment Area	Gujarat national Law University, Pandit Dindayal Petroleum university at the east side of the station.

9. Raysan Station

Chainage	26413.75 m.
Inter-Station Distance	1436.18 m.
Rail Level	81.50 m
Platform Depth from Ground	13.65 m
Location	Located at the north side of the Raysan Road.
Entry / Exit Stairs	Entry Exit stairs will be constructed on the green area (and beside the future TP road parallel to koba Gandhinagar highway) .
Catchment Area	BAPS Swaminarayan Vidyamandir college at the west side of the station. Randesan Village at the East side of the Road.

10. Randesan Station

Chainage	27786.89 m.
Inter-Station Distance	1373.14 m.
Rail Level	83.50 m
Platform Depth from Ground	13.84 m
Location	Located at the north side of the Randesan Road.
Entry / Exit Stairs	Entry Exit stairs will be constructed on the green area (and beside the future TP road parallel to Koba Gandhinagar highway).
Catchment Area	Randesan Road at the south side. City pulse Entertainment complex at the west side of the Station.

11. Dhola Kuva Circle Station

Chainage	28943.26 m.
Inter-Station Distance	1156.37 m.
Rail Level	82.75 m
Platform Depth from Ground	13.51 m
Location	Located on Gandhinagar bypass Road.
Entry / Exit Stairs	Entry Exit stairs will come on green area besides the road connecting to the Ahmedabad Gandhinagar Main Road.
Catchment Area	Urja Nagar at south side and Ahmedabad Gandhinagar Main Road at the west side of the station.

12. Infocity Station

Chainage	30334.00 m.
Inter-Station Distance	1390.74 m.
Rail Level	85.00 m
Platform Depth from Ground	13.83 m
Location	Located on Gandhinagar Ahmadabad main Road.
Entry / Exit Stairs	Entry Exit stairs proposed on green area along the Gandhinagar Ahmadabad main Road.
Catchment Area	NICM - Educational Institution and KUDASAN Housing at the west side. Dhaulakuva region at the east side of the station.

13. Sector 1 Station

Chainage	31600.00 m.
Inter-Station Distance	1266.00 m.
Rail Level	89.00 m
Platform Depth from Ground	13.52 m
Location	Located on CH Road.
Entry / Exit Stairs	Entry Exit stairs proposed along the CH main Road.
Catchment Area	Sector 2 & Sector 7 at the west side and Sector 1C & Sector 8 at the east side of the station.

14. Sector 10A Station

Chainage	32850.00 m.
Inter-Station Distance	1250.00 m.
Rail Level	88.50 m
Platform Depth from Ground	13.75 m
Location	Located on CH main Road
Entry / Exit Stairs	Entry Exit stairs will come beside the Ch-3 road along the foothpath connecting Birsa Munda Bhawan.
Catchment Area	St Xaviers School and St Xaviers Church, Aranya Bhawan, karmayodi Bhawan.

15. Sachivalaya Station

Chainage	34041.26 m.
Inter-Station Distance	1191.26 m.
Rail Level	89.50 m
Platform Depth from Ground	13.73 m
Location	Located on CHH Main Road.
Entry / Exit Stairs	Entry Exit stairs will come on green area along the CHH Main Road.
Catchment Area	Sector 10 at the west side comprising Vidhan Sabha and National Informatics centre.Sector 9 at the west side comprising Gujarat Forensic Sciences University.

16. Akshardham Station

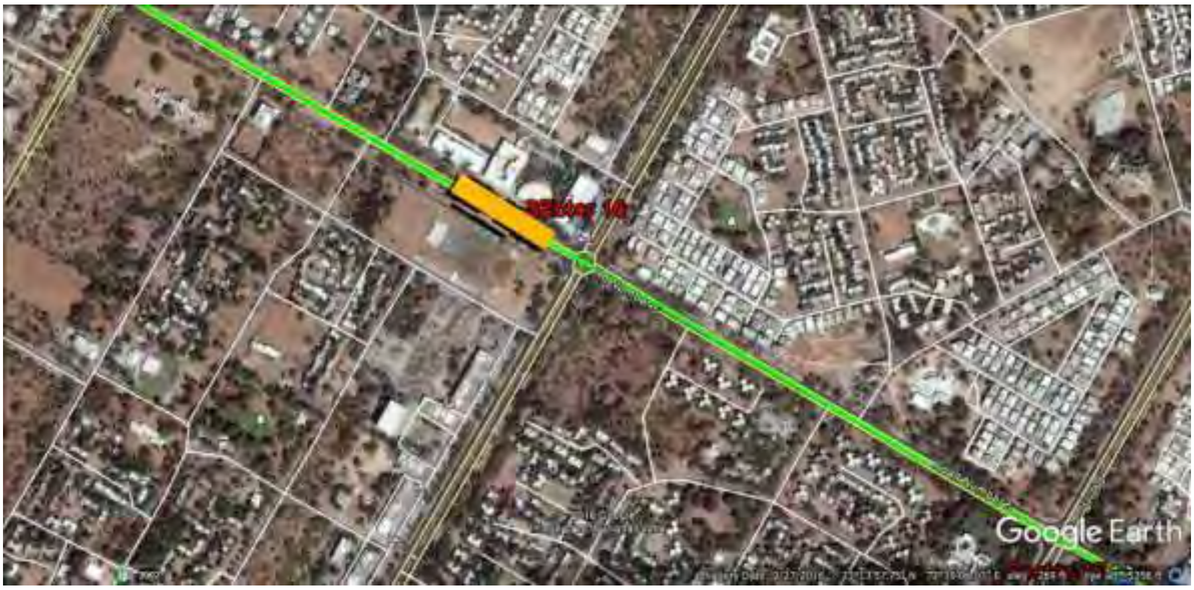
Chainage	35170.00 m.
Inter-Station Distance	1128.74 m.
Rail Level	90.50 m
Platform Depth from Ground	13.54 m
Location	Located on CHH Main Road.
Entry / Exit Stairs	Entry Exit stairs will come on green area along the CHH Main Road.
Catchment Area	Gujarat lokayuka office (Sector 10B), Mount Carmel School, sector 21 shopping market.

17. JUNA Sachivalaya Station

Chainage	36069.00 m.
Inter-Station Distance	899.00 m.
Rail Level	90.50 m
Platform Depth from Ground	13.72 m
Location	Located on Road number five flanked east side of the north Gandhi Nagar.
Entry / Exit Stairs	Entry Exit stairs will come on green area along the Road number 5.
Catchment Area	Raaga Academy – Art Vastu Nirman Society, Sector 21 at the north side and Gujarat Lokayukt Office – Sector 10B at the south-west side of the station.

18. Sector 16 Station

Chainage	37161.35 m.
Inter-Station Distance	1092.35 m.
Rail Level	90.50 m
Platform Depth from Ground	13.74 m
Location	Located on Road number five flanked east side of the north Gandhi Nagar.
Entry / Exit Stairs	Entry Exit stairs will come on green area along the Road number five.
Catchment Area	Methodist Church, Gandhinagar – Church Bhavnagar, Sector 23 at the North side. Siddharth Law college Sector 16 at the North-east side of the station



19. Sector 24 Station

Chainage	38199.01 m.
Inter-Station Distance	1037.66m.
Rail Level	91.50 m
Platform Depth from Ground	13.82 m
Location	Located on Road number five flanked east side of the north Gandhi Nagar.
Entry / Exit Stairs	Entry Exit stairs will come on green area along the Road number 5.
Catchment Area	LDRP Institute of Technology and Research - Engineering College Sector 15 at the north west side of the station. Industrial Training Institute Geri - Educational Institution Sector 15 at the south west side of the station.

20. Mahatma Mandir Station

Chainage	39399.64 m.
Inter-Station Distance	1200.63 m.
Rail Level	90.20 m
Platform Depth from Ground	13.92 m
Location	Located on Mahatma Mandir Road flanked north to south at the west side of Gandhinagar.
Entry / Exit Stairs	Entry Exit stairs will come on green area along the Mahatma Mandir Road.
Catchment Area	Mahatma Mandir at the west side and Sports Authority of India at the east side of the station.

1. PDPU station

Chainage	1749.00 m.
Inter-Station Distance	1749.00 m.
Rail Level	77.50 m
Platform Depth from Ground	13.50 m
Location	Located on the PDPU Road flanked east west side of the city.
Entry / Exit Stairs	Entry Exit stairs will come on green area along the PDPU Road.
Catchment Area	Pandit Deendayal Petroleum University at the north side of the station. And Gujarat National Law University at the south of the station.

2. Gift City Station

Chainage	4605.861 m.
Inter-Station Distance	2365.86 m.
Rail Level	73.50 m
Platform Depth from Ground	13.50 m
Location	Located on the PDPU Road entering to the Gift city.
Entry / Exit Stairs	Entry Exit stairs will come on green area along the PDPU Road.
Catchment Area	Surrounded by the Gift city premises.

3. Sardar Nagar Station

Chainage	4212.19 m.
Inter-Station Distance	4212.19 m.
Rail Level	71.00 m
Platform Depth from Ground	13.50 m
Location	Located on Airport Road coming from Mother Dairy towards the Sabarmati River at the North side of the station.
Entry / Exit Stairs	Entry Exit stairs are proposed in the Right of way of the Road placed beside footpath.
Catchment Area	Sardar Nagar at the east and west side of the station.

4. Airport Station

Chainage	5834.17 m.
Inter-Station Distance	1621.98 m.
Rail Level	68.00 m
Platform Depth from Ground	13.50 m
Location	Located on Internal Airport Road.
Entry / Exit Stairs	Entry Exit stairs will come on green area along the Internal Airport Road.
Catchment Area	Situated in the premises of Ahmedabad International Airport.

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

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

    Minimum distance of travel to and from the platform and between platforms for transfer between lines.
    Adequate capacity for passenger movements.

Convenience, including good signage relating to circulation and orientation.
Safety and security, including a high level of protection against accidents.

11. Following requirements have been taken into account:

a. Minimum capital cost is incurred consistent with maximizing passenger attraction.
b. Minimum operating costs are incurred consistent with maintaining efficiency and the safety of passengers.
c. 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.
d. Provision of good visibility of platforms, fare collection zones and other areas, thus aiding the supervision of operations and monitoring of efficiency and safety.
e. Provision of display of passenger information and advertising.

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

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

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

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

Non Public Area – at Station	
Station Control Room	Fire Tank & Pump room
Platform Supervisor's Booth	Staff Area
Station Master's Office	UPS and Battery Room
Traction Substation	Cleaner's Room
Information & Enquiries	Security Room
Signaling Room	Staff Toilets
Ticket Office	Refuse Store
Communication Room	Miscellaneous Operations Room
Ticket Hall Supervisor & Excess Fare Collection (Passenger Office	First Aid Room
Station Substation	

6.4 TYPICAL ELEVATED STATION - APPLICABLE TO THIS CORRIDOR

The station is generally located on the road median, and its footprint is 140-m long and is a three level structure. Passenger area on concourse is spread as the paid and unpaid area 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, Signalling 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. Station concourse box length and breadth are 80 m. and 28 m. respectively. 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. With respect to its spatial quality, an elevated MRT structure makes a great impact on the viewer as compared to an *At-grade* station. 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 High-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 slopping roof. 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.

6.5 GNLU AND KOTESHWAR ROAD INTERCHANGE STATIONS

GNLU and Koteshwar Road interchange stations are the combination of the Island and the side platforms dedicated to the tracks of two separate corridors. These stations consist common concourse area and contain service areas dedicated to separate corridors.

Two entrances and two exits have been planned to provide easy access to the station for all passengers, from each side of the intersection, without having to cross vehicular traffic on these busy roads. The integrated entrances for intersecting lines are at the ground level from where the passengers can access the concourse. Concourse houses ticketing for corridors, lifts, stairs and escalators to reach both the platforms dedicated to different lines.

6.6 PASSENGER AMENITIES

Passenger amenities such as ticketing counters / automatic ticket vending machines, ticketing gate, etc. are provided in the concourse. Adequate numbers of these facilities have been provided for system wide requirements, although the requirement of the facilities actually varies from station to station. The same applies to provision of platform widths and staircase / escalators. Maximum capacity required at any station by the year 2051 has been adopted for normal operation regarding all stations. For this purpose, *peak minute traffic* is assumed to be 2% of the *peak hour traffic*.

6.7 CONCOURSE

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

6.8 TICKETING GATES

Ticketing gates' requirement has been calculated taking the gate capacity as 28 persons per minute per gate. Passenger forecast for the horizon year 2051 has been used to compute the maximum design capacity. At least three (one entry, one exit and one reversible) ticketing gates or AFC gates shall be provided at any station. Uniform space has been provided in all stations where gates can be installed as and when required.

6.9 TICKET COUNTERS AND TICKET ISSUING MACHINES (TIMs)

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

6.10 PLATFORMS

A uniform platform minimum width of 3.0-m wide including staircases and escalators in the central section is proposed for the elevated stations. All platform widths have been checked for holding capacity of the platform for worst-case scenario (one missed headway and holding section load) in the design year i.e. 2051.

6.11 STAIRS, ESCALATORS AND LIFTS FOR NORMAL AND EMERGENCY OPERATIONS

Provision has been made for escalators in the paid as well as entrance on both sides i.e. from ground to concourse and concourse to platforms. On each platform, two escalators have been proposed. In addition, two staircases with a combined width of 4.6 m are provided on each side platform connecting to the concourse. These stairs and escalator together provide an escape capacity adequate to evacuate passengers in emergency from platforms to concourse in 4.5 minutes in most stations.

6.12 PASSENGER AMENITIES REQUIREMENT IN STATIONS

Passenger Amenities are provided in the unpaid and paid areas of the concourse respectively. Summary of passenger amenities required and proposed at stations based on projected traffic for the year 2051 is given in **Table 6.2.**

6.13 TRAFFIC INTEGRATION

Concept of Traffic Integration - The objective of an integrated transport system and traffic movement is to offer maximum advantage to commuters and society from traffic and planning consideration. Various modes of transport need to be integrated in a way that each mode supplements the other. A large proportion of MRTS users will come to and depart from various stations by public, hired and private modes, for which integration facilities need to be provided at stations to ensure quick and convenient transfers. In order to ensure that entire MRTS function as an integrated network and provides efficient service to the commuter, the following steps have been identified:

Suitable linkages are proposed so that various corridors of MRTS are integrated within themselves, with existing rail services and with road based modes.

Facilities needed at various stations are planned in conformity with the type of linkages planned there. Traffic and transport integration facilities are provided for two different types of linkages:

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

Walk links to provide access to the pedestrians.

Table 6.3: Traffic Integration Requirement for Stations (Projections for Year 2051)

Traffic Integration Requirement for Stations												
S. No.	Name of the Station	Peak Hour Station Load	Number of Bays					Area Required (Sq.M.)			
			Bus	Car	Two Wheelers	Auto	Cycle	Car	Two Wheeler	Cycle	Total
1	**Koteshwar Road**	2914	3	234	781	7	587	5391	1758	792	7941
2	**Vishwakarma college**	354	1	28	95	4	71	655	214	96	965
3	**Tapovan Circle**	1386	1	111	372	4	279	2564	836	377	3777

Traffic Integration Requirement for Stations												
S. No.	Name of the Station	Peak Hour Station Load	Number of Bays					Area Required (Sq.M.)				
			Bus	Car	Two Wheelers	Auto	Cycle	Car	Two Wheeler	Cycle	Total
4	Narmada Canal	490	1	39	131	4	99	907	296	133	1335
5	Koba Circle	1158	1	93	311	4	233	2143	699	315	3156
6	Juna Koba	158	1	13	42	4	32	292	95	43	431
7	Koba Gaam	171	1	14	46	4	34	316	103	46	466
8	GNLU	2430	3	195	652	6	489	4496	1466	660	6622
9	Raysan	278	1	22	75	4	56	514	168	76	758
10	Randesan	397	1	32	106	4	80	735	240	108	1082
11	Dhola Kuva Circle	764	1	61	205	4	154	1414	461	208	2082
12	Infocity	317	1	26	85	4	64	587	191	86	864
13	Sector 1	562	1	45	151	4	113	1040	339	153	1532
14	Sector 10A	404	1	32	108	4	81	747	244	110	1101
15	Sachivalaya	102	1	8	27	4	21	189	62	28	278
16	Akshardham	871	1	70	234	4	175	1612	525	237	2374
17	PDPU	652	1	52	175	4	131	1206	393	177	1777
18	Gift City	2502	3	201	671	6	504	4629	1510	680	6819

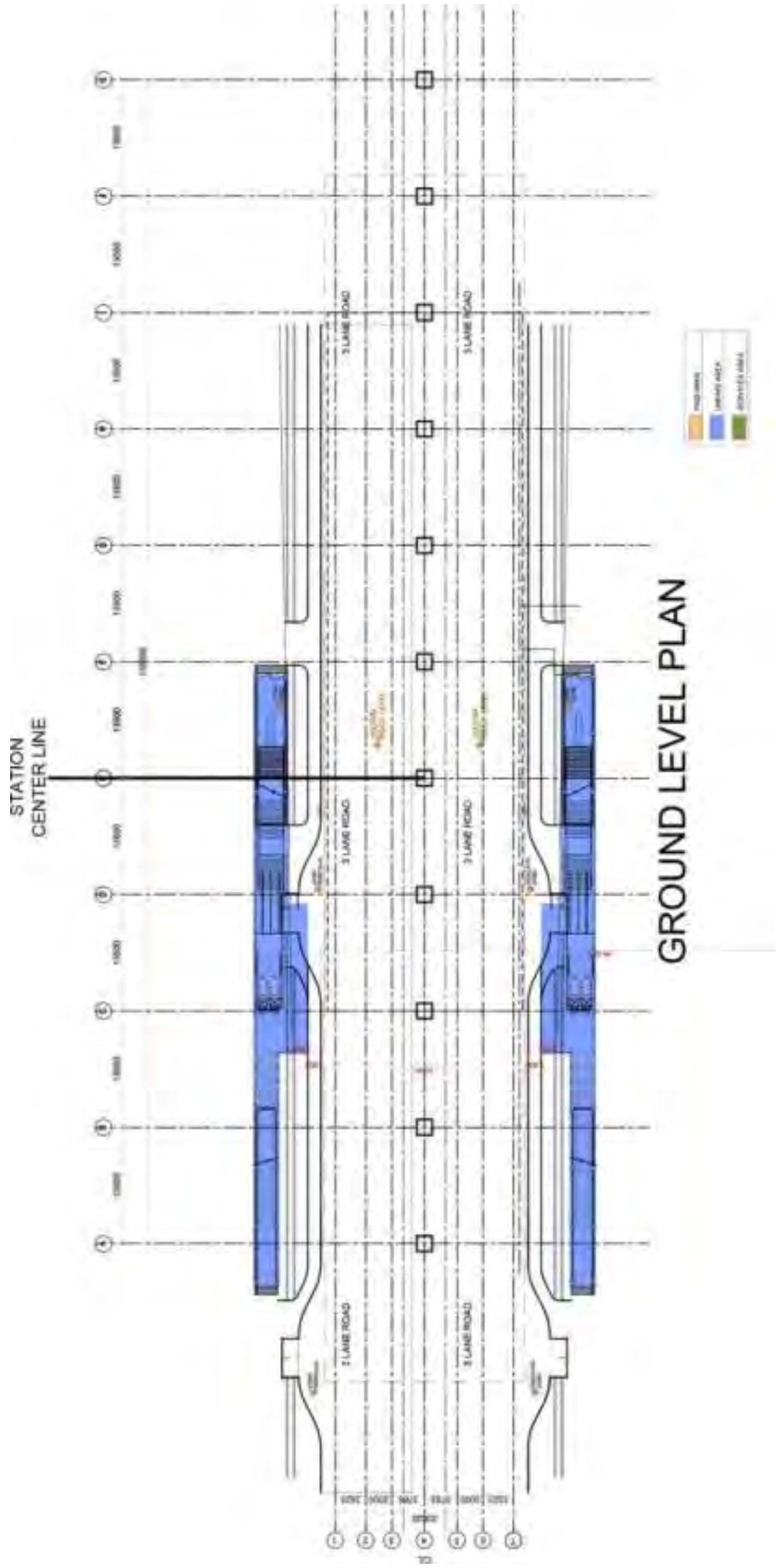
6.13 APPROACH ADOPTED IN PLANNING TRAFFIC INTEGRATION FACILITIES

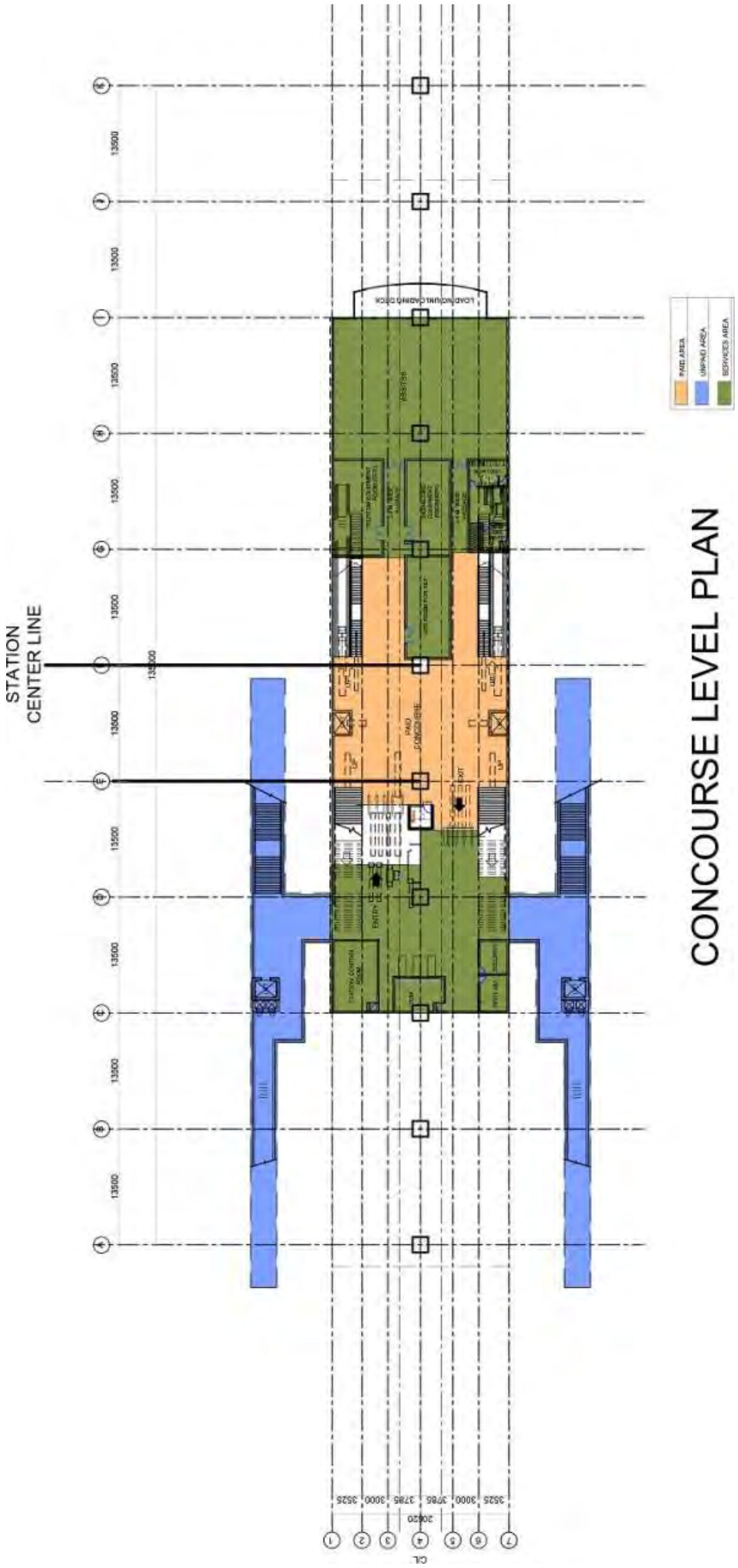
Integration facilities at MRTS stations include approach roads to the stations, circulation facilities, pedestrian ways and adequate circulation areas for various modes likely to come to important stations including feeder bus/mini-buses. Parking for private vehicles has not been proposed.

6.14 OPERATIONAL INTEGRATION

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

TYPE 1 STATION (SIDE PLATFORM)

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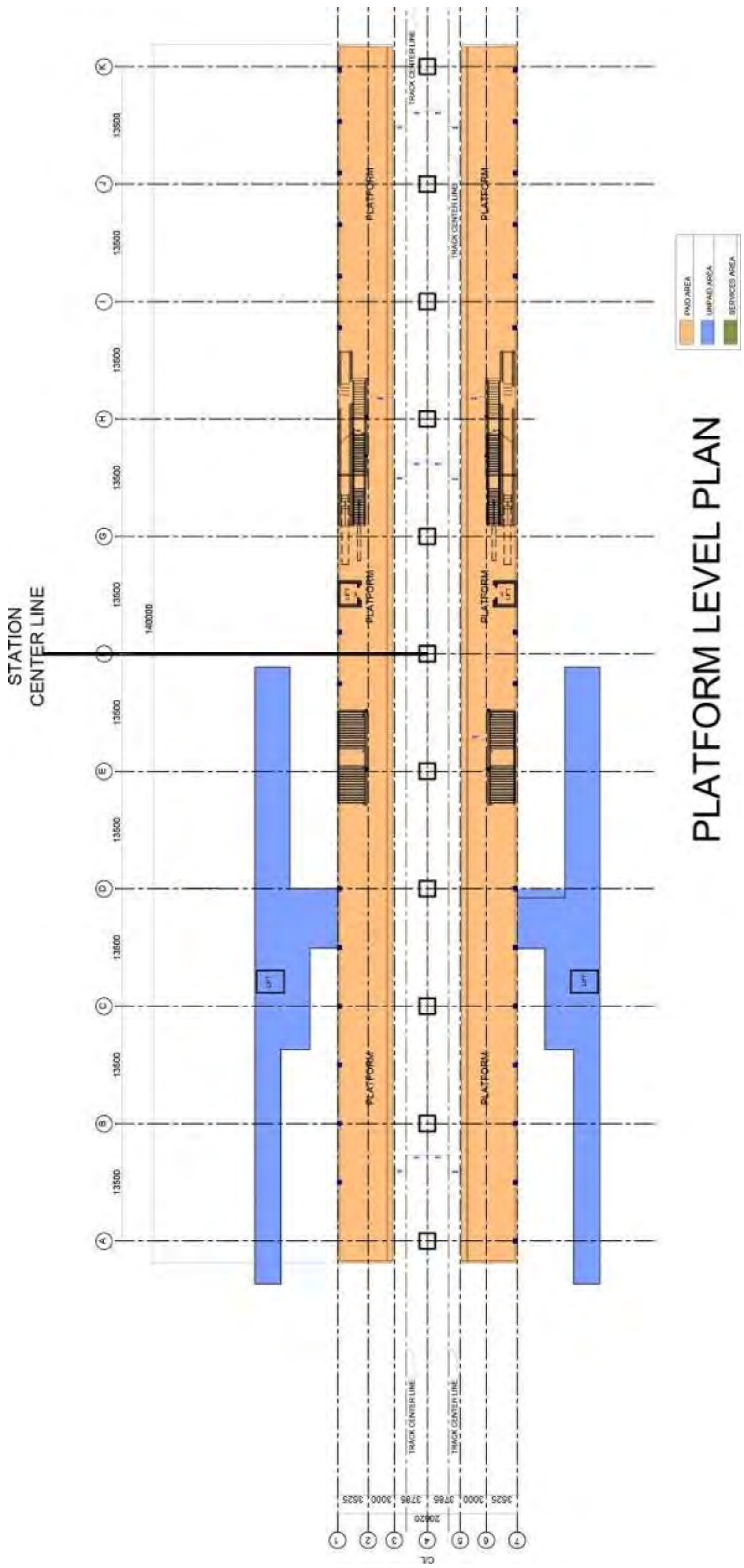
CENTER LINE
CONCOURSE LEVEL PLAN
PAID AREA
UNPAID AREA
SERVICES AREA
LOADING/UNLOADING DECK
PAID CONCOURSE
ENTRY
EXIT
13500
CL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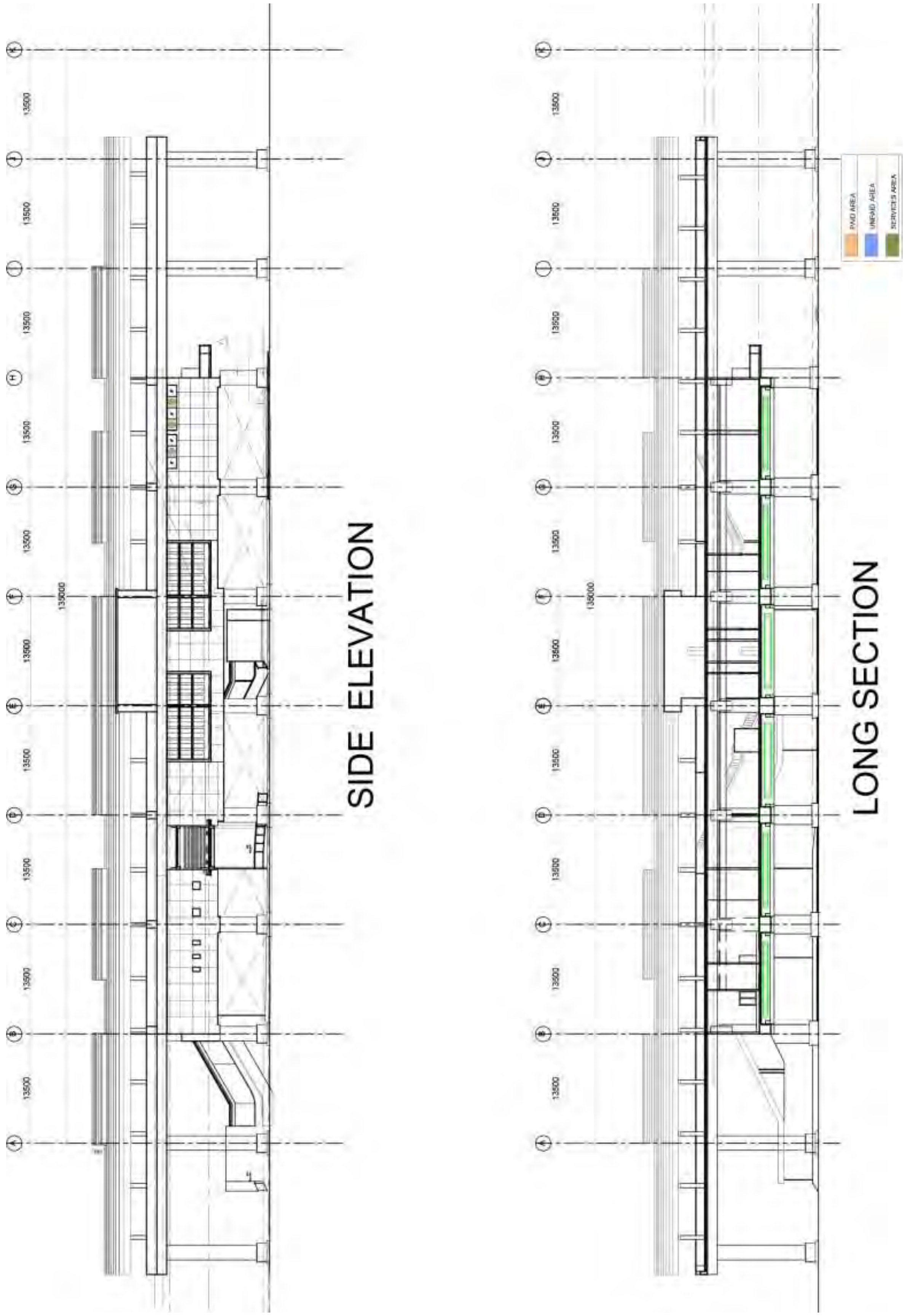
PLATFORM
PLATFORM
PLATFORM
PLATFORM
PLATFORM
PLATFORM
TRACK CENTER LINE
TRACK CENTER LINE
LIFT
LIFT
PAID AREA
UNPAID AREA
SERVICES AREA
PLATFORM LEVEL PLAN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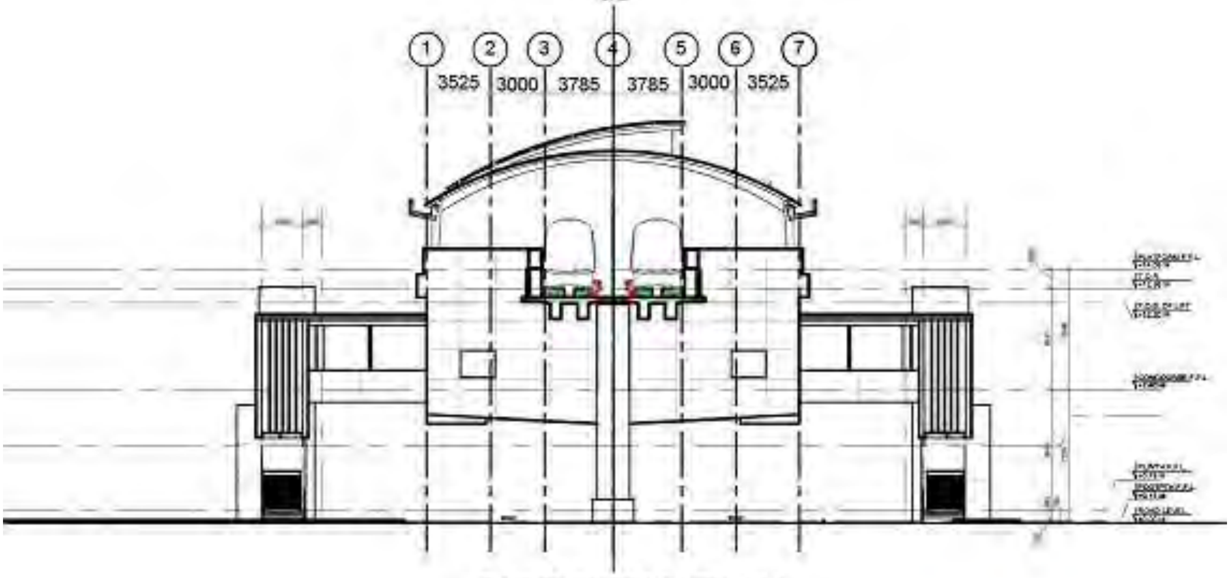
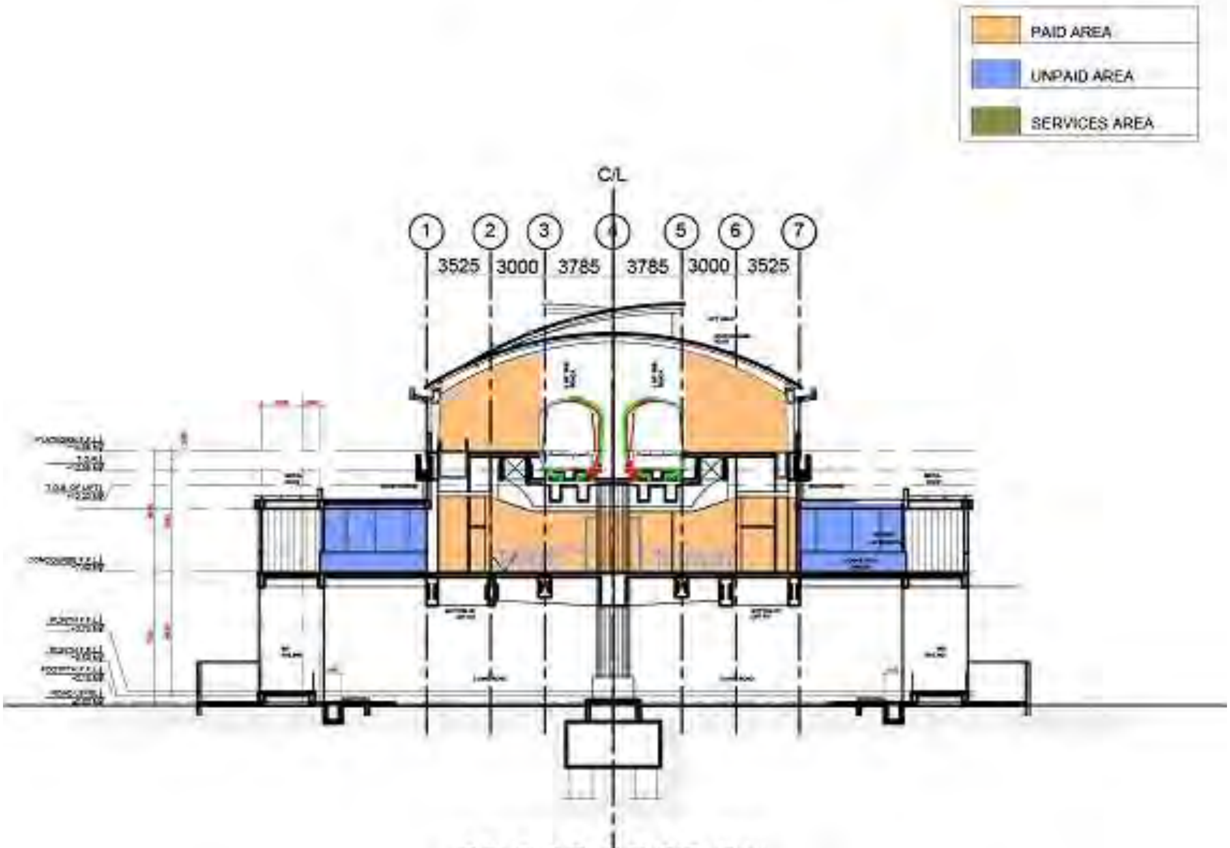
LONG SECTION
PAID AREA
UNPAID AREA
SERVICES AREA

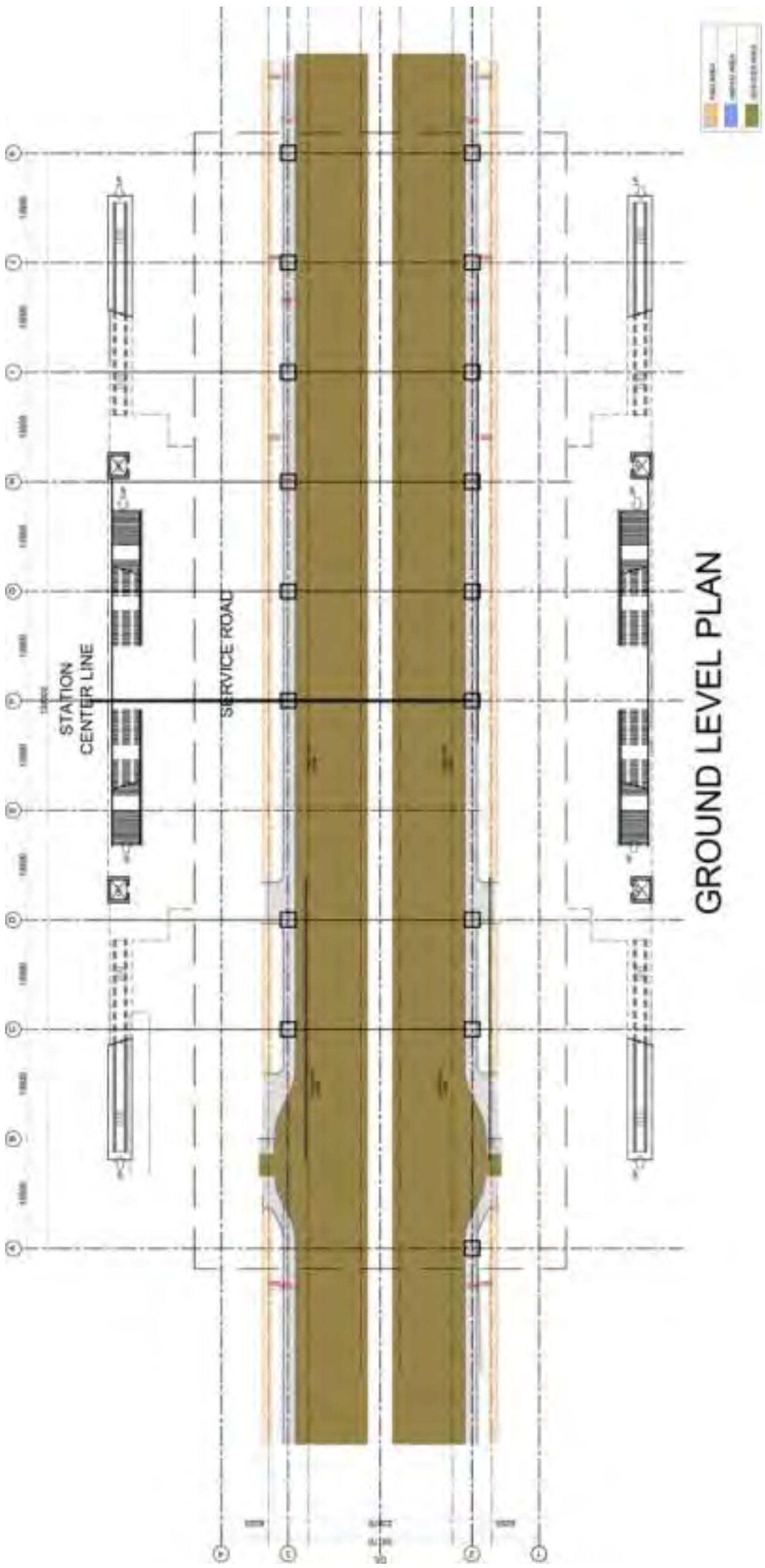


SIDE ELEVATION

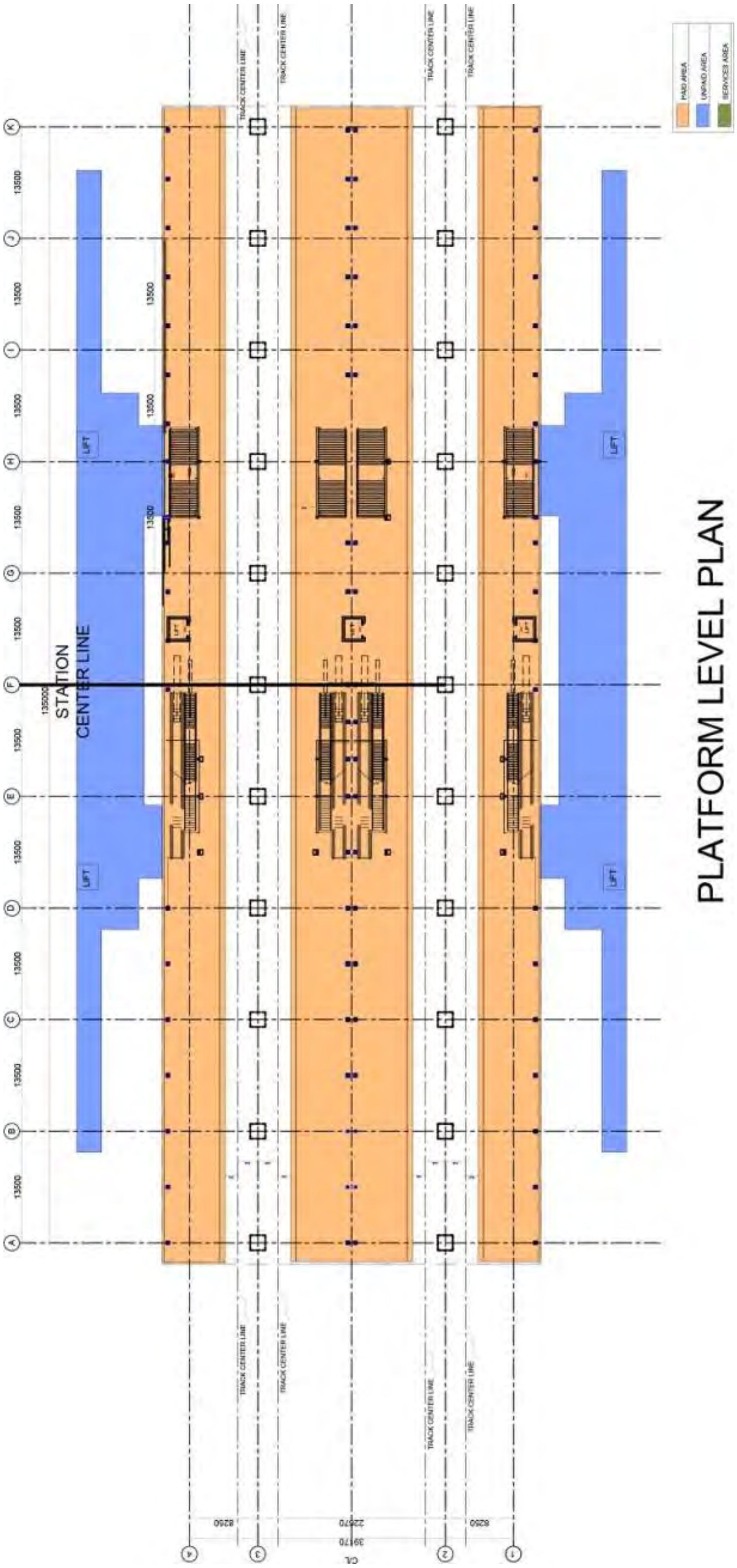


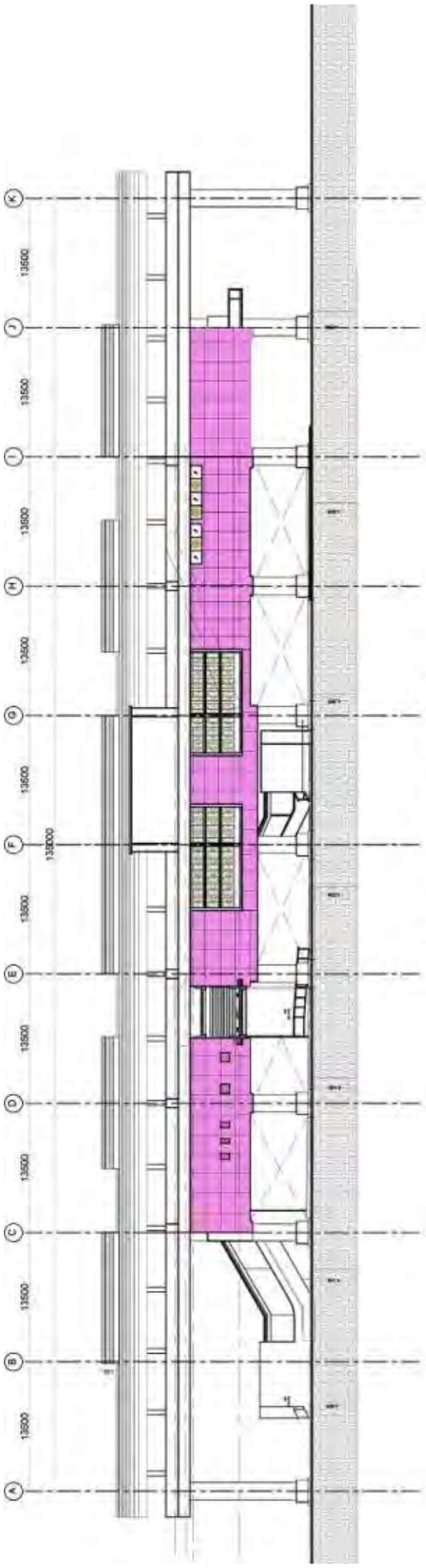
CROSS SECTION

TYPE 2 STATION (SIDE + ISLAND PLATFORM)

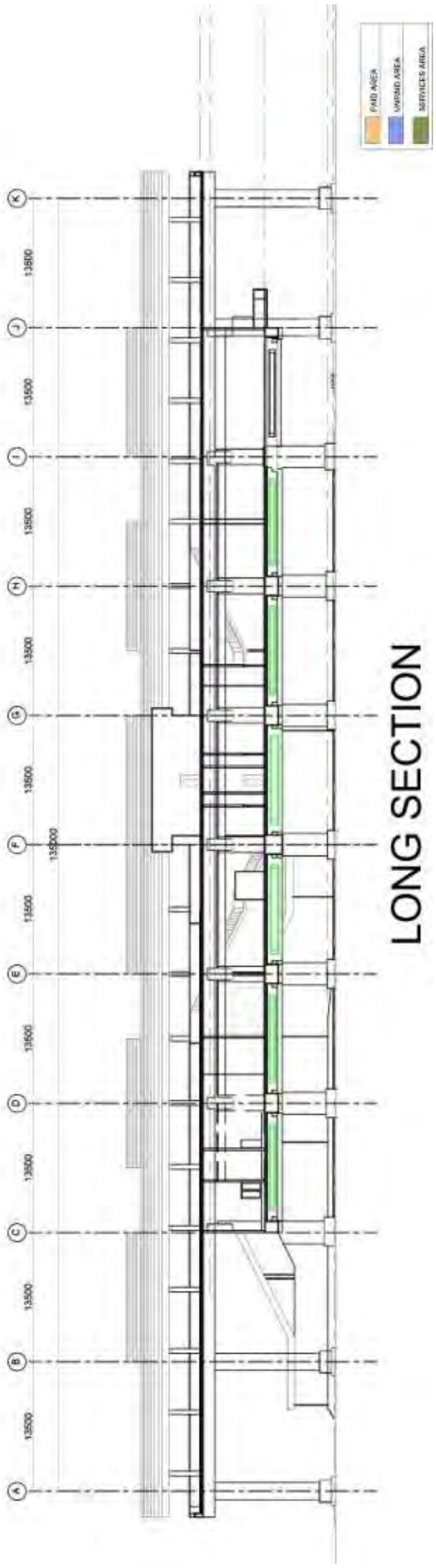



PAID AREA
UNPAID AREA
SERVICES AREA
ASS/TSS
STATION CENTER LINE
UNPAID CONCOURSE
PAID CONCOURSE
CONCOURSE LEVEL PLAN

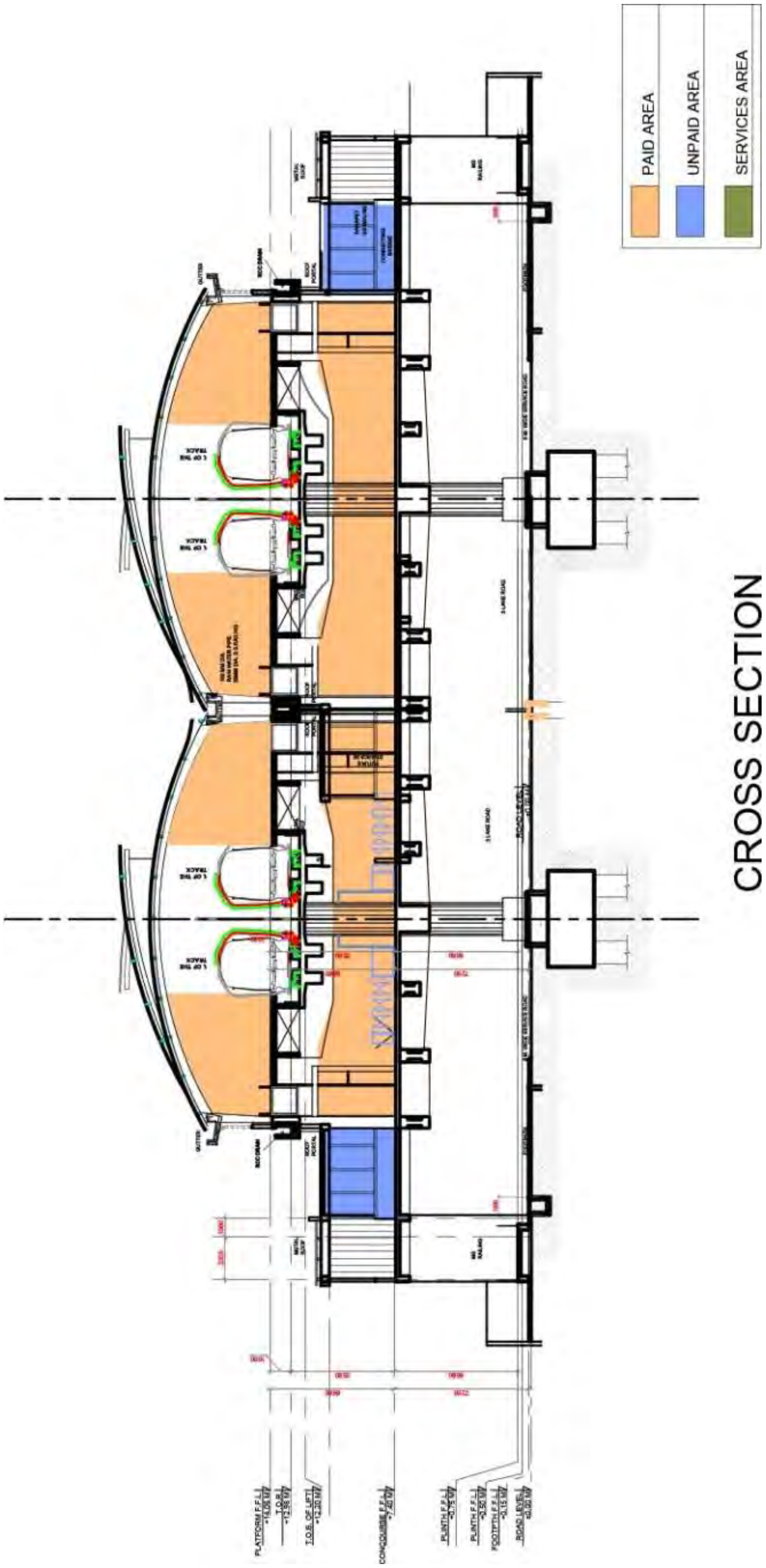

PLATFORM LEVEL PLAN
STATION CENTER LINE
LIFT
13500
TRACK CENTER LINE
PAID AREA
UNPAID AREA
SERVICES AREA



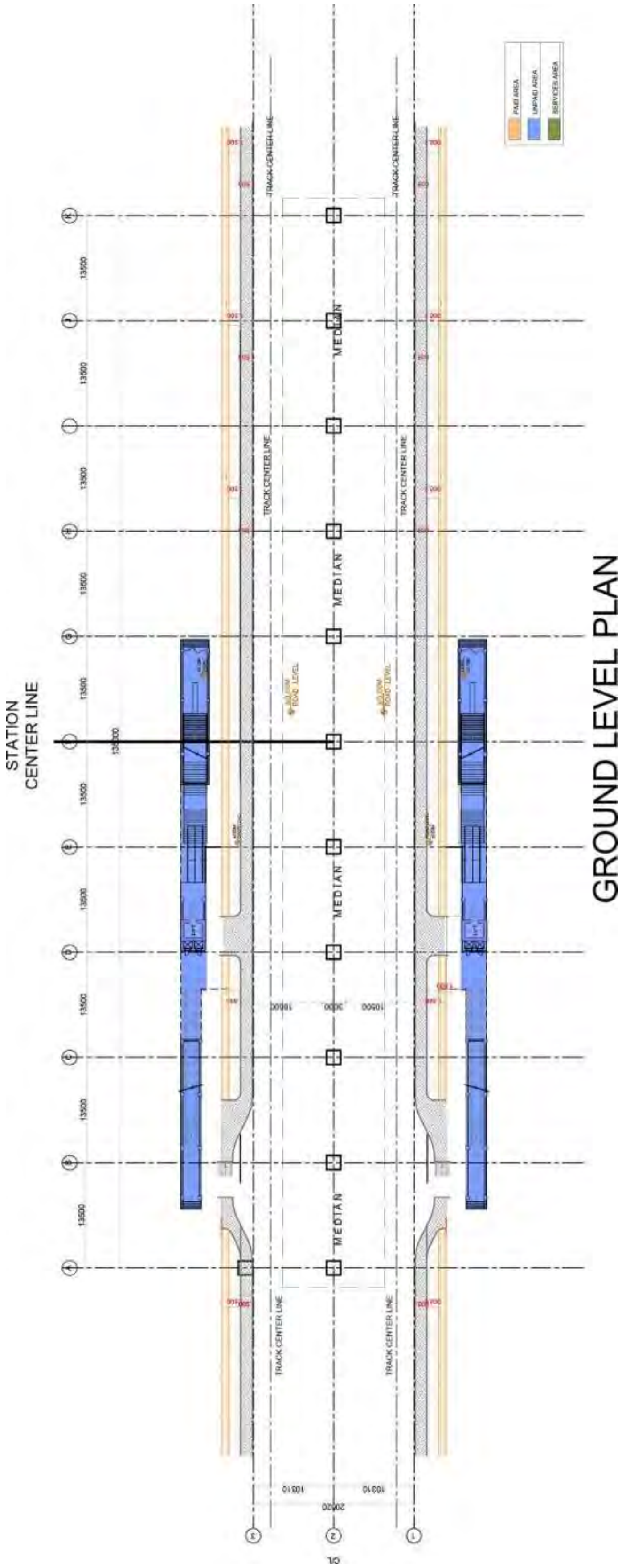
SIDE ELEVATION

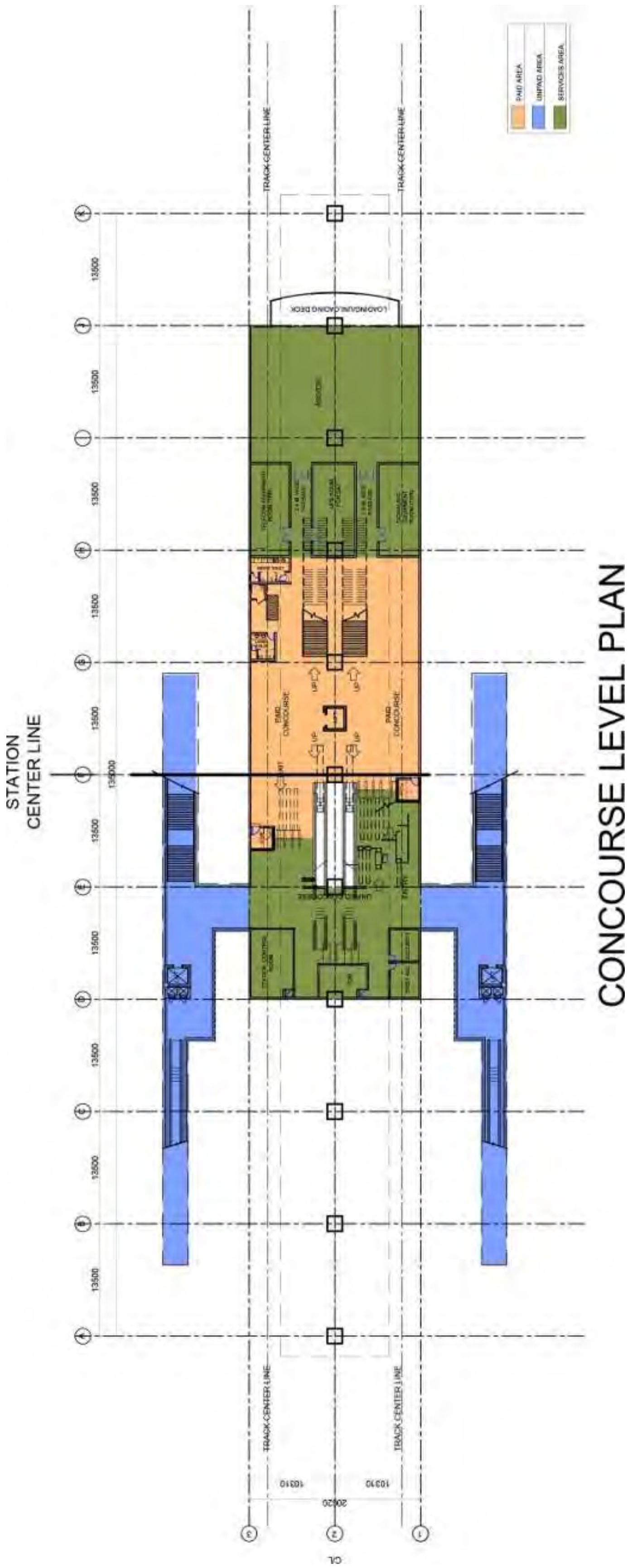


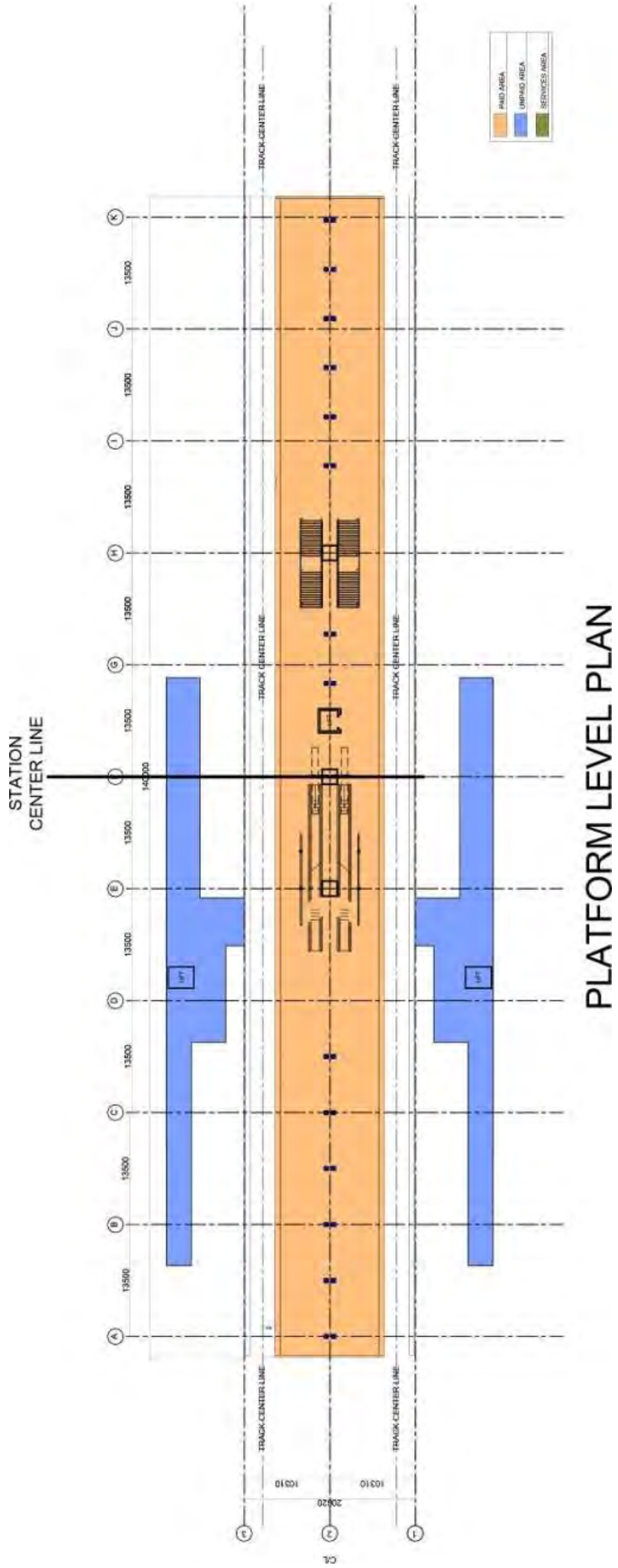
LONG SECTION


PAID AREA
UNPAID AREA
SERVICES AREA
CROSS SECTION

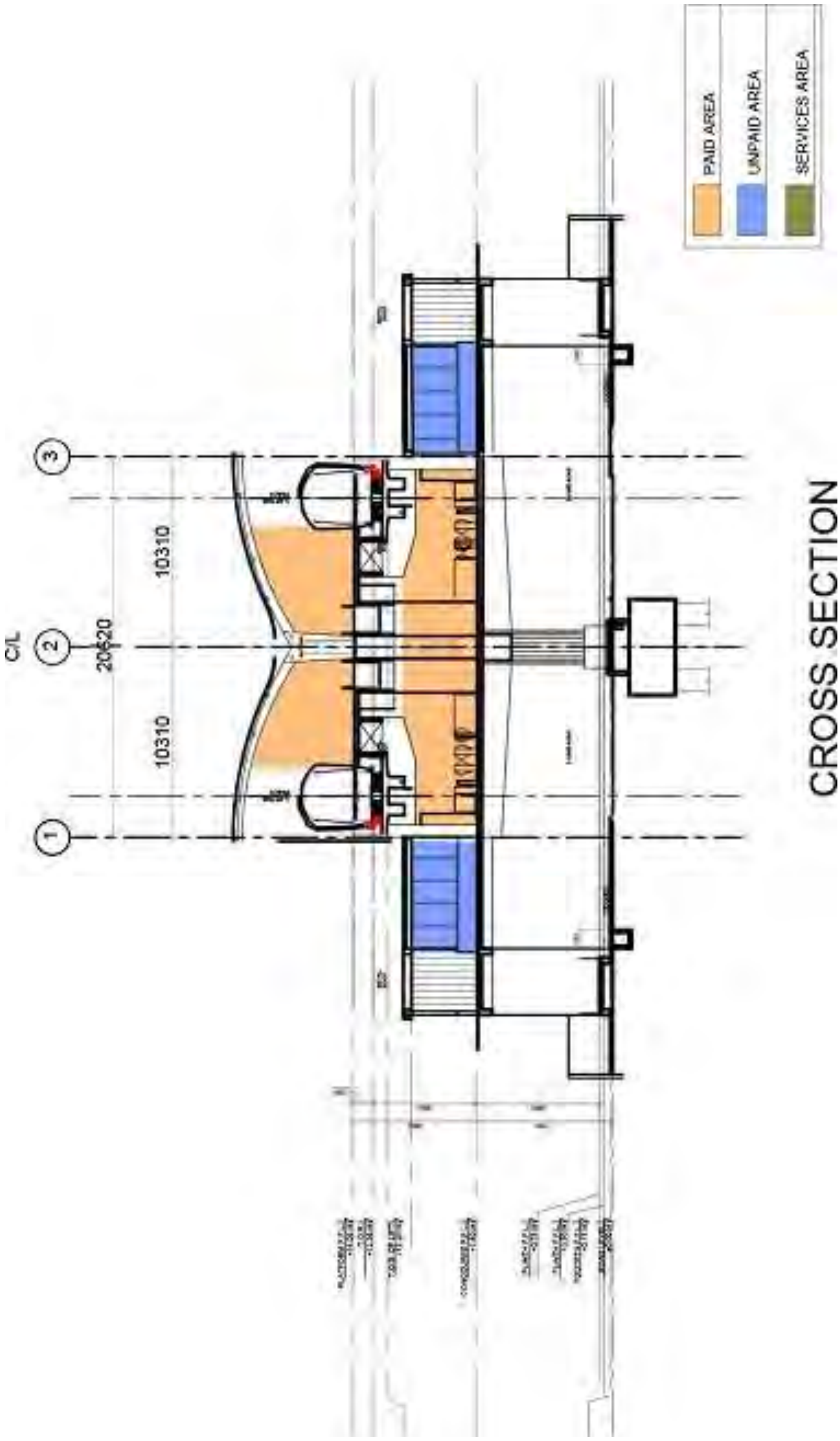
TYPE 3 STATION (ISLAND PLATFORM)




CONCOURSE LEVEL PLAN
STATION CENTER LINE
TRACK CENTER LINE
PAID AREA
UNPAID AREA
SERVICES AREA
LOADING/UNLOADING DECK
PAID CONCOURSE
UNPAID CONCOURSE
13500
10310
20620


PLATFORM LEVEL PLAN
STATION CENTER LINE
TRACK CENTER LINE
PAID AREA
UNPAID AREA
SERVICES AREA
LIFT


SIDE ELEVATION
LONG SECTION


PAID AREA
UNPAID AREA
SERVICES AREA
C/L
1
2
3
20620
10310
10310
CROSS SECTION

Chapter – 7

TRAIN OPERATION PLAN

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.
- Optimization of trains reliability for achieving best possible availability on line.
- A short train consists of 3 coaches.
- Multi-tasking of train operation and maintenance staff.

7.2 STATIONS

List of stations for the Corridor of Ahmedabad Metro are given below: -

TABLE 7.1 : STATIONS

North-South Corridor: APMC to Mahatma Mandir				
S. No	Name of Station	Chainage (m)	Inter – Station Distance (m)	Remarks
	Dead End	-1615.0		
1	APMC	0.0	1615.0	Elevated
2	Jivraj	950.0	950.0	Elevated
3	Rajiv Nagar	1800.0	850.0	Elevated
4	Shreyash	3170.0	1370.0	Elevated
5	Paldi	4524.0	1354.0	Elevated
6	Gandhigram Railway Station	5970.0	1446.0	Elevated
7	Old High Court	7045.0	1075.0	Elevated
8	Ushmanpura	8078.0	1033.0	Elevated
9	Vijay Nagar	9575.0	1497.0	Elevated
10	New Vadaj	10867.0	1292.0	Elevated
11	Ranip	12197.0	1330.0	Elevated
12	Sabarmati Railway Station	12965.0	768.0	Elevated
13	AEC	13906.0	941.0	Elevated
14	Sabarmati	15265.0	1359.0	Elevated
15	Motera Stadium	16661.7	1396.7	Elevated

North-South Corridor: APMC to Mahatma Mandir				
S. No	**Name of Station**	**Chainage (m)**	**Inter – Station Distance (m)**	**Remarks**
16	Koteshwar Road	17598.8	937.1	Elevated
17	Vishwakarma College	19017.0	1418.2	Elevated
18	Tapovan Circle	19994.4	977.4	Elevated
19	Narmada Canal	20900.0	905.6	Elevated
20	Koba Circle	22050.6	1150.6	Elevated
21	Juna Koba	23056.4	1005.8	Elevated
22	Koba Gaam	24066.4	1010.0	Elevated
23	GNLU	24977.5	911.1	Elevated
24	Raysan	26413.7	1436.2	Elevated
25	Randesan	27786.9	1373.2	Elevated
26	Dholakuva Circle	28943.2	1156.3	Elevated
27	Infocity	30334.0	1390.8	Elevated
28	Sectror-1	31600.0	1266.0	Elevated
29	Sector-10A	32850.0	1250.0	Elevated
30	Sachivalaya	34041.3	1191.3	Elevated
31	Akshardham	35170.0	1128.7	Elevated
32	Juna Sachivalaya	36069.0	899	Elevated
33	Sector-16	37161.3	1092.3	Elevated
34	Sector-24	38199.0	1037.7	Elevated
35	Mahatma Mandir	39399.6	1200.6	Elevated
	Dead End	39499.6	100.0	

Koteshwar Road to Airport (Phase-IIA)				
S. No	**Name of Station**	**Chainage (in m)**	**Inter – Station Distance (in m)**	**Remarks**
	Dead End	-405.00		
1	Koteshwar Road	0.00	450.00	Elevated
2	Sardarnagar	4212.19	4212.19	Elevated
3	Airport	5834.17	1621.98	Elevated
	Dead End	5934.17	100.00	

GNLU to Gift City				
S. No	**Name of Station**	**Chainage (in m)**	**Inter – Station Distance (in m)**	**Remarks**
	Dead End	-405.00		
1	GNLU	0.00	405.00	Elevated
2	PDPU	1749.00	1749.00	Elevated
3	Gift City	4605.86	2856.86	Elevated
	Dead End	5010.86	405.00	

7.3 TRAIN OPERATION PLAN: SALIENT FEATURES

Running of services for 19 hours of the day (5 AM to Midnight) with a station dwell time of 30 seconds,
Make up time of 5-10% with 8-12% coasting.
Scheduled speed for these corridors has been considered as: 33 kmph.

7.4 TRAFFIC DEMAND

Peak hour peak direction traffic demands (PHPDT) for the Ahmedabad Metro Extension of North-South Corridor: 'APMC to Mahatma Mandir', 'Koteshwar Road to Airport' & 'GNLU to Gift City' for the year 2021, 2031, 2041 and 2051 for the purpose of planning are indicated in Attachment I/A1, I/B1, I/C1, I/D1, Attachment I/A2, B2, C2, D2 and Attachment I/A3, I/B3, I/C3, I/D3 respectively.

7.5 TRAIN FORMATION

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

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)

7.6 TRAIN OPERATION PLAN

Based on the projected PHPDT demand, Train operation plan with train carrying capacity @ 6 persons per square meter of standee area for the Ahmedabad Metro Extension of North-South Corridor: 'APMC to Mahatma Mandir', 'Koteshwar Road to Airport' & 'GNLU to Gift City' for the year 2021, 2031, 2041 and 2051 are given below:

1. **Corridor: APMC to Mahatma Mandir**

Train Operation Plan for 'APMC to Mahatma Mandir' has been planned in such a way that there are Two loops of train operation, one is from APMC to Mahatma Mandir (end to end) and the other one is from Shreyash to Koteshwar Road as the reversal facility is available at Shreyash and Koteshwar Road stations.

i) Year 2021:

Train operation is planned in 2 loops to meet the PHPDT demand. Train on 10.0 min Headway will run from APMC to Mahatma Mandir and Shreyash to Koteshwar Road. This would generate more PHPDT capacity in the common section between Shreyash to Koteshwar Road.

a) APMC to Shreyash and Koteshwar Road to Mahatma Mandir Section (Refer Attachment I/A1)

10 min Effective Headway with 3-car train.

Available Peak Hour Peak Direction Capacity of 4584@ 6 persons per square meter of standee area.

Available Peak Hour Peak Direction Capacity of 5832@ 8 persons per square meter of standee area under dense loading conditions.

The maximum PHPDT demand of 4052 is in the Section between Rajiv Nagar to Shreyash and demand in the remaining sections is in the range of 3822 to 620 only. The planned capacity is more than the PHPDT demand.

b) Shreyash to Koteshwar Road Section (Refer Attachment I/A1)

5 min Effective Headway with 3-car train.

Available Peak Hour Peak Direction Capacity of 9168@ 6 persons per square meter of standee area.

Available Peak Hour Peak Direction Capacity of 11664@ 8 persons per square meter of standee area under dense loading conditions.

The maximum PHPDT demand of 8747 is in the Section between Ushmanpura to Vijay Nagar and demand in the remaining sections is in the range of 8691 to 4380 only. The planned capacity is more than the PHPDT demand.

Traffic demand and train capacity for these loops in the year 2021 is tabulated and represented on a chart enclosed as Attachment I/A1.

ii) Year 2031:

Train operation is planned in 2 loops to meet the PHPDT demand. Train on 8.0 min Headway will run from APMC to Mahatma Mandir and Shreyash to Koteshwar Road. This would generate more PHPDT capacity in the common section between Shreyash to Koteshwar Road.

a) APMC to Shreyash and Koteshwar Road to Mahatma Mandir Section (Refer Attachment I/B1)

8 min Effective 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 7290@ 8 persons per square meter of standee area under dense loading conditions.

The maximum PHPDT demand of 5178 is in the Section between Koteshwar Road to Vishwakarma College and demand in the remaining sections is in the range of 4981 to 841 only. The planned capacity is more than the PHPDT demand.

b) Shreyash to Koteshwar Road 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 14580@ 8 persons per square meter of standee area under dense loading conditions.

The maximum PHPDT demand of 11597 is in the Section between Old High Court to Ushmanpura and demand in the remaining sections is in the range of 11535 to 5310 only. The planned capacity is slightly less than the PHPDT demand in only two (zero, with dense loading capacity) sections out of twelve sections.

Traffic demand and train capacity for these loops in the year 2031 is tabulated and represented on a chart enclosed as Attachment I/B1.

iii) Year 2041:

Train operation is planned in 2 loops to meet the PHPDT demand. Train on 6.0 min Headway will run from APMC to Mahatma Mandir and Shreyash to Koteshwar Road. This would generate more PHPDT capacity in the common section between Shreyash to Koteshwar Road.

a) APMC to Shreyash and Koteshwar Road to Mahatma Mandir Section (Refer Attachment I/C1)

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 9720@ 8 persons per square meter of standee area under dense loading conditions.

The maximum PHPDT demand of 7240 is in the Section between Koteshwar Road to Vishwakarma College and demand in the remaining sections is in the range of 7055 to 1301 only. The planned capacity is higher than the PHPDT demand.

b) Shreyash to Koteshwar Road 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 19440@ 8 persons per square meter of standee area under dense loading conditions.

The maximum PHPDT demand of 14509 is in the Section between Old High Court to Ushmanpura and demand in the remaining sections is in the range of 14443 to 6518 only. The planned capacity is higher than the PHPDT demand.

Traffic demand and train capacity for these loops in the year 2041 is tabulated and represented on a chart enclosed as Attachment I/C1.

iv) Year 2051:

Train operation is planned in 2 loops to meet the PHPDT demand. Train on 5.0 min Headway will run from APMC to Mahatma Mandir and Shreyash to Koteshwar Road. This would generate more PHPDT capacity in the common section between Shreyash to Koteshwar Road.

a) APMC to Shreyash and Koteshwar Road to Mahatma Mandir Section (Refer Attachment I/D1)

5.0 min Effective Headway with 3-car train.

Available Peak Hour Peak Direction Capacity of 9168@ 6 persons per square meter of standee area.

Available Peak Hour Peak Direction Capacity of 11664@ 8 persons per square meter of standee area under dense loading conditions.

The maximum PHPDT demand of 9066 is in the Section between Koteshwar Road to Vishwakarma College and demand in the remaining sections is in the range of 8962 to 1660 only. The planned capacity is higher than the PHPDT demand.

b) Shreyash to Koteshwar Road Section (Refer Attachment I/D1)

2.5 min Effective Headway with 3-car train.

Available Peak Hour Peak Direction Capacity of 18336@ 6 persons per square meter of standee area.

Available Peak Hour Peak Direction Capacity of 23328@ 8 persons per square meter of standee area under dense loading conditions.

The maximum PHPDT demand of 16968 is in the Section between Old High Court to Ushmanpura and demand in the remaining sections is in the range of 16913 to 7302 only. The planned capacity is higher than the PHPDT demand.

Traffic demand and train capacity for these loops in the year 2051 is tabulated and represented on a chart enclosed as Attachment I/D1.

2. Corridor: Koteshwar Road to Airport (Phase-IIA)

Train Operation Plan for Koteshwar Road to Airport has been planned in such a way that there is Single loop shuttle-train operation from end to end. Koteshwar Road will be the interchange station and shall have the connectivity to APMC - Mahatma Mandir section for carrying out maintenance activity in Gyaspur Depot.

i) Year 2021:

'Koteshwar Road to Airport' Section (Refer Attachment I/A2)

10 min Effective Headway with 3-car train.

Available Peak Hour Peak Direction Capacity of 4584@ 6 persons per square meter of standee area.

Available Peak Hour Peak Direction Capacity of 5832 @ 8 persons per square meter of standee area under dense loading conditions.

The maximum PHPDT demand of 801 is in the Section between Koteshwar Road to Sardarnagar and demand in the remaining section is 62 only. The planned capacity of 4584 (5832 under dense loading) is more than the PHPDT demand.

Traffic demand and train capacity for this corridor in the year 2021 is tabulated and represented on a chart enclosed as Attachment I/A2.

ii) Year 2031:

'Koteshwar Road to Airport' Section (Refer Attachment I/B2)

10 min Effective Headway with 3-car train.

Available Peak Hour Peak Direction Capacity of 4584@ 6 persons per square meter of standee area.

Available Peak Hour Peak Direction Capacity of 5832 @ 8 persons per square meter of standee area under dense loading conditions.

The maximum PHPDT demand of 1062 is in the Section between Koteshwar Road to Sardarnagar and demand in the remaining section is 76 only. The planned capacity of 4584 (5832 under dense loading) is more than the PHPDT demand.

Traffic demand and train capacity for this corridor in the year 2031 is tabulated and represented on a chart enclosed as Attachment I/B2.

iii) Year 2041:

'Koteshwar Road to Airport' Section (Refer Attachment I/C2)

10 min Effective Headway with 3-car train.

Available Peak Hour Peak Direction Capacity of 4584@ 6 persons per square meter of standee area.

Available Peak Hour Peak Direction Capacity of 5832 @ 8 persons per square meter of standee area under dense loading conditions.

The maximum PHPDT demand of 1328 is in the Section between Koteshwar Road to Sardarnagar and demand in the remaining section is 90 only. The planned capacity of 4584 (5832 under dense loading) is more than the PHPDT demand.

Traffic demand and train capacity for this corridor in the year 2041 is tabulated and represented on a chart enclosed as Attachment I/C2.

iv) Year 2051:

'Koteshwar Road to Airport' Section (Refer Attachment I/D2)

10 min Effective Headway with 3-car train.

Available Peak Hour Peak Direction Capacity of 4584@ 6 persons per square meter of standee area.

Available Peak Hour Peak Direction Capacity of 5832 @ 8 persons per square meter of standee area under dense loading conditions.

The maximum PHPDT demand of 1668 is in the Section between Koteshwar Road to Sardarnagar and demand in the remaining section is 101 only. The planned capacity of 4584 (5832 under dense loading) is more than the PHPDT demand.

Traffic demand and train capacity for this corridor in the year 2051 is tabulated and represented on a chart enclosed as Attachment I/D2.

3. <u>Corridor: GNLU to Gift City:</u>

Train Operation Plan for GNLU to Gift City has been planned in such a way that there is Single loop shuttle-train operation from end to end. GNLU will be the interchange station and shall have the connectivity to APMC - Mahatma Mandir section for carrying out maintenance activity in Gyaspur Depot.

i) Year 2021:

'GNLU to Gift City' Section (Refer Attachment I/A3)

10 min Effective Headway with 3-car train.

Available Peak Hour Peak Direction Capacity of 4584@ 6 persons per square meter of standee area.

Available Peak Hour Peak Direction Capacity of 5832 @ 8 persons per square meter of standee area under dense loading conditions.

The maximum PHPDT demand of 638 is in the Section between GNLU to PDPU and demand in the remaining section is 579 only. The planned capacity of 4584 (5832 under dense loading) is more than the PHPDT demand.

Traffic demand and train capacity for this corridor in the year 2021 is tabulated and represented on a chart enclosed as Attachment I/A3.

ii) Year 2031:

'GNLU to Gift City' Section (Refer Attachment I/B3)

10 min Effective Headway with 3-car train.

Available Peak Hour Peak Direction Capacity of 4584@ 6 persons per square meter of standee area.

Available Peak Hour Peak Direction Capacity of 5832 @ 8 persons per square meter of standee area under dense loading conditions.

The maximum PHPDT demand of 1326 is in the Section between GNLU to PDPU and demand in the remaining section is 1156 only. The planned capacity of 4584 (5832 under dense loading) is more than the PHPDT demand.

Traffic demand and train capacity for this corridor in the year 2031 is tabulated and represented on a chart enclosed as Attachment I/B3.

iii) Year 2041:

'GNLU to Gift City' Section (Refer Attachment I/C3)

10 min Effective Headway with 3-car train.

Available Peak Hour Peak Direction Capacity of 4584@ 6 persons per square meter of standee area.

Available Peak Hour Peak Direction Capacity of 5832 @ 8 persons per square meter of standee area under dense loading conditions.

The maximum PHPDT demand of 1766 is in the Section between GNLU to PDPU and demand in the remaining section is 1534 only. The planned capacity of 4584 (5832 under dense loading) is more than the PHPDT demand.

Traffic demand and train capacity for this corridor in the year 2041 is tabulated and represented on a chart enclosed as Attachment I/C3.

iv) Year 2051:

'GNLU to Gift City' Section (Refer Attachment I/D3)

10 min Effective Headway with 3-car train.

Available Peak Hour Peak Direction Capacity of 4584@ 6 persons per square meter of standee area.

Available Peak Hour Peak Direction Capacity of 5832 @ 8 persons per square meter of standee area under dense loading conditions.

The maximum PHPDT demand of 2261 is in the Section GNLU to PDPU and demand in the remaining section is 2028 only. The planned capacity of 4584 (5832 under dense loading) is more than the PHPDT demand.

Traffic demand and train capacity for this corridor in the year 2051 is tabulated and represented on a chart enclosed as Attachment I/D3.

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 different sections of North South corridor in different years of operation is tabulated below:

TABLE 7.2 Corridor: APMC to Mahatma Mandir

<table>
<tr><th>Sections</th><th>Year</th><th>Headway (min)</th><th>No. of Rakes for Phase-I and Phase-II</th><th>Net No. of Rakes for Phase- II**</th><th>Rake Consist</th><th>No. of Coaches</th><th>Max. PHPDT Demand</th><th>PHPDT Capacity Available</th></tr>
<tr><td>APMC to Shreyash and Koteshwar Road to Mahatma Mandir</td><td rowspan="2">2021</td><td>10</td><td rowspan="2">25</td><td rowspan="2">7</td><td>3-car</td><td rowspan="2">21</td><td>4052</td><td>4584 (5832*)</td></tr>
<tr><td>Shreyash to Koteshwar Road</td><td>5</td><td>3-car</td><td>8747</td><td>9168 (11664*)</td></tr>
<tr><td>APMC to Shreyash and Koteshwar Road to Mahatma Mandir</td><td rowspan="2">2031</td><td>8</td><td rowspan="2">31</td><td rowspan="2">4</td><td>3-car</td><td rowspan="2">12</td><td>5178</td><td>5730 (7290*)</td></tr>
<tr><td>Shreyash to Koteshwar Road</td><td>4</td><td>3-car</td><td>11597</td><td>11460 (14580*)</td></tr>
<tr><td>APMC to Shreyash and Koteshwar Road to Mahatma Mandir</td><td rowspan="2">2041#</td><td>6</td><td rowspan="2">40</td><td rowspan="2">0</td><td>3-car</td><td rowspan="2">0</td><td>7240</td><td>7640 (9720*)</td></tr>
<tr><td>Shreyash to Koteshwar Road</td><td>3</td><td>3-car</td><td>14509</td><td>15280 (19440*)</td></tr>
<tr><td>APMC to Shreyash and Koteshwar Road to Mahatma Mandir</td><td rowspan="2">2051##</td><td>5</td><td>36</td><td rowspan="2">48</td><td>3-car</td><td rowspan="2">144</td><td>9066</td><td>9168 (11664*)</td></tr>
<tr><td>Shreyash to Koteshwar Road</td><td>2.5</td><td>12</td><td>3-car</td><td>16968</td><td>18336 (23328*)</td></tr>
</table>

 # The provision for number of rake requirement for the year 2043 considered in Phase-I DPR has been considered against year 2041 in Phase-II DPR for calculating the additional rakes required.

The provision of rakes for year 2051 was not available in phase-I DPR. Hence all the requirements have been considered for Phase-II only.

TABLE 7.3 Corridor: Koteshwar Road to Airport (Phase-IIA)

Sections	Year	Headway (min)	No. of Rakes for Phase-I and Phase-II	Net No. of Rakes for Phase- II**	Rake Consist	No. of Coaches	Max. PHPDT Demand	PHPDT Capacity Available
Koteshwar Road to Airport	2021	10	3	3	3-car	9	801	4584 (5832*)
Koteshwar Road to Airport	2031	10	3	3	3-car	9	1062	4584 (5832*)
Koteshwar Road to Airport	2041	10	3	0#	3-car	0	1328	4584 (5832*)
Koteshwar Road to Airport	2051	10	3	3	3-car	9	1668	4584 (5832*)

TABLE 7.4 Corridor: GNLU to Gift City

Sections	Year	Headway (min)	No. of Rakes for Phase-I and Phase-II	Net No. of Rakes for Phase- II**	Rake Consist	No. of Coaches	Max. PHPDT Demand	PHPDT Capacity Available
GNLU to Gift City	2021	10	3	3	3-car	9	638	4584 (5832*)
GNLU to Gift City	2031	10	3	3	3-car	9	1326	4584 (5832*)
GNLU to Gift City	2041	10	3	3	3-car	9	1766	4584 (5832*)

Sections	Year	Headway (min)	No. of Rakes for Phase-I and Phase-II	Net No. of Rakes for Phase- II**	Rake Consist	No. of Coaches	Max. PHPDT Demand	PHPDT Capacity Available
GNLU to Gift City	2051	10	3	3	3-car	9	2261	4584 (5832*)

* @ 8 persons per square meter of standee area

** Net rake requirement for Phase-II has been calculated after subtracting previous DPR requirements from the total requirements which is shown in attachment V.

Provision for extra 3 rakes available in Phase-I has been utilized for this section in Phase-II.

7.7 TRAIN FREQUENCY

TABLE 7.5 Train Frequency Corridor: APMC to Mahatma Mandir

Section	2021		2031		2041		2051	
	Peak Hour Head-way	Lean Hour Head-way	Peak Hour Head-way	Lean Hour Head-way	Peak Hour Head-way	Lean Hour Head-way	Peak Hour Head-way	Lean Hour Head-way
APMC to Shreyash and Koteshwar Road to Mahatma Mandir	10 min	16 to 32 min	8 min	12 to 32 min	6 min	10 to 24 min	5 min	8 to 16 min
Shreyash to Koteshwar Road	5 min	8 to 16 min	4 min	6 to 16 min	3 min	5 to 12 min	2.50 min	4 to 8 min

TABLE 7.6 Train Frequency Corridor: Koteshwar Road to Airport (Phase-IIA)

Section	2021		2031		2041		2051	
	Peak Hour Head-way	Lean Hour Head-way	Peak Hour Head-way	Lean Hour Head-way	Peak Hour Head-way	Lean Hour Head-way	Peak Hour Head-way	Lean Hour Head-way
Koteshwar Road to Airport	10 min	16 to 32 min	10 min	12 to 32 min	10 min	12 to 24 min	10 min	12 to 24 min

TABLE 7.7 Train Frequency Corridor: GNLU to Gift City

Section	2021		2026		2036		2046	
	Peak Hour Head-way	Lean Hour Head-way	Peak Hour Head-way	Lean Hour Head-way	Peak Hour Head-way	Lean Hour Head-way	Peak Hour Head-way	Lean Hour Head-way
GNLU to Gift City	10 min	16 to 32 min	10 min	12 to 32 min	10 min	12 to 24 min	10 min	12 to 24 min

No services are proposed between 00:00 hrs to 5.00 hrs, which are reserved for maintenance of infrastructure and rolling stock.

7.8 HOURLY TRAIN OPERATION PLAN

The hourly distribution of daily transport capacity is presented in **Table 1.1A1, 1.1A2, 1.2A1, 1.2A2, 1.3A1, 1.3A2, 1.4A1, 1.4A2** for 'APMC to Mahatma Mandir' Section and **Table 1.1B, 1.2B, 1.3B, 1.4B** for 'Koteshwar Road to Airport' Section and **Table 1.1C, 1.2C, 1.3C, 1.4C** for 'GNLU to Gift City' Section respectively for years 2021, 2031, 2041 and 2051 enclosed as **Attachment II.**

The directional splits for 'APMC-Mahatma Mandir' corridor, 'Koteshwar Road to Airport' corridor and 'GNLU to Gift City' corridor is presented in **Table 2.1, 2.2 and 2.3** respectively, enclosed as **Attachment III**.

7.9 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 Network is given in **Table 3** enclosed as **Attachment IV**.

7.10 YEAR WISE RAKE REQUIREMENT

Based on Train formation and headway as decided above to meet Peak Hour Peak Direction Traffic Demand, Rake requirement has been calculated and enclosed as **Attachment V.**

Requirements of coaches is calculated based on following assumptions-

Assumptions –

(i) Train Composition planned as under

3 car Train Composition (66.7% Powering)	: 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 10 % of total requirement (Bare).

(v) The calculated number of bare rakes in fraction is rounded off to next higher number.

(vi) Additional rakes required are calculated by subtracting provision available in DPR for Phase-I from total requirement of Phase-I and Phase-II year wise.

(vii) Schedule speed is taken as: 33 kmph

(viii) Total Turn round time is taken as 6 min at terminal stations.

7.11 COST ESTIMATE

The estimated cost per coach at Jan 2017 Price level exclusive of taxes and duties may be assumed as INR 10.20 Crores per Coach. Total 39 additional coaches are required in year 2021 for extension of North-South Corridor in Phase-II ((APMC - Motera Stadium) to Mahatma Mandir, Koteshwar Road to Airport and GNLU to Gift City) in Ahmedabad Metro Rail Network. Hence budget provision of Rs. 398 Crores (approx.) is to be kept in the Estimate for Rolling stock.

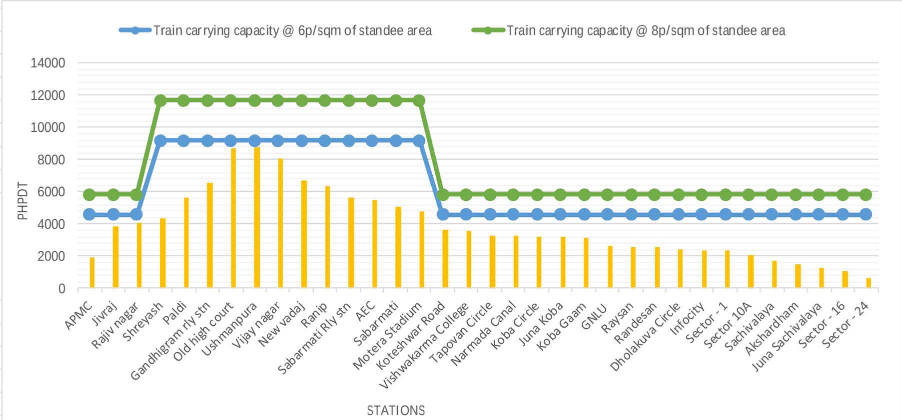
Attachment - I/A1

PHPDT Demand and Capacity Chart

North-South Corridor (APMC to Mahatma Mandir)

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:	**972**
Headway (min)	**10.00** — **APMC to Shreyash and Koteshwar Road to Mahatma Mandir**
Headway (min)	**5.00** — **Shreyash to Koteshwar Road**

S.N	FROM	TO	Traffic Demand in PHPDT	Train carrying capacity @ 6p/sqm of standee	Train carrying capacity @ 8p/sqm of standee area
1	APMC	Jivraj	1,942	4,584	5,832
2	Jivraj	Rajiv nagar	3,822	4,584	5,832
3	Rajiv nagar	Shreyash	4,052	4,584	5,832
4	Shreyash	Paldi	4,380	9,168	11,664
5	Paldi	Gandhigram rly stn	5,631	9,168	11,664
6	Gandhigram rly stn	Old high court	6,583	9,168	11,664
7	Old high court	Ushmanpura	8,691	9,168	11,664
8	Ushmanpura	Vijay nagar	8,747	9,168	11,664
9	Vijay nagar	New vadaj	8,090	9,168	11,664
10	New vadaj	Ranip	6,737	9,168	11,664
11	Ranip	Sabarmati Rly stn	6,351	9,168	11,664
12	Sabarmati Rly stn	AEC	5,617	9,168	11,664
13	AEC	Sabarmati	5,495	9,168	11,664
14	Sabarmati	Motera Stadium	5,085	9,168	11,664
15	Motera Stadium	Koteshwar Road	4,753	9,168	11,664
16	Koteshwar Road	Vishwakarma College	3,627	4,584	5,832
17	Vishwakarma College	Tapovan Circle	3,551	4,584	5,832
18	Tapovan Circle	Narmada Canal	3,290	4,584	5,832
19	Narmada Canal	Koba Circle	3,264	4,584	5,832
20	Koba Circle	Juna Koba	3,203	4,584	5,832
21	Juna Koba	Koba Gaam	3,189	4,584	5,832
22	Koba Gaam	GNLU	3,170	4,584	5,832
23	GNLU	Raysan	2,624	4,584	5,832
24	Raysan	Randesan	2,594	4,584	5,832
25	Randesan	Dholakuva Circle	2,556	4,584	5,832
26	Dholakuva Circle	Infocity	2,420	4,584	5,832
27	Infocity	Sector - 1	2,358	4,584	5,832
28	Sector - 1	Sector 10A	2,334	4,584	5,832
29	Sector 10A	Sachivalaya	2,102	4,584	5,832
30	Sachivalaya	Akshardham	1,704	4,584	5,832
31	Akshardham	Juna Sachivalaya	1,475	4,584	5,832
32	Juna Sachivalaya	Sector - 16	1,257	4,584	5,832
33	Sector - 16	Sector - 24	1,065	4,584	5,832
34	Sector - 24	Mahatma Mandir	620	4,584	5,832



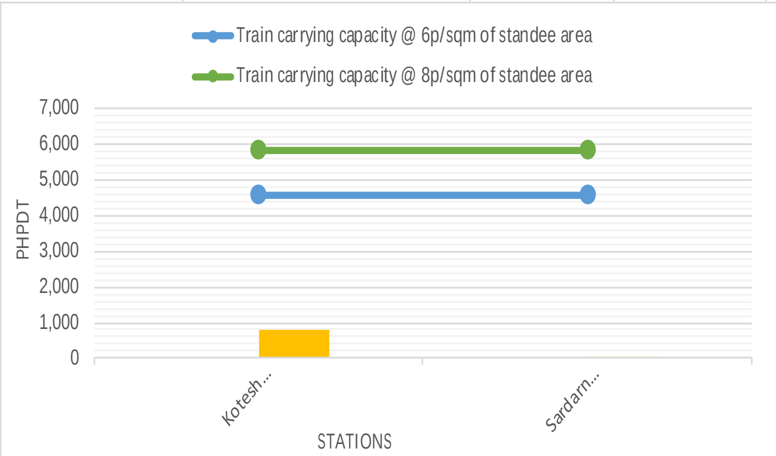
Attachment - I/A2

PHPDT Demand and Capacity Chart

Koteshwar Road to Airport

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:	972
Headway (min)	10.00

S.N	FROM	TO	Traffic Demand in PHPDT	Train carrying capacity @ 6p/sqm of standee area	Train carrying capacity @ 8p/sqm of standee area
1	Koteshwar Road	Sardarnagar	801	4,584	5,832
2	Sardarnagar	Airport	62	4,584	5,832



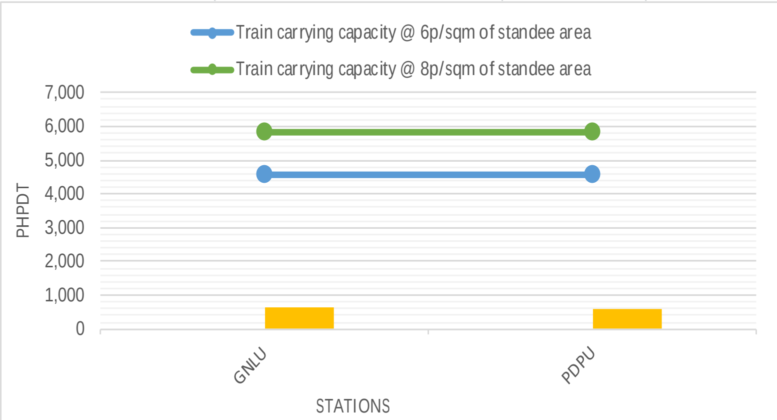
Attachment - I/A3

PHPDT Demand and Capacity Chart

GNLU to Gift City

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:	972
Headway (min)	10.00

S.N	FROM	TO	Traffic Demand in PHPDT	Train carrying capacity @ 6p/sqm of standee area	Train carrying capacity @ 8p/sqm of standee area
1	GNLU	PDPU	638	4,584	5,832
2	PDPU	Gift City	579	4,584	5,832



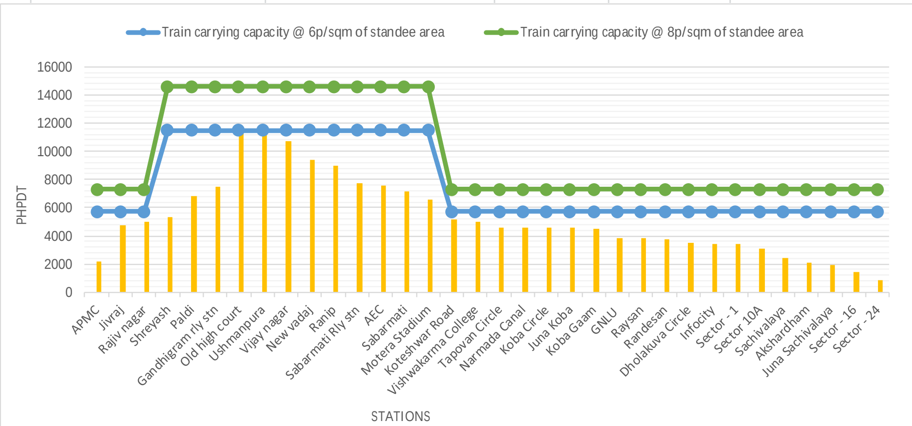
Attachment - I/B1

PHPDT Demand and Capacity Chart

North-South Corridor (APMC to Mahatma Mandir)

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:	972
Headway (min)	8.00 (APMC to Shreyash and Koteshwar Road to Mahatma Mandir)
Headway (min)	4.00 (Shreyash to Koteshwar Road)

S.N	FROM	TO	Traffic Demand in PHPDT	Train carrying capacity @ 6p/sqm of standee area	Train carrying capacity @ 8p/sqm of standee area
1	APMC	Jivraj	2,154	5,730	7,290
2	Jivraj	Rajiv nagar	4,739	5,730	7,290
3	Rajiv nagar	Shreyash	4,972	5,730	7,290
4	Shreyash	Paldi	5,310	11,460	14,580
5	Paldi	Gandhigram rly stn	6,781	11,460	14,580
6	Gandhigram rly stn	Old high court	7,450	11,460	14,580
7	Old high court	Ushmanpura	11,597	11,460	14,580
8	Ushmanpura	Vijay nagar	11,535	11,460	14,580
9	Vijay nagar	New vadaj	10,753	11,460	14,580
10	New vadaj	Ranip	9,374	11,460	14,580
11	Ranip	Sabarmati Rly stn	8,961	11,460	14,580
12	Sabarmati Rly stn	AEC	7,756	11,460	14,580
13	AEC	Sabarmati	7,582	11,460	14,580
14	Sabarmati	Motera Stadium	7,161	11,460	14,580
15	Motera Stadium	Koteshwar Road	6,589	11,460	14,580
16	Koteshwar Road	Vishwakarma College	5,178	5,730	7,290
17	Vishwakarma College	Tapovan Circle	4,981	5,730	7,290
18	Tapovan Circle	Narmada Canal	4,607	5,730	7,290
19	Narmada Canal	Koba Circle	4,596	5,730	7,290
20	Koba Circle	Juna Koba	4,554	5,730	7,290
21	Juna Koba	Koba Gaam	4,547	5,730	7,290
22	Koba Gaam	GNLU	4,518	5,730	7,290
23	GNLU	Raysan	3,850	5,730	7,290
24	Raysan	Randesan	3,810	5,730	7,290
25	Randesan	Dholakuva Circle	3,737	5,730	7,290
26	Dholakuva Circle	Infocity	3,498	5,730	7,290
27	Infocity	Sector - 1	3,450	5,730	7,290
28	Sector - 1	Sector 10A	3,416	5,730	7,290
29	Sector 10A	Sachivalaya	3,100	5,730	7,290
30	Sachivalaya	Akshardham	2,449	5,730	7,290
31	Akshardham	Juna Sachivalaya	2,113	5,730	7,290
32	Juna Sachivalaya	Sector - 16	1,922	5,730	7,290
33	Sector - 16	Sector - 24	1,451	5,730	7,290
34	Sector - 24	Mahatma Mandir	841	5,730	7,290



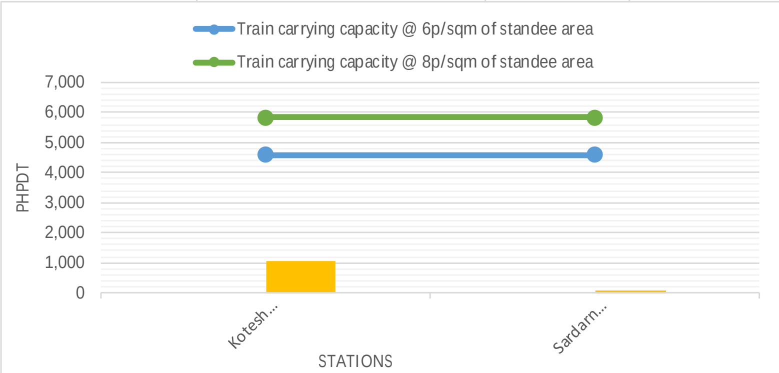
Attachment - I/B2

PHPDT Demand and Capacity Chart

Koteshwar Road to Airport

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:	**972**
Headway (min)	**10.00**

S.N	FROM	TO	Traffic Demand in PHPDT	Train carrying capacity @ 6p/sqm of standee area	Train carrying capacity @ 8p/sqm of standee area
1	Koteshwar Road	Sardarnagar	1,062	4,584	5,832
2	Sardarnagar	Airport	76	4,584	5,832



Attachment - I/B3

PHPDT Demand and Capacity Chart

GNLU to Gift City

Year: 2031

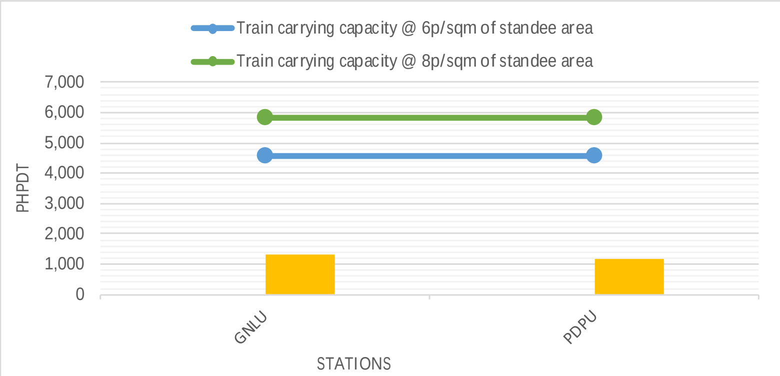
No. of cars per train 3

Passenger Capacity @ 6 persons/sqm of a 3-Car Train: 764

Passenger Capacity @ 8 persons/sqm of a 3-Car Train: 972

Headway (min) 10.00

S.N	FROM	TO	Traffic Demand in PHPDT	Train carrying capacity @ 6p/sqm of standee area	Train carrying capacity @ 8p/sqm of standee area
1	GNLU	PDPU	1,326	4,584	5,832
2	PDPU	Gift City	1,156	4,584	5,832



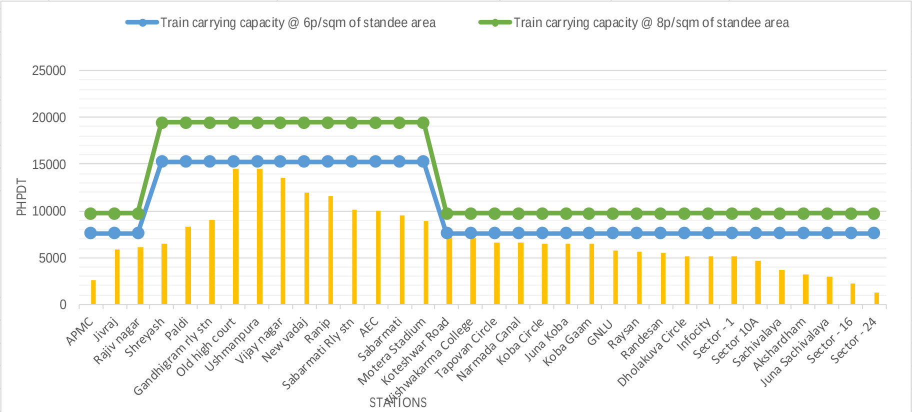
Attachment - I/C1

PHPDT Demand and Capacity Chart

North-South Corridor (APMC to Mahatma Mandir)

Year:	2041	
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:	972	
Headway (min)	6.00	APMC to Shreyash and Koteshwar Road to Mahatma Mandir
Headway (min)	3.00	Shreyash to Koteshwar Road

S.N	FROM	TO	Traffic Demand in PHPDT	Train carrying capacity @ 6p/sqm of standee area	Train carrying capacity @ 8p/sqm of standee area
1	APMC	Jivraj	2,590	7,640	9,720
2	Jivraj	Rajiv nagar	5,825	7,640	9,720
3	Rajiv nagar	Shreyash	6,111	7,640	9,720
4	Shreyash	Paldi	6,518	15,280	19,440
5	Paldi	Gandhigram rly stn	8,286	15,280	19,440
6	Gandhigram rly stn	Old high court	9,011	15,280	19,440
7	Old high court	Ushmanpura	14,509	15,280	19,440
8	Ushmanpura	Vijay nagar	14,443	15,280	19,440
9	Vijay nagar	New vadaj	13,564	15,280	19,440
10	New vadaj	Ranip	11,999	15,280	19,440
11	Ranip	Sabarmati Rly stn	11,531	15,280	19,440
12	Sabarmati Rly stn	AEC	10,166	15,280	19,440
13	AEC	Sabarmati	9,973	15,280	19,440
14	Sabarmati	Motera Stadium	9,513	15,280	19,440
15	Motera Stadium	Koteshwar Road	8,864	15,280	19,440
16	Koteshwar Road	Vishwakarma College	7,240	7,640	9,720
17	Vishwakarma College	Tapovan Circle	7,055	7,640	9,720
18	Tapovan Circle	Narmada Canal	6,554	7,640	9,720
19	Narmada Canal	Koba Circle	6,548	7,640	9,720
20	Koba Circle	Juna Koba	6,507	7,640	9,720
21	Juna Koba	Koba Gaam	6,498	7,640	9,720
22	Koba Gaam	GNLU	6,466	7,640	9,720
23	GNLU	Raysan	5,727	7,640	9,720
24	Raysan	Randesan	5,677	7,640	9,720
25	Randesan	Dholakuva Circle	5,559	7,640	9,720
26	Dholakuva Circle	Infocity	5,191	7,640	9,720
27	Infocity	Sector - 1	5,132	7,640	9,720
28	Sector - 1	Sector 10A	5,102	7,640	9,720
29	Sector 10A	Sachivalaya	4,671	7,640	9,720
30	Sachivalaya	Akshardham	3,724	7,640	9,720
31	Akshardham	Juna Sachivalaya	3,236	7,640	9,720
32	Juna Sachivalaya	Sector - 16	2,973	7,640	9,720
33	Sector - 16	Sector - 24	2,248	7,640	9,720
34	Sector - 24	Mahatma Mandir	1,301	7,640	9,720



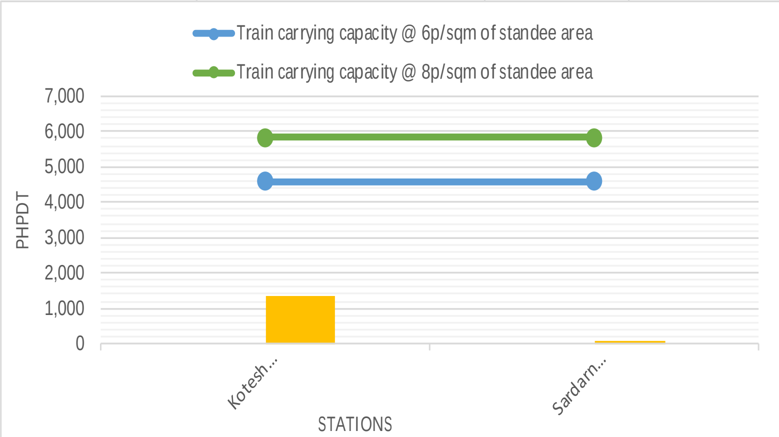
Attachment - I/C2

PHPDT Demand and Capacity Chart

Koteshwar Road to Airport

Year:	2041
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:	972
Headway (min)	10.00

S.N	FROM	TO	Traffic Demand in PHPDT	Train carrying capacity @ 6p/sqm of standee area	Train carrying capacity @ 8p/sqm of standee area
1	Koteshwar Road	Sardarnagar	1,328	4,584	5,832
2	Sardarnagar	Airport	90	4,584	5,832



Attachment - I/C3

PHPDT Demand and Capacity Chart

GNLU to Gift City

Year: 2041

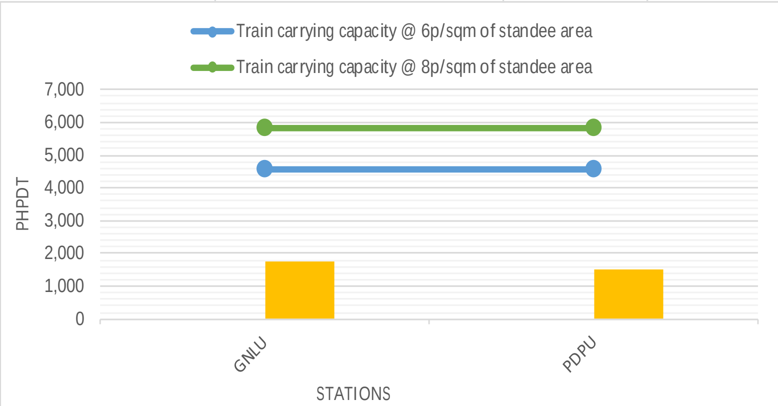
No. of cars per train 3

Passenger Capacity @ 6 persons/sqm of a 3-Car Train: 764

Passenger Capacity @ 8 persons/sqm of a 3-Car Train: 972

Headway (min) 10.00

S.N	FROM	TO	Traffic Demand in PHPDT	Train carrying capacity @ 6p/sqm of standee area	Train carrying capacity @ 8p/sqm of standee area
1	GNLU	PDPU	1,766	4,584	5,832
2	PDPU	Gift City	1,534	4,584	5,832



Attachment - I/D1

PHPDT Demand and Capacity Chart

North-South Corridor (APMC to Mahatma Mandir)

Year:	2051
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:	972
Headway (min)	5.00 (APMC to Shreyash and Koteshwar Road to Mahatma Mandir)
Headway (min)	2.50 (Shreyash to Koteshwar Road)

S.N	FROM	TO	Traffic Demand in PHPDT	Train carrying capacity @ 6p/sqm of standee area	Train carrying capacity @ 8p/sqm of standee area
1	APMC	Jivraj	2,870	9,168	11,664
2	Jivraj	Rajiv nagar	6,523	9,168	11,664
3	Rajiv nagar	Shreyash	6,847	9,168	11,664
4	Shreyash	Paldi	7,302	18,336	23,328
5	Paldi	Gandhigram rly stn	9,279	18,336	23,328
6	Gandhigram rly stn	Old high court	10,185	18,336	23,328
7	Old high court	Ushmanpura	16,968	18,336	23,328
8	Ushmanpura	Vijay nagar	16,913	18,336	23,328
9	Vijay nagar	New vadaj	15,907	18,336	23,328
10	New vadaj	Ranip	14,057	18,336	23,328
11	Ranip	Sabarmati Rly stn	13,562	18,336	23,328
12	Sabarmati Rly stn	AEC	12,097	18,336	23,328
13	AEC	Sabarmati	11,896	18,336	23,328
14	Sabarmati	Motera Stadium	11,407	18,336	23,328
15	Motera Stadium	Koteshwar Road	10,717	18,336	23,328
16	Koteshwar Road	Vishwakarma College	9,066	9,168	11,664
17	Vishwakarma College	Tapovan Circle	8,962	9,168	11,664
18	Tapovan Circle	Narmada Canal	8,387	9,168	11,664
19	Narmada Canal	Koba Circle	8,394	9,168	11,664
20	Koba Circle	Juna Koba	8,379	9,168	11,664
21	Juna Koba	Koba Gaam	8,372	9,168	11,664
22	Koba Gaam	GNLU	8,334	9,168	11,664
23	GNLU	Raysan	7,429	9,168	11,664
24	Raysan	Randesan	7,370	9,168	11,664
25	Randesan	Dholakuva Circle	7,221	9,168	11,664
26	Dholakuva Circle	Infocity	6,752	9,168	11,664
27	Infocity	Sector - 1	6,686	9,168	11,664
28	Sector - 1	Sector 10A	6,659	9,168	11,664
29	Sector 10A	Sachivalaya	6,098	9,168	11,664
30	Sachivalaya	Akshardham	4,849	9,168	11,664
31	Akshardham	Juna Sachivalaya	4,219	9,168	11,664
32	Juna Sachivalaya	Sector - 16	3,876	9,168	11,664
33	Sector - 16	Sector - 24	2,973	9,168	11,664
34	Sector - 24	Mahatma Mandir	1,660	9,168	11,664

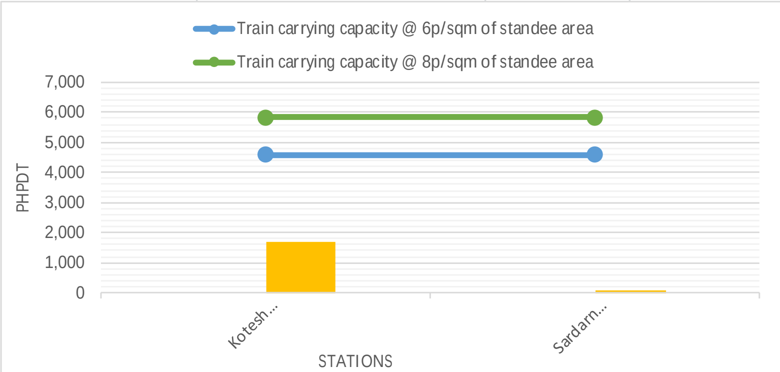
Attachment - I/D2

PHPDT Demand and Capacity Chart

Koteshwar Road to Airport

Year:	**2051**
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:	**972**
Headway (min)	**10.00**

S.N	FROM	TO	Traffic Demand in PHPDT	Train carrying capacity @ 6p/sqm of standee area	Train carrying capacity @ 8p/sqm of standee area
1	Koteshwar Road	Sardarnagar	1,668	4,584	5,832
2	Sardarnagar	Airport	101	4,584	5,832



Attachment - I/D3

PHPDT Demand and Capacity Chart

GNLU to Gift City

Year: 2051

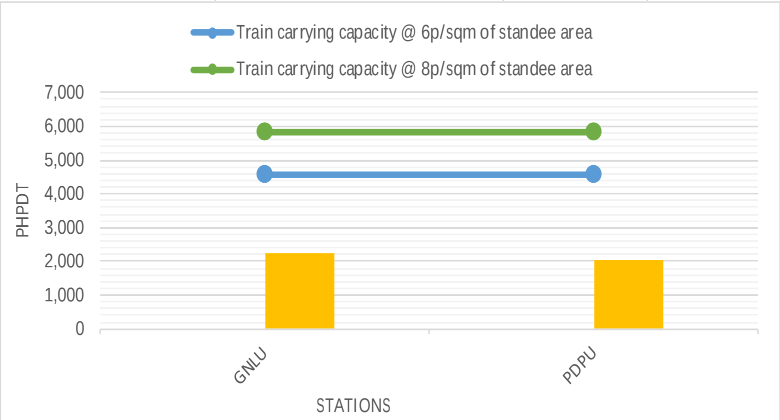
No. of cars per train 3

Passenger Capacity @ 6 persons/sqm of a 3-Car Train: 764

Passenger Capacity @ 8 persons/sqm of a 3-Car Train: 972

Headway (min) 10.00

S.N	FROM	TO	Traffic Demand in PHPDT	Train carrying capacity @ 6p/sqm of standee area	Train carrying capacity @ 8p/sqm of standee area
1	GNLU	PDPU	2,261	4,584	5,832
2	PDPU	Gift City	2,028	4,584	5,832



Attachment- II

TABLE 1.1 A1

Hourly Train Operation Plan

APMC to Shreyash and Koteshwar Road to Mahatma Mandir

Year- 2021

10 -min Headway

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	32	2	2
6 to 7	24	3	3
7 to 8	16	4	4
8 to 9	**10.00**	**6**	**6**
9 to 10	**10.00**	**6**	**6**
10 to 11	**10.00**	**6**	**6**
11 to12	16	4	4
12 to 13	24	3	3
13 to 14	32	2	2
14 to 15	32	2	2
15 to 16	24	2	2
16 to 17	16	4	4
17 to 18	**10.00**	**6**	**6**
18 to 19	**10.00**	**6**	**6**
19 to 20	**10.00**	**6**	**6**
20 to 21	16	4	4
21 to 22	24	2	2
22 to 23	32	1	1
23 to 24	40	1	1
Total No. of train trips per direction per day		**70**	**70**

TABLE 1.2 A1
Hourly Train Operation Plan
APMC to Shreyash and Koteshwar Road to Mahatma Mandir

Year- 2031

8 -min Headway

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	32	2	2
6 to 7	24	3	3
7 to 8	12	5	5
8 to 9	**8.00**	**8**	**7**
9 to 10	**8.00**	**8**	**7**
10 to 11	**8.00**	**8**	**7**
11 to12	12	5	5
12 to 13	24	3	3
13 to 14	32	2	2
14 to 15	32	2	2
15 to 16	24	3	3
16 to 17	12	5	5
17 to 18	**8.00**	**7**	**8**
18 to 19	**8.00**	**7**	**8**
19 to 20	**8.00**	**7**	**8**
20 to 21	12	5	5
21 to 22	24	3	3
22 to 23	32	2	2
23 to 24	40	2	2
Total No. of train trips per direction per day		**87**	**87**

TABLE 1.3 A1
Hourly Train Operation Plan
APMC to Shreyash and Koteshwar Road to Mahatma Mandir

Year- 2041

6 -min Headway

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	24	3	3
6 to 7	20	3	3
7 to 8	10	6	6
8 to 9	**6.00**	**10**	**10**
9 to 10	**6.00**	**10**	**10**
10 to 11	**6.00**	**10**	**10**
11 to12	10	6	6
12 to 13	20	3	3
13 to 14	24	3	3
14 to 15	24	3	3
15 to 16	20	3	3
16 to 17	10	6	6
17 to 18	**6.00**	**10**	**10**
18 to 19	**6.00**	**10**	**10**
19 to 20	**6.00**	**10**	**10**
20 to 21	10	6	6
21 to 22	20	3	3
22 to 23	24	3	3
23 to 24	30	2	2
Total No. of train trips per direction per day		**110**	**110**

TABLE 1.4 A1 Hourly Train Operation Plan APMC to Shreyash and Koteshwar Road to Mahatma Mandir Year- 2051 5 -min Headway			
Time of Day	**Headway in Minutes**	**No. of Trains per day**	
		UP	**DN**
5 to 6	16	4	4
6 to 7	12	5	5
7 to 8	8	8	8
8 to 9	**5.00**	**12**	**12**
9 to 10	**5.00**	**12**	**12**
10 to 11	**5.00**	**12**	**12**
11 to12	8	8	8
12 to 13	12	5	5
13 to 14	16	4	4
14 to 15	16	4	4
15 to 16	12	5	5
16 to 17	8	8	8
17 to 18	**5.00**	**12**	**12**
18 to 19	**5.00**	**12**	**12**
19 to 20	**5.00**	**12**	**12**
20 to 21	8	8	8
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		**143**	**143**

Attachment- II

TABLE 1.1 A2

Hourly Train Operation Plan
Shreyash to Koteshwar Road

Year- 2021

5 -min Headway

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	16	4	4
6 to 7	12	5	5
7 to 8	8	8	7
8 to 9	**5.00**	**12**	**12**
9 to 10	**5.00**	**12**	**12**
10 to 11	**5.00**	**12**	**12**
11 to12	8	8	8
12 to 13	12	5	5
13 to 14	16	4	4
14 to 15	16	4	4
15 to 16	12	5	5
16 to 17	8	8	8
17 to 18	**5.00**	**12**	**12**
18 to 19	**5.00**	**12**	**12**
19 to 20	**5.00**	**12**	**12**
20 to 21	8	7	8
21 to 22	12	5	5
22 to 23	16	3	3
23 to 24	20	3	3
Total No. of train trips per direction per day		**141**	**141**

TABLE 1.2 A2 Hourly Train Operation Plan Shreyash to Koteshwar Road			
		Year- 2031	
4 -min Headway			
Time of Day	**Headway in Minutes**	**No. of Trains per day**	
		UP	**DN**
5 to 6	16	4	4
6 to 7	12	5	5
7 to 8	6	10	10
8 to 9	**4.00**	**15**	**15**
9 to 10	**4.00**	**15**	**15**
10 to 11	**4.00**	**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	**4.00**	**15**	**15**
18 to 19	**4.00**	**15**	**15**
19 to 20	**4.00**	**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		**169**	**169**

TABLE 1.3 A2 Hourly Train Operation Plan Shreyash to Koteshwar Road			
		Year- 2041	
3 -min Headway			
Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	12	5	5
6 to 7	10	6	6
7 to 8	5	12	12
8 to 9	**3.00**	**20**	**20**
9 to 10	**3.00**	**20**	**20**
10 to 11	**3.00**	**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	**3.00**	**20**	**20**
18 to 19	**3.00**	**20**	**20**
19 to 20	**3.00**	**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**

TABLE 1.4 A2 Hourly Train Operation Plan Shreyash to Koteshwar Road Year- 2051 2.5 -min Headway			
Time of Day	**Headway in Minutes**	**No. of Trains per day**	
		UP	**DN**
5 to 6	8	8	8
6 to 7	6	10	10
7 to 8	4	15	15
8 to 9	**2.50**	**24**	**24**
9 to 10	**2.50**	**24**	**24**
10 to 11	**2.50**	**24**	**24**
11 to12	4	15	15
12 to 13	6	10	10
13 to 14	8	8	8
14 to 15	8	8	8
15 to 16	6	10	10
16 to 17	4	15	15
17 to 18	**2.50**	**24**	**24**
18 to 19	**2.50**	**24**	**24**
19 to 20	**2.50**	**24**	**24**
20 to 21	4	15	15
21 to 22	6	10	10
22 to 23	8	8	8
23 to 24	10	6	6
Total No. of train trips per direction per day		**282**	**282**

Attachment- II

TABLE 1.1 B

Hourly Train Operation Plan
Koteshwar Road to Airport

Year- 2021

10 -min Headway

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	32	2	2
6 to 7	24	3	3
7 to 8	16	4	3
8 to 9	**10.00**	**6**	**6**
9 to 10	**10.00**	**6**	**6**
10 to 11	**10.00**	**6**	**6**
11 to12	16	4	4
12 to 13	24	3	3
13 to 14	32	2	2
14 to 15	32	2	2
15 to 16	24	2	2
16 to 17	16	4	4
17 to 18	**10.00**	**6**	**6**
18 to 19	**10.00**	**6**	**6**
19 to 20	**10.00**	**6**	**6**
20 to 21	16	3	4
21 to 22	24	2	2
22 to 23	32	1	1
23 to 24	40	1	1
Total No. of train trips per direction per day		**69**	**69**

TABLE 1.2 B Hourly Train Operation Plan Koteshwar Road to Airport			
		Year- 2031	
10 -min Headway			
Time of Day	**Headway in Minutes**	**No. of Trains per day**	
		UP	**DN**
5 to 6	32	2	2
6 to 7	24	3	3
7 to 8	12	5	5
8 to 9	**10.00**	**6**	**6**
9 to 10	**10.00**	**6**	**6**
10 to 11	**10.00**	**6**	**6**
11 to12	12	5	5
12 to 13	24	3	3
13 to 14	32	2	2
14 to 15	32	2	2
15 to 16	24	3	3
16 to 17	12	5	5
17 to 18	**10.00**	**6**	**6**
18 to 19	**10.00**	**6**	**6**
19 to 20	**10.00**	**6**	**6**
20 to 21	12	5	5
21 to 22	24	3	3
22 to 23	32	2	2
23 to 24	40	1	1
Total No. of train trips per direction per day		**77**	**77**

TABLE 1.3 B
Hourly Train Operation Plan
Koteshwar Road to Airport

		Year- 2041	
10 -min Headway			
Time of Day	**Headway in Minutes**	**No. of Trains per day**	
		UP	**DN**
5 to 6	24	3	3
6 to 7	20	3	3
7 to 8	12	5	5
8 to 9	**10.00**	**6**	**6**
9 to 10	**10.00**	**6**	**6**
10 to 11	**10.00**	**6**	**6**
11 to12	12	5	5
12 to 13	20	3	3
13 to 14	24	3	3
14 to 15	24	3	3
15 to 16	20	3	3
16 to 17	12	5	5
17 to 18	**10.00**	**6**	**6**
18 to 19	**10.00**	**6**	**6**
19 to 20	**10.00**	**6**	**6**
20 to 21	12	5	5
21 to 22	20	3	3
22 to 23	24	3	3
23 to 24	30	2	2
Total No. of train trips per direction per day		**82**	**82**

TABLE 1.4 B

Hourly Train Operation Plan

Koteshwar Road to Airport

Year- 2051

10 -min Headway

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	24	3	3
6 to 7	20	3	3
7 to 8	12	5	5
8 to 9	**10.00**	**6**	**6**
9 to 10	**10.00**	**6**	**6**
10 to 11	**10.00**	**6**	**6**
11 to12	12	5	5
12 to 13	20	3	3
13 to 14	24	3	3
14 to 15	24	3	3
15 to 16	20	3	3
16 to 17	12	5	5
17 to 18	**10.00**	**6**	**6**
18 to 19	**10.00**	**6**	**6**
19 to 20	**10.00**	**6**	**6**
20 to 21	12	5	5
21 to 22	20	3	3
22 to 23	24	3	3
23 to 24	30	2	2
Total No. of train trips per direction per day		**82**	**82**

Attachment- II

TABLE 1.1 C

Hourly Train Operation Plan
GNLU to Gift City

Year- 2021

10 -min Headway

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	32	2	2
6 to 7	24	3	3
7 to 8	16	4	3
8 to 9	**10.00**	**6**	**6**
9 to 10	**10.00**	**6**	**6**
10 to 11	**10.00**	**6**	**6**
11 to12	16	4	4
12 to 13	24	3	3
13 to 14	32	2	2
14 to 15	32	2	2
15 to 16	24	2	2
16 to 17	16	4	4
17 to 18	**10.00**	**6**	**6**
18 to 19	**10.00**	**6**	**6**
19 to 20	**10.00**	**6**	**6**
20 to 21	16	3	4
21 to 22	24	2	2
22 to 23	32	1	1
23 to 24	40	1	1
Total No. of train trips per direction per day		**69**	**69**

TABLE 1.2 C			
Hourly Train Operation Plan GNLU to Gift City			
		Year- 2031	
10 -min Headway			
Time of Day	**Headway in Minutes**	**No. of Trains per day**	
		UP	**DN**
5 to 6	32	2	2
6 to 7	24	3	3
7 to 8	12	5	5
8 to 9	**10.00**	**6**	**6**
9 to 10	**10.00**	**6**	**6**
10 to 11	**10.00**	**6**	**6**
11 to12	12	5	5
12 to 13	24	3	3
13 to 14	32	2	2
14 to 15	32	2	2
15 to 16	24	3	3
16 to 17	12	5	5
17 to 18	**10.00**	**6**	**6**
18 to 19	**10.00**	**6**	**6**
19 to 20	**10.00**	**6**	**6**
20 to 21	12	5	5
21 to 22	24	3	3
22 to 23	32	2	2
23 to 24	40	1	1
Total No. of train trips per direction per day		**77**	**77**

TABLE 1.3 C
Hourly Train Operation Plan
GNLU to Gift City

Year- 2041

10 -min Headway

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	24	3	3
6 to 7	20	3	3
7 to 8	12	5	5
8 to 9	**10.00**	**6**	**6**
9 to 10	**10.00**	**6**	**6**
10 to 11	**10.00**	**6**	**6**
11 to12	12	5	5
12 to 13	20	3	3
13 to 14	24	3	3
14 to 15	24	3	3
15 to 16	20	3	3
16 to 17	12	5	5
17 to 18	**10.00**	**6**	**6**
18 to 19	**10.00**	**6**	**6**
19 to 20	**10.00**	**6**	**6**
20 to 21	12	5	5
21 to 22	20	3	3
22 to 23	24	3	3
23 to 24	30	2	2
Total No. of train trips per direction per day		**82**	**82**

TABLE 1.4 C Hourly Train Operation Plan GNLU to Gift City			
Year- 2051			
10 -min Headway			
Time of Day	**Headway in Minutes**	**No. of Trains per day**	
		UP	**DN**
5 to 6	24	3	3
6 to 7	20	3	3
7 to 8	12	5	5
8 to 9	**10.00**	**6**	**6**
9 to 10	**10.00**	**6**	**6**
10 to 11	**10.00**	**6**	**6**
11 to12	12	5	5
12 to 13	20	3	3
13 to 14	24	3	3
14 to 15	24	3	3
15 to 16	20	3	3
16 to 17	12	5	5
17 to 18	**10.00**	**6**	**6**
18 to 19	**10.00**	**6**	**6**
19 to 20	**10.00**	**6**	**6**
20 to 21	12	5	5
21 to 22	20	3	3
22 to 23	24	3	3
23 to 24	30	2	2
Total No. of train trips per direction per day		**82**	**82**

Attachment III

TABLE 2.1

APMC to Mahatma Mandir

PHPDT for the year 2021

S.No	From Station	To Station	Peak hour Load	Directional Split to APMC	Directional Split to Mahatma Mandir
1	APMC	Jivraj	1,942	50%	50%
2	Jivraj	Rajiv nagar	3,822	50%	50%
3	Rajiv nagar	Shreyash	4,052	50%	50%
4	Shreyash	Paldi	4,380	50%	50%
5	Paldi	Gandhigram rly stn	5,631	50%	50%
6	Gandhigram rly stn	Old high court	6,583	50%	50%
7	Old high court	Ushmanpura	8,691	50%	50%
8	Ushmanpura	Vijay nagar	8,747	50%	50%
9	Vijay nagar	New vadaj	8,090	50%	50%
10	New vadaj	Ranip	6,737	50%	50%
11	Ranip	Sabarmati Rly stn	6,351	50%	50%
12	Sabarmati Rly stn	AEC	5,617	50%	50%
13	AEC	Sabarmati	5,495	50%	50%
14	Sabarmati	Motera Stadium	5,085	50%	50%
15	Motera Stadium	Koteshwar Road	4,753	50%	50%
16	Koteshwar Road	Vishwakarma College	3,627	50%	50%
17	Vishwakarma College	Tapovan Circle	3,551	50%	50%
18	Tapovan Circle	Narmada Canal	3,290	50%	50%
19	Narmada Canal	Koba Circle	3,264	50%	50%
20	Koba Circle	Juna Koba	3,203	50%	50%
21	Juna Koba	Koba Gaam	3,189	50%	50%
22	Koba Gaam	GNLU	3,170	50%	50%
23	GNLU	Raysan	2,624	50%	50%
24	Raysan	Randesan	2,594	50%	50%
25	Randesan	Dholakuva Circle	2,556	50%	50%
26	Dholakuva Circle	Infocity	2,420	50%	50%
27	Infocity	Sector - 1	2,358	50%	50%
28	Sector - 1	Sector 10A	2,334	50%	50%
29	Sector 10A	Sachivalaya	2,102	50%	50%
30	Sachivalaya	Akshardham	1,704	50%	50%
31	Akshardham	Juna Sachivalaya	1,475	50%	50%
32	Juna Sachivalaya	Sector - 16	1,257	50%	50%
33	Sector - 16	Sector - 24	1,065	50%	50%
34	Sector - 24	Mahatma Mandir	620	50%	50%

TABLE 2.2					
Koteshwar Road to Airport (Phase-IIA)					
PHPDT for the year 2021					
S. No.	From Station	To Station	Peak Hour Load	Directional Split to Koteshwar Road	Directional Split to Airport
1	Koteshwar Road	Sardarnagar	801	50%	50%
2	Sardarnagar	Airport	62	50%	50%

TABLE 2.3					
GNLU to GIFT City					
PHPDT for the year 2021					
S. No.	From Station	To Station	Peak Hour Load	Directional Split to GNLU	Directional Split to GIFT City
1	GNLU	PDPU	638	50%	50%
2	PDPU	GIFT City	579	50%	50%

Attachment IV

TABLE 3

Extension of North- South Corridor (APMC to Mahatma Mandir)

Vehicle Kilometer

Year	2021					2031					2041					2051				
	APMC to Shreyash	Shreyash to Koteshwar Road	Koteshwar Road to Mahtma Mandir	Koteshwar Road to Airport	GNLU to Gift City	APMC to Shreyash	Shreyash to Koteshwar Road	Koteshwar Road to Mahtma Mandir	Koteshwar Road to Airport	GNLU to Gift City	APMC to Shreyash	Shreyash to Koteshwar Road	Koteshwar Road to Mahtma Mandir	Koteshwar Road to Airport	GNLU to Gift City	APMC to Shreyash	Shreyash to Koteshwar Road	Koteshwar Road to Mahtma Mandir	Koteshwar Road to Airport	GNLU to Gift City
Section Length	3.17	14.43	21.80	5.83	4.60	3.17	14.43	21.80	5.83	4.60	3.17	14.43	21.80	5.83	4.60	3.17	14.43	21.80	5.83	4.60
No of cars per train	3	3	3	3	3	3	3	3	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	340	340	340	340	340	340	340	340
Number of Trains per day each Way	70	141	70	69	69	87	169	87	77	77	110	216	110	82	82	143	282	143	82	82
Daily Train -KM	444	4070	3052	805	635	552	4878	3794	898	709	698	6234	4796	957	755	907	8139	6235	957	755
Annual Train - KM (10^5)	1.51	13.84	10.38	2.74	2.16	1.88	16.59	12.90	3.05	2.41	2.37	21.20	16.31	3.25	2.57	3.08	27.67	21.20	3.25	2.57
Annual Vehicle - KM (10^5)	4.53	41.51	31.13	8.21	6.48	5.63	49.76	38.70	9.16	7.23	7.12	63.59	48.92	9.76	7.70	9.25	83.02	63.60	9.76	7.70

Attachment V

RAKE REQUIREMENT

Ahmedabad Metro: Extension of North South Corridor (APMC-Motera Stadium) to Mahatma Mandir

Year 2021

S. No.	Section		Length (km)	Gauge	Schedule speed (kmph)	Year	Headway (min)	Run time (min)	Turn round time (min)	Any other time to be considered* (min)	Total round time+any other time	Total round trip time (min)	Bare	Rake Requirement				Total cars (3-car option)
	From	To												Bare	Traffic Reserve	R&M*#	Total	
1	APMC	Mahatma Mandir	39.40	SG	33	2021	10.00	71.64	3	0	6	149.28	14.93	15	1	3	**19**	**57**
2	Shreyash	Koteshwar Road	14.43	SG	33	2021	10.00	26.24	3	0	6	58.48	5.85	6	0	-	**6**	**18**
	Effective Headway of 5 minutes between Shreyas to Koteshwar Road													Total Requirement (Ph-I & Ph-II)			**25**	**75**
														Provision in Phase-I			**18**	**54**
														Additional rakes required for Ph-II			**7**	**21**
3	Koteshwar Road	Airport	5.83	SG	33	2021	10.00	10.60	3	0	6	27.20	2.72	3	0	-	**3**	**9**
4	GNLU	Gift City	4.60	SG	33	2021	10.00	8.36	3	0	6	22.72	2.27	3	0	-	**3**	**9**
														Total Requirement (Ph-I & Ph-II)			**6**	**18**
														Provision in Phase-I			**0**	**0**
														Additional rakes required for Ph-II			**6**	**18**
														Net Total requirements for Phase-II			**13**	**52**

Year 2031

S. No.	Section		Length (km)	Gauge	Schedule speed (kmph)	Year	Headway (min)	Run time (min)	Turn round time (min)	Any other time to be considered* (min)	Total round time+any other time	Total round trip time (min)	Bare	Rake Requirement				Total cars (3-car option)
	From	To												Bare	Traffic Reserve	R&M*#	Total	
1	APMC	Mahatma Mandir	39.40	SG	33	2021	8.00	71.64	3	0	6	149.28	18.66	19	1	3	**23**	**69**
2	Shreyash	Koteshwar Road	14.43	SG	33	2021	8.00	26.24	3	0	6	58.48	7.31	8	0	-	**8**	**24**
	Effective Headway of 4 minutes between Shreyas to Koteshwar Road													**Total Requirement (Ph-I & Ph-II)**			**31**	**93**
														Provision in Phase-I			**27**	**81**
														Additional rakes required for Ph-II			**4**	**12**
3	Koteshwar Road	Airport	5.83	SG	33	2021	10.00	10.60	3	0	6	27.20	2.72	3	0	-	**3**	**9**
4	GNLU	Gift City	4.60	SG	33	2021	10.00	8.36	3	0	6	22.72	2.27	3	0	-	**3**	**9**
														Total Requirement (Ph-I & Ph-II)			**6**	**18**
														Provision in Phase-I			**0**	**0**
														Additional rakes required for Ph-II			**6**	**18**
														Net Total requirements for Phase-II			**10**	**52**

Year 2041

S. No.	Section		Length (km)	Gauge	Schedule speed (kmph)	Year	Headway (min)	Run time (min)	Turn round time (min)	Any other time to be considered* (min)	Total round time+any other time	Total round trip time (min)	Bare	Rake Requirement				Total cars (3-car option)
	From	To												Bare	Traffic Reserve	R&M*#	Total	
1	APMC	Mahatma Mandir	39.40	SG	33	2021	6.00	71.64	3	0	6	149.28	24.88	25	1	4	**30**	**90**
2	Shreyash	Koteshwar Road	14.43	SG	33	2021	6.00	26.24	3	0	6	58.48	9.75	10	0	-	**10**	**30**
	Effective Headway of 3 minutes between Shreyas to Koteshwar Road													**Total Requirement (Ph-I & Ph-II)**			**40**	**120**
														Provision in Phase-I			**43**	**129**
														Additional rakes required for Ph-II#			**0**	**0**
3	Koteshwar Road	Airport	5.83	SG	33	2021	10.00	10.60	3	0	6	27.20	2.72	3	0	-	**3**	**9**
4	GNLU	Gift City	4.60	SG	33	2021	10.00	8.36	3	0	6	22.72	2.27	3	0	-	**3**	**9**
														Total Requirement (Ph-I & Ph-II)			**6**	**18**
														Provision in Phase-I			**0**	**0**
	# Additional provision of 3 rakes in Phase-I has been utilised in Phase-II for shuttle operation in Phase-II													**Additional rakes required for Ph-II#**			**3**	**9**
														Net Total requirements for Phase-II			**3**	**9**

Year 2051

S. No.	Section From	Section To	Length (km)	Gauge	Schedule speed (kmph)	Year	Headway (min)	Run time (min)	Turn round time (min)	Any other time to be considered*	Total round time+any other time	Total round trip time (min)	Bare	Rake Requirement: Bare	Rake Requirement: Traffic Reserve	Rake Requirement: R&M*#	Rake Requirement: Total	Total cars (3-car option)
1	APMC	Mahatma Mandir	39.40	SG	33	2021	5.00	71.64	3	0	6	149.28	29.86	30	1	5	**36**	**108**
2	Shreyash	Koteshwar Road	14.43	SG	33	2021	5.00	26.24	3	0	6	58.48	11.70	12	0	-	**12**	**36**
	Effective Headway of 2.5 minutes between Shreyas to Koteshwar Road													**Total Requirement (Ph-I & Ph-II)**			**48**	**144**
														Provision in Phase-I			**0**	**0**
														Additional rakes required for Ph-II			**48**	**144**
3	Koteshwar Road	Airport	5.83	SG	33	2021	10.00	10.60	3	0	6	27.20	2.72	3	0	-	**3**	**9**
4	GNLU	Gift City	4.60	SG	33	2021	10.00	8.36	3	0	6	22.72	2.27	3	0	-	**3**	**9**
														Total Requirement (Ph-I & Ph-II)			**6**	**18**
														Provision in Phase-I			**0**	**0**
	## All the requirements of Year 2051 has ben considered against Phase-II as there is no provision of rakes for Year 2051 in Phase-I DPR													**Additional rakes required for Ph-II**			**6**	**18**
														Net Total requirements for Phase-II ##			**54**	**162**
														Available rakes upto Year 2041			**46**	**138**
														Net Total requirements for Phase-II in Year 2051			**8**	**24**

* **Passenger capacity @ 6p/sqm for a train of 3 car configuration** 764.00

*# R&M has been considered as 10% of (total Bare+ Traffic reserve combined for all lines)

Attachment-VI

SALIENT FEATURES OF STANDARD GAUGE ROLLING STOCK

S. No.	Parameter	Standard Gauge 2.9m wide stock
1	**Gauge (Nominal)**	1435mm Standard Gauge
2	**Traction system**	
2.1	Voltage	750 V DC
2.2	Method of current collection	Third Rail Bottom Current Collection System
3	**Train composition**	
3.2	For 3 car train	DMC+TC+DMC
4	**Coach Body**	Stainless Steel/Aluminum
5	**Coach Dimensions**	
5.1	Height	3.9m
5.2	Width	2.9m
5.3	Length over body (approx.)	
	- Driving Motor Car (DMC)	21.64m
	- Trailer Car (TC)	21.34m
	Maximum length of coach over couplers/buffers:	*22 to 22.6 m (depending upon Kinematic Envelop and SOD)*
5.4	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)	* The maximum tare weight for 3-car unit shall be 120 T
	DMC	40

S. No.	Parameter	Standard Gauge 2.9m wide stock
	TC	40
8.2	Passenger Weight in tons	@ 0.065 T per passenger
	DMC	16.055 (@ 6 persons per sqm of standee area)
	TC	17.55 (@ 6 persons per sqm of standee area)
8.3	Gross weight in tons (@6 standees per sq.m.)	
	DMC	56.055
	TC	57.55
9	**Axle load(T)(@ 8 persons per sqm of standee area)**	**16**
		System should be designed for 16T axle load
10	**Maximum Train Length (approx.) (3 car configuration)**	67.8m
11	**Speed**	
10.1	Maximum Design Speed	90 Kmph
10.2	Maximum Operating Speed	80 Kmph
12	**Wheel Profile**	UIC 510-2/RDSO Profile
13	**Traction Motors Ventilation**	Self
14	**Acceleration on level tangent track**	1.0 m/sec^2 @ AW3 1.2 m/sec^2 @ AW2
15	**Deacceleration on level tangent track**	1.1 m/sec^2 @ AW3 1.1 m/sec^2 @ AW2 (>1.3 m/sec^2 during emergency)
16	**Type of Bogie**	Fabricated
17	**Secondary Suspension springs**	Air
18	**Brakes**	- An electro-pneumatic (EP) service friction brake - An electric regenerative service brake - Provision of smooth and continuous blending of EP and regenerative braking - A fail safe, pneumatic friction emergency brake - A spring applied air-release parking brake - Tread brakes
19	**Coupler**	
	Driving Cab end of cars (DMC)	Automatic coupler with mechanical & pneumatic coupling but without electrical coupling head

S. No.	Parameter	Standard Gauge 2.9m wide stock
	Between cars of same Unit	Semi-permanent couplers
	Between two units of a train	Automatic coupler with mechanical, pneumatic and electrical coupling head
20	**Detrainment Door**	Front
21	**Type of Doors**	Sliding
22	**Lighting**	LED based with dimmer control
23	**Cooling**	
23.1	Transformer	Forced
23.2	CI & SIV	Self/Forced
23.3	TM	Self-ventilated
24	**Control System**	Train based Monitor & Control System (TCMS)
25	**Traction Motors**	3 phase VVVF controlled
26	**Temperature Rise Limits**	
26.1	Traction Motor	Temperature Index **minus** 70° C
26.2	CI & SIV	10°C temperature margin for Junction temperature
26.3	Transformer	IEC specified limit **minus** 20°C
27	**HVAC**	- Cooling, Heating & Humidifier (As required) - Automatic controlling of interior temperature throughout the passenger area at 25°C with 60% RH all the times under varying ambient conditions up to full load.
28	**PA/PIS**	Required
29	**Passenger Surveillance (CCTV)**	Required
30	**Battery**	Ni-Cd
31	**Headlight type**	LED
32	**Train Operation**	DTO (GoA3)

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 Mass Rapid 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 to 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 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 and trailer 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)

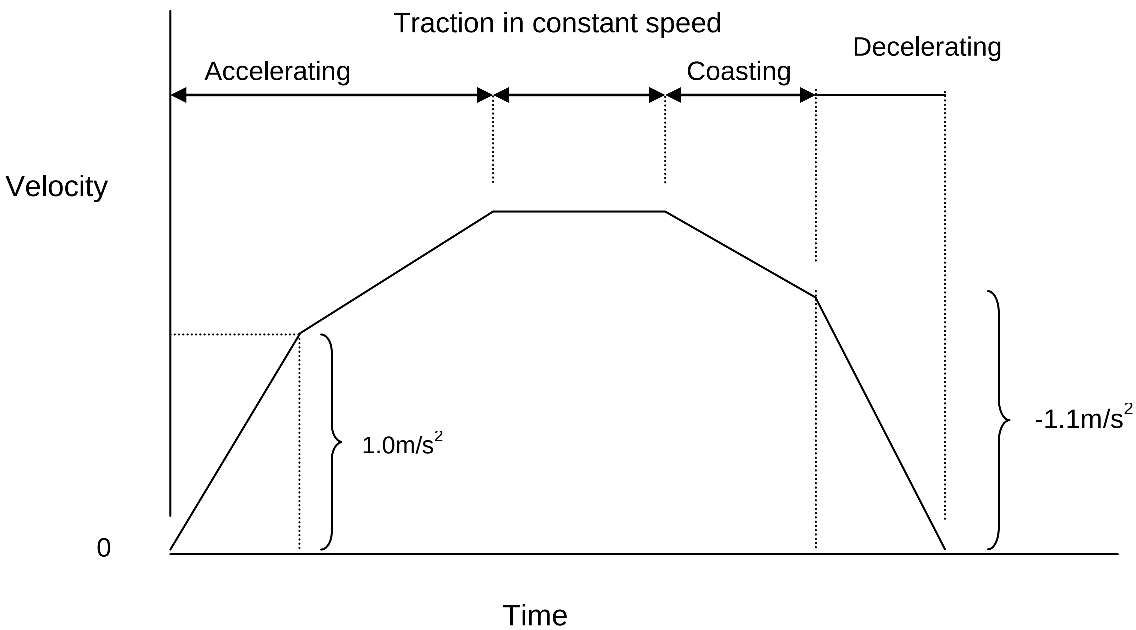
	DMC	TC	3 Car Train
TARE (maximum)	40	40	120
Passenger			
(Normal)	9.425	10.4	29.25
(Crush @6p/sqm)	16.055	17.55	49.66
(Crush @8p/sqm)	20.475	22.295	63.245
Gross			
(Normal)	49.425	50.4	149.25
(Crush @6p/sqm)	56.055	57.55	169.66
(Crush @8p/sqm)	60.475	62.295	183.23
Axle Load @6 person/sqm	14.014	14.388	
Axle Load @8 person/sqm	15.119	15.574	

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)
1.2 m/s^2 (with AW2 load)
Max. Deceleration: 1.1 m/s^2 (with AW3 load)
1.1 m/s^2 (with AW2 load)
>1.3 m/s^2 (Emergency brake)



AW3 Load: 8 Passengers/sqm of the standee area
AW2 Load: 6 Passengers/sqm of the standee area

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

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 tread 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 contains an Insulated Gate Bipolar Transistor (IGBT) and gate drive circuit and protection. The advanced IGBT incorporates its own over current protection, short circuit protection, over temperature protection and low power supply detection. The IGBT has internal protection from over current, short circuit, over temperature and low control voltage. The inverter unit uses optical fiber cable to connect the control unit to the gate interface. This optical fiber cable transmits the gate signals to drive the advanced IGBT via the gate interface. This optical fiber cable provides electrical isolation between the advanced IGBT and the control unit and is impervious to electrical interference. These are recommended for adoption in Trains of MRTS.

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/external sliding type in line with existing proposed design of phase-I rolling stock. Side evacuation through saloon doors may also be considered if the similar design has been proposed in Phase-I rolling stock tender.

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 60% RH all the times under varying ambient conditions up to full load. For emergency situations such as power failure or both AC failures etc, ventilation provision supplied from battery will be made. Provision shall be made to shut off the fresh air intake and re-circulate the internal air of the coach, during an emergency condition, such as fire outside the train causing excessive heat and smoke to be drawn in to the coach.

8.7.8 Cab Layout

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. Cab layout and facilities shall be designed for GoA-3 to meet all possible modes of operation including DTO/non DTO(GoA-2), manual driving in line/depots/stabling yards etc.

Driving cab

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 criterion from public acceptance view point. The sources of noise are (i) rail-wheel interaction (ii) noise generated from equipment like Blower, Compressor, air conditioner, door, Inverter etc. (iii) traction motor in running train. For elimination and reduction of noise following feature are incorporated: -

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

Provision of noise attenuators (Hypno dampers) on wheels to reduce noise due to rail wheel interaction

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

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) 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.

(iv) 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 3.2m wide SG 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	8 car trainset	DMC+TC+DMC
4	**Coach Body**	Stainless Steel/Aluminium
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 22.6m (depending upon Kinematic Envelop and SOD)*
5.4	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	@ 0.065 T per passenger
	DMC	16.055 (@ 6 persons per sqm of standee area)
	TC	17.55 (@ 6 persons per sqm of standee area)
8.3	Gross weight in tons (@ 6 persons per sqm of standee area)	
	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	67.8m
11	**Speed**	
10.1	Maximum Design Speed	90 Kmph
10.2	Maximum Operating Speed	80 Kmph
12	**Wheel Profile**	UIC 510-2/RDSO Profile
13	**Noise Limits (ISO 3381 and 3095 - 2005)**	
13.1	Stationary (Elevated and at grade)	
13.1.1	(a) All cars except in driving console	$L_{pAEq\ 20sec}$ 68 dB(A)
	(b) Driving console	$L_{pAEq\ 20sec}$ 68 dB(A)
13.1.2	External (at 7.5 mtr from centre line of track)	$L_{pAEq\ 20sec}$ 67 dB(A)
13.2	Running at 75 kmph (Elevated and at grade)	
13.2.1	(a) All cars except in driving console	$L_{pAEq\ 20sec}$75 dB(A)
	(b) Driving console	$L_{pAEq\ 20sec}$70 dB(A)
13.2.2	External (at 7.5 mtr from centre line of track)	$L_{pAEq\ 20sec}$ 82 dB(A)
14	**Traction Motors Ventilation**	Self
15	**Acceleration on level tangent track**	1.0 m/sec^2 @ AW3 1.2 m/sec^2 @ AW2
16	**Deacceleration on level tangent track**	1.1 m/sec^2 @ AW3 1.1 m/sec^2 @ AW2 (>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 - Tread Brakes - Brake Electronic Control Unit (BECU) - Independent for each bogie

S. No.	Parameter	Details
20	**Coupler**	Auto
	Driving Cab end of cars (DMC)	Automatic coupler with mechanical & pneumatic coupling but without electrical coupling head
	Between cars of same Unit	Semi-permanent couplers
	Between two units of a train	Automatic coupler with mechanical, pneumatic and electrical coupling head
21	**Detrainment Door**	Saloon doors to be used for passenger evacuation
22	**Type of Doors**	Sliding
23	**Lighting**	LED based with dimmer control
24	**Passenger Seats**	Stainless Steel
25	**Cooling**	
25.1	CI & SIV	Self/Forced
25.2	TM	Self-ventilated
26	**Control System**	Train based Monitor & Control System (TCMS)
27	**Traction Motors**	3 phase VVVF controlled
28	**Temperature Rise Limits**	
28.1	Traction Motor	Temperature Index **minus** 70°C
28.2	CI & SIV	10°C temperature margin for Junction temperature
28.3	Transformer	IEC specified limit **minus** 20° C
29	**HVAC**	- Cooling, Heating & Humidifier (As required) - Automatic controlling of interior temperature throughout the passenger area at 25°C with 60% RH all the times under varying ambient conditions up to full load.
30	**PA/PIS including PSSS (CCTV)**	Required
31	**Passenger Surveillance**	Required
32	**Battery**	Ni-Cd
33	**Headlight type**	LED
34	**Coasting**	8% (Run time with 8% coasting shall be the 'Run Time in All out mode **plus** 8%')
35	**Gradient (max)**	4%
36	**Sharpest Radius**	120m
37	**Train Operation**	DTO (GoA3)

Chapter – 9

DEPOT

9.1 CORRIDOR: Ahmedabad Metro Rail Network Phase-II comprises of following corridors:

S. No.	Corridor	Route length(Km)
1	(APMC to Motera Stadium) to Mahatma Mandir	41.36
2	GNLU to Gift City	5.416
3	Koteshwar Road to Airport Metro (Phase-IIA)	6.339

9.2 DEPOT – CUM – WORKSHOP

9.2.1 It is proposed to use one depot- cum- workshop with following functions at Gyaspur Depot for Phase-II in addition to fulfilling the requirements for Phase-I:

(i) Major overhauls of all the trains.
(ii) All minor schedules and repairs.
(iii) Lifting for replacement of heavy equipment and testing thereafter.
(iv) Repair of heavy equipments.

Another depot at Indroda Circle is planned with only stabling facilities at present.

9.2.2 The Depot planning is based on following assumptions:

(i) Enough space should be available for establishment of a Depot- Cum- workshop for the additional trains required for Phase-II.
(ii) All inspection lines, workshop lines, stabling lines are designed to accommodate two train sets of 3- Car each and space earmarked for future provision.
(iii) All Stabling lines are designed to accommodate two trains of 3- Car each.
(iv) All stabling lines are planned in the proposed depot-cum-workshop assuming adequate space availability. In case of space constraints, if any, stabling facilities may need to be created at terminal stations or elsewhere (preferably as close to depot as possible) to cater to the required stabling facilities.
(v) In case of space constraint for depot two storeyed Stabling lines can also be planned.

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

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

9.3 MAINTENANCE PHILOSOPHY

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

9.4 ROLLING STOCK MAINTENANCE NEEDS

9.4.1 Maintenance Schedule

The following maintenance schedule has been envisaged for conceptual design of depots assuming approx. 336 kms running per train per day, taking in consideration the passenger load of 2021, 2031, 2041 & 2051 respectively.

TABLE - 9.1

Type of Schedule	Interval	Work Content	Locations
Daily	Daily	Check on the train condition and function at every daily service completion. Interval cleaning/mopping of floor and walls with vacuum cleaner.	Stabling Lines
"A" Service Check	5,000 Km (approx. 15 days)	Detailed inspection and testing of sub -systems, under frame, replacement/ topping up of oils & lubricants.	Inspection Bays
"B" Service Check	15,000 Km (approx. 45 days)	Detailed Inspection of „A" type tasks plus items at multiples of 15,000 Km („B" type tasks)	Inspection Bays
Intermediate Overhaul (IOH)	420,000 Km, (3 and half Years approx.)	Check and testing of all sub-assemblies (Electrical + Mechanical). Overhaul of pneumatic valves, Compressor. Condition based maintenance of sub-systems to bring them to original condition.	Workshop

Type of Schedule	Interval	Work Content	Locations
	whichever is earlier	Replacement of parts and rectification, trial run.	
Periodical Overhaul (POH)	840,000 Km, (7 Years approx.) whichever is earlier	Dismantling of all sub-assemblies, bogies suspension system, traction motor, gear, control equipment, air-conditioning units etc. Overhauling to bring them to original condition. Checking repair and replacement as necessary. Inspection and trial.	Workshop
Heavy Repairs	-	Changing of heavy item such as bogies, traction motor, wheelsets/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.

9.4.2 Washing Needs of Rolling Stock

Cleanliness of the trains is essential. Following schedules are recommended for Indian environment:

TABLE-9.2

S. No.	Kind Inspection	Maint. Cycle	Time	Maintenance Place
1.	Outside cleaning (wet washing on automatic washing plant)	3 Days	10 mins.	Single Pass through Automatic washing plant of Depot
2.	Outside heavy Cleaning (wet washing on automatic washing plant and Front Face, Vestibule/Buffer area. Floor, walls inside/outside of cars and roof. Manually)	30 days	2 – 3 hrs.	Automatic washing plant & intensive cleaning shed

9.5 Year-wise planning of maintenance facility setup at depot cum workshop based on planned Rolling Stock requirement in TOP is tabulated below:

Traffic data are available up to year 2051 only; hence space to be earmarked for future expansion beyond 2051 year for stabling, inspection and workshop line.

(i) Planned rakes as per TOP:

TABLE-9.3

Year	No. of rakes for Phase-I & Phase-II	Net no. of Rakes for Phase-II only	Net No. of coaches for Phase-II
2021	31	13	39
2031	37	10	30
2041*	46	3	9
2051**	54	54	162

(ii) Requirement of Stabling Lines (SBL), Inspection Lines (IBL) and Workshop Lines (WSL) in the Depot -cum -Workshop.

Stabling and Inspection lines

TABLE-9.4

Year	No. of Rakes including Phase-I	Total SBLs for Phase-I & Phase-II	Additional SBL required for Phase-II#	Total IBLs required for Phase-I and Phase-II	Additional IBL required for Phase-II
2021	31	14 lines x two train of 3-car	6 lines x two train of 3-car	One bay of 3 lines each with two trains of 3- cars.	Nil
2031	37	17 lines x two train of 3-car	4 line x two train of 3-car	No additional requirement. Available 1 bay of 3 lines with two trains of 3- cars shall also cater to requirements up to year 2031.	No additional requirement. Available 1 bay of 3 lines with two trains of 3- cars shall also cater to requirements up to year 2031.
2041*	46	21 lines x two train of 3-car	No additional requirement, as phase-I SBL lines (21 no.) for year 2043 are sufficient to cater requirements of both Phase-I & Phase-II.	No additional requirement. Available 1 bay of 3 lines with two trains of 3- cars shall also cater to requirements up to year 2041.	No additional requirement. Available 1 bay of 3 lines with two trains of 3- cars shall also cater to requirements up to year 2041.
2051**	54	24 lines x two train of 3-car	24 lines x two train of 3-car	Additional one bay of 2 lines with two trains of 3- cars is required for year 2051.	Additional one bay of 2 lines with two trains of 3- cars is required for year 2051.

6 additional SBLs for year 2021, 4 additional SBLs for year 2031 and 3 additional SBLs for year 2051 has been planned at Indroda Circle. The Inspection Bays(IBL) and Workshop Bays(WSL) at Gyaspur Depot will cater to the requirements of Preventive and Corrective maintenance like service checks, IOH,POH etc. However space shall also be earmarked for one Inspection bay of 2 line with two trains of 3-car at Indroda Circle Depot for future requirement.

Workshop lines

TABLE-9.5

Year	No. of Rakes for Phase-I & Phase-II	Additional no. of Rakes for Phase-II	WSLs required for Phase-I & Phase-II	Additional WSLs required for Phase-II
2021	31	13	Two bays of 2 lines each with two trains of 3- cars is to be required for the year 2021.	One bay of 2 lines each with two trains of 3- cars is to be required for the year 2021.
2031	37	10	Additional one bay of 2 lines each with two trains of 3- cars is to be kept for future provision from 2031 and up to 2051.	No additional requirement for Phase-II, as an additional bay of 2 lines each with two trains of 3- cars is planned in Phase-I DPR for year 2031.

Year	No. of Rakes for Phase-I & Phase-II	Additional no. of Rakes for Phase-II	WSLs required for Phase-I & Phase-II	Additional WSLs required for Phase-II
2041*	46	3	No additional bay is required. Total three bay of 2 line available for 2031 will cater to the requirements of 2041 and 2051	No additional bay is required for Phase-II. Total three bay of 2 line available for 2031 will cater to the requirements of 2041 and 2051
2051**	54	54		

***The provision for number of rakes, IBL, SBL and WSL requirement for the year 2043 considered in Phase-I DPR has been considered against year 2041 in Phase-II DPR for calculating the additional rakes, IBL, SBL and WSL requirement.**
***** The requirement of rakes, IBL, SBL and WSL for year 2051 was not available in phase-I DPR. Hence all the requirements have been considered for Phase-II only.*

9.6 REQUIREMENT OF MAINTENANCE/INSPECTION LINES(IBL) FOR DEPOT-CUM-WORKSHOP:

TABLE-9.6

Schedule	Maintenance Requirement (No. of Cars)	Lines required for rakes of Phase-I & Phase-II.	Additional Requirement for Phase-II only
i) Year 2021 - Maximum no. of rake holding is (31 TS x 3 = 93 Cars)			
„A" Checks (5000 km) approx. 15 days	(31X3) Cars = 93 Cars	1 Line x two train of 3-Cars (with Sunken Floor)	No additional requirement
„B" Checks (15000 km) approx. 45 days.	(31X3) Cars = 93 Cars	1 Line x two train of 3-Cars (with Sunken Floor)	No additional requirement
Unscheduled line & adjustment lines	For minor repairs, testing and after IOH/POH adjustments	1 Line x two train of 3-Cars (with Sunken Floor)	No additional requirement
Requirement		1 bay of 3 lines	No additional requirement for Year 2021 as one bay of three lines is already planned as per Phase-I DPR
ii) Year 2031 -Maximum no. of rake holding is (37 TS x 3 = 111 Cars)			
„A" Checks (5000 km) 15 days	(37 X 3) Cars = 111 Cars	No additional requirement	No additional requirement
„B" Checks (15000 km) 45 days	(37 X 3) Cars = 111 Cars		
Unscheduled line & adjustment lines	For minor repairs, testing and after IOH/POH adjustments		
Requirement		No additional requirement. Available 1 bay of 3 lines each with two train of 3-cars shall also cater to requirements up to year 2031.	No additional requirement. Available 1 bay of 3 lines each with two train of 3- cars shall also cater to requirements up to year 2031.

Schedule	Maintenance Requirement (No. of Cars)	Lines required for rakes of Phase-I & Phase-II.	Additional Requirement for Phase-II only
iii)	**Year 2041 -Maximum no. of rake holding is (46 TS x 3 = 138 Cars)**		
„A" Checks (5000 km) approx. 15 days	(46X3) Cars = 138 Cars	No additional requirement	No additional requirement
„B" Checks (15000 km) approx. 45 days.	(46X3) Cars = 138 Cars		
Unscheduled line & adjustment lines	For minor repairs, testing and after IOH/POH adjustments		
Requirement		No additional requirement. 1 bay of 3 lines each with two trains of 3- cars is sufficient for year 2041.	No additional requirement. 1 bay of 3 lines each with two trains of 3- cars is sufficient for year 2041.
iv)	**Year 2051 -Maximum no. of rake holding is (54 TS x 3 = 162 Cars)**		
„A" Checks (5000 km) approx. 15 days	(54X3) Cars = 162 Cars	2 Line x two train of 3-Cars (with Sunken Floor)	1 Line x two train of 3-Cars (with Sunken Floor)
„B" Checks (15000 km) approx. 45 days.	(54X3) Cars = 162 Cars	2 Line x two train of 3-Cars (with Sunken Floor)	1 Line x two train of 3-Cars (with Sunken Floor)
Unscheduled line & adjustment lines	For minor repairs, testing and after IOH/POH adjustments	1 Line x two train of 3-Cars (with Sunken Floor)	No additional requirement
Requirement		Additional 1 bay of 2 lines would be required for year 2051.	Additional 1 bay of 2 lines would be required for year 2051.

9.7 INSPECTION REQUIREMENTS AT DEPOT

Facilities for carrying out inspection activities shall be provided in the inspection bay for following Systems / Equipments of a train:

Electronics; PA/PIS
Mechanical components, couplers etc
Batteries
Air conditioner
Brake modules and other pneumatic systems.
Bogie
Traction Motor
Vehicle doors, windows and internal fittings
Power system including converter, circuit breaker etc.

These activities shall be grouped into "A" checks and "B" checks. The minor scheduled inspections ("A" checks) shall be carried out during the day off-peak and night. Since "B" checks take longer time, these cannot be completed in the off-peak times. Certain inspection lines will be nominated for “A” checks. For “B” checks, separate line will be nominated where the rakes may be kept for long time.

9.8 DESIGN OF DEPOT- CUM- WORKSHOP FACILITIES

9.8.1 Stabling lines at depot:

As per advised dimensions of the Rolling Stock, the length of 3- Car train would be Approx. 67.8 mts. For the design of the stabling lines in the depot and terminal stations or elsewhere (as may be required), following approximates dimentions have been taken in consideration, however final dimensions shall be decided based on actual site conditions/ area available at the time of design finalization of depot:

(i) Length of one 3- Car rake= 67.8 m
(ii) Gap between two trains 3-car rakes=10m
(iii) Free length at outer ends of two trains of 3- Car rakes (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, approx 166m.

Looking to the car width of 2900 mm on SG, 5m “Track Centre” is proposed for all the stabling lines. Thus, space between stabling shall be sufficient to include 1 m wide pathway to be constructed between tracks to provide access for internal train cleaning and undercarriage inspection with provision of following facilities:

a) Each Stabling line to have water connection facility so that local cleaning, if required, is facilitated.
b) Platforms at suitable points at each end of stabling lines to enable train operators to board or de- board conveniently.

9.8.2 Inspection Bay at depot-cum-workshop:

The length of Inspection shed is computed as below:

(i) Length of one 3- Car rake=67.8 m
(ii) Gap between two train of 3-cars= 10 m
(iii) Cross path at each end= 10 m
(iv) Total length of Inspection lines = (iii)+(i)+(ii)+(i)+(iiii)= 10+67.8+10+67.8+10= 165.6 m, approx 166 m.

The width of the Inspection bay in computed as below:

(i) Centre – to- centre spacing between the lines= 6.5 m
(ii) Centre line of outer lines to column of Shed= 4.5 m
(iii) Width of a 3 line Inspection Bay= (ii)+(i)+(i)+(ii)= 4.5+ 6.5+ 6.5+ 4.5= 22 m
(iv) Width of a 2 line Inspection Bay= (ii)+(i)+(i)+(ii)= 4.5+ 6.5+ 4.5= 16 m

a) There shall be one inspection bay of 166 m X 22 m size (one bay of 3 lines) and another inspection of bay of 166m x 16m size(one bay of 2 lines for future provision for the year 2051) each with provision of accommodating inspection lines each having sunken floor and overhead roof inspection platforms at each of the line. The floor will be sunken by 1100mm. The track spacing between the adjacent IBLs shall be 6.5 m.

b) Roof Inspection platforms of 1.2m width and walkways for roof inspection supported on the columns shall be provided. There would be lighting below the rail level to facilitate the under-frame inspection. Ramps of 1:10 slopes, 3 meter wide should be provided with sunken floor system for movement of material for the cars. Further, 10m cross pathways are left at each end for movement of material by fork lifter/Leister/Hand trolley. 415V 3 phase 50 Hz, 230V 1 phase 50 Hz AC supply and Pneumatic supply shall also be made available on each inspection shed columns. Air-circulators shall be provided on each column. 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 the arrangement close by for cleaning of HVAC filter under high pressure water jet.

9.8.3 Workshop Shed at Depot:

Requirement of workshop lines is planned as under:

TABLE-9.7

Year	IOH & POH	Major Overhauling	Unscheduled repairs /lifting	Total Requirements for Phase-I & Phase-II	Additional Requirements for Phase-II	Remarks
2021	1	2 line 3- Car train and free space of 3-car length for storage of other equipment.	1 line x 2 train of 3 Car train length.	Two bays of 2 lines each with two trains of 3- cars is to be required for the year 2021	Additional one bay of 2 lines with two trains of 3-car is required	The size of workshop shall be 166 X 21 m for one working bay comprising of two lines capable of accommodating one 3- Car rake with Bogie turn table facility, one line of 3-Car rake length with free space of 3- Car rake length for storage of wheel/ bogie/ equipment etc.
2031	1	3 line 3- Car train and free space of 3-car length for storage of other equipment.	2 line x 2 train of 3 Car train length.	Additional one bay of 2 lines each with two trains of 3- cars is required for year 2031	No additional requirement as an additional bay of 2 lines is already planned in Phase-I DPR for year 2031	
2041	1	3 line 3- Car train and free space of 3-car length for storage of other equipment.	2 line x 2 train of 3 Car train length.	No Additional requirement as 3 bay bay of 2 lines each with two trains of 3- cars available for year 2031 is catering to the requirement up to year 2051.	No additional requirement as total 3 bay of 2 lines available in year 2031 is catering to the requirements upto year 2051.	
2051	1	3 line 3- Car train and free space of 3-car length for storage of other equipment.	2 line x 2 train of 3 Car train length.			

(a) Each bay shall comprise of two lines (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. Space on one line shall be available for stocking of Bogies and wheels. These lines are to be provided with pits at regular intervals for inspection of undercarriage and lines are to be interconnected by turn tables. Each workshop bay shall be equipped with two 15T/2T and 5T overhead cranes, each spanning the entire length of the workshop bay.

(b) There shall be space provided for repairs of HVAC, Door, and Traction motor etc. repairs. Distinct spaces shall be earmarked for dismantling/repairs/ assembling and testing of each of these equipments. Related machinery for Overhauling / Repairs & testing activities of every equipment are also to be housed in the space earmarked.

(c) There shall be washing and cleaning equipments on the workshop floor. Bogie test stand shall be provided in the workshop. Other heavy machinery shall also be suitably installed on the workshop floor. Air-circulators, lights, Powers supply points and compressed air supply line shall be provided on each workshop column.

(d) Workshop lines shall be inter-linked through turn tables, each suitable for movement of a train in AW0 (unloaded) condition and shall also be capable to rotate with a fully loaded bogie on it. Repair of heavy equipments such as air conditioners shall be so located so that it does not affect the movement inside workshop.

(e) There shall be walkways on columns for roof inspections, along the workshop lines. These walkways shall not infringe with cars being lifted/ lowered by means of mobile jacks. Suitable space between the nearest exterior of a car and farthest edge of the walkway has to be ensured to avoid conflict in lifting and lowering of cars.

(f) The small component, bogie painting and battery maintenance cells will be located in the workshop with arrangement that fumes are extracted by suitable exhaust systems.

(g) Workshop will have service building with array of rooms along its length. Total size is proposed to be 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 opposite sides widthwise shall be open to facilitate natural air circulation and cross ventilation besides the egress & ingress for coaches. The sidewalls shall also have sufficient width of louvers for providing adequate ventilation.

(h) There shall be space for bogie/ axle repair shop with necessary infrastructure for disassembly, overhead, assembly and testing of mechanical components of bogies/ axle. The repair shop shall be easily approachable from with the workshop for transportation of components.

Following equipment repair/overhaul facilities are planned in the workshop and wheel repairs shop at the workshops:

1. Body furnishing
2. Bogie
3. Wheels
4. Traction Motors
5. Axle Box and Axle Bearing
6. Carbon Pad assembly.
7. 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)

9.9 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 50 m long. The unloading bay should be of 50 m X 30 m and the bearing capacity of the floor should be 15-20 MT/m^2. There should be enough space available for movement of heavy cranes for lifting of coaches. The unloading area should be easily accessible for heavy duty hydraulic trailers and minimum turning radius for the trailer movement should be 20-23 m. in case of space limitation a point lifting jack system can be installed.

9.10 OPERATIONAL FEATURES

The rake induction and withdrawal to main line will be primarily from the stabling shed. Further, provisions are there for direct rake induction and withdrawal to main line from Inspection Shed/workshop area. Movement from depot to the main line is so planned that the main line train operation is not affected. Simultaneous receipt and dispatch of trains from depot to main line is feasible in the present site scenario. Both of these activities will be done effectively without effecting the train operation on the main line. The stabling lines would be interlocked with the main line thereby induction of train from the stabling would be safe and without loss of time. The proposition for a transfer track on the incoming line as well as on the outgoing line to facilitate the movement of rake in the depot by Operation Control Centre (OCC) even though the further path inside the depot is not clear shall be explored in the detailed design stage depending on the actual availability of land.

An emergency line is also provided from which an emergency rescue vehicle may be dispatched to main line in the event of emergency if necessary.

9.11 INFRASTRUCTURE FACILITIES

I. Inspection and Workshop facilities:
As indicated in 9.8.2 & 9.8.3 above.

II. Stabling Lines in Depot:

a) The requirement of lines shall be in accordance with the details indicated in para 9.8.1 above. A part of the stabling siding in the depot shall be covered with a roof in order to facilitate testing of air conditioning of trains and their pre-cooling under controlled condition of temperature.

b) Separate toilets adjustment to stabling lines shall be provided with small room for keeping cleaning aids and for utilization by the working staff.

III. Automatic Coach Washing Plant (AWP)
Provision to be made for Rolling Stock exterior surfaces to be washed using a fully automated Train Washing System, with a throughput capacity of approximately ten trains per hour. The AWP shall be situated at such a convenient point on the incoming route so that incoming trains can be washed before entry to the depot and undesirable movement/shunting over ingress and egress routes within the depot is avoided. Additional space for plant room for AWP system shall be earmarked alongside the washing apron as indicated at S. No. 6 of Table 9.8.

IV. Train Operators Booking Office
Suitable office facility adjacent to the stabling lines at each depot should be provided so that train operators reporting „On" duty or going „Off" duty can obtain updates regarding „Special Notices", „Safety Circulars" and other technical updates/information in vogue. These offices should have an attached a cycle/scooter/car stand facility for convenience of the train operating staff.

V. Test Track
A test track of 1000 mts. in length covered & fenced should be provided beside workshop in the depot. It shall be equipped with signaling equipments (ATP/ATO). It shall be used for the commissioning of the new trains, their trials and testing of the trains after the IOH and POH. Entry into the test track shall be planned for a 3- Car train. In compliance to safety norms, the boundary of the track shall be completely fenced to prevent unauthorized trespassing across or along the track.

VI. Heavy Cleaning Shed

Monthly heavy cleaning of interior walls, floors, seats, windows glasses etc, outside heavy cleaning, Front/rear Face, Vestibule/ Buffer area, outside walls and roof shall be done manually in the interior cleaning plant designed for cleaning of one at a time. A line adjacent to inspection shed should be so provided that placement of rakes is possible from workshop or inspection lines & vice – versa conveniently and with ease.

VII. Power Supply

Auxiliary substations are planned for catering to the power supply requirement of the whole depot and workshop. Details of connected load feeder shall be worked out. Taking diversity factor of 0.5 the maximum demands shall be computed. Two Auxiliary substations are proposed, as the demand by machines in Workshop area would be very large. The standby power supply is proposed through DG set with AMF panel. The capacity of DG set will be adequate to supply all essential loads without over loading.

VIII. Compressed Air Supply

Silent type compressor units shall be suitably installed inside the depots at convenient location for the supply of compressed air to workshop, Inspection and intensive cleaning sheds. Thus, the pneumatic pipeline shall run within the workshop, inspection and intensive cleaning bays as to have compressed air supply line at all convenient points.

IX. Water Supply, Sewerage and Drainage Works

In house facilities shall be developed for the water supply of each depot. Sewerage, storm water drainage shall be given due care while designing the depots for efficient system functioning. Past records of Municipal Corporation shall be used to design the drainage system. Rainwater harvesting would be given due emphases to charge the under-ground reserves.

X. Ancillary Workshop

This workshop will have a line at floor level with provision of pits. Arrangement for repairs of Shunters, Rail Road Vehicles and other ancillary vehicles will be provided. These vehicles will also be housed here itself. Heavy lifting works can be carried out in main workshop.

Ancillary workshop will be used for storing Third Rail assembly parts and their maintenance/ repair for restoration of 750 V DC feed system.

XI. Watch Towers

There shall be provision of adequate number of watchtowers for the vigilance of depot boundary.

XII. Administrative Building

An administrative building close to the main entrance is planned. It can be suitably sized and architecturally designed at the detailed design stage. A time and security office is also provided close to main entrance. It shall be equipped with suitable Access control system for all the staff working in the complex.

XIII. Parking Facilities

a) Ample parking space shall be provided for the two wheelers and four wheelers at the following points.

i) Close to the depot entry.

ii) Close to the stabling lines.

iii) Close to the Workshop/IBL.

b) Space for parking of road cum rail vehicle equipped with re-railing and rescue item:

Enough space for parking of road vehicle/ trailers/ trucks etc. Enough space will also have to be earmarked adjacent to workshops. Similarly, provision of space for parking of road cum rail vehicle equipped with re-railing and rescue item will have to be made close to the main exit gate of the Depot.

XIV. Shed and Buildings

The shed and buildings normally provided in the depot with their sizes and brief functions are indicated at Para 9.12.1. At the detailed design stage depending upon the land availability, the decision to locate these buildings can be taken. These can then be architecturally and functionally grouped.

XV. Plant and Machinery

a) A separate building is planned for housing pit wheel lathe (PWL), approachable from workshop, inspection bay and stabling lines through rail and road for placement of cars for re- profiling of wheels within the depot along with space for depot of scrap.

b) Requirement of buildings and major plants and machinery, is given at Paras 9.12.1 & 9.12.2.

9.11.1 Following Safety features should be incorporated in the design of the

Maintenance Depot-cum-Workshop:

a) 1.5 EOT cranes in the inspection bay should be interlocked with 750 V DC in such a way that, the cranes become operational only when the traction supply is isolated and grounded.

b) Red flasher lights should be installed along the inspection lines at conspicuous location to indicate the 750 V DC 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 750 V DC 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 Stinger System is isolated.

g) Control Centre, PPIO & store depot must be close to Workshop.

h) Width of the doors of the sections wherein repairs of equipments are done should be at least 2 meters wide to allow free passage of equipment through them.

i) Provision of water hydrants should be done in workshops & stabling yards also.

j) Compressed air points along with water taps should be available in interior, workshop & inspection shed for cleaning.

k) Ventilation arrangement inside the inspection shed and workshop should be ensured. Arrangement for natural cross ventilation from one side to another of inspection & workshop bays to be incorporated along with optimum availability of natural light at floor level.

9.12 LIST OF BUILDINGS & LIST OF PLANTS & EQUIPMENT AT DEPOT-CUM-WORKSHOP

9.12.1 List of Buildings at Depot-cum-workshop: The facilities planned as per Phase-I DPR can meet the requirements for Phase-II for below items except IBL, SBL and WSL for which the requirements have been mentioned below.

TABLE-9.8

S. No	Name of Building	Size	Remarks
1.	Inspection Shed	166m x 22m (inspection bay of 3 lines) & 166m x16m (inspection bay of 2 lines)	Servicing of Cars for 15 days & 45 days inspection. Space for future provision of one bay of two lines to be kept for year 2051
	Workshop Shed	166m x 21m (each inspection bay)	Major repair & overhaul of rolling stocks, diesel shunters, electric tractors, tower wagons. All heavy lifting jobs. Space for future provision to be kept up to year 2051.
	Associated Sections	166m x 8m	Rooms for carrying out the inspection & workshop activity.
	Stabling line shed	166m x 30 m (provision for additional 6 SBL lines for Phase-II)	Provisional for total area as per requirement of stabling of 54 rakes during year 2051 is to be made by utilizing stabling facilty of Gyaspur Depot (existing) and additional depot at Indroda Circle.
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

S. No	Name of Building	Size	Remarks
			control. iv. Loading/Unloading of material received by road.
3.	Elect. Substation & DG set room	20m x 15m	To cater for normal and emergency power supply for depot, workshop, service and all other ancillary buildings, essential power supply for essential loads and security light.
4.	Traction repair depot and E &M repair shop	80m x 30m (partly double storey)	Stabling and routine maintenance of shunting engine etc. & Traction maintenance depot. For maintenance of lifts/escalators and other General service works.
5.	Cycle / Scooter / Car Parking	100m x 6m 60m x 6m	i. Close to the depot entry. ii. Close to the stabling lines.
6.	Auto coach washing platform	60m x 10m	For automatic washing of coaches. Provision of Washing apron for collection of dripping water and its proper drainage to be ensured.
	Auto coach washing plant room	20m X 10m	
7.	Washing apron for Interior Cleaning	160m x 6.5m	Heavy wet washing of rakes from inside, under frame, roof at 30 days interval.
8.	Blowdown plant	30m X 5m (additional to intensive cleaning)	Heavy cleaning of underframe and roof through compressed air at 30 days interval.
9.	P-way office, store & Workshop including Welding plant	80m x 20m	i. For track maintenance of section and depot. ii. To weld rails for construction period only. iii. To stable track Tamping machine.
10.	ETU Building	30m X 15m	For parking of CMV and OHE machinery.
11.	Security office & Time Office Garages (4 Nos.)	15m x 8m	For security personnel. For time punching For parking vehicle jeep, truck etc.
12.	Check Post (2 Nos.)	5m x 3m	For security check of incoming/outgoing staff material and coaches.
13.	Depot control centre & Crew booking centre	25mx20m (double storey)	To control movement of trains in and out of the depot and for crew booking. One small
14.	O.H raw water Tank	1,00,000 Ltrs. Capacity	For Storage of water.
15.	Pump house Bore well	7.3mx5.4m (200 mm bore)	Submersible type pump planned with 200 mm diameter bore well.
16.	Dangerous goods Store	15m x 10m	For Storage of paints, inflammables & Lubricants
17.	a) Traction 750 V DC b) Feeding Post	a)120m x 80m b) 15m x30m	Traction Power Supply
18.	Waste Collection Bin	10m x 10m	Garbage dumping
19.	Repair shops for S&T	40m x 20m	For the AFC gates, Signaling and telecom equipment.
20.	Work shop Manager Office	30m x 20m	Office of Depot in charge
21.	ATP & ATO Room	10m x 8m	To keep equipments of ATP/ATO
22.	Waste Water Treatment Plant	12m x 6m	For treating the discharge waters of the depot and remove the oil, acids etc. before discharging into the river, with U/G tank.
23.	Under floor Pit Wheel lathe	50mx 16m	For wheel re-profiling
24.	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.
25.	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.

***** Suitable space shall be allocated for having facilities for DCC, crew booking centre, Inspection room, toilet, pantry etc. which are essential for managing train operation from Indroda Circle Depot.***

9.12.2 LIST OF PLANTS & EQUIPMENT AT DEPOT-CUM-WORKSHOP:

TABLE-9.9

S. No.	Description	Approx. Unit Price (INR Lakh)	Corridor-I Depot IBL-3 Lines of 2 trains WSL-4 Lines of 2 trains		
			Qty. as per Phase-I DPR	Additional for Phase-II	Approx. Cost Provision (INR Lakh)
1	Under floor Pit Wheel lathe	621.00	1	0	0.00
2	Syn. Pit Jacks-for **3 cars** unit	521.00	1	0	0.00
3	Automatic Train Washing Plant	268.00	1	0	0.00
4	Battery Shunting Loco	349.89	0	1	349.89
5	Electric Tractors (RRM)	199.00	1	0	0.00
6	Electric Tractors (RRM) for UFWL	184.00	1	0	0.00
7	Syn. Mobile Jacks for **3 cars** unit	136.40	2	1	136.40
8	Bogie Turn Table	27.86	4	2	55.72
9	Re-railing & Rescue equipment (set)	81.99	1	0	0.00
10	Rail cum Road Vehicle (RRV)	42.26	1	0	0.00
11	Blow Down Plant	196.00	1	0	0.00
12	Mobile jib Cranes (1T Manual)	1.53	1	0	0.00
13	Under track Mobile Lifting Table (1T for IBL)	2.75	4	0	0.00
14	CI/SIV Mobile Lifting Table (3T for WS)	3.62		0	0.00
15	Arial Work Lift Platform	19.61	1	0	0.00
16	High Pressure Wash Pumps	5.37	0	2	10.74
17	AC Filter cleaning machine	23.50	1	0	0.00
18	Mobile compressor-10bar	4.20	1	0	0.00
19	HP compressor-17bar	3.36	1	0	0.00
20	EMU Battery Charger	5.56	2	0	0.00
21	Box Container for re-railing equipment	5.12	0	1	5.12
22	wooden blocks	0.77	0	1	0.77
23	Auxiliary truck	1.82	0	1	1.82

S. No.	Description	Approx. Unit Price (INR Lakh)	Corridor-I Depot IBL-3 Lines of 2 trains WSL-4 Lines of 2 trains		
			Qty. as per Phase-I DPR	Additional for Phase-II	Approx. Cost Provision (INR Lakh)
24	Road Truck (Pick up Van)	10.56	**1**	**0**	**0.00**
25	Battery operated Platform Truck for WS and DCOS	6.33	**0**	**2**	**12.66**
26	Welding & Cutting Equipment	2.24	**1**	**0**	**0.00**
27	Work Benches	0.54	**10**	**0**	**0.00**
28	Vertical Carousal storage system	35.00	**0**	**1**	**35.00**
29	Weighing scales	2.65	**0**	**1**	**2.65**
30	Storage Bins	7.59	**0**	**1**	**7.59**
31	Hand Pallet Trucks	0.39	**0**	**5**	**1.95**
32	Fork Lift Truck-3T(Elect)	10.35	**2**	**0**	**0.00**
33	Stackers (1T for DCOS)	9.50	**1**	**0**	**0.00**
34	Mobile Safety Steps & Ladders	5.12	**LS**	**0**	**0.00**
35	Set of Pallets	15.00	**LS**	**0**	**0.00**
36	Storage racks for DCOS stores	62.50	**LS**	**0**	**0.00**
37	Storage racks for workshop, tool room	31.50	**-**	**LS**	**31.50**
38	Electric/Mechanical and Pneumatic Tools	60.00	**-**	**LS**	**60.00**
39	Measuring & calibration Instruments	40.00	**-**	**LS**	**40.00**
40	Special Jigs and Fixtures (Stands & Trolleys)	60.29	**LS**	**-**	**0.00**
41	Industrial Furniture for Workshop, IBL & DCOS rooms	90.00	**LS**	**-**	**0.00**
42	Miscellaneous/other machinery for Workshop.	93.71	**-**	**LS**	**93.71**
43	Display boards inside depot	7.50	**0**	**1**	**7.50**
44	Industrial vacuum Cleaners (heavy duty + dry/wet)	4.83	**0**	**1**	**4.83**
45	Small Part Cleaner	1.00	**0**	**1**	**1.00**
46	Polyester Web Sling+B51+B51:B70:BB51:B70	1.00	**-**	**LS**	**1.00**
47	750 V DC Live Indicators	2.60	**0**	**3**	**7.80**

S. No.	Description	Approx. Unit Price (INR Lakh)	Corridor-I Depot		
			IBL-3 Lines of 2 trains		
			WSL-4 Lines of 2 trains		
			Qty. as per Phase-I DPR	Additional for Phase-II	Approx. Cost Provision (INR Lakh)
48	Wheel Gauges/Templates	3.80	-	LS	3.80
49	Ultrasonic Flaw Detector	2.18	0	1	2.18
50	Memory Recorder/Chart recorder etc.	10.00	0	1	10.00
51	Induction heater	8.40	1	0	0.00
52	Hyd. Axle Bearing puller	9.60	0	1	9.60
53	Training equipment/ diagnostic software/Camera, Projector, computer equipment/laptop etc.	16.79	-	LS	16.79
54	Industrial Videoscope	10.13	0	2	20.26
55	Lifting jacks for Aircon (two post lift)	4.37	0	1	4.37
56	Auto wheel profile meters and attachments for dia. and back to back measurement	19.18	0	1	19.18
57	Coupler backlog Gauge	8.15	0	1	8.15
58	25 Ton Hydraulic C Frame Press	7.44	0	1	7.44
59	Hydraulic work bench for Gear Box	16.00	0	1	16.00
60	Hydraulic work bench for couplers	7.60	0	1	7.60
61	Special tools for coupler	17.50	-	LS	17.50
62	Other tools/equipment as per RS contractor	50.00	-	LS	50.00
63	Bogie Test Stand	388.00	1	0	0.00
64	Wheel Press (300T)	467.50	1	0	0.00
65	Vertical turret lathe	131.00	1	0	0.00
66	Damper testing machine	52.98	0	1	52.98
67	Spring testing machine	166.10	0	1	166.10
68	Rail fed Bogie wash plant	188.10	1	0	0.00
69	Heating oven for TM	5.88	0	1	5.88
70	Minor Diagnostic equipment (Set)	30.00	0	1	30.00
71	Tool Kit	5.00	0	1	5.00
72	Impulse Tester for TMs	11.05	0	1	11.05

S. No.	Description	Approx. Unit Price (INR Lakh)	Corridor-I Depot IBL-3 Lines of 2 trains WSL-4 Lines of 2 trains		
			Qty. as per Phase-I DPR	Additional for Phase-II	Approx. Cost Provision (INR Lakh)
73	Battery cell topper	3.00	**0**	**1**	**3.00**
74	Articulated Boom lift	45,00	**0**	**1**	**45.00**
75	Hydraulic Scissor lift (1 Ton) with auxiliary table	1.00	**0**	**2**	**2.00**
76	Chemical cleaning tank, Ultrasonic cleaning tanks etc.		**1**	**0**	**0.00**
77	Carbody Stands		**24**	**0**	**0.00**
78	Portable cleaning plant for Rolling Stock		**1**	**0**	**0.00**
79	Oven for the motors	6.00	**1**	**0**	**0.00**
	OVER ALL TOTAL				**1381.53**

9.13 COST ESTIMATE

The total estimated cost at Jan"17 price level may be assumed as Rs. 14 Crores (approx). This would be required for Rolling Stock M&P equipment in addition to provision available in Phase-I, for one depot at Gyaspur for North South corridor (including the extension). No M&P has been planned at Indroda Circle as it will be used only for stabling purpose.

Chapter - 10

POWER SUPPLY ARRANGEMENTS

Power supply is the lifeline of Metro System

10.1 POWER REQUIREMENTS

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

(i) Specific energy consumption of rolling stock at Pantograph/ Current Collector – 60KWh/1000 GTKM as per MOUD guideline for 750 V dc system.

(ii) Elevated/at –grade station auxiliary load – initially 250 kW, which will increase to 300 kW in the year 2051.

Keeping in view of the train operation plan and demand of auxiliary and traction power, power requirements projected for the year 2021, 2031, 2041 and 2051 are summarized in table 10.1 below:-

Table 10.1 Power Demand Estimation (MVA)

Corridors	Load	Year			
		2021	**2031**	**2041**	**2051**
Extension of North-South Corridor; Motera Stadium to Mahatma Mandir, 20 Stations (22.84 km)	Traction	3.47	4.34	5.78	6.93
	Auxiliary	6.17	6.42	6.79	7.41
	Sub-total	**9.64**	**10.76**	**12.57**	**14.34**
Spur of North-South Corridor extension; GNLU to Gift City, 3 Stations (5.4 km)	Traction	0.79	0.79	0.79	0.79
	Auxiliary	0.93	0.96	1.02	1.11
	Sub-total	**1.72**	**1.75**	**1.81**	**1.90**
Spur of North-South Corridor extension; Koteshwar Road to Airport, 3 Stations (6.34 km) (Phase-IIA)	Traction	0.92	0.92	0.92	0.92
	Auxiliary	0.93	0.97	1.02	1.12
	Sub-total	**1.85**	**1.89**	**1.94**	**2.04**
	Grand Total	**13.21**	**14.40**	**16.32**	**18.28**

The detailed calculations of power demand estimation are attached at Annexure 10.1.

10.2 NEED FOR HIGH RELIABILITY OF POWER SUPPLY

The proposed Ahmedabad metro system is being designed to handle about 16,000 passengers per direction during peak hours when trains are expected to run at 2.0 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 signage"s, disruption of operation of lifts and escalators is likely to cause confusion, anxiety and ire in commuters, whose tolerance level are low on account of stress. Effect on signal and communication may affect train operation and passenger safety as well. Therefore, uninterrupted power supply is mandatory for efficient metro operations.

To ensure reliability of power supply, it is essential that both the sources of Supply and connected transmission & distribution networks are reliable and have adequate redundancies built in. Therefore, it is desirable to obtain power supply at high grid voltage of 220 kV, 132 kV or 66 kV from stable grid sub-stations and further transmission & distribution is done by the Metro Authority itself.

10.3 SOURCES OF POWER SUPPLY

The high voltage power supply network of Ahmedabad city was studied in brief. The city has 220 kV, 132 kV and 66 kV network to cater to various types of demand in vicinity of the proposed corridors. A meeting was held on 19.04.2017 with M/s Torrent Power & MEGA official, and various sub-stations sites had been inspected to finalize the Input Power Supply sources & Supply Voltage.

Keeping in view the reliability requirements, Two Receiving Sub-stations (RSS) are proposed to be set up for extension of North-South Corridor Motera Stadium to Mahatma Mandir and its two Spurs Koteshwar Road to Airport & GNLU to Gift City. This is an economical solution without compromising reliability. Based on the discussions in meeting with M/s Torrent Power & MEGA, it is proposed to avail power supply for traction as well as auxiliary services from the following grid sub-stations at 132 kV voltage through cable feeders: -

Table 10.2 Sources of Power Supply

S. No.	Corridor	Grid sub-station of Power Supply Authority (Input voltage)	Location of RSS of Metro Authority	Approx. length of cables
1.	Extension of North-South Corridor; Motera Stadium to Mahatma Mandir and its spur; GNLU to Gift City	One no. 132 kV bays from 132 kV Gandhi Nagar Substation	Near Infocity Station	5.0 km
		One no. 132 kV bays from 132 kV IT Park Substation		2.6 km

<table>
<tr><th>S. No.</th><th>Corridor</th><th>Grid sub-station of Power Supply Authority (Input voltage)</th><th>Location of RSS of Metro Authority</th><th>Approx. length of cables</th></tr>
<tr><td rowspan="2">2.</td><td rowspan="2">Spur of North-South Corridor extension; Koteshwar Road to Airport</td><td>Two no. 132 kV bays from 132 Airport Substation
OR</td><td>Near Airport Station</td><td>0.5 km</td></tr>
<tr><td>Two Nos 66 kV bays from proposed Bhat 220/66 kV Grid Sub-station (GETCO).</td><td>Near Koba Circle</td><td>3.5 km</td></tr>
</table>

M/s Torrent Power MoM, dated:-19.04.2017 have assured that reliable power supply from their 132 kV Sub-station will be provided (Annexure 10.2A). A letter bearing No. DMRC/DPR/AM/10/Part-IV, dated 04.05.17 has been sent to M/s GETCO for the sake of confirmation of power supply at 220/66 kV Bhat Grid Substation (Annexure 10.2B). 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. The summary of expected power demand at various sources is given in table 10.3.

Table 10.3 – Power Demand projections for various sources (in MVA)

<table>
<tr><th rowspan="2">Corridor</th><th rowspan="2">Input Source</th><th colspan="2">Peak demand - Normal</th><th colspan="2">Peak demand** - Emergency</th></tr>
<tr><th>Year (2021)</th><th>Year (2051)</th><th>Year (2021)</th><th>Year (2051)</th></tr>
<tr><td rowspan="8">Extension of North-South Corridor; Motera Stadium to Mahatma Mandir and its spur Koteshwar Road to Airport & GNLU to Gift City</td><td colspan="5">RSS Near Infocity Station</td></tr>
<tr><td>Traction</td><td>2.59</td><td>4.32</td><td>5.18</td><td>8.64</td></tr>
<tr><td>Auxiliary</td><td>4.02</td><td>4.82</td><td>8.03</td><td>9.64</td></tr>
<tr><td>Sub-total (A)</td><td>6.61</td><td>9.14</td><td>13.21</td><td>18.38</td></tr>
<tr><td colspan="5">RSS Near Airport Station/ Koba Circle Station</td></tr>
<tr><td>Traction</td><td>2.59</td><td>4.32</td><td>5.18</td><td>8.64</td></tr>
<tr><td>Auxiliary</td><td>4.02</td><td>4.82</td><td>8.03</td><td>9.64</td></tr>
<tr><td>Sub-total (B)</td><td>6.61</td><td>9.14</td><td>13.21</td><td>18.38</td></tr>
</table>

** Incase of failure of other source of power

The 132 kV, 66 kV power supply will be stepped down to 33 kV level at the RSS"s of metro authority. The 33 kV power will be distributed along the alignment through separate 33 kV Ring main cable network for feeding traction as well as auxiliary loads. These cables will be laid in dedicated ducts/cable brackets along the viaduct.

Interconnection of 33 kV power supply between these corridors has been planned at the Interchange station of Koteshwar Road & GNLU which can be used for transfer of power from one corridor to other in the 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 by feed extension from RSS of other line. But if one more RSS fails, only curtailed services can be catered to. However, in case of total grid failure, all trains may come to a halt but station lighting, signal & telecom system, fire and hydraulics & other essential services can be catered to by stand-by DG sets. However, no train services can be run with power supply received from DG Sets. Therefore, while the proposed scheme is expected to ensure adequate reliability in normal and emergency situation, it would cater to grid failure as well, except for the train running.

Typical High Voltage Receiving Sub-station

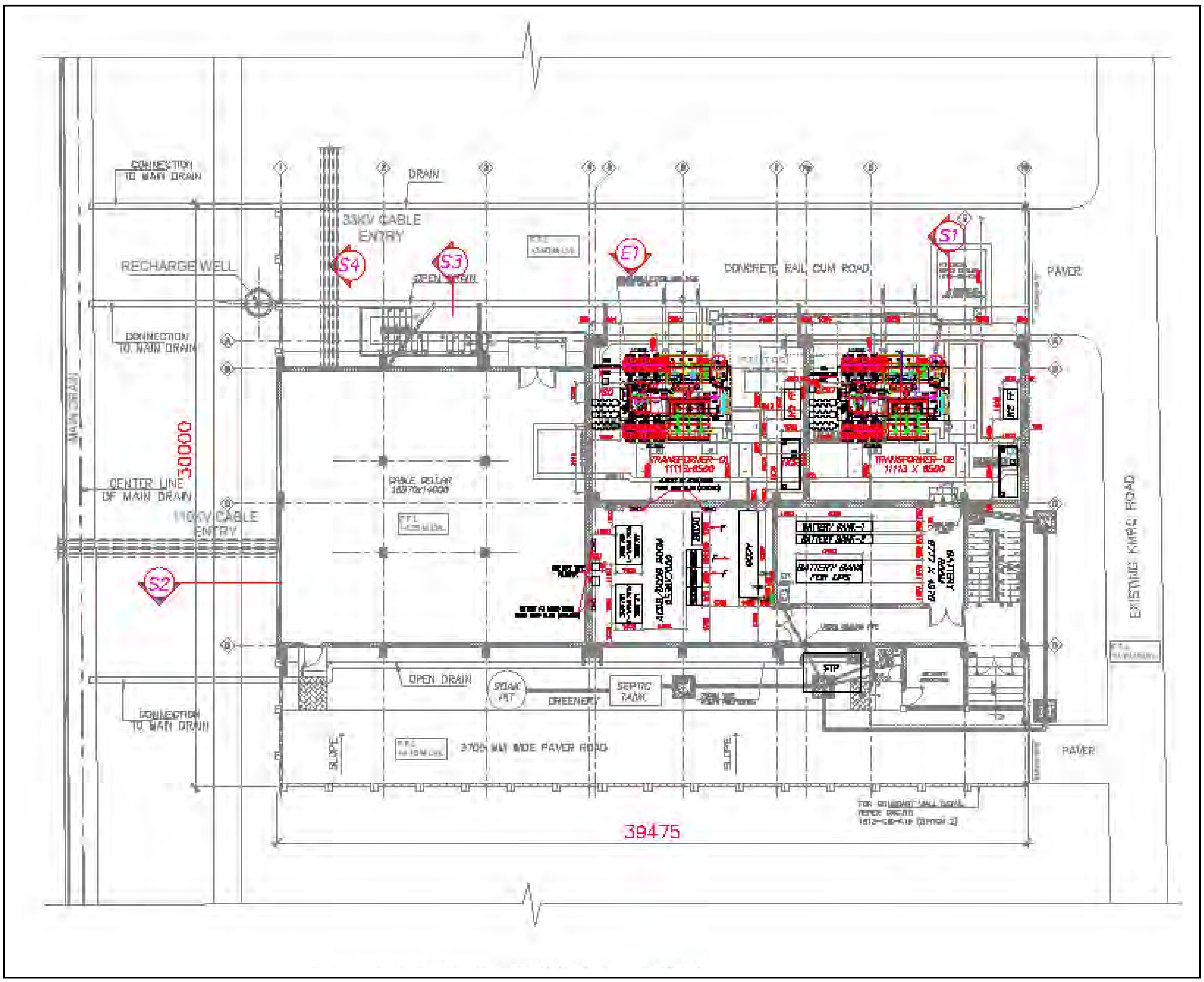
Typical High Voltage Gas Insulated Sub-Station (GIS)

The 132 kV or 66 kV cables will be laid through public pathways from M/s Torrent Power Sub-stations or M/s GETCO to RSS of Metro Authority. RSS near Infocity Station and near Airport Station or Koba Circle shall be provided with 2 nos. (one as standby) 132/33 kV, 20 MVA (ONAN) three phase Transformers for feeding Traction as well as auxiliary loads for all three sections. The capacity of transformers may be reviewed considering the load requirement / Power distribution of both the corridors at the time of detailed design stage.

Gas Insulated Switchgear (GIS) type Switchgear will be planned for these sections of Ahmedabad Metro due to less space and reduced maintenance. Land plot area 40m x 30m (1200 sq. m) is required.

The typical GIS RSS layout is given in figure 10.1

.



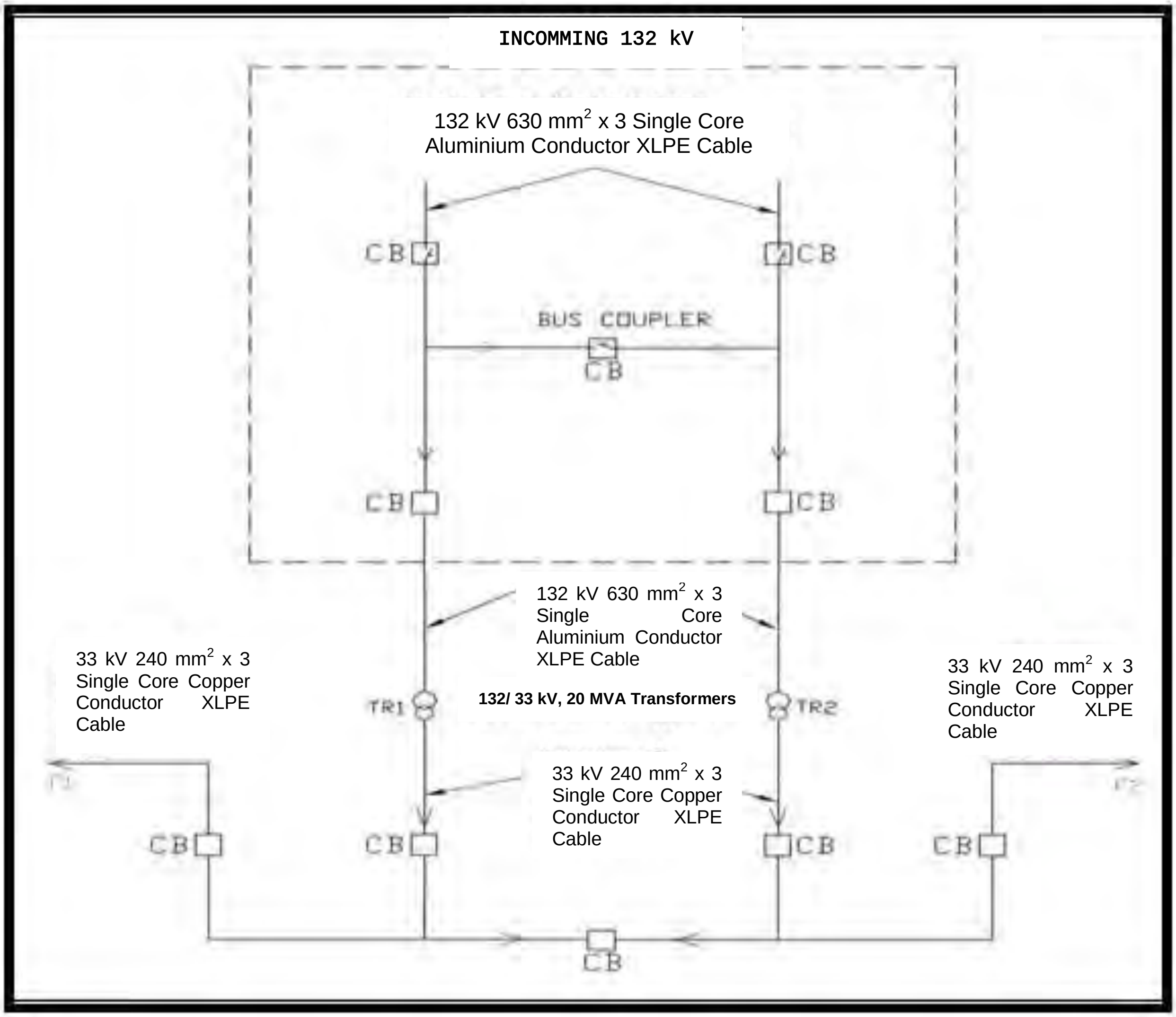
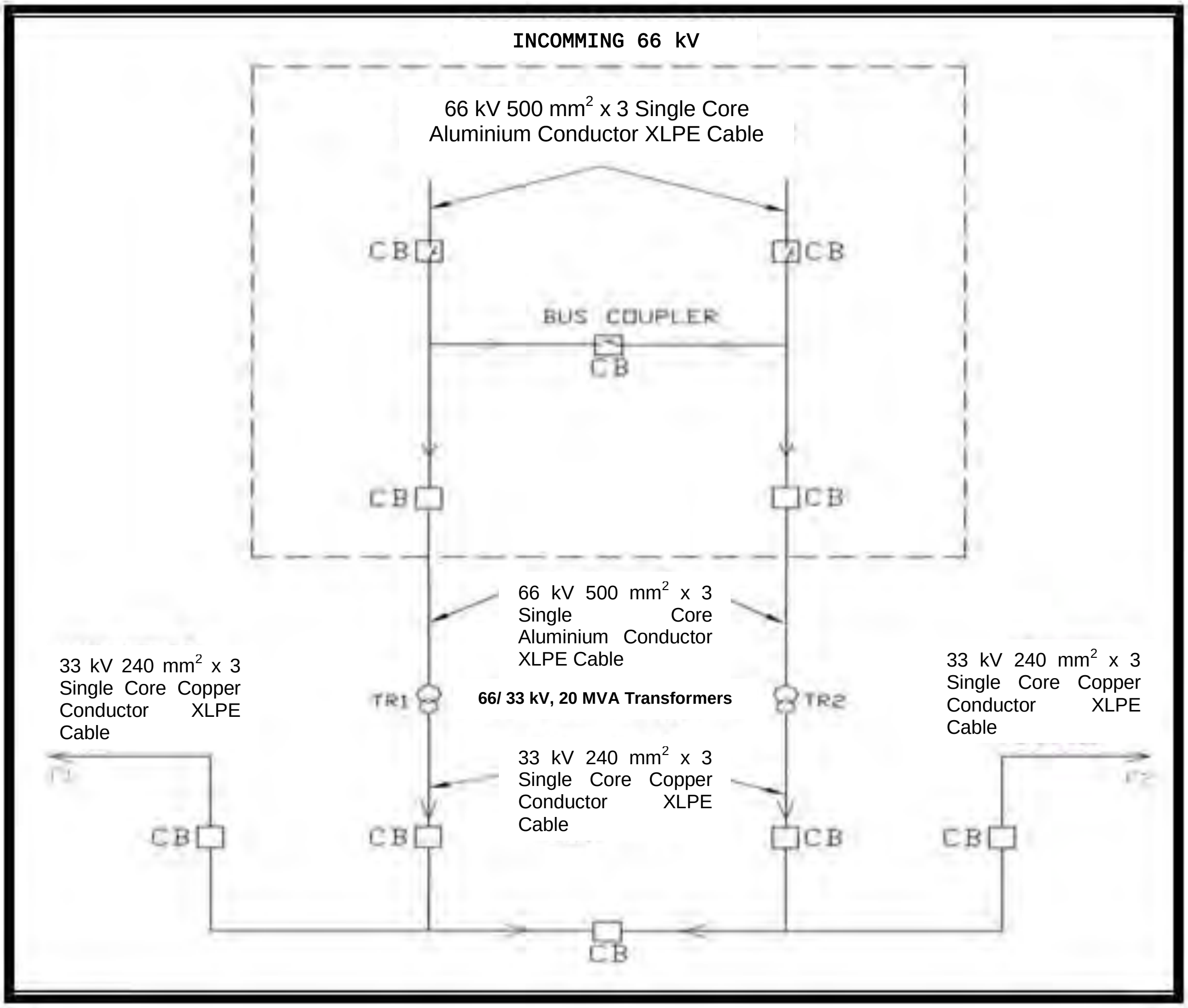


FIGURE 10.1 – TYPICAL 132/33kV RSS LAYOUT



TYPICAL 66/33kV RSS LAYOUT

10.4 VARIOUS OPTIONS OF TRACTION SYSTEM

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

25 kV & 2x25 kV AC Overhead Catenary system.
750 V dc third rail system.
1500 V dc Overhead Catenary system

A sub- committee set up by "Ministry of Urban Development" on Traction system for metro railway has studies various aspects of merits and demerits of various traction system. The following are the highlights of Report:-

Merits and Demerits of various traction systems:

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

Reduced cost – Unlike dc traction this system, does not require substations at frequent intervals due to high voltage, reduced current levels and lower voltage drops as a result, there is substantial reduction in cost. Cost of 25 kV ac traction systems is about 30% less as compared to 750V DC 3rd rail traction system.

Energy regeneration & line losses- Energy regeneration is more than 30% in 25 kV AC traction system as compared to 18% in 750V DC 3rd rail traction system. In 25 kV AC traction system line losses are 12% less as compared to 750V DC 3rd rail traction system

Cost of rolling stock- The cost of rolling stock & maintenance cost of traction system are comparable.

Capacity – In future, the system can cater to traffic needs even in excess of 75000 PHPDT, which, however, is restricted on account of other constraints.

Easy of capacity enhancement – Capacity enhancement can be easily achieved by simply enhancing the transformer and its associated equipment at the receiving substation.

Higher efficiency of operation – The efficiency of regeneration is substantially more than dc systems and line losses are very less of the order of 5%.100% recovery of regenerated energy is possible in the case of 25 KV ac traction compared to a figure of 75% in the case of 1500 V dc systems and 60% in the case of 750 V dc systems.

Less Fire hazards-AC system poses lesser fire hazards as current levels are much lower than DC system.

Stray current - There are no problem of stray currents and hence nearby metallic structures are not affected by corrosion. However there are problems of EMC / EMI which can be controlled by using return conductor & screened cables in signaling applications & fiber optic cable in telecommunication system without using booster transformer as per recent developments. This also helps in avoiding use of booster transformer which causes 2% line loss and excessive voltage drops besides involving maintenance & reliability issues.

Traction equipments in 25kV AC system are standardized & mostly indigenously available.

Though in underground section higher size tunnel diameter is required.

b) **600-850 V dc third rail traction system:-Demerits**

High operating currents and High voltage drops necessitating reduction in spacing of sub-station- This leads to larger voltage drops along the Third Rail distribution system, which necessitates closer spacing of sub- stations at an interval of almost every 2 Km, leading to higher costs of construction.

Low levels of regeneration- The regeneration is 18%, because 60% of re-generated energy in a 750 V dc system is possible to be retrieved.

Safety hazards with use of medium voltage at ground level- Due to existence of the “live” third rail at ground level, this system can be hazardous to safety of commuters and maintenance personnel if they fail to adopt safety precautions.

Line losses- Line losses are more due to higher current. Transmission line losses on 750 V dc traction system are around 21% as against 5% of 25 kV ac traction system.

Phenomenon of stray current- In a third rail system, where the running rails are used as a return path, a part of the return current leaks into track structure. This current is called stray current. It is necessary to manage the stray current to ensure minimal corrosion effect and consequent damages to metallic components in the track structure as well as metallic reinforcement and metal pipes of building of metro and public areas adjacent to the Metro alignment.

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

Higher maintenance requirement and costs as compared to 750V dc third rail system.

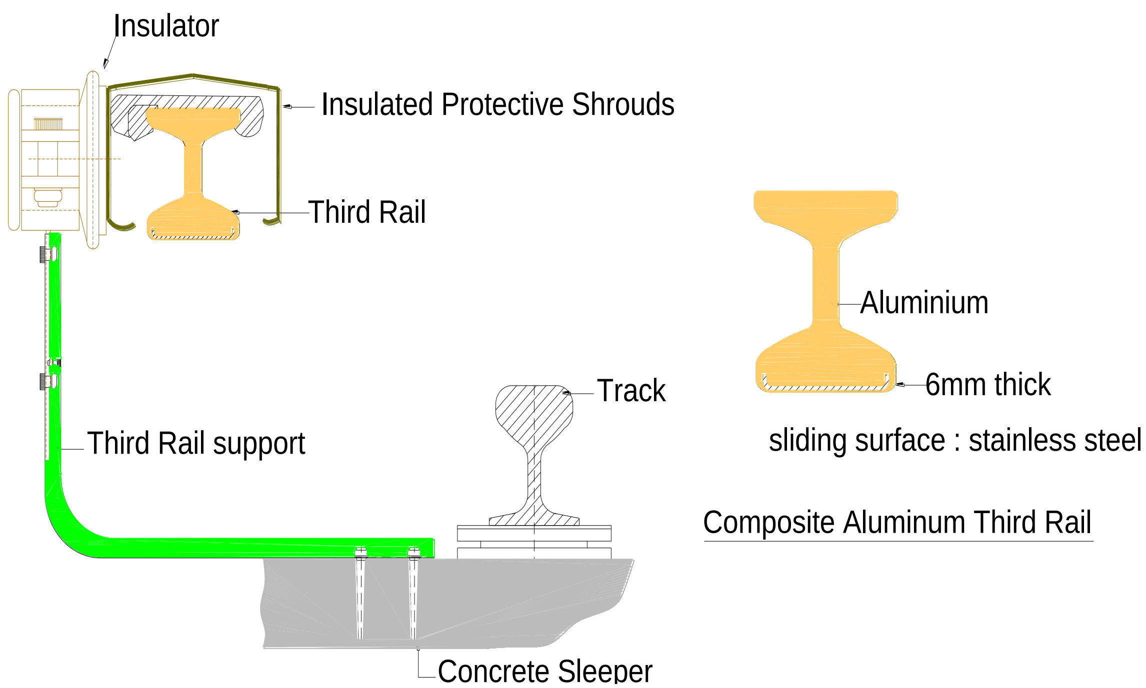
Theoretical traffic capacity with 1500V traction system is less as compared to 25KV ac system.

Line losses are more due to higher current as compared to 25 kV ac. It may be in the range of 10 to 12% as against 5% of 25 kV ac system.

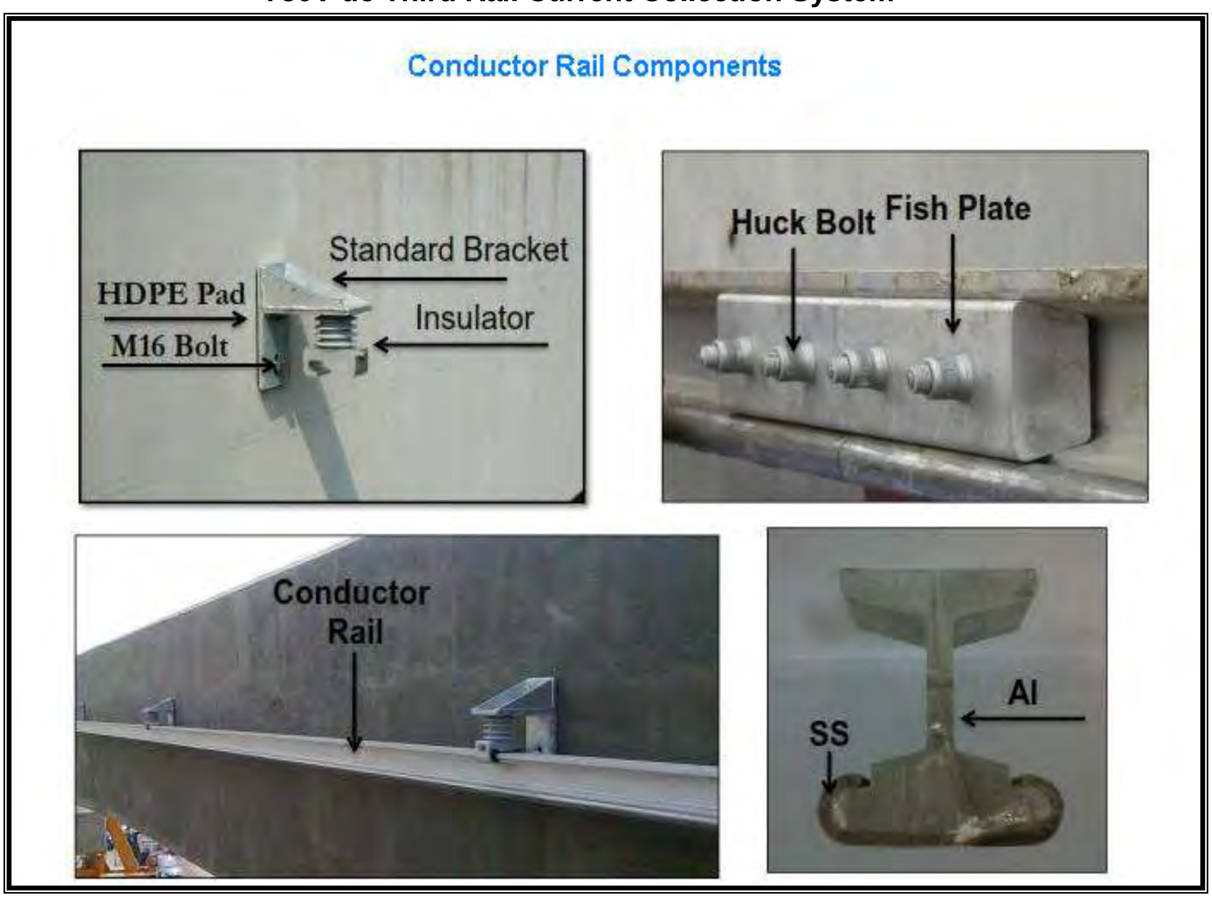
In view of above techno- economic considerations, DMRC recommends 25 kV AC Traction power supply. This is 95% available indigenously. However due to the low PHPDT of the network, lesser network lengths and aesthetics use of 750V DC system as used in Ahmedabad Metro by MEGA for Phase-1, is also suitable and justified. The DC suppliers are located outside India with 95% import content. As the Train Maintenance depot is common for Phase-1 & Phase-2, it is technically necessary to have a common traction system and hence 750 V dc 3rd rail traction system is optimum & recommended. Final decision may be taken by the client in this regard.

10.5 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 & depot is envisaged from reliability and safety considerations (figure below).



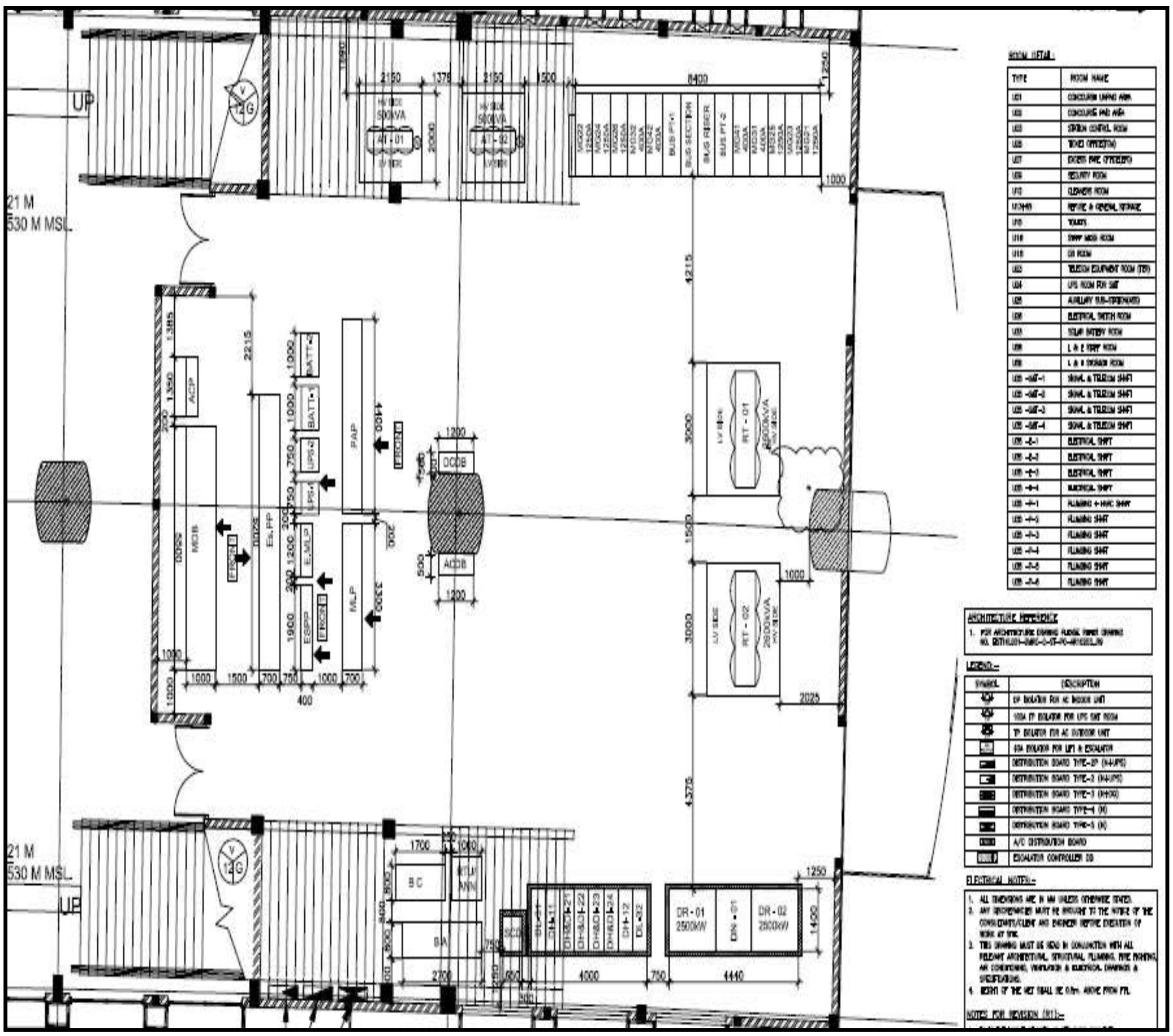
750V dc Third Rail Current Collection System



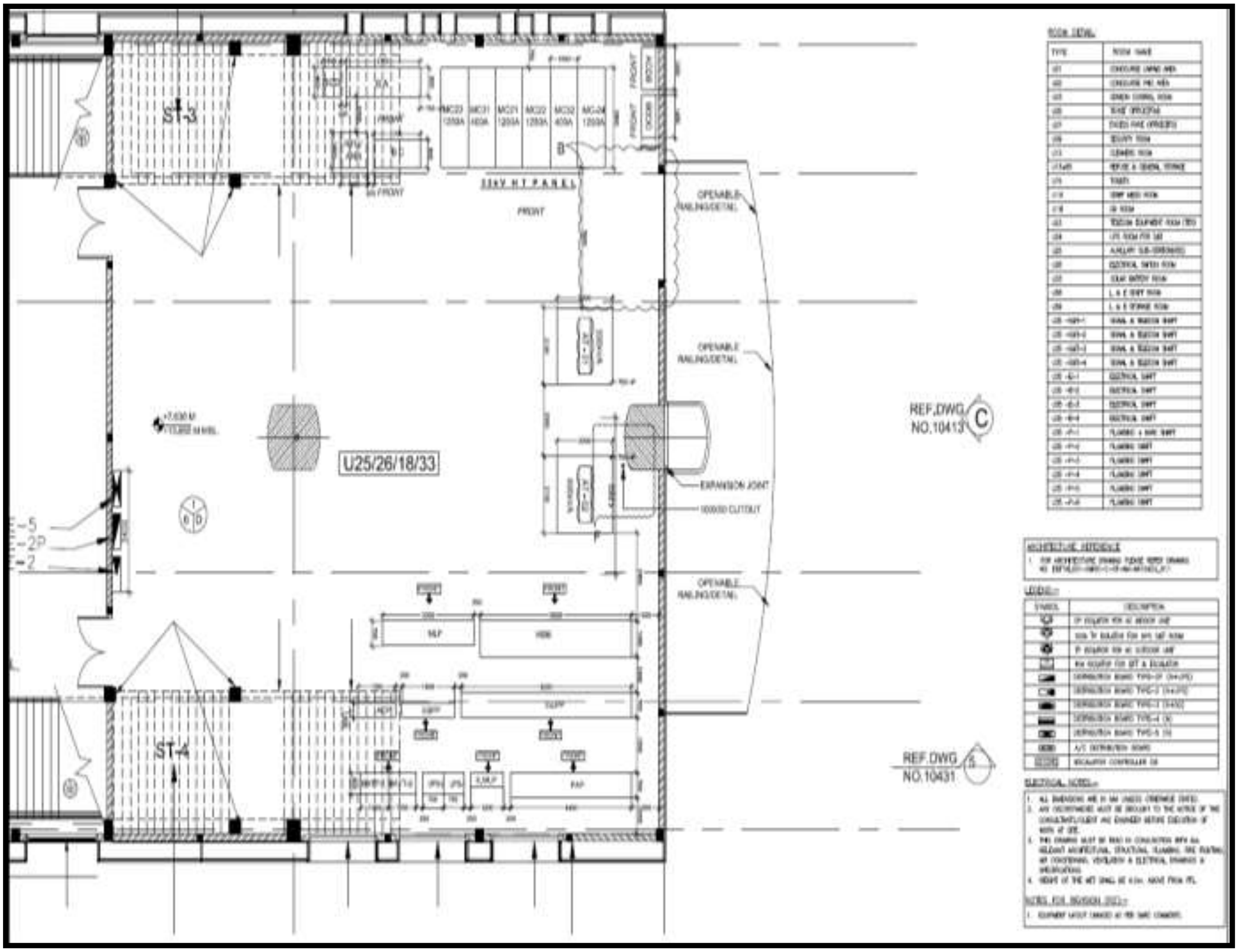
The cross-section of third rail will be about 5000 mm^2. The longitudinal resistance of composite and steel third rail is about 7 and 20 m-ohm/km respectively. The life of composite and steel third rail is expected to be 25-30 years.

10.6 TRACTION SUB-STATIONS (33KV/750V DC)

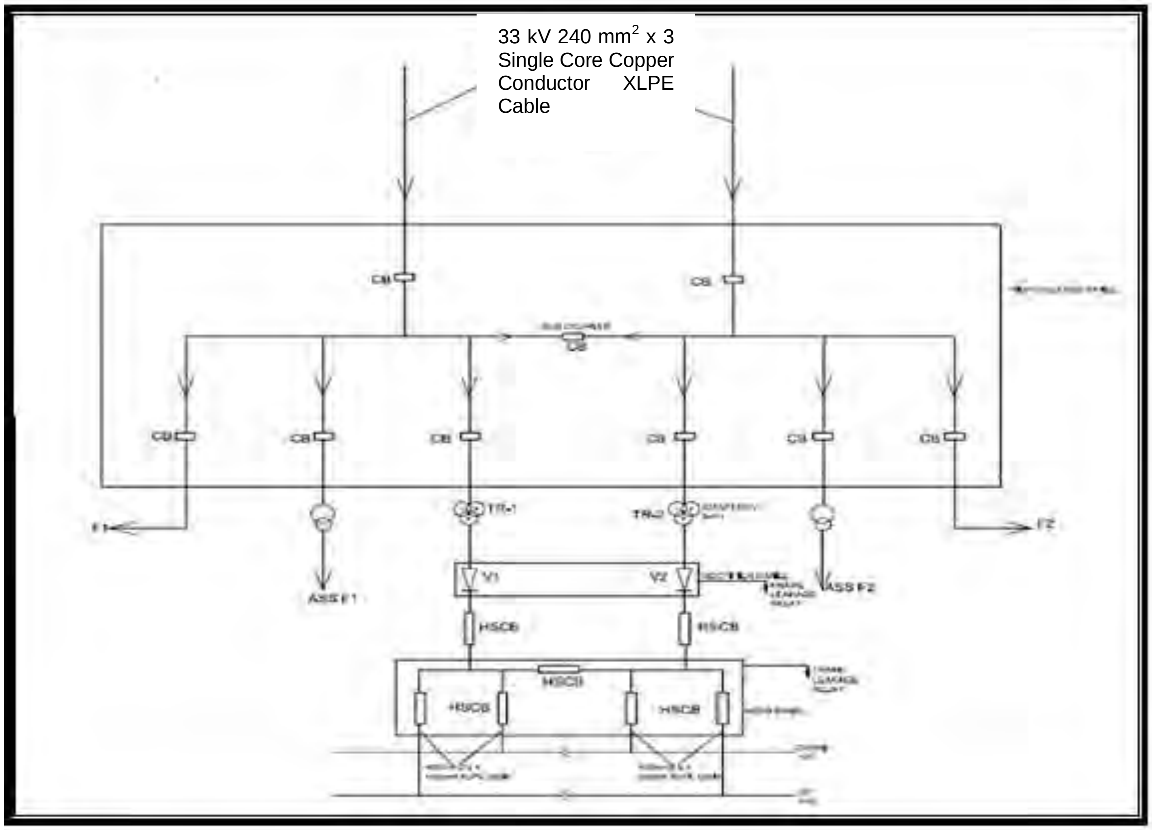
Traction sub-stations (33kV/750V dc) are required to be set up for feeding 750V dc power supply to the third rail. In order to cater to traction load as per train operation plan, it is envisaged to provide traction sub-stations (TSS) at alternate stations. The TSS along with Auxiliary Sub-Stations (ASS) will be located at station building itself at mezzanine or platform or Ground level inside a room. The typical layouts for TSS & ASS are given below. The requirement comes to 11 TSSs for extension of North-South Corridor; Motera Stadium to Mahatma Mandir, 2 TSSs for its first Spur; Koteshwar Road to Airport & 2 TSSs for its second Spur; GNLU to Gift City.



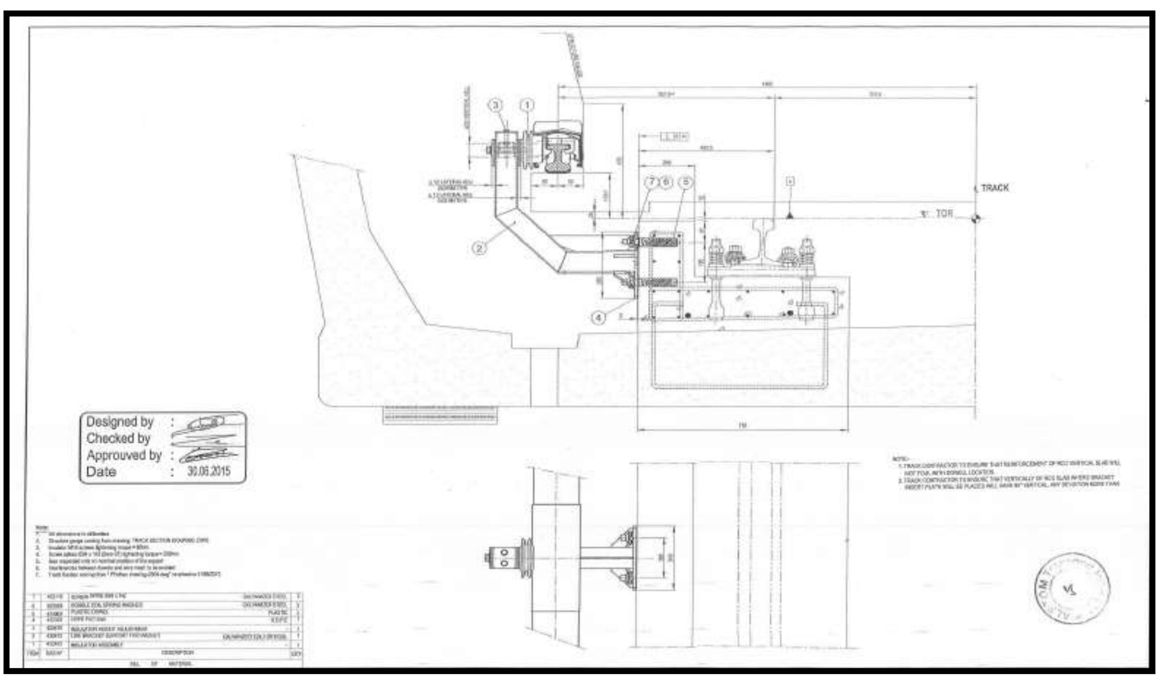
TYPICAL DRAWING OF ASS & TSS



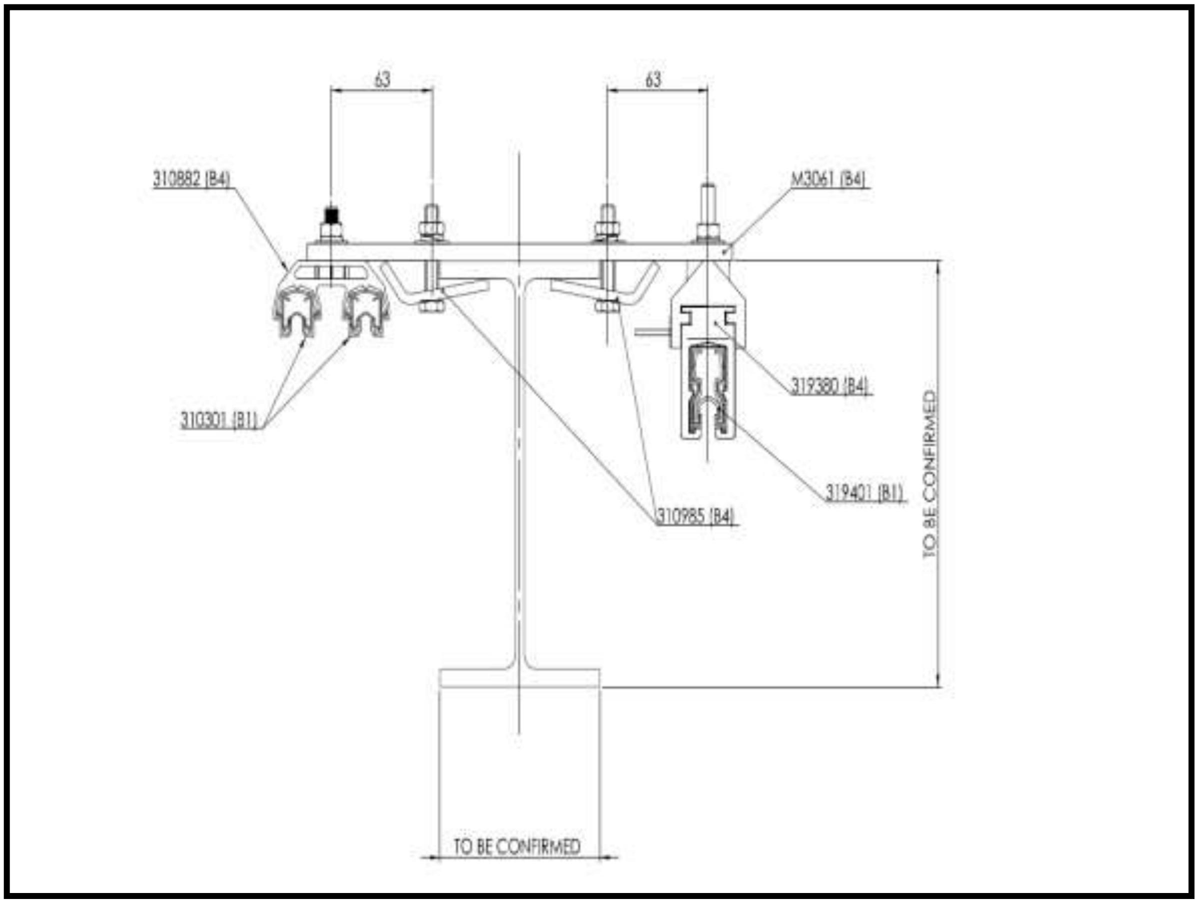
TYPICAL DRAWING OF ASS



Schematic Diagram of DC Traction



Line Bracket Support Assembly for Viaduct



Suspension Assembly in Depot

10.6.1 Stray Current Corrosion Protection Measures

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

$2H_2O + 2e^-$ $H_2 + 2OH^-$ (development of Hydrogen gas)

Stray current exits from metal

Fe $Fe^{2+} + 2e^-$ (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 10.4. Pitting and general form of corrosion are most often encountered on DC Electrified Railways.

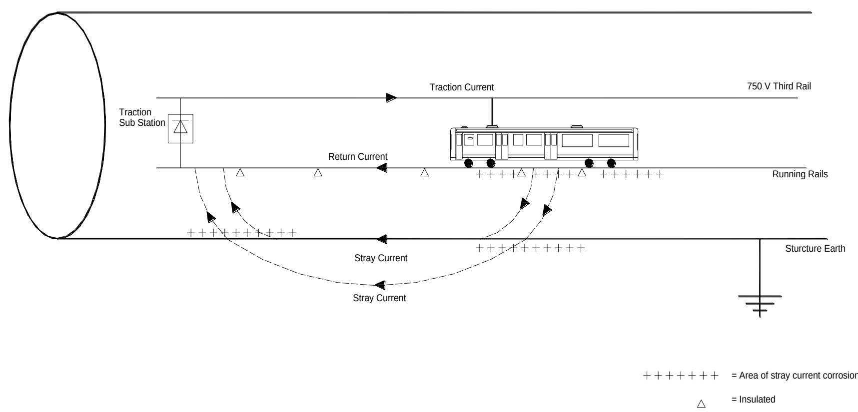


FIGURE 8.4 -- DC TRACTION SYSTEM : STRAY CURRENT CORROSION CONCEPT

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.

Earthing & Bonding

The earthing installation at the RSS, stations, ASS+TSS at the stations and depots shall be provided to cover all the buildings, structures, passenger ways and connected structures during operation or non-operation hours to achieve;

1. Safety of operating personnel and other persons from electrical shock.
2. Minimum of electrical interference between the electrical power supply and other electrical and electronic systems.
3. Minimum of disturbance to existing statutory services and parts of the Metro network system due to any electrolytic corrosion effects arising from dc traction currents flowing to and from the general body of the earth.

Main Line Earthing for DC traction system

1. Floating system (i.e. traction system with floating negative) is to be adopted for all sections except depot area. Under this system electrical isolation from the earth shall be provided with an insulation gasket where ever required.
2. The running rails shall be adequately insulated as per EN 50122-2.
3. Stray current cables: Stray collection cable shall be provided along the viaduct and in the tunnel. The stray collection cable shall enter each traction substation building and terminate on a stray current bus bar adjacent to the DC negative bus bar. The stray current bus bar shall be insulated to earth and shall not be connected to either the rails or to the traction negative bus bar. It shall be connected or bonded at intervals to track plinth sacrificial bars or stray current collection mat, made of continuous longitudinal steel cage, installed within the track support concrete. The stray current collection cable preferably of aluminum. Stray current collection can never be used as a general earth.
4. In addition, provisions shall be made for continuous monitoring of the stray current as per EN-50122 at multiple locations through SCADA system.
5. Trunk earth conductor/System/structural earth cable: A trunk earth conductor of appropriate cross section preferably ACSR shall be provided throughout the viaduct & in the tunnels on up and down lines and to the places where it is required for the earthing without endangering the safety of person.
6. The DC feeder protection, switchgear and return current bonding shall be specified, designed, and maintained so that all short circuits from the conductor rails to the running rails and items bonded to the running rails are interrupted in a sufficiently short time that touch voltages at all points in the system, as functions of time, do not exceed the maximum levels specified in EN 50122-1.
7. The metallic or steel structures like cable trays, pipe lines, railings, trusses, foot over bridges, road over bridges, advertising structures, equipment with metallic frames that can come in contact with the commuters and are in the influence zone must ensure electric isolation every 10-12 meters using insulation gasket for providing electrical

isolation and separately earthed. The chances of accidental potential difference under fault condition due to separate earthing points should be minimized.

Earthing System for AC supplies

1. The Earthing system for AC power supplies shall be maintained distinct and isolated from the DC system for the Main line. The AC earthing shall be provided at RSS, ASS at stations, depots and OCC.

Depot

1. An earthed system shall be used for Depot area.
2. A separate TSS shall be provided for depot so as to facilitate isolation of depot traction supply from mainlines in order to prevent the leakage of return currents to depot area.
3. For safety reasons, the system in depot is negative earthed one therefore, the mainline tracks and third rail supply shall be isolated from depot tracks through double insulted rail joints and sectioning in order to minimize the stray currents, even during the movement of the trains. Remote operated sectionalizing switches will be provided for operational exigencies.
4. Special measures for safety of person in wheel lathe area and washing lines area be provided and at the same time minimize the stray currents as leaky conditions exists in such areas. The non-electrified tracks shall be provided with the Insulated Rail Joint (IRJs).
5. A new system of DC traction with floating neutral in selected lines is followed in Depot in consultation with GC & DDC. Based on the outcome after commissioning & operational trials, a decision may be taken to continue or modify the same.

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

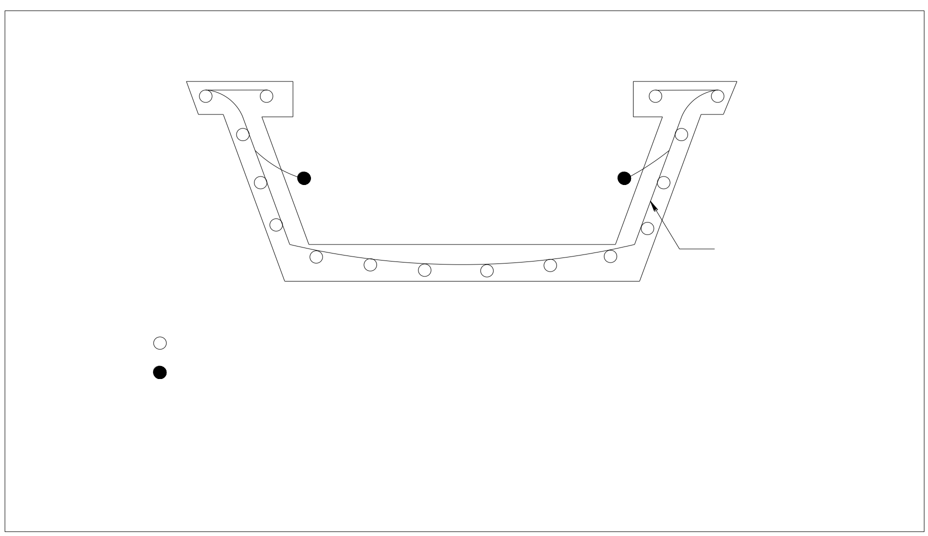
The conceptual scheme of the proposed floating system is described as follows:

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

ii) Stray Current Collector Cables {commonly known as structural earth (SE) cable} (2x185 mm^2 Aluminium) 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 with 120 mm^2 Aluminium 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 10.5.



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.

vi) The third rail installation shall be kept adequately away from the drain for the seepage water in the tunnel section.

The proposed scheme is shown in figure 10.6

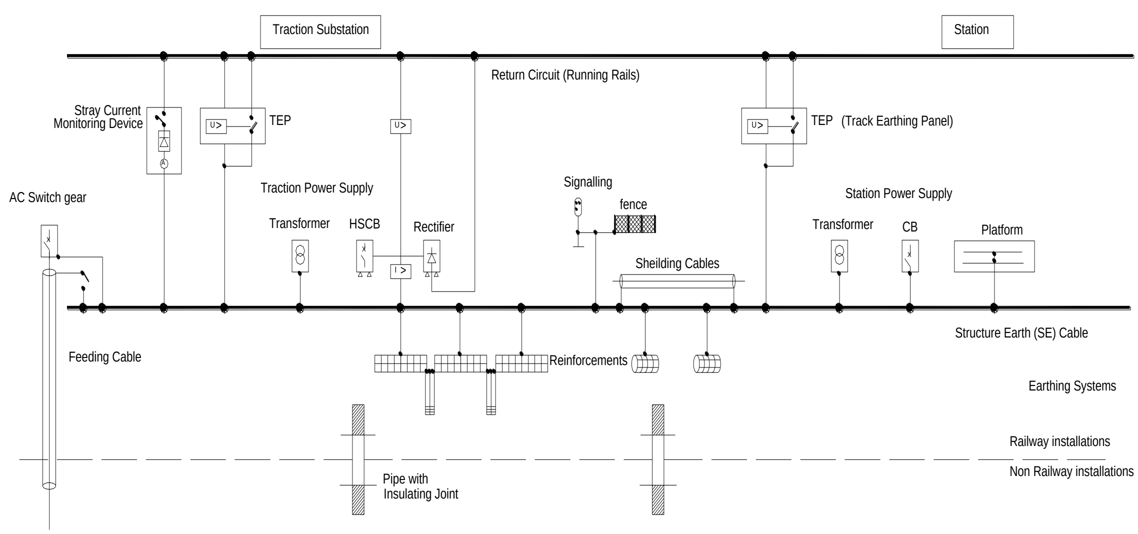


FIGURE 8.6 -- BASIC DIGRAM FOR EARTHING , BONDING AND STRAY CURRENT PROTECTION MEASURES

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

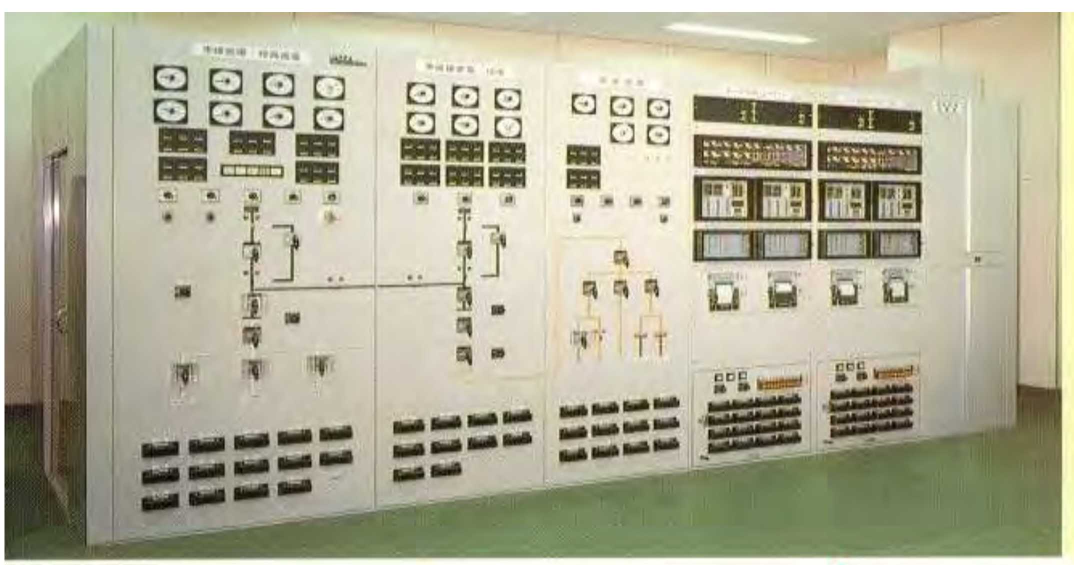
AC traction currents produce alternating magnetic fields that cause voltages to be induced in any conductor running along the track. However, dc traction currents do not cause electromagnetic induction effect resulting in induced voltages and magnetic fields.

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.

10.6.3 Auxiliary Supply Arrangements for Stations

Auxiliary sub-stations (ASS) are envisaged to be provided at each station. The ASS will be located at mezzanine or platform or Ground 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 300 kW for elevated/at-grade stations. Accordingly, two dry type cast resin transformers (33/0.415kV) of 315 kVA capacity are proposed to be installed at the stations (one transformer as standby) for elevated station. 2 x 2.5 MW transformer-rectifier for extension of North-South corridor and its spur up to Airport & Gift city for feeding traction load shall be provided in each TSS with space provisions for an additional set to be accommodated in future as and when the cars per 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.



Typical Indoor Auxiliary Sub-station

10.6.4 Rating of Major Equipment

Based on emergency demand expected at each RSS as shown in Table 10.3, and expected power demand during emergency, RSS near Infocity Station and near Airport Station or near Koba Circle shall be provided with 2 nos. of (One to be in service and one as standby) 132, 66/33 kV, 20 MVA three phase transformers for feeding traction as well as auxiliary loads. The incoming cable 3-phase single core XLPE insulated with 500 mm^2 & 630 mm^2 Aluminum conductors shall be to meet the normal & emergency loading requirements and fault level of the 66 kV & 132 kV supply respectively.

Traction transformer-rectifier set (33 kV/750 V dc) shall be of 2.5 MW (for extension of North-South corridor; Motera Stadium to Mahatma Mandir and for its spurs 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 750 V 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 750 V 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. FRLS Cable for Elevated section. Accordingly, proposed 33kV cables sizes are as under:

> Two runs of 3, Single core x 240 mm^2 Copper conductor (Single run) XLPE insulated for 33kV ring main cable network for extension of North-South Corridor and its spurs.

Adequate no. of cables are required for transfer of power from TSS to third rail. Single-phase XLPE insulated cables with 300 mm^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 Four 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.

10.7 MV/LV SYSTEM

Following major E&M Equipments/system shall be required for elevated stations:-

MV/LV panels
DG set

UPS & Battery system
Lifts (Typical four per station)
Escalators (Typical four per station)
Fire suppression, detection system, Fire Pump and water pump.
Lights & fans
Air conditioning system (VRV)
BMS system
Lightning protection system
Earthing system

Panels shall be front operated front access cubical type indoor duty floor mounted totally enclosed dust and vermin proof with neoprene gaskets fabricated from CRCA sheet with powder coated finish suitable for 415 V 3 Phase 4 wire 50Hz system.

Power for PD area will be given through separate feeder in case of large area is given through station supplies using separate meters for small loads.

10.8 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 180 kVA capacity at the elevated stations to cater to the following essential services:

(i) Essential lighting
(ii) Signaling & telecommunications
(iii) Fire fighting system
(iv) Lift operation
(v) Fare collection system
(vi) Ventilation system
(vii) Smoke management system

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

10.9 SOLAR PHOTO VOLTAIC (PV) POWER SYSTEM

In solar PV power system are installed at various sites in RESCO (Renewable Energy Service Company) model. In DMRC Stations and Depots 17.1 MWp solar PV power system has been installed in RESCO model.

Solar PV Power panel

"RESCO Model" means where the developers intend to provide solar power system on rooftop/sites owned by Metro on mutually agreed terms and conditions from Metro and enters into the PPA (Power purchase agreement) with Metro for supply of Solar power for 25 years from the date of Commissioning of project.

In elevated stations about 50 kWp to 150 kWp capacity of Solar PV power system can be provided depending upon type of roof availability, shadow free roof area, orientation of stations. In DMRC receiving sub-station 20 kWp to 50 kWp capacity Solar PV systems are generally provided. In DMRC Depot area, approx.1000 kWp to 1500 kWp of solar capacity has been provided. Solar PV system in station parking area can also be planned as per availability of area.

10.10 SEWAGE TREATMENT SYSTEM USING INTEGRATED CONSTRUCTED WETLANDS(ICW)

For RSS installation, the sewage shall be connected to the city sewage system if available. If not available, sewage treatment system using integrated constructed wetland (ICW) will be installed. Following are the objectives for providing Sewage Treatment System using Integrated Constructed Wetlands (ICW):-

1) To establish an effective option for treatment of wastewater that is generated from campus.
2) Establish an onsite treatment solution which is effective and cost effective option without producing any by products.
3) To establish a sustainable and environmental friendly solution with minimal maintenance.

4) The treated water can be reused for various non-portable applications landscaping, flushing and cleaning.

The objective of Constructed Wetlands is to utilize the decomposable organic matter present in sewage, which can be disposed of into the environment without causing health hazards or nuisance. The degree of treatment to be adopted would meet the regulatory agencies (surface water discharge standards).

Constructed wetlands (CW) are complex and modular system provides an efficient and sustainable purification treatment method that is applicable to practically all pollutant sources and in all climate and environmental conditions. CW relies on Constructed Wetlands, and is based on the activity of plants together with microorganism communities in the root zone. Together they degrade, accumulate, extract, and volatilize contaminants of all kinds in water, soil and the air, resulting in clean and purified outflow. In DMRC Faridabad RSS 1 KLD capacity Sewage Treatment System provided through integrated constructed wetland method.

10.11 SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA) SYSTEM

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

Digital Protection Control System (DPCS) is proposed for providing data acquisition, data processing, overall protection control, interlocking, inter-tripping and monitoring of the entire power supply system consisting of 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.

10.12 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 benefit of low specific energy consumption and almost unity power factor.

(ii) Rolling stock has regeneration features and it is expected that 18% 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 re-generative braking has been proposed with 3-phase VVVF drive. These lifts are highly energy efficient.

(v) The proposed heavy-duty public services escalators will be provided with 3-phase VVVF drive, which is energy efficient & improves the power factor. Further, the escalators will be provided with infrared sensors to automatically reduce the speed (to idling speed) when not being used by passengers.

(vi) The latest state of art and energy efficient electrical equipment (e.g. transformers, motors, light fittings etc) has been incorporated in the system design.

(vii) Efficient energy management is possible with proposed modern SCADA system by way of maximum demand (MD) and power factor control.

(viii) LED lights to be used in the station area and Depot area.

10.13 ELECTRIC POWER TARIFF

The cost of electricity is a significant part of Operation & Maintenance (O&M) charges of the Metro System, which constitutes about 30-38% of total annual working cost. Therefore, it is the key element for the financial viability of the Project. The annual energy consumption is assessed to be about 27.92 million units for the extension of North-South Corridor, 5.69 million units for its spur (Koteshwar to Airport) and 5.18 Million units for its second spur (GNLU to Gift City) in initial years (2021), which will be about 44.72 Million Units, 6.79 Million Units and 6.18 Million Units in the year 2051 respectively. 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 & 66 kV voltage level) plus nominal administrative Charges i.e. on a no profit no loss basis. The power tariff of Gujarat Electricity Regulatory Commission for the railways for financial Year 2016-17 demand charges Rs.180/kVA/month and energy charges Rs 5.00/kWh. This is expected to be in the range of Rs 5.25 to Rs 5.50 per unit. It is proposed that Government of Gujarat takes necessary steps to fix power tariff for these sections of Ahmedabad Metro at “No Profit No Loss” basis. Similar approach has been adopted for Delhi Metro. For keeping the Electricity cost at the minimum & optimum level, following suggestion are indicated:

Ahmedabad Muncipal Corporation should not levy any municipal taxes on Electricity for Ahmedabad Metro.

DISCOMS to be pursued to give Electricity on cost to serve basis. A separate category of Electricity tariff for Metro system may be finalized by the Regulatory Commission.

DISCOMS shall not object or levy charge/ Gross-subsidy wheeling charges, any other charges etc. if Ahmedabad Metro decides to go for open access to reduce the cost of Energy and thereby the operating expenses of Metro.

For obtaining power connection from DICOMS GSS, Metro normally pays only for the bay commission charges. M/s Torrent has indicated during meeting to charge all expenditure relating to modification/ addition/ alteration will be recovered from the Ahmedabad Metro to this project. This may be dealt by MEGA separately for arriving at a reasonable connection charges.

Chapter – 11

SIGNALLING AND TRAIN CONTROL SYSTEM

11.1 INTRODUCTION

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

This Chapter provides the main design features of the signaling and train control system for the operation of Ahmedabad Phase-II metro corridor from Motera Stadium to Mahatma Mandir and their two extensions from Koteswer Road to Ahmedabad Airport and from GNLU to Gift City corridors taking into account the proven and advance system being used worldwide.

The Proposed North-South Corridor i.e. from Motera Stadium to Mahatma Mandir and their two extensions of Ahmedabad Metro Rail Corridors are planned to be operated at 90 Km/hr.

Koteswar Road and GNLU stations shall be interchange stations and Gyaspur Depot shall be used for Phase II corridor of Ahmedabad Metro Rail Corridor. As per design requirement, the signaling System shall be designed at minimum 90 second headway in one direction.

11.2 SIGNALLING SYSTEM & PSG

The Signalling shall provide the highest safety level to ensure that the operational activities are developed following strict safety requirements. At the same time, it shall meet the requirements for efficient train operations and high quality of service. The proposed signalling system design for metro line corridor is as under:

Continuous Automatic Train Control System (CATC)
Automatic Train Operation System (ATO)
Radio based Automatic Train Control (ATC) System
Automatic Train Protection (ATP) System
On board Equipment
Cab Signalling
Fall-Back Block System
Interlocking device
Track side Radio equipment
Track Vacancy Detection System

Electric Point Machine
Track side Signals
Centralized Traffic Control System
Power Supply of signalling
Cable for signalling
Half Height Integrated Platform Gate (PG)

11.3 OVERVIEW OF SIGNALLING SYSTEM & PSG

It is expected to carry large number of passengers by maintaining shorter spacing between trains requiring a very high level of safety enforcement and reliability. At the same time heavy investment in infrastructure and Rolling stock necessitates optimization of its capacity to provide the best services to the people.

The requirements of the Ahmedabad Metro Corridor planned to be achieved by adopting following basic principles of signalling System: -

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

Computer Based Interlocking System shall be designed on failsafe philosophy. In case of failure of any equipment, the equipment shall fail on safe side or more restrictive state. In such case the signalling System shall authorized movement of train in normal and degraded operations.

Track side equipment shall be connected through Electronic Interlocking (to Station Equipment Room) by secure links to ensure safe movement of train.

Provide high level of safety with trains running at shorter headways ensuring continuous safe train separation.

Eliminate accidents due to driver passing Signal at Danger by continuous speed monitoring and automatic application of brake in case of disregard of signal / warning by the driver.

Provide safety and enforce speed limit on the sections having permanent and temporary speed restrictions.

Improve capacity with safer and smoother operations. Driver will have continuous display of Target Speed in his cab enabling him to optimize the speed potential of the track section. It provides signal / speed status in the cab even in bad weather.

Increased productivity of rolling stock by increasing line capacity and train speeds, and enabling train to arrive at its destination sooner. Hence more trips will be possible with the same number of rolling stock.

Improve maintenance of Signalling and Telecommunication equipment by monitoring System status of trackside and train borne equipment and enabling preventive maintenance.

To avoid any accident at platform, Integrated Passenger Gate shall be provided, which will be a barrier between the track and platform accessible to passengers. Signalling and Rolling Stock interfaces shall be provided for Passenger Gate System.

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

11.4 SYSTEM DESCRIPTION AND SPECIFICATIONS

The requirements of the metro are planned to be achieved by adopting „CATC" (Continuous Automatic Train Control System) based on "CBTC" (Communication based Train Control System) which includes ATP (Automatic Train Protection), ATO (Automatic Train Operation) and ATS (Automatic Train Supervision) sub-systems using radio communication between Track side and Train.

Radio for CBTC shall work in License free ISM band.

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

11.4.1 Continuous Automatic Train Control

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

11.4.2 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.

11.4.3 Automatic Train Operation (ATO)

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

Accelerate and decelerate the train by applying traction power, coasting, and applying and removing brakes.

Automatically control speed, acceleration, preventing unnecessary braking and stopping.

Stop the train at stations.

Provide all indications necessary to operate the train.

Determine continuously the Maximum Safe Speed (MSS) and Limit of Movement Authority (LOMA) with ATP function.

Train doors open indication on the correct side when the train is docked if permitted by the ATP door release.

Prevent the train from starting if train doors are not detected closed.

11.4.4 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.

11.4.5 Automatic Turn Back (ATB)

To minimize the turn back time at terminal and intermediate station, automatic turn back mode is introduced. ATB function is a part of ATO function. At the terminal station or intermediate station the train shall be operated automatically by the on board ATC to the turn back track and back to the terminal station without driver.

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

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

11.4.7 Cut Off Mode

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

11.4.8 Computer Based Interlocking System (CBI)

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

11.4.9 Track Vacancy Detection

Primary mode for track vacancy detection system on main line may be through Radio Ranging Method and for secondary detection, can be through Axle Counter. Secondary detection system shall be used for none CBTC trains/vehicle, fall back operations of CBTC and man detection system.

In view of above advantages and dis- advantages of Axle counter and AFTC Track Circuit, the Axle counters have been used in vital train detection schemes on a large scale in Europe and outside of Europe. Also, an Axle counter is a cost effective alternative to track circuits when applied correctly and are available from several manufacturers. As per site conditions, various advantages & cost effectiveness, Axle counter track detection system is recommended for this section.

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

The axle counter consists of the following equipment: -

Detection Point (or counting head)

Evaluator

11.4.10 Wayside Signals

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

11.4.11 Cab Signalling

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

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

Brake details: distance to first brake application.

Speed information: current train speed, permitted speed, target speed on circular speed gauge with speed pointer preferably with disguise color.

Auxiliary driving information: state of brakes (service brake, emergency brake), state of the connection between the on-board and the track side radio center.

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

11.4.12 Point Machines

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

11.4.13 Train Depot: Signalling

All depot lines except the one which is used for shunting and lines in the workshop shall be interlocked. A workstation shall be provided in the Depot Control Centre for electrical operation of the points, signals and routes of the depot yard. 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.

11.5 SIGNALLING MODE OF OPERATION

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

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

11.6 HALF HEIGHT INTEGRATED PLATFORM GATE (PG)

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

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

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

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

11.7 CENTRALIZED TRAFFIC CONTROL (CTC)

The Railway Operation shall be managed from the Central Traffic Control that located in Operation control Centre (OCC) that is in charge of managing real time traffic, safety of movement, rolling stock, on-board staffing, and work maintenance. The primary objective of the CTC system is to construct the routes of the trains from the origin up to the destination automatically and to supply all the information required to the centralized traffic control operator in order to check the normal operations of the trains. In addition, under its abnormal condition, the CTC system will provide effectively alternatives to minimize the delay of the train.

The CTC system interfaces to the external systems (interlocking, Radio equipment, SCADA, PIDS and PAS, etc.) so as to monitor and control the traffic and to ensure the safe operations of trains.

The CTC system shall meet the following requirements:
The systems and communication lines shall be in redundant configuration and will ensure reliability and safety through continuous operations of the system.
The CTC is interfaced with signalling devices set along the railway line and allow the operator to access different functionalities for traffic management with a man-machine interface (MMI).
MMI allows the command acquisition, alarms display, and the viewing of control images.
Each equipment units used for servers and industrial MMIs will be suitable for the Railway environment with high MTBF. The servers for the CTC shall be self-diagnostic and fault noticing functions.
It shall prepare the emergency situation through the construction of the back-up CTC.
The suitable software for each operator workstation and server is configured to achieve the convenience of the operation.

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

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

A) Operation Room:

The Operational Room is the place from where the operators can monitor and control the traffic on the Line, using dedicated workstations and LDP (Large Display Panel).

B) Central Signalling Equipment Room

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

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

C) Maintenance room

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

D) Power supply room

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

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

The signalling technical room: 40 m2
The maintenance room: 30 m2
The power supply room: 50 m2

At the OCC, BCC and the Depot, the areas required shall be as per the final configuration of the equipment and network configuration keeping space for further expansion. The OCC planned for phase 1 network of Ahmadabad Metro may be used for Phase 2 metro network also.

11.9 BACK UP OF THE OCC (BCC)

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

The BCC planned for phase 1 network of Ahmadabad Metro may be used for Phase 2 metro network also. The BCC shall be similar to OCC and also, BCC shall provide full redundancies of all systems and communications.

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

11.10 STANDARDS

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

Table 11.1

Description	Standards
Interlocking	Computer based Interlocking adopted for station having switches and crossing. All related equipment as far as possible will be centralised in the equipment room at the station. The depot shall be interlocked except for lines mainly used for workshop lines, inspection shed lines etc.
Block Working	Moving Block (CBTC System) working concept may be followed.
Operation of Points	Non-Trailable Electrical Point Machine capable of operating with 3-phase, 50 Hz. 380V AC will be used on main line and the depot point machine will be trailable/ non -trailable type electrical point machine capable of operating with either 3 phases, 50 Hz. 380V AC or 110V DC.
Track Vacancy Detection System	Primary mode for track vacancy detection system on main line and test track (in depot) may be through radio and secondary detection it can be through Axle Counter. In depot,
Signals at Stations with point & crossings	Line Side signals to protect the points (switches). LED type signals for reliability and reduced maintenance cost.
Uninterrupted power Supply at stations as well as for OCC	For Signalling, Telecommunications and AFC.
Train protection system	Train Protection system shall be based on CBTC (Communication based Train Control) System. The system architecture shall provide for redundancy. The system will conform to IEEE 1474 standards.
Train Describer System	Automatic Train Supervision system. Movement of all trains to be logged on to a central computer and displayed on workstations in the Operational Control Centre and at the SCR. Remote control of stations from the OCC. The system architecture shall provide for redundancy.
Fall Back CTC	Backup OCC (BCC)
Platform Gate	Integrated Half Hight Platform Gate System
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

Description	Standards
	implemented for EMC.
Train Working under emergency	Running on site with line side signal with speed automatically restricted between 15-25 Kmph.
Environmental Conditions	Air-conditioners for all equipment rooms.
Maintenance philosophy	Philosophy of continuous monitoring of system status and preventive & corrective maintenance of Signalling equipment shall be followed. Card / module / sub-system level replacement shall be done in the field and repairs under taken in the central laboratory/ manufacturer"s premises.

11.11 SPACE REQUIREMENT FOR SIGNALLING INSTALLATIONS

Adequate space for proper installations of all Signalling equipment and Platform screen doors at each of the stations has to be provided keeping in view the case of maintenance and use of instrumentation set up for regular testing and line up of the equipment/system.

The areas required at Interlocking stations for Signalling Equipment Room shall be generally 40 sqm. For UPS Room (common for signalling, AFC and Telecom) at each of the stations the area required 50 sqm. For Non-interlocking stations, Signalling Equipment can be installed in the Telecommunication Room available at that station.

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

11.12 MAINTENANCE PHILOSOPHY FOR SIGNALLING SYSTEMS

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

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

Chapter – 12

TELECOMMUNICATION AND AUTOMATIC FARE COLLECTION SYSTEMS

12.0 TELECOMMUNICATION SYSTEM

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 operation of trains:

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

The proposed Telecom system will cater to the following requirements:

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

12.3 TELECOMMUNICATION SYSTEM AND TRANSMISSION MEDIA

12.3.1 Fibre Optic System (FOTS) - Main Telecommunication Bearer

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

Additional 244 fiber optical fiber cables may be laid along track as per present commercial requirement for revenue.

12.3.2 Gigabit Ethernet Network (WAN)

A totally IP Based High Capacity, highly reliable and fault tolerant, MPLS Ethernet Network can be provided in lieu of SDH/MUX. IP network shall have important data therefore the network requires high reliability. Considering the rapidly increased demand during the operation for top-level backbone network to 10 Gbps Equipment is proposed. The communications network shall be configured as LAN and WAN – LAN shall be responsible for train operations and maintenance tasks within each passenger station and WAN shall be responsible for mutual communications between the stations and between depot and the central computer system. To maximize the reliability and survivability, each equipment and each transmission line are configured as a dual system.

Redundant Layer-3, Layer-2 switches and Routers at each station, depot & OCC shall be provided to meet requirement of other Telecom systems (like CCTV, ticketing system maintenance management system and Wi-Fi network at station, PA, Clock, PIDS , Telephone System, SCADA etc) and to support comparatively unimportant facilities for the operation.

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

12.3.3 Synchronization Network

The equipment receives standard synchronous signals from upper level stations or GPS at OCC, creates a synchronous clock, and then supplies synchronous signals to various digital communication equipments and lower level stations. 1+1 or N:1 protection switching functions are provided for the synchronous signal outputs.

The GPS receiver, standard input receiver, clock generator, and channel parts are into complete duplexes. In case of malfunctioning of any of these units, 1+1 non-blocking automatic switching is executed to minimize negative impact on services. This automatic switching provides reliability and stability. Clock reception signal for each equipment should be 2.048Mbps or 2.048MHz Clock signal. Clock synchronization mode shall be External Clock, Loop Timing Clock, Free-run, Holdover Clock.

The DOTS shall be configured to receive GPS signals through GPS satellites. Along with the DOTS, Network Time Servers (NTS) are also installed at OCC. NTS provides standard clocks to all Metro systems. NTS of each station is physically configured as a dual.

12.4 TELEPHONE EXCHANGE

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

12.5 MOBILE RADIO COMMUNICATION

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

The frequency band for operation of the system will be in 400/800 MHz band, depending on frequency availability. The system shall provide instant mobile radio communication between the motorman of the moving cars from any place and the Central Control. The motorman can also contact any station in the network through the central control, besides intimating the approaching trains about any emergency like accident, fire, line blocked etc., thus improving safety performance.
To provide adequate coverage, based on the RF site survey to be carried out during detailed Design stage, base stations for the system will be located at sites conveniently selected after detailed survey. Tentatively minimum 7 sites with rooftop

towers with Base Stations shall be required along the proposed North-South Corridor and their two extensions of Ahmedabad Metro Rail corridor.

12.6 PASSENGER ANNOUNCEMENT SYSTEM (PAS)

The PAS shall be provided to broadcast voice messages to passengers /staff in all stations/ Depot from the locally as well as from OCC. It includes a network of amplifier and speakers linked to the station. The system capable of announcements from Station level will have over-riding priority in case of emergency announcements. The System shall be linked to Signalling System for automatic train actuated announcements.

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

12.7 PASSENGER INFORMATION DISPLAY SYSTEM (PIDS)

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

12.8 CENTRALIZED CLOCK SYSTEM

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

12.9 CLOSED CIRCUIT TELEVISION (CCTV) SYSTEM

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

The CCTV System shall be end to end IP based Full HD IP cameras using backbone of FOTS WAN network and shall consist of a mix of Fixed Cameras and

Pan/Tilt/Zoom (PTZ) Cameras. Cameras shall be extended /located at areas where monitoring for security, safety and crowd control purpose is necessary. All Videos shall be extended at Video Wall located at security control room at OCC.

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

12.10 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 Authorized Personnel of the Metro. The System Shall be controlled and monitored centrally from the OCC.

12.11 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.

12.12 TECHNOLOGY

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

Table 12.1 TECHNOLOGIES FOR TELECOMMUNICATION SYSTEMS

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

System	Standards
	running trains, and also special messages in emergencies.
Centralized clock System	Accurate display of time through a synchronization system of slave clocks driven from a GPS master clock at the OCC and sub – master clock in station. This shall also be used for synchronization other systems.
Passenger Announcement System	Passenger Announcement System covering all platform and concourse areas with local as well as Central Announcement.
Redundancy (Major System)	Redundancy on Radio's in the Base Stations, Path Redundancy for Optical Fibre Cable by provisioning in ring configuration.
Environmental Conditions	All equipment rooms to be air-conditioned.
Maintenance Philosophy	System to have, as far as possible, automatic switching facility to alternate routes/circuits in the event of failure. Philosophy of preventive checks of maintenance to be followed. System networked with NMS for diagnosing faults and co-ordination. Card/module level replacement shall be done in the field and repairs undertaken in the central laboratory/manufacture's premises.

12.13 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 40 sqm each for Telecom Room (Common for Signaling & Telecom equipment at non-interlocking stations) and 40 sqm. For UPS Room (common for signal, Telecom and AFC). These areas shall also cater to local storage and space for maintenance personnel to work.

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

12.14 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.

12.15 AUTOMATIC FARE COLLECTION SYSTEM

Introduction

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

AFC system proves to be cheaper than semi-automatic (Manual System) in long run due to reduced manpower cost of ticketing staff, reduced maintenance in comparison to paper ticket machines, overall less cost of recyclable tickets (Smart Card / Token) in comparison to paper tickets and prevention of leakage of revenue. Relative advantages of automatic fare collection system over manual system are as follows.
Seamless ticketing is now being thought of for Ahmedabad Metro Rail. This system is recommended to be adopted as this will enable the commuters to travel hassle free by different modes of transport viz. Metro, suburban trains, buses, water transport (whenever introduced) and even taxies without purchasing multiple tickets for each mode separately.

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

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

B. Automatic fare collection systems have the following advantages:

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

8. AFC systems are the world wide accepted systems for Metro environment.

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

As per Metro Rail Policy 2017, it is mandatory to involve PPP in some form for implementation/ Operation & Maintenance, Fare Collection, etc. It has been proposed that AFC component for all 22 stations may be given on PPP basis in this project. The cost of above may be funded by engaging concessionaire in line with Kochi Metro, Nagpur Metro, etc.

12.16 GATE

Retractable Flap Type/Paddle Type Control Gates are proposed which offer high throughput, require less maintenance and are latest in modern systems.

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

12.16.1 Gate Function

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

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

12.16.2 Features

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

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

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

12.16.3 Types of Gates

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

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

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

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

12.16.4 Spacing

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

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

12.16.5 Gate Enclosure

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

12.16.6 Tail Gating Prevention

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

12.17 TICKET VENDING MACHINE (TVM) & SELF-SERVICE TICKETING KIOSKS

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

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

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

12.17.1 Function

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

12.17.2 Physical

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

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

12.18 TYPES OF TICKET

- **(a)** The system shall provide, or be capable of processing, the following types of ticket:
  - Single Journey Ticket (SJT)
  - Daily Pass
  - Staff/Employee Pass (EP)
  - Stored Value (SV) (at least 16 configurable types)
  - Period Pass (PP)
- **(b)** Each ticket type shall be capable of being associated with at least four fare tables (One full fare and two concession fares).

12.18.1 Ticket Media

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

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

(b) Other Media (for Single Journey Tickets)
Media for Single Journey Tickets shall be determined by the Contractor, which can be a token. Choice of SJT media shall take financial and usage constraints into account.

12.18.2 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.

12.18.3 Recharge Card Terminal Machine (RCTM)

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

12.19 SECURITY

12.19.1 Revenue Protection

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

12.19.2 Revenue Security

(a) The AFC machines and system shall provide a complete audit trail of all transactions, transfers of cash and other payments.

(b) Cash handling equipment and systems shall be an integral part of the audit trail.

(c) Data & Revenue Security shall be ensured by a Key Management System (KMS) which needs to issue a Hardware SAM for each AFC equipment in use in the system. The SAM shall be used to authenticate the equipment and the transaction integrity.

12.19.3 Data Security

(a) In the event the SC fails, each item of equipment shall be able to operate autonomously without loss of data.

(b) Security of communications between the AFC equipment, SC and CC system shall ensure no loss of data in transmission.

12.20 STATION COMPUTER (SC)

a) Station Computer (SC) enables the overall control and monitoring of each item of AFC equipment within the station and transfer of data to the Central Computer (CC).

b) The SC shall include the power and data communication links to each item of AFC equipment and CC system interface.

c) It shall enable printing of reports at stations. The reports shall include accounting and statistical information. It shall include any other reports required for AFC operation.

- **d)** The SC shall be able to download data to the AFC machines individually or as groups.
- **e)** The SC shall receive maintenance data from AFC equipment and transmit the same to CC for monitoring and use of the same as an effective maintenance tool.
- **f)** The SC shall be able to monitor certain critical functions of the AFC system and collect data for warnings and alarms.
- **g)** If there is loss of communication between the SC and AFC equipment (Gates, TOM etc.) then the equipment shall operate in stand-alone mode utilizing the most recent data from the SC. AFC equipment (Gates, TOM etc.) shall store data up to seven days for transmission when SC communication is restored.
- **h)** In the event of loss of communication with the CC the SC shall utilize the most recent operational data received from the CC and shall be capable of storing at least thirty days of transaction data.

12.20.1 Equipment Control

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

12.21 CENTRAL COMPUTER SYSTEM

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

- **a)** The Central Computer System (CC) shall collect and analyze information received from the station computers. It shall produce network-wide revenue and traffic data and monitor the performance of all AFC equipment.
- **b)** A Central Computer (CC) System shall generate the necessary management reports from the CST, CSC and transaction information received from the Station Computer Systems..
- **c)** The CC shall hold and download CST and CSC parameters, Configuration Data (CD), AFC device software and fare table information to each SC from where they shall be distributed to the station AFC equipment.
- **d)** The CC shall automatically collate all CST, CSC and usage data (UD) from the SC to provide accurate audit and traffic statistics for the line.
- **e)** The CC shall be located in a dedicated computer room in the Administration Building or Operations Control Centre.
- **f)** The CC shall maintain a blacklist of invalid tickets. Blacklisted tickets shall be rejected by the AFC Gates.
- **g)** The CC shall support a Fare Table with adequate number of stations.

12.22 AFC EQUIPMENT REQUIREMENT

The AFC equipment required at various locations of Ahmedabad Metro Corridor (APMC to Mahatma Mandir) and extensions are tabulated at Annexure 1 for projection years 2021, 2031, 2041 & 2051.
However, the exact number and type shall depend on the final station layout and traffic being catered to.

12.23 STANDARDS

The standard proposed for AFC systems are as under:

Table 12.2

Standards	Description
Fare media	a) Contactless Smart Token – For single journey. Token are captured at the exit gate. b) Contactless Smart Card – For multiple journeys. Contactless readers shall be as per ISO 14443 standards.
Gates	Computer controlled retractable flap / turnstile type automatic gates at entry and exit. There will be following types of gates : - Entry - Exit - Reversible
Station computer, central computer and AFC Network	All the Fare Collection Equipment shall be connected in a local area network with a station server controlling the activities of all the machines. The station servers will be linked to the AFC central computer situated in the operational control center through the optic fiber communication channels. The centralized control of the system shall provide real time data of earnings, passenger flow analysis, blacklisting of specified cards etc.
Ticket office machine(TOM/ EFO)	Manned Ticked Office Machines shall be installed in the station for selling cards / token to the passengers. Also TVM's shall be provided for Automatic Ticket Vending.
Ticket Readers	Ticket Reader shall be installed near EFO for passengers to check information stored in the token / cards.
Portable ticket decoder(PTD)	PTD will be used to check the card/token during travel
Recharge card terminal machine	RCTM will be used to recharge the card using bank note/debit card/credit card/pre paid card
UPS	Common UPS of S&T system will be utilized.
Maintenance philosophy	Being fully Contactless system, manpower requirement for maintenance is much less compared to system with magnetic tickets. However, adequate facilities to be provided similar to that of S & T systems.

12.24 INTEGRATION OF AFC WITH OTHER LINES AND MODES OF TRANSPORT

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

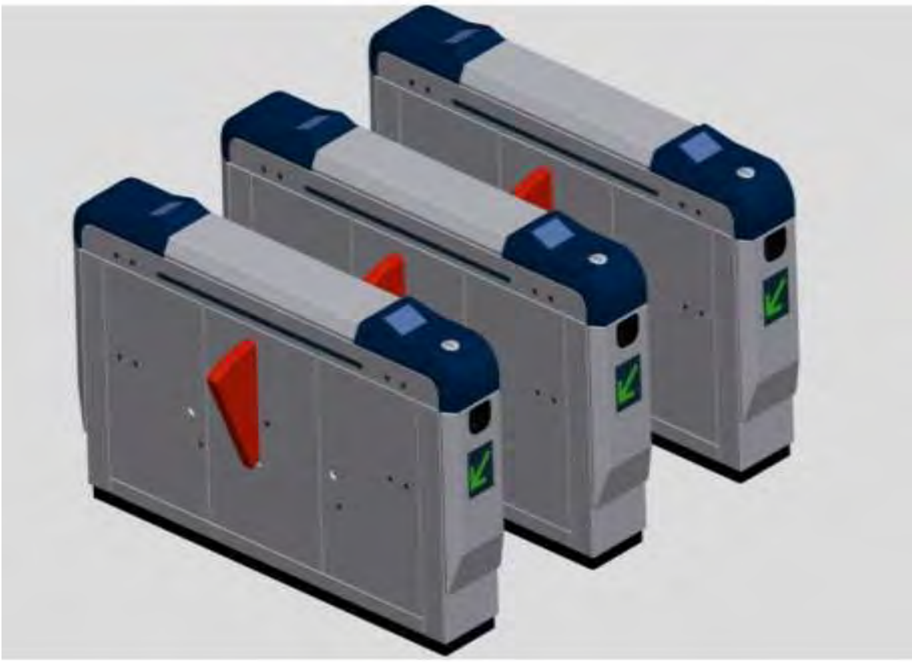


Fig 12.1 Entry/Exit Gates

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

Fig 12.2: Ticket Office Machine

Fig 12.3: Ticket vending machine

Fig. 12.4 Ticket Reader/Add Value Machine

Annexure 1

(A) AFC Equipments for Ahmedabad Metro Corridor from APMC to Mahatma Mandir (Projection for 2021)

Sr. No.	Station Name	Hourly Boarding	Hourly Alighting	Peak min. Boarding	Peak min. Alighting	Entry Gate	Exit Gate	TOM	EFO	TR	TVM	RCTM
1	APMC	1,942	1,145	32	19	2	2	2	2	4	2	2
2	Jivraj	2,316	1,619	39	27	2	2	2	2	4	2	2
3	Rajiv nagar	473	997	8	17	2	2	2	2	4	2	2
4	Shreyash	573	858	10	14	2	2	2	2	4	2	2
5	Paldi	2,215	2,397	37	40	2	2	2	2	4	2	2
6	Gandhigram rly stn	638	2,242	11	37	2	2	2	2	4	2	2
7	Old high court	7,109	8,684	118	145	5	6	6	2	4	2	2
8	Ushmanpura	284	489	5	8	2	2	2	2	4	2	2
9	Vijay nagar	1,882	1,291	31	22	2	2	2	2	4	2	2
10	New vadaj	2,238	1,319	37	22	2	2	2	2	4	2	2
11	Ranip	652	550	11	9	2	2	2	2	4	2	2
12	Sabarmati Rly stn	1,428	1,077	24	18	2	2	2	2	4	2	2
13	AEC	208	234	3	4	2	2	2	2	4	2	2
14	Sabarmati	610	520	10	9	2	2	2	2	4	2	2
15	Motera Stadium	457	243	8	4	2	2	2	2	4	2	2
16	Koteshwar Road	1,730	958	29	16	2	2	2	2	4	2	2
17	Vishwakarma College	319	164	5	3	2	2	2	2	4	2	2
18	Tapovan Circle	489	451	8	8	2	2	2	2	4	2	2
19	Narmada Canal	118	67	2	1	2	2	2	2	4	2	2
20	Koba Circle	383	198	6	3	2	2	2	2	4	2	2
21	Juna Koba	44	27	1	0	2	2	2	2	4	2	2
22	Koba Gaam	88	49	1	1	2	2	2	2	4	2	2
23	GNLU	805	989	13	16	2	2	2	2	4	2	2
24	Raysan	138	79	2	1	2	2	2	2	4	2	2

Sr. No.	Station Name	Hourly Boarding	Hourly Alighting	Peak min. Boarding	Peak min. Alighting	Entry Gate	Exit Gate	TOM	EFO	TR	TVM	RCTM
25	Randesan	165	107	3	2	2	2	2	2	4	2	2
26	Dholakuva Circle	349	290	6	5	2	2	2	2	4	2	2
27	Infocity	146	138	2	2	2	2	2	2	4	2	2
28	Sector - 1	261	146	4	2	2	2	2	2	4	2	2
29	Sector 10A	241	469	4	8	2	2	2	2	4	2	2
30	Sachivalaya	63	645	1	11	2	2	2	2	4	2	2
31	Akshardham	420	427	7	7	2	2	2	2	4	2	2
32	Juna Sachivalaya	356	263	6	4	2	2	2	2	4	2	2
33	Sector - 16	281	383	5	6	2	2	2	2	4	2	2
34	Sector - 24	553	788	9	13	2	2	2	2	4	2	2
35	Mahatma Mandir	620	297	10	5	2	2	2	2	4	2	2
	Total					**73**	**74**	**74**	**70**	**140**	**70**	**70**

GNLU towards GIFT city Corridor

Sr. No.	Station Name	Hourly Boarding	Hourly Alighting	Peak min. Boarding	Peak min. Alighting	Entry Gate	Exit Gate	TOM	EFO	TR	TVM	RCTM
1	GNLU	638	476	11	8	2	2	2	2	4	2	2
2	PDPU	219	125	4	2	2	2	2	2	4	2	2
3	Gift City	324	579	5	10	2	2	2	2	4	2	2

Koteshwar road to Airport corridor

Sr. No.	Station Name	Hourly Boarding	Hourly Alighting	Peak min. Boarding	Peak min. Alighting	Entry Gate	Exit Gate	TOM	EFO	TR	TVM	RCTM
1	GNLU	525	801	9	13	2	2	2	2	4	2	2
2	PDPU	784	472	13	8	2	2	2	2	4	2	2
3	Gift City	26	62	0	1	2	2	2	2	4	2	2

(B) AFC Equipments for Ahmedabad Metro Corridor from APMC to Mahatma Mandir (Projection for 2031)

Sr. No.	Station Name	Hourly Boarding	Hourly Alighting	Peak min. Boarding	Peak min. Alighting	Entry Gate	Exit Gate	TOM	EFO	TR	TVM	RCTM
1	APMC	2,154	1,387	36	23	2	2	2	2	4	2	2
2	Jivraj	3,059	1,943	51	32	2	2	3	2	4	2	2
3	Rajiv nagar	459	926	8	15	2	2	2	2	4	2	2
4	Shreyash	589	907	10	15	2	2	2	2	4	2	2
5	Paldi	2,206	2,201	37	37	2	2	2	2	4	2	2
6	Gandhigram rly stn	749	2,441	12	41	2	2	2	2	4	2	2
7	Old high court	10,637	13,078	177	218	7	9	9	2	4	2	2
8	Ushmanpura	421	557	7	9	2	2	2	2	4	2	2
9	Vijay nagar	2,064	1,671	34	28	2	2	2	2	4	2	2
10	New vadaj	2,443	1,616	41	27	2	2	2	2	4	2	2
11	Ranip	762	665	13	11	2	2	2	2	4	2	2
12	Sabarmati Rly stn	2,021	1,569	34	26	2	2	2	2	4	2	2
13	AEC	325	361	5	6	2	2	2	2	4	2	2
14	Sabarmati	711	639	12	11	2	2	2	2	4	2	2
15	Motera Stadium	800	297	13	5	2	2	2	2	4	2	2
16	Koteshwar Road	2,088	1,328	35	22	2	2	2	2	4	2	2
17	Vishwakarma College	314	220	5	4	2	2	2	2	4	2	2
18	Tapovan Circle	833	744	14	12	2	2	2	2	4	2	2
19	Narmada Canal	288	111	5	2	2	2	2	2	4	2	2
20	Koba Circle	696	313	12	5	2	2	2	2	4	2	2
21	Juna Koba	90	35	2	1	2	2	2	2	4	2	2
22	Koba Gaam	127	82	2	1	2	2	2	2	4	2	2
23	GNLU	1,921	1,655	32	28	2	2	2	2	4	2	2
24	Raysan	175	106	3	2	2	2	2	2	4	2	2
25	Randesan	238	173	4	3	2	2	2	2	4	2	2

Sr. No.	Station Name	Hourly Boarding	Hourly Alighting	Peak min. Boarding	Peak min. Alighting	Entry Gate	Exit Gate	TOM	EFO	TR	TVM	RCTM
26	Dholakuva Circle	459	459	8	8	2	2	2	2	4	2	2
27	Infocity	233	155	4	3	2	2	2	2	4	2	2
28	Sector - 1	399	224	7	4	2	2	2	2	4	2	2
29	Sector 10A	325	639	5	11	2	2	2	2	4	2	2
30	Sachivalaya	79	867	1	14	2	2	2	2	4	2	2
31	Akshardham	558	601	9	10	2	2	2	2	4	2	2
32	Juna Sachivalaya	421	352	7	6	2	2	2	2	4	2	2
33	Sector - 16	379	624	6	10	2	2	2	2	4	2	2
34	Sector - 24	680	1,129	11	19	2	2	2	2	4	2	2
35	Mahatma Mandir	841	468	14	8	2	2	2	2	4	2	2
	Total					**75**	**77**	**78**	**70**	**140**	**70**	**70**

GNLU towards GIFT city Corridor

Sr. No.	Station Name	Hourly Boarding	Hourly Alighting	Peak min. Boarding	Peak min. Alighting	Entry Gate	Exit Gate	TOM	EFO	TR	TVM	RCTM
1	GNLU	1,217	1,326	20	22	2	2	2	2	4	2	2
2	PDPU	447	292	7	5	2	2	2	2	4	2	2
3	Gift City	1,110	1,156	19	19	2	2	2	2	4	2	2

Koteshwar road to Airport corridor

Sr. No.	Station Name	Hourly Boarding	Hourly Alighting	Peak min. Boarding	Peak min. Alighting	Entry Gate	Exit Gate	TOM	EFO	TR	TVM	RCTM
1	GNLU	851	1,062	14	18	2	2	2	2	4	2	2
2	PDPU	1,044	784	17	13	2	2	2	2	4	2	2
3	Gift City	27	76	0	1	2	2	2	2	4	2	2

(C) AFC Equipments for Ahmedabad Metro Corridor from APMC to Mahatma Mandir (Projection for 2041)

Sr. No.	Station Name	Hourly Boarding	Hourly Alighting	Peak min. Boarding	Peak min. Alighting	Entry Gate	Exit Gate	TOM	EFO	TR	TVM	RCTM
1	APMC	2,590	1,676	43	28	2	2	2	2	4	2	2
2	Jivraj	3,805	2,393	63	40	3	2	3	2	4	2	2
3	Rajiv nagar	554	1,109	9	18	2	2	2	2	4	2	2
4	Shreyash	700	1,082	12	18	2	2	2	2	4	2	2
5	Paldi	2,632	2,629	44	44	2	2	2	2	4	2	2
6	Gandhigram rly stn	891	2,902	15	48	2	2	2	2	4	2	2
7	Old high court	13,347	16,204	222	270	9	11	11	2	4	2	2
8	Ushmanpura	503	665	8	11	2	2	2	2	4	2	2
9	Vijay nagar	2,485	2,014	41	34	2	2	2	2	4	2	2
10	New vadaj	2,919	1,957	49	33	2	2	2	2	4	2	2
11	Ranip	906	793	15	13	2	2	2	2	4	2	2
12	Sabarmati Rly stn	2,407	1,875	40	31	2	2	2	2	4	2	2
13	AEC	386	431	6	7	2	2	2	2	4	2	2
14	Sabarmati	844	763	14	13	2	2	2	2	4	2	2
15	Motera Stadium	949	354	16	6	2	2	2	2	4	2	2
16	Koteshwar Road	2,577	1,730	43	29	2	2	2	2	4	2	2
17	Vishwakarma College	372	262	6	4	2	2	2	2	4	2	2
18	Tapovan Circle	1,330	1,155	22	19	2	2	2	2	4	2	2
19	Narmada Canal	499	200	8	3	2	2	2	2	4	2	2
20	Koba Circle	1,132	524	19	9	2	2	2	2	4	2	2
21	Juna Koba	157	64	3	1	2	2	2	2	4	2	2
22	Koba Gaam	164	106	3	2	2	2	2	2	4	2	2
23	GNLU	2,542	2,200	42	37	2	2	2	2	4	2	2
24	Raysan	260	158	4	3	2	2	2	2	4	2	2
25	Randesan	386	302	6	5	2	2	2	2	4	2	2

Sr. No.	Station Name	Hourly Boarding	Hourly Alighting	Peak min. Boarding	Peak min. Alighting	Entry Gate	Exit Gate	TOM	EFO	TR	TVM	RCTM
26	Dholakuva Circle	739	756	12	13	2	2	2	2	4	2	2
27	Infocity	346	232	6	4	2	2	2	2	4	2	2
28	Sector - 1	597	336	10	6	2	2	2	2	4	2	2
29	Sector 10A	499	963	8	16	2	2	2	2	4	2	2
30	Sachivalaya	118	1,295	2	22	2	2	2	2	4	2	2
31	Akshardham	842	923	14	15	2	2	2	2	4	2	2
32	Juna Sachivalaya	626	524	10	9	2	2	2	2	4	2	2
33	Sector - 16	605	987	10	16	2	2	2	2	4	2	2
34	Sector - 24	1,058	1,757	18	29	2	2	2	2	4	2	2
35	Mahatma Mandir	1,301	747	22	12	2	2	2	2	4	2	2
	Total					**78**	**79**	**80**	**70**	**140**	**70**	**70**

GNLU towards GIFT city Corridor

Sr. No.	Station Name	Hourly Boarding	Hourly Alighting	Peak min. Boarding	Peak min. Alighting	Entry Gate	Exit Gate	TOM	EFO	TR	TVM	RCTM
1	GNLU	1,632	1,766	27	29	2	2	2	2	4	2	2
2	PDPU	599	389	10	6	2	2	2	2	4	2	2
3	Gift City	1,458	1,534	24	26	2	2	2	2	4	2	2

Koteshwar road to Airport corridor

Sr. No.	Station Name	Hourly Boarding	Hourly Alighting	Peak min. Boarding	Peak min. Alighting	Entry Gate	Exit Gate	TOM	EFO	TR	TVM	RCTM
1	GNLU	1,113	1,328	19	22	2	2	2	2	4	2	2
2	PDPU	1,307	1,033	22	17	2	2	2	2	4	2	2
3	Gift City	32	90	1	2	2	2	2	2	4	2	2

(D) AFC Equipments for Ahmedabad Metro Corridor from APMC to Mahatma Mandir (Projection for 2051)

Sr. No.	Station Name	Hourly Boarding	Hourly Alighting	Peak min. Boarding	Peak min. Alighting	Entry Gate	Exit Gate	TOM	EFO	TR	TVM	RCTM
1	APMC	2,870	1,877	48	31	2	2	2	2	4	2	2
2	Jivraj	4,283	2,730	71	46	3	2	4	2	4	2	2
3	Rajiv nagar	616	1,237	10	21	2	2	2	2	4	2	2
4	Shreyash	775	1,202	13	20	2	2	2	2	4	2	2
5	Paldi	2,920	2,932	49	49	2	2	2	2	4	2	2
6	Gandhigram rly stn	988	3,242	16	54	2	2	2	2	4	2	2
7	Old high court	15,493	18,593	258	310	10	12	13	2	4	2	2
8	Ushmanpura	558	742	9	12	2	2	2	2	4	2	2
9	Vijay nagar	2,959	2,312	49	39	2	2	2	2	4	2	2
10	New vadaj	3,576	2,354	60	39	2	2	3	2	4	2	2
11	Ranip	1,002	882	17	15	2	2	2	2	4	2	2
12	Sabarmati Rly stn	2,706	2,101	45	35	2	2	2	2	4	2	2
13	AEC	426	479	7	8	2	2	2	2	4	2	2
14	Sabarmati	942	855	16	14	2	2	2	2	4	2	2
15	Motera Stadium	1,049	394	17	7	2	2	2	2	4	2	2
16	Koteshwar Road	3,259	2,163	54	36	2	2	3	2	4	2	2
17	Vishwakarma College	412	291	7	5	2	2	2	2	4	2	2
18	Tapovan Circle	1,653	1,447	28	24	2	2	2	2	4	2	2
19	Narmada Canal	603	243	10	4	2	2	2	2	4	2	2
20	Koba Circle	1,476	686	25	11	2	2	2	2	4	2	2
21	Juna Koba	189	78	3	1	2	2	2	2	4	2	2
22	Koba Gaam	214	140	4	2	2	2	2	2	4	2	2
23	GNLU	3,240	2,887	54	48	2	2	3	2	4	2	2
24	Raysan	341	208	6	3	2	2	2	2	4	2	2
25	Randesan	499	399	8	7	2	2	2	2	4	2	2

Sr. No.	Station Name	Hourly Boarding	Hourly Alighting	Peak min. Boarding	Peak min. Alighting	Entry Gate	Exit Gate	TOM	EFO	TR	TVM	RCTM
26	Dholakuva Circle	962	996	16	17	2	2	2	2	4	2	2
27	Infocity	419	284	7	5	2	2	2	2	4	2	2
28	Sector - 1	783	444	13	7	2	2	2	2	4	2	2
29	Sector 10A	657	1,274	11	21	2	2	2	2	4	2	2
30	Sachivalaya	151	1,709	3	28	2	2	2	2	4	2	2
31	Akshardham	1,045	1,195	17	20	2	2	2	2	4	2	2
32	Juna Sachivalaya	820	694	14	12	2	2	2	2	4	2	2
33	Sector - 16	733	1,235	12	21	2	2	2	2	4	2	2
34	Sector - 24	1,340	2,329	22	39	2	2	2	2	4	2	2
35	Mahatma Mandir	1,660	989	28	16	2	2	2	2	4	2	2
	Total					**79**	**80**	**86**	**70**	**140**	**70**	**70**

GNLU towards GIFT city Corridor

Sr. No.	Station Name	Hourly Boarding	Hourly Alighting	Peak min. Boarding	Peak min. Alighting	Entry Gate	Exit Gate	TOM	EFO	TR	TVM	RCTM
1	GNLU	2,149	2,261	36	38	2	2	2	2	4	2	2
2	PDPU	782	513	13	9	2	2	2	2	4	2	2
3	Gift City	1,871	2,028	31	34	2	2	2	2	4	2	2

Koteshwar road to Airport corridor

Sr. No.	Station Name	Hourly Boarding	Hourly Alighting	Peak min. Boarding	Peak min. Alighting	Entry Gate	Exit Gate	TOM	EFO	TR	TVM	RCTM
1	GNLU	1,369	1,668	23	28	2	2	2	2	4	2	2
2	PDPU	1,646	1,281	27	21	2	2	2	2	4	2	2
3	Gift City	35	101	1	2	2	2	2	2	4	2	2

Assumptions:

A. Each Station has only 2 access

B. Minimum AFC equipments at a station with "2 access-1 for entry, 1 for exit": 2 entry gates, 2 exit gates, 2 EFO, 2 TOM, 4 AVM/TR, 2 TVM

C. Throughput of gate: 25 passengers per minute, TOM: One per access

D. 50% passenger are assumed on Smart card and 50% on single journey token

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 (Fig. 13.4);

Have non-slip and level flooring;

Have seating areas for people with ambulatory disabilities;

Be well illuminated lux level 35 to 40;

There should be no gap or difference in level between the train entry door and the platform.

All platforms should inter-connect by means of an accessible routes or lifts; and provide accessible level entrance to the train coach.

6. WAY FINDING

Way finding references should be available at decision points.

Colour can be used to identify routes and provide assistance in locating doors, walls and hazards. Proper colour contrast between different elements greatly improves visibility for all users and is critical for persons with low vision. For example, colour contrasting of door frames can assist in locating doors, and likewise floors should be contrasted with walls. In addition, furniture should contrast with walls and floors so as not to create an obstacle.

Structural elements such as columns should be colour contrasted or brightly marked so as to be visible to those who may have a visual disability.

Generally, patterns on flooring should be avoided or else should be minimal and small to avoid visual confusion.

In addition to identifying hazards or warnings, tactile floor surfaces can also be used to inform that there is a change in area (e.g. leaving a corridor and entering a boarding area).

Tactile systems should be consistent throughout the building. For example, terminals should not have carpeting in some boarding areas and tile in others as this may create confusion for those who rely on tactile surfaces to guide them to their destination.

Good lighting assists those with a visual disability to see better and allows people who have a hearing impairment to lip read easier. However, care should be taken to properly direct lighting and to use matte finishes on floors, walls and signage, so as not to create glare which may create difficulties for all travellers.

Blinds can be used to adjust lighting levels in areas where the natural lighting changes significantly throughout the day.

7. SIGNAGE

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

8. SIGN DESIGN SPECIFICATIONS

The sign should be in a prominent position.

The face of the sign should be well-illuminated by natural or artificial light.

Letters should be simple such as Arial, Helvetica medium, and san serif or similar and numbers should be Arabic.

The colour of the text should be in a colour that contrasts with the sign board.

The sign board should also contrast with the wall on which it is mounted.

The surface of the sign should not be reflective.

Some signs such as those adjacent to or on a toilet door may be embossed so that they can be read by touch.

Illuminated signs should not use red text on a dark background.

Signs should be supplemented by Braille where possible.

Fig. 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 audio-visual displays that are capable of displaying captions and that are located in any portion of the terminal.

The captioning must be in high contrast for all information concerning travel safety, ticketing, check-in, delays or cancellations, schedule changes, boarding information, connections, checking baggage, individuals being paged by bus railway or airlines, vehicle changes that affect the travel of persons with disabilities, and emergencies (*e.g.*, fire, bomb threat).

12. REST AREAS/SEATING

Seating area / benches should be provided along the circulation path at regular intervals so that passengers do not need to walk more than 50 to 60 metres before being able to sit and rest.

Where seating is provided, designated seating for passengers with disabilities is to be provided at boarding gates and departure areas within viewing distance of communication boards and/or personnel and identified by the symbol of access.

Public transit operators should provide seating in passenger service areas where there may be long waiting lines or times, including at ticket sales counters, check-in counters, secured screening and during inter-country travel in customs areas and baggage retrieval areas.

Designated seating should be provided for at boarding gates and departure areas within viewing distance of communication boards, and within hearing range of audio announcements as well. Such seating areas should be identified by the symbol of accessibility and shelter should be provided where this seating is outdoors.

In outdoor settings, seating should be provided along with the planned hawker spaces.

At waiting lounges for persons with disabilities chairs should have armrests and backrest.

13. TACTILE PAVING- GUIDING & WARNING

(a) Tactile Guiding Paver (Line-Type)

It is recommended to install a row of tactile guidance paver along the entire length of the proposed accessible route for visual impaired persons. Care must be taken to ensure that there are no obstacles, such as wall, pillar, uneven surfaces, Soffit (underside /open area under the stairs, along the route traversed by the guidance paver. Also, there should be clear headroom of at least 2.1 meters height above the tactile guidance paver, free of protruding objects such as overhanging advertisement panel and signage, along the entire length of the walk.

(b) Tactile Warning Paver (Dot-Type)

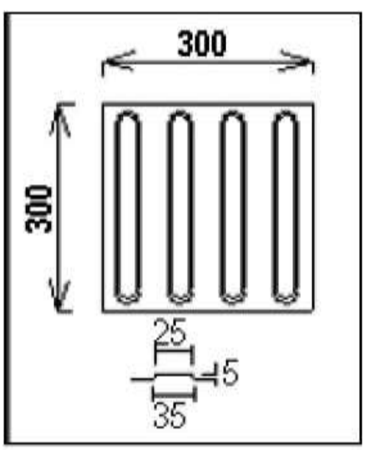
Indicate an approaching potential hazard or a change in direction of the walkway, and serve as a warning of the approaching danger to persons with visual impairments, preparing them to tread cautiously and expect obstacles along the travel path, traffic intersections, doorways, stairs, etc. They are used to screen off obstacles, drop-offs or other hazards, to discourage movement in an incorrect direction, and to warn of a corner or junction. Two rows of tactile warning paver should be installed across the entire width of the designated accessible passenger pathway at appropriate places such as before intersections, terminal entrances, obstacles such as signage, and each time the walkway changes direction.

14. PLACES TO INSTALL WARNING PAVER

In front of an area where traffic is present.

In front of an entrance/exit to and from a staircase or multi-level crossing facility.

Entrances/exits at public transport terminals or boarding areas.



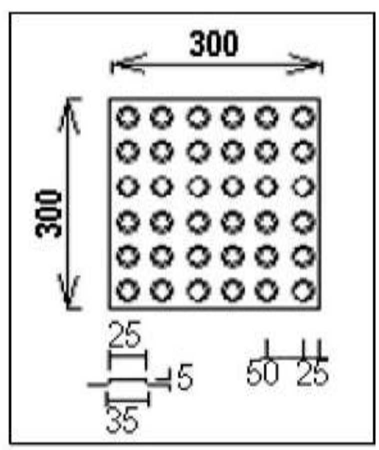


Fig. 13.3 - Guiding paver

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.

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:

- o Critical Surfaces (walls, ceiling and floor),
- o Signage and background sign frame/ wall,
- o Step edges and risers/ treads on steps,
- o Handrails and background walls,
- o Doors and surrounding walls,
- o Switches/ sockets and background wall,
- o 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

ENVIRONMENT AND SOCIAL IMPACT ASSESSMENT

14.1 LEGAL, POLICY AND INSTITUTIONAL FRAME WORK

The available national and state level legal Acts and Legislation referred during the study are:

The Water (Prevention and Control of Pollution) Act, 1974 (Amendment 1988).
The Water (Prevention and Control of Pollution) Cess Act 1977, (Amendment), 2003.
The Water (Prevention and Control of Pollution) Cess Rules, 1978, 1991.
The Air (Prevention and Control of Pollution) Act 1981, amended 1987.
The Air (Prevention and Control of Pollution) (Union Territories) Rules, 1982, 1983
Noise Pollution (Regulation and Control) Rules, 2000 amendment 2002, 2006.
Municipal Solid Waste Rules, 2000
The Environment (Protection) Act, 1986, amended 1991.
The Environment (Protection) Rules,1986.
The Indian Forest Act, 1927.
Forest (Conservation) Act, 1980, amended 1988.
Forest (Conservation) Rules, 2003.
Gujarat (Urban Area) Protection of Trees Act 1975
The Wild Life (Protection) Act 1972, Amendment, 2002

14.1.1 ENVIRONMENTAL CATEGORIZATION

The proposed project does not passes through any Wildlife Sanctuary, National Park, or any other environmentally sensitive or protected areas. The proposed project comprises three alignments viz., between Motera Stadium – Mahatma Mandir, Koteshwar Road – Airport and GNLU – Gift City metro corridors. The alignments are proposed mostly on the centre of the road. Although, the proposed project will bring in many benefits to the area, there is potential for environmental impacts on the ambient environment.

Requirement of Environmental Clearance

As per provisions of the EIA Notification, 14 September 2006 as amended up to 1December 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, 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.

Requirement of 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 refers, in principle agreement, 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 alignment is not passing through any forest land and no diversion of forest land is involved in the proposed project, no forest clearance is required for this project.

Required Clearances/Permissions

For the proposed project, required clearances/ permissions related to environment have been summarized below.

Table 14.1: Permissions/Clearances Required for the Project

S. No.	Permissions/ Clearances	Acts / Rules / Notifications / Guidelines	Concerned Agency	Responsibility
A. Pre-construction Stage				
1	Permission for felling of trees	Forest Conservation Act (1980) Procedural Guidelines developed by the Department of Environment, GoM; Tree removal will be guided as per state government rules.	**MEGA** / District Collector	**MEGA**
B. Implementation Stage				
2	Consent to operate hot mix plant, crushers, batching plant	Air (Prevention and Control of Pollution) Act 1981	Gujarat State Pollution Control Board	Contractor
3	Permission for withdrawal of groundwater	Environment (Protection) Act, 1986	Central Ground Water Authority	Contractor
4	Permission for sand mining from river bed	Environment (Protection) Act, 1986	Mining Department/ MoEF	Contractor
5	Authorization for Disposal of Hazardous Waste	Hazardous Waste (Management and Handling) Rules 1989	GujaratState Pollution Control Board	Contractor
6	Disposal of bituminous and other wastes	Hazardous Waste (Management and Handling) Rules 1989	Local civic body to use local solid waste disposal site	Contractor
7	Consent for disposal of sewage from labour camps.	Water (Prevention and Control of Pollution) Act 1974	Gujarat State Pollution Control Board	Contractor
8	Pollution Under Control Certificate	Central Motor and Vehicle Act 1988	Department of Transport, Govt. of Gujarat authorised testing centres	Contractor

S. No.	Permissions/ Clearances	Acts / Rules / Notifications / Guidelines	Concerned Agency	Responsibility
9	Roof Top Rain Water Harvesting (RWH)	Central Groundwater Authority (CGWA) Guidelines	Central Ground Water Authority/ AMC	Contractor
10	Permission for groundwater extraction for drinking purpose	Environment (Protection) Act, 1986	CGWA	Contractor
11	Employing Labour/ workers	The Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996	District Labour Commissioner	Contractor

14.1.2 OBJECTIVE AND SCOPE OF THE STUDY

The objective of the Environment and Social Impact Assessment study is to facilitate the Metro- Link Express for Gandhinagar and Ahmedabad (**MEGA**) evaluate the environmental impacts of its proposed activity. MEGA proposes to apply for loan to seek financial support from multilateral funding agencies. Thus, the objective of the study is to conduct Environmental Impact Assessment as per requirement of multilateral funding agencies. The scope of EIA includes the impacts resulting from pre-construction, during construction and operation phases of the proposed metro alignments in Ahmedabad. In addition, it is proposed to establish environmental baseline and safeguard measures for protection of environment for sustainable development during project cycles.

14.1.3 APPROACH AND METHODOLOGY

The **MEGA** has considered different alternative corridors. The underlying principles for evaluation for each corridor, without affecting the overall usefulness of the corridor, are minimum private land acquisition, least disturbance to properties, minimal disturbance to ecology/biodiversity. In the analysis of alternatives, a comparison of scenario with and without the project has also been made. The final alternative was fixed based on Technical Feasibility, Socio-economic acceptability, and Environmental sustainability for Metro Corridors. The environmental study is carried out for the alignment proposed by **MEGA**. The approach is to follow the sequence of steps adopted in an EIA study. The basic concept is to ascertain the existing baseline conditions and assess the impacts as a result of construction and operation of the project. The changes likely to occur in different components of the environment viz. physical, biological / ecological, environmental and socio-economic etc. have been studied, analyzed and quantified, wherever possible. The identification of parameters for data generation and impact assessment are important. The analysis of assessment depends upon the reliable data generated/ available on environmental attributes. This study has documented the baseline data for various parameters of physical, ecological and environmental pollution (air, water and noise). The impacts are assessed for various phases of project cycle namely:

Impacts due to project location,
Impacts due to project design,

Impacts due to project construction, and
Impacts due to project operation.

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

14.2 PROJECT AREA

The metro project in Ahmedabad city of Gujarat between Motera stadium and Mahatma Mandir, Koteshwar and Airport and GNLU and Gift City. The proposed alignment would serve the city by providing better connectivity. The project area also includes the viaduct and station areas. The maintenance Depot is not proposed for these corridors and it is proposed to utilize Gyaspur Depot of Phase-I. This metro corridor is proposed in Ahmedabad to cater the requirement of the city for a length of about 34 Km. The total alignment in these corridors will be elevated entirely. The Metro corridor will have standard Guage alignment.

14.3 ENVIRONMENTAL SCOPING

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

The scope of the present study includes detailed characterization of following environmental components, which are most likely to be influenced by the proposed project:
Land Environment
Water Quality (Surface + Ground water)
Meteorological conditions
Ambient Air Quality
Noise Levels
Biodiversity
Socio Economic studies.

The information presented in this chapter has been acquired from various sources. Data on land environment has been collected and compiled from various reports and field surveys. The data on water, air, noise quality, and biodiversity were collected through field studies, sampling in March 2017. Climatological data were collected from India meteorological Department. Efforts have been made to compile the available data from literature, books, maps and reports. The methodology adopted for data collection is highlighted wherever necessary. Environmental Attributes and Frequency of Baseline Survey is presented in **Table 14.2**.

Table 14.2 Environmental Attributes and Frequency of Monitoring

S. No	Attribute	Parameter	No. of Samples	Source
LAND ENVIRONMENT				
1	Geology	Geological Status	---	Literature review
2	Seismology	Seismic Hazard	---	Literature review
WATER ENVIRONMENT				
3	Ground Water	Physical, Chemical and Biological parameters	4	Sampling locations
4.	Surface Water	Physical, Chemical and Biological parameters	4	Sampling locations
AIR, NOISE AND METEOROLOGY				
5	Ambient Air Quality	PM_{10}, SO_2, NO_x	17	Sampling/Monitoring locations
6.	Noise	Noise levels in dB (A) Leq, Lmax, Lmin, L_{10}, L_{50}, L_{90}	17	Sampling/Monitoring locations
7	Soil	Physico-chemical parameters	4	Sampling Locations
8	Vibration	PPV mm/s, V_{rms} mm/s, VdB_{rms}(wrt 2.54×10^{-5} mm/s)	17	Sampling/ Monitoring Locations
SOCIO-ECONOMIC				
9	Socio-economic aspects	Socio-economic profile	Once	Field Studies, Literature review.
Ecology				
10	Trees	Number	Once	Filed Studies

Sampling locations of Water Quality, Noise Levels, and Ambient Air Quality are depicted in **Fig. 14.1**.

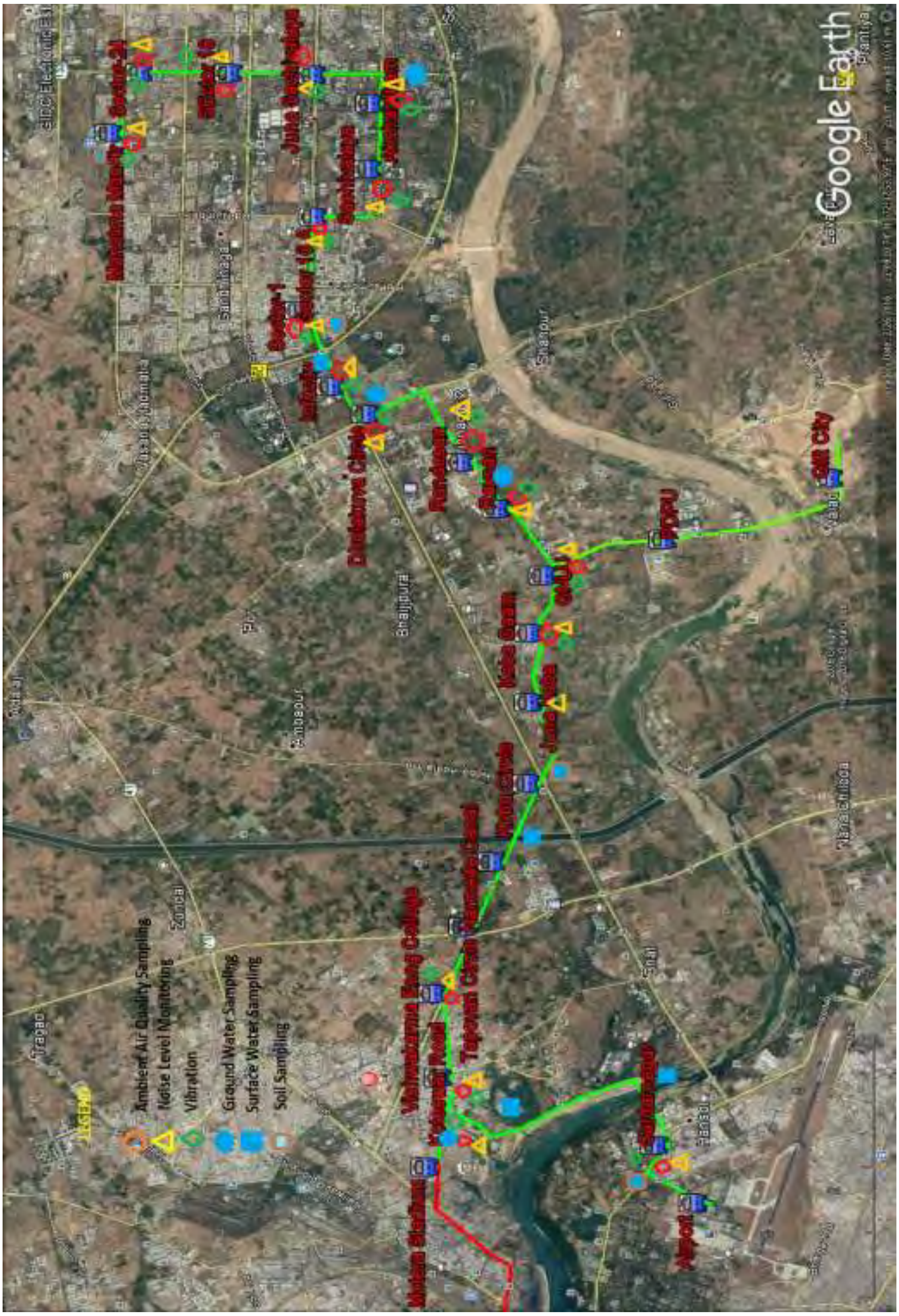


Fig. 14.1 Air Quality, Noise level and Water Sampling/Monitoring Sites

Table 14.3 Sampling / Monitoring Locations:

S. No	Station Name	Air	Noise	Vibration	Ground Water	Surface Water	Soil
	No. of Samples	17	17	17	4	4	4
1	Sardar Nagar	Sardar Nagar	Sardar Nagar	Sardar Nagar		Nr Indira Bridge	Sardar Nagar
2	Koteshwar	Koteshwar	Koteshwar	Koteshwar	Sai Baba Temple	Pond Nr. Ashram	
3	Vishwakarma College	Vishwakarma College	Vishwakarma College	Vishwakarma College			
4	Tapovan Circle	Tapovan Circle	Tapovan Circle	Tapovan Circle		Canal	
5	Koba Gaam	Koba Gaam	Koba Gaam	Koba Gaam			Koba
6	GNLU	GNLU	GNLU	GNLU			
7	Raysan	Raysan	Raysan	Raysan	Rayasan		
8	Randesan	Randesan	Randesan	Randesan			
9	Dhola Kuva Circle	Dhola Kuva Circle	Dhola Kuva Circle	Dhola Kuva Circle	Dhola Kuan		
10	Infocity	Infocity	Infocity	Infocity		Pond near infocity	
11	Sector-1	Sector-1	Sector-1	Sector-1			Sector 1
12	Sector-10A	Sector-10A	Sector-10A	Sector-10A			
13	Sachivalaya	Sachivalaya	Sachivalaya	Sachivalaya			
14	Akshardham	Akshardham	Akshardham	Akshardham	Akshardham		
15	Juna Sachivalaya	Juna Sachivalaya	Juna Sachivalaya	Juna Sachivalaya			
16	Sector 16	Sector 16	Sector 16	Sector 16			
17	Sector 24	Sector 24	Sector 24	Sector 24			
18	Mahatma Mandir	Mahatma Mandir	Mahatma Mandir	Mahatma Mandir			Mahatma Mandir

14.3.1 LAND ENVIRONMENT

The Project area is situated in Ahmedabad and Gandhinagar cities of Gujarat. The elevation of the project area is ranging between 52 m near Koteshwar to 82 m above the mean sea level (a-MSL) in Gandhinagar. The parameters involved in land environment are physiography, geology and soils, and seismicity. These are discussed in the following paragraphs. Ahmedabad is an Industrial hub for textiles and is popularly known as the "Manchester of India". The district headquarter, Ahmedabad was also the State Capital from May 1960 to May 1970, before it was shifted to the new township at Gandhinagar. Ahmedabad district occupies 8087 sq. km. area between 21°58' and 23°30' north latitudes and 71°35' and 73°02' east longitudes in the central part of Gujarat state. It falls in the survey of India degree sheet numbers 41N, 41M, 46A and 46B. It is bounded by Mahesana and Gandhinagar in north, Sabarkantha in north east, Kheda in east Gulf of Cambay (Khambat), Bhavnagar in South and Surendranagar in west.

14.3.1.1 Geography, Geology and Soil

Geomorphologically, the Ahmedabad district can be divided into two zones, the major portion of it forms a flat planar topography except for a few rocky features in the extreme southern portion.

Flat Alluvial Peneplain includes the low-lying land falling below 20 m contour characterised by marshy land, which is believed to be under sea in the past. Water logging is common in these tracts at high tides during monsoon. This barren low land is termed as "The Bhal" area and characterised by high coastal salinity. The spreading of alluvial bed of Sabarmati river from end to end of the district is an important natural feature. Below the city, on the left bank of the river and also midway between it and the Khari river are few small rises. But everywhere else, the surface of the ground is unbroken on every side, except the north, with groves of various trees. Along the Right Bank of Sabarmati river, the prominent characteristics of Dascroi pass into Dholka. However towards west and south-west they pass into fertile but absolutely flat and monotonous black soil of the Bhal. The area from Dholka to Bavliari creek along the coast is characterised by salty and marshy land. Along the western border, the land passes into a reddish form.

A series of low hills are present few kilometres west of Rampur in the western Dhandhuka taluka. The hills around Ninana in the most westerly part of Dhandhuka are covered with fragments of quartz and limestone. Some hills are located around Vasai and Miroli in the southern section of the district, also near Thaltej and Gota of Dascroi taluka in the north, and Chandisar in Dholka and Vastrapur in the City Taluka. The soils in the district can broadly be classified as:

Black Soils: Black soils cover the southern part of Dholka and eastern part of Dhandhuka taluka popularly known as 'Bhal' tract, where cotton is grown in the initial stage of monsoon. It is not very clayey and contains above 20% of clay and about 40 % of sand. Sub-soil invariably contains horizons of lime nodules. This type of soil is highly suitable for cultivation of rabi wheat, which is the main crop raised on this soil. If rains are sufficient in the late monsoon, rabi jowar and grams are sown. Medium Black Soils are found in Viramgam, Sanand and Dholka talukas. This soil is suitable for growing bajri, jowar and cotton.

Goradu Soils: Goradu soils vary from fertile brown to sandy loam and is found in City, Dascroi and parts of Sanand, Dholka and Viramgam talukas. This soil is mostly fertile and responds very well to irrigation and manuring. Practically all kinds of crops can grow on this soil.

Kyari: Kyari soils are found in several parts of City, Dascroi, Sanand, Dholka and Viramgam talukas. It is the most fertile soil with very good moisture and retentive capacity. Well known varieties of paddy such as Pankali, kamod, Jirasar, Sukhvel, Sutarsal and Basumati are grown on this soil.

Rocky soils: Rocky soils are found in Dhandhuka taluka and is known as Kaner tract. It is shallow, light in texture and fit for early maturing crops like cotton, Bajri, Jowar and Math.

The district forms a part of the CAMBAY BASIN. The stratigraphic succession of the formations encountered within the drilled depth of the wells in the district along with its thickness and generalised lithology are presented below:

Stratigraphic succession of geological formations

Age	Formation	Thickness m	Lithology
Holocene	Gujarat Alluvium,	**100**	Unconsolidated coarse sand, pebbly with kankar and minor clays.
Pleistocene	Jambusar	**100**	Sand, coarse grained with occ. Gravel
Pliocene	Broach	**125**	Greenish brown clays and sand clay alteration with variegated claystone.
Unconformity			
Upper to middle Miocene	Jhagadia	**300**	Greenish grey to variegated claystone with coarse to medium grained sand and minor coal.
Middle to lower Miocene	Kand	**200**	Greenish grey clay-stone with occasional bands of med to fine grained sands
Lower Miocene	Babaguru	**125**	Alternate bands of claystone and shale with minor sandstone beds.
Lower Miocene, to upper Oligocene	Tarakeshwar	**125**	Shale with minor clays and claystone with coarse to medium grained sands towards bottom.
Unconformity			
Lower Oligocene to upper Eocene	Tarapur shale.	**175**	Grey to greenish grey shale with argillaceous sandstone in the basal part.
Upper Eocene to middle Eocene	Kalol	**250**	Grey to dark grey shale with silty sandstone, siltstone and coal beds with minor sideritic claystones and oolite with sideritic matrix in Bavla and Ambaliyara areas.
Unconformity			
Lower Eocene	Cambay shale vagadkhol	**>150 0**	Dark grey to black fissile, pyritic, carbonaceous shale with occasional siltstone bands towards bottom and reddish brown shale. The cambay shale Facies changes towards the basin margin to Vagadkhol formation with the lithology of trapo conglomerate, trap wash and brown clay / clay stone.
Unconformity			
Lower Eocene to upper Cretaceous	Deacon traps with intertrappea n beds.		

14.3.1.2Seismicity

The country has been classified into different zones indicating the intensity of damage or frequency of earthquake occurrences. Ahmedabad sits on a seismically active zone owing to the presence of 23 fault lines in the vicinity. Ahmedabad falls in zone III according to IS 1893: 2002 which means an earthquake upto magnitude 6.5 on Richer scale may be expected (Figure 14.2).

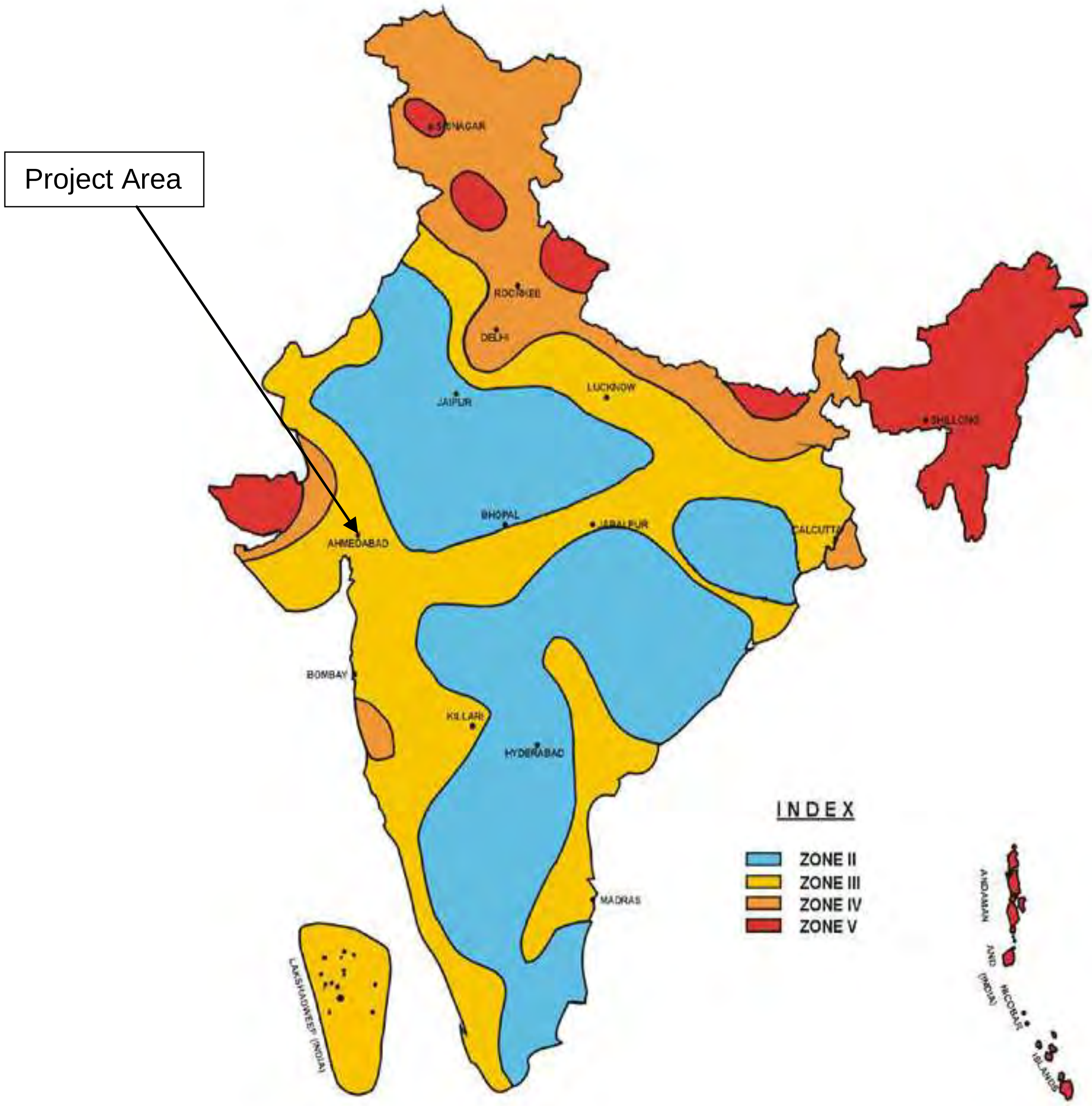


Figure – 14.2 Seismic Zones in India

14.3.2 SOIL QUALITY

In order to ascertain the quality and nature of soil within the vicinity of the project site, soil samples were collected. These samples were collected about 60 cm depth. The samples were tested for physical and chemical properties. Soil Sampling sites have been shown in Fig. 14.1. The results of soil analysis are presented in **Table 14.4.** As per the test results it is observed that soil is tending to become alkaline. Soil is high in nitrogen and the carbon contents at most of the places. However phosphors and potassium content is low. Calcium and magnesium content is adequate at most of the places. At all places the soil texture is of sandy silt.

TABLE 14.4 SOIL TEST RESULTS

S. No.	PARAMETERS	Sardar Nagar	Koba	Sector-1 Gandhi Nagar	Mahatma Mandir
	Sample Code	**S-1**	**S-2**	**S-3**	**S-4**
1.	pH	8.44	7.805	7.40	7.98
2.	Organic Matter (%)	0.68	6.36	1.75	1.34
3.	Nitrogen (kg/Hectare)	157.6	281.2	336.0	169.2
4.	Phosphorus (kg/Hectare)	<1.0	<1.0	2.38	4.10
5.	Sodium (mg/100gm)	10.9	10.63	11.25	9.25
6.	Calcium (ppm)	2610	1498	1560	1850
7.	Potassium (kg/Hectare)	112	98	132	127
8.	Magnesium (ppm)	280	82	69	158
9	Electrical Conductivity	623	766	629	726
10	Texture (%)				
	Sand	79.46	72.53	82.19	77.2
	Slit	16.40	21.06	16.49	11.6
	Clay	4.14	6.36	1.32	11.2

Source: Field study

14.4 WATER ENVIRONMENT

Water environment consists of water resources and its quality. Its study is important from the point of view of assessing the sufficiency of water resources for the needs of the project in its various stages of the project cycle and also to assess the impact of the project on water environment. In the proposed project, ground water is proposed to be used during operations to meet out domestic water requirements of the project in case water is not made available by Ahmedabad Municipal Corporation. Hence its quality has been tested to evaluate its suitability for the intended purpose. Anticipated impacts of the proposed project on water environment have also been addressed.

14.4.1 WATER RESOURCES

The **Sabarmati River** is one of the major west-flowing rivers in India. It originates in the Aravalli Range of the Udaipur District of Rajasthan and meets the Gulf of Cambay of Arabian Sea after travelling 371 km in a south-westerly direction across Rajasthan and Gujarat. 48 km of the river length is in Rajasthan, while 323 km is in Gujarat.

The Sabarmati basin has a maximum length of 300 km. and maximum width of 105 km. The total catchment area of the basin is 21674 km^{2}out of which, 4124 km^2 lies in Rajasthan State and the remaining 18550 km^2 in Gujarat. Sabarmati river basin is situated in the mid-southern part of Rajasthan. To its east lie the Banas and Mahi Basins, to its north the Luni Basin and to its west the West Banas Basin. Its southern boundary is the border with Gujarat State. The Sabarmati river basin extends over parts of Udaipur, Sirohi, Pali and Dungarpur Districts. Orthographically, the western part of the Basin is marked by hilly terrain belonging to the Aravali Range. East of the hills lies a narrow alluvial plain with a gentle eastward slope. The major tributaries are the Sei, Wakal, Watrak, Shedhi, Harnav, Guhai, Hathmati, Khari, Meshwo, Mazam and Mohar.[3][4]Average annual water availability in the Sabarmati basin is 308 m^3/capita, which is significantly lower than the national average of 1545 m^3/capita. The National Water Quality Programme led by Central Pollution Control Board (CPCB) positions Sabarmati River as one of the most polluted rivers in India. There are several reservoirs on Sabarmati and its tributaries. The Dharoi dam is located on the main river. Hathmati dam, Harnav dam and Guhai dam are located on the tributaries meeting the main river upstream of Ahmedabad while Meshvo reservoir, Meshvo pick-up weir, Mazam dam and Watrak dam are located on tributaries meeting downstream. The Kalpasar is planned project in the Gulf of Khambhat.

14.4.2 HYDROGEOLOGY AND GROUND WATER

Ground water in the fissured formations (Hard rocks)

The Deccan trap and the limestone formations occupying the western part of the Dandhuka taluka forms the only hard rock aquifers in the district. It occupies the south western extremity of the district and can be termed as fissured formation. Occurrence and movement of ground water is governed by the extent and thickness of weathered zone, presence and interconnections of joint and fracture systems, which provides secondary porosity. The thickness of the weathered zone of the basalt ranges from less than one meter to more than 6 m and the joints and fracture system is prevalent down to a maximum depth of 80 to 90 mbgl in the basaltic terrain. The occurrence of vesicles and amygdales in the flows of the trap rocks and solution cavities in the limestone formations and the geological contact between limestone and basalt are other factors favourable for ground water storage and movement. Ground water occurs in the weathered and fissured zones mainly under water table conditions. It occasionally occurs under semi-confined conditions in the event of comparatively deeper fracture system in these formations. These fissured formations do not form good repository of groundwater, compared to porous unconsolidated sedimentary formations. Groundwater is being developed in these formations by means of dug and dug-cum-bored wells. Depth of dugwells ranges between 5 and 38.5 mbgl whereas depth of dug-cum-bored wells varies between 15 and 78 mbgl in the case of fissured basaltic formations. Depth of dugwells in the limestone formations varies between 12 and 38 mbgl. Deeper wells are constructed in the western part in these formations. Depth to water levels in basaltic formation varies between 4 and 25 mbgl. In the limestone formation it varies between 12 and 33 mbgl. The deeper water levels are recorded towards western part of the area. The average yield of the wells in the trap formations varies between 50 and 1000 cu.m/day and of the wells in the limestone varies between 50 and 200 cu.m/day.

Ground water in Porous Formations (Sedimentaries)

It occupies the major part (93.5%) of the district. It includes the post-Miocene alluvial deposits at the top underlained by older Miocene formations. The sedimentary formations mainly consist of fine to coarse-grained sand, gravel, silt, clay, clay stone, siltstone and kankar. The thickness of the post-Miocene alluvial formations exceeds 419m near Dholka at Rampur Ground water occurs under phreatic as well as confined conditions in the granular horizons with in the sedimentaries.

Unconfined aquifer (phreatic)

The unconfined aquifer occurs in the upper horizons down to a maximum depth of 60-75 mbg consisting of medium to fine grained sand, silt with local lenses of sandy clay and clay. Medium to fine grained sands are found in the north-eastern part of the district. In this area where only phreatic aquifer is present, base of the alluvium is marked by gravel. Fine grained sands with silt are found further south and south-west at Dholka and Sanand taluka. The thickness of aquifer varies between 20 and 45 m in general, met with in the depth range of 3 and 75 mbgl and can be considered as aquifer 'A'.Ground water occurs under phreatic conditions in the north eastern part of the district. However, the intercalations of silt, at places, induces semi-confined conditions in the south and south western directions of Sanand and Dholka taluka. It bears potable and good quality water in the north eastern part of the district and eastern part of Dascroi taluka (east of Khari river). It is being developed by dug, dug-cum-bored wells and tube wells. The depth of the dug wells and dug-cum-bored wells usually varies between 10 and 60 mbgl. The tube wells range between 42 and 167 mbgl. In the rest part of the area it bears brackish to saline ground water. Hence ground water development is meagre and dug wells are constructed in or vicinity of ponds to meet the local demands. Hydraulic characters of this aquifer are not separately estimated. Tube wells, tapping this aquifer invariably tap one or more aquifers occurring underneath. Yields of such tube wells varies between 225 and 3032 m3/day. Specific capacity of tube wells varies between 0.12 and 38.48 lpm/m, permeability varies between 0.49 and 105 m/day and transmissivity varies between 10.58 and 3867.29 m^2/day.

Confined aquifers

The upper unconfined aquifer is underlained by persistent clay formations of considerable thickness in the entire area of porous sedimentary formations. This separates the lower unit consisting of a few hundred meters of alternating sandy and argillaceous beds forming the confined aquifer system. The arenaceous horizons of the confined aquifer, consists of medium to coarse-grained sand with gravel interstratified locally with silty or clayey sand and clay lenses. As mentioned earlier, the confined aquifers are grouped and designated as B, C & D with in the post Miocene alluvial sediments and G and F aquifers in Miocene sediments with in the drilled depth of 565 m in the district. The distribution of the confined aquifers varies considerably in the district. The sand content of the aquifer decreases considerably both in depth and space. It resulted in the pinching out of certain aquifers occurring below 150 mbgl in the south and south western directions, as seen, in Kalyangarh and Bagodra bore holes. The development of these aquifers hence depends upon the aquifer geometry, yield characters of the individual aquifers and / or salinity of formation waters.

Confined aquifers with potable water occurs down to 300 to 350 m in the area towards north and north east of the low lying 'Bhal' land in the district. The aquifers that are developed include B and C and to some extent the upper part of the D aquifers of the post Miocene alluvial aquifer and can be termed as user confined aquifers (UCA).

14.4.3 WATER QUALITY

Water quality is the physical, chemical and biological characteristics of water. It is most frequently used with reference to a set of standards against which compliance can be assessed. The most common standards used to assess water quality are related to drinking water, safety of human contact, and for health of ecosystems. An understanding of the various factors influencing water quality is thus very important as human health is largely dependent on the quality of water available for our use. Water sampling Sites have been shown in **Fig. 14.1.** Groundwater quality is quite good. However, total dissolved solids are a little higher than the desirable limits but within permissible limits. All other parameters are well within the desirable limits.

Table 14.5 Ground Water Quality at Project Site

Location Parameter	Sai Baba Temple	Rayasan	Dhola Kuva	Akshardham	Standard
Date of Sampling	**12-03-17**	**12-03-17**	**12-03-17**	**12-03-17**	**12-03-17**
Colour, Hazen	Colourless	Colourless	Colourless	Colourless	5 (15) Max
Odour	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable
Taste	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable
Turbidity, NTU	3.3	3.3	2.9	3.0	1 (5) Max
pH	7.79	7.88	7.76	7.75	6.5-8.5 Max
Total Hardness as Caco3, Mg/l	258	261	256	271	200 (600) Max
Chloride as Cl, Mg/l	141	143	154	183	250 (1000) Max
Total Iron as Fe, Mg/l	0.08	0.09	0.08	0.09	0.3 Max
Total Dissolved Solids, Mg/l	1213	1287	1313	1324	500 (2000) Max
Sulphates as So4, Mg/l	179	121	94	92	200 (400) Max
Nitrates as No3, Mg/l	46.1	35.1	31.3	33.1	45 Max
Fluorides as F, Mg/l	1.69	1.56	1.97	2.15	1.0 (1.5) Max
Lead as Pb, Mg/l	BDL	BDL	BDL	BDL	0.01 Max
Copper as Cu,Mg/l	BDL	BDL	BDL	BDL	0.05 (1.5) Max
Manganese as Mn,Mg/l	BDL	BDL	BDL	BDL	0.1 (0.3) Max
Phenolic Compound as C6H5OH,Mg/l	BDL	BDL	BDL	BDL	0.001 (0.002) Max
Mercury as Hg,Mg/l	BDL	BDL	BDL	BDL	0.001 Max
Cadmium as Cd,Mg/l	BDL	BDL	BDL	BDL	0.01 Max
Selenium as Se, Mg/l	BDL	BDL	BDL	BDL	0.01 Max

Location Parameter	Sai Baba Temple	Rayasan	Dhola Kuva	Akshardham	Standard
Date of Sampling	**12-03-17**	**12-03-17**	**12-03-17**	**12-03-17**	**12-03-17**
Arsenic as As,Mg/l	BDL	BDL	BDL	BDL	0.05 Max
Cyanide as Cn,Mg/l	BDL	BDL	BDL	BDL	0.05 Max
Zinc as Zn, Mg/l	1.32	1.53	1.34	1.61	5 (15) Max
Detergent as MBAS, Mg/l	BDL	BDL	BDL	BDL	0.2 (1.0) Max
Chromium as Cr+6 ,Mg/l	BDL	BDL	BDL	BDL	0.05 Max
Total Alkalinity as Caco3,Mg/l	187.3	178.2	176.1	187.3	200 (600) Max
Aluminum as Al,Mg/l	BDL	BDL	BDL	BDL	0.03(2) Max
Boron as B, Mg/l	BDL	BDL	BDL	BDL	0.5(1) Max
Bacteriological Analysis					
Coliform,MPN/100Ml	Nil	Nil	Nil	Nil	10 Max
E-Coli/Ml	Negative	Negative	Negative	Negative	Negative

Surface water quality has also been assessed at 4 locations which have been shown i Fig. 14.1 and the test results are given in Table 14.6. It has been foud that the surface water quality is not good in the project area.

Table 14.6 Surface Water Quality at Project Site

Location Parameter	Sabarmati Nr. Indira Bridge	Pod Nr. Bapu Asaram Ashram	Narmada Canal	Pond Nr. Infocity
Date of Sampling	**13-03-17**	**13-03-17**	**13-03-17**	**13-03-17**
pH	8.38	8.15	7.78	8.83
Dissolved Oxygen	7.0	7.2	5.7	6.5
BOD	3.5	4.3	32	28
COD	18	22	130	122
Total Dissolved Solids, Mg/l	**348**	**285**	**902**	**1402**
Ammonia- N	2.07	2.6	8.23	3.22
TKN	1.66	2.01	6.75	2.93
Nitrates as NO3, Mg/l	1.92	2.09	6.97	3.78
NO_2	1.23	1.78	5.55	2.07
Total Colliform, MPN/100Ml	11	169	398	208
Faecal Colliform, MPN/100Ml	7	59	209	145
Fluorides as F, Mg/l	1.39	1.45	1.27	1.65

14.5 METEOROLOGY

14.5.1 GENERAL

Ahmedabad has a hot, semi-arid climate (Köppen climate classification: BSh), with marginally less rain than required for a tropical savanna climate. There are three main seasons: summer, monsoon and winter. Aside from the monsoon season, the climate is extremely dry. The weather is hot from March to June; the average summer maximum is 43 °C, and the average minimum is 24 °C. From November to February, the average maximum temperature is 30 °C, the average minimum is 13 °C, and the climate is extremely dry. Cold northerly winds are responsible for a mild chill in January. The southwest monsoon brings a humid climate from mid-June to mid-September. The average annual rainfall is about 800 millimetres, but infrequent heavy torrential rains cause local rivers to flood and it is not uncommon for droughts to occur when the monsoon does not extend as far west as usual. The highest temperature in the city was recorded on May 18 and 19, 2016 which was 50 °C.

14.5.2 TEMPERATURE

The temperature data for Ahmedabad has been taken. The month-wise minimum & maximum temperatures have been given in **Table 14.7.**

Table 14.7 Normal Temperature at Ahmedabad

Month	Maximum Temperature°C	Mean Daily Maximum Temperature, °C	Minimum Temperature °C	Mean Daily Minimum Temperature, °C
January	36.1	28.1	3.3	12.4
February	40.6	30.5	2.2	14.3
March	43.9	35.8	9.4	19.5
April	46.2	39.6	12.8	23.9
May	50.	41.6	19.1	27.0
June	47.2	38.8	19.4	27.5
July	42.2	33.6	20.4	25.9
August	40.4	32.0	21.2	25.0
September	41.7	33.8	17.2	24.7
October	42.8	35.7	12.6	21.4
November	38.9	32.9	8.3	16.7
December	35.6	29.5	3.6	13.4
Annual	50.0	34.4	2.2	21.0

Source: India Meteorological Department, Govt. of India.

14.5.3 RAINFALL

The detail of rainfall at the Ahmedabad is given in **Table**14**.8.**

Table 14.8 Month-wise Rainfall at Ahmedabad in mm

S. No.	Month	Rainfall	Peak Rainfall	Rainy Days
1	January	1.0		0.1
2	February	0.8		0.1
3	March	0.6		0.0
4	April	2.4		0.4
5	May	7.0		0.6
6	June	80.0	724.2	3.9
7	July	291.2		11.5
8	August	266.2		10.7
9	September	86.8		5.0
10	October	11.7		0.8
11	November	2.3		0.4
12	December	1.0		0.2
	Annual	751.0		33.7

Source: India Meteorological Department, Govt. of India.

14.5.4 AIR ENVIRONMENT

The atmospheric concentrations of air pollutants were monitored at 39 locations near the proposed alignment during the month of March 2017. Locations of air monitoring station are shown in Figure 14.1. Air Monitoring was carried out for PM_{10}, NOx, SO_2 and CO. Results of the air quality monitoring are presented in **Table 14.9**.

Table 14.9 Ambient Air Quality Results µg/m3

S. No	Location	Date	PM_{10}	$PM_{2.5}$	SO2	NOx	CO
	Regulatory Standards		**100**	**60.0**	**80**	**80**	**2000**
1	Sardar Nagar	12 to14 Mar	84	27.5	22.2	24.6	1601
			82	26.8	22.5	29.2	1591
2	Koteshwar	12 to14 Mar	88	29.2	26.4	25.1	1230
			87	26.1	25.2	27.2	1189
3	Vishwakarma College	12 to14 Mar	85	29.0	22.4	25.7	1298
			89	28.6	23.1	28.7	1327
4	Tapovan Circle	14 to16 Mar	88	29.8	26.2	30.6	1085
			87	27.3	25.7	29.4	1010
5	Koba Gaam	14 to16 Mar	78	25.2	23.5	33.6	1200
			84	23.2	24.1	30.5	1265
6	GNLU	14 to16 Mar	106	33.4	23.2	31.2	1140
			93	34.6	23.5	32.5	1085
7	Raysan	16 to18 Mar	91	39.8	26.3	34.7	1240
			89	37.2	24.5	37.2	1190
8	Randesan	16 to18 Mar	93	34.0	25.5	33.2	1150
			91	34.2	23.6	35.1	1320
9	Dhola Kuva Circle	16 to18 Mar	87	33.6	24.6	37.4	1270
			87	34.2	25.4	36.1	1040
10	Infocity	18 to 20 Mar	88	31.5	21.6	27.4	1070
			85	32.9	23.3	30.4	1130
11	Sector-1	18 to 20 Mar	93	33.5	19.5	29.2	1279
			89	32.8	19.8	26.4	1275
12	Sector-10	18 to 20 Mar	89	32.0	21.8	30.6	1070
			93	33.3	23.6	33.2	1080
13	Sachivalaya	20 to 22 Mar	77	30.1	18.9	28.1	1260
			81	31.1	19.3	26.6	1210
14	Akshardham	20 to 22 Mar	79	29.8	18.4	26.9	1260
			71	28.7	19.3	27.7	990
15	Juna Sachivalaya	20 to 22 Mar	86	30.1	18.2	28.4	1098
			95	29.1	21.3	28.1	1170
16	Sector 16	22 to 24 Mar	95	30.1	25.2	34.4	1220
			98	32.9	27.4	35.2	1260
17	Sector 24	22 to 24 Mar	89	30.1	24.1	34.2	1210
			93	30.3	27.7	35.6	1330
18	Mahatma Mandir	22 to 24 Mar	92	32.0	25.4	37.3	1210
			89	29.0	23.7	31.5	1140

RSPM= Respirable Suspended Particulate Matter.
The results show that the concentration of RSPM (PM_{10}) is higher at all the locations whereas all other parameters are within permissible limits.

14.5.5 NOISE ENVIRONMENT

Noise is responsible for adverse impacts on physical and mental health of the people. The other impacts are:
Physiological effects,
Hearing impairment,
Communication interference, and
Sleep disruption

Noise level survey was conducted along the alignment with an objective to establish the baseline noise levels and assess the impacts of total noise expected due to the proposed metro. Noise levels were measured at 39 locations in January and March 2017 for 24 hours. The locations of Noise level monitoring have been shown in **Fig. 14.1**. The noise levels so obtained are summarized in **Table 14.10.**

Table 14.10 Noise Levels

S.No	Location	Date		Lmax	Lmin	Leq	L_{10}	L_{50}	L_{90}
1	Sardar Nagar	9 to10 Jan	Day	80.1	58.1	72.2	73.5	63.7	60.1
			Night	72.3	45.6	58.4	67.7	53.3	51.8
2	Koteshwar	9 to10 Jan	Day	84.4	58.3	69.1	74.7	64.9	62.1
			Night	73.7	46.4	57.2	61.2	56.2	53.9
3	Vishwakarma College	9 to10 Jan	Day	86.6	58.2	70.6	73.2	68.1	62.4
			Night	72.1	54.1	63.6	70.4	60.2	57.3
4	Tapovan Circle	10 to11 Jan	Day	82.2	56.1	67.2	70.3	66.3	58.5
			Night	72.5	50.0	55.3	62.2	57.1	50.2
5	Koba Gaam	10 to11 Jan	Day	75.7	61.3	74.3	78.9	70.1	67.2
			Night	72.4	51.2	63.2	61.9	56.3	53.2
6	GNLU	10 to11 Jan	Day	75.1	59.3	67.1	70.7	62.4	59.9
			Night	71.1	46.8	61.9	67.6	54.8	51.1
7	Raysan	11 to12 Jan	Day	78.9	53.5	71.4	67.8	66.5	61.7
			Night	71.5	48.4	63.2	66.6	61.3	56.1
8	Randesan	11 to12 Jan	Day	78.7	54.8	67.5	74.7	62.5	57.6
			Night	65.6	46.2	52.9	63.2	51.2	49.7
9	Dhola Kuva Circle	11 to12 Jan	Day	72.6	51.9	67.1	70.2	64.6	60.2
			Night	67.5	51.8	66.2	63.2	60.2	56.7
10	Infocity	12 to 13 Jan	Day	79.7	53.5	66.2	72.6	62.9	56.9
			Night	73.9	46.4	60.1	67.3	573	52.1
11	Sector-1	12 to 13 Jan	Day	78.3	52.1	70.5	76.8	64.7	60.6
			Night	72.8	43.9	57.0	65.1	51.1	46.1
12	Sector-10	12 to 13 Jan	Day	65.6	46.3	57.7	62.6	58.9	52.8
			Night	61.5	44.6	52.4	56.3	49.8	46.1
13	Sachivalaya	13 to14 Jan	Day	92.2	51	71.4	86.2	67.4	59.6
			Night	85.2	45.4	56.7	61.7	53	47.9

S.No	Location	Date		Lmax	Lmin	Leq	L_{10}	L_{50}	L_{90}
14	Akshardham	13 to14 Jan	Day	86.7	63.1	78.9	83.4	76.4	66.9
			Night	79.7	46.5	61.7	66.3	59.1	53.9
15	Juna Sachivalaya	13 to14 Jan	Day	83.5	52.1	62.4	76.3	59.8	58.8
			Night	78.7	48.9	59.6	63.7	55.7	51.7
16	Sector 16	14 to15 Jan	Day	75.3	54.1	67.5	70.1	64.5	60.6
			Night	71.9	48.9	60.4	64.8	60.0	54.1
17	Sector 24	14 to15 Jan	Day	77.3	50.1	74.3	67.5	64.2	53.1
			Night	68.7	47.3	62.8	65.2	60.0	53.1
18	Mahatma Mandir	14 to15 Jan	Day	80.3	68.1	69.6	73.2	67.7	61.3
			Night	72.9	50.1	58.7	63.9	55.5	54.2

Allowable Noise Levels dB (A):

Category of Area/Zone	Day Time	Night Time	
Industrial Area	75	70	EPA-1986, Noise pollution (Regulation Control), Rule-2000, PCLS/02/1992, IVth Edition.
Commercial Area	65	55	
Residential Area	55	45	
Silence Area	50	40	

Day Time (6.00 Am-10.00 Pm); Night Time (10.00 Pm-6.00Am)

The observed noise level is higher than the permissible limits at all locations which may be due to heavy traffic movement and other activities on the roads.

14.5.6 TREES

Tree survey has been carried out along the proposed alignment. Tree with Girth at Breast Height (GBH) 30 cm have been counted. The alignment does not pass through any forest area. A total of 160 trees are located along the alignment and station area. No endangered species of trees have been noticed during field survey. Trees have been found of indigenous and common species like Pipal, Mango, Khajur, Neem, Coconut, Palm, Babool, Ber, Gulmohar and Tadi etc.

14.6 SOCIO- ECONOMIC CONDITIONS

According to the 2014 census the population of Ahmedabad metropolitan was 7,250,000. Ahmedabad has a literacy rate of 89.62%; 93.96% of the men and 84.81% of the women are literate. Ahmedabad's sex ratio in 2011 was 897 women per 1000 men. According to the census for the Ninth Plan, there are 30,737 rural families living in Ahmedabad. Of those, 5.41% (1663 families) live below the poverty line. Approximately 440,000 people live in slums within the city. Ahmedabad is home to a large population of Vanias (i.e., traders), belonging to the Vaishnava sect of Hinduism and various sects of Jainism. Most of the residents of Ahmedabad are native Gujaratis. Over 8% of the population is Muslim, numbering over 300,000 in the 2001 census. In addition, the city is home to some 2000 Parsis and some 125 members of the Bene Israel Jewish community. There is also one synagogue in the city. In 2008, there were 2273 registered non-resident Indians living in Ahmedabad.

In 2010, *Forbes magazine* rated Ahmedabad as the fastest-growing city in India, and listed it as third fastest-growing in the world after the Chinese cities of Chengdu and Chongqing. In 2011, it was rated India's best megacity to live in by leading market research firm IMRB. According to the National Crime Records Bureau (NCRB) report of 2003, Ahmedabad has the lowest crime rate of the 35 Indian cities with a population of more than one million. In December 2011 market research firm IMRB declared Ahmedabad the best megacity to live in, when compared to India's other megacities. Slightly less than half of all real estate in Ahmedabad is owned by "community organisations" (i.e. cooperatives), and according to Prof. Vrajlal Sapovadia of the B.K. School of Business Management, "the spatial growth of the city is to [an] extent [a] contribution of these organisations". Ahmedabad Cantonment provides residential zones for Indian Army officials.

The gross domestic product of Ahmedabad was estimated at US$119 billion in 2011. The RBI ranked Ahmedabad as the seventh largest deposit centre and seventh largest credit centre nationwide as of June 2012. In the 19th century, the textile and garments industry received strong capital investment. On 30 May 1861 Ranchhodlal Chhotalal founded the first Indian textile mill, the Ahmedabad Spinning and Weaving Company Limited, followed by the establishment of a series of textile mills such as the Calico Mills, Bagicha Mills and Arvind Mills. By 1905 there were about 33 textile mills in the city. The textile industry further expanded rapidly during the First World War, and benefited from the influence of Mahatma Gandhi's Swadeshi movement, which promoted the purchase of Indian-made goods. Ahmedabad was known as the "Manchester of the East" for its textile industry. The city is the largest supplier of denim and one of the largest exporters of gemstones and jewellery in India. The automobile industry is also important to the city; after Tata's Nano project, Ford and Suzuki are planning to establish plants near Ahmedabad while the groundbreaking ceremony for Peugeot has already been performed.

The Ahmedabad Stock Exchange, located in the Ambavadi area of the city, is India's second oldest stock exchange. Two of the biggest pharmaceutical companies of India — Zydus Cadila and Torrent Pharmaceuticals – are based in the city. The Nirma group of industries, which runs a large number of detergent and chemical industrial units, has its corporate headquarters in the city. The city also houses the corporate headquarters of the Adani Group, a multinational trading and infrastructure development company. The Sardar Sarovar Project of dams and canals has improved the supply of potable water and electricity for the city. The information technology industry has developed significantly in Ahmedabad, with companies such as Tata Consultancy Services opening offices in the city. India's leading cyber-security firm Cyberoam also has its R&D centre located in Ahmedabad. A NASSCOM survey in 2002 on the "Super Nine Indian Destinations" for IT-enabled services ranked Ahmedabad fifth among the top nine most competitive cities in the country. The city's educational and industrial institutions have attracted students and young skilled workers from the rest of India. Ahmedabad houses other major Indian corporates such as: Rasna, Wagh Bakri, Nirma, Cadila Pharmaceuticals, and Intas Biopharmaceuticals. Ahmedabad is the second largest cotton textile centre in India after Mumbai and the largest in Gujarat. Many cotton manufacturing units are currently running in and around Ahmedabad. Textiles are one of the major industries of the city. Gujarat Industrial Development Corporation has acquired land in Sanand taluka of Ahmedabad to set up three new industrial estates.

14.7 SOCIO-ECONOMIC SURVEY

A socio-economic survey was undertaken for the proposed corridor to assess the socio-economic conditions of project-affected families/people and to examine the impacts of the proposed metro alignment on their conditions. There can be two types of impacts on the PAPs. One is the displacement of residential house and another is displacement of commercial establishments

It has been found during socio-economic survey that any residential structure is not affected by the metro route on all the alignments. Land is mainly required for viaduct, construction of stations and allied services. Additionally, land is also required for RSS. One small Sai Baba Temple is getting affected by Koteshwar Road- Airport alignment near Koteshwar Road which will have to be shifted o nearby Govt. Land with the consent of local people. Two temporary properties of Asaram Bapu Ashram are also getting affected which as per enquiry was found to be institutional properties which shall be compensated by assessment by MEGA at the time of acquisition. During survey it has been found that there is no residential or commercial property affected by the proposed metro alignment under phase –II of Ahmedabad Metro.

14.8 ARCHAEOLOGICAL SITES

The proposed metro alignment in Ahmedabad city is not passing through or near any historical or archaeological monument or heritage site.

14.9 ENVIRONMENTAL IMPACTS ASSESSMENT

14.9.1 ENVIRONMENTAL IMPACTS

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

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

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

14.9.2 IMPACTS DUE TO PROJECT LOCATION

During this phase, those impacts, which are likely to take place due to the layout of the project, have been assessed. These impacts are:

- Project Affected People (PAPs)
- Change of Land use;
- Loss of trees/forest;
- Utility/Drainage Problems,
- Socio-economic impacts;
- Impact on Historical and Cultural Monuments;

14.9.2.1Project Affected People (Paps)

There will be acquisition of private land and property in this project hence there are many PAPs as a result of the project activity. Detailed socio-economic assessment has been made for PAPs in Social Impact Assessment.

14.9.2.2 Change of Land Use

The required land (permanent& temporary) for the construction of the proposed alignment is both government as well as private land which shall be allotted by Ahmedabad Municipal Corporation. Private land will be acquired as per the provisions of The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act 2013 (Act 30 of 2013). Deatisl of Land requirement for all the three corridors have been summarized in **Table 14.11**.

Table 14.11 Land Requirement for Ahmedabad Metro - Phase-II (All figures in Sq. m)

	Description	Permanent Land			Temporary Land		
Motera Stadium to Mahatma		**Govt.**	**Pvt.**	**Total**	**Govt.**	**Pvt.**	**Total**
1	Stations	19694	1763	21457	0	0	0
2	Running Section	5378	35	5413	0	0	0
4	Staff Quarter	15000	0	15000	0	0	0
6	RSS	3600	0	3600	0	0	0
7	Temporary Office/Site Office	0	0	0	8000	0	8000
8	Segment Casting Yard	0	0	0	80000	0	80000
	Total	**43672**	**1798**	**45470**	**88000**	**0**	**88000**
Koteshwar to Airport							
	Stations	2081	0	2081	0	0	0
	Running Section	3893	4540	8433	0	0	0
	RSS	3600	0		0	0	0
	Temporary Office/ Site	0	0	0	2000	0	2000
	Segment Casting Yard	0	0	0	20000	0	22000
	Total	**9574**	**4540**	**14114**	**22000**	**0**	**22000**
GNLU to Gift City							
	Stations	1335	920	2255		0	0
	Temporary Office				2000		

	Description	Permanent Land			Temporary Land		
	Segment Casting Yard				20000		
	Total	**1335**	**920**	**2255**	**22000**	**0**	**0**
	Grand Total	**54581**	**7258**	**61839**	**132000**	**0**	**132000**

14.9.2.3 Loss of Forests/ Trees

The proposed metro lines are in urban/ city area and will not pass through any forests. Hence no loss to forest is anticipated due to the project. However, trees do exist in patches in the corridor selected for the project. There are about 160 trees which are likely to be felled during construction. Trees are assets in purification of urban air, which by utilizing CO_2 from atmosphere, release oxygen into the air. However, with removal of these trees, the process for CO_2 conversion will get effected and the losses are reported below:

i) Total number of Trees : 160
ii) Decrease in CO_2 absorption @ 21.8 Kg/ year tree for 8 years : 27904 kg
iii) Oxygen production @ 49 kg/ year tree For 8 years : 62720 kg

The average consumption of oxygen for a person is about 182 kg/ year. It means these trees will meet the requirement of about 345 people round the year. Trees help carbon sequestration acting as a carbon sink. By removing the carbon and storing it as cellulose, trees release oxygen back into the air.

14.9.2.4 Utility/ Drainage Problems

Metro lines are mostly planned to run through the urban area. The alignment will cross many properties, drains/ nalas, large number of sub-surface, surface and utility services, viz. sewer, water mains, storm water drains, telephone cables, overhead electrical transmission lines, electric pipes, roads, traffic signals etc. These utilities/ services are essential and have to be maintained in working order during different stages of construction by temporary/permanent diversions or by supporting in position. Since these affect construction and project implementation time schedule/ costs for which necessary planning/ action needs to be initiated in advance.

14.9.2.5 Socio-Economic Impact on PAPs

The metro alignment runs between Motera Stadium and Mahatma Mandir, Koteshwar – Airport and GNLU- Gift City. Land is mainly required for viaduct, construction of stations and allied services in addition to storage facilities. Additionally, land is also required for RSS. There is no residential unit affected by the land acquisition for the proposed metro corridors.

14.9.2.6 Impact on Archaeological Sites

There is no historical monument having any archeological value in the close vicinity of the proposed alignment. Thus, on this aspect there would be no impact.

14.9.2.7 Impact on Sensitive Receptors

There are many sensitive receptors along the alignment like hospitals, schools and religious places but care has been taken to keep safe distance between the alignment and sensitive receptors. However, during operation stage care would be taken to provide noise barriers of suitable design between hospitals and the alignment to minimize the impact.

14.9.3 IMPACTS DUE TO PROJECT DESIGN

Considered impacts, due to project designs are:

- Lighting,
- Risk Due to Earthquake.

14.9.3.1 Lighting

The platforms, concourse, staircase and escalator areas for the elevated stations will have adequate and uniform fluorescent lighting to provide pleasant and cheerful environment. It is proposed to adopt the norms prevailing in Metro for illumination. It is pertinent to note that care has been taken at design stage itself to avoid too much illuminating the stations. Maximum illumination level proposed is 200Lux which provides normal lighting.

14.9.3.2 Risk Due to Earthquake

The project area lies in Zone III of Bureau of Indian Standards (BIS) Seismic Zoning Map (**Fig. 14.2**). Seismic factor proposed by India Meteorological Department (IMD) for the purpose of design of Civil Engineering structures shall be incorporated suitably while designing the structures.

14.9.4 IMPACTS DUE TO PROJECT CONSTRUCTION

Although environmental hazards related to construction works are mostly of temporary nature. Appropriate measures should be included in the work plan and budgeted for. The most likely negative impacts related to the construction works are:

- Top Soil erosion, pollution and health risk at construction site,
- Traffic diversion and risk to existing building,
- Excavated soil disposal problems,
- Dust Generation,
- Increased water demand,
- Impact due to Supply of Construction Material,
- Disposal of Construction and Demolition Waste,
- Impacts due to batching plant and casting yard,
- Noise Pollution,

14.9.4.1 Soil Erosion, Pollution and Health Risk at Construction Site

Every care will be taken to avoid damage to the top soil. It shall be preserved and utilized. Problems could arise from dumping of construction spoils (Concrete, bricks) waste materials (from contractor camps) etc. causing surface and ground water pollution. However, it is proposed to have mix concrete directly from batching plant for use at site. Health risks include disease hazards due to lack of sanitation facilities in labour camps (water supply and human waste disposal) and insect vector disease hazards of local workers and disease hazards to the local population. Mitigation measures should include proper water supply, sanitation, drainage, health care and human waste disposal facilities. In addition to these, efforts need to be made to avoid water spills, adopt disease control measures and employment of local labour. Problems could arise due to difference in customs of workers from immigrant workers and local residents. These risks could be reduced by providing adequate facilities in worker's camps, raising awareness amongst workers and by employment of preferably local labour.

14.9.4.2 Traffic Diversions and Risk to Existing Buildings

During construction period, complete/ partial traffic diversions on road will be required, as most of the construction activities are on the central verge of road. Traffic would get affected on the roads. Rather than completely blocking the roads it will be advisable to make the narrow portion of roads as one way to allow for operation of traffic together with construction activities. Advance traffic updates/ information on communication systems will be an advantage to users of affected roads. The rail corridor does not pose any serious risk to existing buildings since there is safe distance between buildings and proposed corridor except at a few places where the buildings are affected due to the turning of alignment. Moreover, at many places facilities for station would affect open spaces and a few buildings which may be avoided by suitably adjusting the station layouts. Special care shall be taken for safety of the structures during construction.

14.9.4.3 Problems of Excavated Soil and Bentonite Disposal

The proposed alignment is elevated and thus the excavation would be limited to piers and their piling. The soil would be used for refilling at station sites. If there would be some residual soil, it would be utilized by **MEGA** for internal use for refilling lo lying areas and, if surplus, it would be disposed off at designated locations as per Ahmedabad Authority directions. Some Bentonite muck would also be generated in the project. Disposal of Bentonite would be at designated land fill site.

14.9.4.4 Air Pollution and Dust Generation

Transportation of earth and establishment of the material will involve use of heavy machinery like compactors, rollers, water tankers, and dumpers. This activity is machinery intensive resulting in dust generation. Simultaneously there would be fugitive gas emissions due to vehicular and machinery exhausts during their working during construction. However, this activity will be only short-term. Protective measures shall be undertaken during construction phase. Movement of trucks and other heavy equipment at construction site would generate dust during construction phase.

14.9.4.5 Water Pollution

Source of Water contamination will be from the washings and the surplus water from curing the structures which shall be diverted and passed through desilting chambers before letting it go outside the working site. Muck shall not be allowed to confluence with any water course. Controlled water should be used for curing.

14.9.4.6 Increased Water Demand

The water demand will increase during construction phase for meeting out drinking and domestic water requirement of workers. Sufficient water for construction purpose would be made available by AMC as it is responsible for water supply in Ahmedabad. Water requirement for construction of Metro will be met through the public supply. It is suggested to use treated STP water for the purpose of Construction. Proper care shall be taken while drawing water from public facilities to avoid any negative impact on the residents living in the vicinity of the project whose water demand is, in any case, met by AMC supplied water.

14.9.4.7 Impact due to Supply of Construction Material

Metro construction is a material intensive activity. Huge quantity of different construction materials will be required for construction of metro corridor. These shall be sourced from the nearest source. Quarry operations are independently regulated activities and outside the purview of the project proponent. It is nonetheless, appropriate to consider the environmental implications in selection of quarry sources since poorly run operations create dust problems, contribute noise pollution, ignore safety of their employees, or cause the loss of natural resources. Although quarry operation is out of purview of the metro construction but, the construction material shall be sourced only from legalized and approved quarries.

14.9.4.8 Generation of Construction and Demolition Waste

Construction and demolition (C&D) debris is defined as that part of the solid waste stream that results from land clearing and excavation, and the construction, demolition, remodeling and repair of structures, roads and utilities. C&D waste includes concrete, stones and dirt generated during excavation (sometimes collectively referred to as "fill material" or rubble). C& D Waste may be generated from Pile caps, residual cement bags, residual steel scrap, excess construction material stacked at site etc. It is a waste stream that is separate and distinct from residential and commercial waste, commonly called municipal solid waste (MSW).

About 10-15% of the construction material such as waste material from contractor camps is left behind by the contractor as construction waste/ spoils. Dumping of construction waste/spoil in haphazard manner may cause surface and ground water pollution near the construction sites. The C& D waste would be handled and disposed-off to C&D waste processing facility or for back filling of low lying areas, leaving no significant impact on environment.

14.9.4.9 Impacts due to Casting Yard and Batching Plant

During construction phase, there would be establishment and operation of Batching Plant and Casting Yard which would be located in an area designated and allotted by AMC/ AUDA away from habitation. There would be requirement to get NOC (Consent to establish) and Consent to operate under water and air Acts from Gujarat Pollution Control Board at the time of establishing the facilities. Simultaneously, there would be requirement to get the authorization for storage and handling of hazardous chemicals to store and handle used oils and other such materials. The Application forms for seeking Consent to establish, Consent to Operate and Authorization for storage of

Hazardous chemicals are available from the office of Gujarat Pollution Control Board at Ahmedabad.

There would be significant movement of men, material and machinery in batching plant and casting yard. It is expected that both batching and casting yard would be located at same complex. Huge quantity of Cement, aggregates and other construction materials would be used in batching plant and casting yard. There would be generation of dust, noise, flue gases and other contaminants from the working of heavy machinery for handling and transporting the construction materials. The mitigation measures have been elaborated in EMP.

14.9.4.10 Noise Pollution

The major sources of noise pollution during construction are movement of vehicles for transportation of construction material to the construction site and the noise generating activity at the construction site itself. The Metro construction is equipment intensive.

14.9.4.11 Vibrations

During Construction

There may be vibration during piling operations due to working of heavy construction machinery and the movement of heavy transport vehicles, loading and unloading of materials etc. This would be a short-term activity and effort will be made to avoid piling operations during night between 11.00 pm to 5.00 am in the vicinity of residential areas.

14.9.4.12 Loss of Historical and Cultural Monuments

No historical/ cultural monuments will be lost because of the proposed development.

14.9.5 IMPACTS DUE TO PROJECT OPERATION

Along with many positive impacts, the project may cause the following negative impacts during operation of the project due to the increase in the number of passengers and trains at the stations:

- Noise pollution,
- Water supply and sanitation at Stations,
- Station refuse disposal and sanitation,
- Pedestrianization and visual issues

14.9.5.1 Noise Pollution

During the operation phase the main source of noise will be from running of metro trains. Noise radiated from train operations and track structures generally constitute the major noise sources. Airborne noise is radiated from elevated structures. The noise level at 2 m distance from the rail alignment is about 73 dB(A) as per the experience in operating metro system. The noise level reduces with distance logarithmically. At places, the alignment is likely to be passing close to the buildings which may affect the residents. At such places noise barriers would be used to minimize the noise impact in the vicinity of the alignment.

14.9.5.2 Water Supply and Sanitation at Stations

Public facilities such as water supply, sanitation and wash rooms are very much needed at the stations. The water requirement for stations would be for drinking, toilets, cleaning and also for other purpose like AC. Water Demand as per existing Metro corridors is calculated and presented in **Table 14.12**. It is assumed that there would be similar water requirements in Ahmedabad Metro as well. Raw water should be treated and brought to national drinking water standards, before used for consumption. In addition, water will be required for contractor's camps during construction. The water requirement for the stations will be met through the public water supply system or purpose built tube wells after taking necessary approvals from CGWA. However, as an environmental conservation measure, rainwater harvesting structure will also be constructed at stations and along the via-duct.

Table 14.12 Water Requirement at Stations

S. No.	Particular	Water Demand for each station KLD
1	At Stations for Drinking Purpose	6
2	At Elevated stations for AC, cleaning, chiller and other purposes	17
Total		**23**

Thus, there would be total water requirement of 552 KLD in 24 stations. However, arrangement of water will have to be made at each station separately.

14.9.5.3 Station Refuse

The collection and removal of refuse from stations in a sanitary manner is of great importance for effective vector control, nuisance abatement, aesthetic improvement and fire protection. The refuse from station includes;

- Garbage,
- Rubbish, and
- Floor Sweepings.

As per the available data from Delhi Metro Phase I and II and other operational metros, the solid waste generation is about 0.8 – 1.2 cum/day at elevated stations. At elevated stations, the solid waste generation is more due to airborne dust. At underground stations the waste generation would be lesser. However, it is estimated that a maximum of 19.2 to 28.8 cum of solid waste will be generated from the twenty four stations of these corridors of Ahmedabad metro. The maintenance of adequate sanitary facilities for temporarily storing refuse on the premises is considered a responsibility of the project authorities. The storage containers for this purpose need to be designed. However, it is suggested that the capacity of these containers should not exceed 50 litres and these should be equipped with side handles to facilitate handling. To avoid odour and the accumulation of fly-supporting materials, garbage containers should be washed at frequent intervals.

14.9.5.4 Visual Impacts

The introduction of MRTS implies a change in streets through which it will operate. An architecturally well designed elevated section can be pleasing to the eyes of beholders. Recent MRTS projects have attempted to incorporate this objective in their designs. Since a low profile would cause the least intrusion, the basic elevated section has been optimised at this stage itself.

14.9.5.5 Vibrations

This corridor is elevated throughout the alignment. As per the experience from working metros particularly Delhi Metro it is found that the problem of ground vibration is generally felt in case of Underground sections. In elevated corridors there has been no complaint of vibration in the vicinity of alignments. Therefore, the vibration impact is not considered significant for most of the corridor section. However, preventive measures to reduce the vibration at source would be applied in the rail design itself for the entire metro corridor.

The effects of ground-borne vibration include perceptible movement of the building floors, rattling of windows, shaking of items on shelves or hanging on walls, and rumbling sounds. In extreme cases, such vibration can damage buildings and other structures. In addition, the sound reradiated from vibrating room surfaces, referred to as ground-borne noise, may be audible in the form of a low-frequency rumbling sound. The train wheels rolling on the rails create vibration energy transmitted through the track support system into the track bed or track structure. The amount of energy that is transmitted into the track structure depends strongly on factors such as how smooth the wheels and rails are and the resonance frequencies of the vehicle suspension system and the track support system. The vibration of the track or guideway structure excites the adjacent ground, creating vibration waves that propagate through the various soil and rock strata to the foundations of nearby buildings. The vibration propagates from the foundation throughout the remainder of the building structure. The maximum vibration amplitudes of floors and walls of a building often occur at the resonance frequencies of those building elements.

14.10 POSITIVE ENVIRONMENTAL IMPACTS OF THE PROJECT

Based on project particulars and existing environmental conditions, potential impacts that are likely to result from the proposed Ahmedabad metro corridors development have been identified and wherever possible these have been quantified. This section deals with the positive impacts of the project. The introduction of the corridor will also yield benefits from non-tangible parameters such as savings due to equivalent reduction in road construction and maintenance, vehicle operating costs, less atmospheric air pollution and socio-economic benefits of travel time, better accessibility, better comfort and quality of life. However, all benefits cannot be evaluated in financial terms due to non-availability of universally accepted norms. The parameters such as economic growth, improvement in quality of life, reduction in public health problems due to reduction in pollution, etc have not been quantified.

Various positive impacts have been listed under the following headings:

Employment Opportunities;
Enhancement of Economy;
Mobility, Safety and reduced accidents;
Traffic Congestion Reduction;
Reduced Fuel Consumption;
Reduced Air Pollution;
Reduction in Number of Buses/ Auto rickshaws, and

Employment Opportunities

The project is likely to be completed in a period of about 4 years. During this period manpower will be needed to take part in various activities. About 3500 persons are likely to work during peak period of activity. In operation phase of the project about 35 persons per kilo meter length of the corridor, i.e., (approx. 1190 persons) will be employed for operation and maintenance of the proposed system in shifts. Thus, the project would provide substantial direct employment. Besides, more people would be indirectly employed in allied activities and trades.

Enhancement of Economy

The proposed transport facility of **MEGA** will facilitate sub-urban population to move quickly. With the development of metro corridors in Ahmedabad, it is likely that more people will be involved in trade, commerce and allied services. **MEGA** will, however, make it convenient for more people to move in the present suburban areas. This will reduce population pressure on transport facilities in the urban area.

Mobility Safety and Reduced Accidents

The metro network increases the mobility of people at faster rate. The proposed corridor will provide more people connectivity to other parts of the city. Metro journey is safe and result in reduced accidents on roads.

Traffic Congestion Reduction

To meet the forecast transport demand in the year 2021, 2031 and 2041 it is estimated that the number of buses will have to be more. During this period personalised vehicles may also grow. Together, they will compound the existing problems of congestion and delay. The proposed development will reduce journey time and hence congestion and delay. Estimated person Trips shifted to Metro in metro and estimated PCE have been depicted in following table:

Year	Option	Trips Shifted to Metro in Person Trips	Average Trip Length	Estimated PCE
2021	I	5,14,065	5.50	1,28,516
2031	I	6,63,426	5.54	1,65,857
2041	I	8,39,477	5.75	2,09,869
2051	I	9,80,672	5.86	2,45,168
2021	II	4,65,754	5.55	1,16,439
2031	II	5,99,669	5.59	1,49,917
2041	II	7,58,662	5.80	1,89,666
2051	II	8,84,940	5.92	2,21,235

Year	Option	Trips Shifted to Metro in Person Trips	Average Trip Length	Estimated PCE
2021	III	4,21,977	5.59	1,05,494
2031	III	5,29,970	5.68	1,32,493
2041	III	6,75,801	5.89	1,68,950
2051	III	7,85,030	6.03	1,96,258

These substitutions have been worked out assuming a switchover of 4 Person per PCE. The Asian Development Bank's "Transport Emissions Model" for the National Environment Commission has been used to predict/calculate the fuel consumption as well as the emissions of the harmful pollutants into the environment. This will lead to substantial reduction in traffic congestion on roads.

Reduced Fuel Consumption

On implementation of the project, it is estimated that both petrol and diesel consumption will get reduced. The saving will be due to two factors namely Reduction in vehicles and decongestion on roads. On the basis of assumptions as give in following table there will be significant saving of Petrol and Diesel consumption in litres as per **Table14.13**.

Table 14.13 Saving of Petrol and Diesel due to Metro

Year	Option	Person Trips Shifted to Metro	Average Trip Length	**Estimated PCE**	**Petro litres**
2021	I	5,14,065	5.50	1,28,516	42885
2031	I	6,63,426	5.54	1,65,857	55464
2041	I	8,39,477	5.75	2,09,869	72384
2051	I	9,80,672	5.86	2,45,168	
2021	II	4,65,754	5.55	1,16,439	38855
2031	II	5,99,669	5.59	1,49,917	50586
2041	II	7,58,662	5.80	1,89,666	65984
2051	II	8,84,940	5.92	2,21,235	
2021	III	4,21,977	5.59	1,05,494	35203
2031	III	5,29,970	5.68	1,32,493	45426
2041	III	6,75,801	5.89	1,68,950	59689
2051	III	7,85,030	6.03	1,96,258	

Reduced Air Pollution

Based on available data and assumptions, an attempt has been made to model the air quality scenario for future using Asian Development Bank's "Transport Emissions Model". On the basis of above referred assumptions, daily reduction in pollutants would be as given in **Table 14.14** below:

Table 14.14 Reduction in Emmissio of Greenhouse Gasses due to Modal Shift to Metro

All Values are in Kg.

Year	Option	Person Trips Shifted to Metro	Average Trip Length	Estimated PCE	CO	CO2	NOx	VOC	Particles	SO2
2021	I	5,14,065	5.50	1,28,516	2,750.14	1,20,884.25	478.16	425.68	7.20	14.97
2031	I	6,63,426	5.54	1,65,857	2,852.03	1,59,271.15	506.55	473.75	6.97	19.71
2041	I	8,39,477	5.75	2,09,869	3,032.01	2,11,331.32	544.92	551.22	6.65	26.20
2051	I	9,80,672	5.86	2,45,168						
2021	II	4,65,754	5.55	1,16,439	2,491.68	1,09,523.48	433.22	385.67	6.52	13.56
2031	II	5,99,669	5.59	1,49,917	2,601.19	1,45,263.41	462.00	432.08	6.36	17.98
2041	II	7,58,662	5.80	1,89,666	2,763.96	1,92,648.31	496.75	502.48	6.06	23.88
2051	II	8,84,940	5.92	2,21,235						
2021	III	4,21,977	5.59	1,05,494	2,257.49	99,229.38	392.50	349.43	5.91	12.29
2031	III	5,29,970	5.68	1,32,493	2,335.89	1,30,447.22	414.88	388.01	5.71	16.14
2041	III	6,75,801	5.89	1,68,950	2,500.28	1,74,269.43	449.36	454.55	5.48	21.61
2051	III	7,85,030	6.03	1,96,258						

Carbon Credits

Due to savings in fuel and reduction in air pollution etc. carbon credit would be generated during operation of the metro rail similar to the experience with Delhi Metro Rail Corporation Ltd. However, at this stage calculation of carbon credits is not feasible which would be worked out after the system become operational.

Improvement of Quality of Life

Development of Metro rail in the city would lead to overall improvement of quality of life of local populace by virtue of availability of better transport facility at competitive rates, better road safety, reduced pollution, improved general health etc.

14.11 CHECKLIST OF IMPACTS

The impact evaluation determines whether a project development alternative is in compliance with existing standards and regulations. It uses acceptable procedures and attempts to develop a numeric value for total environmental impact. A transformation of the review of multiple environmental objectives into a single value or a ranking or projects is the final step in impact assessment. There are about hundred methods for carrying out impact assessment, which can be grouped into the following categories:

Ad-hoc method,
Checklist,
Matrix,
Network,
Overlays,
Environmental Index and
Cost Benefit analysis.

Each of the methods is subjective in nature and none of these is applicable in every case. Of the 7 methods listed above, checklist has been used and presented. Checklist is a list of environmental parameters or impact indicators which encourages the environmentalist to consider and identify the potential impacts. A typical checklist identifying anticipated environmental impacts is shown in **Table 14.15**.

Table 14.15 Checklist of Impacts

S. No.	Parameter	Negative Impact	No Impact	Positive Impact
A.	**Impacts due to Project Location**			
i.	Displacement of People		*	
ii.	Change of Land use and Ecology	*		
iii.	Loss of Cultural and Religious Structures		*	
iv.	Socio-economic Impacts	*		
v.	Loss of Trees	*		
vi.	Drainage & Utilities Problems	*		
B.	**Impact due to Project Design**			
i.	Platforms - Inlets and Outlets		*	
ii.	Ventilation and Lighting		*	
iii.	Station Refuse	*		
iv.	Risk due to Earthquakes		*	
C.	**Impact due to Project Construction**			
i.	Top Soil Erosion, Pollution and Health risk	*		
ii.	Traffic Diversions and	*		
iii.	Risk to Existing Buildings	*		
iv.	Problems of Soil Disposal and Seepage Risk	*		
v.	Dust Generation	*		
vi.	Increased Water Demand	*		
vii.	Supply of Construction Material	*		
viii.	Construction and Demolition Waste	*		
ix.	Batching Plant and Casting Yard	*		
x.	Noise	*		
D.	**Impact due to Project Operation**			
i.	Oil Pollution	*		
ii.	Noise	*		
iii.	Water supply and sanitation	*		
iv.	Vibrations	*		
v.	Pedestrian Issues		*	
vi.	Visual Impacts		*	
vii.	Station Illumination		*	
viii.	Employment Opportunities			*
ix.	Enhancement of Economy			*
x.	Mobility			*
xi.	Safety			*
xii.	Traffic Congestion Reduction			*
xiii.	Less fuel Consumption			*
xiv.	Less Air Pollution			*
xv.	Carbon dioxide Reduction			*
xvi.	Reduction in Buses			*
xvii.	Reduction in Infrastructure			*

14.12 PUBLIC CONSULTATION AND DISCLOSURE

Public consultation and participation is a continuous two way process, involving, promoting of public understanding of the processes and mechanisms through which developmental problems and needs are investigated and solved. The public consultation, as an integral part of environmental and social assessment process throughout the project preparation stage not only minimizes the risks and unwanted political propaganda against the project but also abridges the gap between the community and the project formulators, which leads to timely completion of the project and making the project people friendly.

Public consultations with the people of different sections of the society along the project alignment, shopkeepers, and influential persons of the project area will be made. Attention shall be given to potential vulnerable people like, squatters, encroachers, schedule caste, and other backward section (OBC) of society shall be consulted to make them aware and identify adverse impacts of the project.

A. Consultation with Stakeholders

As required for Category A projects, preliminary consultations were conducted at the early stage of EIA preparation, mostly involving local communities. Successive consultations shall be conducted by the **MEGA** after the finalization of this report that includes representatives of local communities and entities tasked with the regulation of the road development and environmental protection.

B. Compliance with Regulatory and Funding Agency Requirement

As per Indian Environmental Regulations, public hearing is not required, as railway projects do not attract EIA Notification 2006, amended 2009. Meaningful consultations will be undertaken. All the five principles of information dissemination, information solicitation, integration, co ordination and engagement into dialogue will be incorporated in the consultation process.

14.13 ENVIRONMENTAL MANAGEMENT PLAN

14.13.1 MANAGEMENT PLANS

The Ahmedabad Metro Project will provide employment opportunity, quick mobility service and safety, traffic congestion reduction, less fuel consumption and air pollution on one hand and problems of muck disposal, traffic diversion, utility dislocation etc. on the other hand.

Protection, preservation and conservation of environment have always been a primary consideration in Indian ethos, culture and traditions. Management of Environment by provision of necessary safeguards in planning of the project itself can lead to reduction of adverse impacts due to a project. This chapter, therefore, spells out the set of measures to be taken during project construction and operation to mitigate or bring down the adverse environmental impacts to acceptable levels based on the proposed 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. For optimal integration of EMP into the project, there should be investment links for:

- Funding,
- Management and training, and
- Monitoring.

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

- Mitigation measures,
- Disaster management, and
- Emergency measures.

14.13.2 MITIGATION MEASURES

The main aim of mitigation measures is to protect and enhance the existing environment of the project. Mitigation measures have to be adopted during construction at all the construction sites including Batching Plant and Casting Yards on all the aspects. The mitigation measures to be adopted have been described under following heads:

- Compensatory Afforestation,
- Construction Material Management,
- Labour Camp,
- Energy Management
- Hazardous Waste Management
- Environmental Sanitation,
- Utility Plan,
- Air Pollution Control Measures,
- Noise Control Measures,
- Vibration Control Measures,
- Traffic Diversion/Management,
- Soil Erosion Control,
- Water Supply, Sanitation and Solid Waste management,
- Rain water harvesting
- Training and Extension

14.13.3 COMPENSATORY AFFORESTATION

The objective of the afforestation program should be to develop natural areas in which ecological functions could be maintained on a sustainable basis. According to the results of the present study, it is found that about 160 trees are likely to be lost due to the project. Three saplings are to be planted for felling a single tree. Hence 480 trees need to be planted. Plantation program will be finalized in consultation with

MEGA and project proponent would provide the funds for compensatory afforestation as per government policy.

14.13.4 CONSTRUCTION MATERIAL MANAGEMENT – STORAGE AND PROCUREMENT

The major construction material to be used for construction of the proposed corridor are coarse aggregates, cement, coarse sand, reinforcement steel, structural steel, water supply, drainage and sanitary fittings etc. The material will be loaded and unloaded by engaging labour at both the locations by the contractor.

The duties of the contractor will include monitoring all aspects of construction activities, commencing with the storing, loading of construction materials and equipment in order to maintain the quality. During the construction period, the construction material storage site is to be regularly inspected for the presence of uncontrolled construction waste. Close liaison with the **MEGA** Officer and the head of the construction crew will be required to address any environmental issues and to set up procedures for mitigating impacts. The scheduling of material procurement and transport shall be linked with construction schedule of the project. The Contractor shall be responsible for management of such construction material during entire construction period of the project. Sufficient quantity of materials should be available before starting each activity. The contractor should test all the materials in the Government labs or Government approved labs in order to ensure the quality of materials before construction. This is also the responsibility of the contractor, which would be clearly mentioned in the contractor‘s agreement. Care shall be taken to avoid spillage of material during construction. Procurement of material would be from environment friendly source. The materials shall be procured from nearest available source and shall be transported in coverd trucks. All the material would be stored in a manner to avoid multiple handling for use in construction activities.

14.13.5 LABOUR CAMP

The Contractor during the progress of work will provide, erect and maintain the necessary (temporary) living accommodation and ancillary facilities for labour to standards and scales approved by the **MEGA**. All temporary accommodation must be constructed and maintained in such a fashion that uncontaminated water is available for drinking, cooking and washing. Safe drinking water should be provided to the dwellers of the construction camps. Adequate washing and bathing places shall be provided, and kept in clean and drained condition. Construction camps are the responsibility of the concerned contractors and these shall not be allowed in the construction areas but sited away. Adequate health care is to be provided for the work force.

Sanitation Facilities: Construction sites and camps shall be provided sanitary latrines and urinals. Mobile STP/ septic tanks should be provided for the flow of used water outside the camp. Drains and ditches should be treated with bleaching powder on a regular basis. The sewage system for the camp must be properly designed, built and operated so that no health hazard occurs and no pollution to the air, ground or adjacent watercourses takes place. Garbage bins must be provided in the camp and regularly emptied and the garbage disposed off in a hygienic manner

Shelter at Workplace: At every workplace, shelter shall be provided free of cost, separately for use of men and women labourers. Sheds shall be maintained in proper hygienic conditions.

First aid facilities: At every workplace, a readily available first-aid unit including an adequate supply of sterilized dressing materials and appliances shall be provided. Suitable transport shall be provided to facilitate taking injured and ill persons to the nearest hospital.

Day Crèche Facilities: At every construction site, provision of a day crèche shall be worked out so as to enable women to leave behind their children. At construction sites where 25 or more women are ordinarily employed, at least a hut shall be provided for use of children under the age of 6 years belonging to such women. Huts shall be provided with suitable and sufficient openings for light and ventilation. Size of crèches shall vary according to the number of women workers employed.

14.13.6 ENERGY MANAGEMENT

The contractor shall use and maintain equipment so as to conserve energy and shall be able to produce demonstrable evidence of the same upon **MEGA** request. Measures to conserve energy include but not limited to the following:

Use of energy efficient motors and pumps,
Use of energy efficient lighting, which uses energy efficient luminaries,
Adequate and uniform illumination level at construction sites suitable for the task,
Proper size and length of cables and wires to match the rating of equipment, and
Use of energy efficient air conditioner.

The contractor shall design site offices maximum daylight and minimum heat gain. The rooms shall be well insulated to enhance the efficiency of air conditioners and the use of solar films on windows may be explored.

14.13.7 HAZARDOUS WASTE MANAGEMENT

The contractor shall identify the nature and quantity of hazardous waste generated as a result of his activities and shall file a ‗Request for Authorization' with Gujarat Pollution Control Board along with a map showing the location of storage area. Outside the storage area, the contractor shall place a ‗display board', which will display quantity and nature of hazardous waste, on date. Hazardous Waste needs to be stored in a secure place. It shall be the responsibility of the contractor to ensure that hazardous wastes are stored, based on the composition, in a manner suitable for handling, storage and transport. The labeling and packaging is required to be easily visible and be able to withstand physical conditions and climatic factors. The contractor shall approach only Authorized Recyclers for disposal of Hazardous Waste, under intimation to the **MEGA**.

14.13.8 ENVIRONMENTAL SANITATION

Environmental sanitation also referred to as Housekeeping, is the act of keeping the working environment cleared of all unnecessary waste, thereby providing a first-line of defense against accidents and injuries. Contractor shall understand and accept that improper environmental sanitation is the primary hazard in any construction site and ensure that a high degree of environmental sanitation is always maintained. Environmental sanitation is the responsibility of all site personnel, and line management commitment shall be demonstrated by the continued efforts of supervising staff towards this activity.

General environmental sanitation shall be carried out by the contractor and at all times at Work Site, Construction Depot, Batching Plant, Labour Camp, Stores, Offices and toilets/urinals. The contractor shall employ a special group of environmental sanitation personnel to carry out following activities:

Full height fence, barriers, barricades etc. shall be erected around the site in order to prevent the surrounding area from excavated soil, rubbish etc, which may cause inconvenience to and endanger the public. The barricade especially those exposed to public shall be aesthetically maintained by regular cleaning and painting as directed by the Employer. These shall be maintained in one line and level.

The structure dimension of the barricade, material and composition, its colour scheme, **MEGA** logo and other details.

All stairways, passageways and gangways shall be maintained without any blockages or obstructions. All emergency exits passageways, exits fire doors, break-glass alarm points, fire-fighting equipment, first aid stations, and other emergency stations shall be kept clean, unobstructed and in good working order.
All surplus earth and debris are removed/disposed off from the working areas to officially designated dumpsites. Trucks carrying sand, earth and any pulverized materials etc. in order to avoid dust or odour impact shall be covered while moving.

No parking of trucks/trolleys, cranes and trailers etc. shall be allowed on roads, which may obstruct the traffic movement.

Roads shall be kept clear and materials like: pipes, steel, sand boulders, concrete, chips and brick etc. shall not be allowed on the roads to obstruct free movement of road traffic.

Water logging or bentonite spillage on roads shall not be allowed.

Proper and safe stacking of material are of paramount importance at yards, stores and such locations where material would be unloaded for future use. The storage area shall be well laid out with easy access and material stored / stacked in an orderly and safe manner.

Flammable chemicals / compressed gas cylinders shall be safely stored.

Unused/surplus cables, steel items and steel scrap lying scattered at different places within the working areas shall be removed to identified locations.

All wooden scrap, empty wooden cable drums and other combustible packing materials, shall be removed from work place to identified location(s).

Empty cement bags and other packaging material shall be properly stacked and removed.

14.13.9 UTILITY PLAN

The proposed Metro alignment runs along major arterial roads of the city, which serve Institutional, Commercial and Residential areas. A number of sub-surface, surface and overhead utility services, viz. sewers, water mains, storm water drains, telephone cables, electrical transmission lines, electric poles, traffic signals etc. exists along the proposed alignment. These utility services are essential and have to be maintained in working order during different stages of construction by temporary / permanent diversions or by supporting in position. As such, these may affect construction and project implementation time schedule /costs, for which necessary planning / action needs to be initiated in advance. Prior to the actual execution of work at site, detailed investigation of all utilities and location will be undertaken well in advance by making trench pit to avoid damage to any utility. While planning for diversion of underground utility services e.g. sewer lines, water pipe lines, cables etc., during construction of Metro alignment, the following guidelines could be adopted:

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

The elevated viaduct does not pose any serious difficulty in negotiating the underground utility services, especially those running across the alignment. In such situation, the spanning arrangement of the viaduct may be suitably adjusted to ensure that no foundation need be constructed at the location, where utility is crossing the proposed Metro alignment. In case of utility services running along the alignment either below or at very close distance, the layout of piles in the foundations shall be suitably modified such that the utility service is either encased within the foundation piles or remains clear of them.

14.13.10 AIR POLLUTION CONTROL MEASURES

During the construction period, the impact on air quality will be mainly due to increase in PM_{10} along haul roads and emission from vehicles and construction machinery. Though the estimation of air quality during construction shows some impact on ambient air quality, nevertheless certain mitigation measures which shall be adopted to reduce the air pollution are presented below:

The Contractor shall take all necessary precautions to minimise fugitive dust emissions from operations involving excavation, grading, and clearing of land and disposal of waste. He shall not allow emissions of fugitive dust from any transport, handling, construction or storage activity to remain visible in atmosphere beyond the property line of emission source for any prolonged period of time without notification to the Employer.

The Contractor shall use construction equipment to minimize or control of air pollution. He shall maintain evidence of such design and equipment and make these available for inspection by Employer.

Contractor‘s transport vehicles and other equipment shall conform to emission standards fixed by Statutory Agencies of Government of India or the State Government from time to time. The Contractor shall carry out periodical checks and undertake remedial measures including replacement, if required, so as to operate within permissible norms.

The Contractor shall cover loads of dust generating materials like debris and soil being transported from construction sites. All trucks carrying loose material should be covered and loaded with sufficient free - board to avoid spills through the tailboard or sideboards.

The temporary dumping areas shall be maintained by the Contractor at all times until the excavate is re-utilized for backfilling or as directed by Employer. Dust control activities shall continue even during any work stoppage.

The Contractor shall place material in a manner that will minimize dust production. Material shall be minimized each day and wetted, to minimize dust production. During dry weather, dust control methods must be used daily especially on windy, dry days to prevent any dust from blowing across the site perimeter.

The Contractor shall water down construction sites as required to suppress dust, during handling of excavation soil or debris or during demolition. The Contractor will make water sprinklers, water supply and water delivering equipment available at any time that it is required for dust control use. Dust screens will be used, as feasible when additional dust control measures are needed especially where the work is near sensitive receptors.

The Contractor shall provide a wash pit or a wheel washing and/or vehicle cleaning facility at the exits from work sites such as construction depots and batching plants. At such facility, high-pressure water jets will be directed at the wheels of vehicles to remove all spoil and dirt.

14.13.11 CONSTRUCTION AND DEMOLITION WASTE

Waste prevention, reuse and recycling can not only save money, but also generate broad environmental benefits, including the conservation of natural resources. Reuse and waste prevention reduce the air and water pollution associated with materials manufacturing and transportation. This saves energy and reduces attendant greenhouse gas production. The recycling of many materials requires less energy than production from virgin stock, and can also reduce transportation requirements and associated impacts. Opportunities for reducing C&D waste focus on three approaches, typically expressed as **Reduce-Reuse-Recycle**.

The source of C & D waste are pile caps, excess RMC and demolition material. An effort shall be made to recover embedded energy and to recycle the maximum quantity of C & D Waste to manufacture tiles, curb stones, paver block etc. The contractor shall store C&D waste separately at the site and sent to recycling facility periodically. There shall be no disposal of any waste along storm water drains, canals and/ or any other water body or depression. Rather C & D waste shall be collected and sent to any authorized waste recycling facility.

14.13.12 NOISE CONTROL MEASURES

There will be an increase in noise level in nearby ambient air due to construction and operation of the Metro corridors. During construction, the exposure of workers to high noise levels especially near the machinery need to be minimized. This could be achieved by:

Job rotation,
Automation,
Construction of permanent and temporary noise barriers,
Use electric instead of diesel powered equipment,
Use hydraulic tools instead of pneumatic tools,
Acoustic enclosures should be provided for individual noise generating construction equipment like DG sets,
Scheduling and staggering truck loading, unloading and hauling operation,
Schedule and stagger work to avoid simultaneous activities which generate high noise levels,
Anti drumming floor and noise absorption material,
Low speed compressor, blower and air conditioner,
Mounting of under frame equipment on anti-vibration pad,
Smooth and gradual control of door,
Provision of sound absorbing material in the supply duct and return grill of air conditioner,
Sealing design to reduce the aspiration of noise through the gap in the sliding doors and piping holes, and
Sound proof compartments control rooms etc.

Special acoustic enclosures should be provided for individual noise generating equipment, wherever possible. Workers in sections where periodic adjustment of equipment/ machinery is necessary, should be provided with sound proof control rooms so that exposure to higher noise level is reduced. During construction, there may be high noise levels due to pile driving, use of compressors and drilling machinery. Effective measures should be taken during the construction phase to reduce the noise from various sources. The noise from air compressor can be reduced by fitting exhaust and intake mufflers.

The pile driving operation can produce noise levels up to 100 dB (A) at a distance of 25-m from site. Suitable noise barriers can reduce the noise levels to 70 dB (A) at a distance of 15m from the piles. A safety precaution as stipulated in IS: 5121 (1969) *‗Safety Code for Piling and other Deep Foundation'* need to be adopted.

Noise level from loading and unloading of construction materials can be reduced by usage of various types of cranes and placing materials on sand or sandy bag beds.

14.13.13 VIBRATION CONTROL

Mitigation can minimize the adverse effects of project ground-borne vibration on sensitive land uses. Vibrations arise due to rail - wheel interaction during operations. Vibrations could be reduced by improving track geometry, providing elastic fastenings, minimizing surface irregularities of wheel and rail, and separation of rail seat assembly from the concrete plinth with insertion of resilient and shock absorbing pad.

Adequate wheel and rail maintenance in controlling levels of ground-borne vibration is very important. Problems with rough wheels or rails can increase vibration levels by as much as 20 dB, negating the effects of even the most effective vibration control measures. It is rare that practical vibration control measures will provide more than 15- to 20-decibel attenuation. When ground-borne vibration problems are associated with existing rails and rolling stock, often the best control measure is to implement new or improved maintenance procedures. Grinding rough or corrugated rail and implementing wheel truing to restore the wheel surface and contour may reduce vibration more than completely replacing the existing track system with floating slabs.Assuming that the track and vehicles are in good condition, the options to further reduce ground-borne vibration fit into one of seven categories: (1) maintenance procedures, (2) location and design of special track work, (3) vehicle modifications, (4) changes in the track support system, (5) building modifications, (6) adjustments to the vibration transmission path, and (7) operational changes.

Maintenance

Effective maintenance programs are essential for keeping ground-borne vibration levels under control. When the wheel and rail surfaces are allowed to degrade, the vibration levels can increase by as much as 20 dB compared with a new or well-maintained system. Maintenance procedures that are particularly effective at avoiding increases in ground-borne vibration include the following:

Rail grinding on a regular basis, particularly for rail that develops corrugations. Rail condition monitoring systems are available to optimize track conditions.

Wheel truing to re-contour the wheel, provide a smooth running surface, and remove wheel flats. The most dramatic vibration reduction results from removing wheel flats. However, significant improvements also can be observed simply from smoothing the running surface. Wheel condition monitoring systems are available to optimize wheel conditions.

Reconditioning vehicles, particularly when components such as suspension system, brakes, and wheels will be improved and slip-slide detectors will be installed.

Installing wheel condition monitoring systems to identify those vehicles most in need of wheel truing.

Location and Design of Special Track Work

Most vibration impact from a new train system is caused by wheel impacts at the special track work for turnouts and crossovers. Careful review of crossover and turnout locations during the preliminary engineering stage is an important step in minimizing potential for vibration impact. When feasible, the most effective vibration control measure is to relocate the special track work to a less vibration-sensitive area. Another approach is to install movable point or spring frogs that eliminate the gaps that occur when standard railbound frogs are used. These special frogs significantly reduce vibration levels near crossovers, and they are often specified because of their longer lifespan under repetitive high-speed conditions.

Vehicle Suspension

The ideal rail vehicle, with respect to minimizing ground-borne vibration, should have a low unsprung weight, a soft primary suspension, a minimum of metal-to-metal contact between moving parts of the truck, and smooth wheels that are perfectly round. A thorough dynamic analysis, including the expected track parameters, should be part of the specifications for the proposed high-speed trainset.

Special Track Support Systems

When the vibration assessment indicates that vibration levels will be excessive, it is usually the track support system that is modified to reduce the vibration levels. Floating slabs, resiliency supported ties; high-resilience fasteners, ballast mats, and tire-derived aggregate (shredded tires) all have been used to reduce the levels of ground-borne vibration. To be effective, these measures must be optimized for the frequency spectrum of the vibration.

While designing of the structures such as viaducts and pillars following points shall be taken into consideration:

A heavy rail section of 60-kg/m, 90 UTS, supported at every 60-cm. has been proposed in order to prevent the development of surface irregularities on the rail.

The rail used shall be the one which is continuously welded which shall lead to reduction of noise/vibration especially on account of irregular track geometry and at curves.

Elastic fastening system is proposed to be used which shall reduce the vibration generated from rail- wheel interaction.

Monitoring requirements for vibrations at regular intervals throughout the construction period.

Pre-construction structural integrity inspections of historic and sensitive structures in project activity.

The ballast-less track is supported on two layers of rubber pads to reduce track noise and ground vibrations. The concept of a ―low-noise‖ electric locomotive must be adopted at a very early stage of planning and must be followed up with detailed work throughout the project execution and operation. In addition, baffle walls as parapets will be constructed up to the rail level so as to reduce sound levels.

In addition, we have proposed to provide skirting of coach shell covering the wheel which will screen any noise coming from the rail wheel interaction as of propagating beyond the viaduct. In sensitive areas, track can be suitably designed so as to avoid propagation of noise to adjacent structures.

The lower vibration can be achieved by providing bolster less type bogies having secondary air spring.

All these measures would be part of project cost.

14.13.14 TRAFFIC DIVERSION/ MANAGEMENT

During construction, traffic is likely to be affected. Hence Traffic Diversion Plans are required in order to look for options and remedial measures so as to mitigate any traffic congestion situations arising out due to acquisition of road space during Metro construction of the corridor. Any reduction of road space during Metro construction results in constrained traffic flow. In order to retain satisfactory levels of traffic flow during the construction period; traffic management and engineering measures need to be taken. They can be road widening exercises, traffic segregation, one-way movements, traffic diversions on influence area roads etc. Maintenance of diverted roads in good working condition to avoid slow down and congestion shall be a prerequisite during construction period.

Various construction technologies are in place to ensure that traffic impedance is done at the minimum. They are:

The requirement would be mainly along the central verge/ side of the road.
As regards to the alignment cutting across a major traffic corridor, 'Box Girder Construction Technology' would be applied to prevent traffic hold-ups or diversions of any kind.
Only temporary diversion plans will be required during construction of the proposed Metro corridor. At the onset, all encroachments from road ROW will have to be removed. These encroachments vary from ‗on-street' parking to informal activities.

Keeping in view the future traffic growth and reduction of carriageway due to Metro construction, implementation of traffic management/diversion plans shall become inevitable for ensuring smooth traffic movement and similar traffic diversion plans shall be formulated and followed during the execution stage.

Traffic Management Guidelines: The basic objective of the following guidelines is to lay down procedures to be adopted by contractor to ensure the safe and efficient movement of traffic and also to ensure the safety of workmen at construction sites.

All construction workers should be provided with high visibility jackets with reflective tapes as most of viaduct and station works are on the right-of-way. The conspicuity of workmen at all times shall be increased so as to protect from speeding vehicular traffic.
Warn the road user clearly and sufficiently in advance.
Provide safe and clearly marked lanes for guiding road users.
Provide safe and clearly marked buffer and work zones
Provide adequate measures that control driver behavior through construction zones.
The primary traffic control devices used in work zones shall include signs, delineators, barricades, cones, pylons, pavement markings and flashing lights.

14.13.15 SOIL EROSION CONTROL

Prior to the start of the relevant construction, the Contractor shall submit to the **MEGA** for approval, his schedules for carrying out temporary and permanent erosion/sedimentation control works are as applicable for the items of clearing and grubbing, roadway and drainage excavation, embankment/sub-grade construction, bridges and/ or other structures across water courses, pavement courses and shoulders. He shall also submit for approval his proposed method of erosion/sedimentation control on service road and his plan for disposal of waste materials. Work shall not be started until the erosion/sedimentation control schedules and methods of operations for the applicable construction have been approved by the project authority.

The surface area of erodible earth material exposed by clearing and grubbing, excavation shall be limited to the extent practicable. The Contractor may be directed to provide immediate control measures to prevent soil erosion and sedimentation that will adversely affect construction operations, damage adjacent properties, or cause contamination of nearby streams or other watercourses. Such work may involve the construction of temporary berms, dikes, sediment basins, slope drains and use of temporary mulches, fabrics, mats, seeding, or other control devices or methods as necessary to control erosion and sedimentation. Top soil shall be preserved by the contractor and stacked separately at designated place and utilize it to cover the refilled area and to support vegetation.

The Contractor shall be required to incorporate all permanent erosion and sedimentation control features into the project at the earliest practicable time as outlined in his accepted schedule to minimize the need for temporary erosion and sedimentation control measures.

Temporary erosion/sedimentation and pollution control measures will be used to control the phenomenon of erosion, sedimentation and pollution that may develop during normal construction practices, but may neither be foreseen during design stage or associated with permanent control features on the Project. Under no conditions shall a large surface area of credible earth material be exposed at one time by clearing and grubbing or excavation without prior approval of the project authority.

The **MEGA** may limit the area of excavation, borrow and embankment operations in progress, commensurate with the Contractor's capability and progress in keeping the finish grading, mulching, seeding and other such permanent erosion, sedimentation and pollution control measures, in accordance with the accepted schedule.

Temporary erosion is sometimes caused due to the Contractor's negligence, care-lessness or failure to install permanent controls. Sedimentation and pollution control measures then become necessary as a part of the work as scheduled or ordered by the project authority, and these shall be carried out at the Contractor's own expense. Temporary erosion, sedimentation and pollution control work required, which is not attributed to the Contractor's negligence, carelessness or failure to install permanent controls, will be performed as ordered by the project authority.

14.14 WATER SUPPLY, SANITATION AND SOLID WASTE MANAGEMENT

During Construction

The public health facilities, such as water supply, sanitation and toilets are much needed at the stations. Water should be treated before use up to national drinking water standards. The collection and safe disposal of human wastes are among the most important problems of environmental health. The water carried sewerage solves the excreta disposal problems. The mobile STP/ septic tanks should be adopted for sewage disposal. The water for domestic consumption shall be sourced from public water supply or alternatively designated bore wells may be installed with due permission from statutory authority prior to installation of bore well.

For Construction activity, there is a restriction to utilize groundwater all over the nation as per order of National Green Tribunal (NGT). Thus, construction water shall be sourced from Ahmedabad Municipal Corporation which is responsible for sewage disposal in Ahmedabad area. Alternatively, contractor shall arrange tie up for surface water supply or tanker water supply for construction activity. Best option is to use treated STP water for construction activity.

Solid waste shall be stacked at designated place and when sufficient quantity accumulates it shall be disposed-off through covered trucks to land fill site designated and authorized by **MEGA**.

During Operations

Practically, public facilities at stations have to be operated by regular staff or may be designated to any NGO working in the area in the field of sanitation as per policy of **MEGA**. Requirement of drinking water supply at an elevated station is about 6 KL/day. The water consumption for an elevated station to meet the requirements of its activities is 17 KLD. This shall be provided from **MEGA**.

Solid waste will be generated at station is about 0.8 – 1.2 m^3/Day. The maintenance of adequate sanitary facilities for temporarily storing refuse on the premises is considered a responsibility of the project authority. The storage containers for this purpose need to be designed. However, it is suggested that the capacity of these containers should not exceed 50 litres and these should be equipped with side handles to facilitate handling. To avoid odour and the accumulation of fly-supporting materials, garbage containers should be washed at frequent intervals. This should be collected and transported to local municipal bins for onward disposal to disposal site by municipality. During operation, as mitigation measures rainwater harvesting will be carried out at stations and along the viaduct.

14.14.1 RAIN WATER HARVESTING

To conserve and augment the storage of groundwater, it is suggested to construct rainwater harvesting structures of suitable capacity along the alignment and at stations. The stations shall be provided with the facility of rainwater harvesting and artificial recharge. The total length of the proposed alignment is about 34 km and there would be 24 stations. The estimated cost of rain water harvesting for elevated corridor is about Rs. 11 lakhs per km (Rs. 374 Lakh) and Rs. 3.5 lakhs per station (Rs. 84 Lakhs). The total cost of rainwater harvesting would be Rs. 484 Lakh.

14.14.2 TREE PROTECTION

There is requirement of felling 160 trees during construction of Metro corridors in Ahmedabad. An attempt shall be made to minimize the tree felling. As remediation of tree felling it is suggested to plant 3 trees for each tree felled. Thus 480 trees would be planted. Moreover, **MEGA** would chalk out the plantation program in close coordination with Tree Authority **MEGA** by making the payment for plantation work including after care for three years. An attempt would be made to minimize the felling of trees to the bare minimum while working and undertaking construction work. The left out trees shall be protected by providing metal or brick tree guard around the tree at a distance of one metre surrounding the tree. Scope of transplantation of trees would also be explored with discussion with the Tree Authority MCGM. A provision of 9.60 Lakh has been made @ Rs. 2000/- per tree to be planted and maintained for a period of three years.

14.14.3 DISASTER MANAGEMENT

Disaster is an unexpected event due to sudden failure of the system, external threats, internal disturbances, earthquakes, fire and accidents. The first step is to identify the causes which develop/ pose unexpected danger to the structural integrity of Metro overhead rail. The potential causes are excessive load, cracks, failure and malfunctioning of sensing instruments, accident, etc. This need to be looked into with care.

Preventive Action

Once the likelihood of a disaster is suspected, action has to be initiated to prevent a failure. Engineers responsible for preventive action should identify sources of repair equipments, materials, labour and expertise for use during emergency.

Reporting Procedures

The level at which a situation will be termed a disaster shall be specified. This shall include the stage at which the surveillance requirements should be increased both in frequency and details.

The Engineer-in-Chief should notify the officer for the following information:

Exit points for the public,
Safety areas in the tunnel/overhead rail, and
Nearest medical facility

Communication System

An efficient communication system is absolutely essential for the success of any disaster management plan. This has to be worked out in consultation with local authorities. More often, the entire communication system gets disrupted when a disaster occurs. The damage areas need to be clearly identified and provided with temporary and fool proof communication system.

Emergency Action Committee

To ensure coordinates action, an Emergency Action Committee should be constituted. The civic administrator may be the Chairman of this Committee. The committee may comprise of:

Station Manager concerned,
Police Officer of the area,
Ahmedabad Transport Corporation Representative,
Home Guard representative,
Fire Brigade representative,
Health Department representative,
Department of Information and Publicity, and
Non-Governmental Organization of the area

Emergency Action Committee will prepare the evacuation plan and procedures for implementation based on local needs and facilities available. The plan should include:

Demarcation of the areas to be evacuated with priorities,
Safe route to be used, adequacy of transport for evacuation, and traffic control,
Safe area and shelters,
Security of property left behind in the evacuated areas,
Functions and responsibilities of various members of evacuation teams, and
Setting up of joint control room

All personnel involved in the Emergency Action Plan should be thoroughly familiar with all the elements of the plan and their responsibilities. They should be trained through drills for the Emergency Action Plan. The staff at the site should be trained for problem detection, evaluation and emergency remedial measures. Individual responsibility to handle the segments in emergency plan must be allotted.

Success of an emergency plan depends on public participation, their response to warning notifications and timely action. Public has to be educated on the hazards and key role in disaster mitigation by helping in the planned evacuation and rescue operations.

It is essential to communicate by whom and how a declared emergency will be terminated. There should be proper notification to the public on de-alert signals regarding termination of the emergency. The notification should be clear so that the evacuees know precisely what to do when re-entering or approaching the affected areas.

14.14.4 EMERGENCY MEASURES

The emergency measures are adopted to avoid any failure in the system such as lights, fire, means of escape etc. The aim of Emergency Action Plan is to identify areas, population and structures likely to be affected due to a catastrophic event of accident. The action plan should also include preventive action, notification, warning procedures and co-ordination among various relief authorities. These are discussed in following sections.

Emergency Lighting

The emergency lights operated on battery power should be provided at each station. The battery system should supply power to at least 25% of the lights at the station, platforms, viaduct for a period of 2 hours.

Fire Protection

The building materials should be of appropriate fire resistance standard. The fire resistance period should be at least 2 hours for surface or over head structures. Wood shall not be used for any purpose, excluding artificial wood products, which are flame resistant. The materials which have zero surface burning characteristics need to be used. The electrical systems shall be provided with automatic circuit breakers activated by the rise of current as well as activated by over current. The design of a station will include provision for the following:

Fire prevention measures,
Fire control measures,
Fire detection systems,
Means of escape,
Access for fireman, and
Means of fire fighting

A. Fire Prevention and Safety Measures

Fire prevention measures will be designed and implemented to minimize the risk of outbreak of fire by appropriate choice, location and installation of various materials and equipment. In stations planning, potential sources of fire can be reduced by:

i. Fire Prevention

Use of non-combustible or smoke retardant materials where possible,
Rolling stock is provided with fire retarding materials, low smoke zero halogen type electric cable is also provide,
Provision of layout which permits ease of maintenance for equipment and cleaning of the station premises,
Provision of special storage spaces for combustible materials such as paint and oil,
Prohibition of smoking in fire prone areas,
Provision of cigarette and litter bins, and
Good housekeeping.

ii. Safety

Following provisions will be required from fire safety point of view:

Automatic sprinkler/detection system to be provided if floor area exceeds 750 sq.m
One wet riser-cum-down comer per 1000 sqm floor area with static underground storage tank, overhead tanks and pumps of suitable capacity with hydrants, first-aid reel, etc.

Portable fire non-aqueous extinguishers of Carbon Dioxide, chemical dry powder etc. at suitable places.

Automatic smokes venting facilities.

Two separate means of exit shall be provided, if more than 10 persons are working and the area exceeds 1400 sq.m.

Fire resisting doors shall be provided at appropriate places along the escape routes to prevent spread of fire and smoke.

The travel distance for fire escape shall not exceed 20 m where escape is available in more than one direction; the distance could be upto 40 m.

B. Fire Alarm and Detection System

A complete fire detection system with equipment complying with the requirements of Ahmedabad Fire Services shall be provided through out each station and ancillary buildings including entrance passageways, subways and adits etc. to give visual and audible indication of alarm conditions actuated by the operation of break glass contact or fire sensors e.g. detector heads, linear heat detecting cables etc. The system shall be operated from 24 V DC Power sources.

Manually operated call points shall be provided at every hydrant and nose reel points, station head wall, tail wall and other locations. Alarm bells shall be installed in each plant room complex at both platform and concourse level and shall be clearly audible at all points in the room/area.

Beam detector or heat detector shall be installed at roof level, ceiling and floor cavity, whilst linear detecting cables shall be installed in under platform cable ducts and cable shafts. Smoke probe units shall be installed in rooms/compartments. When an alarm point is operated, the fire pump shall start to operate automatically. A station fire control and indicating panel shall be provided an installed in the station controllers room, for the control, indication and monitoring of the whole detection and fire fighting systems. While designing the fire fighting system, Ahmedabad Fire Services shall be taken into account for linking with the same.

C. Fire Control Measures

Control of the spread of fire and smoke will be achieved by partition of fire risk areas, planning for smoke extraction, and arrangement for smoke containment. Partition is aimed at limiting the extent of a fire. The openings must be capable of being sealed in the event of fire. With the exception of station public areas, a fire compartment will not exceed 1500 m^2. Partition of the public areas in stations is not practicable for operational reasons. The fire resistance period of this separated area should be about 3 hours.

D. Access for Fireman

A secondary access to the station, not used by passengers for evacuation, shall be available to fireman should the need arise. The entry point shall be easily accessible from the road. Access shall be available to all levels of the station. The minimum width of the stairs is 1.0 m and maximum height should not exceed 25 cm.

E. Emergency Door

The rolling stock is provided with emergency doors at both ends of the cab to ensure directed evacuation of passengers in case of any emergency including fire in the train.

14.15 SUMMARY OF ENVIRONMENTAL MANAGEMENT PLAN (EMP)

The environmental impacts stemming out of the proposed project can be mitigated with simple set of measures, dealing with careful planning and designing of the metro alignment and structures. Adequate provision of environmental clauses in work contracts and efficient contract management will eliminate or reduce significantly all possible problems. A common problem encountered during implementation of environmental management plans of such projects is lack of environmental awareness among engineers and managers concerned with day to day construction activities, which can be solved through regular environmental training programs. A set of preliminary EMP is presented in **Table 14.16,** which defines actions to be undertaken during the design stage, pre-construction, construction and operation stage of the project. The effectiveness of environmental considerations will, however, depend on appropriate inclusion of these in the work contracts.

The major concern during the construction stage is that the contractors, due to lack of enforcement, would not practice good environmental sanitation (housekeeping) may intend to get unauthorized use of the easily available natural resources and other available infrastructure like roads and water resources. This would result in degradation of ambient air quality, water resources and land environment around the construction sites and workers camp. Improper management of earthwork and bridge construction activities would disrupt the natural drainage and increase soil erosion. Improper management may result in spillage of explosives into the hands of unsocial elements. Finally, the implementation of the mitigation actions requires that the project implementation unit would record an end-of-construction mitigation checklist, before releasing the final payment of any work contract. Additionally, project authority should develop and establish Environmental and Health Policy and Procedures as per earlier Phases and that should become an integral part of contract document.

Operational phase mitigation would involve good environmental sanitation (housekeeping) practice at metro establishments including effective solid waste collection and disposal, wastewater disposal, upbringing of plantations and green area. Protection of earth slopes in landslide prone area would be a very important task. During the operation period, the metro operating unit will be required to confirm receipt of the construction period mitigation report through the **MEGA** and prepare a follow on timetable of actions.

TABLE 14.16 ENVIRONMENTAL MANAGEMENT ACTION PLAN (EMP)

Environmental Impact	Mitigation Measures Taken or To Be Taken	Time Frame	Implementing Organization	Responsible Organization
DESIGN PHASE				
Metro Alignment	The proposed corridor alignment was selected to minimise the land	During Design	DPR and design consultant	**MEGA**

Environmental Impact	Mitigation Measures Taken or To Be Taken	Time Frame	Implementing Organization	Responsible Organization
	disturbance to avoid environmentally sensitive areas.			
Cultural Heritage	Avoided by adjustment of alignment.	During Design	DPR and design consultant	**MEGA**
Flood	Bridges shall be well designed	During Design	DPR and design consultant	**MEGA**
Inadequate design provision for safety against seismological hazard	Make sure that design provides for safety of structures against worst combination of forces in the probability of an earthquake likely to occur in seismic zone-III.	DPR and detailed design stage	DPR and design consultant	**MEGA**
PRE –CONSTRUCTION STAGE				
Water requirement	The requirement of water for construction purpose etc shall be planned and shall be arranged from available and authorized sources in order to avoid digging of Tube wells.	Pre construction stage	Contractor	**MEGA**/ EMP implementing agency
Disposal of final treated effluent from treatment plant	Options for final disposal shall be studied and the suitable disposal route shall be decided carefully to minimize the impact on receiving bodies. As far as possible zero discharge rules may be adopted.	During design stage / and pre construction of treatment plant	Contractor	**MEGA**/ EMP implementing agency
Batching Plant and Casting Yard	These facilities to be located away from habitation. Consent to Establish and Consent to Operate to be taken from MPCB and to comply with all stipulations.	During Pre-construction Stage	Contractor	**MEGA**/EMP implementing agency
CONSTRUCTION PHASE				
Environmental Management and Monitoring	This will include institutional requirements, training, environmental management and monitoring	During and after construction	Contractor	**MEGA**/EMP implementing agency
Dust	Water should be sprayed during construction phase, wherever it is required to avoid dust. Vehicles delivering materials should be covered to reduce spills and dust blowing off the load.	During construction	Contractor	**MEGA**/EMP implementing agency
Air Pollution	Vehicles and machinery are to be regularly maintained so that emissions conform to National and State AAQ Standards. No vehicle without valid PUC certificate would be allowed at Construction Sites.	Beginning with and continuing throughout construction period	Contractor	**MEGA**/EMP implementing agency
Equipment Selection maintenance and operation	Construction plants and equipment will meet acceptable standards for emissions and will be maintained and operated in a manner that ensures that relevant air, noise, and discharge regulations are met.	During construction	Contractor	**MEGA**/EMP implementing agency

Environmental Impact	Mitigation Measures Taken or To Be Taken	Time Frame	Implementing Organization	Responsible Organization
Noise	Noise standard at processing sites, will be strictly enforced as per GOI noise standards. Workers in vicinity of strong noise will wear earplugs and their working time should be limited as a safety measure. At construction sites within 150m of sensitive receptors construction will be stopped from 22:00 to 06:00. Machinery to be provided noise barriers (Stone walls and plantation) for silence zones including schools and hospitals.	Beginning and through construction	Contractor	**MEGA**/EMP implementing agency
Vibration	The vibration level limits at work sites adjacent to the alignment shall conform to the permitted values of peak velocity as given in Environmental Manual	Beginning and through construction	Contractor	**MEGA**/EMP implementing agency
WATER				
Contamination from Wastes	All justifiable measures will be taken to prevent the wastewater produced in construction from entering directly into any rivers, drainage and irrigation system	Throughout construction period	Contractor	**MEGA**/EMP implementing agency
Wastage of water	Measures shall be taken to avoid misuse of water. Construction agency shall be instructed accordingly to follow strict procedures while using the water for construction and drinking purpose.	Beginning with and continuing throughout construction	Contractor	**MEGA**/EMP implementing agency
Sewerage disposal during construction at Service Centres	A minimum distance of any sewage or toilet facility from water sources should be 200 meters.	Throughout construction period	Contractor	**MEGA**/EMP implementing agency
Sanitation and Waste Disposal in Construction Camps	Sufficient measures will be taken in the construction camps, i.e. provision of garbage tank and sanitation facilities. Waste in septic tanks will be cleared periodically. Drinking water will meet Indian National Standards. Garbage will be collected in a tank and disposed off daily. Special attention shall be paid to the sanitary condition of camps. Camps will be located at a minimum distance of 200 m from water sources.	Before and during building of construction camps	Contractor	**MEGA**/ EMP implementing agency
SOIL				
Quarrying	Quarrying will be carried out at approved and licensed quarries only. All environmental mitigation measures shall be enforced at	During construction	Contractor	**MEGA**/ EMP implementing agency

Environmental Impact	Mitigation Measures Taken or To Be Taken	Time Frame	Implementing Organization	Responsible Organization
	Quarry site also.			
FLORA AND FAUNA				
Loss of trees and Avenue Plantation	Areas of tree plantation cleared will be replaced according to Compensatory Afforestation Policy under the Forest Conservation Act. Ten trees will be planted against every tree felled as per norms.	During and after completion of construction activities	MCGM	MCGM
SOCIAL				
Loss of Access	Temporary access should be built at the interchange and other roads.	During construction	Contractor	**MEGA**/ Traffic department
Traffic jams and congestion	If there are traffic jams during construction, measures should be taken to relieve the congestion with the co-ordination of transportation and traffic police department	During construction	Contractor	**MEGA**/ Traffic department
Safety with vehicles, people and livestock and signage	Safety education and fines. Allow for adequate traffic flow around construction areas Provide adequate signage, barriers and flag persons for safety precautions.	During construction	Contractor	**MEGA**/ Traffic department
	Communicate to the public through radio, TV & newspaper announcements regarding the scope and timeframe of projects, as well as certain construction activities causing disruptions or access restrictions			
Increase in disease Water-borne Insect-borne Communicable diseases	Make certain that there is good drainage at all construction areas, to avoid creation of stagnant water bodies. Provide adequate sanitation and waste disposal at construction camps. Provide adequate health care for workers and locate camps away from vulnerable groups, if any	During construction At start-up Throughout construction	Contractor	**MEGA**/ EMP implementing agency
Location of camps depots and storage areas	Location of camps depots and storage areas shall be as per the contract specifications.	Throughout construction	Contractor	**MEGA**/ EMP implementing agency
OPERATION PHASE				
Noise and Vibration	Suitable measures should be considered where warranted. The public shall be educated about the regulations of noise and vibration pollution and its implications.	After completion of construction	**MEGA**/EMP implementing agency	**MEGA**/ EMP implementing agency
WATER				
Maintenance of Storm Water	The urban drainage systems will be periodically checked and	Beginning and end of monsoon	**MEGA**/EMP implementing	**MEGA**/ EMP implementing

Environmental Impact	Mitigation Measures Taken or To Be Taken	Time Frame	Implementing Organization	Responsible Organization
Drainage System	cleared so as to ensure adequate storm water flow.		agency	agency

14.16 ENVIRONMENTAL MONITORING PLAN

14.16.1 PRE-CONSTRUCTION PHASE

The environmental monitoring programme is a vital process of any Environmental Management Plan (EMP) of development project for review of indicators and for taking immediate preventive action. This helps in signalling the potential problems resulting from the proposed project activities and will allow for prompt implementation of corrective measures. Historically, environmental monitoring has been integral part of works of **MEGA** towards better environmental management of air, noise, vibration, water quality etc. both during construction and in operation. Generation of dust and noise are two main issues during any large construction activity. Degradation of water quality is another. The parameters are monitored in pre- construction, construction and operation phase and are based on the need to evaluate the deviation of environmental conditions from baseline environmental conditions due to construction and operation of the Metro. The environmental monitoring will be required during both construction and operational phases. The following parameters are proposed to be monitored:

Water Quality,
Air Quality,
Noise and Vibration,
Environmental Sanitation and Waste Disposal
Ecological Monitoring and Afforestation,
Workers Health and Safety

Environmental monitoring during pre-construction phase is important to know the baseline data and to predict the adverse impacts during construction and operations phases. Pre-construction phase monitoring has been done for the proposed project for air, noise, water, soil quality and ecology.

14.16.2 CONSTRUCTION PHASE

During construction stage environmental monitoring will be carried out for air quality, noise levels and water quality. Keeping a broad view of the sensitive receptors and also the past experience of Metro projects, an estimate of locations has been made and are summarized in **Table 14.17.** The number could be modified based on need when the construction actually commences.

Water Quality

Since water contamination leads to various water related diseases, the project authorities shall establish a procedure for water quality surveillance and ensure safe water for the consumers. The water quality parameters are to be monitored during the entire period of project construction. Monitoring should be carried out by NABL certified laboratory. Water quality should be analyzed following the procedures given in standard methods. Parameters for monitoring will be as per BIS: 10500. The monitoring points could be ground and surface water.

Air Quality

Air quality should be monitored at the locations of baseline monitoring. The parameter recommended is Particulate Matter (PM_{10}). The contractor will be responsible for carrying out air monitoring during the entire construction phase under the supervision of project authority.

Noise and Vibration

The noise levels will be monitored at construction sites for entire phase of construction by the site contractor and under the supervision of project authority.

Workers Health and Safety

Monitoring of health risk issues that might arise throughout the project life time will be done. Epidemiological studies at construction sites and workers camp will be performed to monitor the potential spread of diseases. Regular inspection and medical checkups shall be carried out to worker's health and safety monitoring. Any reoccurring incidents such as irritations, rashes, respiratory problems etc shall be recorded and appropriate mitigation measures shall be taken. Contractor will be the responsible person to take care health and safety of workers during the entire period of the construction and project proponent is responsible to review/audit the health and safety measures/plans. The monitoring Schedule for Water Air, noise and ecology are presented in **Table 14.17.**

TABLE 14.17 CONSTRUCTION STAGE MONITORING SCHEDULE

Item	Parameter	Frequency and Duration	Locations
Air	PM_{10}	2×24 hours Twice a month During entire civil construction stage or even later, if directed by **MEGA**	24 locations
Water	Groundwater quality (IS 10500:1991)	Once in 6months During entire civil construction stage or even later, if directed by **MEGA**	4 locations
Noise	Noise Level (Leq and Lmax)	24hours Once a week During entire civil construction stage or even later, if directed by **MEGA**	24 locations
Ecology	Felled and planted trees	Once a year till all trees that were to be planted by Gujarat Government on behalf of project authority, are planted	All the trees felled and newly planted

14.16.3 OPERATION PHASE

Even though the environmental hazards during the operation phase of the project are minimal, the environmental monitoring will be carried out for air, noise, water, waste water, solid waste and ecology during operation phase of the project. The parameters monitored during operation will be PM_{10} for air, heavy metals for solid waste, pH, TSS, BOD, COD, oil and grease for waste water. However, water quality parameters that will be monitored will be as per BIS 10500. The monitoring schedule is presented in **Table 14.18**. The monitoring program shall be conducted by an external agency certified by NABL under the supervision of **MEGA**. Project proponent (**MEGA**) is responsible for successful environmental monitoring of the proposed project during operation phase.

TABLE14.18 OPERATION STAGE MONITORING SCHEDULE

Item	Parameter	Frequency and Duration	Locations
Air	PM_{10}	2×24hours Once a month For 3 years	10 location
Water	Surface, Ground water quality (IS 10500:1991)	Once a year For 3years	1+1 location
Noise	Noise Level (Leq)	24hours Once a year For 3years	24 locations (Sensitive Receptors)

The results of Air quality, water quality, waste-water will be submitted to management quarterly during construction phase and half yearly during operation phase.

14.17 ESTABLISHMENT OF AN ENVIRONMENTAL DIVISION

MEGA already has the setup for environmental Management and the proposed corridor is an extension of already existing operative line, additional set-up for environmental management is not recommended. Existing set up for environmental management can also handle this extension.

14.18 COST ESTIMATES

14.18.1 SUMMARY OF COSTS

All costs involved in Environmental mitigation and management and monitoring has to be put on the account of Ahmedabad Metro Project corridors. A summary of these is presented in **Table 14.19**.

Table 14.19 Environmental Costs

S. No.	ITEM	COST Rs. lakh
1.	Rain Water Harvesting at stations and along alignment	484.00
2.	Air, Noise, vibration, Water, Waste Water, Solid waste, during construction and operation	50.00
3.	Ecological monitoring	10.00
4.	Tree Plantation 480 trees @ Rs.2000/- per tree	9.60
	Total	**553.60**

The compensation for loss of land, fire control, information systems and contractor's obligations has been incorporated in project costs.

The Environmental management plan should be implemented in phases so that optimum benefit could be achieved and should be synchronized with the construction schedules.

Table 14.20 Details of Cost of Resettlement and Rehabilitation (Rs. Lakh)

S. No.	Description	Entitlement	Unit	Quantity	Rate	Amount
1	Acquisition of Permanent land Private Land	Total Replacement Cost of land *	m^2	7258	0.30	2177.40
2	Solatium	100% as per Act 30 of 2013.	m^2	7258		2177.40
3	Acquisition of temporary private land	6% of total land cost per year for 3 years	m^2	Nil	-	-
4	Acquisition of structures					
4.1	Residential PAPs	Area equivalent to affected area 20.91 m2 free of cost	Per unit	0	-	0
4.2	Commercial PAPs**	Area equivalent to affected area 20.91 m2 free of cost	Per unit	0		0
5.	Subsistence Allowance ***	For a period of one year @Rs.3000/ month	Family	0	0.36	0
6.	Shifting Allowance ***	A lump sum shifting allowance of Rs. 50,000/-	No.	0	0.50	0
7.	One time resettlement allowance ***	For All the affected families excluding employees in shops	Per Family	0	0.50	0
9.	Independent Evaluation		LS		5.00	5.00
10.	Miscellaneous		LS		5.00	5.00
	Cost of R & R					**4364.80**

* *Land for the project to be provided by* ***MEGA***

refers the similar accommodation would be provided by* ***MEGA *in the vicinity so additional cost is not given.*

14.19 CONCLUSION

The proposed Metro line is proved to have significant positive effects to the development of Ahmedabad City. Benefits to the economy, traffic congestion reduction, quick and safety transport, employment opportunities, fuel consumption reduction, and air quality improvement are the obvious positive effects from this Metro line. Besides, the potential adverse environmental impacts on air quality (during construction phase), water environment, noise, solid waste, ecology, population resettlement are also taken into consideration. Based on these detailed potential adverse environmental impacts, appropriate mitigation measures have been developed for consideration. The EIA concluded that project impacts from both construction and operation will be minimal when mitigated through the use of prevailing current practices and appropriate technologies. With the implementation of the EMP and the monitoring plan, the Project is not expected to have significant adverse environmental impacts.

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 human casualties poses greater threat to its security. Security is a relatively new challenge in the context of public transport. It addresses problems caused intentionally. Security differs from safety which addresses problems caused accidentally. Security problems or threats are caused by people whose actions aim to undermine or disturb the public transport system and/or to harm passengers or staff. These threats range from daily operational security problems such as disorder, vandalism and assault to the terrorist threat.

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 with 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
(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 an 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 along with 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 Array)
    Wooden Ramp - 1 per DFMD for security check points.

15. Wall mounted/ pedestal fan at security check point, ladies frisking booth and bullet proof morcha, as per requirement.

16. Physical barriers for anti scaling at Ramp area, low height of via duct by providing iron grill of appropriate height & design/concertina wire.

17. Adequate number of ropes. Queue managers, cordoning tapes, dragon search lights for contingency.

18. Iron grill at station entrance staircases, proper segregation of paid and unpaid by providing appropriate design grills etc.

19. Proper design of emergency staircase and Fireman entry to prevent unauthorized entry.

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 even may 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 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 and/or stations
5. Fire in metro buildings, 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) Track-Way Exhaust System (TES)
(E) Station Power Supply System
(F) Dg Sets & Ups
(G) Lighting System
(H) Station Area Lights
(I) Seepage System
(J) Water Supply And Drainage System
(K) Sewage System
(L) Any Other System Deemed Necessary

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

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 TRAFFIC INTEGRATION AT METRO STATIONS

17.1 INTRODUCTION

Ridership of a Mass rapid Transit system is directly or indirectly dependent on the accessibility of the trip generating and trip attracting areas within catchment zone. Importance of Last mile connectivity becomes crucial. A well connected, integrated network of footpath, cycle and bus feeder system acts as complimentary modes to generate ridership of Metro

Ahmedabad Gandhinagar Metro is a proposed rail rapid transit system connecting the city of Ahmedabad, Gandhinagar and the very ambitious GIFT city of Gujarat. The metro would be constructed in two phases and has two corridors Phase I consists of 36 km network comprising of East West Corridor and North South Corridor(Gyaspur to Motera- Phase II). Phase II consists of 34 km network that comprises of extension of North South Corridor, (Motera to Gandhinagar - Phase II) and two segment connectivity to GIFT City & Airport (Phase II) . This report consists of last mile connectivity only for Phase II of the planned metro.

Currently, due to unavailability of planned services, an user would tend to take metro only by accessing it by a car, auto or cabs, in case the place of origin of the user is situated within 500 to 800 mts from metro station, he/she will tend to walk to metro or take any shared services if available. Due to these consequences, with time an user would start depending on private vehicles more than public services available. To do otherwise strategic planning and design for services is required.

An on ground assessment of Phase II station area was conducted to identify potential local area access plan network consisting of footpath, cycling network, and feeder bus network.

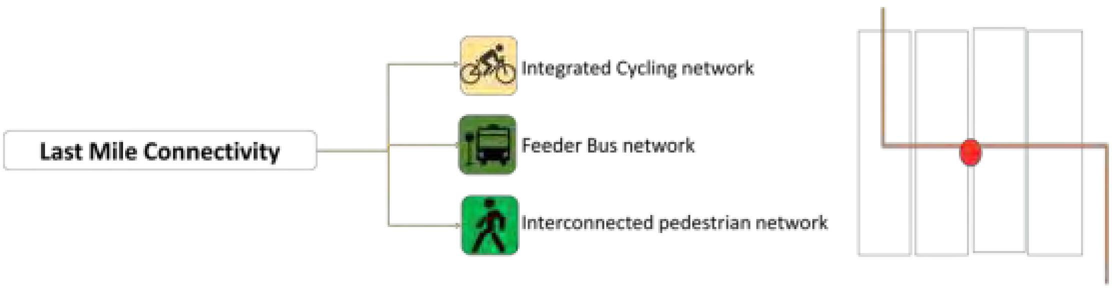


Fig. 17.1 Parameters of Last mile connectivity

17.2 BENEFITS OF LAST MILE CONNECTIVITY

Improved accessibility to metro stations
Provision of last mile connectivity
Promotes use of sustainable public transport
Focuses on improving station area integration and connectivity
Long term impact on low pollution
Long term impact on traffic solutions
Improve reliability on public transport systems

17.3 CURRENT ISSUE

For Phase II of Ahmedabad Gandhinagar metro, 38% i.e. 9 stations are located within Gandhinagar urban area, 25% i.e. 6 stations are located along Gandhinagar Ahmedabad highway, 21% i.e. 5 stations are located within rural villages of GUDA, 2 stations towards GIFT and 2 stations towards airport.

Fig. 17.2

In Phase II, 15 metro stations that lies within Gandhinagar urban and Gandhinagar Ahmedabad highway are situated along arterial roads with uniform cross-section and uniform ROW of 30 mts.

The issues located along these roads are:

- Lack of pedestrian network along road network
- Unsignalised continuous road stretch without pedestrian crossing facilities
- Lack of non motorised lane along road network
- Lack of bus stops for long stretches

Remaining 9 stations that are located within rural Gandhinagar, GIFT and Airport area are along road with existing ROW of 15 mts and carriage way 6 mts.


Fig. 17.3 Juna Koba


PDPU road near GIFT

The issues located along these roads are:

- Unavailability of adequate ROW due to constructions along road
- Lack of pedestrian network along road network
- Unsignalised continuous road stretch without pedestrian crossing facilities
- Lack of non motorised lane along road network
- Lack of bus stops for long stretches

17.4 ASSESSMENT OF METRO CORRIDOR

17.4.1 Mahatma Mandir to Juna Sachivalaya

Mahatma Mandir is the terminal station for the north south corridor extending from Motera to Gandhinagar. There are four stations in this 5.6 km stretch of metro network, average distance between stations is 800m. The right of way along this corridor is 30m with six lane divided carriage way and 3m footpath on each side. The cross-section is homogeneous along the entire route length. The network connects residential, commercial and Institutional land use within Gandhinagar. The major areas of importance in this region that the MRTS provides access within 500 m radius are Sachivalaya, Mahatma Mandir, LDRP Institute, Sports Authority of India, Gujarat Exhibition Ground, GIDC Industrial sectors and Akshardham temple

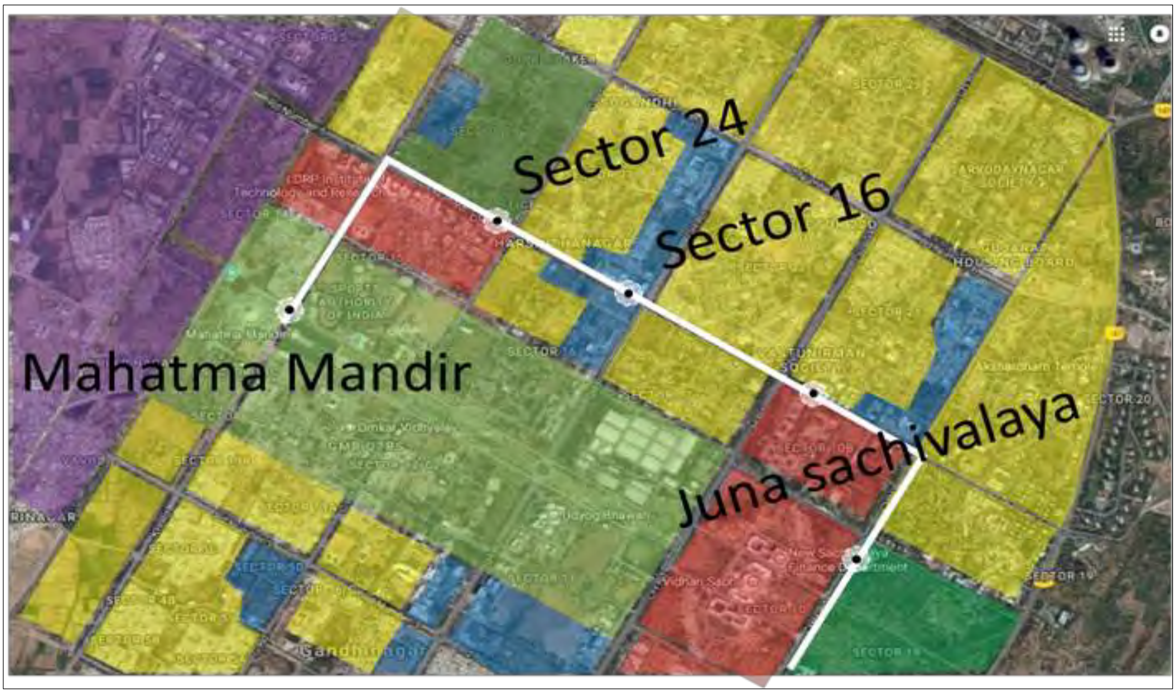


Fig. 17.4 Landuse from Mahatma Mandir to Juna Sachivalaya

Required provisions of last mile connectivity for metro stations in this stretch are presented below

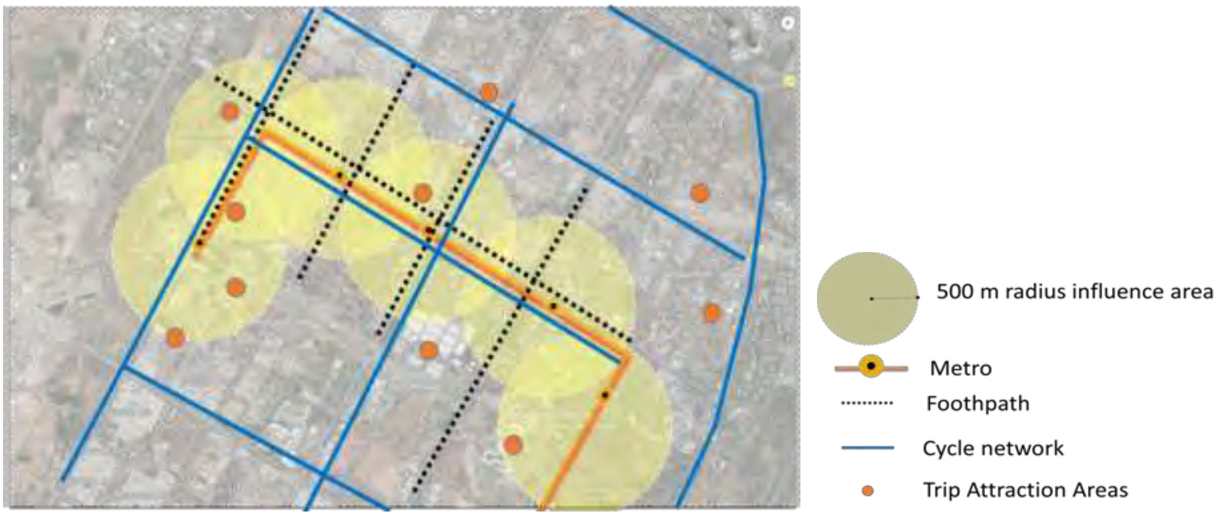


Fig. 17.5 Last mile connectivity network from Mahatma Mandir to Juna Sachivalaya

17.4.2 Akshardham to Infocity

There are 5 stations in this stretch of approximately 6 km metro network, namely Akshardham, Sachivalaya, St. Xavier's school, Sector 1 and Infocity. The average distance between stations is 800m. The right of way along this corridor is 30m, however carriageway ranges from 4 lane divided to 3 lane divided along the stretch with 3m footpath on each side. The network connects major residential, Commercial and Institutional land use within the region. The major areas of importance in this region that the MRTS provides access within 500 mts radius are Sachivalaya, Vidhan sabha, Udyog bhawan, Gujarat Exhibition Ground, pathika circle and Infocity.

Fig. 17.6 Landuse profile and required last mile connectivity network from Sachivalaya to Infocity

Required provisions of last mile connectivity for metro stations in this stretch includes pedestrian network, cycle network and feeder routes to enhance accessibility to the metro stations

17.4.3 GIFT to GNLU

Fig. 17.7

This is an approximately 4.6 km network stretching from NLU to GIFT city. The ROW along is corridor is 15m to 20m. However, carriageway in the stretch is only 6m. The network connects institutional areas, research centres and GIFT city within 500 mts radius. It provides access to most ambitious GIFT city, Gujarat law university, Pandit Dendayal petroleum University, Gujarat Energy Research and management.

As envisaged, GIFT would generate 1.75 lakh employment by 2020, 3 lakh by 2025 and 3 lakh employment by 2030. Thus GIFT, which would be the biggest employment hub within two decade would generate 6-8 lakh trips by 2030

Fig. 17.8

Since GIFT is envisaged as an employment hub with enormous economic activities, as a result of same it will lead to tremendous trip generation in the coming decade. A very well connected pedestrian network with landscaping and accessibility to metro station should be provided

17.4.4 Gift City Circle to PDPU

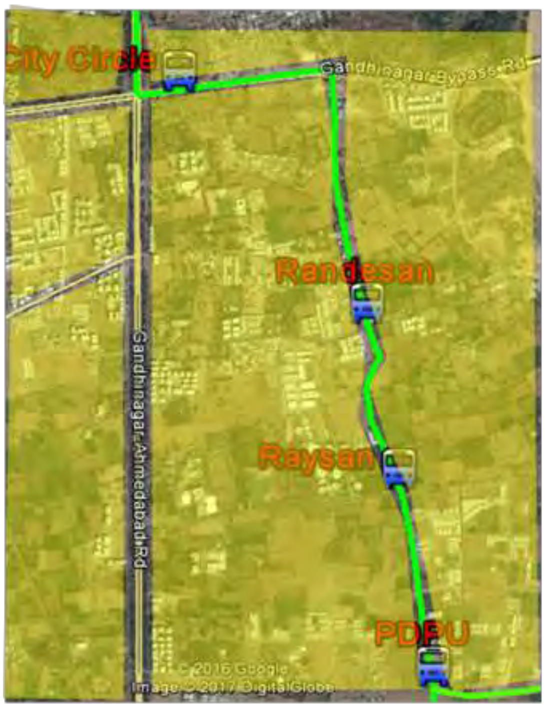


Fig. 17.9

This stretch from Gift city circle to PDPU is of 4.2 km in length approximately. The ROW along is corridor is 12m to 15m. However, carriageway in the stretch is only 6m. The network connects low density residential areas between GIFT and Gandhinagar. It also provides access to PUPDU University and some other research institutions within 500m radius

17.4.5 PDPU to Koba Circle

Fig. 17.10

This stretch from Gift PDPU to Koba circle is of 4 km in length approximately. The ROW along is corridor is 12m to 15m. However, carriageway in the stretch is only 6m. The network connects low density residential areas between Koba Circle and GIFT City.

17.4.6 Narmada Canal to Koteshwar Road

Fig. 17.11

This stretch from Narmada Canal to Koteshar road is approximately 4 kms. The ROW along this stretch is 40 m with 21m carriageway. The stretch connects medium density residential areas within Ahmedabad region.

17.5 STRATEGIC INTERVENTION AT CORRIDOR LEVEL

Corridor level intervention is proposed for 10 km stretch that includes 9 stations from Mahatma Mandir to Info city. The stations in this area lie within Gandhinagar Municipal area with residential sectors accessible within 500m from the station.

A. Pedestrian network

Improvement in walking environment demands for more quality pedestrian infrastructure at station access area level, hence there is requirement of more pedestrian network and pedestrian amenities to increase walk ability in the area.

For construction of a new pedestrian network, route identification was done on the basis of:

- Landuse distribution
- Important landmarks
- and missing pedestrian infrastructure links within the catchment area

Fig. 17.12

This was followed by identification on major residential areas and major destinations within the surrounding. The network was planned with an assumption that construction of pedestrian network around the areas will improve local environment, encourage walking as well provide connectivity to metro stations.

Fig. 17.13

The pedestrian network is identified by along existing road network and metro alignment. The network is developed by connecting grid network layout. The network consists of 21 km of north south links and 37.8 km of east west links.

B. Public Bicycle Sharing

Along with having vehicular and pedestrian network along all vertical and horizontal networks, provision of cycle lane or non motorized lane is also needed to boost use of sustainable and non motorized modes within Gandhinagar. To facilitate use of cycles as a last mile connectivity to metro station, provision of cycle docking station should be made at metro station, and also in major residential, commercial, institutional areas. As a general assumption, a person will only ride from metro in a cycle if he/she has a docking station near his place of destination to keep the cycle. Thus a cycling network is incomplete without facilitating docking stations at places beyond metro stations. Such a system is called public bicycle sharing.

Public Bicycle Sharing (PBS) systems are a flexible public transport service that is created by a dense network of cycles to provide last mile connectivity. Here, the docking station where a cycle is returned need not be the same station from where a cycle was picked up from .This kind of flexibility that PBS provides makes it different from cycle renting systems. It encourages short trips to be completed by use of a sustainable mode.

Stations should be ideally placed in such a way, so as to ensure that the user will not have to walk long distances to access the system and, in case where users are not able to find cycles at one station, another station is easily accessible nearby.

PBS should be installed on a progressive renting structure, that allows a person to ride initial 15 mins or half hr for free, after which a standard rate of Rs 10 or Rs 15 can be taken for every extra hour.

Table 17.1 PBS Standards

Parameters	Standard
No of Bicycles in each Docking station(DS	10- 15
No of Docks	1.5 times of cycle = 20 -22 DS
Length of Dock	1.1m/Bicycle = 16m
Width per dock	2 m
Area (for typical DS with 15 cycles)	32 sqkm

Source: National Public Bicycle scheme, MOUD, ITDP, 2012

As per standards, a small size PBS docking station should stand 10 -15 cycles at once, and the no of docks would be 1.5 times more than the no of cycles, such that there is provision for extra cycles to stand if required. Length required for one cycle is

1.1m and width is 2m. Thus for a docking station with 10 cycles, docks provided should be 15 and length of the docking station should be 16m

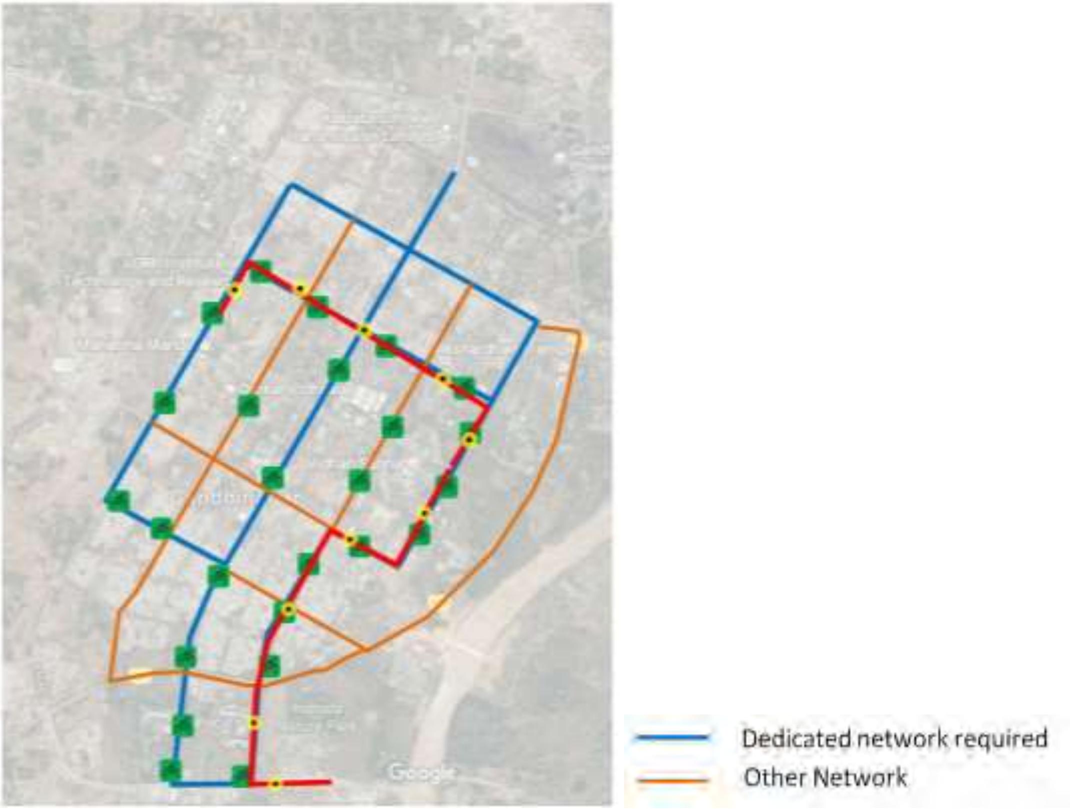


Fig. 17.14 Identified cycle network

For making PBS complimentary to metro station, a cyle network has been identified in the Gandhinagar area along metro influence area. The network follows major roads and metro alignment. The purpose is to provide last mile connectivity to metro. A interconnected network that connects metro stations is proposed for better connectivity.

Along the network, 25 locations have been identified for provision of docking stations for public cycle sharing.

Table 17.2

	Standard
No of Docking stations	25
No of cycles * 25 DS	10* 25 = 250 + 10%
Total docks required= No of Docks * station	15*25 = 375
Area per DS	32 sqkm
Total Land area required	800 sqkm

Requirements for 25 docking stations will be, 250 cycles + 10% extra. 375 docks will be required in these docking stations. Area per docking station is 32 sqkm, thus 800 sqkm. space will be required to house 25 docking stations.

Fig. 17.15 PBS station by GUDA

AT present there are 10 PBS docking stations operated by GUDA at a minimal rate of only Rs. 5 per hour. The same service can be enhanced by sharing of operation with GUDA.

C. Feeder network

Fig. 17.16

Feeder becomes essential and majorly targets users beyond 1 km from metro catchment zone. Within 1 km, users would tend to take a NMT or walk to station, but absence of a feeder option beyond 1 km will propagate use of private mode of transport.

Feeder system ideally consists of mini buses operating within certain frequency in small loop routes, providing connectivity between trip generating/attracting areas and metro

A reconnaissance survey was carried out in Gandhinagar to identify potential route for feeder services. Identification of feeder route was done on the basis of

- Landuse distribution
- Identification of Major trip generating and attracting activities
- Availability of ROW
- And distance from metro station.

Six feeder loop routes have been identified for feeder services that cater to all planned sectors in Gandhinagar. Average length of the routes is 7kms.

Identified Feeder Routes

Each route connects to at least one metro station. The detailed description of all feeder routes is given on the table below:

Table 17.3 Feeder route details

Route	Metro stations	Roads	Route length
Route 1 (Sector 26/27/24/23, Mehganinagar, Anand nagar, Telephone society, Doubleakes, Sugandh, Post office colony, harshita nagar, bhavnagar	Sector 24,	KH Road, Road no 6, toad no 7, K road	6.13
Route 2 (Sector 21/22/29/30, Akshardham, kendriya vidyalaya, Sarvodayanagar, Gujarat housing board, panchshil park	Sector 16	Road 7, CH road, road 6, road 5	6
Route 3 (Vidhan sabha, Udyog bhawan, Sector 11/17/10A/10B/12/16/18/22, cinemax, Gujarat secondary and higher secondary)	Juna Sachivalaya	CHH Road, GH road, road 3, road 5	4.8
Route 4 (Mahatma mandir, Sector 13/15,16/12/17/11, SAI, police training ground, omkar vidhyalaya, GMB Quarters, LDRP, Vibrant Gujarat Exhibition Ground	Mahatma Mandir,	G Road, GH road, KH road, road no 3, road no 5	7.5
Route 5 Sector 7/7A/6/6A/5/5A/5B/5C/4B/8, zakaria masjid	St. Xavier's school, Sector 1	Road 3, road 2, KH road, CH road	7
Route 6 (Sector 1C/2A/2B/2C/3/3D/3C/3B/4/4A/4C/4D	Sector 1 and Infocity	Road 1, road 2, GH road, sarkhej gandhinagar highway	7.5

On the basis of current operational characteristics, standards identified for feeder buses are:

Table 17.4

Parameters	Standard
Capacity	22
Frequency	5 – 15 mins
Route length	5-7 km
Cycle time	Round trip + layover time
Operating cost/Bus	Rs 25
Veh km/Day	160

As per current practices, the physical performance of feeder buses should be:

Table 17.5

Parameters	Standards
Capacity Mini Bus	22
Speed	15 kmph
Load factor/Day	0.7
Vehicle utilization (km/bus/day)	160 - 180
FU/day/route	0.9
Operating cost (km/Bus/Day)	Rs. 25 - 30
Fare (current) 5km &>5km	Rs 5 & Rs 10

17.6 STRATEGIC INTERVENTION AT STATION AREA LEVEL

Station area should include provision of safe, accessible and comfortable infrastructure provision. Station area infrastructure includes Bus stops, IPT stops, continuous and connected pedestrian network, information board with feeder timings, adequate lighting and interactive public space outside metro with seating area with self-explanatory signage's and symbols. Purpose of a station area plan is to make last mile more accessible.

A conceptual design on bases of the requirements is shown in figure below

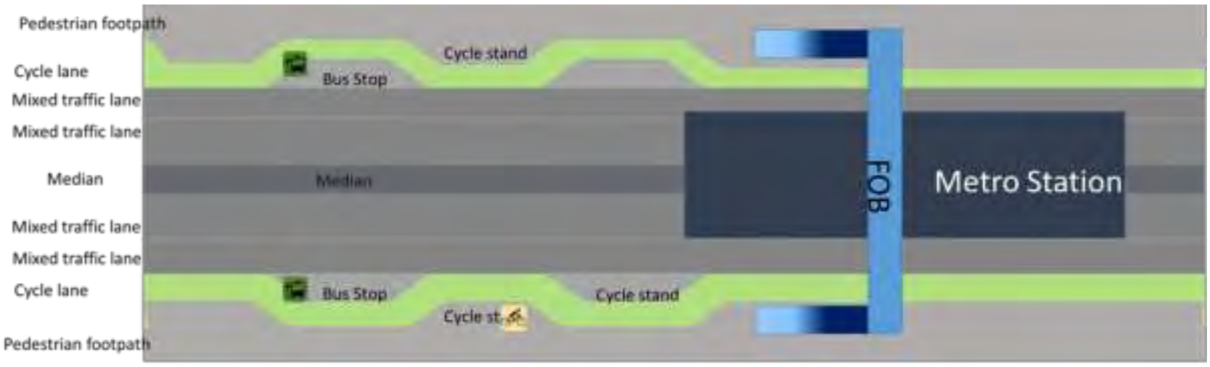


Fig. 17.17 Conceptual design

As per design, provision of passenger access & egress area should be located at the entry and exit of metro station for easy accessibility. Cycle docking stations are placed near stairs such that, it is within visible limits of a passenger while exiting the station.

It was found that cross-section roads in Gandhinagar have uniform ROW of 30 mts and 6 land divided road with 3m footpath on each side along most of the stretch along metro alignment. To make provision for NMT and feeder services, the cross section of the road is reconstructed as shown in figure below:

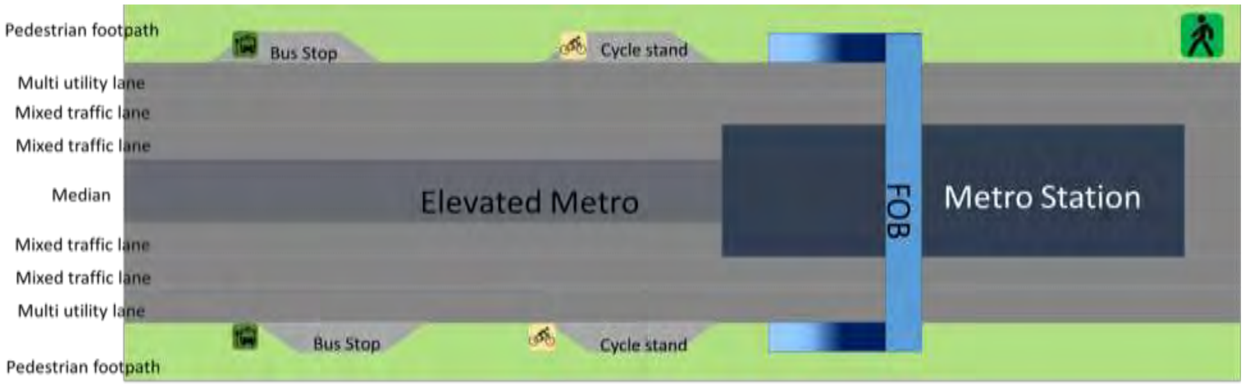


Fig. 17.18 Conceptual design as per available ROW

The design is detailed as:

- 4 lane divided carriage way for continuous vehicular movement
- A multi utility lane on both side of road, where provision can be made for feeder stop, IPT stop and cycle docking station alternatively by creating islands
- Cycle lane is not segregated, and is located in the third most lane towards footpath, for less friction with vehicular movement. Though, an ideal behind bus stand for uninterrupted flow, but due to unavailability of ROW, Multi utility lane will be used as cycle lane:

The design traffic flow is shown in figure below:

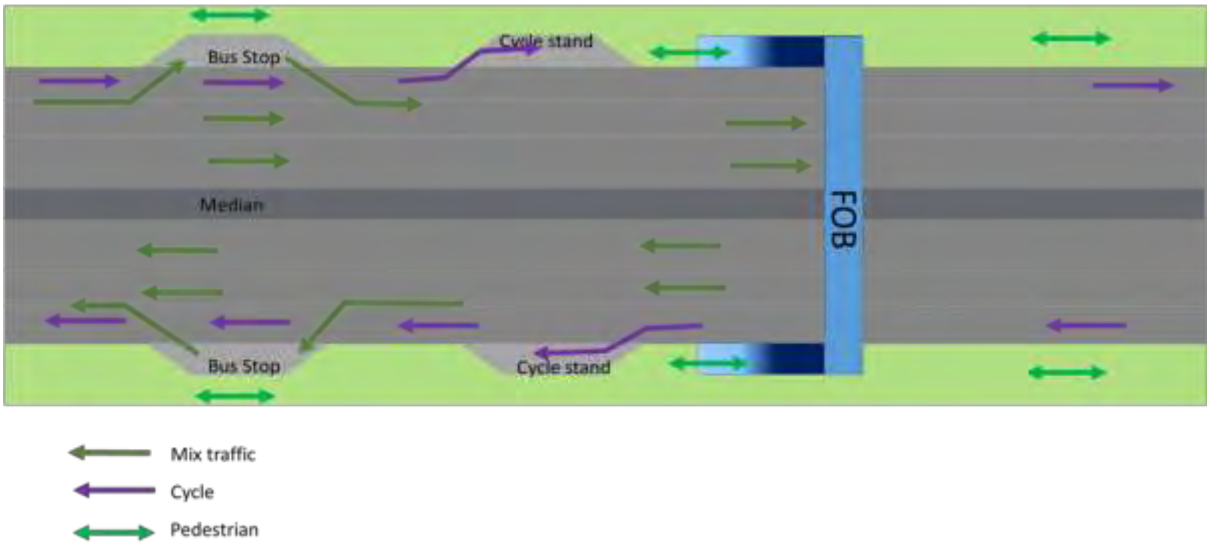


Fig. 17.19 Traffic Flow at Station area

17.7 STATION AREA DESIGN GUIDELINES

Multimodal integration at station areas is crucial, it aims seamless integration of modes at metro station. It is generally a integration of spaces and its relation between accessible modes to and from metro station. It should also be sustainable and provide affordable mobility solution to metro users. As per location of stations, it was found that most of the stations are located at midblock road segments whereas some are located near intersections. Based on the requirements to fit both type of stations, two design options have been detailed out.

A. Design prototype A shows stations that are located near intersection

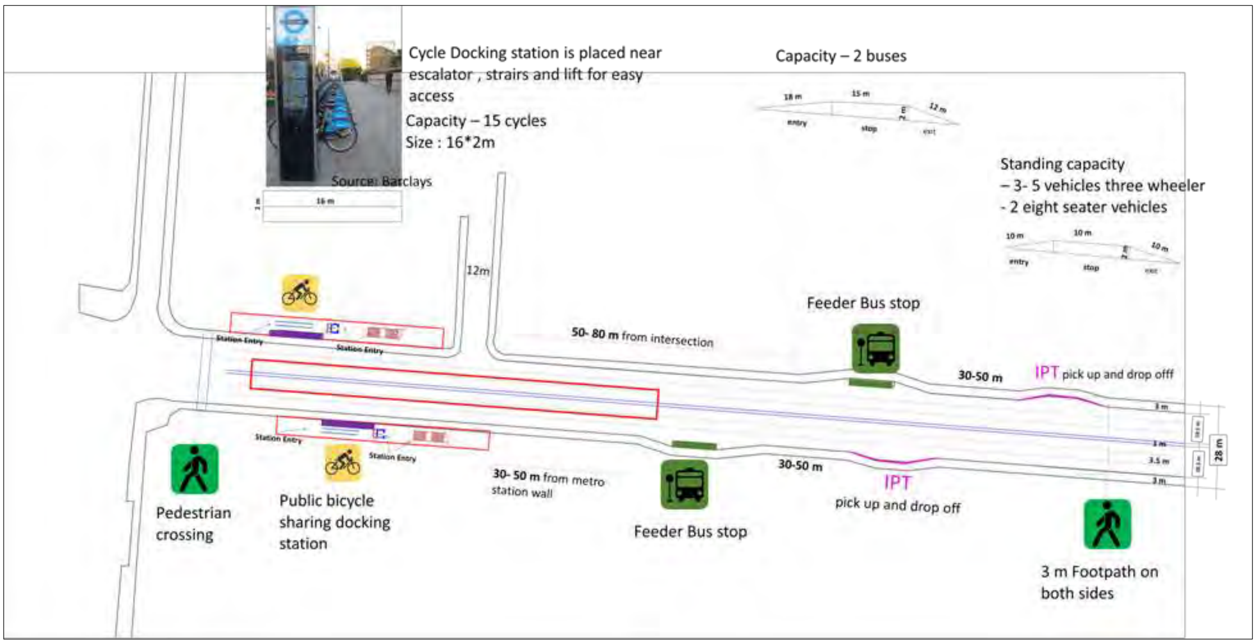


Fig. 17.20

B. Design prototypes B are for stations that are located in midblock segments

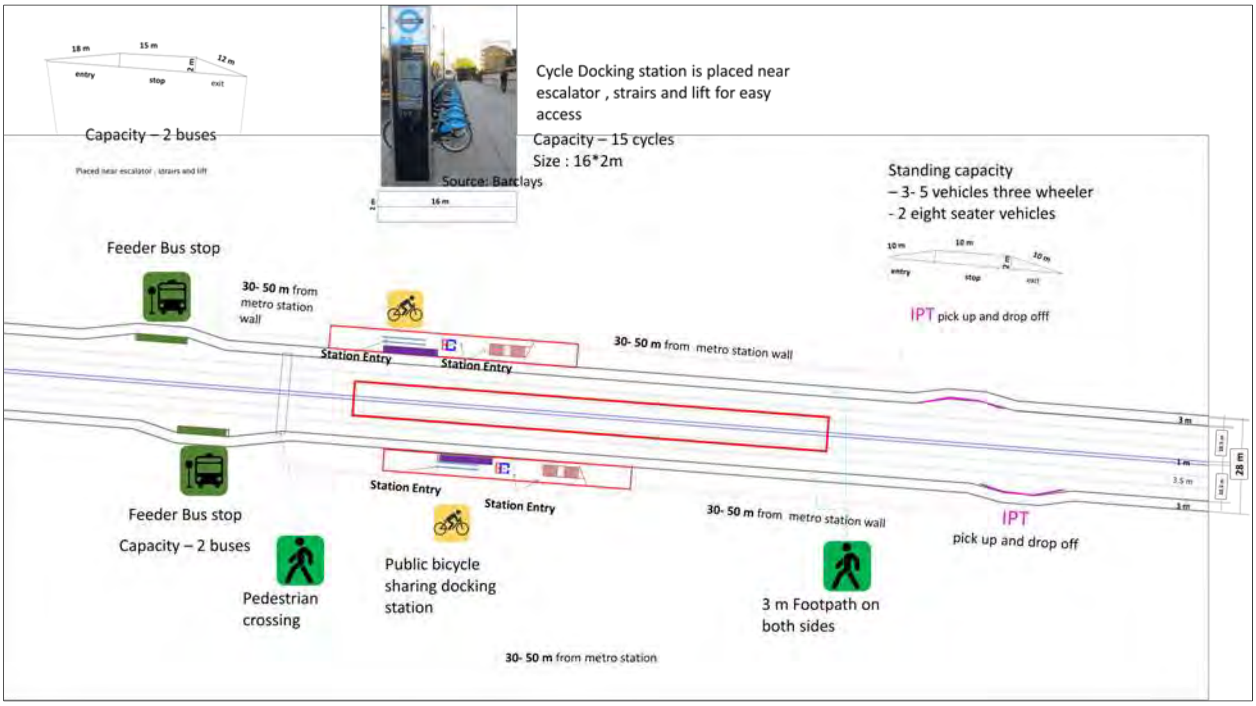


Fig. 17.21

In both the design cases, priority of accessibility has been given in the sequence of:

(i) Footpath
(ii) Cycle
(iii) Bus
(iv) IPT

As per the location of the stations, certain stations are located at midblock and certain stations are located near intersections. Thus a probable match for table below:

Table 17.6 Proposed Station design w.r.t location of station.

Stations	Prototype A	Prototype B
Koteshwar Road		
Vishwakarma College		
Tapovan Circle		
Narmada Canal		
Koba Circle		
Juna Koba		
Koba Gaam		
GNLU		
Raysan		
Randesan		
Dholakuva Circle		

Stations	Prototype A	Prototype B
Infocity		
Sector - 1		
Sector 10A		
Sachivalaya		
Akshardham		
Juna Sachivalaya		
Sector - 16		
Sector - 24		
Mahatma Mandir		
PDPU		
Gift City		
Sardarnagar		
Airport	Specific	

A detail description of proposed of integration of feeder buses, IPT, cycle at the station area and interconnected pedestrian movement is given in the table below:

Table 17.7 Interchange Facilities Available at metro stations

Stations	Footpath	Cycle	Feeder Bus	IPT	Others, Specify
Koteshwar Road					
Vishwakarma College					
Tapovan Circle					
Narmada Canal					
Koba Circle					
Juna Koba					
Koba Gaam					
GNLU					
Raysan					
Randesan					
Dholakuva Circle					
Infocity					
Sector - 1					
Sector 10A					
Sachivalaya					
Akshardham					
Juna Sachivalaya					
Sector - 16					
Sector - 24					
Mahatma Mandir					
PDPU					
Gift City					
Sardarnagar					
Airport					Airport

An example of station area design at Mahatma Mandir metro station is illustrated in details.

Fig. 17.22 Space distribution of multimodal integration at metro station

Fig. 17.23 Multimodal Integration at Metro Station Area

Chapter – 18

COST ESTIMATES

18.1 INTRODUCTION

Project Cost estimates for Ahmedabad Metro Phase-II corridors have been prepared covering civil, electrical, signaling and telecommunication works, rolling stock, environmental protection, rehabilitation, considering 750 V dc third rail traction system etc. at December 2018 price level.

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

(i) Route km. Length of alignment
(ii) No. of units of that item and
(iii) Item being an independent entity.

All items related with alignment, permanent way, 750 V dc third rail current collection system, signaling and telecommunication, have been estimated on rate per route km basis. The cost of elevated stations includes civil work for station structures, architectural finishes, platform, roofing, etc. Provisions for electrical and mechanical works, air conditioning, lifts, escalators, etc. have been worked out separately. These rates do not include cost of permanent way, 750 V dc third rail current collection system, power supply, signaling and telecommunication, automatic fare collection (AFC) installations, for which separate provisions have been made in the cost estimates. Similarly, for other items like Rolling stock, Traction & Power, etc. costs have been summed up separately. In remaining items, viz. land, utility diversions, rehabilitation, etc. the costs have been assessed on the basis of each item taken as an independent entity.

In order to arrive at realistic cost of various items, costs have been assessed on the basis of rates considered in DPR of Delhi Metro Phase-IV network. Taxes & Duties such as Customs Duty, CGST, SGST and IGST wherever applicable, have been worked out on the basis of prevailing rates and included in the cost estimates separately.

The overall Capital Cost for **Motera Stadium to Mahatma Mandir Metro Corridor** of Ahmedabad Phase-II at December 2018 price level works out to **Rs.3529 Crores** excluding applicable Taxes & Duties of **Rs. 529 Crores**.

Capital Cost for **GNLU to GIFT City Metro Corridor** at December 2018 price level works out to **Rs.660 Crores** excluding applicable Taxes & Duties of **Rs. 104 Crores**.

Capital Cost for **Koteshwar Road to Airport Metro Corridor** (Phase-IIA) at December 2018 price level works out to **Rs.790 Crores** excluding applicable Taxes & Duties of **Rs. 123 Crores**.

Capital Cost for additional corridor inside **GIFT City** (Phase-IIB) at December 2018 price level works out to **Rs.579 Crores** excluding applicable Taxes & Duties of **Rs. 87 crores**. All the above costs are tabulated below.

Table 18.1 – Details of Capital Cost

Sr. No.	Name of the corridor	Capital Cost (Rs. Crore)	Taxes & Duties (Rs. Crore)	Total (Rs. Crore)
Phase-II				
1	Motera Stadium to Mahatma Mandir	3529	529	4058
2	GNLU to GIFT City	660	104	764
	Total	**4189**	**633**	**4822**
Phase-IIA				
3	Koteshwar Road to Airport	790	123	913
Phase-IIB				
4	Additional corridor in GIFT City	579	87	666
	Total (Phase – II + IIA + IIB)	**5558**	**843**	**6401**

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 minimized as far as possible. Elevated alignment is proposed within the Right of way as far as possible. The land acquisition is required to be done mainly for exit and entries and also for running section at few locations where alignment runs outside the ROW.

Cost of Govt. land is based on the rate presently being charged by the concerned authorities. Private land for MRTS project shall be acquired by MEGA/ Gujarat State Government and compensation shall be paid as per Land Acquisition Act 2013. The average rate of private land has been worked out to be Rs.20.84 Crore per hectare after suitably escalating the rates taken in Ahmedabad Metro Phase-I DPR. Similarly average rate for govt. land has been taken as Rs. 8.68 Crore per hectare to work out the cost of land.

Provision for Rehabilitation and Resettlement is made separately.

In addition to the lands required permanently, some areas of land (mainly Govt.) are proposed to be taken over temporarily for construction depots. Ground rent charges @ 5% per year for a period of 4 years have been provided for in project cost estimates.

Details of the land with costs have been shown in corridor wise cost estimate.

18.2.2 Formation and Alignment

Elevated section: Entire alignment is proposed with elevated viaduct and the rates adopted are based on recently updated DPR of Delhi Metro Phase-IV network.

18.2.3 Stations

Elevated Stations: Rates adopted for elevated stations cover works of station structures, platforms, architectural finishes, covering, etc. Provisions for Electrical and Mechanical works have been made separately. Also provisions for Lifts and Escalators, Viaduct, P-way, 750 V dc third rail current collection system, Signalling & Telecommunication works, Automatic fare collection installations, etc. have been summed up in the cost estimates.

18.2.4 Permanent way

For elevated alignment ballastless track and for depot, ballasted track is proposed except for washing lines, repair lines etc. Rates adopted are based on recently updated DPR of Delhi Metro Phase-IV network.

18.3 DEPOT

It is proposed to have a Stabling Yard at Indroda Circle and to augment Gyaspur depot of North-South corridor under implementation, for serving corridors of Phase-II project.

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 recently updated DPR of Delhi Metro Phase-IV network.

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 in the recent past.

18.6 TRACTION AND POWER SUPPLY

Provisions have been made to cover the cost of 750 V dc third rail current collection system, Auxiliary sub stations, receiving substations, service connection charges, SCADA and miscellaneous items, on route km basis separately for elevated and at-grade section (Depot augmentation).

Provisions towards cost of lifts, escalators for elevated stations have been made in the cost estimates. Rates provided are based on cost of similar works as considered in recently updated DPR of Delhi Metro Phase-IV network.

18.7 SIGNALLING AND TELECOMMUNICATION WORKS

Rates adopted are based on recently updated DPR of Delhi Metro Phase-IV network. These rates include escalation during manufacturing and supply of equipment and their installation at site.

18.8 AUTOMATIC FARE COLLECTION

Adopted rates are based on recently updated DPR of Delhi Metro Phase-IV network.

18.9 ROLLING STOCK

Adopted rates are based on recently updated DPR of Delhi Metro Phase-IV network.

18.10 SECURITY

A lump sum provision for providing security infrastructure in the station premises has been made on per station basis. Adopted rates are as per recently updated DPR of Delhi Metro Phase-IV network.

18.11 MULTIMODAL TRAFFIC INTEGRATION

A lump sum provision of Rs. 3 Crore per station has been made to have seamless integration of metro stations with other modes of transport. It is envisaged that in case this money is not sufficient for this purpose the deficient part of money will borne by the Urban Local Body (ULB) in whose area station is located.

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

18.13.1Motera Stadium to Mahatma Mandir Metro Rail Corridor

The overall Capital Cost for the Motera Stadium to Mahatma Mandir Metro Corridor of Ahmedabad Phase-II at December 2018 price level works out to **Rs. 3529 Crores** excluding applicable Taxes & Duties of **Rs. 529 Crores** as tabulated hereunder.

Table 18.2 - Capital Cost Estimate

Total length = 22.838 km (Entirely Elevated)

Total Station (All Elevated) =20

December 2018 level

S. No.	Item	Unit	Rate	Qty.	Amount (Rs. in Cr.)
				Without taxes	
1.0	**Land and R & R incl. Hutments etc.**				
1.1	Permanent				
a	Government	ha	8.68	14.37	124.73
b	Private	ha	20.84	0.18	3.75
1.2	Temporary Land (@5% pa for 4 years)	ha	1.74	8.80	15.28
1.3	**R & R incl. Hutments etc.**	R. Km.	3.83	22.84	87.48
	Subtotal (1)				**231.24**
2.0	**Alignment and Formation**				
2.1	Elevated section including station length (Including Cost of Rain Water Harvesting)	R. Km.	37.00	22.84	845.08
2.2	Additional Cost for crossing canal and river and for any other special span	LS			25.00
	Subtotal (2)				**870.08**
3.0	**Station Buildings**				
3.1	Elevated station (Civil including finishes) excluding viaduct in station portion	Each	26.00	20	520.00
3.2	Elevated Station (E&M including lift & escalator)	Each	8.00	20	160.00
3.3	Augmentation of Metro Bhawan & OCC				
a	Civil works	LS			40.00
b	EM works etc	LS			10.00
	Subtotal (3)				**730.00**
4.0	**Depot (Stabling Yard and Augmentation of Gyaspur Depot)**	LS			
4.1	Augmentation of Gyaspur Depot				
a	Civil works	LS			50.00
b	EM works etc	LS			23.00
c	M&P	LS			15.00
4.2	Additional Cost for Indroda Circle Stabling Yard including Civil and E&M cost	LS			50.00
	Subtotal (4)				**138.00**
5.0	**P-Way**				
5.1	Ballastless track for elevated Section	R. Km.	6.60	22.84	150.74
5.2	Ballasted track for at grade in Stabling Yard/depot	T. Km.	3.90	7.00	27.30
	Subtotal (5)				**178.04**
6.0	**Traction & power supply**				
6.1	750 V DC Third Rail				
a	Elevated section	R. Km.	11.00	22.84	251.24
b	Depot	T. Km.	3.00	7.00	21.00
c	RSS	Each	25.00	2.00	50.00
d	132 kV double run double circuit cable from GSS to RSS	R. Km.	4.89	7.60	37.16
	Subtotal (6)				**359.40**
7.0	**Signalling and Telecom.**				

S. No.	Item	Unit	Rate	Qty.	Amount (Rs. in Cr.)
				Without taxes	
7.1	**Signalling**				
a	Main line including OCC	R. Km.	4.40	22.84	100.50
b	Depot including DCC	T. Km.	3.2	7.00	22.4
c	On Board Equipment	Per Train	1.7	7	11.9
7.2	**Telecommunication**				
a	Station	Per Station	4.50	20	90.00
b	Depot	Per Depot	3.50	1.00	3.50
	Subtotal (7)				**228.30**
8.0	**Automatic Fare Collection (AFC) system (as PPP Model)**	Per station	3.5	20	70
	Subtotal (8)				**70.00**
9.0	**Platform Screen Doors (PSD)**	Per station	3	20	60
	Subtotal (9)				**60.00**
10.0	**Shifting of Miscellaneous Utilities**				
10.1	Civil works and E&M	R. Km.	6.00	22.84	137.04
	Subtotal (10)				**137.04**
11.0	**Rolling Stock (2.9 m wide Coaches)**	Each	8.00	21	168.00
	Subtotal (11)				**168.00**
12.0	**Capital expenditure on security**	Per station	0.37	20	7.40
	Subtotal (12)				**7.40**
13.0	**Staff quarter for O & M**				
a	Civil works	R.Km.	1.28	22.84	29.24
b	EM works etc	R.Km.	0.31	22.84	7.08
	Sub Total (13)				**36.32**
14.0	**Multimodal Integration and Last mile connectivity**	Per station	3.00	20	60.00
	Sub Total (12)				**60.00**
13.0	**Total of all items except Land**				**3130.06**
14.0	**General Charges incl. Design charges @ 5 % on all items except land ##**				**156.50**
15.0	**Total of all items including G. Charges except land**				**3286.56**
16.0	**Contingencies @ 3 %**				**98.60**
17.0	**Gross Total**				**3385.16**
	Cost without land			**=**	**3385**
	Cost with land (without contingencies on land)			**=**	**3529**

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

Table 18.3 - Details of Taxes and Duties

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

S. No.	Description	Total cost without Taxes & duties (Cr.)	Taxes and duties		Total taxes & duties (Cr.)
			Total Customs Duty (Cr.)	Total GST (CGST & SGST) (Cr.)	
1	**Alignment & Formation**				
	Elevated	870.08		104.41	**104.41**
2	**Station Buildings**				
	Elevated station - civil works	520.00		62.40	**62.40**
	Elevated station-EM works	160.00	7.70	15.36	**23.06**
	Augmentation of Metro Bhawan & OCC-civil works	40.00		4.80	**4.80**
	Augmentation of Metro Bhawan & OCC -EM works	10.00	0.48	1.44	**1.92**
3	**Stabling Yard/Depot**				
	Civil works	87.50	6.32	7.35	**13.67**
	EM works and M&P	50.50	2.43	7.27	**9.70**
4	**P-Way**	178.04	34.29	6.41	**40.70**
5	**Traction & power supply**	359.40	34.61	38.82	**73.43**
6	**S & T**	228.30	43.97	8.22	**52.19**
7	**AFC as PPP model**	70.00	12.64	3.15	**15.79**
8	**PSD**	60.00	11.56	2.16	**13.72**
9	**R & R hutments**	87.48		10.50	**10.50**
10	**Misc.**				
	Civil works	182.57	0.00	21.91	**21.91**
	EM works	58.19	0.00	10.47	**10.47**
11	**Rolling stock**	168.00	35.60	3.63	**39.22**
12	**Rent on Temporary Land**	15.28		2.75	**2.75**
13	**General Charges**	156.50		28.17	**28.17**
	Total	**3301.84**	**189.61**	**339.21**	**528.83**
	Total taxes & Duties				**529**
Rate of Taxes & Duties on Total cost without taxes & duties					**16.02%**
Total Central GST & Basic Customs duty					284.69
Total State GST					244.13
Total State Taxes & Duties					**528.83**

18.13.2 Koteshwar Road to Airport Metro Rail Corridor (Phase-IIA)

The overall Capital Cost for the Koteshwar Road to Airport Metro Corridor of Ahmedabad Phase-II at December 2018 price level works out to **Rs. 790 Crores** excluding applicable Taxes & Duties of **Rs. 123 crores** as tabulated hereunder.

Table 18.4 - Capital Cost Estimate

Total length = 6.339 km (Entirely Elevated)
Total Station (All Elevated) =3

December 2018 level

S. No.	Item	Unit	Rate	Qty.	Amount (Rs. in Cr.)
				Without taxes	
1.0	**Land and R & R incl. Hutments etc.**				
1.1	Permanent				
a	Government	ha	8.68	0.96	8.33
b	Private	ha	20.84	0.45	9.38
1.2	Temporary Land (@5% pa for 4 years)	ha	1.74	2.20	3.82
1.3	**R & R incl. Hutments etc.**	R. Km.	3.83	6.34	24.28
	Subtotal (1)				**45.81**
2.0	**Alignment and Formation**				
2.1	Elevated section including station length (Including Cost of Rain Water Harvesting)	R. Km.	37.00	6.34	234.58
	Subtotal (2)				**234.58**
3.0	**Station Buildings**				
3.1	Elevated station (Civil including finishes) excluding viaduct in station portion	Each	26.00	3	78.00
3.2	Elevated Station (E&M including lift & escalator)	Each	8.00	3	24.00
	Subtotal (3)				**102.00**
4.0	**P-Way**				
4.1	Ballastless track for elevated Section	R. Km.	6.60	6.34	41.84
	Subtotal (4)				**41.84**
5.0	**Traction & Power supply**				
5.1	750 V DC Third Rail				
a	Elevated section	R.Km.	11.00	6.34	69.74
b	Depot	T. Km.	3.00	0.00	0.00
c	RSS	Each	25.00	1.00	25.00
d	66 kV double run double circuit cable from GSS to RSS	R.Km.	4.89	3.50	17.12
	Subtotal (5)				**111.86**
6.0	**Signalling and Telecom.**				
6.1	**Signalling**				
a	Main line including OCC	R. Km.	4.40	6.34	27.90
b	Depot including DCC	T.Km.	3.2	0.00	0
c	On Board Equipment	Per Train	1.7	3	5.1
6.2	**Telecommunication**				
a	Station	Per Station	4.50	3	13.50
	Subtotal (6)				**46.50**
7.0	**Automatic Fare Collection (AFC) system (as PPP Model)**	Per station	3.5	3	10.5
	Subtotal (7)				**10.50**

S. No.	Item	Unit	Rate	Qty.	Amount (Rs. in Cr.)
				Without taxes	
8.0	**Platform Screen Doors (PSD)**	Per station	3	3	9
	Subtotal (8)				**9.00**
9.0	**Shifting of Miscellaneous Utilities**				
a	Civil and E&M	R. Km.	6.00	6.34	38.04
	Subtotal (9)				**38.04**
10.0	**Rolling Stock (2.9 m wide Coaches)**	Each	8.00	9	72.00
	Subtotal (10)				**72.00**
11.0	**Capital expenditure on security**	Per station	0.37	3	1.11
	Subtotal (11)				**1.11**
12.0	**Staff quarter for O & M**				
a	Civil works	R.Km.	1.28	6.34	8.12
b	EM works etc	R.Km.	0.31	6.34	1.97
	Sub Total (12)				**10.08**
13.0	**Capital expenditure on Multimodal Traffic Integration and Last mile connectivity**	Per station	3.00	3	9.00
	Sub Total (13)				**9.00**
14.0	**Total of all items except Land**				**710.79**
15.0	**General Charges incl. Design charges @ 5 % on all items except land ##**				**35.54**
16.0	**Total of all items including G. Charges except land**				**746.33**
17.0	**Contingencies @ 3 %**				**22.39**
18.0	**Gross Total**				**768.72**
	Cost without land			**=**	**769**
	Cost with land (without contingencies on land)			**=**	**790**

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

Table 18.5 - Details of Taxes and Duties

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

S. No.	Description	Total cost without Taxes & duties (Cr.)	Taxes and duties		Total taxes & duties (Cr.)
			Total Customs Duty (Cr.)	Total GST (CGST & SGST) (Cr.)	
1	**Alignment & Formation**				
	Elevated	234.58		28.15	**28.15**
2	**Station Buildings**				
	Elevated station - civil works	78.00		9.36	**9.36**
	Elevated station-EM works	24.00	1.16	2.30	**3.46**
3	**P-Way**	41.84	8.06	1.51	**9.57**
4	**Traction & power supply**	111.86	10.77	12.08	**22.85**
5	**S & T**	46.50	8.96	1.67	**10.63**
6	**AFC as PPP model**	10.50	1.90	0.47	**2.37**
7	**PSD**	9.00	1.73	0.32	**2.06**
8	**R & R hutments**	24.28		2.91	**2.91**
9	**Misc.**				
	Civil works	44.23	0.00	5.31	**5.31**
	EM works	14.00	0.00	2.52	**2.52**
10	**Rolling stock**	72.00	15.26	1.56	**16.81**
11	**Rent on Temporary Land**	3.82		0.69	**0.69**
12	**General Charges**	35.54		6.40	**6.40**
	Total	**750.15**	**47.83**	**75.25**	**123.08**
	Total taxes & Duties				**123**
Rate of Taxes & Duties on Total cost without taxes & duties					**16.41%**
Total Central GST & Basic Customs duty					66.66
Total State GST					56.43
Total State Taxes & Duties					**123.08**

18.13.3 GNLU to GIFT City Metro Rail Corridor

The overall Capital Cost for the GNLU to GIFT City Metro Corridor of Ahmedabad Phase-II at December 2018 price level works out to **Rs. 660 Crores** excluding applicable Taxes & Duties of **Rs. 104 crores** as tabulated hereunder.

Table 18.6 - Capital Cost Estimate

Total length = 5.416 km (Entirely Elevated)

Total Station (All Elevated) =3

December 2018 level

S. No.	Item	Unit	Rate	Qty.	Amount (Rs. in Cr.)
				Without taxes	
1.0	**Land and R & R incl. Hutments etc.**				
1.1	Permanent				
a	Government	ha	8.68	0.13	1.13
b	Private	ha	20.84	0.09	1.88
1.2	Temporary Land (@5% pa for 4 years)	ha	1.74	2.20	3.82
1.3	**R & R incl. Hutments etc.**	R. Km.	3.83	5.42	20.76
	Subtotal (1)				**27.58**
2.0	**Alignment and Formation**				
2.1	Elevated section including station length (Including Cost of Rain Water Harvesting)	R. Km.	37.00	5.42	200.54
	Subtotal (2)				**200.54**
3.0	**Station Buildings**				
3.1	Elevated station (Civil including finishes) excluding viaduct in station portion	Each	26.00	3	78.00
3.2	Elevated Station (E&M including lift & escalator)	Each	8.00	3	24.00
	Subtotal (3)				**102.00**
4.0	**P-Way**				
4.1	Ballastless track for elevated Section	R. Km.	6.60	5.42	35.77
	Subtotal (4)				**35.77**
5.0	**Traction & Power supply**				
5.1	750 V DC Third Rail				
a	Elevated section	R.Km.	11.00	5.42	59.62
b	Depot	T. Km.	3.00	0.00	0.00
c	RSS	Each	25.00	0.00	0.00
	Subtotal (5)				**59.62**
6.0	**Signalling and Telecom.**				
6.1	**Signalling**				
a	Main line including OCC	R. Km.	4.40	5.42	23.85
b	Depot including DCC	T.Km.	3.2	0.00	0
c	On Board Equipment	Per Train	1.7	3	5.1
6.2	**Telecommunication**				
a	Station	Per Station	4.50	3	13.50
	Subtotal (6)				**42.45**
7.0	**Automatic Fare Collection (AFC) system (as PPP Model)**	Per station	3.5	3	10.5
	Subtotal (7)				**10.50**
8.0	**Platform Screen Doors (PSD)**	Per station	3	3	9

S. No.	Item	Unit	Rate	Qty.	Amount (Rs. in Cr.)
				Without taxes	
	Subtotal (8)				**9.00**
9.0	**Shifting of Miscellaneous Utilities**				
a	Civil and E&M	R. Km.	6.00	5.42	32.52
	Subtotal (9)				**32.52**
10.0	**Rolling Stock (2.9 m wide Coaches)**	Each	8.00	9	72.00
	Subtotal (10)				**72.00**
11.0	**Capital expenditure on security**	Per station	0.37	3	1.11
	Subtotal (11)				**1.11**
12.0	**Staff quarter for O & M**				
a	Civil works	R.Km.	1.28	5.42	6.94
b	EM works etc	R.Km.	0.31	5.42	1.68
	Sub Total (12)				**8.62**
13.0	**Capital expenditure on Multimodal Traffic Integration and Last mile connectivity**	Per station	3.00	3	9.00
	Sub Total (13)				**9.00**
14.0	**Total of all items except Land**				**603.89**
15.0	**General Charges incl. Design charges @ 5 % on all items except land ##**				**30.19**
16.0	**Total of all items including G. Charges except land**				**634.08**
17.0	**Contingencies @ 3 %**				**19.02**
18.0	**Gross Total**				**653.10**
	Cost without land			**=**	**653**
	Cost with land (without contingencies on land)			**=**	**660**

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

Table 18.7 - Details of Taxes and Duties

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

S. No.	Description	Total cost without Taxes & duties (Cr.)	Taxes and duties		Total taxes & duties (Cr.)
			Total Customs Duty (Cr.)	Total GST (CGST & SGST) (Cr.)	
1	**Alignment & Formation**				
	Elevated	200.54		24.06	**24.06**
2	**Station Buildings**				
	Elevated station - civil works	78.00		9.36	**9.36**
	Elevated station-EM works	24.00	1.16	2.30	**3.46**
3	**P-Way**	35.77	6.89	1.29	**8.18**
4	**Traction & power supply**	59.62	5.74	6.44	**12.18**
5	**S & T**	42.45	8.18	1.53	**9.70**
6	**AFC as PPP model**	10.50	1.90	0.47	**2.37**
7	**PSD**	9.00	1.73	0.32	**2.06**
8	**R & R hutments**	20.76		2.49	**2.49**
9	**Misc.**				
	Civil works	38.91	0.00	4.67	**4.67**
	EM works	12.34	0.00	2.22	**2.22**
10	**Rolling stock**	72.00	15.26	1.56	**16.81**
11	**Rent on Temporary Land**	3.82		0.69	**0.69**
12	**General Charges**	30.19		5.43	**5.43**
	Total	**637.90**	**40.85**	**62.84**	**103.69**
	Total taxes & Duties				**104**
Rate of Taxes & Duties on Total cost without taxes & duties					**16.25%**
Total Central GST & Basic Customs duty					56.21
Total State GST					47.48
Total State Taxes & Duties					**103.69**

18.13.4 Additional Corridor inside GIFT City (Phase-IIB)

The overall Capital Cost for the additional Corridor in GIFT City at December 2018 price level works out to **Rs. 579 Crores** excluding applicable Taxes & Duties of **Rs. 87 crores** as tabulated hereunder.

Table 18.8 - Capital Cost Estimate

Total length = 6.00 km (Entirely Elevated)

Total Station (All Elevated) =3

December 2018 level

S. No.	Item	Unit	Rate	Qty.	Amount (Rs. in Cr.)
				Without taxes	
1.0	**Land and R & R incl. Hutments etc.**				
1.1	Permanent				
a	Government	ha	0.00	0.42	0.00
b	Private	ha	0.00	0.00	0.00
1.2	Temporary Land (@5% pa for 4 years)	ha	0.00	2.20	0.00
1.3	**R & R incl. Hutments etc.**	R. Km.	0.00	6.00	0.00
	Subtotal (1)				**0.00**
2.0	**Alignment and Formation**				
2.1	Elevated section including station length (Including Cost of Rain Water Harvesting)	R. Km.	37.00	6.00	222.00
	Subtotal (2)				**222.00**
3.0	**Station Buildings**				
3.1	Elevated station (Civil including finishes) excluding viaduct in station portion	Each	26.00	3	78.00
3.2	Elevated Station (E&M including lift & escalator)	Each	8.00	3	24.00
	Subtotal (3)				**102.00**
4.0	**P-Way**				
4.1	Ballastless track for elevated Section	R. Km.	6.60	6.00	39.60
	Subtotal (4)				**39.60**
5.0	**Traction & Power supply**				
5.1	750 V DC Third Rail				
a	Elevated section	R.Km.	11.00	6.00	66.00
b	Depot	T. Km.	3.00	0.00	0.00
c	RSS	Each	25.00	0.00	0.00
	Subtotal (5)				**66.00**
6.0	**Signalling and Telecom.**				
6.1	**Signalling**				
a	Main line including OCC	R. Km.	4.40	6.00	26.40
b	Depot including DCC	T.Km.	3.2	0.00	0
c	On Board Equipment	Per Train	1.7	0	0
6.2	**Telecommunication**				
a	Station	Per Station	4.50	3	13.50
	Subtotal (6)				**39.90**
7.0	**Automatic Fare Collection (AFC) system (as PPP Model)**	Per station	3.5	3	10.5
	Subtotal (7)				**10.50**
8.0	**Platform Screen Doors (PSD)**	Per station	3	3	9

S. No.	Item	Unit	Rate	Qty.	Amount (Rs. in Cr.)
				Without taxes	
	Subtotal (8)				**9.00**
9.0	**Shifting of Miscellaneous Utilities**				
a	Civil and E&M	R. Km.	6.00	6.00	36.00
	Subtotal (9)				**36.00**
10.0	**Rolling Stock (2.9 m wide Coaches)**	Each	8.00	0	0.00
	Subtotal (10)				**0.00**
11.0	**Capital expenditure on security**	Per station	0.37	3	1.11
	Subtotal (11)				**1.11**
12.0	**Staff quarter for O & M**				
a	Civil works	R.Km.	1.28	0.00	0.00
b	EM works etc	R.Km.	0.31	0.00	0.00
	Sub Total (12)				**0.00**
13.0	**Capital expenditure on Multimodal Traffic Integration and Last mile connectivity**	Per station	3.00	3	9.00
	Sub Total (13)				**9.00**
14.0	**Total of all items except Land**				**535.11**
15.0	**General Charges incl. Design charges @ 5 % on all items except land ##**				**26.76**
16.0	**Total of all items including G. Charges except land**				**561.87**
17.0	**Contingencies @ 3 %**				**16.86**
18.0	**Gross Total**				**578.72**
	Cost without land			**=**	**579**
	Cost with land (without contingencies on land)			**=**	**579**

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

Table 18.9 - Details of Taxes and Duties

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

S. No.	Description	Total cost without Taxes & duties (Cr.)	Taxes and duties		Total taxes & duties (Cr.)
			Total Customs Duty (Cr.)	Total GST (CGST & SGST) (Cr.)	
1	**Alignment & Formation**				
	Elevated	222.00		26.64	**26.64**
2	**Station Buildings**				
	Elevated station - civil works	78.00		9.36	**9.36**
	Elevated station-EM works	24.00	1.16	2.30	**3.46**
3	**P-Way**	39.60	7.63	1.43	**9.05**
4	**Traction & power supply**	66.00	6.36	7.13	**13.48**
5	**S & T**	39.90	7.69	1.44	**9.12**
6	**AFC as PPP model**	10.50	1.90	0.47	**2.37**
7	**PSD**	9.00	1.73	0.32	**2.06**
8	**R & R hutments**	0.00		0.00	**0.00**
9	**Misc.**				
	Civil works	34.58	0.00	4.15	**4.15**
	EM works	11.53	0.00	2.07	**2.07**
10	**Rolling stock**	0.00	0.00	0.00	**0.00**
11	**Rent on Temporary Land**	0.00		0.00	**0.00**
12	**General Charges**	26.76		4.82	**4.82**
	Total	**561.87**	**26.45**	**60.13**	**86.59**
	Total taxes & Duties				**87**
Rate of Taxes & Duties on Total cost without taxes & duties					**15.41%**
Total Central GST & Basic Customs duty					46.12
Total State GST					40.46
Total State Taxes & Duties					**86.59**

Appendix-I

Metro-Link Express for Gandhinagar and Ahmedabad (MEGA) Company Limited
(A Joint Venture of Govt. of India & Govt. of Gujarat)

Ref.:- MEGA/DPR/Phase-II/May-17/1

Date: 22nd May, 2017

To,
Shri A.K.Gupta
GM (Consultancy)
Delhi Metro Rail Corporation Limited
25, Ashoka Road,
Near Patel Chowk Metro Station,
New Delhi-110001

Outward No. G/GC/175
Date 22/5/2017

Dear Sir,

Sub.:- Information pertaining to preparation of DPR of Phase-II

Ref.:- Your Letter No. DMRC/Adv.(CS)/05/AHM-DPR/Ph.2/2016 Dated 16th Feb., 2017

With reference to the above mentioned letter, details has been desired in the prescribed format pertaining to rates of the items based on the recently awarded works of Ahmedabad Metro Phase-I for preparation of DPR for Phase-II.

In view of the above the details in the desired format has been attached herewith along with the schedule containing the State Tax rates. The estimated rates being forwarded is for your reference only. However, DMRC shall arrive at the final cost after detailed examination and comparing the same with the other Metro Projects.

Thanking you,

(S.S.Sabuwala)
Chief Financial Officer

Encl.:- As above

Block No.1, 1st Floor, Karmyogi Bhavan, Sector-10A, Gandhinagar-382010, Gujarat
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CIN: U60200GJ2010SGC059407 2009-2010

Chapter – 19

FINANCING OPTIONS, FARE STRUCTURE, FINANCIAL VIABILITY AND NON FARE BOX REVENUE

19.1 INTRODUCTION

The Phase-II of Ahmedabad Metro Rail Project from Motera Stadium to Mahatma Mandir (Corridor 1), Koteshwar Road to Ahmedabad Airport (Corridor 2) and GNLU to GIFT City (Corridor 3) is proposed to be constructed from September 2019 to March 2024. The route length of the metro system and estimated cost at December-2018 price level without central taxes, with central taxes and with all taxes were worked out under the three options as given in table 19.1 below;

Table 19.1 Cost Details (at December-2018 price level)

Cost Details (at March 2017 Price Level)					
Corridor	**Name of Corridor**	**Distance (km)**	**Estimated cost without taxes (Rs/Crore)**	**Estimated cost with Central taxes & land cost (Rs/Crore)**	**Estimated cost with all taxes & land cost (Rs/Crore)**
Option I – Considering Corridor I, II & III					
I	Motera Stadium to Mahatma Mandir Corridor	22.838	3529.00	3814.00	4058.00
II	GNLU to GIFT City Corridor	5.416	660.00	716.00	764.00
III	Koteshwar Road to Ahmedabad Airport (Phase-IIA)	6.339	790.00	857.00	913.00
Total		**34.593**	**4979.00**	**5387.00**	**5735.00**
Option II – Corridor I & II					
I	Motera Stadium to Mahatma Mandir Corridor	22.838	3529.00	3814.00	4058.00
II	GNLU to GIFT City Corridor	5.416	660.00	716.00	764.00
	Total	**28.254**	**4189.00**	**4530.00**	**4822.00**
Option III – Corridor I					
I	Motera Stadium to Mahatma Mandir Corridor	22.838	3529.00	3814.00	4058.00
Total		**22.838**	**3529.00**	**3814.00**	**4058.00**

The estimated cost at December-2018 price level includes an amount of Rs. 7.40 Crore for corridor 1, Rs. 1.11 crore for corridor 2, Rs. 1.11 crore for corridor 3 and Rs. 1.11 for corridor 4 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 personnel have not taken in to account in the FIRR calculation since providing required security at metro stations shall be the responsibility of state police. The financial viability has been worked out for Option II only.

19.2 COSTS

19.2.1 Investment Cost

19.2.1.1 For the purpose of calculating the Financial Internal Rate of Return (FIRR), the completion cost with all taxes has been calculated by taking escalation factor @5.00% per annum. It has been assumed that the Government of Gujarat will provide the land worth Rs. 262.48 crore under option II either free of cost or it shall provide Interest Free Subordinate Debt. The taxes and duties consist of Custom Duty (CD), Central Goods and Service Tax (CGST), State Goods and Service Tax (SGST), Integrated Goods and Service Tax (IGST). It is understood that Phase-II of Ahmedabad metro project is eligible for availing concessional project import duty under chapter 98.01 of the Custom Tariff Act. The effective CD works out to 24.077% {Basic CD @ 5%, IGST (CGST & SGST) @ 18% and cess} on the imported portions. Post-GST, the GST rate on construction of original works of metro project has been considered @ 6% each for CGST and SGST while the GST rate has been considered @ 18% for supply of indigenously manufactured items and services. The above taxes and duties have been considered for working out the estimated taxes and duties. The Interest Free Subordinate Debt is normally repayable in 5 equal instalments (31-35 years) after repayment of Multilateral/Overseas Development Assistance Loan.

It is assumed that the construction work will start from 01.09.2019 and is expected to be completed on 31.03.2024 with Revenue Opening Date (ROD) as 01.04.2024. The total completion costs duly escalated and shown in the table 19.2 have been taken as the initial investment. The cash flow of investments under option II is placed in Table –19.2 as below;

Table 19.2 Year wise Investment for Option II

Rs./Crore

Financial Year	Estimated Cost including cost of land and all taxes & duties at December 2018 Price Level	Completion Cost including cost of land cost and all taxes & duties
2019-20	482.2	482.16
2020-21	964.4	1008.73
2021-22	1205.5	1316.44
2022-23	1446.6	1646.34
2023-24	723.3	856.5
Total	**4822**	**5310.17**

19.2.3 Operation & Maintenance (O&M) Costs

19.2.3.1 The Operation & Maintenance costs can be divided into three major parts:

(i) Staff costs
(ii) Maintenance cost which include expenditure towards upkeep and maintenance of the system and consumables
(iii) Energy costs

The requirement of staff has been assumed @ 30 persons per kilometre. The escalation factor used for staff costs is 9% per annum to provide for both escalation and growth in salaries. The impact of IDA pay revision due from 1st January 2017 has not been considered in FIRR calculation.

The cost of other expenses is based on the actual O & M unit cost for the Delhi Metro Phase-II project. The average rate of electricity being paid in Ahmedabad City is Rs. 6 per unit. The O&M cost (excluding staff cost) has been obtained by providing an escalation of 5.00% per annum. The O&M costs under option II have been tabulated in Table 19.3 below:

Table 19.3 Operation and Maintenance Costs (Option II)

Rs./Crore

YEAR			Staff	Maintenance Expenses	Energy	Total
2022	-	2023	55.59	34.47	25.35	115.41
2023	-	2024	60.59	36.19	26.62	123.41
2024	-	2025	66.05	38.00	27.95	132.00
2025	-	2026	71.99	39.90	29.35	141.24
2026	-	2027	78.47	41.90	30.82	151.19
2027	-	2028	85.53	43.99	32.36	161.88
2028	-	2029	93.23	46.19	33.98	173.40
2029	-	2030	101.62	48.50	35.68	185.80
2030	-	2031	110.77	50.93	37.46	199.15
2031	-	2032	120.74	53.47	44.35	218.56
2032	-	2033	131.60	56.15	46.57	234.31
2033	-	2034	143.45	58.96	48.89	251.29
2034	-	2035	156.36	61.90	51.34	269.60
2035	-	2036	170.43	65.00	53.91	289.33
2036	-	2037	185.77	68.25	56.60	310.62
2037	-	2038	202.49	71.66	59.43	333.58
2038	-	2039	220.71	75.24	62.40	358.35
2039	-	2040	240.57	79.01	65.52	385.10
2040	-	2041	262.22	82.96	68.80	413.98
2041	-	2042	285.82	87.10	83.12	456.05
2042	-	2043	311.55	91.46	87.27	490.28
2043	-	2044	339.59	96.03	91.64	527.26
2044	-	2045	370.15	100.83	96.22	567.20
2045	-	2046	403.47	105.88	101.03	610.37
2046	-	2047	439.78	111.17	106.08	657.03
2047	-	2048	479.36	116.73	111.38	707.47
2048	-	2049	522.50	122.56	116.95	762.02

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 equipments 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 Ahmedabad Metro mainly consists of fare box collection and other non-fare box collection 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.

19.3.2 Traffic

19.3.2.1 a. The projected ridership is as indicated in Table 19.4 as below:

Table 19.4 Projected Ridership

Financial Year	Trips per day (lakhs)		
	Option I	Option II	Option III
2021-22	1.24	1.12	1.00
2031-32	2.05	1.86	1.59
2041-42	2.88	2.64	2.27
2051-52	3.65	3.34	2.87

b. The growth rate for traffic is assumed @5.75% Per Annum up to 2031-32, @3.45% Per Annum up to 2041-42 and thereafter at @ 2.40% Per Annum under Option I, @ 5.85% Per Annum up to 2031-32, @ 3.55% Per Annum up to 2041-42 and thereafter at @ 2.40% Per Annum under Option II and @ 5.30% Per Annum up to 2031-32, @3.65% Per Annum up to 2041-42 and thereafter at @ 2.35% Per Annum under Option III.

19.3.2.2 Trip Distribution

The trip distribution has been worked out by considering average lead of 9.26 km for option I, 9.85 km for Option II and 10.53 km for Option III, which is placed in Table 19.5 as below:

Table 19.5 Trip Distribution (2021-22)

Distance in km	Percentage distribution		
	Option I	Option II	Option III
0-2	9.49%	10.10%	8.35%
2-5	20.00%	18.00%	16.00%
5-12	44.00%	44.00%	44.00%
12-21	24.00%	22.00%	24.00%
21-32	1.51%	4.00%	6.00%
>32	1.00%	1.90%	1.65%
Total	**100.00%**	**100.00%**	**100.00%**

The graphic presentation of the same is placed below in Figure-19.1.1, 19.1.2 and 19.1.3 for option I, option II and option III respectively.

Figure 19.1.1 –Trip Distribution (Option I)

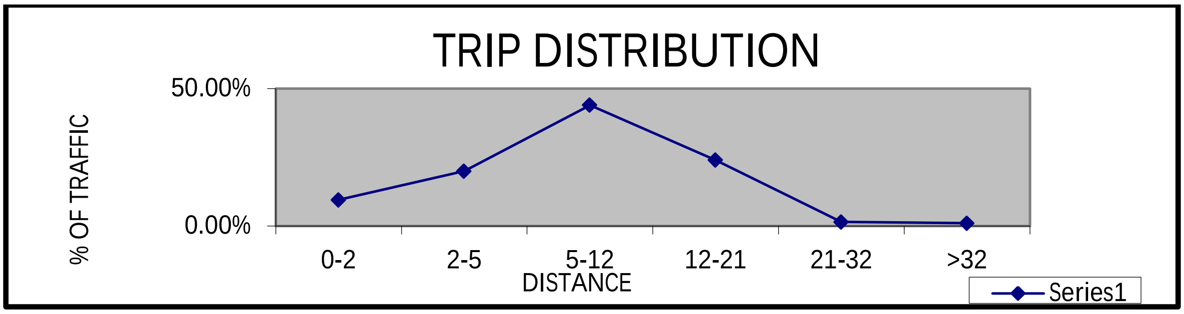


Table 19.1.2 Trip Distribution (Option II)

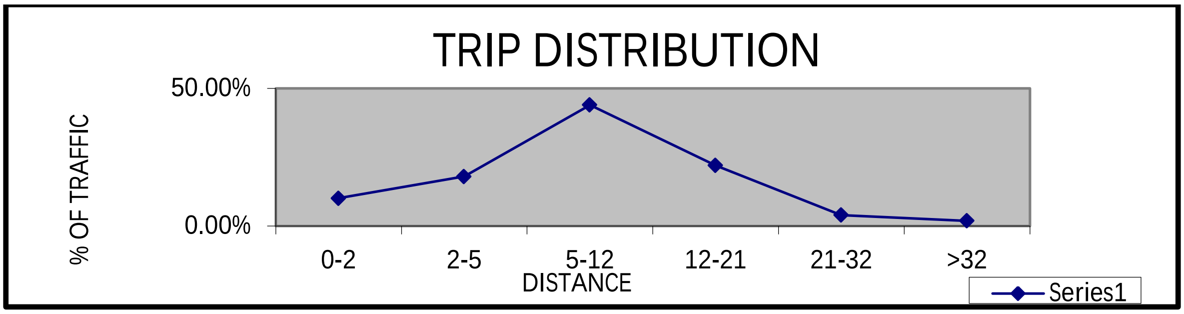
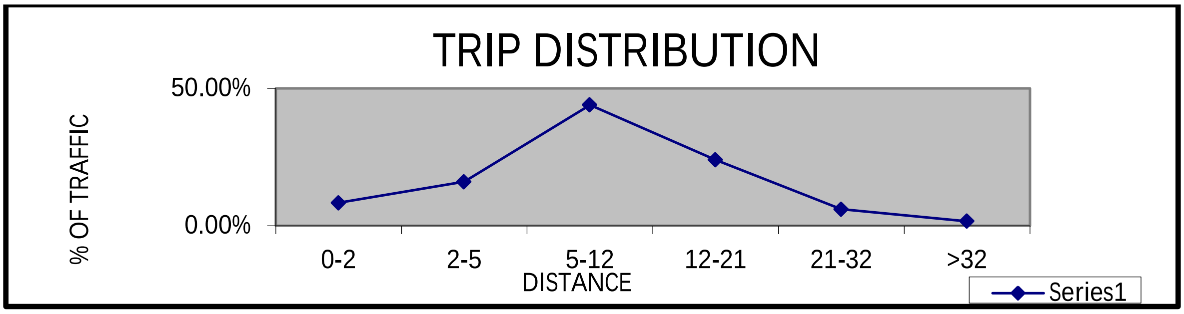


Table 19.1.3 Trip Distribution (Option III)



19.3.3 Fare Structure

The 4th Fare Fixation Committee has recommended 6 fare slabs to DMRC. The fare recommended to DMRC from October 2017 has been assumed as the base for all the corridors of Phase-II of Ahmedabad Metro project. The same has been escalated by using @ 12.00% once in every two years considering the increase in the Consumer Price Index (CPI) and input costs of operation. The fare structure for the FY 2022-23 is shown in the Table 19.6 below:

Table 19.6 Fare Structure in 2022-23 (All options)

Distance in kms.	Fare (Rs)	
	DMRC Fare from October 2017	Proposed Fare in 2022-23
0-2	10	10
2-5	20	30
5-12	30	40
12-21	40	50

Distance in kms.	Fare (Rs)	
21-32	50	70
>32	60	80

19.3.4 Non Fare Box Revenues

19.3.4.1 Non Fare Box revenues from Property Development and advertisement under all the three options have been assumed @ 15% of the fare box revenues. Apart from development of property on metro stations and depot, it is possible to raise resources through leasing of parking rights at stations, advertisement on trains and tickets, advertisements within stations and parking lots, advertisements on viaducts, columns and other metro structures, co-branding rights to corporate, naming rights, film shootings and special events on metro premises. Major areas to raise resources from advertisements, renting of space for shops, kiosks, ATMs etc. are as under;

(i) Advertisements:

a) ***Inside Station Advertisement****:* - All section/Lines of Metro may be awarded for advertisement purposes. Scope of the inside station advertisement may be display static advertisement on fixed advertisement boards/panels as well as through digital displays, putting up promotional canopies etc. Area of advertisement space may be fixed based on type of station i.e. elevated or underground station, size of station, footfall of station etc.

b) ***Outdoor Advertisement:*** - Commercial Advertisement may be allowed by putting Advertisement boards on Metro Civil Structure/Ancillary Buildings/Via Duct/FOBs/Metro Pillars. Scope of the Outdoor advertisement may be to put up static advertisement display at the Metro Pillars/FOBs/Metro Viaduct/Ancillary Building/Lift Lobby etc. Area of advertisement space may be decided based on type, size of station and footfall of station etc. and as per policy of Urban Local Body.

c) ***Advertisement on Trains:*** - MEGA may allow Commercial Advertisement on Metro Rail Trains; inside on prefabricated advertisement spaces and outside by wrapping of trains. Bidder may wrap 10% of available cars subject to maximum of 20% trains available in the line as well as may do advertisement on pre-designated spaces inside the Metro Trains.

d) ***Co-Branding:-*** Co-Branding by Suffixing/Prefixing of Brand Name with the Metro Station name may be allowed for selected metro stations. Co-branding rights may be awarded to the eligible/competent parties through tendering process. The Scope under this type of advertisement may be to Suffix the Brand name with the Metro Station name whereas for Stations. Colouring of the station in brand colour as well as inside and outside Advertisement rights for the station may also be permitted. The contract may be awarded generally for tenure of 10 years which may be further extendable by 5 years on mutually agreeable terms and conditions. The bidders quote the lump sum rate/annum for the total scope offered at the station.

e) ***Advertisement on Smart Card/Tokens****:* - One time commercial advertisement on Metro smart cards/tokens may be permitted. The rights of advertise may be awarded tendering process.

(ii) Shops:

a) ***Built Up shops:*** - Built up shops on the selected Metro Stations may be available on license basis. These types of Shops may have an inbuilt structure and located within the Metro Stations. The Shops awarded to the eligible/competent parties through tendering process. The shops which fail to attract any bid through tendering process may be made available through Walk-in-basis Scheme (First come first serve basis) wherein the bidders may take the shops at reserve price.

b) **Bare spaces:** - Unutilized bare spaces may also be licensed. The bare spaces may be awarded to the eligible/competent parties through tendering process with a scope to do all permitted/legal commercial activities by developing the bare spaces into a commercial space at their own cost. The tenure for the spaces may be decided based on the area which is to be developed by the bidder.

(iii) Kiosk

a) ***Kiosks: -*** Leasing of small bare spaces to operate small *kiosks* for commuters facilitations may be allowed on the metro stations.

b) ***Tom spaces:*** -Unused TOM spaces may be leased to operate eateries etc. through tendering process.

c) **Health Monitors/BMI Machines:** - Small bare spaces may be allotted to install Health Monitor/BMI Machines as commuter facilitation.

d) **Parcel Machines:** - Small bare spaces may be allotted to install smart parcel delivery system as commuter facilitation.

e) **Water Vending Kiosk:** - Small bare spaces may be allotted to install Water Vending Kiosks as commuter facilitation.

f) **ATMs -** Bare spaces may be leased to Banks to install and operate their *ATMs/e-lobby* at Metro Stations as commuter facility.

vi) Telecoms:

a) ***Telecom Towers****:* - The spaces in metro corridor premise may be leased for installation of Telecom Towers to enhance/provide the mobile connectivity. Commuters may get better mobile connectivity at the Metro Stations and its vicinity and MEGA may earns revenue also.

b) **Small Cells: -** Leasing of spaces on DMRC pillars to install Small Telecom equipment to enhance the mobile connectivity may also be considered. The spaces may be allotted to the different telecom operators through tendering mode for commuters to get better mobile connectivity at the vicinity of DMRC viaduct as well as for MEGA to earn revenue also.

19.3.4.2 Additional Income from Property Development: MEGA/BOT operator will engage a developer/Concessionaire for generating rental income. It is assumed that about 20.00 Hectare. i.e., 80,00,000 square feet area will be available for property development with a FAR of 4. The developer will bring equity to the extent of Rs. 444.00 crore and the balance amount towards construction shall be raised by SPV as 12% Market Debt. The current rental revenue in Ahmedabad City is Rs. 35 per Sq. ft. The estimated development cost will be Rs.1770.00 crore. It is assumed that the rental revenue will accrue to the developer from the FY 2023-24 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 under all the three options is tabulated as under; -

Table 19.7 Estimated generation of Rental Income from PD
(In respect of all the three Options)

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
2018 - 2019	320			209	13		222		-111	
2019 - 2020	336			225	28		475		-111	
2020 - 2021	353			242	33		750		-111	
2021 - 2022	371			260	37		1047		-111	
2022 - 2023	390			390	47		1484		0	
2023 - 2024		86	9			148	1336	178	62	-311
2024 - 2025		118	12			148	1188	160	65	-267
2025 - 2026		165	17			148	1040	143	68	-211
2026 - 2027		261	26			148	892	125	71	-109
2027 - 2028		438	44			148	744	107	75	64
2028 - 2029		460	46			148	596	89	79	98
2029 - 2030		483	48			148	448	72	83	132
2030 - 2031		507	51			148	300	54	87	167
2031 - 2032		532	53			148	152	36	91	204
2032 - 2033		559	56			152	0	18	96	237
2033 - 2034		587	59						101	427
2034 - 2035		616	62						106	448
2035 - 2036		647	65						111	471
2036 - 2037		679	68						117	494
2037 - 2038		713	71						123	519
2038 - 2039		749	75						129	545
2039 - 2040		786	79						135	572
2040 - 2041		826	83						142	601
2041 - 2042		867	87						149	631
2042 - 2043		910	91						156	663
2043 - 2044		956	96						164	696
2044 - 2045		1004	100						172	732
2045 - 2046		1054	105						181	768
2046 - 2047		1106	111						190	805
2047 - 2048		1162	116						200	846
Total	**1770**	**16271**	**1630**	**1326**	**158**	**1484**		**982**	**2509**	**9222**

19.4 FINANCIAL INTERNAL RATE OF RETURN (FIRR)

19.4.1 The Financial Internal Rate of Return (FIRR) obtained for 30 years life cycle business model including construction period without additional PD Income and with additional PD Income from 20 Hectare Land under option II is tabulated in Table 19.8.1 below:

19.8.1 FIRR

Alternative	FIRR without Additional PD Income	FIRR with Additional PD Income
Option II	2.12%	6.01%

19.4.2 The FIRR with all taxes & duties including land cost without additional PD Income and with additional PD Income for options II is produced in Table 19.8.2 and 19.8.3 below:

Table 19.8.2 –FIRR with All Taxes without additional PD Income (Option II)

Figs in Rs./crore

Year			Outflow					Inflow			Cash Flow
			Completion Cost	Additional Cost	Running Expenses	Replacement costs	Total Costs	Fare Box Revenue	PD &ADVT	Total Revenue	IRR
2019	-	2020	482.16				482			0	-482
2020	-	2021	1008.73				1009			0	-1009
2021	-	2022	1316.44				1316			0	-1316
2022	-	2023	1646.34				1646			0	-1646
2023	-	2024	856.5	0			857			0	-857
2024	-	2025	0	0	165		165	158	24	182	17
2025	-	2026	0	0	173		173	168	25	193	20
2026	-	2027	0	0	183		183	199	30	229	46
2027	-	2028	0	0	193		193	211	32	243	50
2028	-	2029	0	0	204		204	249	37	286	82
2029	-	2030	0	0	216		216	264	40	304	88
2030	-	2031	0	0	229		229	313	47	360	131
2031	-	2032	0	0	244		244	331	50	381	137
2032	-	2033	0	0	259		259	393	59	452	193
2033	-	2034	0	0	282		282	415	62	477	195
2034	-	2035	0	0	289		289	483	72	555	266
2035	-	2036	0	0	311		311	500	75	575	264
2036	-	2037	0	0	334		334	582	87	669	335
2037	-	2038	0	0	359		359	603	90	693	334
2038	-	2039	0	0	386		386	700	105	805	419
2039	-	2040	0	0	416		416	725	109	834	418
2040	-	2041	0	0	447		447	841	126	967	520
2041	-	2042	0	0	482		482	871	131	1002	520
2042	-	2043	0	0	519		519	1010	152	1162	643
2043	-	2044	0	0	571		571	1046	157	1203	632
2044	-	2045	0	0	615	846	1461	1202	180	1382	-79
2045	-	2046	0	0	663	888	1551	1231	185	1416	-135
2046	-	2047	0	0	714	0	714	1408	211	1619	905
2047	-	2048	0	0	770	0	770	1443	216	1659	889
2048	-	2049			831	0	831	1655	248	1903	1072
Total			**5310**	**0**	**9855**	**1734**	**16899**	**17001**	**2550**	**19551**	**2.12%**

Table 19.8.3 –FIRR with All Taxes with additional PD Income (Option II)

Figs in Rs./crore

Year			Outflow					Inflow			Cash Flow
			Completion Cost	Additional Cost	Running Expenses	Replacement costs	Total Costs	Fare Box Revenue	PD &ADVT	Total Revenue	IRR
2019	-	2020	482.16				482			0	-482
2020	-	2021	1008.7				1009			0	-1009
2021	-	2022	1316.4				1316			0	-1316
2022	-	2023	1646.3				1646			0	-1646
2023	-	2024	856.5				857			0	-857
2024	-	2025	0	0	165		165	158	-287	-129	-294
2025	-	2026	0	0	173		173	168	-242	-74	-247
2026	-	2027	0	0	183		183	199	-181	18	-165
2027	-	2028	0	0	193		193	211	-77	134	-59
2028	-	2029	0	0	204		204	249	101	350	146
2029	-	2030	0	0	216		216	264	138	402	186
2030	-	2031	0	0	229		229	313	179	492	263
2031	-	2032	0	0	244		244	331	217	548	304
2032	-	2033	0	0	259		259	393	263	656	397
2033	-	2034	0	0	282		282	415	299	714	432
2034	-	2035	0	0	289		289	483	499	982	693
2035	-	2036	0	0	311		311	500	523	1023	712
2036	-	2037	0	0	334		334	582	558	1140	806
2037	-	2038	0	0	359		359	603	584	1187	828
2038	-	2039	0	0	386		386	700	624	1324	938
2039	-	2040	0	0	416		416	725	654	1379	963
2040	-	2041	0	0	447		447	841	698	1539	1092
2041	-	2042	0	0	482		482	871	732	1603	1121
2042	-	2043	0	0	519		519	1010	783	1793	1274
2043	-	2044	0	0	571		571	1046	820	1866	1295
2044	-	2045	0	0	615	846	1461	1202	876	2078	617
2045	-	2046	0	0	663	888	1551	1231	917	2148	597
2046	-	2047	0	0	714	0	714	1408	979	2387	1673
2047	-	2048	0	0	770	0	770	1443	1021	2464	1694
2048	-	2049	0	0	831	0	831	1655	1094	2749	1918
Total			**5310**	**0**	**9855**	**1734**	**16899**	**17001**	**11772**	**28773**	**6.01%**

The various sensitivities with regard to increase/decrease in capital costs, O&M costs and revenues for option II is placed in Table 19.9 below:

Table 19.9 –FIRR SENSITIVITY (Without Additional PD Income) (Option II)

Capital Cost with Central Taxes but without land cost			
20% increase in capital cost	**10% increase in capital cost**	**10% decrease in capital cost**	**20% decrease in capital cost**
1.25%	1.66%	2.63%	3.19%
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**
-1.33%	0.63%	3.34%	4.39%
O&M COSTS			
10% increase in O&M cost		**10% decrease in O&M cost**	
1.40%		2.78%	

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
- o Low infrastructure maintenance costs
- o Longer life span
- o 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)/Chennai Metro Rail Corporation/Mumbai Metro Rail Corporation
(ii) Design-Build-Finance-Operate-Transfer (DBFOT), and
(iii) Public Private Partnership (PPP)

19.5.1.1SPV Model: - The corridors are a standalone one and a separate SPV with the name Metro Link Express for Gandhinagar and Ahmedabad (MEGA) Company Ltd, A SPV of GoI and GoG is already in existence for execution of Phase I Metro project. The funding pattern under this model (SPV) for option II is placed in table 19.10 below: -

Table 19.10 Funding pattern under SPV model (with all taxes)

(Rs./Crore)

Particulars	With Taxes & Duties	
	Amount (Rs./Crore)	% of contribution
Equity By GOI	757.11	15.28%
Equity By GOG	757.11	15.28%
SD for Total Taxes by GOG (2/3rd)	468.06	9.44%
SD for Total Taxes by GOI (1/3rd)	234.03	4.72%
Loan from bilateral/ multilateral agencies	2739.38	55.28%
Sub-Total	**4955.69**	**100.00%**
Subordinate Debt for Land Including R&R cost by GoG	262.48	
Sub-Total	**5218.17**	
Concessionaire Fund for PPP Component (AFC for Stations)	92.00	
Sub-Total	**5310.17**	
IDC for Loan to be borne by GoG	74	
Grand Total	**5384.17**	

19.5.1.2 DBFOT Model: In this model, the private firm will be responsible for financing, designing, building, operating and maintaining of the entire project. The contribution of Government of Gujarat will be limited to cost of land only. Such a project become eligible for Viability Gap Funding (VGF) up to 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.

19.5.1.3 PPP Model: - Under this option, Government funds the fixed infrastructure such as land and basic civil structures, and a private investor funds all the systems such as rolling stock, signalling, power supply, traction, track, fare collection, E&M works etc including station architectural finishes. An example of this is Delhi Metro Airport line. Under this arrangement the government's investment will be about 57% of the cost of the Project and the PPP operator funds the remaining 43%. Under this model the concessionaire, operates and maintains the system to the required and agreed service and safety levels. All the revenues will accrue to the Operator and at the end of the concession period the project is handed over to the owner. Ridership risks are taken by the operator or shared by the operator and owner. The PPP operator pays a specified amount every year to the Govt. out of his revenues. It could be that he may need a viability gap funding (VGF) even. The VGF (positive or negative) will be known only after competitive bidding.

As per new Metro Policy 2017 issued by Ministry of Housing and Urban Affairs (MH&UA), the private participation either for complete provisioning of metro rail or for some unbundled components will form an essential requirement for all metro rail project proposals seeking central financial assistance. Accordingly, cost of Automatic Fare Collection (AFC) system has been proposed under PPP mode.

19.6. RECOMMENDATIONS

The FIRR without and with Additional PD Income from 20 Hectare land is 2.12% and 6.01% under option II.

As per Metro Rail Policy 2017, issued by the Ministry of Housing and Urban Affairs, (MOH&UA), GOI, apart from financial viability, the economic and social viability of the project is also required to be assessed. The Economic Internal Rate of Return (EIRR) for any metro rail project proposal should be 14% and above for consideration of its approval. Accordingly, the metro corridors under option II discussed above are recommended for implementation provided the required EIRR works out to 14% or above. The Metro Link for Gandhinagar to Ahmedabad (MEGA) may explore the possibility for generation of fund from TOD development, Value Capture Financing, Increase in Floor Area Ratio (FAR), Imposition of Green Cess etc to make the system self-sustainable.

The detailed cash flow statements under various alternatives under option II are enclosed as per detail given below:-

Option	Table No.
SPV Model with bilateral/ multilateral Loan	19.11
SPV Model with bilateral/ multilateral Loan with Additional PD Income	19.12
SPV Model with Market Borrowings	19.13
SPV Model with Market Borrowings with Additional PD Income	19.14

The funding pattern assumed under SPV model is depicted in the pie chart i.e., Figure 19.2 for Option II as under: -

Figure 19.2 Funding pattern under SPV Model Option II

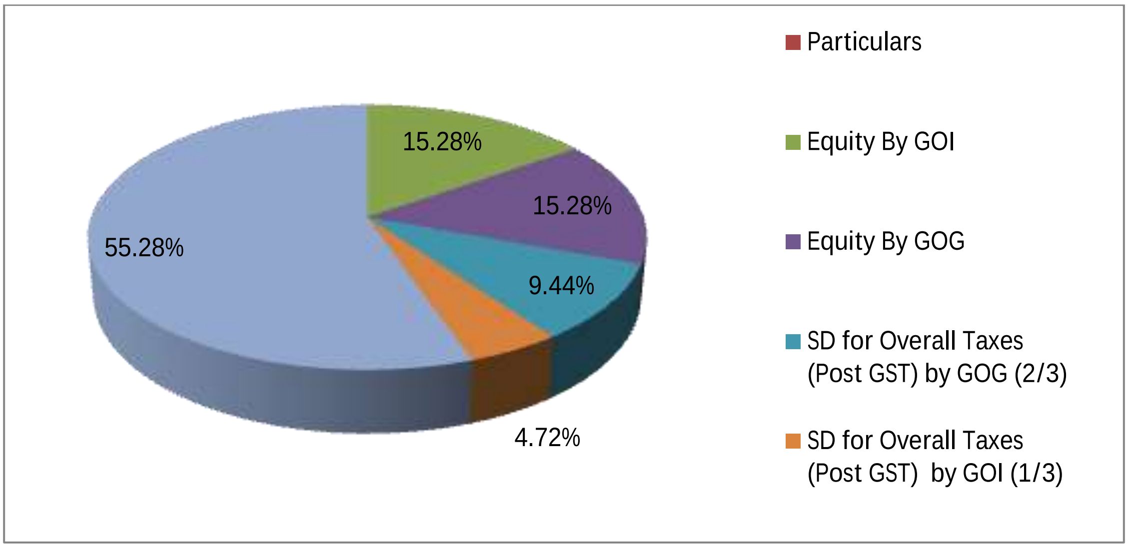


Table 19.11

Ahmedabad Metro (Phase-II) : Motera Stadium to Mahatma Mandir Corridor and GNLU to Gift City Corridor

CAPITAL COST-FIXED 4822

CAPITAL COST - CURRENT 5310.17

Multilateral/Bilateral 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+PPP component	Availability of cash	Cumulative cash	Cum. Loan	Loan	Repayment of Loan	IDC	Cumulative loan incl. IDC	Interest	Profit before Tax	Cash Balance	Cumulative Cash
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
2019 - 2020	482.16					482			0	-482	478	-4	-4	4	4	0	0	4				
2020 - 2021	1008.73					1009			0	-1009	682	-327	-331	331	327	0	2	333				
2021 - 2022	1316.44					1316			0	-1316	682	-634	-965	965	634	0	9	976				
2022 - 2023	1646.34					1646			0	-1646	591	-1055	-2021	2021	1055	0	21	2053				
2023 - 2024	856.5					857			0	-857	203	-654	-2674	2674	654	0	33	2739				
2024 - 2025	0	0	165	161		165	158	24	182	17	0	0	0	0	0	0		2739	38	-182	-21	-21
2025 - 2026	0	0	173	161		173	168	25	193	20		0	0	0	0	0		2739	38	-180	-19	-40
2026 - 2027	0	0	183	161		183	199	30	229	46		0	0	0	0	0		2739	38	-153	8	-32
2027 - 2028	0	0	193	161		193	211	32	243	50		0	0	0	0	0		2739	38	-149	12	-20
2028 - 2029	0	0	204	161		204	249	37	286	82		0	0	0	0	0		2739	38	-117	44	23
2029 - 2030	0	0	216	161		216	264	40	304	88		0	0	0	0	137		2602	38	-112	-88	-64
2030 - 2031	0	0	229	161		229	313	47	360	131		0	0	0	0	137		2465	36	-67	-43	-107
2031 - 2032	0	0	244	161		244	331	50	381	137		0	0	0	0	137		2328	35	-58	-34	-141
2032 - 2033	0	0	259	161		259	393	59	452	193		0	0	0	0	137		2191	33	-1	23	-118
2033 - 2034	0	0	282	161		282	415	62	477	195		0	0	0	0	137		2054	31	4	28	-90
2034 - 2035	0	0	289	161		289	483	72	555	266		0	0	0	0	137		1917	29	76	100	10
2035 - 2036	0	0	311	161		311	500	75	575	264		0	0	0	0	137		1780	27	77	101	111
2036 - 2037	0	0	334	161		334	582	87	669	335		0	0	0	0	137		1644	25	149	173	284
2037 - 2038	0	0	359	161		359	603	90	693	334		0	0	0	0	137		1507	23	150	174	458
2038 - 2039	0	0	386	161		386	700	105	805	419		0	0	0	0	137		1370	21	237	261	719
2039 - 2040	0	0	416	161		416	725	109	834	418		0	0	0	0	137		1233	19	238	262	981
2040 - 2041	0	0	447	161		447	841	126	967	520		0	0	0	0	137		1096	17	341	365	1347
2041 - 2042	0	0	482	161		482	871	131	1002	520		0	0	0	0	137		959	15	344	368	1714
2042 - 2043	0	0	519	161		519	1010	152	1162	643		0	0	0	0	137		822	13	469	493	2207
2043 - 2044	0	0	571	161		571	1046	157	1203	632		0	0	0	0	137		685	12	459	483	2691
2044 - 2045	0	0	615	186	846	1461	1202	180	1382	-79		0	0	0	0	137		548	10	571	-226	2465
2045 - 2046	0	0	663	213	888	1551	1231	185	1416	-135		0	0	0	0	137		411	8	532	-279	2185
2046 - 2047	0	0	714	213	0	714	1408	211	1619	905		0	0	0	0	137		274	6	686	762	2947
2047 - 2048	0	0	770	213	0	770	1443	216	1659	889		0	0	0	0	137		137	4	672	748	3695
2048 - 2049	0	0	831	213	0	831	1655	248	1903	1072		0	0	0	0	137		0	2	857	933	4629
	5310.17	0	9855	4258	1734	16899	17001	2550	19551	2.12%	2636				2674	2739	65		594	4844	4629	

Table 19.12

Ahmedabad Metro (Phase-II) : Motera Stadium to Mahatma Mandir Corridor and GNLU to Gift City Corridor

CAPITAL COST-FIXED 4822

CAPITAL COST - CURRENT 5310.17

Multilateral/Bilateral 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+PPP component	Availability of cash	Cumulative cash	Cum. Loan	Loan	Repayment of Loan	IDC	Cumulative loan incl. IDC	Interest	Profit before Tax	Cash Balance	Cumulative Cash
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
2019 - 2020	482.16					482			0	-482	478	-4	-4	4	4	0	0	4				
2020 - 2021	1008.73					1009			0	-1009	682	-327	-331	331	327	0	2	333				
2021 - 2022	1316.44					1316			0	-1316	682	-634	-965	965	634	0	9	976				
2022 - 2023	1646.34					1646			0	-1646	591	-1055	-2021	2021	1055	0	21	2053				
2023 - 2024	856.5					857			0	-857	203	-654	-2674	2674	654	0	33	2739				
2024 - 2025	0	0	165	161		165	158	-287	-129	-294	0	0	0	0	0	0		2739	38	-493	-332	-332
2025 - 2026	0	0	173	161		173	168	-242	-74	-247		0	0	0	0	0		2739	38	-447	-286	-618
2026 - 2027	0	0	183	161		183	199	-181	18	-165		0	0	0	0	0		2739	38	-364	-203	-821
2027 - 2028	0	0	193	161		193	211	-77	134	-59		0	0	0	0	0		2739	38	-258	-97	-918
2028 - 2029	0	0	204	161		204	249	101	350	146		0	0	0	0	0		2739	38	-53	108	-811
2029 - 2030	0	0	216	161		216	264	138	402	186		0	0	0	0	137		2602	38	-14	10	-800
2030 - 2031	0	0	229	161		229	313	179	492	263		0	0	0	0	137		2465	36	65	89	-711
2031 - 2032	0	0	244	161		244	331	217	548	304		0	0	0	0	137		2328	35	109	133	-578
2032 - 2033	0	0	259	161		259	393	263	656	397		0	0	0	0	137		2191	33	203	227	-351
2033 - 2034	0	0	282	161		282	415	299	714	432		0	0	0	0	137		2054	31	241	265	-86
2034 - 2035	0	0	289	161		289	483	499	982	693		0	0	0	0	137		1917	29	503	527	441
2035 - 2036	0	0	311	161		311	500	523	1023	712		0	0	0	0	137		1780	27	525	549	990
2036 - 2037	0	0	334	161		334	582	558	1140	806		0	0	0	0	137		1644	25	620	644	1634
2037 - 2038	0	0	359	161		359	603	584	1187	828		0	0	0	0	137		1507	23	644	668	2302
2038 - 2039	0	0	386	161		386	700	624	1324	938		0	0	0	0	137		1370	21	756	780	3082
2039 - 2040	0	0	416	161		416	725	654	1379	963		0	0	0	0	137		1233	19	783	807	3889
2040 - 2041	0	0	447	161		447	841	698	1539	1092		0	0	0	0	137		1096	17	913	937	4827
2041 - 2042	0	0	482	161		482	871	732	1603	1121		0	0	0	0	137		959	15	945	969	5795
2042 - 2043	0	0	519	161		519	1010	783	1793	1274		0	0	0	0	137		822	13	1100	1124	6919
2043 - 2044	0	0	571	161		571	1046	820	1866	1295		0	0	0	0	137		685	12	1122	1146	8066
2044 - 2045	0	0	615	186	846	1461	1202	876	2078	617		0	0	0	0	137		548	10	1267	470	8536
2045 - 2046	0	0	663	213	888	1551	1231	917	2148	597		0	0	0	0	137		411	8	1264	453	8988
2046 - 2047	0	0	714	213	0	714	1408	979	2387	1673		0	0	0	0	137		274	6	1454	1530	10518
2047 - 2048	0	0	770	213	0	770	1443	1021	2464	1694		0	0	0	0	137		137	4	1477	1553	12071
2048 - 2049	0	0	831	213	0	831	1655	1094	2749	1918		0	0	0	0	137		0	2	1703	1779	13851
	5310.17	0	9855	4258	1734	16899	17001	11772	28773	6.01%	2636				2674	2739	65		594	14066	13851	

Ahmedabad Metro (Phase-II) : Motera Stadium to Mahatma Mandir Corridor and GNLU to Gift City Corridor

Table 19.13

CAPITAL COST-FIXED 4822

CAPITAL COST - CURRENT 5310.17

DOMESTIC FUNDING - BASE CASE

Market Borrowing 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	Equity from GOI & GOG+PPP component	Availability of cash	Cumulative cash	Cum. Loan	Loan	Repayment of Loan	IDC	Cumulative loan incl. IDC	Interest	Profit before Tax	Cash Balance	Cumulative Cash
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
2019 - 2020	482.16					482			0	-482	478	-4	-4	4	4	0	0	4				
2020 - 2021	1008.73					1009			0	-1009	682	-327	-331	331	327	0	20	351				
2021 - 2022	1316.44					1316			0	-1316	682	-634	-965	965	634	0	78	1063				
2022 - 2023	1646.34					1646			0	-1646	591	-1055	-2021	2021	1055	0	179	2298				
2023 - 2024	856.5					857			0	-857	203	-654	-2674	2674	654	0	282	3233				
2024 - 2025	0	0	165	176		165	158	24	182	17	0	0	0	0	0	0		3233	388	-547	-371	-371
2025 - 2026	0	0	173	176		173	168	25	193	20		0	0	0	0	0		3233	388	-544	-368	-739
2026 - 2027	0	0	183	176		183	199	30	229	46		0	0	0	0	0		3233	388	-518	-342	-1081
2027 - 2028	0	0	193	176		193	211	32	243	50		0	0	0	0	0		3233	388	-514	-338	-1419
2028 - 2029	0	0	204	176		204	249	37	286	82		0	0	0	0	0		3233	388	-482	-306	-1725
2029 - 2030	0	0	216	176		216	264	40	304	88		0	0	0	0	162		3072	388	-476	-462	-2187
2030 - 2031	0	0	229	176		229	313	47	360	131		0	0	0	0	162		2910	369	-414	-400	-2586
2031 - 2032	0	0	244	176		244	331	50	381	137		0	0	0	0	162		2748	349	-388	-374	-2960
2032 - 2033	0	0	259	176		259	393	59	452	193		0	0	0	0	162		2587	330	-313	-299	-3258
2033 - 2034	0	0	282	176		282	415	62	477	195		0	0	0	0	162		2425	310	-291	-277	-3535
2034 - 2035	0	0	289	176		289	483	72	555	266		0	0	0	0	162		2263	291	-201	-187	-3722
2035 - 2036	0	0	311	176		311	500	75	575	264		0	0	0	0	162		2102	272	-183	-169	-3890
2036 - 2037	0	0	334	176		334	582	87	669	335		0	0	0	0	162		1940	252	-93	-79	-3969
2037 - 2038	0	0	359	176		359	603	90	693	334		0	0	0	0	162		1778	233	-75	-60	-4030
2038 - 2039	0	0	386	176		386	700	105	805	419		0	0	0	0	162		1617	213	29	44	-3986
2039 - 2040	0	0	416	176		416	725	109	834	418		0	0	0	0	162		1455	194	48	63	-3923
2040 - 2041	0	0	447	176		447	841	126	967	520		0	0	0	0	162		1293	175	169	183	-3740
2041 - 2042	0	0	482	176		482	871	131	1002	520		0	0	0	0	162		1132	155	189	203	-3536
2042 - 2043	0	0	519	176		519	1010	152	1162	643		0	0	0	0	162		970	136	331	346	-3191
2043 - 2044	0	0	571	176		571	1046	157	1203	632		0	0	0	0	162		808	116	340	354	-2837
2044 - 2045	0	0	615	201	846	1461	1202	180	1382	-79		0	0	0	0	162		647	97	469	-338	-3175
2045 - 2046	0	0	663	228	888	1551	1231	185	1416	-135		0	0	0	0	162		485	78	448	-374	-3549
2046 - 2047	0	0	714	228	0	714	1408	211	1619	905		0	0	0	0	162		323	58	618	685	-2864
2047 - 2048	0	0	770	228	0	770	1443	216	1659	889		0	0	0	0	162		162	39	622	688	-2176
2048 - 2049	0	0	831	228	0	831	1655	248	1903	1072		0	0	0	0	162		0	19	825	891	-1285
	5310.17	0	9855	4633	1734	16899	17001	2550	19551	2.12%	2636				2674	3233	559		6014	-951	-1285	

Table 19.14

Ahmedabad Metro (Phase-II) : Motera Stadium to Mahatma Mandir Corridor and GNLU to Gift City Corridor

CAPITAL COST-FIXED 4822

CAPITAL COST - CURRENT 5310.17

Market Borrowing 12.00%

DOMESTIC FUNDING - BASE CASE

Year	Completion Cost	Additional Capital	Running Expenses	Depreciation	Replacement Cost	Total Cost	Fare box Revenue	PD & Advertisement	Total Revenue	Net Cash Flow for IRR	Equity from GOI & GOG+PPP component	Availability of cash	Cumulative cash	Cum. Loan	Loan	Repayment of Loan	IDC	Cumulative loan incl. IDC	Interest	Profit before Tax	Cash Balance	Cumulative Cash
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
2019 - 2020	482.16					482			0	-482	478	-4	-4	4	4	0	0	4				
2020 - 2021	1008.73					1009			0	-1009	682	-327	-331	331	327	0	20	351				
2021 - 2022	1316.44					1316			0	-1316	682	-634	-965	965	634	0	78	1063				
2022 - 2023	1646.34					1646			0	-1646	591	-1055	-2021	2021	1055	0	179	2298				
2023 - 2024	856.5					857			0	-857	203	-654	-2674	2674	654	0	282	3233				
2024 - 2025	0	0	165	176		165	158	-287	-129	-294	0	0	0	0	0	0		3233	388	-858	-682	-682
2025 - 2026	0	0	173	176		173	168	-242	-74	-247		0	0	0	0	0		3233	388	-811	-635	-1317
2026 - 2027	0	0	183	176		183	199	-181	18	-165		0	0	0	0	0		3233	388	-729	-553	-1870
2027 - 2028	0	0	193	176		193	211	-77	134	-59		0	0	0	0	0		3233	388	-623	-447	-2317
2028 - 2029	0	0	204	176		204	249	101	350	146		0	0	0	0	0		3233	388	-418	-242	-2559
2029 - 2030	0	0	216	176		216	264	138	402	186		0	0	0	0	162		3072	388	-378	-364	-2923
2030 - 2031	0	0	229	176		229	313	179	492	263		0	0	0	0	162		2910	369	-282	-268	-3190
2031 - 2032	0	0	244	176		244	331	217	548	304		0	0	0	0	162		2748	349	-221	-207	-3397
2032 - 2033	0	0	259	176		259	393	263	656	397		0	0	0	0	162		2587	330	-109	-95	-3491
2033 - 2034	0	0	282	176		282	415	299	714	432		0	0	0	0	162		2425	310	-54	-40	-3531
2034 - 2035	0	0	289	176		289	483	499	982	693		0	0	0	0	162		2263	291	226	240	-3291
2035 - 2036	0	0	311	176		311	500	523	1023	712		0	0	0	0	162		2102	272	265	279	-3011
2036 - 2037	0	0	334	176		334	582	558	1140	806		0	0	0	0	162		1940	252	378	392	-2619
2037 - 2038	0	0	359	176		359	603	584	1187	828		0	0	0	0	162		1778	233	419	434	-2186
2038 - 2039	0	0	386	176		386	700	624	1324	938		0	0	0	0	162		1617	213	548	563	-1623
2039 - 2040	0	0	416	176		416	725	654	1379	963		0	0	0	0	162		1455	194	593	608	-1015
2040 - 2041	0	0	447	176		447	841	698	1539	1092		0	0	0	0	162		1293	175	741	755	-260
2041 - 2042	0	0	482	176		482	871	732	1603	1121		0	0	0	0	162		1132	155	790	804	545
2042 - 2043	0	0	519	176		519	1010	783	1793	1274		0	0	0	0	162		970	136	962	977	1521
2043 - 2044	0	0	571	176		571	1046	820	1866	1295		0	0	0	0	162		808	116	1003	1017	2538
2044 - 2045	0	0	615	201	846	1461	1202	876	2078	617		0	0	0	0	162		647	97	1165	358	2896
2045 - 2046	0	0	663	228	888	1551	1231	917	2148	597		0	0	0	0	162		485	78	1180	358	3254
2046 - 2047	0	0	714	228	0	714	1408	979	2387	1673		0	0	0	0	162		323	58	1386	1453	4707
2047 - 2048	0	0	770	228	0	770	1443	1021	2464	1694		0	0	0	0	162		162	39	1427	1493	6200
2048 - 2049	0	0	831	228	0	831	1655	1094	2749	1918		0	0	0	0	162		0	19	1671	1737	7937
	5310.17	0	9855	4633	1734	16899	17001	11772	28773	6.01%	2636				2674	3233	559		6014	8271	7937	

No. K-14011/5/2017-UT-II
Government of India
Ministry of Housing and Urban Affairs
Urban Transport Division

Nirman Bhawan, New Delhi.
Dated: 9th March, 2019

To,

Chief Secretary,
Government of Gujarat,
New Sachivalaya, Gandhinagar,
Gujarat.

Subject: Approval for Ahmedabad Metro Rail Project Phase II comprising two corridors, viz. (i) Motera Stadium to Mahatma Mandir and (ii) GNLU to GIFT City.

Sir,

I am directed to convey the approval of the Government of India (GoI) for Ahmedabad Metro Rail Project Phase II for a total length of 28.254 km in two corridors viz. Motera Stadium to Mahatma Mandir (22.838 km) and Gujarat National law University (GNLU) to GIFT city (5.416 km), at a total completion cost of ₹5384.17 crore as per financing plan in **para 5** and subject to the conditions as given in **para 8** below. The Project will be implemented within a period of 05 years from the date of approval.

2. This project will be implemented by the existing Special Purpose Vehicle (SPV) i.e. Gujarat Metro Rail Corporation (GMRC) Limited, a 50:50 Joint Venture company of Government of India (GoI) and Government of Gujarat (GoG).

3. **Legal Framework**

Legal cover for Ahmedabad Metro Phase-II Project shall be under the Metro Railways (Construction of Works) Act, 1978; the Metro Railways (Operation & Maintenance) Act, 2002; Metro Railways (Amendment) Act, 2009 and the Railways Act, 1989, as amended from time to time.

4. **Corridor**

Ahmedabad metro rail project phase-II covering 28.254 km in two corridors as below:

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Corridor/Line	Name of Corridor/Line	Total Stations	Length in km
		Elevated	Elevated
1	Motera Stadium to Mahatma Mandir	20	22.838
2	GNLU to GIFT city	2	5.416
Total		22	28.254

Line 1 has one station (GNLU) which shares concourse with line 2. Gyaspur depot of Ahmedabad & Gandhinagar Metro Phase-I will fulfill the requirement of Phase-II after suitable augmentation and other than that a stabling depot proposed at Indroda Circle.

5. **Cost of the project and Project Financing**

The completion cost of the project is ₹5384.17 crore (including taxes, land and R & R hutments, IDC, PPP component). Component-wise break-up cost is placed at **Annexure-1** and project financing pattern is as below:

S.No.	Source	Amount (Rs. in Crores)	% Contribution
1	Equity by GoI	757.11	15.28%
2	Equity by GoG	757.11	15.28%
3	SD for Overall Taxes (Post GST) by GoG (2/3)	468.06	9.44%
4	SD for Overall Taxes (Post GST) by GoI (1/3)	234.03	4.72%
5	Loan from bilateral/ multilateral agencies	2739.38	55.28%
6	**Total cost excluding Land, R&R and PPP component**	**4955.69**	**100.00%**
7	Subordinate Debt for Land Including R&R cost by GoG	262.48	
8	**Sub Total**	**5218.17**	
9	PPP component (AFC for Stations)	92.00	
10	**Sub Total**	5310.17	
11	IDC for Loan to be borne by GoG	74.00	
12	**Total completion cost**	**5384.17**	

6. **Institutional Arrangement**

This Project is shall be implemented by Gujarat Metro Rail Corporation Limited (GMRC) (former Metro-Link Express for Gandhinagar and Ahmedabad (MEGA) Company Limited), a 50:50 Joint Venture of Government of India and Government of Gujarat.

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7. High Powered Committee

The existing High Powered Committee under the Chairmanship of the Chief Secretary of the Government of Gujarat, with other Secretaries concerned as members, will take expeditious decisions on land acquisition matters, diversion of utilities, shifting of structures and other structures in the project alignment, rehabilitation of Project Affected Persons, multimodal integration and such other matters where the State Government has to facilitate quick action including various conditions of sanction of this project.

8. Conditions of Sanction

8.1 There will be no liability on the part of the Government of India if the ridership does not materialize and/or the project does not make adequate profits/surplus.

8.2 Central Laws, i.e., the Metro Railways (Construction of Works) Act, 1978, the Metro Railways (Operation & Maintenance) Act, 2002 as amended through Metro Railways (Amendment) Act, 2009 and the Railways Act, 1989 would be applicable. Central Government's decisions with regard to safety, standardization and indigenization of rolling stock across all metro systems would be applicable.

8.3 The project shall be implemented by a 50: 50 joint owned Special Purpose Vehicle (SPV) of Govt. of India and Govt. of Gujarat.

8.4 Govt. of India and Govt. of Gujarat, shall nominate five Directors each to the Board of Directors (BoD), of SPV totalling 10 nominee Directors. The ex-officio Chairman of BoD will be amongst the five nominee Directors from GoI and the full-time Managing Director (MD) with adequate technical experience, among the five nominee Directors from Govt. of Gujarat, will be appointed with the prior permission of GoI. The Managing Director shall not be given any other/additional assignment by Govt. of Gujarat without the prior written permission of Ministry of Housing and Urban Affair, GoI.

8.5 The Special Purpose Vehicle (SPV), which shall implement this project, shall generally adopt the guidelines of Department of Public Enterprises, the Department of Economic Affairs and the Central Vigilance Commission as necessary to strengthen the Corporate Governance and shall be subject to the Parliamentary scrutiny.

8.6 The SPV shall be bound by such directions on question of policy, as the Central Government may give in writing from time to time after giving due opportunity to the SPV to express its views before giving any direction.

8.7 The complete cost of land acquisition, resettlement and rehabilitation (including escalation) shall be met by the State Government. The State Government would ensure that land acquisition does not become reason for delay in implementation of the project.

8.8 **Procurement of Additional Rolling Stock:** Government of India will not share any cost towards procurement of additional rolling stock in the second and subsequent years of operation, as this would not be a part of the project cost.

8.9 **Cost Escalation:** GoI's proposed funding in the form of equity and subordinate debt will be completely ring-fenced to Rs. 991.14 crore which includes equity and subordinate debt for central taxes (customs duty and CGST) in terms of Para E (iii) (c) of Metro Rail Policy, 2017. This should be suitably incorporated in Memorandum of Association (MoA) and /or shareholder Agreement. Cost escalation due to price escalation or exchange rate variation leading to increase in the cost of the project within or beyond the approved project time limit, inclusion of any item not referred to in DPR and also any other cost escalation due to change in scope or delay beyond the approved time cycle shall be borne/met/arranged by the State government. This should be suitably incorporated in Memorandum of Association (MoA) and/or Shareholder Agreement.

8.10 The Government of India would not finance cash losses and capital expenditure during the operational phase and its requirements would be financed by the SPV and/ or the State Govt. from its own resources.

8.11 **Taxes:**

i. The State Government will either exempt the SPV from its State/local taxes and duties/levies or reimburse the same.

ii. The State/local taxes would not form part of the project cost to be shared by the Government of India.

iii. There will be no waiver of Central taxes/duties by the Government of India.

8.12 **Repayment of Loan:** In case of SPV not being able to repay the loan (as and when it becomes due), the responsibility for the same shall be borne by the State Government, and not by the Government of India.

8.13 The State Government is also advised to rework the DPR on realistic basis with adequate deliberation on the issues, if any, raised by various stakeholders before going ahead with implementation to ensure sustainability of the project.

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8.14 **Dedicated Urban Transport Fund:** The State Government should set up a dedicated urban transport fund at the state level as well as at the city/metropolitan area level to create pool of resources for replacement of assets and providing operational subsidies, if any, not only for this project but other Urban Transport projects as well.

8.15 **Multimodal Integration:**

i. Integration of various modes of transport which would act as feeder/evacuation system to the proposed metro for improved ridership including adequate parking space for bicycles & cars and bus/taxi/auto stands at the stations, improvement in city bus service to introduce modern ITS enabled buses, should be given high priority by the State Government.

ii. The State Government should provide multimodal integration, including sub-urban railways (by involving Ministry of Railways) to provide a well-connected network in the region.

iii. The State Government should ensure that the metro rail project provides for first and last mile connectivity, accessibility and appropriate security arrangements.

iv. The State Government should provide common mobility card to provide integrated ticketing and seamless travel across all modes and all operators in the city.

8.16 **Price-Based Measures to promote and facilitate Metro Rail Ridership:** The State Government should ensure price-based measures to promote and facilitate Metro Rail ridership, as part of integrated traffic rationalization plan and Comprehensive Mobility Plan for the city with a view to ensure that the projected ridership is realized.

8.17 **Land Use Densification:** Land Use densification around the stations also needs to be done to increase the rider-ship and decrease the overall travel demand.

8.18 **Periodic Fare Revision:** A suitable arrangement, independent of the SPV formed to implement the Metro Rail project, shall be provided for periodic fare revision for the Metro Rail as well as other competing modes.

8.19 **Unified Metropolitan Transport Authority:** The State Government should set up a Unified Metropolitan Transport Authority (UMTA), duly backed by legislation, to facilitate coordinated planning and implementation of projects related to urban transport and their integrated management.

8.20 **Traffic Information Management Control Centre:** The State Government should set up a traffic information management control centre for effective traffic monitoring and enforcement as well as for data generation and data collection for future planning.

8.21 **National Public Transport Helpline:** The State Government should implement National Public Transport Helpline to provide information regarding various aspects of public transport such as routes, arrival/departure times, route planning, ticketing etc. in the city.

8.22 **Parking Policy:** The State Government should come up with a parking policy wherein parking fee represents the true value of the land occupied, which is used to make public transport more attractive; banning of parking on arterial/ring roads; provision of multi-level parking centres in city centres with park-and-ride facility etc.

8.23 **Advertisement Policy:** The State Government should come up with an advertisement policy which taps advertisement revenue on public transport, intermediate public transport, public utilities and street furniture.

8.24 **Memorandum of Understanding:** The State Government, the SPV and the Government of India shall enter into a tripartite Memorandum of Understanding regarding detailed terms and conditions for implementation of the project in accordance with sanction of the Union Cabinet. The share of Govt. of India will not be released till the tripartite MoU is signed.

8.25 Metro stations should be designed and constructed with toilets in the paid area. The toilets should be part of the project cost and meet the needs/ requirements of the Persons with Disabilities.

8.25 The State Government will endeavour to economise on the cost of the project through value engineering, minimum land acquisition, adoption technological innovation during project life cycle.

8.26 Expenditure on O&M and debt servicing should be the responsibility of the SPV. In case the SPV fails in respect of this, the losses will be borne by the State Government, in terms of Para (D) (iv) (D) of Metro Rail Policy, 2017.

8.27 The project timeline should be reduced to the maximum limit and at least one section of the project should be completed in four years.

8.28 90% of land required should be in the possession of the SPV before start of the work.

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8.29 The external assistance will flow on back to back basis as per the standard arrangement of Department of Economic Affairs.

8.30 The SPV should explore the possibility of PPP in other areas of activities related to the metro project in terms of Para (E) (iii) (b) of Metro Rail Policy, 2017.

8.31 Keeping in view the overarching fiscal consolidation path, the state government should ensure flow of realisable VCF in the SPV account in terms of Para (D) (vii) (b) of Metro Rail Policy, 2017 for meeting O&M, escalation, debt servicing etc. of the project, in a manner that will reduce burden on the State exchequer.

8.32 The State Government should enable the SPV to raise cheaper long term debt in the domestic market by allowing it to issue corporate debt bonds in terms of Para (D)(xi) of Metro Rail Policy,2017.

9. The sanction of the funds for the project will be from the Plan Budget, Ministry of Housing Urban Affairs under MH-4217, Sub-Major Head 60 - Other Urban Development Schemes, Minor Head 60.190- Investment in Public Sector and other undertakings, Sub-Head 14 – MRTS and Metro Projects, Sub Head 14.15.54 – Investment (Plan); and loans will be from the MH-6217, 60 - Other Urban Development Schemes (Sub Major Head), 60.190 – Loans to public sector and other undertakings (Minor Head), 01 – MRTS and Metro projects (Sub Head), 01.02 – Subordinate Debt to Metro Projects (Detailed Head), 01.02.55 - Loans and Advances (Plan).

10. This issues with the concurrence of the Internal Finance Division of this Ministry accorded vide their E-Note #182 of Computer No.9034509 dated 01/03/2019.

Yours Faithfully

(Priya Mahadevan)
Under Secretary to the Govt. of India
Telefax: 23061358

Copy to:

1. Principal Secretary to Prime Minister, Prime Minister's Office, New Delhi.
2. CEO, NITI Aayog, Yojana Bhawan, New Delhi.
3. Secretary, Department of Expenditure, Ministry of Finance, New Delhi.
4. Secretary, Department of Economic Affairs, Ministry of Finance, New Delhi.
5. Chairman, Railway Board, Ministry of Railways, New Delhi.
6. Secretary, Ministry of Environment & Forests, New Delhi.
7. Secretary, Ministry of Statistics and Programme Implementation, Sardar Patel Bhawan, Sansad Marg, New Delhi.

8. Secretary, Ministry of Housing Urban Affairs, New Delhi.
9. Principal Secretary, Urban Development and Urban Housing Department, Government of Gujarat, New Sachivalaya, Gandhinagar.

Copy also forwarded, for information to:

1. Director, Cabinet Secretariat with reference to their communication No. 9/CM/2019 (i) dated 21.02.2019.
2. PS to MoS (I/C) for Housing and Urban Affairs.
3. Chief Controller of Accounts, MoHUA
4. JS & FA / OSD (UT) & e.o. JS, MoHUA, New Delhi.
5. All Directors & Deputy Secretaries in UT Division of MoHUA, New Delhi.
6. Sanction Folder.

(Priya Mahadevan)
Under Secretary to the Govt. of India
Ph. 23061358.

Annexure-1

Component wise cost of Ahmedabad Metro Rail Project Phase-II

(Rs. In Crore)

S. N.	Item	Corridor-1 Motera Stadium to Mahatma Mandir (22.84 Km)	Corridor-2, GNLU to GIFT city (5.42 Km)	Total
1	Land	144	6.82	150.82
2	Alignment and Formation	870.08	200.54	1070.62
3	Station Buildings	730	102	832
4	Depot	138	0	138
5	Permanent Way	178.04	35.77	213.81
6	Traction & power supply	359.4	59.62	419.02
7	Signalling and Telecom.	228.3	42.45	270.75
8	Automatic Fare Collection (AFC) system	70	10.5	80.5
9	Platform Screen Doors	60	9	69
10	R & R incl. Hutments etc.	87.48	20.77	108.25
11	Shifting of Miscellaneous Utilities	137.04	32.53	169.57
12	Rolling Stock	168	72	240
13	Security	7.4	1.11	8.51
14	Staff quarter for O & M	36.32	8.62	44.94
15	Multimodal Integration and Last mile connectivity	60	9	69
16	Total of all items except Land	3130.06	603.91	3733.97
17	General Charges incl. Design charges @ 5 % on all items except land	156.50	30.19	186.69
18	Total of all items including G. Charges except land	3286.56	634.10	3920.64
19	Contingencies @ 3 %	98.60	19.02	117.62
20	**Gross Total**	**3385.16**	**653.12**	4038.28
	Total Cost with land	**3529.16**	**659.94**	4189.10
21	Central and state Taxes	528.83	103.69	632.52
22	**Gross Total**	4057.99	763.63	4821.62

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23	Escalation cost @ 5% per year upto project Completion on all items except contigencies and Land including R&R	**409.76**	**78.79**	**488.55**
24	Total Completion Cost	**4467.75**	**842.42**	**5310.17**
25	IDC to be borne by the GoG			**74**
26	**Grand Total**			**5384.17**

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Chapter – 20

ECONOMIC APPRAISAL

20.1 INTRODUCTION

Economic appraisal aims to represent a complete view of contribution of upcoming Metro system benefiting the society in form of money value. Thus calculating Economic Internal Rate of Return measures viability of the project. This part of study quantifies benefits by saving of time, saving in cost of public and private transport, saving in fuel consumption, increasing safety of passengers, reduction in traffic congestion and reduction in air pollution.

Metro corridors in phase-I and phase-II with corridor-I (East-West Corridor: Thaltej Gam to Vastral Gam), corridor-II (North-South Corridor: APMC to Motera Stadium) and corridor-II extension (Motera Stadium to Mahatma Mandir) are proposed to be operational from 2022. However, start of construction is considered from 2019 and economic benefits are estimated from this year (2019) onward for coming 30 years. Therefore, 2048 is considered as horizon year for the project.

20.2 OPTION EVALUATION

An option collating with financial Analysis for operation of two corridors – Motera Stadium to Mahatma Mandir and GNLU to GIFT City has been evaluated for second phase of metro project. Summary Table for this is as follows. The detail of economic evaluation along with EIRR estimation for this option has been highlighted in the preceding write up.

Table 20.1 Summary of Estimated EIRR

Corridor	Name of Corridor	Distance (km)	Calculated EIRR
I	Motera Stadium to Mahatma Mandir Corridor	22.838	
II	GNLU to GIFT City Corridor	5.416	
Total		**28.254**	**18.28%**

20.3 TRANSPORT DEMAND ON METRO CORRIDOR

The public transportation system of the city consists of City bus operation by AMTS and VTCOS, BRTS operation „Janmarg" and Auto rickshaw by private operators. The forecasted value of traffic for 2021 for various mode are presented in Table 20.2

Table 20.2 Travel Demand Forecast for Ahmedabad in 2021 with Metro

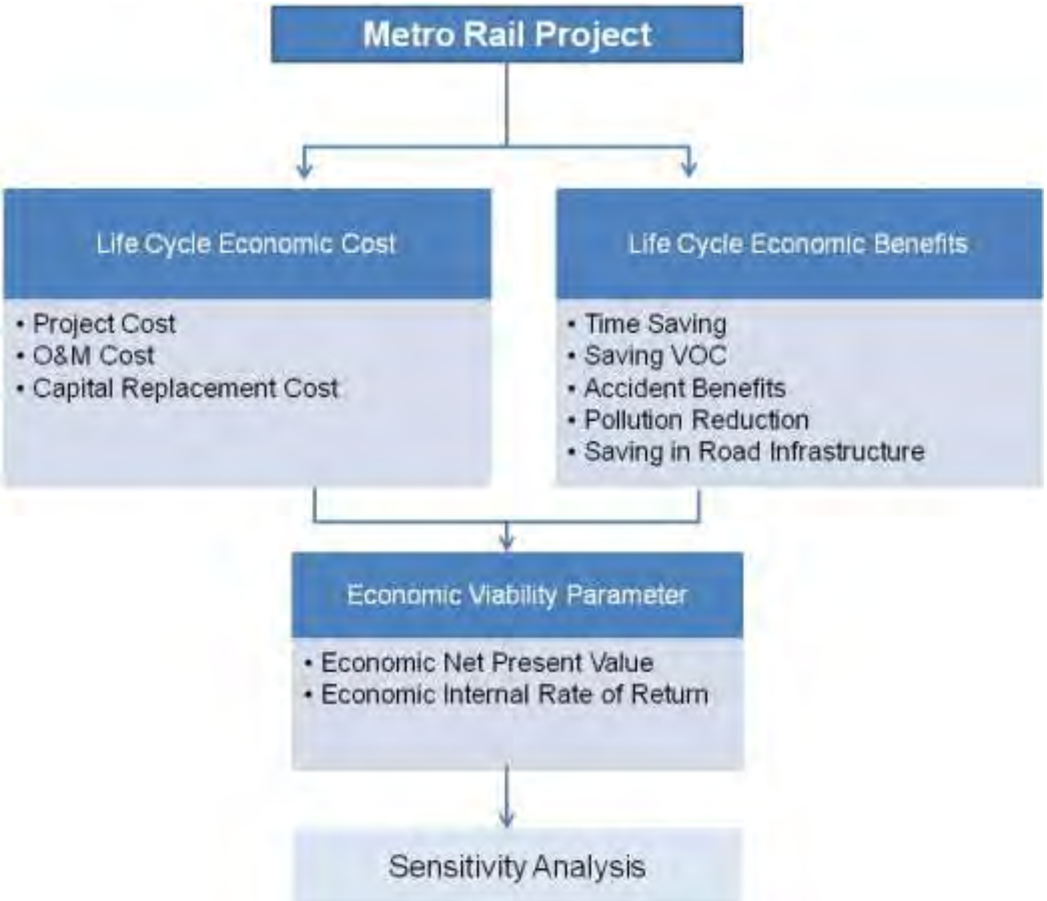
Mode	Trips in 2021		
	Option I	Option II	Option III
Two Wheeler	1,483,148	1,206,681	970,065
IPT (Auto + Others)	356,790	290,331	233,450
Four wheeler	596,851	485,482	390,171
Bus	345,315	280,968	225,895
Metro	124,938	111,589	99,791
Total Trips	2,907,042	2,375,052	1,919,371

20.4 ECONOMIC ANALYSIS APPROACH

The economic appraisal for this project is based on principles of Social Cost Benefit Analysis. Incremental costs and benefits are considered for estimation of “with” or “without” the system in two alternative scenarios. The benefit streams are calculated according to the market price by converting it using proper shadow prices. In favor of expected externalities and anomalies on pricing system of real world this conversion is carried out. Economic Net Present Value as the sum of differences between discounted benefits and cost flows is calculated. Estimation of net cost/benefit and economic viability in terms of Economic Internal Rate of Return is prepared with Discounted Cash Flow Method. The adopted framework for economic analysis is shown in

Figure 20.1.

Figure 20.1 Analytical Framework for Economic Appraisal



20.5 EVALUATION ASSUMPTIONS

Value of some of the key factors have been assumed for economic evaluation are enlisted in Table 20.3

Table 20.3 Evaluation Assumptions

Parameter	Assumption
Price Level	2017
First year of operation	2024
Last year of operation	2048
Construction period	4 years (2019-2023)
Daily to annual factor	365

20.6 COST ESTIMATION

Total cost of project comprises of capital cost, operation/maintenance cost and capital replacement cots. While calculating capital cost infrastructure cost including civil engineering, land, track, power supply, traction system, signaling, telecommunication and cost of rolling stock are considered. Cost of operation and maintenance is calculated based on Metro operation in other parts of the country.

Estimated capital cost for Ahmedabad Metro including all phases is Rs. 5,310 Crores with assumption of escalation factor of 7%. The summary of values is shown in Table 20.4

Table 20.4 Estimated Cost to Economy for Ahmedabad Metro Corridor

Component	Cost in Rs. Crores
Completion Cost	5,310
Operating Cost	165 (first operational year)

Source: Cash Flow Estimation by DMRC

20.7 ESTIMATION OF BENEFITS

Metro System operation will contribute to various socio-economic benefits causing reduction Starting of metro system operation will show significant reduction on road traffic thus will contribute to various socio-economic benefits. It may reduce the number of buses in the public transport and number of private vehicles on road. It may increase the overall speed of traffic by mitigating congestion. It will show significant reduction in fuel consumption thus decrease air pollution. It may reduce number of road accidents and ensure safe passenger movement.

The estimated streams of benefit in this analysis has following components

Capital and Operating Cost of Public and Private vehicle depending on current congestion norms and total volume of passenger traffic in absence of Metro operation.
Saving in Capital and Operating Cost of Public and Private vehicle based on estimated shift of passenger trips to Metro from other modes of transport.
Saving in time of passengers travelling in Metro by increasing travel speed
Saving in time of passengers in other modes by reducing congestion in traffic on road
Saving in Road accidents and air pollution after introduction of Metro
Saving in road infrastructure and development cost to cope up with future travel demand without Metro operation

Some of the social benefits could be evaluated due to lack of universally acceptable norms. These benefits include:

Increased accessibility of catchment area
Reduction in road stress
Economic stimulation in the micro region of the infrastructure
Increase in overall mobility
Business Opportunities
Improving the image of the city

20.7.1 Saving in Capital & Operating Cost of Public & Private Vehicles

With starting of Metro operation in Ahmedabad city significant number of buses will be reduced from public transportation system. The value would be saved in form of capital and operating cost of public and private vehicles. Estimated saving operating cost of public and private vehicles in 2024, 2032 and 2042 are Rs. 423 Crores, Rs. 727 Crores and Rs. 1,943 Crores respectively. Estimated saving in capital for public transportation buses is Rs. 12 Crores in 2024. Cost for fuel, maintenance, installation cost and depreciation are taken into account while calculation vehicle operating cost.

20.7.2 Passenger Time Saving

Following Metro Operation traffic congestion is expected to decrease thus travel time of commuters on road in both public and private transportation will be saved. Estimated passenger travel time saving on road in form of value of money is Rs. 223 Crores in 2024.

While estimating passenger wage per hour the value from the household survey samples are considered for per capita income regarding various classification. The value of time for non-working trips is taken as 30% of the household income as per the thumb rules.

20.7.3 Road Accident Cost Saving

Metro operation is expected to reduce traffic from road significantly thus reduction of road accident is also anticipated. The cost of accident includes medical and insurance expenses and damage to vehicle which can be saved by reduction of road accident due to Metro. The value of benefit for 2024, 2032 and 2042 are Rs. 47 Crores, Rs. 154 Crores, Rs. 605 Crores respectively. In due calculation of vehicle operating cost

20.7.4 Air Pollution Reduction

Reduced traffic on road duo to implementation of Metro will lead to lesser vehicular emission. This will improve the quality of environment by reduction of air pollution. The amount calculated as saving is Rs. 19 Crores in 2024. Further in 2032 and 2042 Rs. 40 Crores and Rs. 88 Crore could be saved.

20.7.5 Shadow Pricing

Estimation of values is based on market prices. The prices however are translucent due lack of information regarding source cost. Market price varies depending on number of factors. These factors can be governed by prices of inputs, monopolistic market inputs, tax structure. In order to reduce the gap between hypothesis and reality the following factors are considered for evaluation.

Table 20.5 Conversion factors

S. No.	Item	Factor
1	Capital Cost	0.83
2	Operations & Maintenance Cost	0.87
	Replacement Cost	0.90
3	Saving in Capital & Operating Cost of Buses	0.90
4	Saving in Passenger Time	1.00
5	Saving in VOC	0.90
6	Saving in Accident Cost	0.90
7	Saving in Pollution Cost	1.00

Source: Appraisal Guidelines for Metro Rail Proposals MoUD, 2017

20.8 RESULT OF ECONOMIC ANALYSIS

Cost and benefits for 25 years after commencement of Metro operation is estimated and elaborated in Table 20.6. The years of construction is assumed as 2019 to 2023 for two phases of Metro with two corridors and extension. Estimated total cost is subtracted from total benefit to arrive at net benefit. The cash flow is prepared in discounting process to evaluate internal rate of return. The result proves this project to be economically viable. While calculating the Net Present Value 12% discount rate is considered as per ADB. EIRR for Metro system in Ahmedabad for Option -II is estimated using shadow prices is 18.28%.

20.9 SENSITIVITY ANALYSIS

Sensitivity analysis with probable contingencies has been carried out. EIRR is calculated with a) 10% cost overrun, b) 10% increase in Maintenance Cost, c) 10% reduction in benefits and d) 10% reduction in benefits and 10% rise in cost. Calculated EIRR for all these conditions are show in Table 20.6.

Table 20.6 Sensitivity Analysis and EIRR

Sensitivity	EIRR
10% cost overrun	16.97%
10% increase in Maintenance Cost	18.07%
10% reduction in benefits	18.25%
10% reduction in benefits and 10% rise in cost	16.94%

Table 20.7 Estimated EIRR

Economic Cost Benefit Analysis for Ahmedabad Metro											
Year	Capital	Running Expenses of Metro	Replacement costs	Total Costs	Savings Buses	Time Saving	VOC Saving	ACC/POL	Total Savings	Net Cash Flow	Discount Rate (12%)
2019	400			400	0	0	0	0	0	-400	-357
2020	837			837	0	0	0	0	0	-837	-667
2021	1,093			1,093	0	0	0	0	0	-1,093	-778
2022	1,366			1,366	0	0	0	0	0	-1,366	-868
2023	711			711	0	0	0	0	0	-711	-403
2024		143		143	12	223	423	65	723	580	294
2025		151		151	12	239	453	70	774	623	282
2026		159		159	13	255	484	75	828	669	270
2027		168		168	14	273	518	80	886	718	259
2028		178		178	15	292	555	86	948	770	248
2029		188		188	16	313	593	92	1,014	826	237
2030		200		200	17	335	635	98	1,085	886	227
2031		212		212	19	358	679	105	1,161	949	217
2032		226		226	40	383	727	194	1,344	1,118	229
2033		245		245	43	694	1,057	207	2,001	1,756	321
2034		251		251	46	743	1,131	222	2,141	1,890	308
2035		270		270	49	795	1,210	237	2,291	2,021	294
2036		290		290	53	850	1,295	254	2,452	2,161	281
2037		312		312	56	910	1,385	272	2,623	2,311	268
2038		336		336	60	973	1,482	291	2,807	2,471	256
2039		362		362	65	1,041	1,586	311	3,003	2,642	245
2040		389		389	69	1,114	1,697	333	3,214	2,824	233

2041		419		419	74	1,192	1,816	356	3,439	3,019	223
2042		451		451	116	1,276	1,943	693	4,028	3,577	236
2043		497		497	124	1,661	2,588	742	5,114	4,618	272
2044		535	761	1,297	133	1,777	2,769	794	5,472	4,176	219
2045		577	799	1,376	142	1,901	2,963	850	5,855	4,480	210
2046		622		622	152	2,034	3,170	909	6,265	5,644	236
2047		670		670	162	2,177	3,392	973	6,704	6,034	226
2048		723		723	174	2,329	3,630	1,041	7,173	6,450	215
Total	**4,407**	**8,574**	**1,561**	**14,542**	**1,676**	**24,137**	**38,182**	**9,352**	**73,346**	**58,805**	**3,233**
										EIRR	NPV
										18.28%	**5904**

The below assumptions are used for estimation of vehicle operating cost and value of time calculation.

Table 20.8 Assumptions for benefit estimation

Mode	Average Speed (km/hr) in 2024		Occupancy	VOC/ km	VOT / vehicle hr
	Without Metro	With Metro			
Two Wheeler	32	33	1.46	2.89	53
IPT (Auto + Others)	20	21	1.64	5.49	50
Four wheeler	24	25	1.34	8.46	95
Bus	16	16	24.25	19.47	49

Emission Estimated by the EIA Expert is considered as the base for calculation of reduced air pollution benefits are shown in table below.

Table 20.9 Estimated Emission by EIA Expert

Estimation of Saving of Green House Gases Emission from substituted Vehicles										
Year	Average Trip Length	Estimated PCE	Petro litres	Diesel litres	All Values in Grams					
					CO2	CO	NOx	SO2	Particles	VOC
2024	5.55	116439	38855	8199	109523484	2491679	433221	13563	6523	385675
2032	5.59	149917	50586	11214	145263412	2601195	461999	17976	6357	432081
2042	5.80	189666	65984	15370	192648312	2763965	496750	23884	6058	502485

Chapter - 21

IMPLEMENTATION PLAN

21.1 WAY FORWARD FOR IMPLEMENTING AHMEDABAD METRO PROJECT PHASE-II

On receipt of the Detailed Project Report, following action will be required for implementing the Ahmedabad Metro Phase-II:

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), NITI Aayog 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 if earlier it is available only for Phase-I.

In view of new Metro Rail Policy 2017, the State Government should formulate the funding plan unbundling of PPP component 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 and Gandhinagar area as Metropolitan Area.

In view of new metro policy Unified Metropolitan Transport Authority (UMTA) should be formed within one year of submission of proposal of any metro project to GoI.

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 corridors 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 Public Investment Board	D +3months
6	Sanction of Project by Government of India	D +6months
7	Appoint General Consultant	D +9months
8	Tendering, Execution of works and Procurement of equipments, coaches and installations	D +45months
9	Testing and Commissioning	D +46moths
10	Revenue Operation	D +46months

21.3 ORGANISATIONAL SET-UP OF MEGA

MEGA is already implementing Phase-I of Ahmedabad Metro. Phase-II may also be implemented by the same organization by augmenting the man power. However, it would be worthwhile considering a stake of the local body like AMC, GMC, GUDA, AUDA, etc.

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 km in length including stations therein.

(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

Corridor	Length (km)	Stations (Nos.)	Proposed Packages
Motera Stadium to Mahatma Mandir	22.838	20	3
GNLU to GIFT City	5.416	2	1

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 for augmentation of Gyaspur Depot and stabling depot at Indroda Circle. One package for civil works will be for each location.

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 LEGAL COVER FOR AHMEDABAD METRO PHASE-II

Construction of Ahmedabad Metro Phase-II should commence soon. Thus there will be immediate need to declare Ahmedabad and Gandhinagar area put together as Metropolitan area.

Implementation of proposed Ahmedabad Metro Phase-II 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.

21.7 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 State Goods and Services Tax (SGST) to Ahmedabad Metro. However MEGA will explore possibility of loan for State Taxes from Multilateral Funding Agencies. 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.

21.8 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 of Corridor by way of selling of Floor Area Ratio (FAR) along the proposed metro corridors.

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रजिस्ट्री सं॰ डी॰ एल॰-33004/99

REGD. NO. D. L.-33004/99

भारत का राजपत्र
The Gazette of India

असाधारण

EXTRAORDINARY

भाग II—खण्ड 3—उप-खण्ड (ii)

PART II—Section 3—Sub-section (ii)

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शहरी विकास मंत्रालय

(मैट्रो रेल प्रकोष्ठ)

अधिसूचना

नई दिल्ली, 7 सितम्बर, 2009

का.आ. 2279(अ).—केन्द्रीय सरकार, मैट्रो रेल (संशोधन) अधिनियम, 2009 (2009 का 34) की धारा 1 की उप-धारा (2) द्वारा प्रदत्त शक्तियों का प्रयोग करते हुए, 7 सितम्बर, 2009 को उस तारीख के रूप में नियत करती है, जिसको उक्त अधिनियम के उपबंध प्रवृत्त होंगे।

[फा.सं. के-14011/40/2003-एमआरटीएस/मैट्रो]

बिमल कुजूर, अवर सचिव

MINISTRY OF URBAN DEVELOPMENT

(Metro Rail Cell)

NOTIFICATION

New Delhi, the 7th September, 2009

S.O. 2279(E).—In exercise of the powers conferred by sub-section (2) of Section 1 of the Metro Railways (Amendment) Act, 2009 (34 of 2009) the Central Government hereby appoints the Seventh September, 2009 as the date on which the provisions of the said Act, shall come into force.

[F. No.K-14011/40/2003-MRTS/Metro]

BIMAL KUJUR, Under Secy.

3269 GI/2009

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भारत का राजपत्र
The Gazette of India

असाधारण

EXTRAORDINARY

भाग II — खण्ड 1

PART II — Section 1

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No. 38] **NEW DELHI, THURSDAY, AUGUST 27, 2009 / BHADRA 5, 1931**

इस भाग में भिन्न पृष्ठ संख्या दी जाती है जिससे कि यह अलग संकलन के रूप में रखा जा सके।

Separate paging is given to this Part in order that it may be filed as a separate compilation.

MINISTRY OF LAW AND JUSTICE
(Legislative Department)

New Delhi, the 27th August, 2009/Bhadra 5, 1931 (Saka)

The following Act of Parliament received the assent of the President on the 26th August, 2009, and is hereby published for general information:—

THE METRO RAILWAYS (AMENDMENT) ACT, 2009

No. 34 OF 2009

[26th *August*, 2009.]

An Act further to amend the Metro Railways (Construction of Works) Act, 1978 and to amend the Delhi Metro Railway (Operation and Maintenance) Act, 2002.

Be it enacted by Parliament in the Sixtieth Year of the Republic of India as follows:—

CHAPTER I

PRELIMINARY

1. (*1*) This Act may be called the Metro Railways (Amendment) Act, 2009. Short title and commencement.

(*2*) It shall come into force on such date as the Central Government may, by notification in the Official Gazette, appoint.

CHAPTER II

AMENDMENT TO THE METRO RAILWAYS (CONSTRUCTION OF WORKS) ACT, 1978

Amendment of section 1.

2. In the Metro Railways (Construction of Works) Act, 1978 (hereafter in this Chapter referred to as the Metro Railways Act), in section 1, in sub-section (*3*), for the portion beginning with the words "such other metropolitan city" and ending with the words "to that city accordingly", the following shall be substituted, namely:— 33 of 1978.

"the National Capital Region, such other metropolitan city and metropolitan area, after consultation with the State Government, and with effect from such date as may be specified in that notification and thereupon the provisions of this Act shall apply to the National Capital Region, such metropolitan city or metropolitan area accordingly.".

Substitution of words "metropolitan city" by words "metropolitan city, metropolitan area and National Capital Region".

3. In the Metro Railways Act, for the words "metropolitan city" occurring in clause (*h*) of sub-section (*1*) of section 2, clause (*c*) of sub-section (*1*) of section 4 and clause (*a*) of sub-section (*1*) of section 32, the words "metropolitan city, metropolitan area and the National Capital Region" shall be substituted.

Amendment of section 2.

4. In section 2 of the Metro Railways Act, in sub-section (*1*),—

(*i*) after clause (*h*), the following clause shall be inserted, namely:—

'(*ha*) "metropolitan area" shall have the meaning assigned to it in clause (*c*) of article 243P of the Constitution;';

(*ii*) after clause (*o*), the following clause shall be inserted, namely:—

'(*oa*) "National Capital Region" means the National Capital Region as defined in clause (*f*) of section 2 of the National Capital Region Planning Board Act, 1985;'. 2 of 1985.

CHAPTER III

AMENDMENT TO THE DELHI METRO RAILWAY (OPERATION AND MAINTENANCE) ACT, 2002

Substitution of references to "metropolitan city of Delhi" by references to "National Capital Region and any other metropolitan area".

5. Throughout the Delhi Metro Railway (Operation and Maintenance) Act, 2002 (hereafter in this Chapter referred to as the Delhi Metro Railway Act), for the words "metropolitan city of Delhi" wherever they occur, the words "the National Capital Region, metropolitan city and metropolitan area" shall be substituted. 60 of 2002.

Amendment of section 1.

6. In section 1 of the Delhi Metro Railway Act, for sub-sections (*1*) and (*2*), the following sub-sections shall be substituted, namely:—

"(*1*) This Act may be called the Metro Railways (Operation and Maintenance) Act, 2002.

(*2*) It extends in the first instance to the National Capital Region and the Central Government may, by notification, after consultation with the State Government, extend this Act to such other metropolitan area and metropolitan city, except the metropolitan city of Calcutta, and with effect from such date as may be specified in that notification and thereupon the provisions of this Act shall apply to that metropolitan area or metropolitan city accordingly.".

7. In section 2 of the Delhi Metro Railway Act, in sub-section (*1*),— Amendment of section 2.

(*i*) for clause (*a*), the following clauses shall be substituted, namely:—

'(*a*) "Central Government", in relation to technical planning and safety of metro railways, means the Ministry of the Government of India dealing with Railways;

(*aa*) "Claims Commissioner" means a Claims Commissioner appointed under section 48;';

(*ii*) for clause (*h*), the following clauses shall be substituted, namely:—

'(*h*) "metropolitan area" shall have the meaning assigned to it in clause (*c*) of article 243P of the Constitution;

(*ha*) "metropolitan city" means the metropolitan city of Bombay, Calcutta, Delhi or Madras;';

(*iii*) after clause (*k*), the following clause shall be inserted, namely:—

'(*ka*) "National Capital Region" means the National Capital Region as defined in clause (*f*) of section 2 of the National Capital Region Planning Board Act, 1985;'. 2 of 1985.

8. In section 6 of the Delhi Metro Railway Act, in sub-section (*2*), after clause (*b*), the following clauses shall be inserted, namely:— Amendment of section 6.

"(*ba*) develop any metro railway land for commercial use;

(*bb*) provide for carriage of passengers by integrated transport services or any other mode of transport;".

9. Section 7 of the Delhi Metro Railway Act shall be renumbered as sub-section (*1*) thereof and after sub-section (*1*) as so renumbered, the following sub-section shall be inserted, namely:— Amendment of section 7.

"(*2*) The Commissioner shall function under the administrative control of the Chief Commissioner of Railway Safety appointed under section 5 of the Railways Act, 1989.". 24 of 1989.

10. For section 12 of the Delhi Metro Railway Act, the following section shall be substituted, namely:— Substitution of new section for section 12.

"12. The Chief Commissioner of Railway Safety shall, for each financial year, prepare in such form, and within such time, as may be prescribed, an annual report giving a full account of the activities of the Commissioners during the financial year immediately preceding the financial year in which such report is prepared and forward copies thereof to the Central Government.". Annual report.

11. In section 13 of the Delhi Metro Railway Act, for the word "Commissioner", the words "Chief Commissioner of Railway Safety" shall be substituted. Amendment of section 13.

12. In section 23 of the Delhi Metro Railway Act, in sub-section (*1*), for the words "Hindi and English", the words "Hindi, English and official language of the State in which such station is located" shall be substituted. Amendment of section 23.

13. In section 26 of the Delhi Metro Railway Act, in sub-section (*1*), the words "a small" shall be omitted. Amendment of section 26.

14. In section 34 of the Delhi Metro Railway Act, for sub-section (*4*), the following sub-section shall be substituted, namely:— Amendment of section 34.

"(4) The Central Government and the State Government shall nominate one member each to the Fare Fixation Committee:

Provided that a person who is or has been an Additional Secretary to the Government of India or holds or has held an equivalent post in the Central Government or the State Government shall be qualified to be nominated as a member.".

Amendment of section 38.

15. In section 38 of the Delhi Metro Railway Act, in sub-section (2), for the words "Government of the National Capital Territory of Delhi", the words "State Government" shall be substituted.

Amendment of section 85.

16. In section 85 of the Delhi Metro Railway Act,—

(i) in sub-section (1), for the words "Government of the National Capital Territory of Delhi", the words "State Government" shall be substituted;

(ii) in sub-section (2), for the words "Government of the National Capital Territory of Delhi in the Delhi Gazette", the words "State Government" shall be substituted.

T.K. VISWANATHAN,
Secretary to the Govt. of India.

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Chapter – 22

CONCLUSIONS AND RECOMMENDATIONS

22.1 Ahmedabad has witnessed enormous growth during the last 10 years. The growth is mainly the result of immigration as the city provided better employment opportunities. Ahmedabad is the principal administrative, commercial and distribution center of the State. Ahmedabad 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, Ahmedabad'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) Motera Stadium to Mahatma Mandir (22.838km) and (ii) GNLU to GIFT City (5.416km) at a completion cost of **5310.17 Crores** (including Cost of Land and all taxes & duties) to be made operational as recommended in implementation chapter. In addition to this, Rs. 74 Crore IDC for Loan is to be borne by GoG.

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 Ahmedabad Metro Project Phase-II**,** it has been recommended that the project should be got executed through M/s MEGA. **However, AFC component for all 22 stations of Phase-II will be executed by MEGA on PPP model.** The cost of above may be funded by engaging concessionaire on similar lines as of Kochi Metro, Nagpur Metro for the supply, installation, Testing, commissioning, operation & Maintenance of AFC gates and Allied services etc.

22.4 Delhi Metro fare recommended by 4th Fare Fixation Committee from October 2017 has been assumed to be taken as the base for all the corridors of Phase-II of Ahmedabad Metro Project. Subsequently, for the purpose of assessing returns from the project, the fares have been revised every second year with an escalation of 12% every two years.

22.5 As in the case of Delhi Metro, the State Government should exempt/ reimburse the State Goods and Services Tax (SGST) to Ahmedabad Metro. However MEGA will explore possibility of loan for State Taxes from Multilateral Funding Agencies. It should also exempt the following:

Tax on electricity required for operation and maintenance of the metro system.
Municipal Taxes.

22.6 MOUD vide letter no. F.No. K-14011/03/2017-UT-V-Part(1) dated 6th July 2017 has proposed for sharing of overall Goods and Service Tax (GST) in the ratio of 1:2. Maharashtra State Government may pursue the Central Government to extend the same benefit to Ahmedabad Metro Phase-II.

22.7 While the Financial Internal Rate of Return (FIRR) for the project has been assessed as 2.12% without PD income for Option II and the Economic Internal Rate of Return (EIRR) for same option works out to 18.28%. Therefore, it is recommended for implementation.

22.8 The FIRR of the corridors with additional PD Income from 20 Hectare Land is 6.01% for Option II.

22.9 Implementation of Option II consisting of following corridors is recommended on Part PPP model.

Motera Stadium to Mahatma Mandir (22.838km)
GNLU to GIFT City (5.416km)
AFC Component for all 22 Stations as PPP model

Chapter – 23

Transit Oriented Development (TOD) and Value Capture Finance (VCF)

23.1 BACKGROUND

India is urbanizing at a rapid pace with urban population rising much faster than its total population. Level of urbanisation has increased from 17.29% in 1951 to 31.6 % in 2011. India is competing with the fastest growing countries in the world. The urban population in India, which is nearly 377 million is poised to grow to 600 million by 2030. The urban population of India contributes 65% of country‟s Gross Domestic Product (GDP), which is expected to grow to 75% in the next 15 years. With India witnessing a high economic growth, Indian cities are growing at a rate faster than other cities in the world.

Urbanization has led to horizontal growth of the cities thus creating problems of urban sprawl. This has resulted in increase of trip lengths and higher usage of private vehicles, problems of pollution and increased demand of infrastructure. To address these issues, many cities have strengthened their public transport by developing mass rapid transit systems (MRTS) such as metro rails and Bus Rapid Transit Systems (BRTS). It is however, important to efficiently use these systems by integrating the land use with the transport infrastructure to make the cities livable, healthy and smart.

New Metro Rail Policy 2017 emphasizes that “Transit Oriented Development (TOD)” with proposed intermodal integration, universal accessibility, adequate walkways and pathways for Non-Motorized Transport (NMT), stations for public bike sharing, commensurate parking lots for cycles and personal vehicles, as well as adequate arrangement for receiving and dispatch of feeder buses at all metro stations. The commitment by the State Government to adhere the guidelines issued by the central government w.r.t. TOD and adoption of VCF framework should be an integral part of the project proposal. The commitment should inter alia include commitment of transfer of the financial benefits accruing in the influence zone of the metro alignment on account of the TOD policies and VCF framework directly to the Special Purpose Vehicle (SPV)/agency implementing the metro rail project. The project report should specify the proposed quantum of such benefits being transferred to the project. This requirement would form a mandatory part of all metro rail project proposals.

Commercial/property development at stations and on other urban land has been used as a key instrument for maximizing revenues in metro rail/ railway systems in cities around the world. Notable examples are Hong Kong and Tokyo. Metro rail implementing agencies should endeavor to maximize revenue through commercial development at stations and on land allocated for this purpose.

The McKinsey report has estimated that around Rs. 325,000 crore of urban infrastructure investments are required annually. The High Powered Expert Committee Report 2011 projects urban infrastructure requirement at 0.75%, which will increase to 1.5% of the GDP by 2032 (Rs. 97,500 crore to Rs. 195,000 crore annually). Presently, national Urban Missions are investing about Rs. 32,500 crore annually leading to an investment gap of nearly Rs. 65,000 crore.

Ordinarily, own sources of revenue in ULBs can be classified into three categories, (a) taxes levied by the municipality, (b) user charges levied for provision of civic services, and (c) fees and fines levied for performance of regulatory and other statutory functions. Octroi, which was one of the main sources of own income of the ULBs has been abolished, resulting in a serious dent on ULBs" resources. On the other hand, property tax, which is at present the main source of own resources is underused and has issues related to its narrow tax base, exemptions, etc. Furthermore, the State Governments are increasingly fixing the rate for services being provided by ULBs, even though these functions are mandated to be performed by ULBs under the 74th Constitutional Amendment. Overall, this has led to increased dependency on State Governments and reduction in efforts made by ULBs to mobilize resources.

Land is the most fundamental asset that is owned and managed by the States/ULBs and is a resource to generate revenues. Traditionally, States/ULBs have relied on direct sale of lands to raise funds, which is a less efficient form of resource mobilization, as compared to value capture. It is not that States/ULBs have not used Value Capture methods to raise resources. In fact, States/ ULBs are using different Value Capture methods, especially in urban areas, such as impact fee, betterment charges, etc. For example, the Mumbai Metropolitan Region Development Authority (MMRDA) and City and Industrial Development Corporation Limited (CIDCO) of Maharashtra have used different Value Capture methods to finance infrastructure development in the urbanizing areas. Similarly, Haryana and Gujarat have successfully used land pooling schemes, where owners agree to exchange their lands for infrastructure services.

While States/ULBs have been developing and using some of the Value Capture Finance (VCF) methods, the Central Government Ministries/Departments have not yet systematically used VCF methods as a revenue generation tool. One reason is that land is a State subject and VCF Policies have to be made by the concerned State Governments. A promising way is to link the location and construction of the projects by the Central Government Ministries and their agencies with the existing VCF Policy of the generated within the area of influence of the projects. Alternatively, the State VCF Policy could be revised whenever new projects are being planned in order to capture full value being generated due to proposed investment in projects.

There is an increasing focus on creation of infrastructure by Ministries/Departments of Government of India and their agencies. For example, the Ministry of Ports is constructing a series of projects as part of the Sagarmala program. Moreover, the Delhi-Mumbai Industrial Corridor (DMIC) is being developed by the Department of Industrial Policy and Promotion (DIPP) and the Metro Rail projects by the Ministry of Urban Development (MoUD). All these projects have an area of influence in which they lead to increase in value of lands and buildings, creating opportunities for using value capture methods to mop up additional resources.

23.2 OBJECTIVES OF TOD

TOD integrates land use and transport planning to develop compact growth centers within the influence zone of 500-800 m on either side of the transit stations i.e. areas within walking distance, to achieve the following objectives:

To promote the use of public transport by developing high density zones in the influence area, which would increase the share of transit and walk trips made by the residents/ workers to meet the daily needs and also result in reduction in pollution and congestion in the influence area.

To provide all the basic needs of work/ job, shopping, public amenities, entertainment in the influence zone with mixed land-use development which would reduce the need for travel.

To establish a dense road network within the development area for safe and easy movement and connectivity of NMT and pedestrians between various uses as well as to transit stations.

To achieve reduction in the private vehicle ownership, traffic and associated parking demand.

To develop inclusive habitat in the influence area so that the people dependent on public transport can live in the livable communities within the walkable distance of transit stations.

To integrate the Economically Weaker Sections (EWS) and affordable housing in the influence zone by allocating a prescribed proportion of built-up area for them in the total housing supply.

To provide all kinds of recreational/entertainment/ open spaces, required for a good quality of life in the influence area.

To ensure development of safe society with special attention to safety of women, children, senior citizen and differently abled by making necessary amendments to the building bye laws.

To prevent urban sprawl by accommodating the growing population in a compact area with access to the transit corridor, which would also consolidate investments and bring down the infrastructure cost for development.

To reduce carbon footprints by shifting towards environmentally friendly travel options for the line haul as well as for access and egress trips.

23.3 PRINCIPLES OF TOD

TOD focuses on compact mixed use development around transit corridor such as metro rail, BRTS etc. International examples have demonstrated that though transit system facilitates transit oriented development, improving accessibility and creating walkable communities is equally important. Based on the objectives of National Urban Transport Policy, this TOD policy defines 12 Guiding Principles and 9 Supportive tools, as shown in Figure 23.1 and 23.2, for realizing the objectives of TOD.

Figure 23.1: TOD Principles

23.4 APPROACH FOR TOD IMPLEMENTATION

Influence Zone

The area in the immediate vicinity of the transit station, i.e. within a walking distance, having high density compact development with mixed land use to support all basic needs of the residents is called the influence zone of a transit station/ corridor.

Figure 23.2: TOD Support Principles Tools

Figure 23.3: TOD Influence Zone

Influence zone is either established at a transit stations or along the transit corridors. It is generally up to a radius of nearly 500-800m of the transit station. Where the distance between the transit stations is less than 1 km and there is overlap in the influence area, it can be identified as a delineated zone (around 500m) on either side of the transit corridor within 10 - 12 minutes walking distance.

The area of influence, where the TOD is planned for implementation, should be demarcated and notified through master plan and local area plans before implementation. If in any case the TOD is to be implemented in a phased manner, the influence area of the TOD can also be notified in phases. The principles for delineating the influence area should be clearly indicated so that there is no speculation or confusion regarding the influence zone.

High Density Compact Development

TOD promotes densification in the influence area by providing higher Floor Area Ratio (FAR)/ Floor Space Index (FSI) and higher population & job density as compared to the area around and beyond the influence areas. To ensure sustainable development, the minimum FAR should be 300 - 500%, and can be higher, depending on the city size. This will promote higher concentration of people within the walking distances of transit station, thereby increasing the ridership of the public transport and resulting in increased fare revenue, pollution and congestion reduction.

It is not necessary to keep the density and FAR norms consistent for the influence areas across the city. It can vary depending on the infrastructure available, land use zoning, transit capacity etc.

City willfollow green building norms, adopt renewal sources of energy such as solar and waste to energy options, adopt rain water harvesting and ground water recharge techniques, which would encourage water conservation, utilization of clean energy and promote sustainable waste management so as to make them self-sustaining through efficient use of resources and infrastructure.

Mixed Use Development

Mixed land use should be stipulated for development/ redevelopment in the TOD zone as it would reduce the need for travel by providing most of the activities such as shopping, entertainment and public amenities such as schools, parks, playgrounds, hospitals etc. within the walking distance of the residents. It would also improve the accessibility of the transit facilities and at the same time link origins and destinations, i.e. residences with work places or activity nodes. This would ensure better utilization of transit fleet by distributing loads in both directions, rather than creating unidirectional peak hour flows.

A blend of land-uses help in the optimization of physical infrastructure and resources, as all components like roads, parking, water, sewerage etc., remain functional at all times of the day.

The TOD benefits cannot be realized with the kind of developments that encourage the use of personalized vehicles. It is therefore imperative to restrict developments such as low-density housing, low-rise development, warehouses, petrol pumps/CNG stations, cremation ground and surface/Multilevel parking etc. in the influence area.

Mix of uses within the TOD can be achieved either by horizontal mixing i.e. separate activities in separate plots/ buildings or vertical mixing i.e. combining different activities within the same building.

To ascertain mixed use development along with the required street network and open spaces, the minimum plot area in the influence zone should be defined. The developer may, however, be permitted to undertake construction in a phased manner. In case, the individual landowners want to collaborate for development as per TOD norms, necessary provisions may be made to facilitate it. The landowner(s) may also be permitted to collaborate with developers in case they lack the required experience and institutional & financial capacity to undertake such development as per TOD norms. However, care needs to be taken that the amalgamated plots are redesigned to allow finer network of streets and dispersion of open spaces.

The mix of uses to be proposed shall be decided as per the local conditions and the trends in real estate market, however, the minimum percentage of built up area for housing, commercial and other amenities should be fixed. The use of balance built up area may depend on the prevailing market conditions and demand of the city.

(i) Value Capture Methods

A comparative study on land based financing tools being used in India and the world shows a large number of diverse VCF tools being used. The main types of VCF methods are given below.

Land value tax – is considered the most ideal Value Capture tool which apart from capturing any value increment, helps stabilize property prices, discourage speculative investments and is considered to be most efficient among all Value Capture methods. Maharashtra and Tamil Nadu, through State laws, have expanded the scope of this mechanism to cover urban land also. Globally, land value tax is widely used in Denmark, Australia, and New Zealand.

Fees for changing land use (agricultural to non-agricultural) – land revenue codes provide for procedures to obtain permission for conversion of land use from agricultural to non-agricultural use.

Betterment levy – one-time upfront charge on the land value gain caused by public infrastructure investment. This occurs in two forms – revenue source for improvement schemes and for specific projects. In India, the Mumbai Metropolitan Regional Development Authority (MMRDA) Act, 1974 provides for levying betterment charges for specific projects. The Hyderabad Municipal Corporation Act, 1955 originally provided for the levy of betterment charges to meet the costs of internal infrastructure and services in the case of development projects. In the late nineties, the Government of Andhra Pradesh amended the Act to enhance the scope of such levy to include external betterment. Under this concept, the municipal authority is empowered to collect external betterment charges at the time of according approval to layouts or sub-divisions of plot or issue of building permit for the laying of trunk water lines, development of freeways/major roads, percent of the land value gain attributable to public investment.

Development charges (Impact fees) are area-based and link the development charge to the market value of land by carrying out periodic revisions. This is the most widely used land based fiscal tool in States. States like Andhra Pradesh, Gujarat, Maharashtra, Tamil Nadu and Madhya Pradesh levy Impact Fee and collect it upfront while granting development permissions. Impact fee is widely used to fund infrastructure in the United States. The Government of Andhra Pradesh in the late nineties also permitted Hyderabad Municipal Corporation to levy Impact Fees to mitigate the impacts of construction of commercial buildings, which lead to increase in traffic and necessitate decongestion measures. This is meant to address citywide problems emanating from high-density commercial development and is expected to be utilized for the Capital Improvement and Decongestion Plan. This includes works such as road widening, link roads, slip roads, parallel roads, junction improvements including traffic signals, flyovers, rail over-bridges, rail under-bridges, modern lighting on major roads, development of major storm water drains, riverfront and parks and for Geographic Information System (GIS) applications.

Transfer of Development Rights (TDRs) – used for trading development rights. Maharashtra, Karnataka and Gujarat have enabling laws for using TDRs for developing open spaces, promoting affordable housing, etc. In New York City, TDRs are given for preservation of the property owners for loss in revenue on their properties.

Premium on relaxation of rules or additional FSI/FAR – widely used in States such as Maharashtra, Karnataka, Gujarat, Tamil Nadu, etc. to allow for additional development rights beyond the permissible limits in the State Town Planning Laws and Regulations. Sale of additional Floor Area Ratio (FAR) is an important Value Capture tool in Brazil and France. The French Land-use Policy restricts the landowner"s building right to a low baseline FAR and additional FAR has to be purchased.

Vacant Land Tax (VLT) – is applicable on those landowners who have not yet initiated construction on their lands. In Andhra Pradesh, the Greater Hyderabad Municipal Corporation (GHMC) imposes a tax of 0.5% of the registration value of the land if not used exclusively for agriculture purpose or is vacant without a building.

Tax Increment Financing (TIF) – is one of the most popular Value Capture tools in many developed countries, especially the United States. In TIF, the incremental revenues from future increases in property tax or a surcharge on the existing property tax rate is ring-fenced for a defined period to finance some new investment in the designated area. Tax Increment Financing tools are especially useful to finance new investments in existing habitations. Some of the Smart City Proposals have planned for TIF in their area-based developments (ABD).

Land Acquisition and Development – acquiring and developing land could be adopted as a useful Value Capture method to mobilize resources. In Hyderabad, impact fees are levied on all new developments within a one-kilometer wide growth corridor on both sides of the Outer Ring Road (ORR). Another innovative „Road widening Scheme" is being implemented in Hyderabad in which the Municipal Corporation gives additional FAR and relaxes zoning for property owners who give land free of cost for road widening.

Land pooling System (LPS) – is a form of land procurement where all land parcels in an area are pooled, converted into a layout, infrastructure developed, and a share of the land, in proportion to original ownership, returned as reconstituted parcels. In India, States such as Gujarat and Haryana have used land assembly programs where the owners agree to exchange their barren lands for infrastructure-serviced smaller plots. Gujarat has used these tools to guide the development of Ahmedabad city and its surrounding infrastructure. The State of Andhra Pradesh has used LPS to get land for Amravati, its new Capital City. Such LPS are also a common feature in countries like Japan and Germany.

(ii) Types of Value Capture

Tools like betterment levy, development charge, etc. have been extensively used across States whereas some tools like TDRs and VLT have been used less frequently. Value capture methods can be used in an area or can be specific to a project. Area-based value capture attempts to capture the basic appreciation of the value of the area as a result of infrastructure development, while project-based value captures the appreciation of land and building values in the area of influence of the project. The area of influence determines the geographic extent of immediate positive impact of project investments. Table 23.1 gives the different VCF methods that can be applied to the two types of interventions.

Area-based application of Value Capture is best suited for urban areas. The area could be a locality, city or a larger planning area. On the other hand, project-based value capture can be used for projects being implemented by Ministries/Departments/Agencies of the Government of India. Some examples are given below.

Ministry of Railways for high-speed rail projects and expansion of railway network through SPVs.
Ministry of Road Transport and Highways for the phased implementation of the Indian National Expressway Network.
Department of Industrial Policy and Promotion for setting up of Special Economic Zones (SEZs) and industrial corridors such as the Delhi Mumbai Industrial Corridor (DMIC).
Ministry of Power for setting up power generation plants.
Ministry of Shipping for projects requiring significant land resources such as cargo terminals, constructions of ferry and cruise terminals, and establishment of free trade zones.

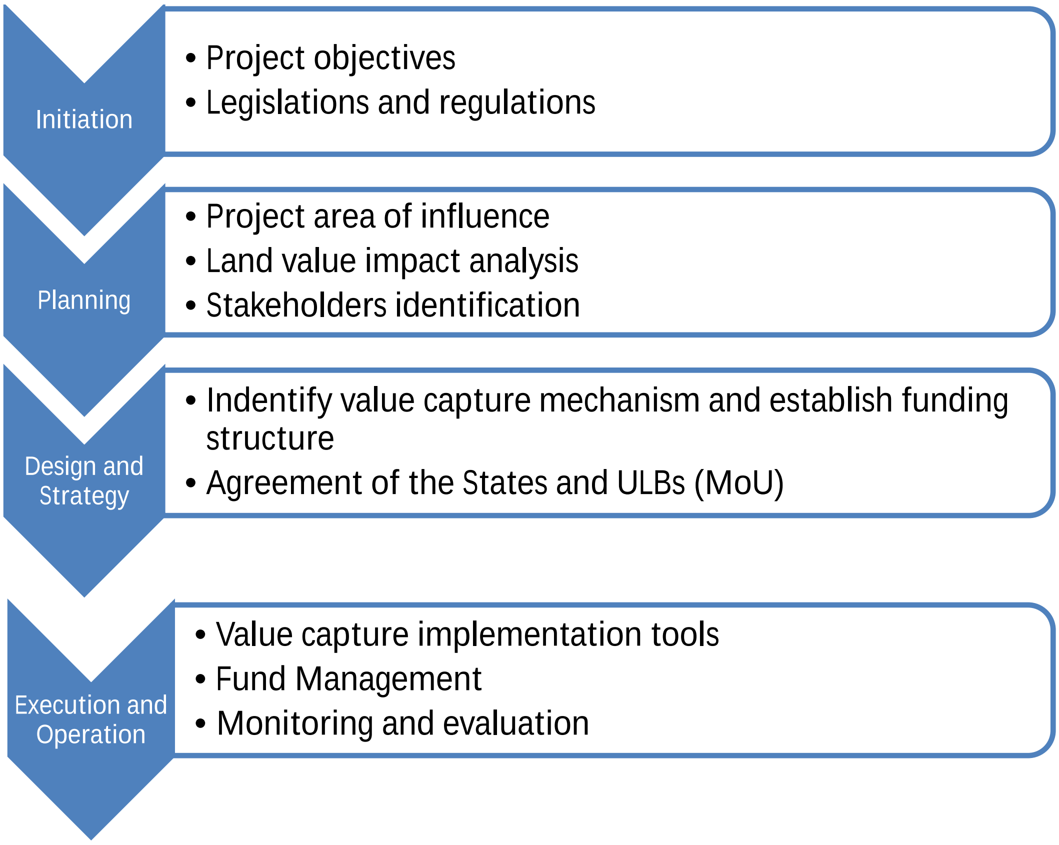
Table 23.1. Value Capture Methods and Scale of Intervention

S. No.	Value Capture Method	Frequency of Incidence	Scale of Intervention
1.	Land value tax	Annual rates based on gain in land value uniformly	Area-based
2.	Fees for changing land use (agriculture to non-agricultural)	One-time at the time of giving permission for change of land use	Area/Project-based
3.	Betterment levy	One-time while applying for project development rights	Area/Project-based
4.	Development charges (Impact fees)	One-time	Area-based
5.	Transfer of Development Rights	Transaction-based	Area/Project-based
6.	Premium on relaxation of rules or additional FSI	One-time	Area (Roads, railways)/Project(Metro)
7.	Vacant land tax	Recurring	Area-based
8.	Tax increment financing	Recurring and for a fixed period	Area-based
9.	Land Acquisition and Development	One-time upfront before project initiation	Area/Project-based
10.	Land Pooling System	One-time upfront before project initiation	Area/Project-based

(iii) Application of VCF Methods to Area

In order to capitalize on the full range of VCF tools to mobilize additional resources, the States/ULBs will have to use the Scope-Coverage-Optimization Model of Value Capture. Scope refers to the type of existing and new tools which can be used in the State/ULBs. Coverage is replication of an existing tool to all parts of the State; and Optimization is related to use of scientific methods to assess, levy and collect taxes from a range of VCF tools. Below, are given the steps for States/ULBs to assess the opportunities for using VCF tools to generate additional resources.

Figure 23.4: Steps Required for Project-based VCF



Scope - Different types of Value Capture tools being used in other States and countries reviewed and decided on the type which could be used in the Ahmedabad Area. Optimization - VCF methods based on an examination of the rates will be levied by State.

Coverage – Presently VCF tools are applied to small parts of the corridor and can easily be extended to other Areas. These will be identified and scaled-up.
After studying the scope, optimization possibilities and coverage of the Value Capture methods, the State will examine if existing Acts, rules, regulations and bye-laws have to be amended.

Finally, a mechanism for sharing of their venues through value capture between the States/ULBs and other entities will have to be designed and implemented.

(iv) Value Capture Financing (VCF) for TOD

Value Capture is based on the principle that private land and buildings benefit from public investments in infrastructure and policy decisions of the Government. Part of the increment in value of land and building should be captured to fund projects being set up for the public by the Central/ State government and the ULBs. The additional value is generated by actions other than the land owner"s direct investment. Land value capture is distinct from the user charges or fees that agencies collect for providing services.

The investment in transit system as well as increase in FAR and provision for mixed use development would result in increase in value of land within the influence zone. Land Value Capture can be used as a mechanism to finance the required upgradation of infrastructure and amenities within the influence zone and expansion of the public transport system.

Value capture financing is an opportunity for the private sector because the projects are planned for the overall development, thus increasing the value and are also backed by the government.

In TOD influence zones, land value capture can be done through enhanced or additional land value tax3 or one time betterment levy4, development charges or impact fee5, transfer of development rights (TDRs)6, or other such mechanisms which have been adopted in various states across the country and abroad.

The resources generated through various mechanism should be credited into a TOD fund created for funding the infrastructure upgradation/ maintenance, enhancement of viability of transit systems, development and maintenance of transit corridor and public transport etc. within and beyond the influence zone. The fund should be in the form of an escrow account, from which financing is provided to various agencies for the identified activities and the balance can be used by the ULBs for other development purposes such as public transport expansion.

The real-estate market can be erratic and therefore caution should be observed while estimating the revenue from land value capture. In case the revenues are lower than expectations, ULBs should prepare alternate financing plans to circumvent problems in implementing TOD.

(v) Statutory Framework

TOD policy should be notified as part of the Master Plan/Development plan of the city. The policy document should clearly outline the importance of the high capacity transit networks in the city"s development.

The vision of the Master Plan/ Development Plan should be resonated by all the stakeholders, especially those involved in infrastructure development and preparation of development plans. The building bye-laws and development control regulations would need to be amended to incorporate the changes required for implementing TOD.

The influence zone of the TOD should be clearly notified by the concerned authority to ensure that the infrastructure created in the influence zone is provided in a planned manner, the ULBs and the concerned authorities/agencies should prepare a comprehensive plan integrating all the utilities, physical infrastructure and essential facilities such as roads, sewers, drainage, electric lines, green spaces, police post, fire post, electric sub-stations, etc. The plan would be useful to assess the carrying capacity of the existing infrastructure and the upgradation needed to meet the increased demand once TOD is implemented.

23.5 POTENTIAL OF TOD AND VCF IN AHMEDABAD METRO PHASE – II CORRIDORS

Main corridor of Ahmedabad phase II is extension of North south corridor of phase I beyond Motera Stadium to Mahatma Mandir, which passes through under developed area between Vishwakarma Engineering Colleges to Koba Cirle for a length of 3.033km.Corridor beyond Koba Circle passes on the centre of a proposed road upto Randesan for a length of 5.737km. Most of the land in this stretch of the alignment is either under development or agriculture land. Prevailing FSI permitted in various areas the corridor is as under.

Table 23.2 FSI for various zones of Ahmedabad Urban Development Authority (AUDA) Area

S. No.	Zones	Codes	Permissible (BASE)	Chargeable	Maximum permissible
1	Residential Zone I	R1	1.8	0.9-within SP Ring Road	2.7
				0.45-Outside SP Ring Road	2.25
2	Residential Zone II	R2	1.2	0.6-within SP Ring road and for Bopal TP1, TP3	1.8
				Nil-outside SP ring road	1.2
3	Residential Zone III	R3	0.3	Nil	0.3
4	Transit Oriented Zone	TZ	As per base zone	As applicable	4
5	Commercial and Logistics Zone	C	1.8	0.9 – Within SP Ring Road	2.7
				0.45 – Outside SP Ring Road	2.25
6	Knowledge and Institutional Zone	KZ	1.8	Nil	1.8

Table 23.3 FSI for various zones of Gandhinagar Municipal Corporation Area

S. No.	Zones	Codes	Permissible (BASE)	Chargeable	Maximum permissible
1	Residential renewal zone	RR1	2.5		2.7
					2.25
2	Commercial	C1	Floor space upto 25m height shall be considered as base FSI. Floor space above 25m & upto 45m shall be chargeable.		
3	Institutional zone III	I3	1.5	Nil	1.5

Table 23.4 FSI for Various Zones of Gandhinagar Urban Development Authority (GUDA) Area

S. No.	Zones	Codes	Permissible (BASE)	Chargeable	Maximum permissible
1	Residential renewal zone	R4	1.8	0.45	2.25
		R5	1.5	0.5	2.0
2	Commercial	C2	1.8	2.2	4.0
			1.8	0.9 (for RAH only)	2.7
3	Institutional zone III	I3	1.8	Nil	1.5

(vi) Current Conversion charges from Agriculture land use to mixed land use:

Residential – Rs 10 /sqm
Commercial – Rs 30/sqm
Institutional – Rs 30/sqm

It is proposed to generate revenue by following means
Allowing FSI upto 4 and charging additional FSI along the Metro corridor from Vishwakarma Engineering college station upto Dholakuan.

Allowing Redevelopment along the Metro corridor from Vishwakarma Enginerring college station upto Dholakuan.

The prevailing rate of FSI chargeable is 40% of the Jantri Rate. The total revenue generated from the sale of additional FSI and redevelopment charges along the Metro corridor from Vishwakarma Enginerring college station upto Dholakuan works out to be **Rs. 8486 Crore** over the horizon of 30 years. It is presumed that State government will part 60% from the total revenue generated to MEGA Co i.e. **Rs5091 Crore** in lieu of development along metro corridor & sale of additional FSI up to 4. Detailed calculations are place in the Table No. 23.5

Table No. 23.5

Table 1 - Estimate of FSI sale Revenue for MEGA @ 60% Share in Total Revenue (Corridor from Vishwakarma College to Koba Circle - 3.6 km) (Rs. in Crore)

	2018 - 2021	2022 - 2025	2026 - 2029	2030 - 2033	2034 - 2037	2038 - 2041	2042 - 2045	2046 - 2048	Total Accrued to MEGA in 30 years @ 60% Share	Total Revenue accrued in 30 years
%age distribution for vacant land development	10%	10%	10%	10%	20%	10%	10%	20%	100%	
%age distribution for Redevelopment	5%	5%	20%	20%	20%	10%	10%	10%	100%	
70% Vacant Development & 20% Redevelopment in 30 years										
Vacant Area in Sq Mt.	100800	100800	100800	100800	201600	100800	100800	201600		
Vacant Area Development Revenue	₹ 67.78	₹ 82	₹ 100	₹ 122	₹ 296	₹ 180	₹ 219	₹ 518	₹ 950.72	₹ 1,585
Redevelopment in Sq. Mt.	14400	14400	57600	57600	57600	28800	28800	28800		
Redevelopment Revenue	₹ 10	₹ 12	₹ 57	₹ 70	₹ 85	₹ 51	₹ 62	₹ 74	₹ 252.58	₹ 821
Total Revenue	**₹ 77.46**	**₹ 94.15**	**₹ 157.36**	**₹ 191.27**	**₹ 380.43**	**₹ 231.21**	**₹ 281.04**	**₹ 592.24**	**₹ 1,203.09**	**₹ 2,005.16**

Table 2 - Estimate of FSI sale Revenue for MEGA @ 60% Share in Total Revenue (Corridor from Koba Circle TO Dholakuan - 8.5 km) (Rs. in Crore)

	2018 - 2021	2022 - 2025	2026 - 2029	2030 - 2033	2034 - 2037	2038 - 2041	2042 - 2045	2046 - 2048	Total Accrued to MEGA in 30 years @ 60% Share	Total Revenue accrued in 30 years
%age distribution for vacant land development	10%	10%	10%	10%	20%	10%	10%	20%	100%	
%age distribution for Redevelopment	5%	5%	20%	20%	20%	10%	10%	10%	100%	
Area statement as received from GUDA										
Vacant Area in Sq Mt.	777770.8	777770.8	777770.8	777770.8	1555541.6	777770.8	777770.8	1555541.6		
Vacant Area Development Revenue	₹ 261.48	₹ 318	₹ 386	₹ 470	₹ 1,142	₹ 694	₹ 843	₹ 1,999	₹ 3,667.86	₹ 6,113
Redevelopment in Sq. Mt.	20138.3	20138.3	80553.2	80553.2	80553.2	40276.6	40276.6	40276.6		
Redevelopment Revenue	₹ 7	₹ 82	₹ 40	₹ 49	₹ 59	₹ 36	₹ 44	₹ 52	₹ 220.91	₹ 368
Total Revenue	**₹ 268.25**	**₹ 400.12**	**₹ 426.33**	**₹ 518.21**	**₹ 1,200.66**	**₹ 729.71**	**₹ 886.96**	**₹ 2,051.03**	**₹ 3,888.77**	**₹ 6,481.28**

Table 3 -Estimate of FSI sale Revenue for MEGA @ 60% Share in Total Revenue (Rs. in Crore)

	2018 - 2021	2022 - 2025	2026 - 2029	2030 - 2033	2034 - 2037	2038 - 2041	2042 - 2045	2046 - 2048	Total Accrued to MEGA in 30 years @ 60% Share	Total Revenue accrued in 30 years
Total Revenue (1 + 2)	**₹ 345.71**	**₹ 494.27**	**₹ 583.69**	**₹ 709.48**	**₹ 1,581.10**	**₹ 960.92**	**₹ 1,168.00**	**₹ 2,643.28**	**₹ 5,091.86**	**₹ 8,486.44**

Note

1. The above envisaged Scenario is for 30 years in respect of development and utilization of the additional FSI

Table 1

1. Total TOZ Area	1440000 Sq. Mt.	'=3.6 km X 400 m
2. Chargeable FSI	2880000	
3. Jantri Rate Considered	Rs. 7800/ Sq. Mt.	
4. Chargeable FSI Rate (40% of Jantri Rate)	Rs. 3120	
3. Assumed Annual Escalation in Jantri Rate	5%	
4. Total Development years	30 Years	
5. Assumed MEGA's Share from Additional FSI sale	60%	

Table 2

1. Total TOZ Area		
2. Chargeable FSI (As received from GUDA)	7777708	Vacant Development
	402766	Redevelopment
3. Jantri Rate Considered	Rs. 7890/ Sq. Mt.	
4. Chargeable FSI Rate (40% of Jantri Rate)	Rs. 3120	
3. Assumed Annual Escalation in Jantri Rate	5%	
4. Total Development years	30 Years	
5. Assumed MEGA's Share from Additional FSI sale	60%	

Appendix

MEGA's Comments & DMRC's Responses on Ahmedabad Phase-II Metro Rail Corridor

From S&T Department:

Sr. No.	Chapter No.	Clause No.	Observations / Comments	DMRC Reply
1	11	Title of Chapter	Heading may be changed to Signalling and Train control and PSG	PSG (Platform Screen Gate) is a small system and part of interface with Signaling System. It is not desirable to change the heading of the signaling chapter.
2	11	11.2	Signalling provides "Safety" and not "Security"	Agreed, it shall be Corrected accordingly.
3	11	11.3	The main system uses CBTC Technology with ATP, ATS and ATD. Back-up uses CBI, Axel counters and line-side signals etc. overview to be split between S&TC system and PSD system as these are separate systems	Brief for PSD system overview has been included in signaling system overview as explained in item no 1. There is no need to split overview of S&TC and PSD system. Since, PSD system is also a safety related system which highly depends on the signaling system interface. Installation and commissioning of PSG shall be done by Signaling team.
4	11	11.4.3	In Auto mode for GoA3, GoA4, the system operates the train and driver has no role. May be incorporated suitably.	In ATO mode, driver will close the train doors and press a button (start) when ready to depart. The same ATO mode is recommended in draft DPR. However, GOA3 & GOA4 are for Driverless Train Operation (DTO) and Unattended Train Operation (UTO) respectively. DTO & UTO may be reviewed & considered during detail design stage.
5	11	11.4.11	Speed information: description given in brackets may be vendor specific- to be removed.	Given details are not vendor specific, However, it is corrected.
6	11	11.4.13	Depot may have full complement of CBTC system in which case the CBI system and Axel counters will be a back-up system.	In depot, CBTC system is not required. Only CBI system with Axel counters shall fulfill the requirement, when ATO mode system is

Sr. No.	Chapter No.	Clause No.	Observations / Comments	DMRC Reply
				considered without DTO & UTO (as already explained in item 4).
7	11	11.9	OCC for phase-II should be same as for phase-I. Similarly for BCC. May be suitably incorporated.	Noted. OCC & BCC provided for Phase 1 network shall cater for Phase 2 also & shall be incorporated suitably in DPR.
8	12	12.3.1	FOTS as backbone of signaling is not required as signaling contractor lays his own FOTS/suitable communication system.	A minimum 96/144 fiber, optical fiber cable with redundancy (cable on both side of track) is proposed to be laid as given in Para 12.2.1 of Telecom chapter. Required fibers shall be provided for Signaling, Networking, CCTV, SCADA etc, if required. Fiber cables laid by signaling or others separately are not justified & cost effective.
9	12	12.3.2	Reference to SDH system to be removed as current phase-I uses IP based systems only.	It is already mentioned in Para 12.3.2 that "Alternating a totally IP based High Capacity, highly reliable and fault tolerant, MPLS Ethernet Network can be provided in Lieu of SDH/MUX". It is alternative option which shall be finalized during detailed design stage. However, SDH system has been removed from the chapter 12.
10	12	12.3.2	Reference to STM 64, 2 MB streams is irrelevant with IP based systems.	Gigabit WAN network is already included in Para 12.3.2. Necessary modifications in WAN para shall be done accordingly.
11	12	Annexure 12.1	Tables in the end show stations wrongly for Airport link.	Printing mistake, and it is Corrected.
12	12	12.8.1	NFC – Near Field Communication to be included in ticket fare media.	Incorporated suitably in AFC chapter.

From P & D Department:

Sr. No.	Chapter No.	Clause No.	Observation/Comments	DMRC Reply
1	5	5.2.1	Modify: Double U girder is suggested by DMRC keeping in view the open area in the proposed corridor. However, MEGA Co. may opt for any other method of segmental construction, if found technically feasible and economically viable.	Modified
2	18		Separate cost for crossing (including canal and river) may be provided subsequently.	Complied
3	18		DMRC should provide detailed breakup of cost calculation subsequently.	Cost estimate in DPR has been prepared using unit cost of various items based on the actual work awarded. Some of the unit costs have been provided by MEGA and some of the costs have been worked out by DMRC on the basis of awarded works of Phase-III
4	18		Cost of interchange station may be provided subsequently.	Cost of Interchange stations is considered in both the corridors for which that particular station is interchange station. Therefore the cost of interchange station is double the cost of non-interchange similar type of station and hence extra cost for interchange station is not required.
5	6	6.3	Size of all system rooms, paid and unpaid area need to be provided subsequently.	Size of individual rooms are generally decided at the later stages of the design, after interfacing with system and service department and are generally provided by DDC after interfacing
6	6		The station evacuation plan should satisfy the latest National Building Code, 2016	All Station Plans provided satisfies the latest NBC, verification of the same

Sr. No.	Chapter No.	Clause No.	Observation/Comments	DMRC Reply
				may be needed if there is modification in later stages and after detail design is prepared.
7	6	6.1	DMRC has proposed the entry/exit locations as per the present site conditions. However, position of the entry/exit can be suitably changed sa per land availability and ROW.	The necessary modifications are done in the station planning chapter as per requirement, however, the survey plans shows same agricultural land, which may be instead designated as green area.
8	6	Details at 6,7,8,9,10	Entry/exit locations comment for Juna Koba, Koba Gaam, GNLU, Raysan, Randeshan: entry/exit will come on present Green area (and besides the future TP road parallel to Koba Gandhinagar Highway.	
9	6	Details at 14	Entry/exit location comment for sector 10A: entry/exit is proposed besides the Ch. 3 road along the footpath connecting birsa munda bhavan.	
10	6	Details at 14	Catchment area for St. Xavier school: St. Xaviers Church, Aranya Bhavan, Karmayogi Bhavan (delete nirman bhavan)	The necessary modifications are done in the station planning chapter as per the comments received.
11	6	Details at 16	Catchment area for Akshardham Station: Gujarat lokayuka (sector 10B), Mount Carmel School, Sector 21 shopping market. (delete Swarnim Gujarat Sports).	

Sr. No.	Chapter No.	Clause No.	Observation/Comments	DMRC Reply
1	5	5.2.4	Modify Grade of Concrete for: 1) Piers – M-40/M-50 2) All precast element for viaduct & station- M-45/M-50 3) Cantilever piers & portals- M-45/M-50/M-60	Changed
2	5	5.4(A) 5.4(B)	Details of Running Section in table 5.4 (A) and 5.4 (B) may be provided subsequently.	Land parcels have been marked on the alignment plans already submitted to MEGA. Consolidated Table of the same has been included in the DPR. Drawings may be referred for the exact details of land parcels
5	5	5.11	In Table 5.11 Sr. No. 1 needs to be corrected for agency to be coordinated for cutting or trees(Add AMC/ Forest Deptt)	Corrected
6	9		It is proposed that stabling shade is provided at Indroda circle , 10 Ha. Land is reserved/mentioned. Drawing showing stabling & ancillary facility at Indroda circle Depot may be provided subsequently.	Drawing is under preparation and will be provided as soon as it is ready.

Sr. No.	Chapter No.	Clause No.	Observation/Comments	DMRC Reply
7	9	9.13	Rs. 14 Cr. Additional cost is considered for capacity augmentation of Gyaspur depot for catering need of Phase-II but in chapter-18 of cost estimate, it is mentioned as 95 Cr. Which consists of Rs. 60 Cr. for civil work, 20 Cr. for EM works and 15 Cr. for P&M work. However it is not clear that cost of developing stabling shad at Indroda circle is included in the cost and what facilities are planned at Indroda circle for supporting the stabling shad activity, its cost should also be included in the DPR. Therefore DMRC may bifurcate the depot cost in 2 parts: 1) Additional cost for Gyaspur depot 2) Cost calculation for Indroda depot considering future augmentation.	1. The cost of approx. INR 14 cr as indicated in the Chapter 8 (Depot for Phase-II Corridor) for M&P is considered adequate for Phase-II 2. If stabling facility is utilized at Indroda Depot, it is expected that no major M&P would be required for Indroda Depot. However DCC room, crew booking centre, Inspection room, toilet and pantry etc. may be planned for Indroda depot, to facilitate smooth operation of trains from Indroda Depot. 3. Cleaning facility through Auto Wash Plant need not be planned at Indroda depot as the train cleaning can be planned for Gyaspur depot and stabling of train shall be accordingly planned at Gyaspur/Indroda depot keeping in view the cleaning requirements. However space may be earmarked for future expansion of Indroda Depot for one inspection bay of 2 lines having two trains of 3 car each, based upon future requirement, so that Gyaspur Depot would function as main depot and Indroda Depot will work as satellite depot.

From System Department:

Sr. No.	Chapter No.	Clause No.	Observation/Comments	DMRC Reply
1	8	8.3	Passenger capacity calculation to be done as 4 persons/sqm of standee area in Normal condition, in line with ERTS clause 3.4.3 of RS tender of Phase-I.	The passenger capacity has been calculated based upon DMRC experience. And the rake calculation has also been done based upon 6 person/sqm of standee area. If required, the decision to decrease the passenger capacity to 4 persons/sqm of standee area may be reviewed by MEGA. This will however result in increase in rake requirement and also maintenance facilities i.e. number of SBL, IBL & WSL.
2	8	8.5	The conditions of AW3 and AW2 may be defined.	AW3 and AW2 are related to 8 passengers/sqm and 6 passengers/sqm of the standee respectively. It has been added in the chapter
3	8	8.7.6	Passenger doors should be external sliding type in line with Phase-I RS tender	Added in the chapter
4	8	8.7.8	Following lines may be added in line with Phase-1 RS tender: "Cab layout and facilities shall be designed for GoA-3 to meet all possible modes of operation including DTO/non DTO (GoA-2), Manual driving in line/depots/stabling yards etc."	Added in the chapter
5	8	8.7.8	Vide DMRC letter no. DMRC/GM/CS/16/AHD/2014/250 dated 01.12.2014, DMRC suggest side evacuation for Phase-I and accordingly planned in Phase-I, therefore the same may be changed suitably for Phase-II	Front evacuation has been advised as per Phase-I DPR (refer Para 8.7.8 and 8.7.11(iii), copy of relevant page of RS chapter of Phase-I is attached for reference). On the same line front evacuation was envisaged for Phase-II also. However if MEGA has considered side evacuation in Phase-I, the same can also be considered for Phase-II to have

Sr. No.	Chapter No.	Clause No.	Observation/Comments	DMRC Reply
				uniformity. Accordingly, it is added in the chapter.
6	9	9.2.1	Proposal of stabling depot at Indroda circle mentioned in salient features of instant DPR should be also part of this clause/chapter.	The Depot chapter has been revised accordingly, considering that additional stabling lines shall be planned at Indroda Circle Depot.
7	9	Table 9.5	As per Phase-I Gyaspur Depot plan, no availability for additional workshop lines extension. Therefore, Additional stabling lines mentioned earlier at Gyaspur depot may suitably be utilized as additional workshop line for both Phase-I & II. DMRC may propose stabling lines at Indroda depot if required in the year 2021.	Earlier additional stabling lines required for Phase-II, were planned at Gyaspur depot. However, now as proposed this additional stabling facility is shifted to Indroda Depot. Accordingly, the Depot chapter has been revised.
8	9	9.8.1	Total length of each stabling lines may be 167m, in line with Phase-I modified stabling line length variation approval.	The total length of each stabling lines has been calculated as 166m based upon the calculation to accommodate two trains in SBL with sufficient gap on either side. Same has been proposed in phase-I DPR also. Phase-I DPR may be referred.
9	10	10.1 (i)	As per rolling Stock tender for Phase-I, the requirement for Specific Energy Consumption shall not exceed 65 Wh/GTKM under AW4 load condition with operation in normal mode (with coasting), therefore suitable change may be done.	SEC of rolling stock has been considered 60 kWh/1000GTKM at Pantograph/ current collector. It has been taken vide MOUD letter No. 14011/9/2014-UT.II-Part I, dated 21.04.2017
			Depot The tender condition of Power Supply & Traction tender for Phase-I states that: For depots the traction return system shall be a floating system. The running rails of Depots are Electrically separated from mainlines through	

Sr. No.	Chapter No.	Clause No.	Observation/Comments	DMRC Reply
10	10	10.6.1	Insulated Rail Joints (IRJ). These IRJs are placed in between the main line and the depot line to isolate them from each other by a length depending on the rolling stock. The arrangement in depots and workshop are in compliant with clause 9 of EN50122-2. Proposed floating traction return system shall be understood as follows: a) There is no direct earthing of the return circuit within the depot. b) Multiple earthing of return circuit within the depot can create uncontrolled stray current flow within earthing systems and shall be avoided. c) Rails of inspection bay, heavy maintenance building, washing machine and wheel lath are separated from depot tracks by IRJs. d) Within inspection bay, heavy maintenance building and wheel lath rails are permanently bonded to structure earth. e) A diode is placed in the negative circuit in parallel to the IRJs at the entrance of the inspection bay. This diode will block the flow of negative return currents (stray current) into the structure earth, however it allows the flow of return current during testing of rolling stock in the inspection bay. f) A VLD-F in parallel to the diode acts as back-	A new system of DC traction with floating neutral in selected lines is followed in Depot in consultation with GC & DDC. Based on the outcome after commissioning & operational trials, a decision may be taken to continue or modify the same.

Sr. No.	Chapter No.	Clause No.	Observation/Comments	DMRC Reply
			up protection in case of a diode failure. It is also informed that Clause 9 of EN 50122-2 is being followed. Therefore suitable change in the said clause may be incorporated.	
11	10	10.6.6 (ii)	The tender condition of Power supply & Traction tender for Phase-I states that: Stray current collector cables (commonly known as structural earth cable, 2 X 185 mm2 aluminium) shall be provided along the viaduct/tunnel and all the metallic parts of equipment, cable sheath, tunnel/pillar etc. shall be connected to structural earth (SE) cable with 120 mm2 aluminium conductor. Therefore, sixes of cables and type of conductor may be changed in the said clause.	In line with similarity with existing line hence same may be adopted in Phase-II extension.
12	10	10.6.3	1. In phase-1, 2 x 500 kVA (33/0.415 KV) dry type transformers are to be used in each elevated ASS. However in interchange ASS the size of auxiliary transformer is 2 x 800 kVA (33/0.415 KV) dry type transformers. 2. Rated output power of Rectifier is 2 X 2.5 MW. Also Number of Pulses is 12 (24 pulses for the 2 rectifiers mounted in same substations). Therefore, similar provisions may be adopted for Phase-II	1. The transformer 2x315 kVA is enough for elevated station as per loading requirement. This may be reviewed at detailed design stage. 2. 2x2.5 MW rectifier transformer is adopted.
13	10	10.6.4	In Phase-I, the power supply at 33kV is distributed to various traction substations as well as auxiliary substations located in stations, by means of a 2 nos. 33kV ring main feeder cable network. (2x[3x(1Cx240 mm2)] Copper Conductor).	Accepted.

Sr. No.	Chapter No.	Clause No.	Observation/Comments	DMRC Reply
			Therefore, similar provision may be adopted for Phase-II.	
14	10	10.8	1. In Phase-I, Capacity of DG set is 180 kVA for elevated stations. Therefore, similar provisions may be adopted for Phase-II. 2. PSD may be included in essential services.	May be adopted for similarity with Phase-I.
15	10	10.12 (ii)	For effective utilization of regenerative energy from Rolling stock, MEGA has made provision for Inverters and feed back to 33 KV AC network. Therefore, similar provisions may be adopted for Phase-II	May be adopted after satisfactory experience at detailed design stage.