GUJARAT METRO RAIL
CORPORATION (GMRC) LIMITED

DETAILED PROJECT REPORT FOR

Metro Rail Corridor from
GIFT City to GIFT



Client: Gujarat Metro Rail Corporation Ltd.

Prepared By:

दिल्ली मेट्रो रेल कॉरपोरेशन लिमिटेड
DELHI METRO RAIL CORPORATION LTD.

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Salient Features



1.0	Gauge
2.0	Route Length
3.0	Number of Stations
4.0	Traffic Forecast
5.0	Train Operation Plan
6.0	Speed
7.0	Traction Power Supply
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12.0	Construction Methodology
13.0	Total Estimated Cost
14.0	Total Completion Cost
15.0	Indices



SALIENT FEATURES

1. GAUGE (Nominal) — 1435 mm

2. ROUTE LENGTH (start to dead end)

Corridors	Total Length (km) Completely Elevated
GIFT City (excluding) to Shahpur (First Phase)	3.332 **
Shahpur to GIFT (Second Phase)	4.253
Total Length	**7.585 ** **

**** including 380m section kept for future extension provision towards IIT Gandhinagar**

3. NUMBER OF STATIONS

Corridor Name	Total Stations (All Elevated)
GIFT City (excluding) to Shahpur (First Phase)	3
Shahpur to GIFT (Second Phase)	3
Total Stations	**6**

4. TRAFFIC FORECAST

Corridor	Year	Daily Ridership	PHPDT	ATL (km)
GIFT City Corridor (Combined MRTS Phase-II & Phase-II(B))	2029	39,119	2,083	-
	2031	46,241	2,346	-
	2041	99,220	5,105	-
	2051	1,11,575	5,733	-
GIFT City Corridor (MRTS Phase-II(B) only)	2029	26,214	1,437	24.52
	2031	32,567	2,346	25.23
	2041	73,868	5,105	25.33
	2051	82,054	5,733	25.31

Note: This corridor is proposed for implementation in two phases. In first phase it will be implemented till Shahpur and remaining section shall be implemented in second phase. First phase shall be implemented by 2029 and second phase by 2033. Accordingly, traffic shown above in year 2031 is till Shahpur only and 2041 onwards it is till GIFT station.

5. TRAIN OPERATION PLAN

The PHPDT capacity provided in Phase-II A and B in different years of operation is tabulated below:

Sections	Year	Headway (min)	No. of Rakes operational in APMC to Motera (Phase-I)	Total No of Rakes Ordered in Phase-II Corridor	Rake Consist	No. of Rakes required	Additional Rakes Required	Max. PHPDT Demand	PHPDT Capacity Available
APMC to GNLU	2027	6	14	10	3-car	30	6	4572	7640* (9720#)
GNLU to Mahatma Mandir and GNLU to Shahpur		12						1763	3820* (4860#)
Koteshwar Road to Airport		12	N/A	N/A		4	4	1269	3820* (4860#)
APMC to Mahatma Mandir	2031	6	37		3-car	31	Nil	5128	7640* (9720#)
GNLU to Mahatma Mandir and GNLU to GIFT		12						2346	3820* (4860#)
Koteshwar Road to Airport		12				4		1662	3820* (4860#)
APMC to Mahatma Mandir	2041	4.5	46		3-car	42	Nil	7757	10187* (12960#)
GNLU to Mahatma Mandir and GNLU to GIFT		9						5105	5093* (6480#)
Koteshwar Road to Airport		12				4		2164	3820* (4860#)
APMC to Mahatma Mandir	2051	4.15	54		3-car	44	Nil	8956	11046* (14053#)
GNLU to Mahatma Mandir and to GIFT		8.3						5733	5523* (7027#)
Koteshwar Road to Airport		12				4		2719	3820* (4860#)

6. SPEED

Design Speed	90kmph
Maximum operating speed	80kmph
Schedule speed	30kmph

7. TRACTION POWER SUPPLY

a) Voltage — 750v dc
b) SCADA system — Provided
c) Power Demand (MVA)

Power Demand (in MVA)

SN	Corridors	Load	Year			
			2027	2031	2041	2051
1.	**Phase – II Extension A**: From 'Koteswar Road' To 'Sardar Vallabhbhai International Airport'. Total 04 Stations, comprising of 03 Elevated Stations & 01 Underground Station, 6.33 km	Headway (min)	12.0	12.0	12.0	12.0
		Traction Power	0.79	0.79	0.79	0.79
		Auxiliary Power	2.37	2.37	2.67	3.10
		Total Power Demand	**3.16**	**3.16**	**3.46**	**3.89**
2.	**Phase – II Extension B**: From 'Gift City (Existing)' To 'Shahpur Metro' comprising of 3 Elevated Stations,3.33 km	Headway (min)	12.0	12.0	9.0	8.30
		Traction Power	0.42	0.42	0.56	0.61
		Auxiliary Power	0.79	0.79	0.88	0.99
		Total Power Demand	**1.21**	**1.21**	**1.44**	**1.60**
3.	**Phase – II Extension C**: From 'Shahpur' To 'Gift' comprising of 3 Elevated Stations, 4.32 km	Headway (min)	Not Applicable	12.0	9.0	8.30
		Traction Power	Not Applicable	0.54	0.72	0.79
		Auxiliary Power	Not Applicable	0.79	0.89	0.99
		Total Power Demand	Not Applicable	**1.33**	**1.61**	**1.78**
4.	**Grand Total Power Demand**		**4.37**	**5.70**	**6.51**	**7.27**

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 - 764 Passengers
   Crush - 972 Passengers
e) Class of accommodation - One

9. MAINTENANCE FACILITIES

Gyaspur Depot of Phase-I and Indroda Circle stabling depot of Phase-II shall fulfill the requirements of Phase-II B also after suitable augmentation.

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 Trackside and Train.

11. TELECOMMUNICATION AND AUTOMATIC FARE COLLECTION

i) Fiber Optic System (FOTS), SCADA, Train Radio, PA system etc.
ii) Train information system, Control telephones and Centralized Clock System.
iii) Automatic Fare collection system with TIM 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, GMRC 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 JANUARY 2024 PRICES)

Phase-wise Details of Capital Cost

Sr. No.	Name of the corridor	Capital Cost (Rs. Crore)	Taxes & Duties (Rs. Crore)	Total (Rs. Crore)
1	GIFT City to Shahpur (First Phase)	754.62	137.31	891.93
2	Shahpur to GIFT (Second Phase)	626.22	108.93	735.15
	Total at January 2024 level	1380.84	246.24	1627.08

Note: GIFT City (excluding) to GIFT corridor is proposed to be implemented under two phases. First phase consisting first three stations is proposed to be implemented by 2029 and second phase consisting of remaining three stations is proposed to be implemented by 2033. Accordingly, cost for the two phase have been shown above separately.

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)
GIFT City to Shahpur (First Phase) by March 2029	**1050.64**	**1067.55**
Shahpur to GIFT (Second Phase) by March 2033	**1042.08**	**1058.76**

15. INDICES

a) FIRR : 8.58%

b) EIRR : 17.61%

Note: For above indices, entire corridor from GIFT City (excluding) to GIFT i.e. first and second phase combined has been considered

Executive Summary



0.1 Introduction

0.2 Transport Demand Forecast

0.3 System Selection

0.4 Geometric Designing Parameters and Alignment Description

0.5 Civil Engineering

0.6 Station Planning

0.7 Train Operation Plan

0.8 Rolling Stock

0.9 Depot

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Finance (VCF)
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0.22 Conclusions & Recommendations
0.23 Implementation Plan
0.24 Conclusion and Recommendations



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, a newly built stadium, called Narendra Modi Stadium, at Motera can accommodate 132,000 spectators, making it the largest stadium in the world. The world-class Sardar Vallabhbhai Patel Sports Enclave is currently under construction and once complete, it will be one of the biggest sports centers (Sports City) in India. 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. The historic city of Ahmedabad, or Old Ahmedabad, was declared a UNESCO World Heritage City in July 2017. In 2020, the gross domestic product of Ahmedabad metro was estimated at $68 billion and it was ranked as the third-best city in India to live by the Ease of Living Index. Recently Time magazine included Ahmedabad in its list of world's 50 greatest places of 2022. 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 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.

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 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.

Subsequently vide Work Order No. MEGA/DMRC/DPR/PHASE-II/2016/WO, dated 23.02.2016, MEGA Co. Ltd. entrusted the work of preparation of DPR for Ahmedabad Metro Phase-II to DMRC for connecting APMC – Motera line to Gandhinagar and also to connect GIFT City and Airport. DPR for the same submitted in September 2017. Later this DPR got revised in September 2018 and subsequently updated in March 2019 which got approved by GoI. According to the approved DPR, following Metro Rail Corridors are already under implementation under Ahmedabad Metro Phase-II:

a. Extension of existing N-S Corridor from Motera Stadium to Mahatma Mandir (22.838 km)
b. GNLU to GIFT City (5.416 km)

0.1.1 Present Study area

GMRC vide Letter of Acceptance No. GMRC/Phase-IIB/G/0/438 dated 10/02/2023 and subsequent letter No. GMRC/Phase-IIB/G/0/856 dated 23/03/2023, entrusted the work of preparation of Detailed Project Report (DPR) for additional metro corridor inside GIFT City from GIFT City Station to DMRC.

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 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 B Corridor in Horizon Years

Daily ridership on the Ahmedabad Metro Phase-II B in 2029 is expected to be 39,119 passengers. The average trip length will be 24.52 km in year 2029. Daily ridership, Average Trip Length (ATL) and PHPDT for the years 2029, 2031, 2041 and 2051 are shown in table below.

Table 0.1 - Daily Ridership, ATL and PHPDT

Corridor	Year	Daily Ridership	PHPDT	ATL (km)
GIFT City Corridor (Combined MRTS Phase-II & Phase-II(B))	2029	39,119	2,083	-
	2031	46,241	2,346	-
	2041	99,220	5,105	-
	2051	1,11,575	5,733	-
GIFT City Corridor (MRTS Phase-II(B) only)	2029	26,214	1,437	24.52
	2031	32,567	2,346	25.23
	2041	73,868	5,105	25.33
	2051	82,054	5,733	25.31

Note: This corridor is proposed for implementation in two phases. In first phase it will be implemented till Shahpur and remaining section shall be implemented in second phase. First phase shall be implemented by 2029 and second phase by 2033. Accordingly, traffic shown above in year 2031 is till Shahpur only and 2041 onwards it is till GIFT station.

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 5,733 on this extension from GIFT City to GIFT, 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 GNLU to GIFT City, hence 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, therefore it is recommended to adopt same system i.e. Light Capacity Metro System. Further, since GNLU to GIFT City corridor is a spur line of APMC to Mahatma Mandir (N-S) corridor, thus extending the same system shall provide seamless metro connectivity from inside of GIFT City to APMC and Mahatma Mandir ends.

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/I-Girder 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

The corridor identified under Ahmedabad Metro Phase-II B is as follows:-

Table 0.3

Sr. No.	Corridors	Total Length (km)
i)	GIFT City (excluding) to GIFT	7.204

** excluding 380m section kept for future extension provision towards IIT Gandhinagar

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 B Metro corridor, 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, GMRC 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)

S. No.	Description	First Phase			Second Phase		
		Govt.	Pvt.	Total	Govt.	Pvt.	Total
1	Stations	0	2052	2052	0	2052	2052
2	Running Section	0	0	0	0	1067	1067
3	Depot/Stabling Yard	0	0	0	0	0	0
4	Staff Quarters	0	0	0	0	0	0
5	Office Complex and OCC	0	0	0	0	0	0
6	RSS	0	0	0	0	0	0
	Total	**0**	**2052**	**2052**	**0**	**3119**	**3119**

Total (Pvt.) = 0.2052 ha (First Phase); 0.3119 ha (Second Phase)

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

Sr.	Description	First Phase	Second Phase	OWNER-SHIP
1	Temporary Office/ Site Office	2000	2000	Government
2	Segment Casting Yard	20000	20000	Government
	Total	**22000**	**22000**	

Total land required for temporary acquisition is **2.2 ha** in both phases**,** which assumed that it will be government land.

0.6 STATION PLANNING

The proposed Metro corridor from **Gift City House to GIFT Station** is planned as Phase-II-B spurs from existing **Gift City Station**. The stretch of the proposed **Gift City House to GIFT Station** corridor is 7.204 km long open loop. Along this Corridor, six stations have been planned, along the Gift City Road- 1C.

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

The corridor has been envisaged with elevated stations. The elevated stations are all standard side platform architecture made for 6-coach train operation.

Average inter-station distance is 1.2 km approximately varying from 0.731 km to 1.5 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 between the concourse bottom and the road, allowing 3.50-m concourse height for the commuters, about 2-m for concourse floor services and 2.00-m for structure of tracks above the concourse(the same may vary based on actual girder used). 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, outside the right-of-way planned for gift city area and allotted to the MRTS. This arrangement can be modified based on availability of land within ROW of the area.

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 on the ground, preferably near entry structures for elevated station and in ancillary structure for underground stations.

10. The system is being designed to attract potential passengers with following features:

    - Minimum distance of travel to and from the platform and between platforms for transfer between lines.
    - Adequate level of service for all passenger areas.
    - 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. Minimization of capital cost while maximizing the attractiveness of metro system for the commuters
    b. Minimization of operational costs while maintaining efficiency and the safety of commuters.
    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 on platforms, fare collection zones and other passenger areas, thus aiding the supervision of operations and monitoring of efficiency and safety.
    e. Provision of space for 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 station entry on ground to platforms and vice versa, station planning has been based on established principles of pedestrian flow and has been planned to minimize passenger travel 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 entry structures on ground 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	Station Name	Chainage (m)	Inter Distance Between Two Stations.	Station Type	Remarks
	Dead End	-1615			Already Operational
1	APMC	0		Elevated	
2	Jivraj	950	950	Elevated	
3	Rajiv Nagar	1800	850	Elevated	
4	Shreyash	3170	1370	Elevated	
5	Paldi	4524	1354	Elevated	
6	Gandhigram Railway Station	5970	1446	Elevated	
7	Old High Court	7045	1075	Elevated	
8	Ushmanpura	8078	1033	Elevated	
9	Vijay Nagar	9575	1497	Elevated	
10	New Vadaj	10867	1292	Elevated	
11	Ranip	12197	1330	Elevated	
12	Sabarmati Railway	12965	768	Elevated	

S. No	Station Name	Chainage (m)	Inter Distance Between Two Stations.	Station Type	Remarks
	Station				
13	AEC	13906	941	Elevated	
14	Sabarmati	15265	1359	Elevated	
15	Motera Stadium	16661.70	1396.695	Elevated	Already under Construction
16	Koteshwar Road	17598.80	937.11	Elevated	
17	Vishwakarma College	19017.00	1418.20	Elevated	
18	Tapovan Circle	19994.45	977.45	Elevated	
19	Narmada Canal	20900.00	905.55	Elevated	
20	Koba Circle	22050.63	1150.63	Elevated	
21	Juna Koba	23056.45	1005.82	Elevated	
22	Koba Gaam	24066.45	1010.00	Elevated	
23	GNLU	24977.57	911.12	Elevated	
24	Raysan	26413.75	1436.18	Elevated	
25	Randesan	27786.89	1373.14	Elevated	
26	Dholakuva Circle	28943.26	1156.37	Elevated	
27	Infocity	30334.00	1390.74	Elevated	
28	Sector - 1	31600.00	1266.00	Elevated	
29	Sector 10A	32850.00	1250.00	Elevated	
30	Sachivalaya	34041.26	1191.26	Elevated	
31	Akshardham	35170.00	1128.74	Elevated	
32	Juna Sachivalaya	36069.00	899.00	Elevated	
33	Sector - 16	37161.35	1092.35	Elevated	
34	Sector - 24	38199.01	1037.66	Elevated	
35	Mahatma Mandir	39399.64	1200.63	Elevated	
	DEAD END	39499.64	100.00		

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

S. No	Station Name	Chainage (m)	Inter Distance Between Two Stations.	Station Type	Remarks
0	Koteshwar	-389.954		Elevated	Already under Construction
	End of under construction section and start of this DPR Corridor	0.00			Present DPR under study
1	Koteshwar Prachin Mandir	2394.93	2394.93	Elevated	
2	Sabarmati River	3041.57	646.64	Elevated	
3	Sardarnagar	4545.22	1503.65	Elevated	
4	Airport	6218.61	1673.39	Underground	

S. No	Station Name	Chainage (m)	Inter Distance Between Two Stations.	Station Type	Remarks
	DEAD END	6333.61	115.00		

Table 0.7 C: Stations - GNLU to Gift Corridor

S. No	Station Name	Chainage (m)	Inter Distance Between Two Stations.	Station Type	Remarks
	DEAD END	-405.00			Already under Construction
1	GNLU	0.00	405.00	Elevated	
2	PDPU	1749.00	1749.00	Elevated	
3	Gift City	4605.86	2856.86	Elevated	
	End of under Construction section and start of this DPR Corridor	4982.69			Present DPR under study (Will be constructed in first phase)
4	Gift City House	5908.95	1303.09	Elevated	
5	Gujarat Biotechnology University	7132.68	1223.72	Elevated	
6	Shahpur	7864.29	731.61	Elevated	
7	Ratanpur	9400.00	1535.71	Elevated	Present DPR under study (Will be constructed in second phase)
8	Lavarpur	10820.00	1420.00	Elevated	
9	GIFT	12071.00	1251.00	Elevated	
	Dead End	12187.42	116.42		

Note: Second Phase of GIFT City extension shall be operation from 2031-32.

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: 30 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)

Capacity AW3 (@ 8 passengers per square meter of standee area)

Driving Motor Car (DMC) - 315 (43 seated + 272 standing)
Trailer Car (TC) - 342 (50 seated + 292 standing)
3 Car Train - 972 (136 seated + 836 standing)

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

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 ' for the year 2027, 2031, 2041 and 2051 are given below:

TABLE 0.8 Rake Requirement

A	Year	Headway (min)	No. of Rakes operational in APMC to Motera (Phase-I)	Total No of Rakes Ordered in Phase-II Corridor	Rake Consist	No. of Rakes required	Additional Rakes Required	Max. PHPDT Demand	PHPDT Capacity Available
APMC to GNLU	2027	6	14	10	3-car	30	6	4572	7640* (9720#)
GNLU to Mahatma Mandir and GNLU to Shahpur		12						1763	3820* (4860#)
Koteshwar Road to Airport		12	N/A	N/A		4	4	1269	3820* (4860#)
APMC to Mahatma Mandir	2031	6	37		3-car	31	Nil	5128	7640* (9720#)
GNLU to Mahatma Mandir and GNLU to GIFT		12						2346	3820* (4860#)
Koteshwar Road to Airport		12				4		1662	3820* (4860#)
APMC to Mahatma Mandir	2041	4.5	46		3-car	42	Nil	7757	10187* (12960#)
GNLU to Mahatma Mandir and GNLU to GIFT		9						5105	5093* (6480#)
Koteshwar Road to Airport		12				4		2164	3820* (4860#)
APMC to Mahatma Mandir	2051	4.15	54		3-car	44		8956	11046* (14053#)

A	Year	Headway (min)	No. of Rakes operational in APMC to Motera (Phase-I)	Total No of Rakes Ordered in Phase-II Corridor	Rake Consist	No. of Rakes required	Additional Rakes Required	Max. PHPDT Demand	PHPDT Capacity Available
GNLU to Mahatma Mandir and to GIFT		8.3					Nil	5733	5523* (7027#)
Koteshwar Road to Airport		12				4		2719	3820* (4860#)

0.7.5 TRAIN FREQUENCY

Table 0.9 - Train Frequency

Section	2027		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 GNLU	6 min	10 to 30 min	6 min	10 to 30 min	4.5 min	6 to 20 min	4.15 min	6 to 20 min
GNLU to Mahatma Mandir and GNLU to Shahpur	12 min	16 to 40 min	12 min	16 to 40 min	9 min	12 to 40 min	8.3 min	12 to 40 min
Koteshwar Road to Airport	12 min	16 to 40 min	12 min	16 to 40 min	12 min	16 to 40 min	12 min	16 to 40 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 for a Medium Rail Transit System (MRTS).

0.8.1 Optimization of Coach Size

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

Following train composition is recommended:

3-car Train: DMC + TC + DMC

Table 0.11 and 0.12 shows the carrying capacity of Rail Vehicles with standing passenger @ 6 passengers per sqm of standee area and @ 8 passengers per sqm of standee area respectively.

Table 0.11: Carrying Capacity of Rail Vehicles (Normal @6 Person/sqm of standee area)

	Driving Motor car	Trailer car / Motor car	3 Car Train
Seated	43	50	136
Standing	204	220	628
Total	247	270	764

Table 0.12: Carrying Capacity of Rail Vehicles (Crush@8 Person/sqm of standee area)

	Driving Motor car	Trailer car / Motor car	3 Car Train
Seated	43	50	136
Standing	272	292	836
Total	315	342	972

0.8.3 Weight

The weights of driving motor car and trailer car have been estimated as in Table 0.13 below.

Table 0.13 - Weight of Light Rail Vehicles (TONNES)

3 car train	Gross Weight
DMC+TC+DMC	126T
Per Axle Load (max.)	16T

0.8.4 Performance Parameters

Motorisation of 67% for all categories of Metro Rolling Stock. The recommended performance parameters are:

Table 0.14 – Performance Parameters

Item	Values
Minimum Design Average Acceleration rate for fully loaded (seating plus standees @8 persons per sqm) train on level tangent track shall be as under:	
0 to 40 kmph	1.0m/s^2
0 to 60 kmph	0.6m/s^2
0 to 80 kmph	0.3m/s^2

Item	Values
Minimum Operational Average Acceleration rate for (seating plus standees @6 persons/sq.m) loaded on level tangent track shall be as under: 0 to 35 kmph 0 to 60 kmph 0 to 80 kmph	 1.20 m/s^2 0.65 m/s^2 0.35 m/s^2
Service braking rate from 80 kmph to standstill for fully loaded(seating plus standees @8 persons per sqm) train on level tangent track:	1.0 m/s^2
Service braking rate from 80 kmph to standstill for fully loaded(seating plus standees @6 persons per sqm) train on level tangent track:	1.1 m/s^2
Emergency braking rate from 80 kmph to 0 kmph for fully loaded train on level tangent track:	1.3 m/s^2
Jerk rate (maximum)	0.75 m/s^2

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 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.

(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, firefighting, 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 Current Collector – 60KWh/1000 GTKM as per MoHUA guideline for 750 V DC system.

(ii) Elevated/at –grade station auxiliary load – initially 250 kVA, which will increase to 315kVA in the year 2051.
(iii) Underground station auxiliary load – initially 1500 kVA, which will increase to 2000kVA 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 2027, 2031, 2041 and 2051 are summarized in table 0.15 below:-

Table 0.15 - Power Demand Estimation (MVA)

SN	Corridors	Load	Year			
			2027	2031	2041	2051
1.	**Phase – II Extension A**: From 'Koteswar Road' To 'Sardar Vallabhbhai International Airport'. Total 04 Stations, comprising of 03 Elevated Stations & 01 Underground Station, 6.33 km	Headway (min)	12.0	12.0	12.0	12.0
		Traction Power	0.79	0.79	0.79	0.79
		Auxiliary Power	2.37	2.37	2.67	3.10
		Total Power Demand	**3.16**	**3.16**	**3.46**	**3.89**
2.	**Phase – II Extension B**: From 'Gift City (Existing)' To 'Shahpur Metro' comprising of 3 Elevated Stations,3.33 km	Headway (min)	12.0	12.0	9.0	8.30
		Traction Power	0.42	0.42	0.56	0.61
		Auxiliary Power	0.79	0.79	0.88	0.99
		Total Power Demand	**1.21**	**1.21**	**1.44**	**1.60**
3.	**Phase – II Extension C**: From 'Shahpur' To 'Gift' comprising of 3 Elevated Stations, 4.32 km	Headway (min)	Not Applicable	12.0	9.0	8.30
		Traction Power	Not Applicable	0.54	0.72	0.79
		Auxiliary Power	Not Applicable	0.79	0.89	0.99
		Total Power Demand	Not Applicable	**1.33**	**1.61**	**1.78**
4.	**Grand Total Power Demand**		**4.37**	**5.70**	**6.51**	**7.27**

0.10.1 Need for High Reliability of Power Supply

The proposed Ahmedabad metro system is being designed to handle about 2,719 & 5,773 passengers per direction during peak hours when trains are expected to run at 12 minutes & 8.3 minutes intervals in 2051 for Koteswar Road to Sardar Vallabhbhai International Airport & Metro corridor inside Gift City, respectively based on Train Operation Plan. Incidences of any power interruption, apart from affecting train running, will cause congestion at stations. Interruption of power at night is likely to

cause alarm and increased risk to traveling public. Lack of illumination at stations, non-visibility of appropriate signages, disruption of operation of lifts and escalators is likely to cause confusion, anxiety and ire in commuters, whose tolerance level are low on account of stress. Effect on signal and communication may affect train operation and passenger safety as well. Therefore, uninterrupted power supply is mandatory for efficient metro operations.

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

0.10.2 Sources of Power Supply

In the previous DPR of Phase – II Network (extension of North-South Corridor from Motera Stadium to Mahatma Mandir and its two Spurs from Koteshwar Road to Airport & from GNLU to Gift City) of Ahmedabad Metro prepared by DMRC in the Year 2018, it was suggested that any two of the three proposed RSS may be constructed to meet the Power Supply (Traction as well as Auxiliary) Requirements of the above mentioned Phase – II Network.

Based upon the inputs received from Ahmedabad Metro, following Receiving Substations are being constructed:-

Table 0.16 RSSs Under Construction for Phase – II of Ahmedabad Metro

Corridor	Location of RSS of Metro Authority	Proposed Capacity of 132 / 33kV Transformer
Phase – II (Under Construction): From Motera Stadium to Mahatma Mandir, Including 'Spur From GNLU to Gift City'	Indroda Depot	30 / 40 MVA (ONAN / ONAF)
	Koba Gaam	30 / 40 MVA (ONAN / ONAF)

Power demand of the under construction Motera Stadium to Mahatma Mandir is proposed to be fed from upcoming Indroda Depot RSS & Koba Gaam RSS of GMRC's Network which have sufficient capacities of Transformer to cater to additional demand as per the Train Operation plan (Chapter 7: Train Operation Plan) up to 2051, which would arise due to the proposed Koteshwar to Sardar Vallabhbhai International Airport (Phase – II Extension B)&Metro corridor inside Gift City (Phase – II Extension B & Phase – II Extension C).

However, final decision regarding the augmentation of the capacities at existing RSS or /and construction of a new RSS may be reviewed based on the Electrical load along with associated parameters assessed on the basis of detailed simulation

studies to be carried out at the detailed design stage and depending up on the availability of Power & availability of Spare Bays in the Grid Substations.

Table 0.17: Power Demand projections for the upcoming 02 nos RSSs in Phase – II of Ahmedabad Metro (Under Construction)

Corridor	Input Source	Peak demand in Scenario 1: Normal Feed (i.e., All RSS are in service		Peak demand in Scenario 2 : (n-1) Feed (i.e., the adjacent RSS is Out of Service)	
		Year (2027)	Year (2051)	Year (2027)	Year (2051)
Phase – II (Under Construction): From Motera Stadium to Mahatma Mandir, **Including 'Spur From GNLU to Gift City'** **Excluding 'Phase – II extension A, B & C'** (as brought out in Table 8.1 above)	**Koba Gaam RSS** (Presently Under Construction) **Capacity: 30/40 MVA** (as communicated by Ahmedabad Metro)	**Normal Feed Scenario,** Considering both RSS **i.e., Koba Gaam & Indroda RSS** are **'In Service'.**		**(N-1) Feed Scenario**, considering **Indroda RSS** to be **'Out of Service'.**	
	Traction Load	2.09	3.02	4.54	6.56
	Auxiliary Load	2.36	2.98	6.04	7.61
	Sub-Total	**4.45**	**6.00**	**10.58**	**14.17**
	Indroda Depot RSS (Presently Under Construction) **Capacity: 30/40 MVA** (as communicated by Ahmedabad Metro)	**Normal Feed Scenario,** Considering both RSS **i.e., Koba Gaam & Indroda RSS** are **'In Service'.**		**(N-1) Feed Scenario**, considering **Koba Gaam RSS** to be **'Out of Service'.**	
	Traction Load	2.45	3.54	4.54	6.56
	Auxiliary Load	3.68	4.63	6.04	7.61
	Sub-total	**6.13**	**8.17**	**10.58**	**14.17**

0.18: Power Demand projections for the upcoming 02 nos. RSSs in Phase – II along with Phase – II Extensions A, B & C of Ahmedabad Metro

Corridor	Input Source	Peak demand in Scenario 1: Normal Feed (i.e., All RSS are in service		Peak demand in Scenario 2 : (n-1) Feed (i.e., the adjacent RSS is Out of Service)	
		Year (2027)	Year (2051)	Year (2027)	Year (2051)
Phase – II (Under Construction): From 'Motera Stadium' to 'Mahatma Mandir' **Including 'Spur From GNLU to Gift City'** **Phase – II Extension A**: From 'Koteshwar' to 'Sardar Vallabhbhai International Airport' **Phase – II Extension B:** From 'Gift City (Existing)' To 'Shahpur Metro' **Phase – II Extension C:** From 'Shahpur' To 'Gift'	**Koba Gaam RSS** (Presently Under Construction) **Capacity: 30/40 MVA** (as communicated by Ahmedabad Metro)	**Normal Feed Scenario,** Considering both RSS **i.e., Koba Gaam & Indroda RSS** are **'In Service'.**		**(N-1) Feed Scenario**, considering **Indroda RSS** to be **'Out of Service'.**	
	Traction Load	2.88	3.81	5.75	8.73
	Auxiliary Load	4.72	6.07	9.19	12.68
	Sub-Total	**7.60**	**9.88**	**14.94**	**21.41**
	Indroda Depot RSS (Presently Under Construction) **Capacity: 30/40 MVA** (as communicated by Ahmedabad Metro)	**Normal Feed Scenario,** Considering both RSS **i.e., Koba Gaam & Indroda RSS** are **'In Service'.**		**(N-1) Feed Scenario**, considering **Koba Gaam RSS** to be **'Out of Service'.**	
	Traction Load	2.87	4.92	5.75	8.73
	Auxiliary Load	4.47	6.61	9.19	12.68
	Sub-total	**7.34**	**11.53**	**14.94**	**21.41**

The 132kV / 66kV power supply from Grid Substation (GSS) is stepped down to 33 kV level at each of the RSS of Metro Authority. The 33kV power is then distributed further along the alignment through separate 33kV Ring main cable network for feeding the TSS and ASS at the Metro Stations for meeting the Traction and Auxiliary load requirements. These 33 kV cables are laid in dedicated ducts/cable brackets along the viaduct.

In case of tripping of One RSS on fault or input supply failure, train services can be maintained by feed extension from other RSS. 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.

0.10.3 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).

Adequate protection measures are required to be taken to ensure proper drainage of water on the viaduct so that the Third Rail and the Running Rails do not get affected due to accumulation of water on viaduct.

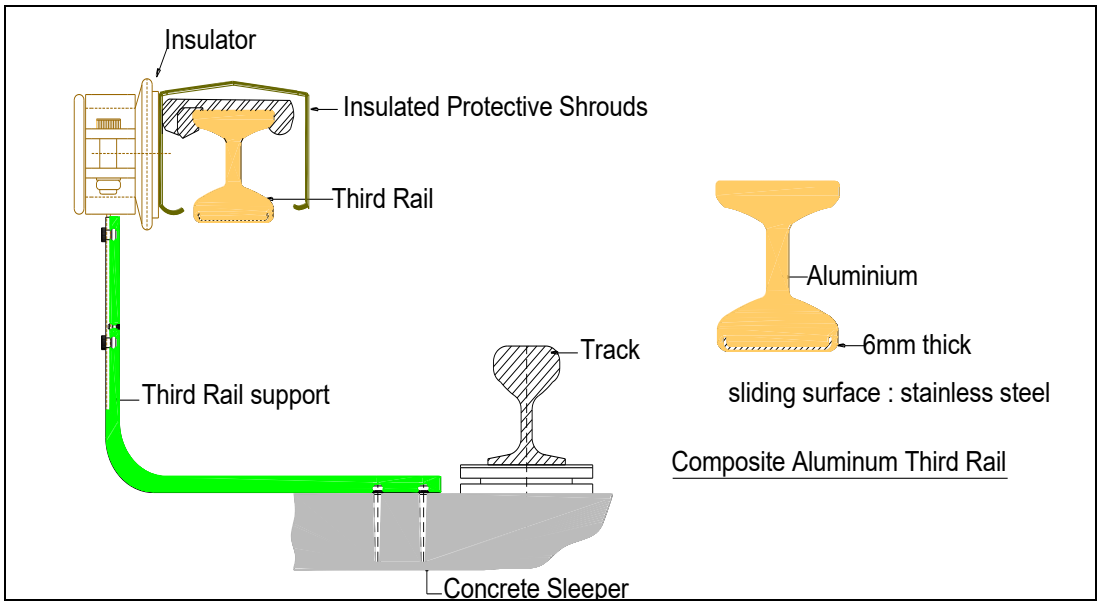


Figure 0.1

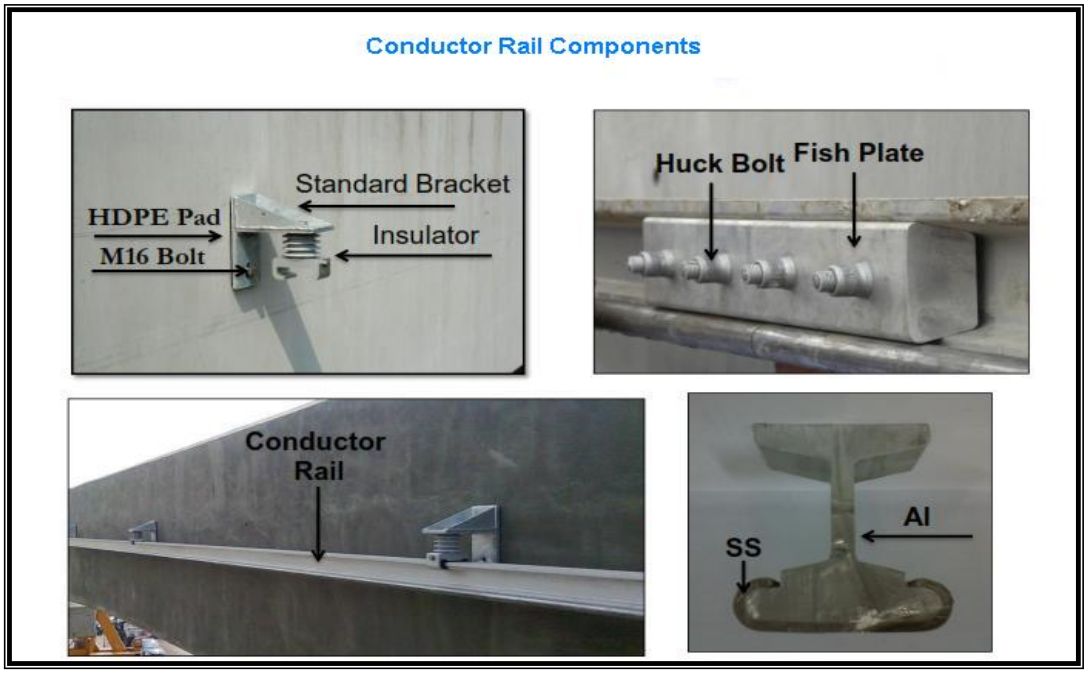


Fig. 0.2 750V dc Third Rail Current Collection System

0.11 SIGNALLING AND TRAIN CONTROL SYSTEM

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

This Chapter provides the main design features of the Signalling and train control system for the operation of the Ahmedabad Phase-II metro corridor extension mentioned below taking into account the proven and advanced 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 service.

The proposed Signalling system design for the metro line corridor isas under:

- Continuous Automatic Train Control System (CATC)
- Driverless Train Operation (DTO)
- Automatic Train Operation System (ATO)
- Automatic Train Protection (ATP) System
- Communication-Based Train Control (CBTC) based Automatic Train Control (ATC) System
- Onboard Equipment for Cab Signalling
- Fall-Back Block System along with Track Vacancy Detection System
- Interlocking device

- Trackside Radio equipment
- Electric Point Machine
- Trackside Signals
- Automatic Train Supervision (ATS) based Centralized Traffic Control System
- Optical Fiber Based Backbone Network (Redundant)
- Power Supply of Signalling
- Cable for Signalling
- Half Height Integrated Platform Screen Gate for Elevated stations (PG System) and Full Height Platform Gate for Under-ground stations

It is expected to carry a 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 the following basic principles of the Signalling System: -

- The Train Control and Monitoring shall be ensured from the Centralized Traffic Control System located at the Operation Control Centre (OCC). OCC equipment shall be connected to the station equipment room through an 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 the safe side or more restrictive state. In such case, the Signalling System shall authorise the movement of trains in normal and degraded operations.
- Equipment shall be connected through Electronic Interlocking (to Station Equipment Room) by secure links to ensure the safe movement of train.
- Provide a 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 the brake in case of disregard of signal/warning by the driver.
- Provide safety and enforce speed limits on the sections having permanent and temporary speed restrictions.
- Improve capacity with safer and smoother operations. The driver will have a 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 the System status of trackside and train-borne equipment and enabling preventive maintenance.
- To avoid any accident at the platform, an 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 the Passenger Screen Gate System.

- Signalling and 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 the operational and administrative requirements of the metro network.

The Telecommunication facilities proposed are helpful in meeting the requirements for the 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,
- 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 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 stations inside GIFT City House to GIFT station MRTS corridor. 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 worldwide accepted systems for Metro environment.

The proposed ticketing system shall be of Contact less Card/ Single Journey Ticket (SJT) 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/ SJT based AFC system is similar to magnetic ticket based AFC system, but Contactless system proves cheaper due to reduced maintenance, less wear and tear and less prone to dusty environment.

In light of new guidelines, itis proposed that AFC components for all stations may be installed using Project Cost.

0.12.2 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 (QR code, NFC etc.).

0.12.3 Ticket Issuing Machine (TIM) & Self-Service Ticketing Kiosks

The self-service ticket kiosks and TIM 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 Issuing Machines (Automatic Ticket Issuing Machines) are proposed. The TIM'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 Tickets for single journey
2. Add Value in Smart card by paying money using Bank Notes or through Credit Card /Debit card /pre-Paid card/ UPI.
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/ media balance,
- 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.
- as cashless Smart Machine to add value directly through UPI, etc.

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, 2016. 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

This section deals with the Environmental Impact Assessment of proposed metro corridor from **Gift City existing station to inside the Gift City at Ahmedabad**. The

EIA study comprises of information on bio-physical and socio-cultural environment of the project influence area, as available in literature, gathered through stakeholders' consultations and through primary survey. Based on project particulars and the existing environmental conditions, potential impacts have been assessed on the bio-physical and socio-cultural environment. An environmental management plan has been suggested with cost estimates to mitigate the adverse impacts.

Objectives of the EIA Study

The objective of the EIA study was to establish present environmental conditions along the project corridor through available data / information supported by field studies / environmental monitoring, to predict the impacts on relevant environmental attributes due to the construction & operation of the proposed project; to recommend adequate mitigation measures to avoid/ minimize / compensate adverse impacts and suggest mitigation measures to make the project environmentally sound and sustainable.

Environmental Impact Assessment has been carried out in accordance with the Government of India Guidelines and as per the requirement of DMRC.

Approach & Methodology

- **Reconnaissance Survey:** A reconnaissance survey has been conducted by the environmental specialists along the project corridor. Location of protected areas (National Parks, Wildlife Sanctuaries, Conservation Reserves), Forests, Archeological Monuments etc. surface water bodies; environmental sensitive receptors (educational institutions, religious structures, medical facilities etc.) along the alignment were identified. Locations for environmental monitoring / sampling were also identified at this stage.
- **Secondary Data Collection & Review:** Secondary data such as Survey of India Toposheets, Forest Working Plans, booklet of Central Ground Water Board, details of Archaeological Monuments etc. have been collected from various secondary sources. Further, secondary data, which are relevant to understand the baseline as pertaining to physical and biological environments has been collected and reviewed.
- **Baseline Environmental Monitoring:** The secondary data collected has been appropriately supplemented by generating primary data through field study and monitoring. The field monitoring for Ambient Air Quality, Ambient Noise Level, Surface Water Quality, Ground Water Quality and Soil Quality will be carried out in October 2023 (Post-monsoon Season) as per the guidelines of CPCB & BIS and requirement of the MoEFCC by NABL Accredited laboratory.
- **Prediction of Impacts & Mitigation Measures:** Potential positive and negative impacts on land environment, air environment, noise, water environment and biological environment has been assessed for construction and operation phase. Mitigation measures have been suggested to reduce potentially significant adverse environmental impacts to acceptable levels.
- **Environment Management Plan:** The EMP envisages the plans for the proper implementation of mitigation measures to reduce the adverse impacts arising due to the project activities. Institutional set up for implementation of the EMP

including institutional strengthening and training has been recommended. Environmental Monitoring Program during construction and operation phase has been suggested and the expenditures for environmental protection measures and budget for implementation of the EMP have been provided.

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 GMRC 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 GMRC 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

Public transport is like a tree, with a large trunk that feeds into smaller branches, and ultimately, twigs. Inter-city railways represent the trunks; high capacity urban, suburban and underground rail systems represent the major branches; metrolite, monorails, urban tramways, bus rapid transit systems and city bus systems represent

the smaller branches, etc., down to smaller capacity public sharing autos and taxi transport systems for the twigs.

Multimodal integration planning refers to considerations for various modes and the interconnections between them. Integration means that whatever modes or types of transport (rail, road, NMT, etc.) are involved they all operate as one 'seamless' entity - for the benefit of the fare paying customer. This is achieved by planning services so that where a change of vehicle is required passengers can enjoy easy to use, pleasant and sheltered interchange facilities plus short waits for the next service. Furthermore, just as when a motorist buys fuel they do so once for the whole journey so with passenger transport the passenger should be able to benefit from through 'one purchase' ticketing for the whole journey.

0.17.2 Need for Multimodal Integration

Multimodal Integration ensures the smooth movement of commuters by various transportation modes like buses, IPT, private vehicles, NMT in such a way that efficiency is achieved in terms of time, cost, comfort, safety and accessibility. A successful multimodal integration can result in increased demand for public transportation by optimizing travel cost and time and allow seamless interchange between the various modes. 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.

In public transport group there are Mini Buses (20 seaters), and large buses (50 seaters) and Chartered Buses hired by schools and private offices. Auto Rickshaw (3-seater), Vikram and Grameen Sewa (large-shared 3 wheelers-6-seater) & Tata Magic (4-wheel light passenger vehicle which can carry 8-10 persons at a time) which are Intermediate Public Transport (IPT) Modes. In the personalized transport modes, there are Bicycles, Two wheelers and Cars of all possible sizes.

A chaotic situation is observed when all the above-mentioned transport vehicles are seen jostling to each other for space for moving forward. More pathetic conditions are seen at the Road Intersections. The solution lies in showcasing a workable arrangement of co-existence through identification of good points of each mode and then utilize the same to get the attention and embedding it in public psyche.

Multimodal Integration consists of combining and coordinating the operation of varied transport modes in order to offer continuous and door-to-door services. Intermodal facilities are infrastructures where people who use public transit can shift between different modes of transport. These infrastructures are especially planned to allow for the operation of at least two transport modes at the same time.

The approach to be adopted while planning for multi modal integration is to focus on last mile connectivity and ensure seamless travel from door to door. Importance of last mile connectivity becomes crucial for the success of a public transport system. A well connected, integrated network of footpath, cycle and bus feeder system acts as complimentary modes to generate ridership of mass transit system.

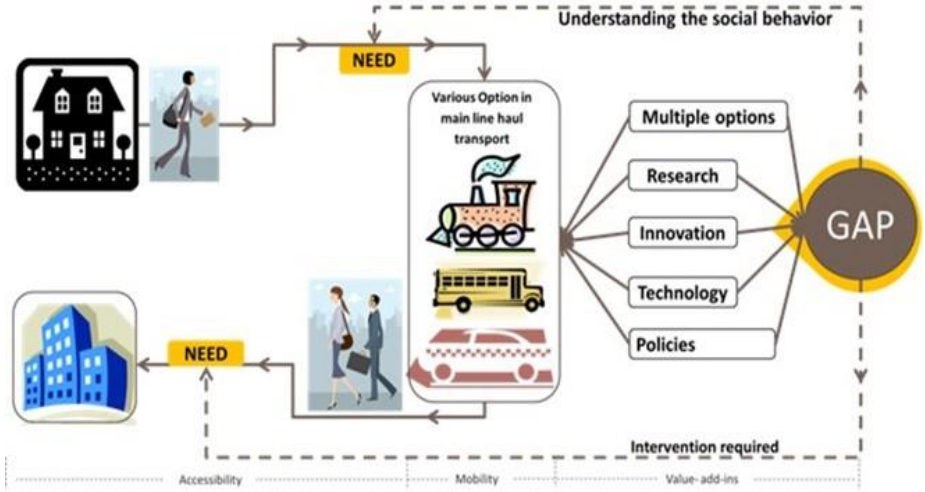


Fig. 0.3 Approach for Multimodal Integration

0.18 COST ESTIMATES

Project Cost estimates for Ahmedabad Metro Phase-II B corridor 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 January 2024 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 published in “Report on Benchmarking for Cost Estimation of Metro Rail Projects” by M/o Housing & Urban Affairs, February 2019, duly escalated to January 2024 price level. 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 estimate separately.

The overall Capital Cost of this corridor from GIFT City to Shahpur under First Phase and Shahpur to GIFT under Second Phase at January 2024 price level has been tabulated hereunder.

Table 0.19 – Details of Capital Cost

Sr. No.	Name of the corridor	Capital Cost (Rs. Crore)	Taxes & Duties (Rs. Crore)	Total (Rs. Crore)
1	GIFT City to Shahpur (First Phase)	754.62	137.31	891.93
2	Shahpur to GIFT (Second Phase)	626.22	108.93	735.15
	Total at January 2024 level	1380.84	246.24	1627.08

Note: GIFT City to GIFT corridor is proposed to be implemented under two phases. First phase consisting first three stations is proposed to be implemented by 2029 and second phase consisting of remaining three stations is proposed to be implemented by 2033. Accordingly, cost for the two phases have been shown above separately.

0.18.1 Capital Cost Estimates

0.18.1.1 GIFT City to Shahpur (First Phase)

The overall Capital Cost for the first phase of Ahmedabad Phase-II B at January 2024 price level works out to **Rs. 754.62 Crores** excluding applicable Taxes & Duties of **Rs. 137.31 crores** as tabulated hereunder.

Table 0.20 - Capital Cost Estimate

Total length = 3.332 km (Entirely Elevated)

Total Stations = 3 (All Elevated)

January 2024 level

S. No.	Item	Unit	Rate	Qty.	Amount (Rs. in Cr.)
				Without taxes	
1.0	**Land**				
1.1	Permanent				
a	Government	ha	11.08	0.0000	0.00
b	Private	ha	26.60	0.2052	5.46
1.2	Temporary Land (@5% pa for 4 years)				
a	Government	Ha.	2.22	2.20	4.87
1.3	**R & R incl. Hutments etc.**	R. Km.	4.89	3.332	16.29
	Subtotal (1)				**26.62**
2.0	**Alignment and Formation**				

S. No.	Item	Unit	Rate	Qty.	Amount (Rs. in Cr.)
				Without taxes	
2.1	Elevated section (viaduct) including in station portion (Including Cost of Rain Water Harvesting)	R. Km.	47.22	3.332	157.34
	Subtotal (2)				**157.34**
3.0	**Station Buildings**				
3.1	Elevated stations (including finishes)	Each			
a	Civil works excluding viaduct in station portion	Each	33.18	3	99.54
b	EM works including lifts and escalators	Each	10.21	3	30.63
3.2	Providing Platform Screen Doors (PSD) at all stations	Per Station	3.83	3	11.49
	Subtotal (3)				**141.66**
4.0	**Augmentation of Depot, Admin Building and OCC**				
a	Civil works	LS			5.00
b	E&M and M&P works	LS			5.00
	Subtotal (4)				**10.00**
5.0	**P-Way**				
5.1	Ballast less track	R. Km.	8.42	3.332	28.06
5.2	Ballasted track for Depot, At Grade Section	T. Km.	4.98	0.20	1.00
	Subtotal (5)				**29.05**
6.0	**750 v DC Third Rail**				
6.1	Elevated Section	R.Km.	14.04	3.332	46.78
6.2	Depot	T.Km.	3.83	0.20	0.77
6.3	Catenary Maintenance Vehicle	Each	8.93	0	0.00
6.4	RSS cum TSS	Each	31.91	0	0.00
	Subtotal (6)				**47.55**
7.0	**Signalling and Telecom.**				
7.1	**Signalling**				
	Main line including OCC/BCC	R.Km.	5.62	3.332	18.73
	Depot including DCC	T.Km.	4.08	0.2	0.82
	On Board Equipment	Per Train	2.17	6	13.02
7.2	**Telecom**				
	Station	Per Station	5.74	3	17.22
	Depot	Per Depot	4.47	1	4.47
7.3	**Automatic Fare Collection(AFC) system**	Per Station	4.47	3	13.41
	Subtotal (7)				**67.66**

S. No.	Item	Unit	Rate	Qty.	Amount (Rs. in Cr.)
				Without taxes	
8.0	**Shifting of Miscellaneous Utilities**				
a	Civil and EM works	R. Km.	3.83	3.332	12.76
	Subtotal (8)				**12.76**
9.0	**Rolling Stock (2.9 m wide Coaches)**	Each	10.21	18	183.78
	Subtotal (9)				**183.78**
10.0	**Capital expenditure on security**	Per Station	0.47	3	1.41
	Subtotal (10)				**1.41**
11.0	**Staff quarter for O & M**				
a	Civil works	R.Km.	2.16	0.000	0.00
b	EM works etc	R.Km.	0.54	0.000	0.00
	Sub Total (11)				**0.00**
12.0	**Multimodal Integration and Last mile connectivity**				
a	Multimodal Integration and Last mile connectivity	Per Station	3.83	3	11.49
	Sub Total (12)				**11.49**
13.0	**Total of all items except Land**				**678.99**
14.0	**Total Tax and Duties**				**137.31**
15.0	**Total of all items including taxes and duties excluding land**				**816.30**
16.0	**General Charges incl. Design charges @ 5 % on all items except land**				**40.81**
17.0	**Contingencies @ 3 % on all items except land and G. Charges**				**24.49**
18.0	**Gross Total**				**881.60**
	Cost without land			**=**	**881.60**
	Cost including land			**=**	**891.93**

Table 0.21 - Details of Taxes and Duties

Basic Customs duty =	8.2500	%
CGST Customs Duty=	9.7425	%
SGST Customs Duty=	9.7425	%
Total Customs Duty=	**27.7350**	%
General IGST=	18	%
General CGST =	9	%
General SGST =	9	%

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	157.34		28.32	**28.32**
2	**Station Buildings**				
	Elevated station-Civil works	99.54		17.92	**17.92**
	Elevated station-EM works	30.63	1.70	4.41	**6.11**
3	**Depot**				
	Civil works	5.00	0.28	0.72	**1.00**
	EM works	5.00	0.28	0.72	**1.00**
4	**P-Way**	29.05	1.61	4.18	**5.79**
5	**Traction & Power Supply**	47.55	5.27	5.14	**10.41**
6	**Signalling and Telecom.**				
a	Signalling	32.56	4.52	2.93	**7.45**
b	Telecom	21.69	3.01	1.95	**4.96**
c	AFC	13.41	1.86	1.21	**3.07**
7	**PSD**	11.49	1.59	1.03	**2.63**
8	**R & R hutments**	16.29		2.93	**2.93**
9	**Misc. Utilities, Staff Quarters and Security**				
	Civil works	19.25	0.00	3.46	**3.46**
	EM works	6.42	0.00	1.15	**1.15**
10	**Rolling stock**	183.78	20.39	19.85	**40.24**
11	**Rent on Temporary Land**	4.87		0.88	**0.88**
	Total	**683.86**	**40.51**	**96.81**	**137.31**
	Total Taxes & Duties				**137.31**
Rate of Taxes & Duties on Total cost without Taxes & Duties					**20.08%**
Total Central GST & Basic Customs duty					74.68
Total State GST					62.63
Total Taxes & Duties					**137.31**

0.18.1.2 Shahpur to GIFT (Second Phase)

The overall Capital Cost for the second phase of Ahmedabad Phase-II B at January 2024 price level works out to **Rs. 626.22 Crores** excluding applicable Taxes & Duties of **Rs. 108.93 crores** as tabulated hereunder.

Table 0.22 - Capital Cost Estimate

Total length = 4.253 km (Entirely Elevated)
Total Stations = 3 (All Elevated)

January 2024 level

S. No.	Item	Unit	Rate	Qty.	Amount (Rs. in Cr.)
				Without taxes	
1.0	**Land**				
1.1	Permanent				
a	Government	ha	11.08	0.0000	0.00
b	Private	ha	26.60	0.3119	8.30
1.2	Temporary Land (@5% pa for 4 years)				
a	Government	Ha.	2.22	2.20	4.87
1.3	**R & R incl. Hutments etc.**	R. Km.	4.89	4.253	20.79
	Subtotal (1)				**33.96**
2.0	**Alignment and Formation**				
2.1	Elevated section (viaduct) including in station portion (Including Cost of Rain Water Harvesting)	R. Km.	47.22	4.253	200.83
	Subtotal (2)				**200.83**
3.0	**Station Buildings**				
3.1	Elevated stations (including finishes)	Each			
a	Civil works excluding viaduct in station portion	Each	33.18	3	99.54
b	EM works including lifts and escalators	Each	10.21	3	30.63
3.2	Providing Platform Screen Doors (PSD) at all stations	Per Station	3.83	3	11.49
	Subtotal (3)				**141.66**
4.0	**Augmentation of Depot, Admin Building and OCC**				
a	Civil works	LS			5.00
b	E&M and M&P works	LS			5.00
	Subtotal (4)				**10.00**
5.0	**P-Way**				
5.1	Ballast less track	R. Km.	8.42	4.253	35.81
5.2	Ballasted track for Depot, At Grade Section	T. Km.	4.98	0.20	1.00
	Subtotal (5)				**36.81**
6.0	**750 v DC Third Rail**				
6.1	Elevated Section	R.Km.	14.04	4.253	59.71
6.2	Depot	T.Km.	3.83	0.20	0.77

S. No.	Item	Unit	Rate	Qty.	Amount (Rs. in Cr.)
				Without taxes	
6.3	Catenary Maintenance Vehicle	Each	8.93	0	0.00
6.4	RSS cum TSS	Each	31.91	0	0.00
	Subtotal (6)				**60.48**
7.0	**Signalling and Telecom.**				
7.1	**Signalling**				
	Main line including OCC/BCC	R.Km.	5.62	4.253	23.90
	Depot including DCC	T.Km.	4.08	0.2	0.82
	On Board Equipment	Per Train	2.17	0	0.00
7.2	**Telecom**				
	Station	Per Station	5.74	3	17.22
	Depot	Per Depot	4.47	1	4.47
7.3	**Automatic Fare Collection(AFC) system**	Per Station	4.47	3	13.41
	Subtotal (7)				**59.82**
8.0	**Shifting of Miscellaneous Utilities**				
a	Civil and EM works	R. Km.	3.83	4.253	16.29
	Subtotal (8)				**16.29**
9.0	**Rolling Stock (2.9 m wide Coaches)**	Each	10.21	0	0.00
	Subtotal (9)				**0.00**
10.0	**Capital expenditure on security**	Per Station	0.47	3	1.41
	Subtotal (10)				**1.41**
11.0	**Staff quarter for O & M**				
a	Civil works	R.Km.	2.16	0.000	0.00
b	EM works etc	R.Km.	0.54	0.000	0.00
	Sub Total (11)				**0.00**
12.0	**Multimodal Integration and Last mile connectivity**				
a	Multimodal Integration and Last mile connectivity	Per Station	3.83	3	11.49
	Sub Total (12)				**11.49**
13.0	**Total of all items except Land**				**559.57**
14.0	**Total Tax and Duties**				**108.93**
15.0	**Total of all items including taxes and duties excluding land**				**668.50**
16.0	**General Charges incl. Design charges @ 5 % on all items except land**				**33.43**
17.0	**Continegencies @ 3 % on all items except land and G. Charges**				**20.06**
18.0	**Gross Total**				**721.98**
			Cost without land	**=**	**721.98**
			Cost including land	**=**	**735.15**

Table 0.23 - Details of Taxes and Duties

Basic Customs duty =	8.2500	%
CGST Customs Duty=	9.7425	%
SGST Customs Duty=	9.7425	%
Total Customs Duty=	**27.7350**	%
General IGST=	18	%
General CGST =	9	%
General SGST =	9	%

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	200.83		36.15	**36.15**
2	**Station Buildings**				
	Elevated station-Civil works	99.54		17.92	**17.92**
	Elevated station-EM works	30.63	1.70	4.41	**6.11**
3	**Depot**				
	Civil works	5.00	0.28	0.72	**1.00**
	EM works	5.00	0.28	0.72	**1.00**
4	**P-Way**	36.81	2.04	5.30	**7.34**
5	**Traction & Power Supply**	60.48	6.71	6.53	**13.24**
6	**Signalling and Telecom.**				
a	Signalling	24.72	3.43	2.22	**5.65**
b	Telecom	21.69	3.01	1.95	**4.96**
c	AFC	13.41	1.86	1.21	**3.07**
7	**PSD**	11.49	1.59	1.03	**2.63**
8	**R & R hutments**	20.79		3.74	**3.74**
9	**Misc. Utilities, Staff Quarters and Security**				
	Civil works	21.89	0.00	3.94	**3.94**
	EM works	7.30	0.00	1.31	**1.31**
10	**Rolling stock**	0.00	0.00	0.00	**0.00**
11	**Rent on Temporary Land**	4.87		0.88	**0.88**
	Total	**564.44**	**20.89**	**88.04**	**108.93**
	Total Taxes & Duties				**108.93**
Rate of Taxes & Duties on Total cost without Taxes & Duties					**19.30%**
Total Central GST & Basic Customs duty					57.57
Total State GST					51.36
Total Taxes & Duties					**108.93**

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

The Gift City Metro corridor from Gift City to Gift is proposed to be constructed in two phases:

Phase I: From Gift City to Shahpur. The construction of the corridor is expected to commence from July 2025 and complete by June 2029. The revenue operation is scheduled to commence on 01-07-2029.

Phase II: From Shahpur to Gift. The construction of the corridor is expected to commence from July 2029 and complete by June 2033. The revenue operation of the phase is scheduled to commence on 01-07-2033.

The route length of the metro system and estimated cost at January-2024 price level is placed in table 0.24 as under:

Table 0.24 Cost Details

Name of Corridor	Length (km)	Estimated cost without Land & taxes (Rs/Crore)	Estimated cost with land cost (Rs/Crore)	Estimated cost with all taxes & land cost (Rs/Crore)
Phase I: From Gift City to Shahpur	3.332	726.70	754.62	891.93
Phase II: From Shahpur to Gift	4.253	590.59	626.21	735.14

0.19.1 Investment Cost

The completion cost with taxes & duties have been calculated by taking escalation factor @ 5% p.a. on all items except land. The effective Customs Duty (CD) rate under project import scheme, post GST, works out to 27.735% {Basic CD @ 7.5%, IGST @ 18% and Cess @ 10%} on the imported portions. The GST rate on supply of works contract services has been considered @ 18% (CGST & SGST @ 9% each).

The total completion costs duly escalated and shown in the table 0.25 below have been taken as the initial investment.

Table 0.25A Year –wise Investment (Completion Cost) of Phase I

Rs./ Cr.

Financial Year	Completion Cost including all Taxes & Land Cost
2025-26 (9 Months)	151.36
2026-27	305.62
2027-28	320.26
2028-29	217.55
2029-30 (3 Months)	55.84

Financial Year	Completion Cost including all Taxes & Land Cost
Total	**1050.64**

Table 0.25B Year –wise Investment (Completion Cost) of Phase II

Rs./ Cr.

Financial Year	Completion Cost including all Taxes & Land Cost
2029-30 (9 Months)	151.67
2030-31	303.48
2031-32	317.88
2032-33	214.09
2033-34 (3 Months)	54.95
Total	**1,042.08**

0.19.2 Fare Structure

The following fare structure considered during traffic survey and ridership projections; have being used as base fare for calculation of FIRR of the project. The FIRR has been calculated by using an escalation factor @14% once in every two years on the existing fare structure considering the average trend in the Consumer Price Index (CPI) and for the last ten years and input costs of operation. While estimating revenue, it is presumed that 30% of the commuters will be using smart card and therefore 10% additional discount on smart card travellers has been considered. The fare structure assumed for the Year 2028 with an escalation @ 14% once in two years on the existing fare structure as per the proposed fare slabs is shown in the Table 0.26 below**:**

Table 0.26 Fare Structure

Distance	Fare in 2024	Fare in 2029
0-2 Km	10	14
2-5 Km	20	28
5-12 Km	30	42
12-21 Km	40	56
21-32 Km	50	69
More than 32 Km	60	83

0.19.3 Financial Internal Rate of Return (FIRR)

The Financial Internal Rate of Return (FIRR) has been calculated for 30 years business model, from start of Phase-I, and is placed in table 0.27. Separate FIRR for complete cycle of Phase-II has not been shown.

Table 0.27: FIRR

Figures in cr. (Rs.)

YEAR	Completion Cost	Replacement Cost	Fare Box Revenue	Non-Fare Box Revenue	Total Revenue	Running Exp	Net Cash Flow

YEAR	Completion Cost	Replacement Cost	Fare Box Revenue	Non-Fare Box Revenue	Total Revenue	Running Exp	Net Cash Flow
25 - 26	151						-151
26 - 27	306						-306
27 - 28	320						-320
28 - 29	218						-218
29 - 30	208		45	5	50	13	-170
30 - 31	303		68	7	75	18	-247
31 - 32	318		82	8	90	19	-247
32 - 33	214		89	9	98	21	-137
33 - 34	55		110	11	121	43	23
34 - 35			119	12	131	53	78
35 - 36			147	15	161	57	104
36 - 37			159	16	175	61	114
37 - 38			198	20	218	65	152
38 - 39			215	21	236	70	166
39 - 40			265	27	292	75	217
40 - 41			288	29	317	80	236
41 - 42			356	36	392	88	304
42 - 43		-	360	36	396	94	301
43 - 44			416	42	457	101	356
44 - 45			420	42	462	108	354
45 - 46			484	48	532	116	416
46 - 47			489	49	538	125	413
47 - 48			562	56	619	134	484
48 - 49			568	57	625	144	481
49 - 50		128	656	66	721	155	439
50 - 51		135	663	66	729	166	428
51 - 52			763	76	840	181	659
52 - 53			771	77	848	194	654
53 - 54		155	887	89	976	209	612
54 - 55		162	896	90	986	225	599
Total	**2093**	**580**	**10076**	**1008**	**11083**	**2617**	**8.58%**

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 (SPV) under the Government Control (Delhi Metro Rail Corporation (DMRC) /Bangalore Metro Rail Corporation (BMRC))

(ii) Design, Build, Finance, Operate & Transfer (DBFOT)

i) SPV model

It is assumed that the funding of the corridor would be on similar lines as per the funding patterns of already running lines of Gujarat Metro. Besides, land including R&R should be made available free from all encumbrances by the State Government

Authorities when the project starts. Accordingly, the funding pattern under SPV model assumed is placed in table 0.28A and 0.28B as under: -

Table 0.28A: Funding pattern SPV Model Phase I

Sources of Funds	Amount (Rs/Crore)	% contribution
Equity from Govt. of India	145.52	**15.34%**
Subordinate debt for Central Taxes by Govt. of India	44.20	**4.66%**
Equity from Government of Gujarat	145.52	**15.34%**
Subordinate debt for Central Taxes by Govt. of Gujarat	44.20	**4.66%**
PTA against Bilateral/Multilateral Loan	569.15	**60.00%**
Sub Total	**948.59**	**100.00%**
Land Cost to be borne by Govt. of Gujarat	27.92	
State Taxes to be borne by Govt. of Gujarat	74.13	
Project Completion Cost	**1050.64**	
Interest during construction (IDC) on Bilateral/ Multilateral Loan	16.71	
Completion Cost including IDC	**1067.55**	

Table 0.28B: Funding pattern SPV Model Phase II

Sources of Funds	Amount (Rs/Crore)	% contribution
Equity from Govt. of India	145.10	**15.56%**
Subordinate debt for Central Taxes by Govt. of India	41.41	**4.44%**
Equity from Government of Gujarat	145.10	**15.56%**
Subordinate debt for Central Taxes by Govt. of Gujarat	41.41	**4.44%**
PTA against Bilateral/Multilateral Loan	559.54	**60.00%**
Sub Total	**932.56**	**100.00%**
Land Cost to be borne by Govt. of Gujarat	35.62	
State Taxes to be borne by Govt. of Gujarat	73.90	
Project Completion Cost	**1042.08**	
Interest during construction (IDC) on Bilateral/Multilateral Loan	16.42	
Completion Cost including IDC	**1058.76**	

ii) Design-Build-Finance-Operate-Transfer (DBFOT) Model:-

In this model, the private firm will be responsible for designing, building, financing, operating and maintaining the entire project for the period of concession. Ownership of the Project shall be transferred to Government after the concession period. Apart from equity contribution from the promoters, it is assumed that the funding for the

project shall be achieved through market borrowings. The rate of interest on market borrowings is assumed at 12% p.a. The Metro Rail being a social sector project, not many private parties are likely to bid for such a project. Besides, the private operator may demand assured rate of return on its equity, which is in the range of 20% p.a. to 22% p.a. (pre-tax) or a comfort of guaranteed ridership, sweeteners in the form of huge parcels of land free of cost for commercial exploitations. Viability Gap Funding (VGF) shall be required from Govt. of India as well as Govt. of Gujarat to ensure an Equity IRR of approx. 16% for the Concessionaire. The funding pattern under the above model has been worked out with a pre-tax Equity Internal Rate of Return (EIRR) @ 16% is shown in the table 0.29 below:

Table 0.29 Funding pattern under DBFOT model

Particulars	Amount (Rs/Crore)	% of contribution
VGF by GOI	376.23	20.00%
VGF by Govt. of Gujarat	392.20	20.85%
Equity by Concessionaire	370.91	19.72%
Concessionaire's Debt	741.81	39.43%
Sub-Total (A)	**1881.15**	**100.00%**
Land including R&R by State Government	63.54	
State Taxes by State Government	148.03	
Sub-Total (B)	**2092.72**	
Interest during construction (IDC) on Debt	358.52	
Total including IDC	**2451.24**	

The total fund to be contributed by GoI & GoG, excluding bilateral/multilateral loan, is shown in Table 0.30 below under SPV and BOT mode.

Table 0.30 *Rs. In crore*

Particulars	SPV Model	DBFOT
GOI	376.23	376.23
Govt. of Gujarat	587.80	603.77
Total	**964.03**	**980.00**

0.19.5 Recommendations

The project is operationally viable as the FIRR for a period of 30 years period including construction period with all the taxes is 8.58%. However, FIRR is not the only criteria to take up the metro project. As per Metro Rail Policy 2017, issued by the Ministry of Housing and Urban Affairs, 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. Considering the positive FIRR as well as social considerations of requirement of reliable public transport, the project is recommended for its implementation.

From Table 0.30, it is evident that the VGF required to be contributed by GOI & GoG for executing the project through a DBFOT operator is higher as compared to the SPV model. The fund requirement under DBFOT model has been made with the assumption of 16% pre-tax EIRR. However, the DBFOT operator may expect the pre-tax EIRR of at least 20%, in such a situation, the VGF amount will only increase further. Therefore, it is recommended to implement the project through SPV model as per the funding pattern shown in Table 0.28.

0.20 ECONOMIC APPRAISALS

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

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

0.20.1 Economic Performance Indicators

After generating the cost and benefit stream tables, values of economic indicators are derived and are given in the table below. Project period is 2025 to 2054. On the basis of economic cost, EIRR is 17.61%, B/C Ratio is 4.27 and NPV is Rs. 1,348 Cr. As per the Appraisal Guidelines for Metro Rail Project Proposals, a project is considered viable when the ENPV is 14% or above.

Table 20.11 Economic Indicator Values (on 2053-54)

Economic Indicators	Economic Price
Total cumulative cost	4,495
Total cumulative benefit	19,183
Benefit Cost Ratio	4.27
NPV	1,348
EIRR	**17.61%**

0.21 TRANSIT ORIENTED DEVELOPMENT (TOD) AND VALUE CAPTURE FINANCE (VCF)

0.21.1 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.

0.21.2 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.

0.21.3 Potential of TOD and VCF in Ahmedabad Metro Phase – II B Corridor

GMRC may explore possibility of capturing land value by selling higher FSI in the corridor influence area. Further, various Value Capture Methods such as Land Value Tax, Fees for changing land use, Betterment levy, etc. as detailed in earlier paras may be adopted by GMRC as suitable for generating revenue. State TOD policy or guidelines, if any issued by Government of Gujarat (GoG) may be followed for Transit Oriented Development and Value Capture Financing.

0.22 CYBER SECURITY

0.22.1 Introduction

Strong cyber security is an important component of Digital Strategy enabling the effective use of emerging technologies and ensuring confidence in the services.

Cyber Security is becoming more important as cyber risked contraire to evolve. It becoming more challenging due to increased thrust on distribution which increasing cyber connectivity.

Cyber security is a complex and multifaceted issue, where details relating to vulnerabilities, threat, risk, mitigation, or other factors are likely to be highlighted contextually to a specific organization and its operations.

0.22.2 Scope

The scope was designed to focus on metro-specific systems and cyber problems which could cause major (or exacerbate) disruption. Metro Rail system can be categorized into OT (Operation technology) system and IT (Information Technology) system.

- OT (Operation technology) system includes SCADA, CBTC, passenger information, maintenance management and other proprietary systems at the heart of metro operation.
- Information Technology (IT) systems includes corporate computer networks, fare collection system, payment systems and ERP which are not unique to metros and general in nature.

0.22.3 Overview of Domain of Cyber Security

- **Data Security** - Protection of data from unauthorized, accidental or intentional modification, destruction, or disclosure.
- **Physical Security** - It describes security measures that are designed to deny unauthorized access to facilities, equipment and resources and to protect personnel and property from any damage or harm.
- **Identity, Access and Privilege Management** - It is about safeguarding data by protecting who has access to the systems; and what they are allowed to do.
- **Application Security** - It involves suitable application security measures to protect information of the organization which can be compromised or exposed if applications are not securely designed, developed, tested, configured and deployed.
- **Network and Infrastructure Security** - It is used to manage and restrict access to the network, application security, email security, firewalls, antivirus, intrusion prevention systems, and VPNs (Virtual Private Network) etc.
- **Virtualization Security** - It describes collective measures, procedures and processes that ensure the protection of a virtualized infrastructure / environment.

  Governance - It describes various security measures to ensure timely identification, prioritization and remediation of the security risks. Further, it lists guidelines for continuous monitoring of the implemented cyber security processes.

0.23 IMPLEMENTATION PLAN

Implementation on Delhi Metro/Chennai Metro Model

GMRC has to take action for appointment of General Consultants for project management including preparation of tender documents. Till the General Consultants are in position, GMRC 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 0.32

Table 0.32 - Implementation Schedule through DMRC model

S. No.	Item of Work	Completion Period
1	Submission of Final DPR to State Govt.	D

S. No.	Item of Work	Completion Period
2	Approval of DPR by State Government	D + 0.5 month
3	Submission of DPR for Approval of Ministry of Urban Development (MoUD).	D + 1 month
4	Appoint interim Consultant for preliminary works	D + 2 months
5	Approval of Project by Public Investment Board	D + 2 months
6	Sanction of Project by Government of India	D + 3 months
7	Appoint General Consultant	D + 9 months
8	Tendering, Execution of works and Procurement of equipments, coaches and installations	D + 48 months
9	Testing and Commissioning	D + 49 months
10	Revenue Operation	D + 49 months

Note: The above schedule is proposed for implementation of first phase of Phase-II B i.e. from GIFT City to Shahpur. Remaining section from Shahpur to GIFT is proposed to be implemented in second phase from 2029-2033.

0.24 CONCLUSIONS & RECOMMENDATIONS

- 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 for extension of under construction GNLU to GIFT City corridor is proposed for implementation under two phases.

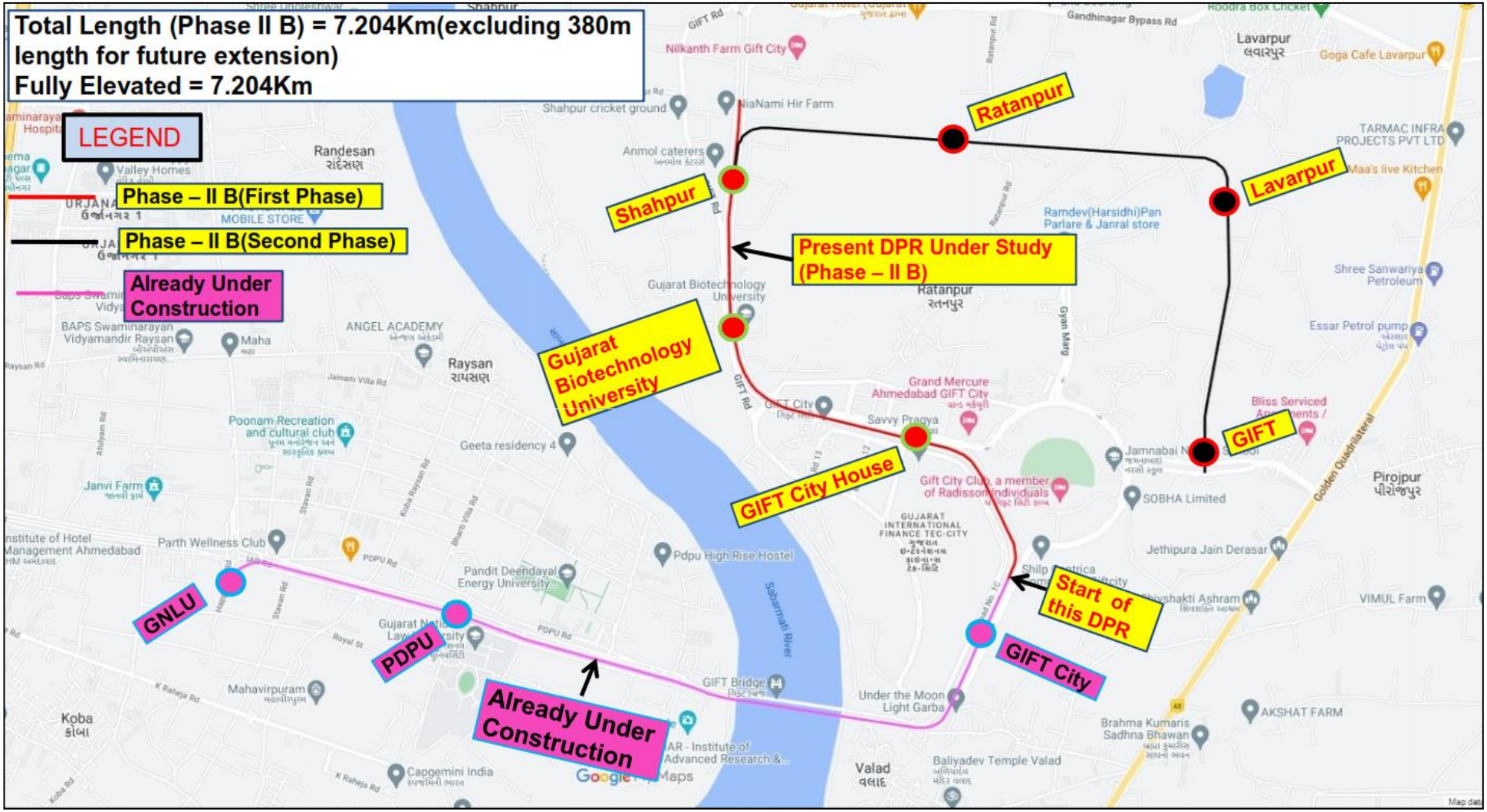
- In first phase GIFT City (excluding) to Shahpur (3.33 km) at a completion cost of Rs.1050.64 Crores (including Cost of Land and all taxes & duties) to be made operational by July 2029 as recommended in implementation chapter. In addition to this, Rs. 16.71 Crore IDC for Loan is to be borne by GoG.

- In second phase Shahpur (excluding) to GIFT (4.253 km) at a completion cost of Rs.1042.08 Crores (including Cost of Land and all taxes & duties) to be made operational by July 2033 as recommended in implementation chapter. In addition to this, Rs. 16.42 Crore IDC for Loan is to be borne by GoG.

- While the Financial Internal Rate of Return (FIRR) for the project (entire corridor from GIFT City (excluding) to GIFT i.e. first and second phase combined) has been assessed as 8.58% and the Economic Internal Rate of Return (EIRR) for same works out to 17.61%. Therefore, it is recommended for implementation.

INDEX PLAN

Phase – II B



Chapter -1

Introduction



1.1 Background

1.2 Study Background

1.3 Present Study

1.4 Structure of the Report

1.5 Observation Closed on Draft Report



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, a newly built stadium, called Narendra Modi Stadium, at Motera can accommodate 132,000 spectators, making it the largest stadium in the world. The world-class Sardar Vallabhbhai Patel Sports Enclave is currently under construction and once complete, it will be one of the biggest sports centers (Sports City) in India. 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. The historic city of Ahmedabad, or Old Ahmedabad, was declared a UNESCO World Heritage City in July 2017. In 2020, the gross domestic product of Ahmedabad metro was estimated at $68 billion and it was ranked as the third-best city in India to live by the Ease of Living Index. Recently Time magazine included Ahmedabad in its list of world's 50 greatest places of 2022. 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) implemented under Metro Phase I are already operational since September 2022. The same is shown in the Figure below.

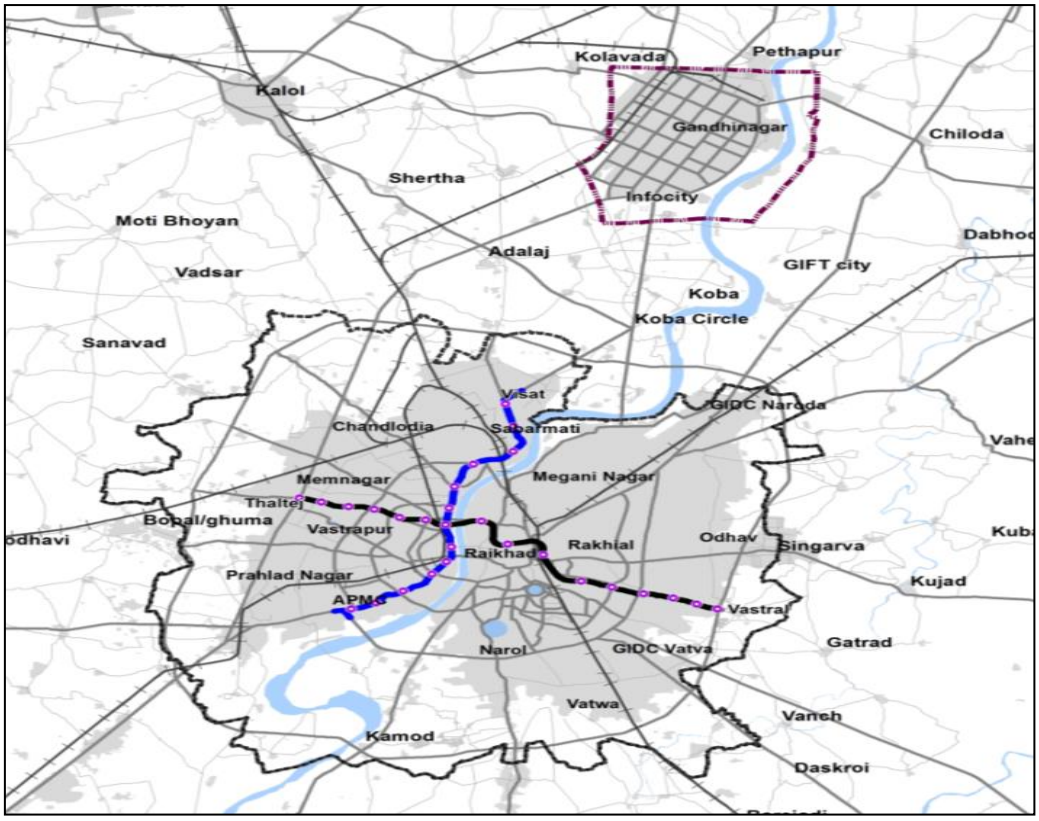


Fig.1.1 Operational Metro Corridors – Phase I

Subsequently vide Work Order No. MEGA/DMRC/DPR/PHASE-II/2016/WO, dated 23.02.2016, MEGA Co. Ltd. entrusted the work of preparation of DPR for Ahmedabad Metro Phase-II to DMRC for connecting APMC – Motera line to Gandhinagar and also to connect GIFT City and Airport. DPR for the same submitted in September 2017. Later this DPR got revised in September 2018 and subsequently updated in March 2019 which got approved by GoI. According to the approved DPR, following Metro Rail Corridors are already under implementation under Ahmedabad Metro Phase-II:

a. Extension of existing N-S Corridor from Motera Stadium to Mahatma Mandir (22.838 km)
b. GNLU to GIFT City (5.416 km)

1.3 PRESENT STUDY

GMRC vide Letter of Acceptance No. GMRC/Phase-IIB/G/0/438 dated 10/02/2023 and subsequent letter No. GMRC/Phase-IIB/G/0/856 dated 23/03/2023, entrusted the work of preparation of Detailed Project Report (DPR) for additional metro corridor inside GIFT City from GIFT City Station to DMRC.

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.

(iii) Multi modal Traffic integration, planning for feeder bus service, public bike sharing and pedestrianization 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 including the topography surveys for adequate width for the viaduct and stations to accommodate any future minor modifications in the alignment and the location 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./GIFT City Ltd. through the concerned utility agencies. The responsibility to collect the utility data from the respective agencies lies with DMRC. However, the necessary co-operation/co-ordination will be extended by GMRC to carry out the same.

(vi) Geometric design of the route alignments covering horizontal as well as vertical profiles including viaduct and station GAD along the tentative pier 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 identified corridors.

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

(xi) Conceptual Plan for the rolling stock maintenance depots.

(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 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 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-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	TOD & VCF
Chapter-22	Cyber Security
Chapter-23	Implementation Plan
Chapter-24	Conclusions and Recommendations

1.5 RESPONSE TO THE OBSERVATION ON DRAFT DPR:

DMRC has submitted the DPR connecting inside GIFT City from GIFT City Station vide letter no. DMRC/Sr.GM/BD/99/GIFT CITY/2022-23/772 dated 28.03.3024.

Subsequently, GMRC has made observations vide letter no. GMRC/Phase-IIA/C&P/915 dated 15.05.2024 and email dated 14th August 2024 requested DMRC to submit the DPR after complying these observations.

The observation raised by GMRC, and necessary changes made in the report is given in Appendix- A of this DPR.

GOVT. OF GUJARAT

Dr. Manjula Subramaniam, IAS (Retd.)
Chairperson

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,

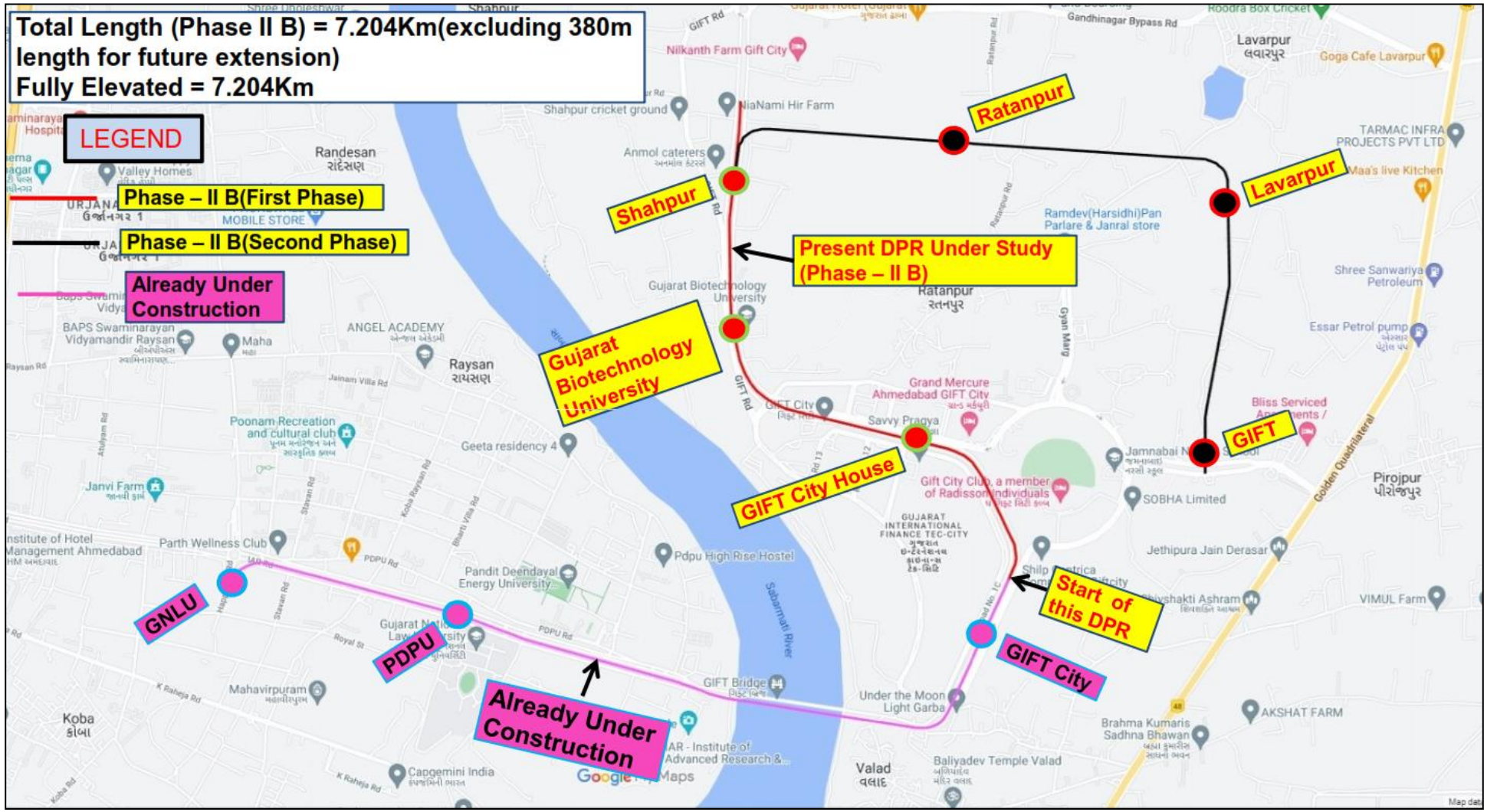
Yours sincerely,

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

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Phase – II B



Chapter - 2

Traffic Demand Forecast



2.1 Introduction

2.2 Study Area Delineation

2.3 Study Area Appreciation

2.4 Analysis of Existing Traffic and Travel Pattern

2.5 Ridership Estimation

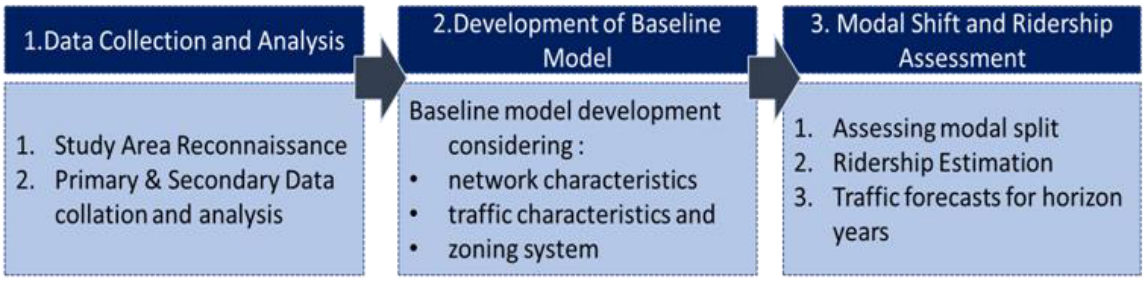


Chapter – 2

TRAFFIC DEMAND FORECAST

2.1 INTRODUCTION

The fundamental objective of this chapter is to provide an estimation of the proposed MRTS ridership with a fair degree of accuracy. The approach towards this ridership estimation has been divided into the following modules and is discussed in detail in subsequent sections.



1. Module-1: Data Collation and Analysis

This study requires a string of primary surveys to collect the required quantitative and qualitative information to understand the traffic and travel patterns emanating within the study area, and the consequent impact on travel demand. A number of primary and secondary surveys are conducted, which are discussed below:

(i) Stage-1: Primary Data Collection

The first stage in the estimation of metro ridership is to collate data on all factors that are likely to influence travel pattern of the study area. The work involves a number of surveys so as to have an idea about the existing travel pattern of the passengers. The main purpose of primary surveys is to collect the base line data; for

- understanding the existing travel characteristics,
- estimation and calibration of parameters of travel demand models and
- validation of model.

The data has been collected through both primary and secondary surveys. The primary surveys are as follows:

- Video-graphic Traffic Volume Counts including manual Occupancy Survey with software based vehicular classification
- Roadside Passenger Origin Destination Survey

(ii) Stage-2: Secondary Data Collection

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. Secondary data is also required for establishing trends and development patterns.

Past studies and reports related to traffic and transportation provide insights into the transportation characteristics and their associated trends. This includes Master Plans, Comprehensive Mobility Plan (CMP), Past Traffic Survey reports and other studies relevant for understanding the possible traffic and travel patterns of the corridor and the proposed development.

(iii) Stage-3: Data Analysis

The next stage involves analysis of the collated data. Various checks and quality measures are adopted to ensure data authenticity and accuracy. Primary indications of the data analysis are validated to ground conditions. The data analysis gives an insight of the existing traffic and transportation characteristics along the study corridors and its surrounding region.

2. Module-2: Development of Baseline Model Using Updated Traffic Data

(i) Stage-1: Development of Traffic Zone System

The catchment area of the project corridor is delineated into various traffic zones. Since the corridor under focus is spread over the whole city, an all-encompassing zoning system has been designed to take into account the relevant travel pattern.

(ii) Stage-2: Transport Network Representation

Digitized map of the area with road and proposed metro corridor network is generated with sufficient accuracy. This is in lieu of road network inventory data and other secondary information. During development of ridership estimation model, the prepared network is further used for traffic assignment purpose.

(iii) Stage-3: Trip Generation and Distribution

In this stage, zone wise generation-attraction parameters are estimated. Population, employment and visitor's data are considered for the same. Further, zone wise person trips are estimated using the above-mentioned zonal generation–attraction parameters in conjunction with the standard trip generation rates. Zone-wise estimated trip-ends are distributed using gravity model to obtain trip matrix for green field development. Further, existing travel pattern from Origin-Destination primary survey is added to get the complete passenger trip matrix.

3. Module-3: Modal Shift and Ridership Assessment

(i) Stage-1: Modal Split

Modal share of metro for the catchment area trips has been estimated and applied on the passenger trip matrix prepared in Module-2 to obtain trip matrix for proposed metro system.

(ii) Stage-2: Trip Assignment & Ridership Estimation

The obtained trip matrix mentioned in Stage-1 of Module-3 is assigned onto the network to estimate the ridership details. This is further forecasted for future horizon years.

2.2 STUDY AREA DELINEATION

The study corridors are for metro connectivity to GIFT City and Sardar Vallabhbhai Patel International Airport in Ahmedabad. These two connections are proposed as Phase-2(A) and Phase-2(B) of Ahmedabad Metro network. Ahmedabad Metro Phase-1 network of around 40 km consisting of two corridors, APMC to Motera Stadium (North–South) and Thaltej to Vastral Gam (East–West) are already operational. Phase-2 network as extension of north–south corridor from Motera in Ahmedabad to Mahatma Mandir in Gandhinagar (around 24 km) with a branch line from Gujarat National Law University (GNLU) linking Pandit Deendayal Energy University (PDEU) and GIFT City (around 5 km) is approved and under construction.

In view of the above, the entire Ahmedabad and Gandhinagar are considered as the study area.

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 based on contiguous built up and interaction with Ahmedabad. 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 (sq. km)	Place Name
GUDA	388	Urban Area (Gandhinagar Municipal Area, Adalaj) and 39 Villages of GUDA
AMC	466	Ahmedabad Municipal Corporation
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,

Area Boundary	Area (sq. km)	Place Name
		Rakanpur, Dantali, Iapkaman, Ranasan, Sanathal, Shela, Sugad, Zundal)
Outside AUDA	19.98	2 villages (Changodar, Moraiya)
Grand Total	**1146.41**	

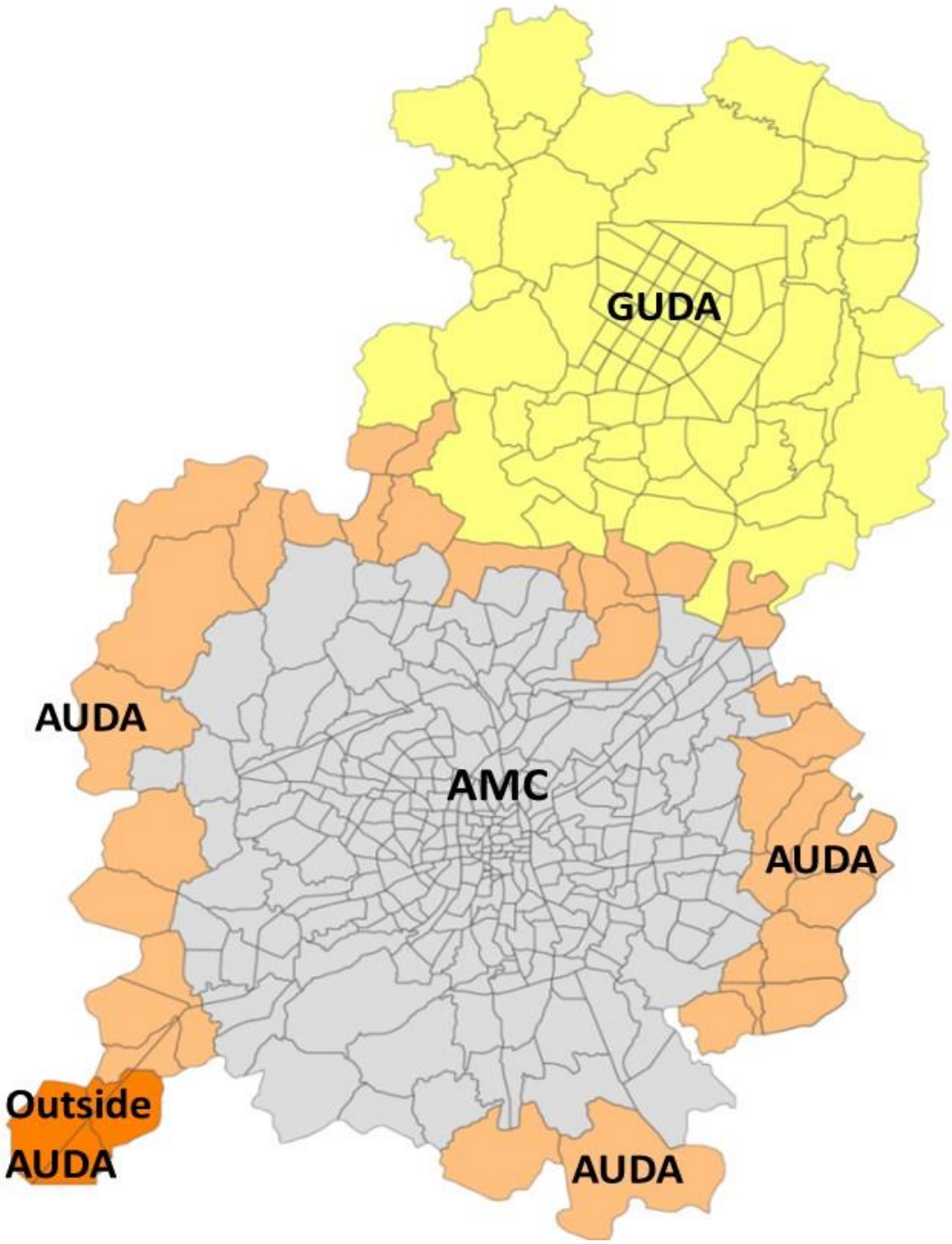


Figure 2.1 Study Area

2.3 STUDY AREA APPRECIATION

2.3.1 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.

2.3.2 City Profile

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.

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

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%.

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 2025 this economic hub would cater to 3 lakh jobs which would subsequently increase to 5 lakhs in the year 2030.

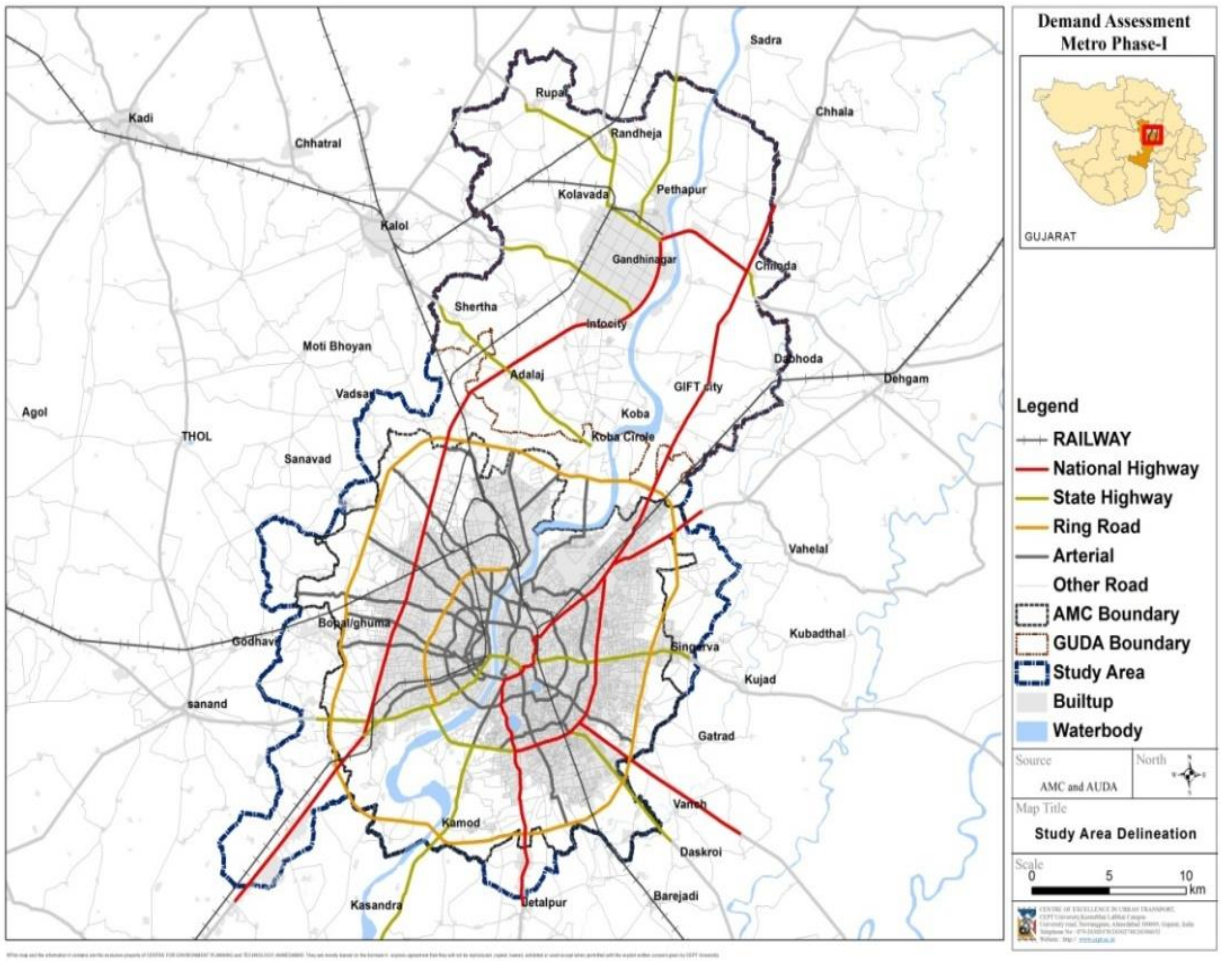
Table 2.3 Projected Employment of GIFT 2030

Year	Employment (lakh)
2025	3
2030	5

Data Source: MEGA Office, 2017

2.3.4 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 2.2 Existing Road Network in Study Area

Table 2.4 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*

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

Table 2.5 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

2.3.5 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 2.6 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

2.3.6 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 25 kmph along corridors.

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

2.3.7 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).

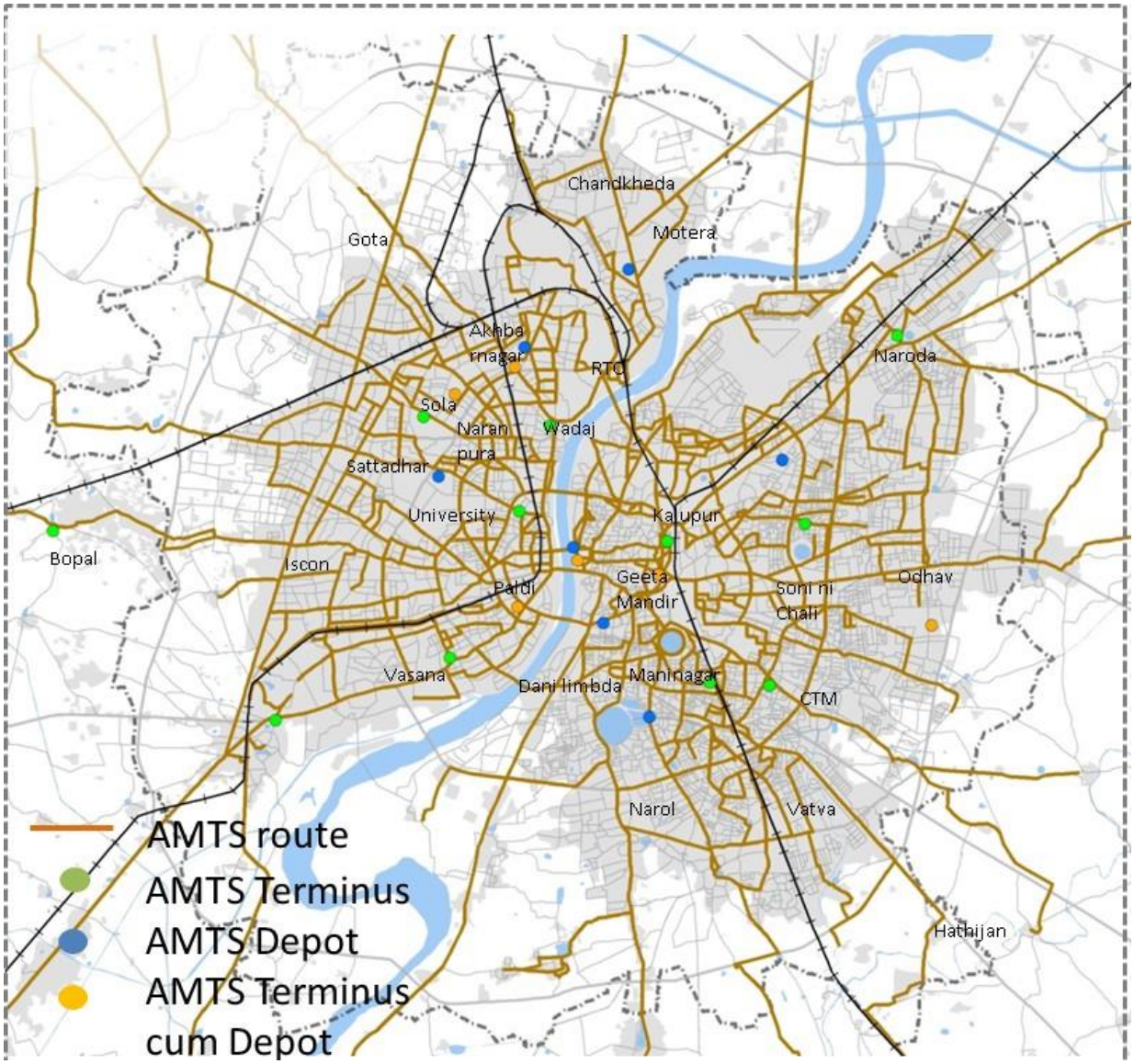
Ahmedabad is a city that is connected with 631 km network of Bus routes comprising of Bus Rapid Transit System - JANMARG and Ahmedabad Municipal Transport Service (AMTS) City Bus Services. BRTS services are operated by Ahmedabad Janmarg Limited (AJL), a special purpose vehicle (SPV) formulated by Ahmedabad 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 km 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.

The observed speed of AMTS is approximately 17 km/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 is 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 terminals cum depots.

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.

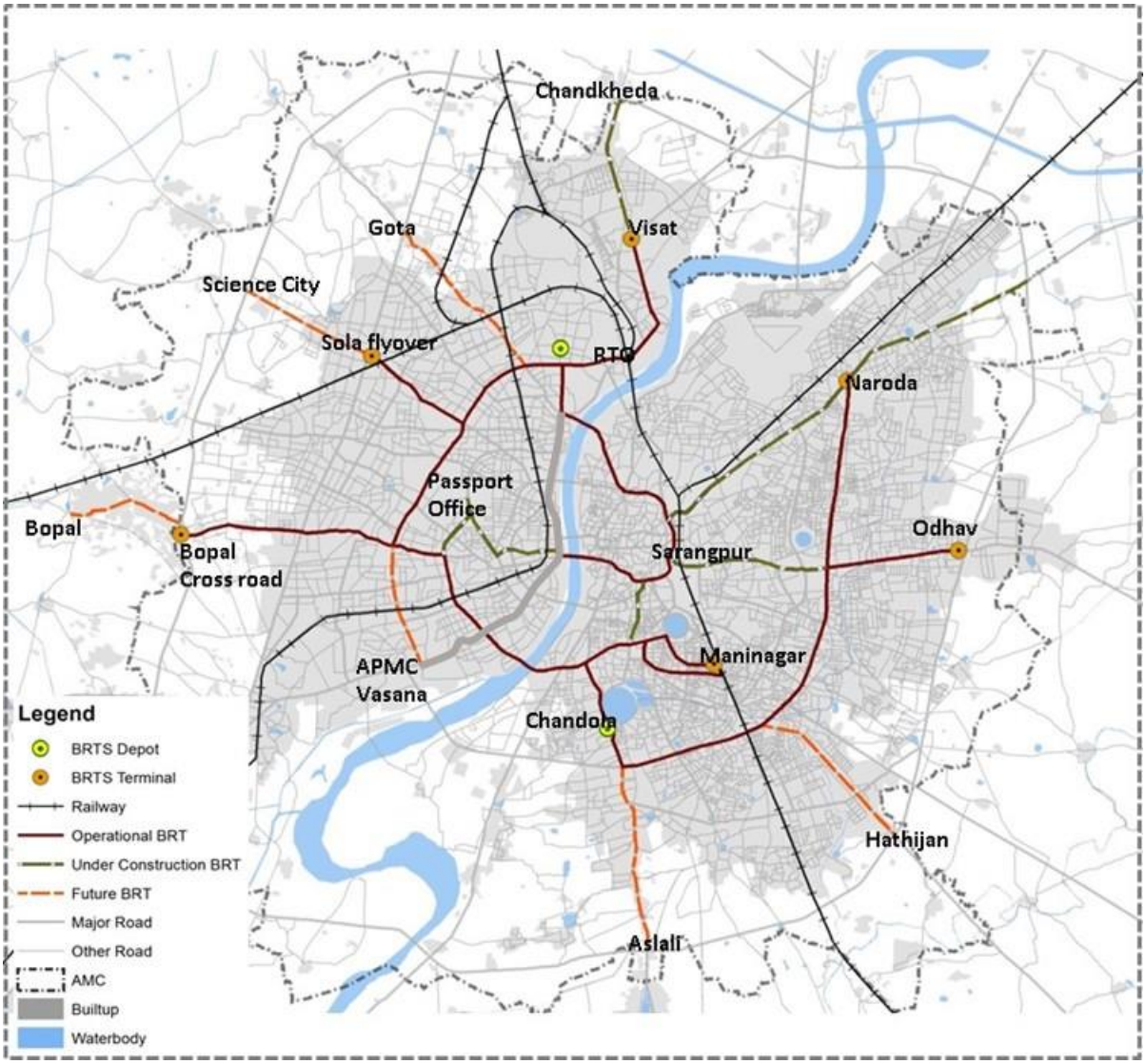


Source: COE (Centre of Excellence) in Urban Transport, CEPT University, Ahmedabad

Figure 2.3 AMTS Route network

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 18 routes with a network length of 160 kms. The BRT attracts a 2-lakh passenger daily. The 18 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 25 kmph 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 2.4 BRTS Route network

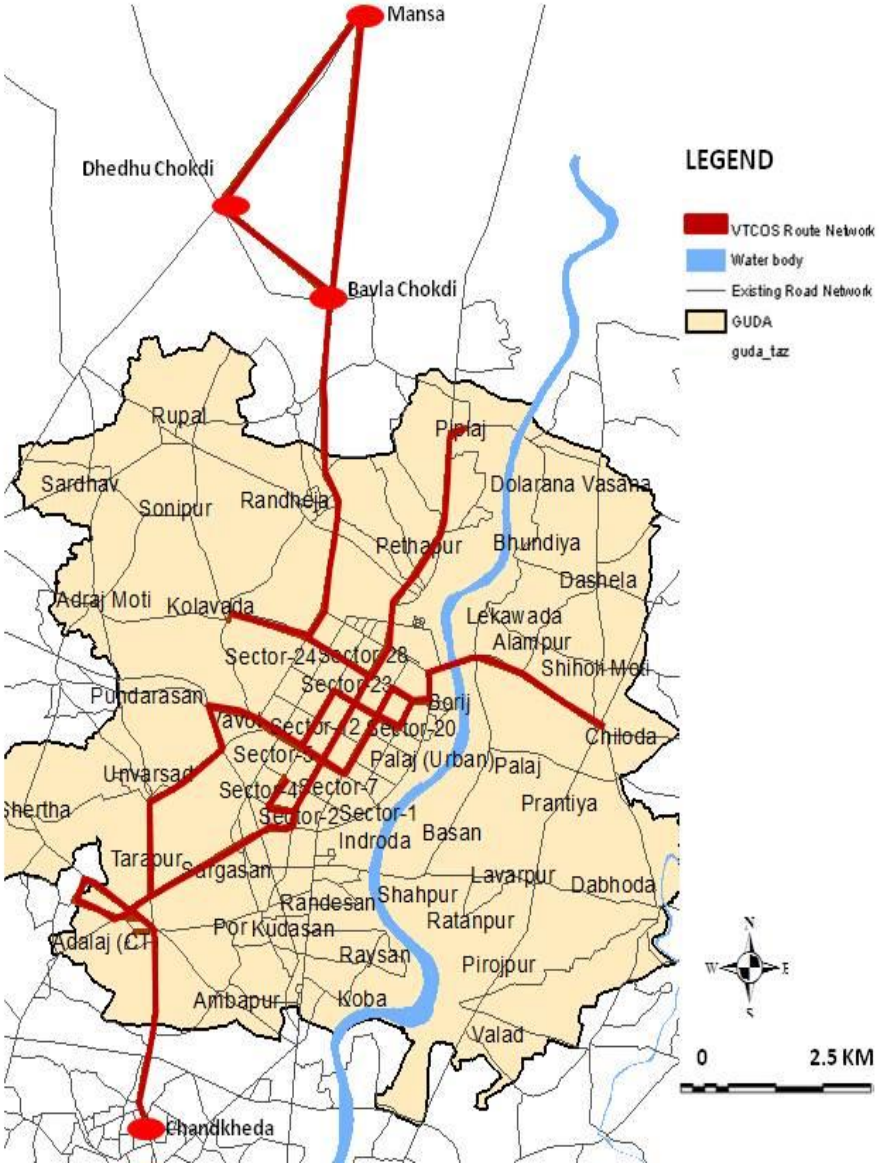
Vallabhipur Transportation Co-Operative Society Pvt. Ltd. (VTCOS) City Bus Service

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 2.5 City Bus Services in Gandhinagar

Ahmedabad Metro

Ahmedabad Metro is connecting the city of Ahmedabad, Gandhinagar, and the very ambitious Gujarat International Finance Tech-city (GIFT). The existing metro is currently operational on two corridors which forms the phase-I of the MRTS network:

1. Thaltej Gam – Vastral Gam (E-W Corridor)
2. APMC – Motera Stadium (N-S Corridor)

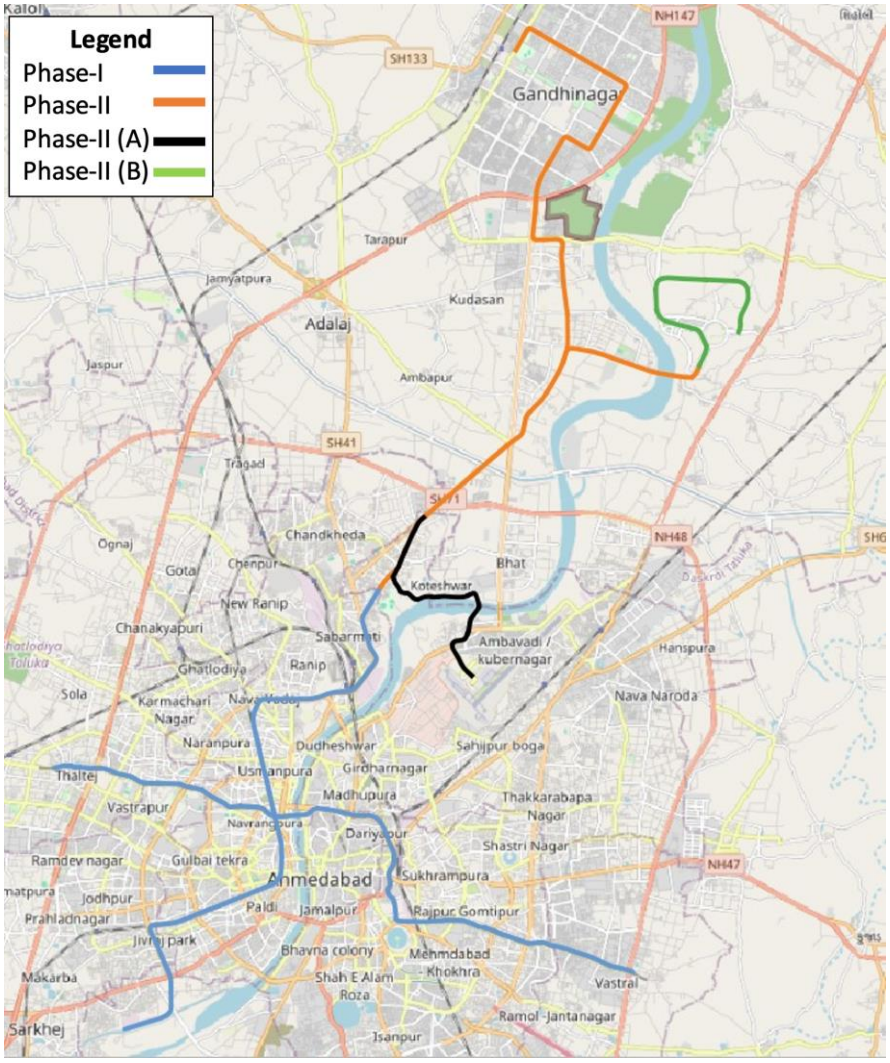
The Phase-II of the MRTS system is currently under construction which links Ahmedabad city to Gandhinagar is as follows:

1. Motera Stadium – Mahatma Mandir. (Extension of N-S Corridor) and
2. Branch line from Gujarat National Law University (GNLU) linking Pandit Deendayal Energy University (PDEU) and GIFT City

Moreover, as an extension of the said MRT system, two extensions of Phase-II are being considered to enhance the connectivity to important economic and transportation nodes. The two additional corridors being considered are as follows:

1. Phase-II (A): Koteshwar Road to Ahmedabad Airport
2. Phase-II (B): Extension of MRTS Corridor in GIFT City

Gujarat Metro Rail Corporation Ltd. (GMRCL) 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.



Source: DMRC, 2024

Figure 2.6 Ahmedabad Metro Route Map

2.4 ANALYSIS OF EXISTING TRAFFIC AND TRAVEL PATTERN

The primary surveys consist of two campaigns, one was done in 2018 for initial DPR preparation whereas another exercise was done in 2023 for the purpose of DPR updating and model updating and validation. 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 2.7 Description of Type of Surveys (2018)

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

Table 2.8 Description of Type of Surveys (2023)

Sl. No.	Types of Survey	Type of Survey Location	No of Locations
1	Traffic Volume Count (24 hrs for 1 day)	Mid-Block	4
2	Road Side Interview – OD Survey (16 hrs for 1 day)	Mid-Block	1
3	Airport Terminal OD Survey (16 hrs for 1 day)		2

Table 2.9 Traffic Volume Count and Origin-Destination Locations for 2018

Location ID	Survey Locations	City Area
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

Location ID	Survey Locations	City Area
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
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

Location ID	Survey Locations	City Area
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 are given in the following figure.

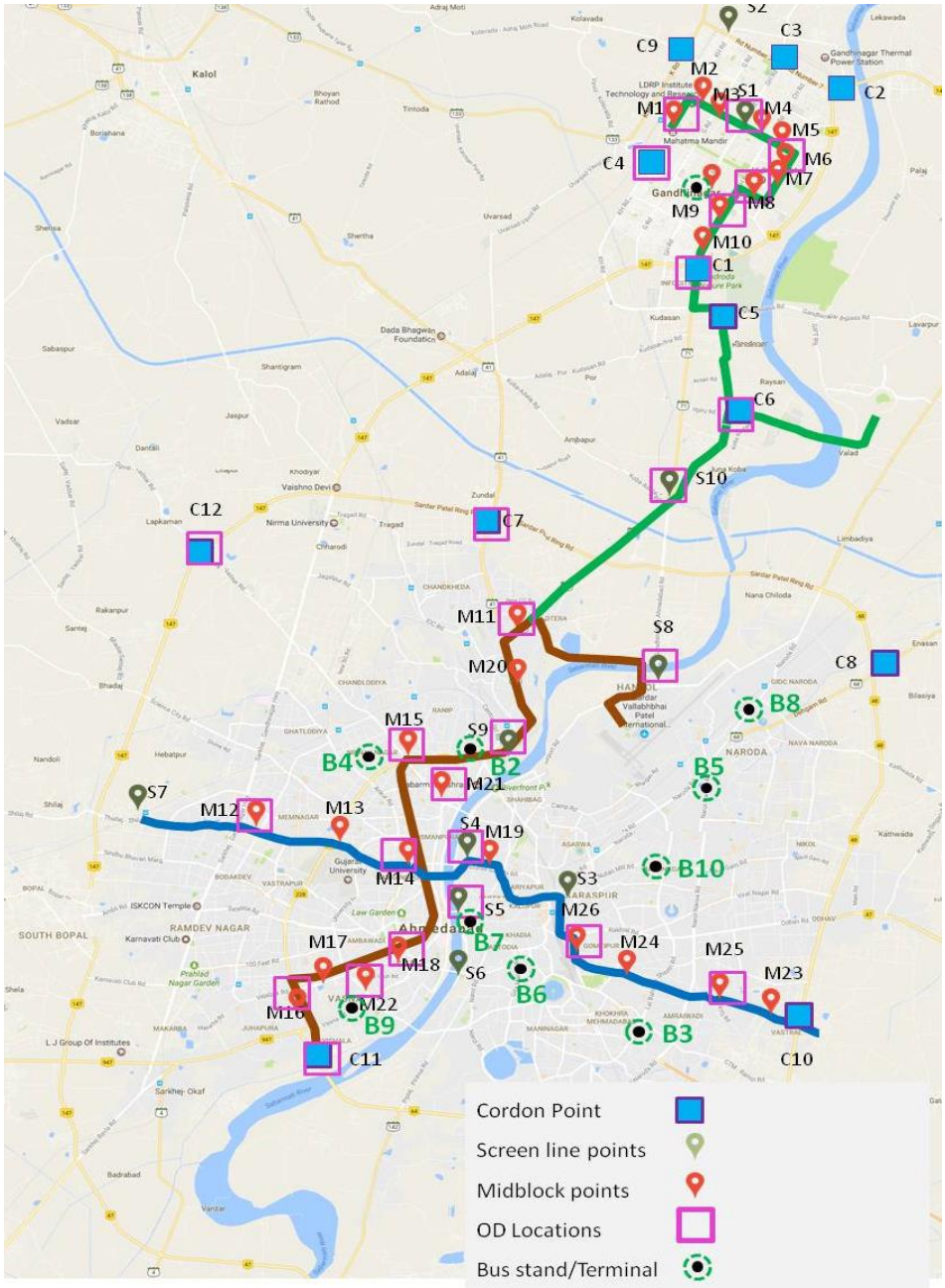


Figure 2.7 Primary Survey Location Map, 2017

Table 2.10 Traffic Volume Count and Origin-Destination Locations for 2023

Type of Survey	TVC & OD Locations	City Area
Traffic Volume Count	GIFT Bridge (PDPU Road)	GIFT
Traffic Volume Count	East Gate of GIFT City	GIFT
Traffic Volume Count	GIFT City Circle (GIFT Road)	GIFT
Traffic Volume Count	Indira Bridge Circle (Airport Road)	Ahmedabad
Origin-Destination	Ahmedabad Airport Terminal 1	Ahmedabad
Origin-Destination	Ahmedabad Airport Terminal 2	Ahmedabad
Origin-Destination	Indira Bridge Circle	Ahmedabad

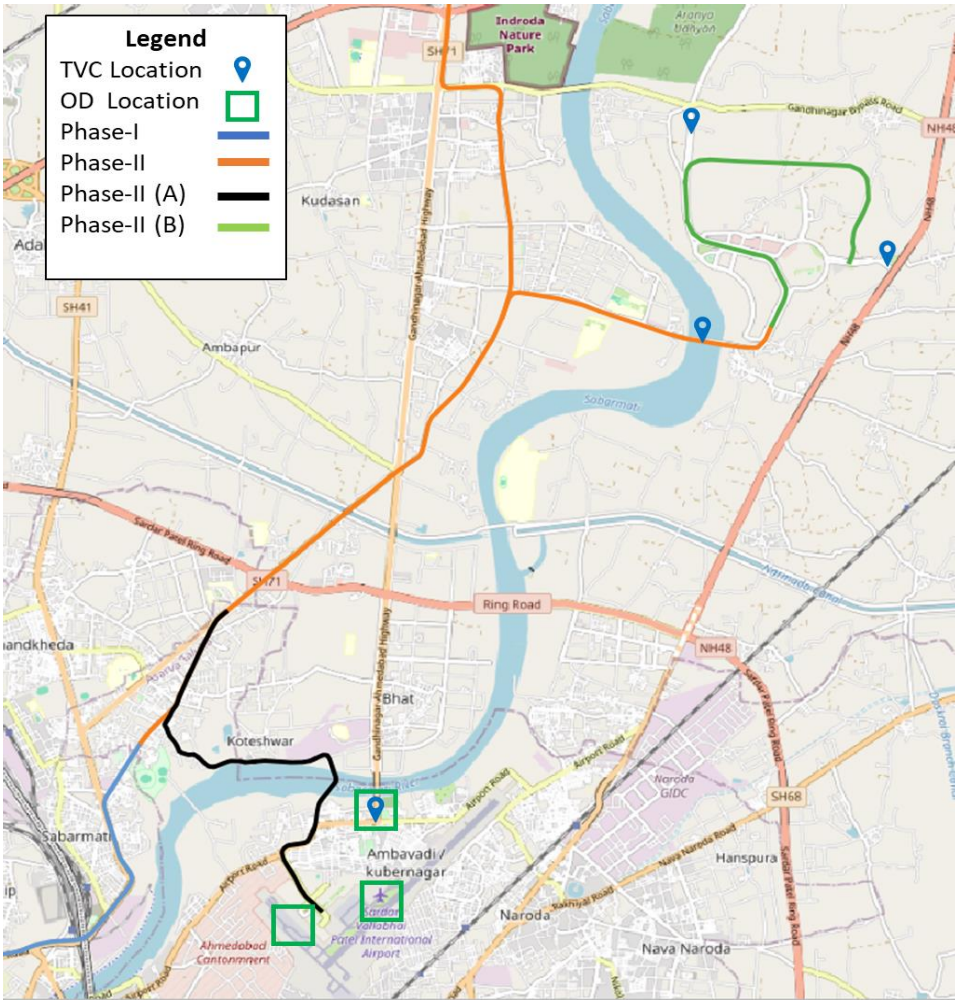


Figure 2.8 Primary Survey Location Map for Surveys Conducted in 2023

2.4.1 Classified Traffic Volume Count

Classified traffic volume count survey in 2018 was conducted at the 48 identified locations, which includes Screen line, Mid-Block and Cordon points. The same surveys in 2023 were conducted at 4 locations to gauge the change in traffic flow trends. 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 are presented below:

Table 2.11 Location wise Total Passenger, Vehicles and PCU (2018)

Location ID	Total Passenger	Total Vehicles	Total PCU's	Location ID	Total Passenger	Total Vehicles	Total PCU's
C1	58,269	31,833	27,242	M3	36,362	20,971	17,704
C2	24,104	14,012	12,003	M4	33,946	19,053	16,200
C3	17,452	9,815	8,369	M5	29,365	17,019	14,460
C4	24,744	15,000	12,673	M6	26,468	15,469	13,457
C5	5,576	2,425	2,149	M7	29,060	15,063	13,243
C6	924	691	497	M8	32,299	16,544	14,372
C7	49,975	28,138	24,587	M9	64,209	36,504	31,215
C8	18,260	11,172	9,913	M10	68,236	38,200	32,617
C9	12,708	6,607	6,307	M11	59,426	30,718	26,642
C10	30,527	19,237	16,414	M12	68,139	39,914	34,610
C11	37,856	21,616	19,381	M13	89,506	49,541	43,131
C12	36,055	20,281	17,857	M14	1,34,720	74,172	64,353
S1	37,123	20,169	17,088	M15	1,19,553	63,091	57,763
S2	23,017	13,603	11,482	M16	87,911	51,053	47,330
S3	76,792	42,980	37,286	M17	70,195	37,838	34,716
S4	2,08,105	1,06,827	97,000	M18	72,020	38,212	35,988
S5	1,31,698	75,325	65,469	M19	1,70,237	87,740	77,280
S6	1,26,360	71,171	62,321	M20	1,22,375	66,463	58,526
S7	36,786	21,488	18,675	M21	1,28,640	66,917	60,844
S8	34,792	19,823	17,995	M22	67,530	39,993	34,902
S9	1,18,735	64,922	59,273	M23	28,749	17,973	15,677
S10	71,488	35,966	32,439	M24	40,934	24,463	22,140
M1	26,977	16,532	13,967	M25	32,069	20,537	18,407
M2	31,538	17,531	14,931	M26	40,846	24,034	21,523

Table 2.12 Location wise Total Passenger, Vehicles and PCU (2023)

Location	Total Passenger	Total Vehicles	Total PCU's
GIFT Bridge (PDPU Road)	14,762	8,885	6,540
East Gate of GIFT City	19,627	11,702	8,656
GIFT City Circle (GIFT Road)	22,145	12,888	10,228
Indira Bridge Circle (Airport Road)	85,797	48,516	40,945

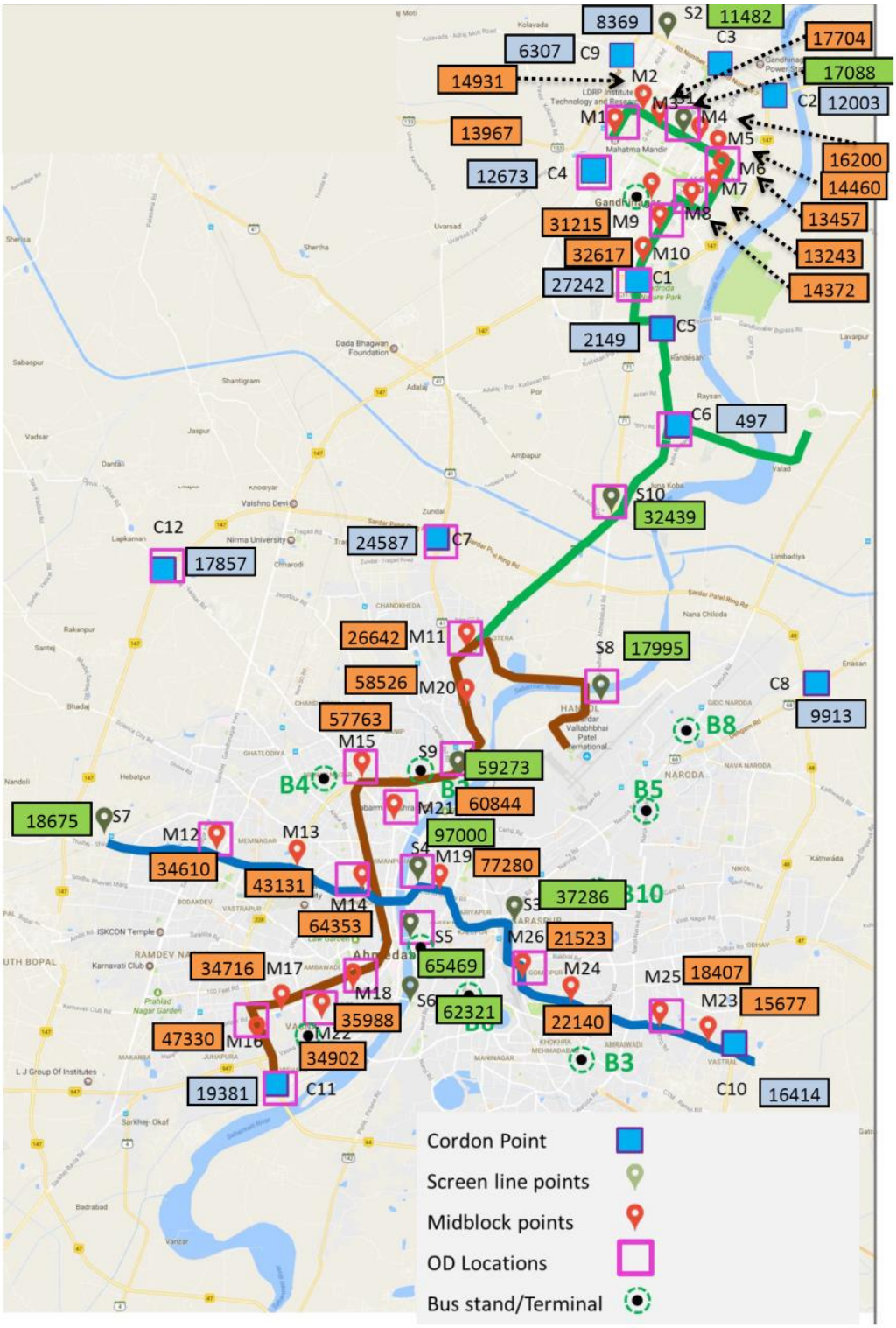


Figure 2.9 Passenger Traffic Volume (in PCU) at Different Survey Locations (from 2023 Survey)

Vehicular Composition

Vehicular composition 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. The surveys done in 2023 shows an increased share of cars/taxi as compared to the

scenario in 2018. One particular reason for the same is that the surveys were done on routes on which people travel longer distances due to their spatial positioning.

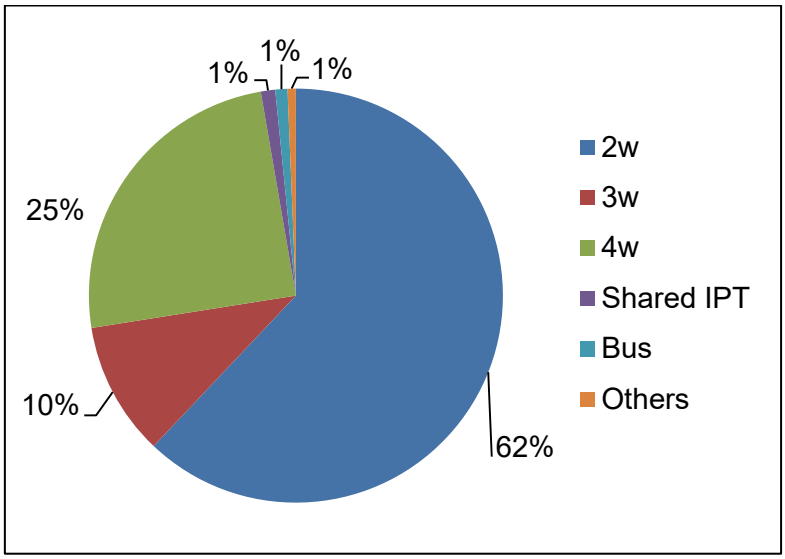


Figure 2.10 Vehicular Composition for Ahmedabad and Gandhinagar (as per 2018 Survey)

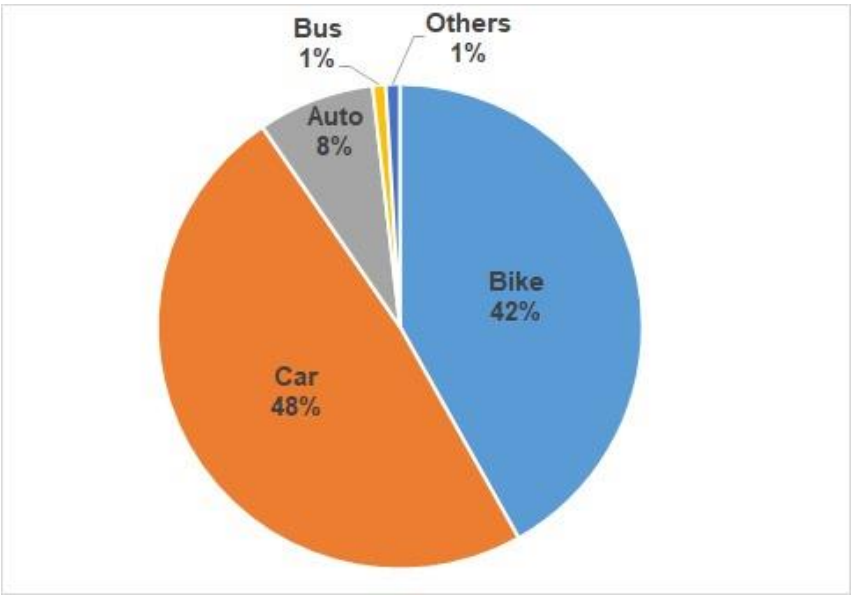


Figure 2.11 Vehicular Composition for GIFT City Area and Surrounding Areas of Ahmedabad Airport (as per 2023 Survey)

Table 2.13 Mode-wise Average Vehicle Occupancy

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

2.4.2 Traffic Area Zoning

For the purpose of origin destination surveys, traffic demand modelling, estimating travel pattern and updating loading and unloading at stations, 189 traffic area zones were created within the study area boundary that comprises of GUDA, AUDA, AMC and other areas beyond AUDA.

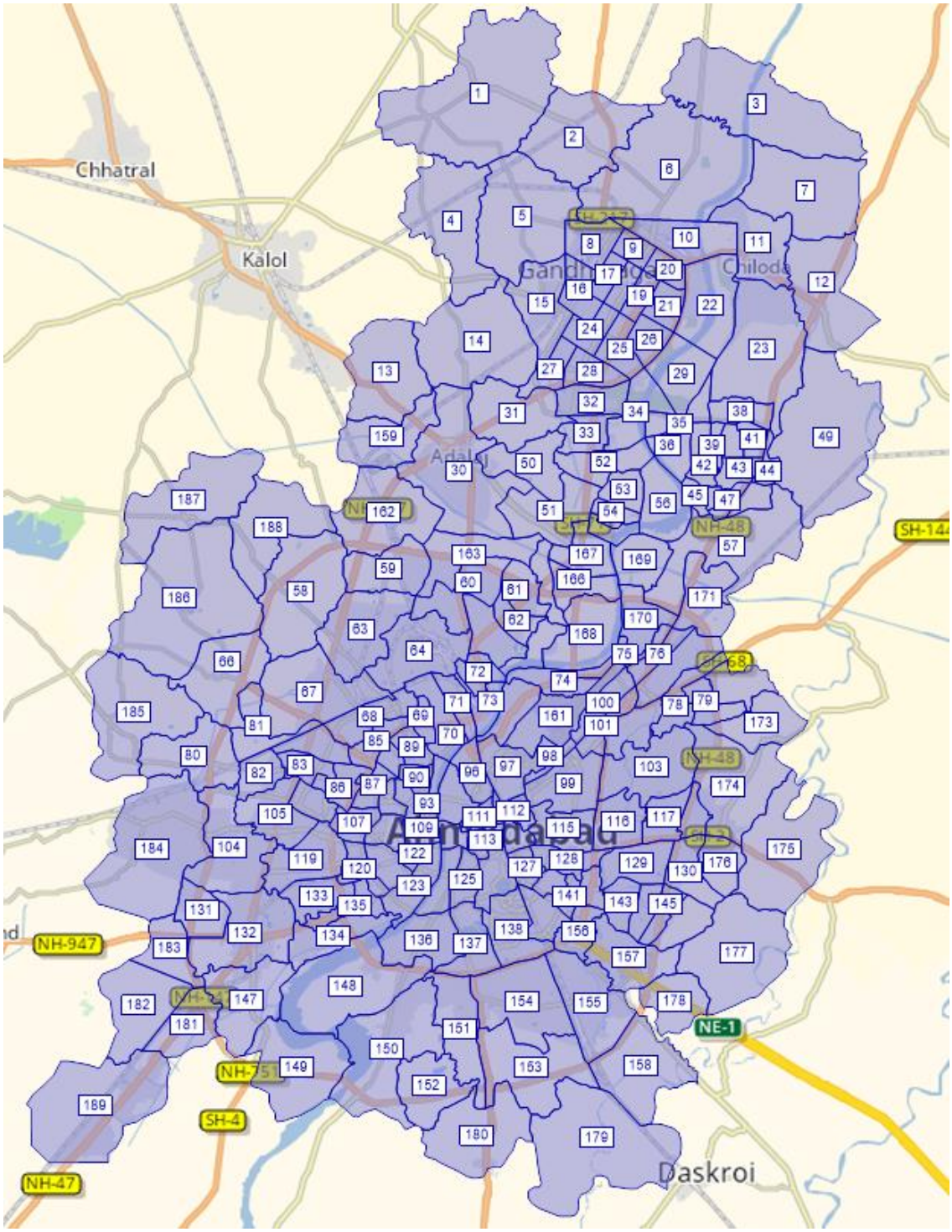


Figure 2.12 Traffic Area Zone Map

2.5 RIDERSHIP ESTIMATION

2.5.1 Planning Period

The base year of the study is considered as 2023. 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 2023 and secondary sources available.

2.5.2 Analytical Framework for Model Development

The figure below discusses the analytical framework towards the model built up. Worldwide accepted PTV VISUM software has been utilized to develop the ridership estimation model. A complete threefold 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. Network development is based on existing road network, route network of AMTS, BRTS routes, VTCOS routes, route network of existing and proposed metro.

- **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.

  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.

Table 2.14 Projected Population

Year	Population	CAGR	Source
2001	50,55,650	2.83%	Census 2001
2011	62,63,409	2.17%	Census 2011
2017	69,10,675	1.65%	Ahmedabad metro DPR-I
2021	78,53,584	2.29%	Development Plan of GUDA and Greater Ahmedabad, Revised development Plan Ahmedabad, Employment phasing of GIFT city
2031	86,41,875	0.96%	Development Plan of GUDA and Greater Ahmedabad, Employment phasing of GIFT city
2041	94,27,065	0.87%	IMaCS Projection
2051	1,00,30,912	0.45%	IMaCS Projection

Table 2.15 Population, Employment and Person Trips Forecast

Parameters	2017	2021	2031	2041	2051
Population	70,24,877	78,53,584	87,94,696	95,90,495	1,00,30,912
Employment	28,93,598	33,05,276	37,94,379	43,52,888	47,14,529
Trips	52,68,658	59,68,724	68,59,863	76,72,396	85,26,275
PCTR	0.75	0.76	0.78	0.80	0.85

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 2.16 Modal Split (%) of Motorized Trips for 2017

Mode	Modal Split (%)	Person Trips
Two-Wheeler	53.3	28,08,195
IPT (Auto + Others)	12.8	6,74,388
Four-wheeler	21.5	11,32,761
Bus	12.4	6,53,314

- **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.

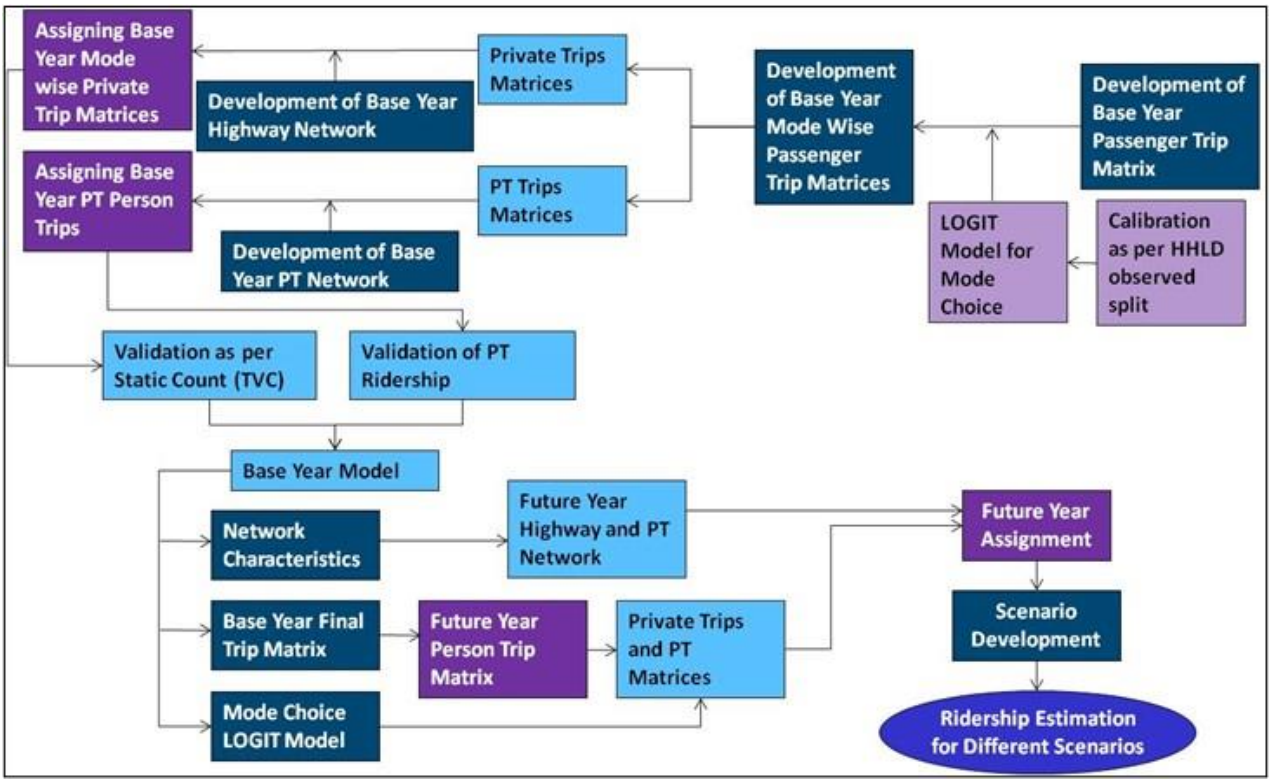


Figure 2.13 Analytical Framework for Ridership Estimation Model

2.5.3 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:

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

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:
$U(EM) = \alpha WT(EM) + \beta TT(EM) + \gamma TC(EM) + \varphi TR(EM) + \eta DC(EM)$
and $U(Metro) = \alpha WT(Metro) + \beta TT(Metro) + \gamma TC(Metro) + \varphi TR(Metro) + \eta DC(Metro)$
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 (₹/km) for utility function.

2.5.4 Estimated Ridership

Public transport network loading from public transport assignment represents the metro ridership separately. Both the peak hour and daily ridership have been assessed. The tables below represent the concise summary for Phase-II(A) and Phase-II(B) of the proposed metro for all horizon years.

Table 2.17 Ridership Summary for Phase-II (A & B)

Corridor	Year	Daily Ridership	PHPDT	ATL (km)
GIFT City Corridor (Combined MRTS Phase-II & Phase-II(B))	2029	39,119	2,083	-
	2031	46,241	2,346	-
	2041	99,220	5,105	-
	2051	1,11,575	5,733	-
GIFT City Corridor (MRTS Phase-II(B) only)	2029	26,214	1,437	24.52
	2031	32,567	2,346	25.23
	2041	73,868	5,105	25.33
	2051	82,054	5,733	25.31
Airport Corridor (MRTS Phase-IIA)	2029	27,496	1,452	18.92
	2031	31,462	1,662	18.97
	2041	41,011	2,164	18.93
	2051	51,636	2,719	18.84

Note: This corridor is proposed for implementation in two phases. In first phase it will be implemented till Shahpur and remaining section shall be implemented in second phase. First phase shall be implemented by 2029 and second phase by 2033. Accordingly, traffic shown above in year 2031 is till Shahpur only and 2041 onwards it is till GIFT station.

Table 2.18 Daily Boarding Alighting for GIFT City Corridor (Phase-II-B)

Daily Boarding Alighting of the MRTS Corridor in GIFT City									
2029									
UP Direction (GNLU to GF-III)					DN Direction (GF-III to GNLU)				
Station No.	Station Name	Boarding	Alighting	Sectional Load	Station No.	Station Name	Boarding	Alighting	Sectional Load
1	GNLU	20,832	0	0	6	Shahpur	77	0	0
2	PDPU	438	2,630	20,832	5	Gujarat Biotechnology University	2,793	0	77
3	GIFT City	155	4,448	18,640	4	GIFT City House	8,971	26	2,870
4	GIFT City House	26	10,890	14,347	3	GIFT City	3,793	139	11,815
5	Gujarat Biotechnology University	0	3,418	3,483	2	PDPU	2,034	363	15,469
6	Shahpur	0	65	65	1	GNLU	0	17,140	17,140
	Total	21,451	21,451				17,668	17,668	
	Ridership	**39,119**							

Daily Boarding Alighting of the MRTS Corridor in GIFT City									
2031									
UP Direction (GNLU to GF-III)					DN Direction (GF-III to GNLU)				
Station No.	Station Name	Boarding	Alighting	Sectional Load	Station No.	Station Name	Boarding	Alighting	Sectional Load
1	GNLU	23,461	0	0	9	GIFT	3,157	0	0
2	PDPU	574	2,471	23,461	8	Lavarpur	193	0	3,157
3	GIFT City	305	4,345	21,564	7	Ratanpur	43	2	3,350
4	GIFT City House	133	10,517	17,524	6	Shahpur	74	5	3,391
5	Gujarat Biotechnology University	64	3,297	7,140	5	Gujarat Biotechnology University	2,698	77	3,460
6	Shahpur	7	61	3,907	4	GIFT City House	8,674	157	6,081
7	Ratanpur	2	35	3,853	3	GIFT City	3,722	318	14,598
8	Lavarpur	0	158	3,820	2	PDPU	3,134	482	18,002
9	GIFT	0	3,662	3,662	1	GNLU	0	20,653	20,654
	Total	24,546	24,546				21,695	21,694	
	Ridership	**46,241**							

Daily Boarding Alighting of the MRTS Corridor in GIFT City									
2041									
UP Direction (GNLU to GF-III)					DN Direction (GF-III to GNLU)				
Station No.	Station Name	Boarding	Alighting	Sectional Load	Station No.	Station Name	Boarding	Alighting	Sectional Load
1	GNLU	51,052	0	0	9	GIFT	7,076	0	0
2	PDPU	1,396	3,265	51,052	8	Lavarpur	209	0	7,076
3	GIFT City	508	9,746	49,183	7	Ratanpur	46	2	7,285
4	GIFT City House	168	24,467	39,945	6	Shahpur	77	7	7,329
5	Gujarat Biotechnology University	192	7,306	15,646	5	Gujarat Biotechnology University	5,975	236	7,399
6	Shahpur	8	64	8,532	4	GIFT City House	20,169	190	13,138
7	Ratanpur	2	37	8,476	3	GIFT City	8,198	493	33,117
8	Lavarpur	0	172	8,441	2	PDPU	4,144	1,170	40,822
9	GIFT	0	8,269	8,269	1	GNLU	0	43,796	43,796
	Total	53,326	53,326				45,894	45,894	
	Ridership	**99,220**							

Daily Boarding Alighting of the MRTS Corridor in GIFT City									
2051									
UP Direction (GNLU to GF-III)					DN Direction (GF-III to GNLU)				
Station No.	Station Name	Boarding	Alighting	Sectional Load	Station No.	Station Name	Boarding	Alighting	Sectional Load
1	GNLU	57,328	0	0	9	GIFT	7,919	0	0
2	PDPU	1,532	4,269	57,328	8	Lavarpur	233	0	7,919
3	GIFT City	601	10,856	54,591	7	Ratanpur	50	2	8,152
4	GIFT City House	201	27,144	44,336	6	Shahpur	86	7	8,200
5	Gujarat Biotechnology University	219	8,088	17,393	5	Gujarat Biotechnology University	6,617	268	8,279
6	Shahpur	9	70	9,524	4	GIFT City House	22,382	227	14,628
7	Ratanpur	2	41	9,463	3	GIFT City	9,149	579	36,783
8	Lavarpur	0	191	9,424	2	PDPU	5,247	1,288	45,353
9	GIFT	0	9,234	9,233	1	GNLU	0	49,313	49,312
	Total	59,892	59,893				51,683	51,684	
	Ridership	**1,11,575**							

Table 2.19 Daily Boarding Alighting for Airport Corridor (Phase-II-A)

Daily Boarding Alighting of the Airport MRTS Corridor									
2029									
UP Direction (GNLU to GF-III)					**DN Direction (GF-III to GNLU)**				
Station No.	**Station Name**	**Boarding**	**Alighting**	**Sectional Load**	**Station No.**	**Station Name**	**Boarding**	**Alighting**	**Sectional Load**
1	Koteshwar Road	11,872	0	0	5	Airport	13,280	0	0
2	Koteshwar Prachin Mandir	187	398	11,872	4	Sardarnagar	942	205	13,280
3	Sabarmati River	145	340	11,661	3	Sabarmati River	416	177	14,017
4	Sardarnagar	168	769	11,466	2	Koteshwar Prachin Mandir	486	228	14,256
5	Airport	0	10,865	10,865	1	Koteshwar Road	0	14,514	14,514
	Total	12,372	12,372				15,124	15,124	
	Ridership	**27,496**							

Daily Boarding Alighting of the Airport MRTS Corridor									
2031									
UP Direction (GNLU to GF-III)					**DN Direction (GF-III to GNLU)**				
Station No.	**Station Name**	**Boarding**	**Alighting**	**Sectional Load**	**Station No.**	**Station Name**	**Boarding**	**Alighting**	**Sectional Load**
1	Koteshwar Road	13,600	0	0	5	Airport	15,388	0	0
2	Koteshwar Prachin Mandir	205	412	13,600	4	Sardarnagar	992	239	15,388
3	Sabarmati River	157	343	13,393	3	Sabarmati River	420	191	16,141
4	Sardarnagar	196	812	13,207	2	Koteshwar Prachin Mandir	504	251	16,370
5	Airport	0	12,590	12,591	1	Koteshwar Road	0	16,623	16,623
	Total	14,158	14,157				17,304	17,304	
	Ridership	**31,462**							

Daily Boarding Alighting of the Airport MRTS Corridor									
2041									
UP Direction (GNLU to GF-III)					DN Direction (GF-III to GNLU)				
Station No.	Station Name	Boarding	Alighting	Sectional Load	Station No.	Station Name	Boarding	Alighting	Sectional Load
1	Koteshwar Road	17,709	0	0	5	Airport	19,873	0	0
2	Koteshwar Prachin Mandir	299	606	17,709	4	Sardarnagar	1,458	324	19,873
3	Sabarmati River	182	396	17,402	3	Sabarmati River	485	223	21,007
4	Sardarnagar	265	1,193	17,188	2	Koteshwar Prachin Mandir	740	365	21,269
5	Airport	0	16,260	16,260	1	Koteshwar Road	0	21,644	21,644
	Total	18,455	18,455				22,556	22,556	
	Ridership	**41,011**							

Daily Boarding Alighting of the Airport MRTS Corridor									
2051									
UP Direction (GNLU to GF-III)					DN Direction (GF-III to GNLU)				
Station No.	Station Name	Boarding	Alighting	Sectional Load	Station No.	Station Name	Boarding	Alighting	Sectional Load
1	Koteshwar Road	22,247	0	0	5	Airport	24,360	0	0
2	Koteshwar Prachin Mandir	420	922	22,247	4	Sardarnagar	2,219	401	24,360
3	Sabarmati River	241	568	21,745	3	Sabarmati River	694	295	26,178
4	Sardarnagar	328	1,816	21,418	2	Koteshwar Prachin Mandir	1,127	513	26,577
5	Airport	0	19,931	19,930	1	Koteshwar Road	0	27,191	27,191
	Total	23,236	23,237				28,400	28,400	
	Ridership	**51,636**							

Table 2.20 Peak Hour Boarding Alighting for GIFT City Corridor (Phase-II-B)

Peak Hour Boarding Alighting of the MRTS Corridor in GIFT City									
2029									
UP Direction (GNLU to GF-III)					DN Direction (GF-III to GNLU)				
Station No.	Station Name	Boarding	Alighting	Sectional Load	Station No.	Station Name	Boarding	Alighting	Sectional Load
1	GNLU	2,083	0	0	6	Shahpur	8	0	0
2	PDPU	44	264	2,083	5	Gujarat Biotechnology University	279	0	8
3	GIFT City	15	444	1,863	4	GIFT City House	897	2	287
4	GIFT City House	2	1,090	1,434	3	GIFT City	379	14	1,182
5	Gujarat Biotechnology University	0	342	346	2	PDPU	203	37	1,547
6	Shahpur	0	7	4	1	GNLU	0	1,715	1,713
	Total	2,144	2,147				1,766	1,768	
	PHPDT	**2,083**							

Peak Hour Boarding Alighting of the MRTS Corridor in GIFT City									
2031									
UP Direction (GNLU to GF-III)					DN Direction (GF-III to GNLU)				
Station No.	Station Name	Boarding	Alighting	Sectional Load	Station No.	Station Name	Boarding	Alighting	Sectional Load
1	GNLU	2,346	0	0	9	GIFT	316	0	0
2	PDPU	57	247	2,346	8	Lavarpur	19	0	316
3	GIFT City	31	435	2,156	7	Ratanpur	4	0	335
4	GIFT City House	13	1,052	1,752	6	Shahpur	7	1	339
5	Gujarat Biotechnology University	6	330	714	5	Gujarat Biotechnology University	270	8	346
6	Shahpur	1	6	391	4	GIFT City House	867	16	608
7	Ratanpur	0	4	385	3	GIFT City	372	32	1,460
8	Lavarpur	0	16	382	2	PDPU	313	48	1,800
9	GIFT	0	366	366	1	GNLU	0	2,065	2,065
	Total	2,455	2,455				2,170	2,169	
	PHPDT	**2,346**							

Peak Hour Boarding Alighting of the MRTS Corridor in GIFT City									
2041									
UP Direction (GNLU to GF-III)					DN Direction (GF-III to GNLU)				
Station No.	Station Name	Boarding	Alighting	Sectional Load	Station No.	Station Name	Boarding	Alighting	Sectional Load
1	GNLU	5,105	0	0	9	GIFT	708	0	0
2	PDPU	140	327	5,105	8	Lavarpur	21	0	708
3	GIFT City	51	975	4,918	7	Ratanpur	5	0	729
4	GIFT City House	17	2,447	3,995	6	Shahpur	8	1	733
5	Gujarat Biotechnology University	19	731	1,565	5	Gujarat Biotechnology University	598	24	740
6	Shahpur	1	6	853	4	GIFT City House	2,017	19	1,314
7	Ratanpur	0	4	848	3	GIFT City	820	49	3,312
8	Lavarpur	0	17	844	2	PDPU	414	117	4,082
9	GIFT	0	827	827	1	GNLU	0	4,380	4,380
	Total	5,333	5,333				4,589	4,589	
	PHPDT	**5,105**							

Peak Hour Boarding Alighting of the MRTS Corridor in GIFT City									
2051									
UP Direction (GNLU to GF-III)					DN Direction (GF-III to GNLU)				
Station No.	Station Name	Boarding	Alighting	Sectional Load	Station No.	Station Name	Boarding	Alighting	Sectional Load
1	GNLU	5,733	0	0	9	GIFT	792	0	0
2	PDPU	153	427	5,733	8	Lavarpur	23	0	792
3	GIFT City	60	1,086	5,459	7	Ratanpur	5	0	815
4	GIFT City House	20	2,714	4,434	6	Shahpur	9	1	820
5	Gujarat Biotechnology University	22	809	1,739	5	Gujarat Biotechnology University	662	27	828
6	Shahpur	1	7	952	4	GIFT City House	2,238	23	1,463
7	Ratanpur	0	4	946	3	GIFT City	915	58	3,678
8	Lavarpur	0	19	942	2	PDPU	525	129	4,535
9	GIFT	0	923	923	1	GNLU	0	4,931	4,931
	Total	5,989	5,989				5,168	5,168	
	PHPDT	**5,733**							

Table 2.21 Peak Hour Boarding Alighting for Airport Corridor (Phase-II-A)

Peak Hour Boarding Alighting of the Airport MRTS Corridor									
2029									
UP Direction (GNLU to GF-III)					**DN Direction (GF-III to GNLU)**				
Station No.	**Station Name**	**Boarding**	**Alighting**	**Sectional Load**	**Station No.**	**Station Name**	**Boarding**	**Alighting**	**Sectional Load**
1	Koteshwar Road	1,188	0	0	5	Airport	1,328	0	0
2	Koteshwar Prachin Mandir	18	40	1,188	4	Sardarnagar	94	21	1,328
3	Sabarmati River	15	34	1,166	3	Sabarmati River	41	18	1,401
4	Sardarnagar	18	77	1,147	2	Koteshwar Prachin Mandir	51	23	1,424
5	Airport	0	1,088	1,088	1	Koteshwar Road	0	1,452	1,452
	Total	1,239	1,239				1,514	1,514	
	PHPDT	**1,452**							

Peak Hour Boarding Alighting of the Airport MRTS Corridor									
2031									
UP Direction (GNLU to GF-III)					**DN Direction (GF-III to GNLU)**				
Station No.	**Station Name**	**Boarding**	**Alighting**	**Sectional Load**	**Station No.**	**Station Name**	**Boarding**	**Alighting**	**Sectional Load**
1	Koteshwar Road	1,360	0	0	5	Airport	1,539	0	0
2	Koteshwar Prachin Mandir	21	41	1,360	4	Sardarnagar	99	24	1,539
3	Sabarmati River	16	34	1,339	3	Sabarmati River	42	19	1,614
4	Sardarnagar	20	81	1,321	2	Koteshwar Prachin Mandir	50	25	1,637
5	Airport	0	1,259	1,259	1	Koteshwar Road	0	1,662	1,662
	Total	1,416	1,416				1,730	1,730	
	PHPDT	**1,662**							

Peak Hour Boarding Alighting of the Airport MRTS Corridor									
2041									
UP Direction (GNLU to GF-III)					DN Direction (GF-III to GNLU)				
Station No.	Station Name	Boarding	Alighting	Sectional Load	Station No.	Station Name	Boarding	Alighting	Sectional Load
1	Koteshwar Road	1,771	0	0	5	Airport	1,987	0	0
2	Koteshwar Prachin Mandir	30	61	1,771	4	Sardarnagar	146	32	1,987
3	Sabarmati River	18	40	1,740	3	Sabarmati River	49	22	2,101
4	Sardarnagar	27	119	1,719	2	Koteshwar Prachin Mandir	74	37	2,127
5	Airport	0	1,626	1,626	1	Koteshwar Road	0	2,164	2,164
	Total	1,846	1,846				2,256	2,256	
	PHPDT	**2,164**							

Peak Hour Boarding Alighting of the Airport MRTS Corridor									
2051									
UP Direction (GNLU to GF-III)					DN Direction (GF-III to GNLU)				
Station No.	Station Name	Boarding	Alighting	Sectional Load	Station No.	Station Name	Boarding	Alighting	Sectional Load
1	Koteshwar Road	2,225	0	0	5	Airport	2,436	0	0
2	Koteshwar Prachin Mandir	42	92	2,225	4	Sardarnagar	222	40	2,436
3	Sabarmati River	24	57	2,175	3	Sabarmati River	69	30	2,618
4	Sardarnagar	33	182	2,142	2	Koteshwar Prachin Mandir	113	51	2,658
5	Airport	0	1,993	1,993	1	Koteshwar Road	0	2,719	2,719
	Total	2,324	2,324				2,840	2,840	
	PHPDT	**2,719**							

Table 2.22 Trip Distribution for the Phase-II (A & B) Corridors

Corridor	Distance Zone (km)	Trips in 2029	Trips in 2031	Trips in 2041	Trips in 2051
Airport Corridor (Phase-II-A)	0 – 2	584	649	861	1128
	2 – 5	616	680	924	1262
	5 – 12	2731	3113	4059	5152
	12 – 21	11189	12753	16657	21111
	21 – 32	12376	14265	18509	22983
	32+	0	0	0	0
	Total	**27,496**	**31461**	**41011**	**51637**
GIFT City Extension Corridor (Phase-II-B)	0 – 2	79	77	118	147
	2 – 5	627	943	2008	2295
	5 – 12	1728	2389	5232	5796
	12 – 21	4705	5146	11778	13066
	21 – 32	15887	17301	39523	43847
	32+	3186	6713	15210	16904
	Total	**26,214**	**32567**	**73868**	**82054**

Chapter - 3

System Selection



3.1 Options for Public Transport System

3.2 Capacity of Various Modes

3.3 Daily Ridership on Ahmedabad Metro Corridors in Horizon Years

3.4 Mode of Selection



Chapter - 3

SYSTEM SELECTION

3.1 OPTIONS FOR PUBLIC TRANSPORT SYSTEM

The following systems are mainly available for Urban Mass Transit:

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

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

iii) **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**:-**

Table 3.1 Salient features of the various Transit Systems

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)
8 car PHPDT	24,480	17,300 (100%)	34,300

System	LRT (Light Rail Transit) (elevated)	AGT (Automated Guide way Transit)	Straddle type Monorail
(170% , headway 2.5 min)			
	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 method for rescue.
Operation cost			

System	LRT (Light Rail Transit) (elevated)	AGT (Automated Guide way Transit)	Straddle type Monorail
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
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

System	Urban Maglev (HSST)	Metro/Subway	Bus Rapid transit
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 movement.	It has less maintenance of track.	It requires maintenance of roads.
Vehicle	As it has no rotary motor, it is excellent on maintenance.	Maintenance of rotary motor and grinding of steel wheels shall be necessary.	Maintenance of engine and rubber tyres shall be necessary.
Effect on ambient surrounding and harmony with urban			

System	Urban Maglev (HSST)	Metro/Subway	Bus Rapid transit
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 3.2

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

SYSTEM	PHPDT IN 2021	POPULATION IN 2011	AVG. TRIP LENGTH
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 PHASE-II B IN HORIZON YEARS

This corridor is proposed to be implemented in two phases, in first phase it will be constructed till Shahpur and in second phase it will be constructed upto GIFT. Accordingly daily ridership on this extension from GIFT City to Shahpur is expected to be 39,119 passengers in 2029 and from GIFT City to GIFT it is expected to be 99,290 passengers in 2041. Daily ridership, PHPDT and average trip length for years 2029, 2031, 2041 and 2051 and PHPDT are shown in table below.

Table 3.3: Ridership Summary for Phase-II B

Corridor	Year	Daily Ridership	PHPDT	ATL (km)
GIFT City Corridor (Combined MRTS Phase-II & Phase-II(B))	2029	39,119	2,083	-
	2031	46,241	2,346	-
	2041	99,220	5,105	-
	2051	1,11,575	5,733	-
GIFT City Corridor (MRTS Phase-II(B) only)	2029	26,214	1,437	24.52
	2031	32,567	2,346	25.23
	2041	73,868	5,105	25.33
	2051	82,054	5,733	25.31

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 5,733 on this extension from GIFT City to GIFT, 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 GNLU to GIFT City, hence 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, therefore it is recommended to adopt same system i.e. Light Capacity Metro System. Further, since GNLU to GIFT City corridor is a spur line of APMC to Mahatma Mandir (N-S) corridor, thus extending the same system shall provide seamless metro connectivity from inside of GIFT City to APMC and Mahatma Mandir ends.

Chapter - 4

Geometric Designing Parameters and Alignment Description



4.1 General

4.2 Geometric Design Parameters

4.3 Track Structure

4.4 Rail Section

4.5 Ballastless Track on Main Lines

4.6 Ballastless Track in Stabling Yard/Depot

4.7 Turnouts

4.8 Buffer Stops

4.9 Rail-Structure Interaction

4.10 Route Alignment



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/ I-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 GIFT City to GIFT corridor is close to 1.2m.

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 R260 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

The corridor identified under Ahmedabad Metro Phase-II B is as follows:-

Table 4. 4

Sr. No.	Corridors	Total Length (km)
i)	GIFT City (excluding) to GIFT	7.204**

** excluding 380m section kept for future extension provision towards IIT Gandhinagar

4.11 GIFT CITY HOUSE TO GIFT CORRIDOR

This corridor is extension of already approved corridor of Ahmedabad Metro namely Gujrat National Law University (GNLU) to GIFT city which is under construction presently. The proposed corridor starts from the dead end of under construction GNLU to GIFT city corridor. This extension will be constructed in two phases. Initially in phase-I, GIFT city house to Shahpur will be constructed and in phase-II from Shahpur to GIFT will be constructed. After Shahpur station, provision is kept for taking a branch of this corridor towards IIT Gandhi Nagar.

The features of **GIFT City (excluding) to GIFT** corridor along with the details of route alignment has been described below:-

4.11.1 References

(a) Chainages

This corridor starts from chainage 4982.685 m (end of under construction via duct of GNLU to Gift city corridor). First station in this extension shall be GIFT City House at chainage 5908.952m. Thereafter chainage increases towards GIFT.

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

4.11.2 Features of the Corridor

- First station on this Corridor is named as GIFT City House and last station is GIFT.
- This extension will be constructed in two phases. Length of the corridor constructed in first phase will be 3.332 km (including via duct kept for future extension) and in second phase 4.253km.
- Total length of the corridor from start to dead end is 7.204 km (excluding 380m length of via duct kept in first phase for future extension). The entire corridor proposed is elevated.

- Six nos. of stations have been proposed on the corridor. Name of stations are GIFT City House, Gujrat Biotechnology University, Shahpur, Ratanpur, Lavapur and GIFT. 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 1535.714m and 731.611m respectively.

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. 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.

4.11.4 Terminals

GIFT Terminal

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

4.11.5 Scissors Crossovers

Scissors Crossovers will be provided at the terminal station i.e. GIFT.

4.11.6 Description of Alignment

Horizontal Alignment:

This extension starts from the dead end of under construction terminal point of GNLU to Gift city corridor at chainage 4982.685m, It continues along the same road; the alignment turns left from chainage 5010.773m with radius of 169.400m and comes onto Samruddhi marg. Thereafter, first station of this corridor is proposed as Gift City House at Chainage 5908.92 m.

Afterward, the alignment runs straight along the Samruddhi road on median upto chainage 6644.502m and takes right turn from here. Second station Gujarat Biotechnology University is proposed at chainage 7132.675m on this corridor. The alignment runs straight and, third station namely Shahpur at chainage 7864.286m is proposed. From chainage 8008.00 a Y junction is proposed and the corridor turns right with a provision of future extension towards IIT Gandhi Nagar. The future extension branch is upto chainage 8314.286m, till this chainage 1st phase will be constructed, thereafter under 2nd phase, three stations namely Ratanpur, Lavapur

and GIFT are proposed at chainage 9400.00m ,10820.00m and 12071.00m respectively. The corridor will terminate at chainage 12187.417m.

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 4 Nos. of curves have been provided in the entire length of GIFT City House to GIFT Corridor. The details of curves and abstracts of horizontal curves are indicated in Table 4.5, 4.6 and 4.7 & ,4.8 respectively.

Table 4.5 Details of Horizontal Curves - Phase-II B (1st phase)

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	169.400	94.517	55	55	31 58 05	48.524	317.778
2	Left	250.000	165.885	55	55	38 01 04	86.126	780.550
3	Right	350.000	333.173	55	55	54 32 28	180.421	63.740
4	Right	1020.000	182.076	30	30	10 13 39	91.280	295.667
5	Right	800.000	60.127	40	40	04 18 22	30.078	354.833
6	Left	1010.000	31.919	30	30	01 48 38	15.961	93.249

Table 4.6 Details of Horizontal Curves - Phase-II B (2nd Phase)

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	Right	125.100	136.002	55	55	62 17 19	75.597	2202.129
2	Right	125.100	131.040	55	55	60 00 59	72.250	430.152
3	Right	452.545	41.174	50	50	05 12 46	20.601	544.759
4	Left	397.455	25.369	55	55	03 39 25	12.689	199.918

Table 4.7 Abstract of Horizontal Curves Phase- II B (1st phase)

S. No.	Radius (m)	Nos. Occurrences	Curved Length with TL (m)	% w. r. t. total curved length
1	>125m - 200m	1	204.517	14.63%
2	>200m - 500m	2	719.058	51.45%
3	>500m - 1020m	3	474.122	33.92%
4	>1020m - 1500m	0	0	0.00%
5	>1500m	0	0	0.00%
	Total	**6**	**1397.697**	**100.00%**

Table 4.8 Abstract of Horizontal Curves - II B (2nd Phase)

S. No.	Radius (m)	Nos. Occurrences	Curved Length with TL (m)	% w. r. t. total curved length
1	>125m - 200m	2	487.042	63.78%

S. No.	Radius (m)	Nos. Occurrences	Curved Length with TL (m)	% w. r. t. total curved length
2	>200m - 500m	2	276.543	36.22%
3	>500m - 1020m	0	0	0.00%
4	>1020m - 1500m	0	0	0.00%
5	>1500m	0	0	0.00%
	Total	**4**	**763.585**	**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 14.5 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 2.864%%. Detailed description of vertical alignment is as follows:

The proposed rail levels are given in **Table 4.9, 4.10** and abstracts of gradients are given in **Table 4.11, 4.12.**

Table 4.9: Proposed Gradients of Rail Track (Vertical Curve Details) Phase- II B (1st Phase)

S. No.	Chainage		Length	Rail Level		Gradient	Remarks
	From	To		From	To		
1	4982.685	5110.000	127.315	79.000	79.000	0.000%	LEVEL
2	5110.000	5410.000	300.000	79.000	75.800	-1.067%	FALL
3	5410.000	5700.000	290.000	75.800	78.900	1.069%	RISE
4	5700.000	6040.000	340.000	78.900	78.900	0.000%	LEVEL
5	6040.000	6490.000	450.000	78.900	74.000	-1.089%	FALL
6	6490.000	6940.000	450.000	74.000	80.300	1.400%	RISE
7	6940.000	7280.000	340.000	80.300	80.300	0.000%	LEVEL
8	7280.000	7500.000	220.000	80.300	86.600	2.864%	RISE
9	7500.000	8314.286	814.286	86.600	86.600	0.000%	LEVEL

Table 4.10: Proposed Gradients of Rail Track (Vertical Curve Details) phase - II B (2nd Phase)

S. No.	Chainage		Length	Rail Level		Gradient	Remarks
	From	To		From	To		
1	7934.285	8400.000	465.715	86.600	86.600	0.000%	LEVEL
2	8400.000	8680.000	280.000	86.600	84.500	-0.750%	FALL
3	8680.000	9250.000	570.000	84.500	89.100	0.807%	RISE

S. No.	Chainage		Length	Rail Level		Gradient	Remarks
	From	To		From	To		
4	9250.000	9560.000	310.000	89.100	89.100	0.000%	LEVEL
5	9560.000	10080.000	520.000	89.100	86.600	-0.481%	FALL
6	10080.000	10600.000	520.000	86.600	86.300	-0.058%	FALL
7	10600.000	10980.000	380.000	86.300	86.300	0.000%	LEVEL
8	10980.000	11350.000	370.000	86.300	83.900	-0.649%	FALL
9	11350.000	11680.000	330.000	83.900	85.500	0.485%	RISE
10	11680.000	12179.082	499.082	85.500	85.500	0.000%	LEVEL

Table 4.11: Abstract of Phase- II B (1st Phase)

S. No.	Description	Nos. Occurrences	Length (m)	% w. r. t. Total Alignment length
1	Level	4	1621.601	48.67%
2	> 0% to = 1%	0	0.000	0.00%
3	> 1% to = 2%	4	1490.000	44.72%
4	> 2% to = 3%	1	220.000	6.60%
5	> 3% to = 4%	0	0.000	0.00%
	Total	**9**	**3331.601**	**100.00%**

Table 4.12: Abstract of Gradients Phase II B (2nd Phase)

S. No.	Description	Nos. Occurrences	Length (m)	% w. r. t. Total Alignment length
1	Level	4	1654.797	38.98%
2	> 0% to = 1%	6	2590.000	61.02%
3	> 1% to = 2%	0	0.000	0.00%
4	> 2% to = 3%	0	0.000	0.00%
5	> 3% to = 4%	0	0.000	0.00%
	Total	**10**	**4244.797**	**100.00%**

Chapter - 5

Civil Engineering



5.1 General

5.2 Civil Structures

5.3 Geo-Technical Investigations

5.4 Land

5.5 Utility Diversions

5.6 Issues Related to Interface with External Agencies

5.7 Traffic Diversion



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 B Metro corridor, 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, GMRC 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 Objectives of Investigation

The purpose and objectives of the investigation was to obtain reliable information regarding sub surface conditions at the project site of Metro Corridor inside GIFT City and Connectivity to Ahmedabad Airport (Gujarat) in Gujarat so as to evaluate the soil parameter which are required for evaluating safe bearing capacity of soil for design and suitability of foundation for the proposed structure. The knowledge of general geotechnical subsoil characteristics, compressibility and information about ground water table is an essential requirement for the geotechnical engineer, which would assist the designer to design the foundation system.

5.3.2 Topography & Climate of Project Site

Ahmedabad is located on the banks of the River Sabarmati in the northern part of Gujarat and the western part of India. It is located at 23.03°N 72.58°E spanning an area of 205 km². The average elevation is 53 metres. The city is located in a sandy and dry area. Except for the small hills of Thaltej-Jodhpur Tekra, the entire city is almost flat. The Sabarmati bifurcates the city into eastern and western parts. Though the river is perennial, it gets dried up in the summer, leaving only a small stream of water flowing.

Barring monsoon, the climate of Ahmedabad is very dry. The weather is very hot during the months of March to June with the average summer temperature ranging from maximum 43 °C to minimum 23 °C. The months of November to February have an average maximum temperature 36 °C and a minimum of 15 °C. The average rainfall is 932 mm. The highest temperature recorded is 50 °C and the lowest is 5 °C.

5.3.3 Scope of Work

The scope of work of geotechnical investigation for the project was limited to the following:

- Mobilization of equipment and personnel to the project site, setting up the equipment and carrying out the field investigation and demobilization of the same after completion of field work.
- Drilling of nos. of boreholes, for GIFT City Metro in Ahmedabad, of 150mm diameters in all types of soil up to 30.00m depth or up to hard stratum showing refusal (N>50) for further advancement of drilling.
- Conducting standard penetration test at regular depth intervals of 1.50m or at the change of strata whichever occurs earlier and collect each SPT samples for further testing.
- Collection of the undisturbed soil samples (38mm dia 450 mm long) at every 3.0m depth interval (first at 2.25m) and/or at the change of the strata.
- Collection of the disturbed soil samples at depths where failed to collect undisturbed soil samples.
- Recording the depth of ground water table (If observed).
- Conducting all necessary and relevant laboratory test on representative soil samples limited to following:
  - Natural moisture content
  - Grain Size Distribution
  - Liquid and Plastic limit
  - Specific gravity
  - Bulk and Dry density
  - Consolidation Test
  - Unconfined Compression Test
  - Triaxial / Direct Shear Test
  - Chemical Analysis Tests
- Evaluating Safe Bearing Capacity of open foundation as per latest IS codes.

- Submission of soil testing report in triplicate includes interpretation of test results and suggesting recommendations for safe bearing capacity of open foundation.

5.3.4 Field Investigation

- Testing equipment and personnel for carrying out the requisite field works were mobilized to the site. These were shifted from one test location to another location during the course of fieldwork and demobilized after satisfactory completion of entire field work.

- The prescribed 8 boreholes of 150mm dia in soil stratum were drilled up to 30.00m depth at the proposed GIFT City Metro in Ahmedabad, Gujarat using rotary drilling machine in accordance with IS:1892 - 2021.

- Standard penetration tests were conducted in all boreholes at regular intervals of 1.5m. For this, bore were cleaned up to the desired depth where the SPT test was to conduct. Standard split spoon sampler was attached to lower end of 'A' size drill rods and driven into borehole by means of a standard hammer of 63.5 kg falling freely from a height of 75 cm. The sampler was driven 45cm into soil by blows of this hammer and the numbers of blow required for each 15 cm penetration were recorded. Blows required for first 15cm penetration are not taken into account for N value as it is considered as seating drive. The number of blows for last 30 cm penetration is designated as SPT 'N' values. A 'refusal' has been indicated where there is less than 15 cm penetration in more than 50 blows.

- Soil samples obtained from standard split spoon sampler for all above standard penetration tests were collected in the polythene bags of suitable size. These samples were properly sealed, labeled, recorded and carefully transported to the laboratory for further testing.

- Un-disturbed soil samples were collected by using thin walled steel sampling tubes of 100mm dia and 450mm length from all the bores, first at 2.50m and next at 3.00m depth interval as per IS: 2131-1986.

- These sampling tube after retrieval from the boreholes were properly waxed and sealed on both ends. These were carefully labeled and transported to the laboratory for testing.

- The ground water table in borehole generally measured after 24 hours of the boring or after the full stabilization of water level in boreholes.

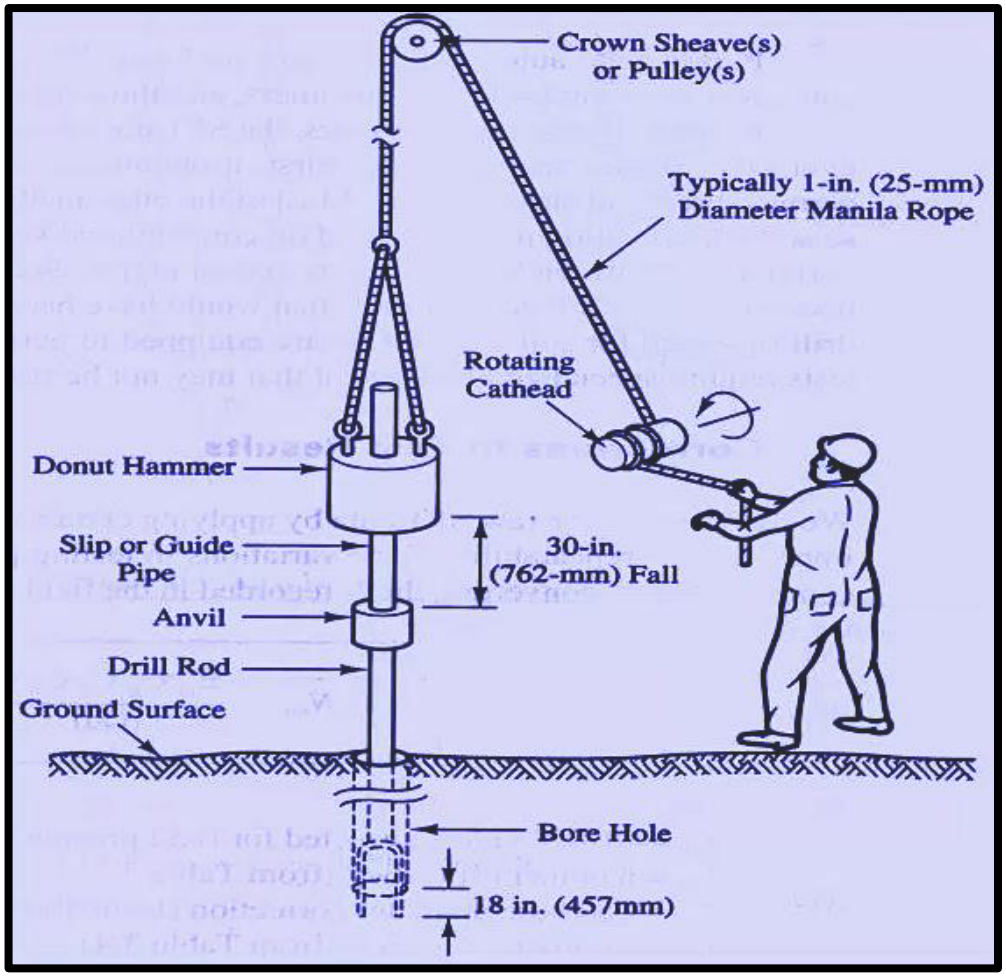


Figure 5.1

5.3.5 Laboratory Investigation

The following laboratory tests were conducted on selected samples recovered from the boreholes:

Soil Samples

a) Natural moisture content
b) Grain size analysis
c) Liquid and Plastic limit
d) Specific gravity
e) Bulk and Dry density
f) Direct shear Test

The above laboratory tests were carried out as per relevant Indian standard code of practice. All the soil samples were identified and classified as per IS: 1498-1970. The results of laboratory tests are shown in soil profile sheets.

5.3.6 Borehole Co-Ordinates

Table 5.1 Bore Holes Coordinates

AHMEDABAD METRO									
S.No.	Borehole Number	Location	North	East	Level	Terminal Depth of BH	Water Table (m)	Drilling in Soil	Drilling in Rock
1	BH 1	GIFT City	2563018.14	263347.95	64.127	30.00m	Not Found	30.00m	Nil
2	BH 2	GIFT City	2563677.69	262268.46	62.448	30.00m	Not Found	30.00m	Nil
3	BH 3	GIFT City	2564864.22	261905.7	72.256	30.00m	Not Found	30.00m	Nil
4	BH 4	GIFT City	2565069.05	262451.9	72.266	30.00m	Not Found	30.00m	Nil
5	BH 5	GIFT City	2564814.49	263965.48	72.211	30.00m	Not Found	30.00m	Nil
6	BH 6	GIFT City	2564253.46	264403.46	71.321	30.00m	Not Found	30.00m	Nil
7	BH 7	GIFT City	2563920.30	265519.40	71.023	30.00m	Not Found	30.00m	Nil
8	BH 7A	GIFT City	2563454.83	264664.81	71.032	30.00m	Not Found	30.00m	Nil

5.3.7 Conclusion and Recommendations

Based on the field and laboratory test results the conclusion and Recommendations are given below.

- The sub soil stratum of all the 8 boreholes, (**BH-1 to BH-7 & BH-7A) at the site of proposed Metro Corridor inside GIFT City Ahmedabad (Gujarat)** mostly consists of Silty Sandy Soil, Silty Sand with occasional gravels and Silty Clayey Soil.

- The sub soil stratum of all the boreholes is presented in log of boreholes.

- **Water Table:** Water table was NOT met up to a drilled depth of 30.00m during investigation period in all the 8 boreholes in the GIFT City.

- **Compactness:** The Standard Penetration Tests (SPT) curve reveals that the soil stratum is in medium to highly dense state of compactness from GL to 30.00m depth of all the 8 boreholes.

- Chemical tests on soil samples suggest that no harmful chemicals are present in soil responsible for deteriorating concrete/reinforcement.

- Factor of Safety is taken as 2.5.

- Recommended piles of diameters 1000/1200 of 20.00-25.00m depth.

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 new depot proposed for this extension. It is proposed to augment existing Gyaspur Depot and under construction Indroda Circle stabling depot for serving this Phase-IIB corridor.

5.4.5 Land for Traction and Receiving Substation and Radio Towers

No new RSS proposed for this extension. RSS already existing in Phase-I and under implementation in Phase-II shall cater this section also.

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 this corridor are indicated in **Table 5.2 & 5.3** respectively.

Table 5.2 Land Required for Stations

S.NO.	STATION NAME	AREA (m^2)	REMARKS
1.	GIFT City House	684	Pvt.
2.	Gujarat Biotechnology University	684	Pvt.
3.	Shahpur	684	Pvt.
4.	Ratanpur	684	Pvt.
5.	Lavarpur	684	Pvt.
6.	GIFT	684	Pvt.
		TOTAL = 4104 m^2 (PVT.)	

Table 5.3 - Land Required for Running Section

S.NO.	PLOT NO.	AREA (m^2)	REMARKS
1.	RS-1 (Under Second Phase)	1067	Pvt.

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 B corridor. Further, since this is a small extension of Phase-II corridor already under implementation, thus staff quarters proposed under Phase-II shall serve this corridor also.

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 5.4 Details of Temporary Land office accommodation

S. No.	Corridor	AREA (m^2)	OWNER-SHIP
1.	GIFT City House to Shahpur (First Phase)	2000	Government
2.	Ratanpur to GIFT (Second Phase)	2000	Government

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 One casting yard each for GIFT City House to Shahpur (First Phase) and Ratanpur to GIFT (Second Phase). Accordingly, a provision of **2.0 ha** land each has been proposed on temporary basis for both the phases 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 5.5 - Summary of Permanent Land Requirement (All figures in Sq. m)

Sr.	Description	First Phase			Second Phase		
		Govt.	Pvt.	Total	Govt.	Pvt.	Total

1	Stations	0	2052	2052	0	2052	2052
2	Running Section	0	0	0	0	1067	1067
3	Depot/Stabling Yard	0	0	0	0	0	0
4	Staff Quarters	0	0	0	0	0	0
5	Office Complex and OCC	0	0	0	0	0	0
6	RSS	0	0	0	0	0	0
	Total	**0**	**2052**	**2052**	**0**	**3119**	**3119**

Total (Pvt.) = 0.2052 ha (First Phase); 0.3119 ha (Second Phase)

Table 5.6 - Summary of Temporary Land Requirement (All figures in Sq. m)

S. No.	Description	First Phase	Second Phase	OWNER-SHIP
1	Temporary Office/ Site Office	2000	2000	Government
2	Segment Casting Yard	20000	20000	Government
	Total	**22000**	**22000**	

Total land required for temporary acquisition is **2.2 ha** in both phases, 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 5.7 below

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Table 5.7 - Affected Aboveground Services

Section	LP	EP
GIFT City to GIFT Corridor	11	2

LP – Light Pole, EP – Electric Pole

Table 5.8 - Details of the HT Lines, Electric Lines

S. No.	Location	Position w.r.t alignment	Affected Length (m)
1	Ch. 7768.885 (11kv)	Across	
2	Ch. 8225.243 (11kv)	Across	

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 5.9.**

Table 5.9 - Interface with External Agencies

S. No.	Name of Agency	Issue
1	GIFT city	1. Removal of trees under the area of proposed corridors. 2. Clearance of ROW & Bridges for Metro wherever encroached/occupied. 3. Alignment of various corridors under Phase-II network shall pass on/along the roads. 4. Shifting of HT Line and others.

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

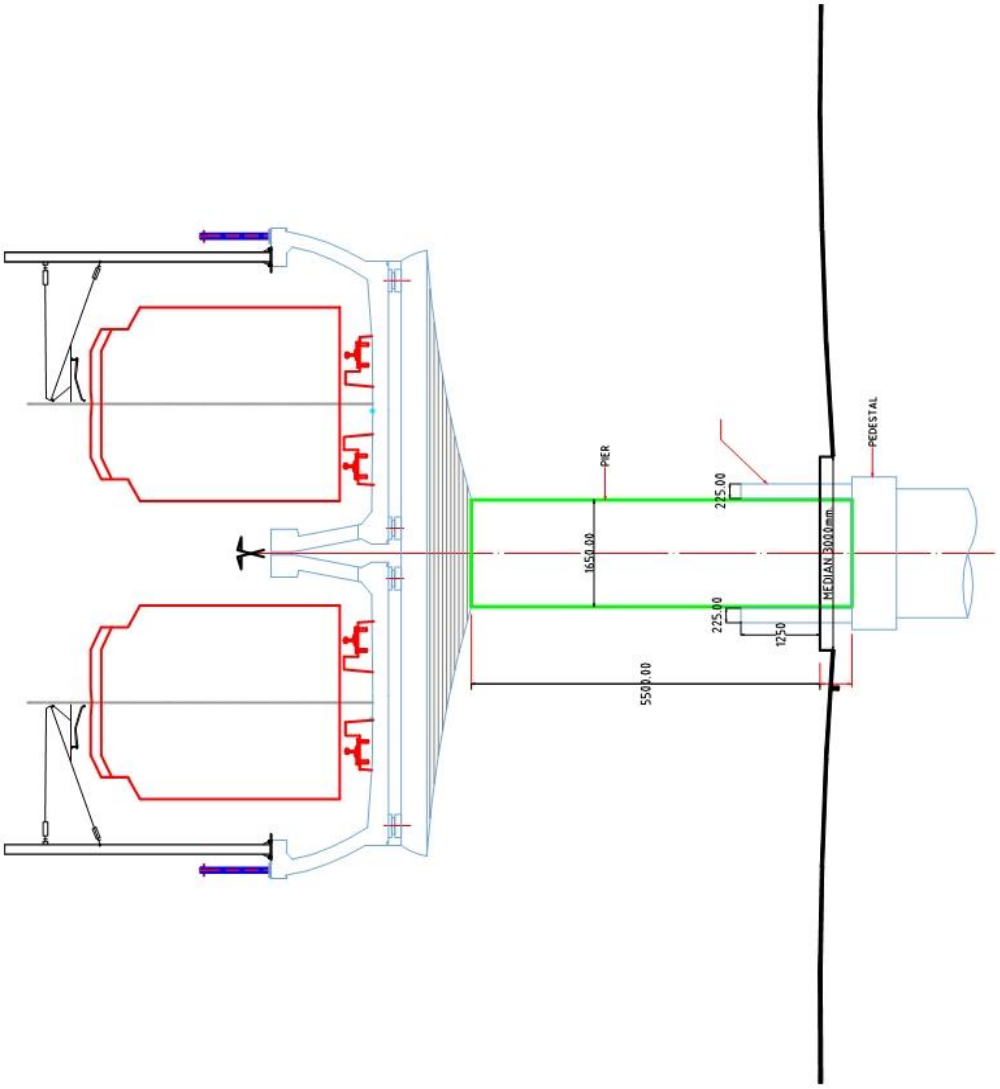
Only temporary diversion plans will be required during construction of the Metro corridors under Ahmedabad Metro Rail Project Phase-II B network. At the onset, all encroachments from road ROW will have to be removed. These encroachments vary from ‘on-street’ parking to informal activities.

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

TYPICAL CROSS SECTION OF THE VIADUCT WITH DOUBLE U GIRDER

SCALE:-NTS



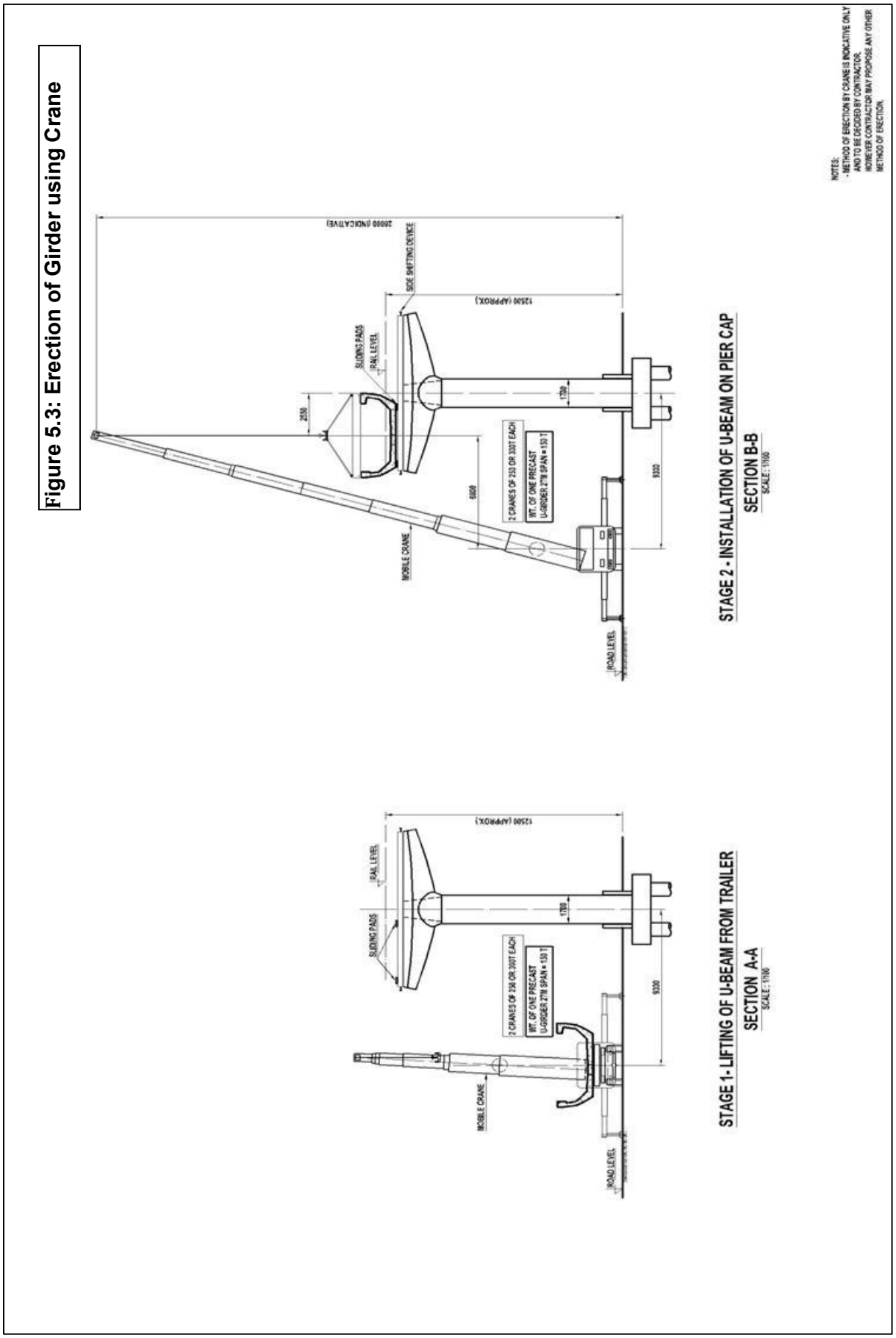


Figure 5.3: Erection of Girder using Crane

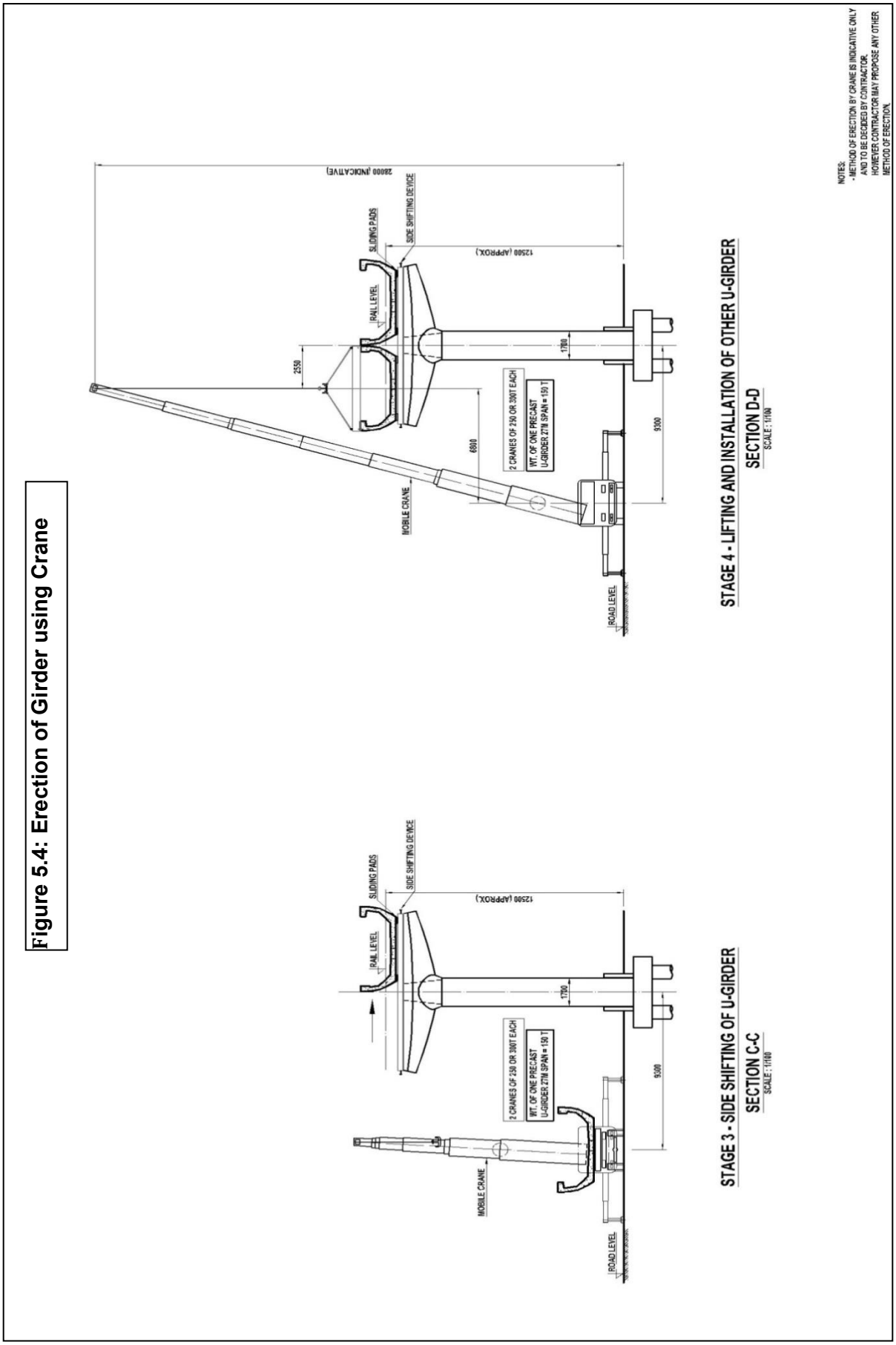


Figure 5.4: Erection of Girder using Crane

Chapter – 6

Station Planning



6.1 General

6.2 Station Types

6.3 Planning and Design Criteria for Stations

6.4 Typical Elevated Station

6.5 Passenger Amenities

6.6 Concourse

6.7 Ticketing Gates

6.8 Ticket Counters and Ticket Issuing Machines (TIMS)

6.9 Platforms

6.10 Stairs, Escalators and Lifts for Normal and Emergency Operations

6.11 Traffic Integration

6.12 Approach Adopted In Planning Traffic Integration Facilities

6.13 Operational Integration



Chapter – 6

STATION PLANNING

6.1 GENERAL

The proposed Metro corridor from **Gift City House to GIFT Station** is planned as Phase-II-B spurs from existing **Gift City Station**. The stretch of the proposed **Gift City House to GIFT Station** corridor is 12.18 km long open loop. Along this Corridor, six stations have been planned, along the Gift City Road- 1C.

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.

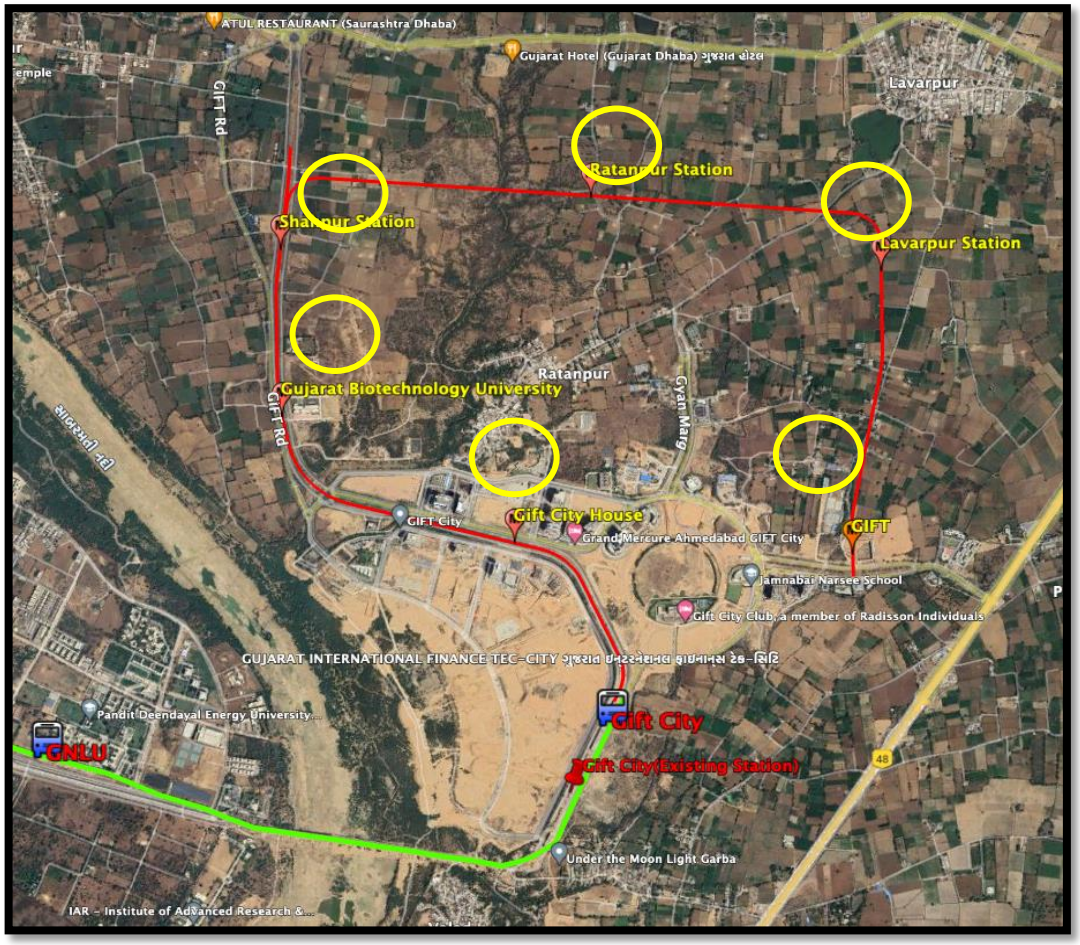


Figure-1: Alignment of the corridor

6.2 STATION TYPES

The corridor has been envisaged with elevated stations. The elevated stations are all standard **side platform** architecture made for 6-coach train operation.

Average inter-station distance is 1.18 km approximately varying from 0.731km to 1.5 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

Station List GIFT City to Shahpur				
S. No.	**Stations**	**Chainage (m)**	**Inter Station Distance (m)**	**Remarks**
0	**GIFT City**			**Existing Station**
	Dead End	4982.685		
1	GIFT City House	5908.952	926.267	Elevated
2	Gujarat Biotechnology University	7132.675	1223.723	Elevated
3	Shahpur	7864.286	731.611	Elevated
4	Ratanpur	9400.000	1535.714	Elevated
5	Lavarpur	10820.000	1420.000	Elevated
6	GIFT	12071.000	1251.000	Elevated
	Dead End	12187.417	116.417	

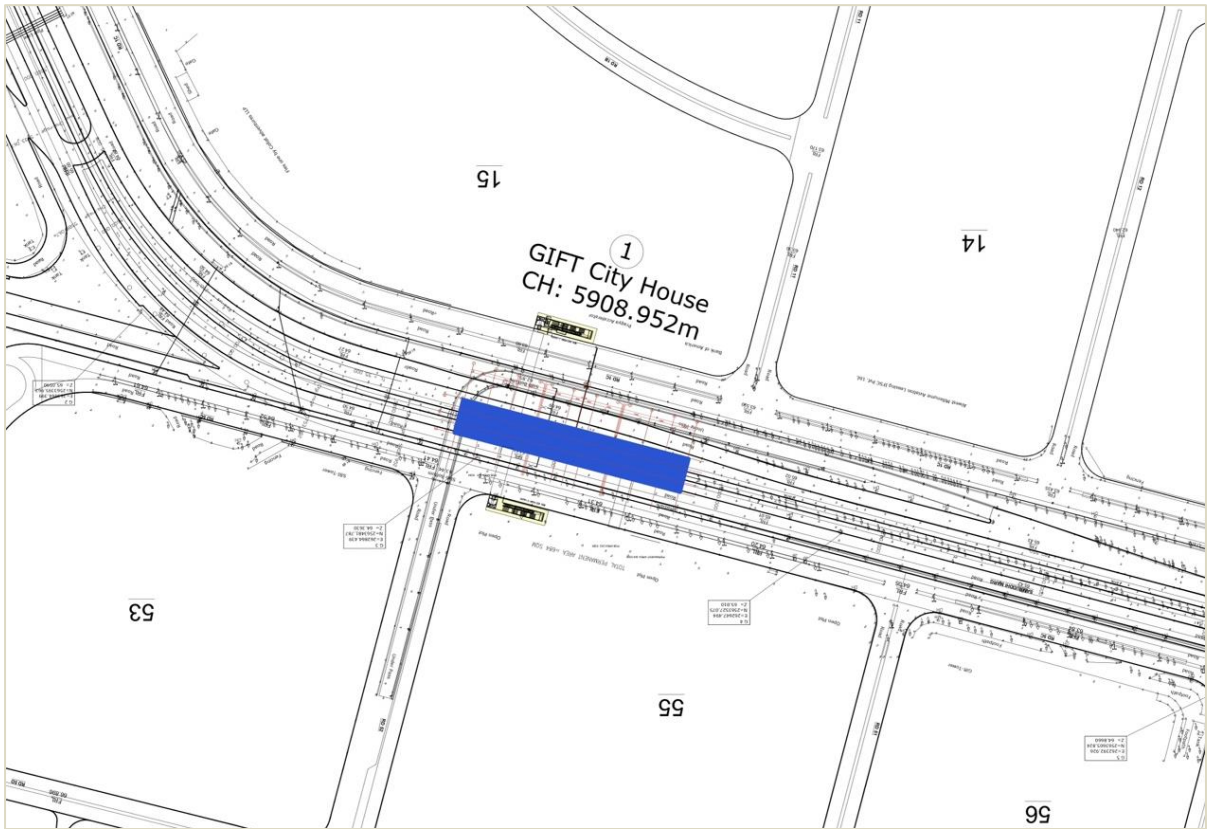
Daily Boarding Alighting of the MRTS Corridor in GIFT City									
2051									
UP Direction (GNLU to GF-III)					DN Direction (GF-III to GNLU)				
Station No.	**Station Name**	**Boarding**	**Alighting**	**Sectional Load**	**Station No.**	**Station Name**	**Boarding**	**Alighting**	**Sectional Load**
					6	GIFT	7,919	0	0
					5	Lavarpur	233	0	7,919
					4	Ratanpur	50	2	8,152
1	GIFT City House	201	27,144	44,336	3	Shahpur	86	7	8,200
2	Gujarat Biotechnology	219	8,088	17,393	2	Gujarat Biotechnology	6,617	268	8,279

Daily Boarding Alighting of the MRTS Corridor in GIFT City									
2051									
UP Direction (GNLU to GF-III)					DN Direction (GF-III to GNLU)				
Station No.	Station Name	Boarding	Alighting	Sectional Load	Station No.	Station Name	Boarding	Alighting	Sectional Load
	University					University			
3	Shahpur	9	70	9,524	1	GIFT City House	22,382	227	14,628
4	Ratanpur	2	41	9,463					
5	Lavarpur	0	191	9,424					
6	GIFT	0	9,234	9,233					

Peak Hour Boarding Alighting of the MRTS Corridor in GIFT City (Phase - 1 & 2)									
2051									
UP Direction (GNLU to GF-III)					DN Direction (GF-III to GNLU)				
Station No.	Station Name	Boarding	Alighting	Sectional Load	Station No.	Station Name	Boarding	Alighting	Sectional Load
					6	GIFT	792	0	0
					5	Lavarpur	23	0	792
					4	Ratanpur	5	0	815
1	GIFT City House	20	2,714	4,434	3	Shahpur	9	1	820
2	Gujarat Biotechnology University	22	809	1,739	2	Gujarat Biotechnology University	662	27	828
3	Shahpur	1	7	952	1	GIFT City House	2,238	23	1,463
4	Ratanpur	0	4	946					
5	Lavarpur	0	19	942					
6	GIFT	0	923	923					

1. GIFT City House Station

Chainage	5908.952m
Inter-Station Distance	926.267m from the previous station
Rail Level	78.90 m
Platform Height from Ground	15.55 m
Location	On- Road station near intersection of Road no 1 with Road 1C
Entry / Exit Stairs	Entry Exit stairs proposed on the pedestrians footpaths
Catchment Area	GIFT city pockets56, 13, 14, 15, 16, 52, 36, 53, 55 and 51



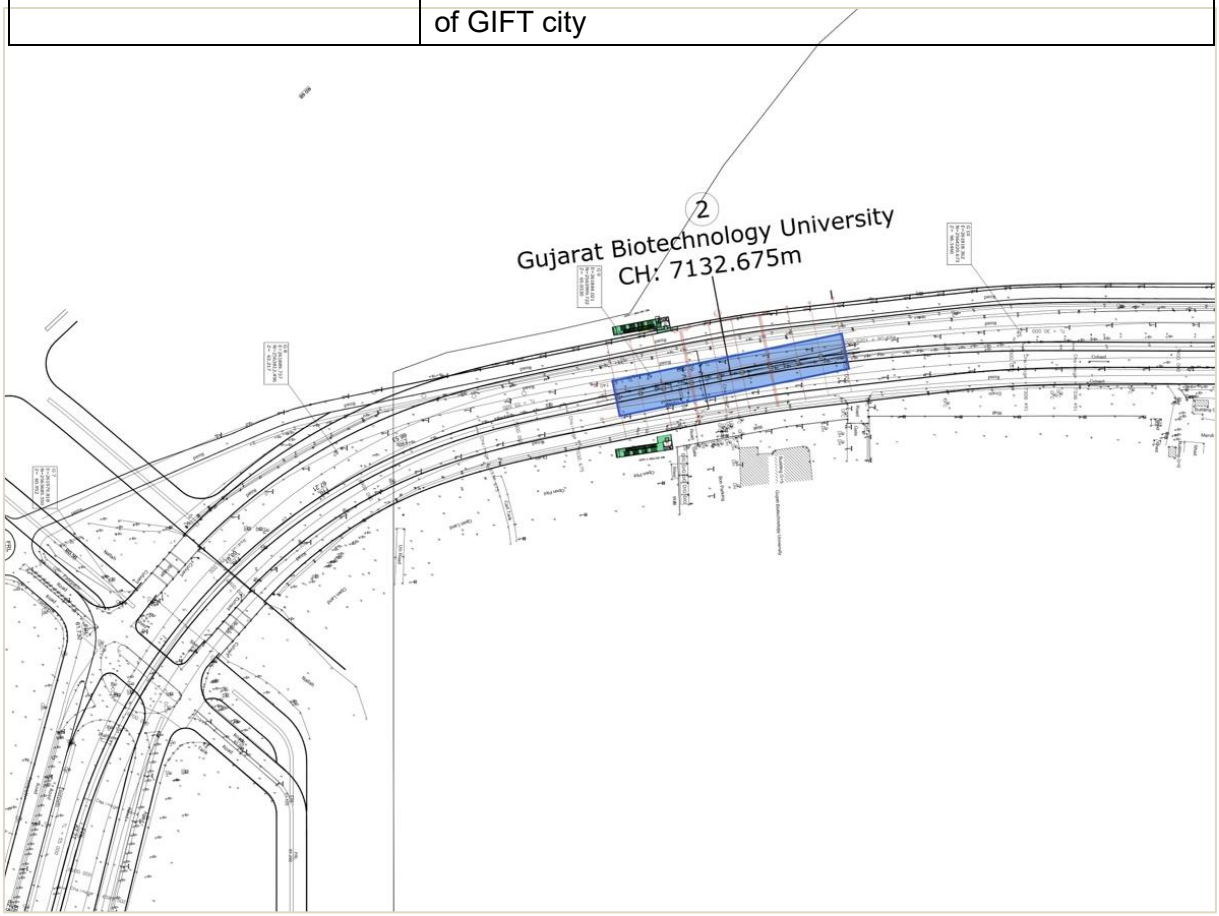






2. Gujarat Biotechnology University station

Chainage	7132.675 m.
Inter-Station Distance	1223.723 m from the previous station
Rail Level	80.30 m
Platform height from Ground	15.91 m
Location	On-Road station located opposite to Gujarat Biotechnology University
Entry / Exit Stairs	Entry Exit stairs proposed on the pedestrians footpaths
Catchment Area	GIFT city pockets 57 and 58, Gujarat Biotechnology University and nearby residential areas as per master plan of GIFT city



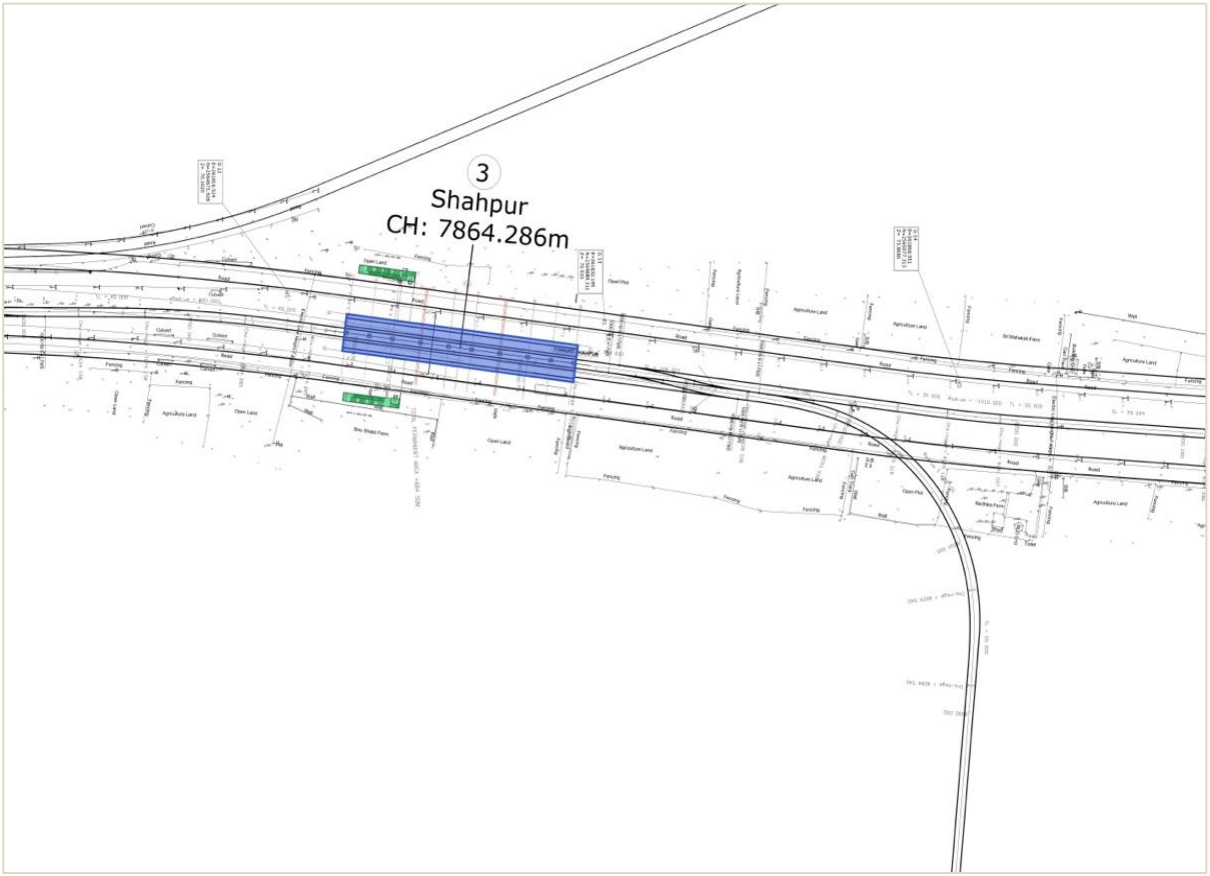






3. Shahpur station

Chainage	7864.286 m
Inter-Station Distance	731.611 m from the previous station
Rail Level	86.60 m
Platform height from Ground	15.55 m
Location	Located on Gift City Road 1C 225m from GIFT Road spur
Entry / Exit Stairs	Entry Exit stairs proposed on the pedestrians footpaths
Catchment Area	All residential areas, institutional areas and recreational areas in GIFT city master plan



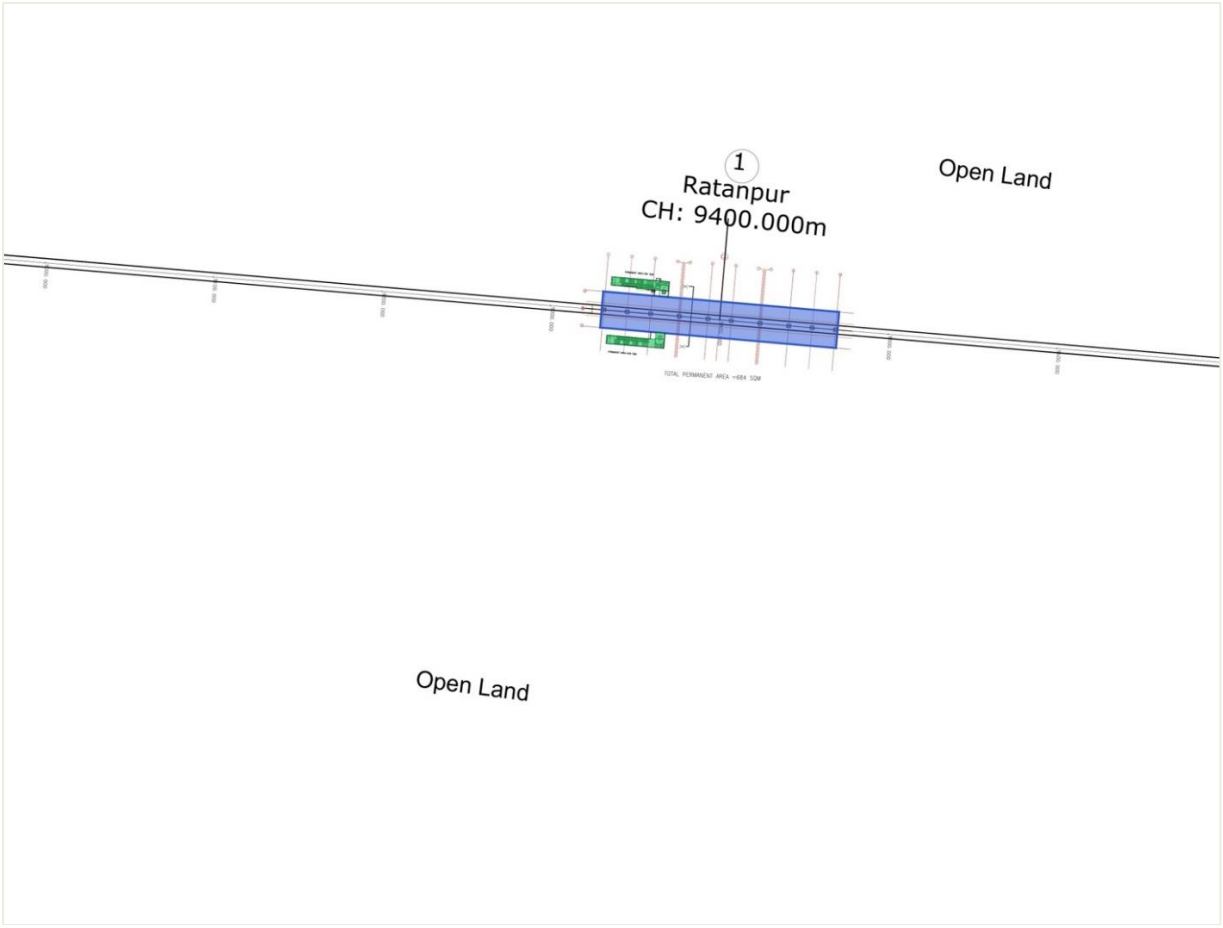






4. Ratanpur station

Chainage	9400.00 m
Inter-Station Distance	1535.714 m from the previous station
Rail Level	89.10 m
Platform height from Ground	15.57 m
Location	Located proposed Gift City Road
Entry / Exit Stairs	Entry Exit stairs proposed on the pedestrians footpaths
Catchment Area	All residential areas, institutional areas and recreational areas in GIFT city master plan



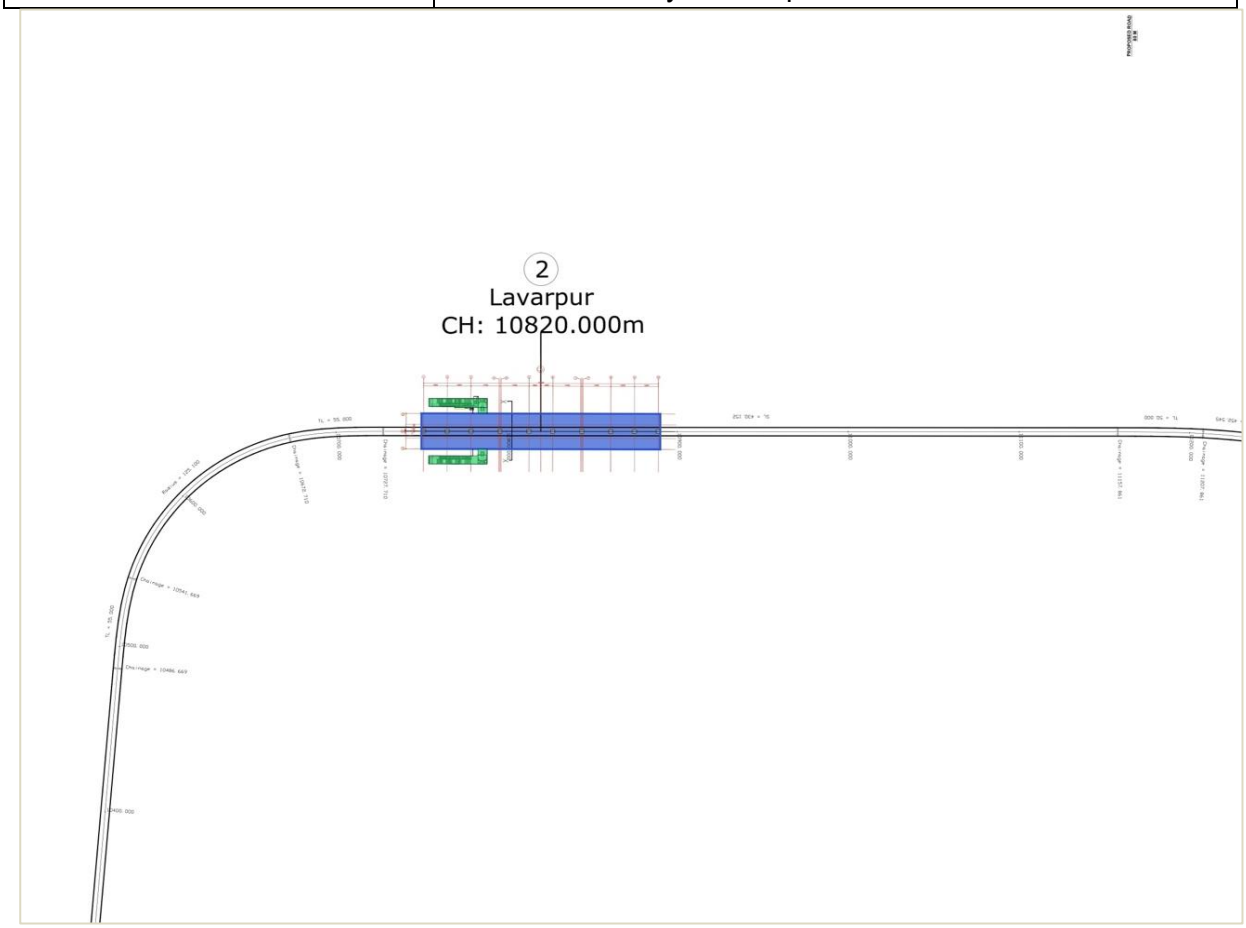






5. Lavarpur station

Chainage	10820.00 m
Inter-Station Distance	1420.00 m from the previous station
Rail Level	86.30 m
Platform height from Ground	15.70 m
Location	Located proposed Gift City Road
Entry / Exit Stairs	Entry Exit stairs proposed on the pedestrians footpaths
Catchment Area	All residential areas, institutional areas and recreational areas in GIFT city master plan



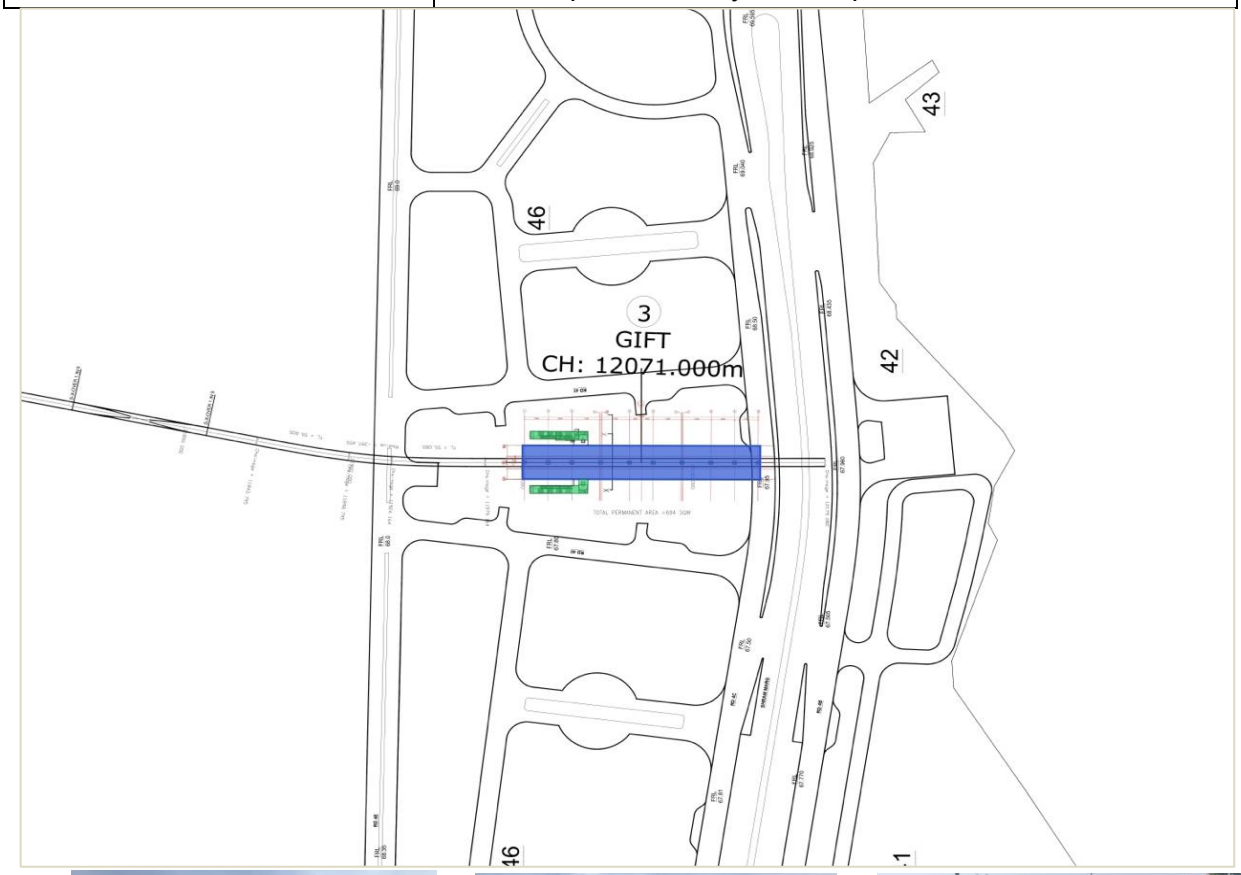






6. GIFT station

Chainage	12071.00 m
Inter-Station Distance	1251.00 m from the previous station
Rail Level	85.50 m
Platform height from Ground	20.70 m(due to on ground construction depression)
Location	Located proposed Gift City Road
Entry / Exit Stairs	Entry Exit stairs proposed on the pedestrians footpaths
Catchment Area	GIFT city pockets 40, 41, 42, 43, 46, 47 and upcoming areas as per GIFT City master plan









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 between the concourse bottom and the road, allowing 3.50-m concourse height for the commuters, about 2-m for concourse floor services and 2.00-m for structure of tracks above the concourse (the same may vary based on actual girder used). 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, outside the right-of-way planned for gift city area and allotted to the MRTS. This arrangement can be modified based on availability of land within ROW of the area.

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 on the ground, preferably near entry structures for elevated station and in ancillary structure for underground stations.

10. The system is being designed to attract potential passengers with following features:

- Minimum distance of travel to and from the platform and between platforms for transfer between lines.
- Adequate level of service for all passenger areas.
- 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. Minimization of capital cost while maximizing the attractiveness of metro system for the commuters
b. Minimization of operational costs while maintaining efficiency and the safety of commuters.
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 on platforms, fare collection zones and other passenger areas, thus aiding the supervision of operations and monitoring of efficiency and safety.
e. Provision of space for 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 station entry on ground to platforms and vice versa, station planning has been based on established principles of pedestrian flow and has been planned to minimize passenger travel 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 entry structures on ground to platform and vice-versa (these facilities must also enable evacuation of the station under emergency conditions, within a set safe time limit).

6.4 TYPICAL ELEVATED STATION

The station is generally located on the road median with 140m long footprint with three levels namely ground, concourse and platform.

Passenger area on concourse can be categorised as 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 Manager Room, UPS & Battery Room, Signalling Room, Security Room, Station Store Room, 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 140m. and 21.39 m. respectively.

With respect to its spatial quality, an elevated MRT structure makes a great impact on the viewer with the structure that afford maximum transparency and are light looking. A slim and ultra-modern concrete form is proposed, rendering both modern and compatible elevation 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 curved 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 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 actual requirement of the facilities somewhat 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*.

6.6 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.

6.7 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.

6.8 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.

6.9 PLATFORMS

A uniform platform minimum width of 3.2-m wide with staircases and escalators appropriately located 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.

6.10 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 4.8 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 5.5 minutes in most stations.

6.11 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 board and alight from various stations by public transport, IPT, NMT 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.

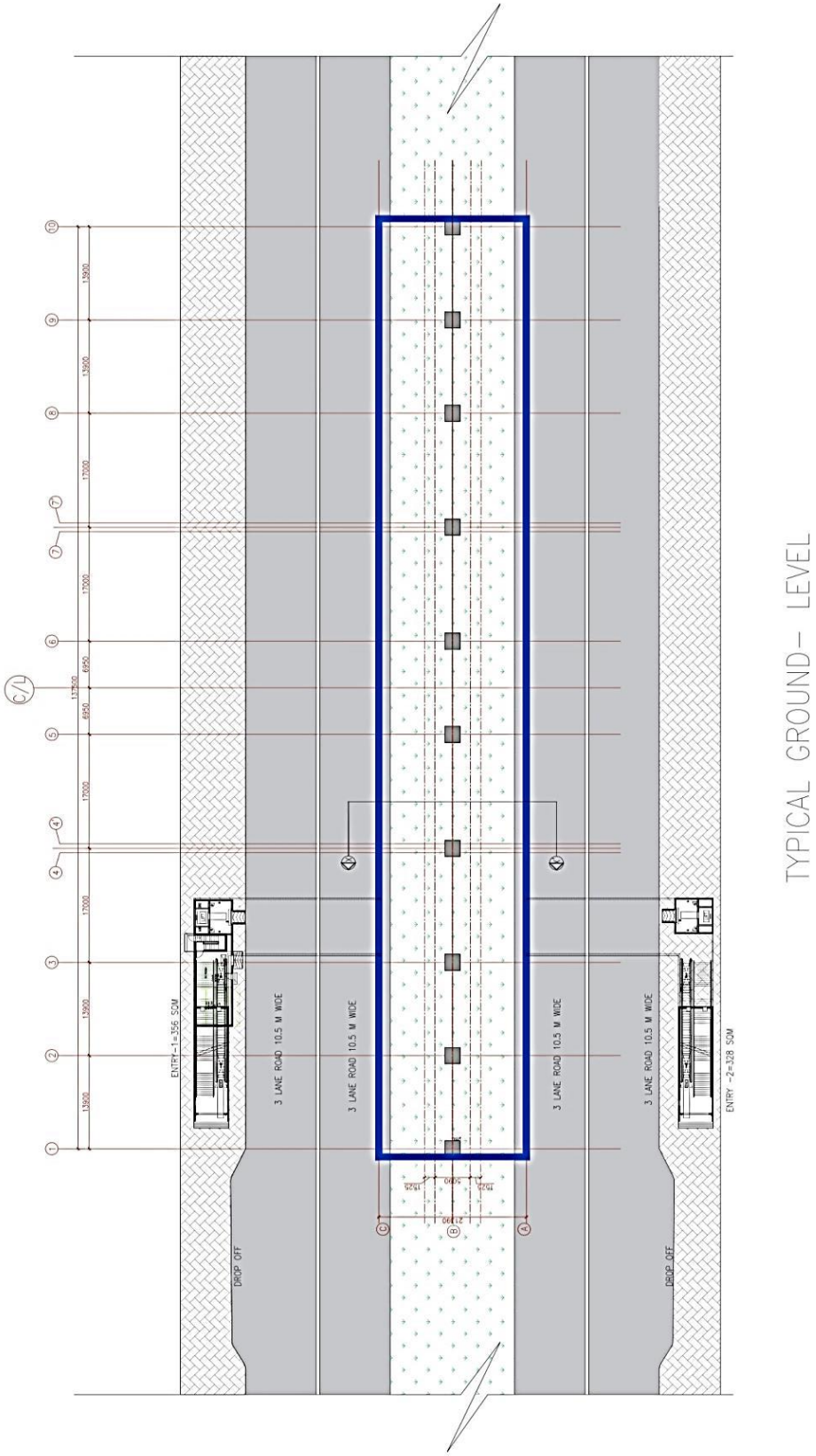
6.12 APPROACH ADOPTED IN PLANNING TRAFFIC INTEGRATION FACILITIES

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.

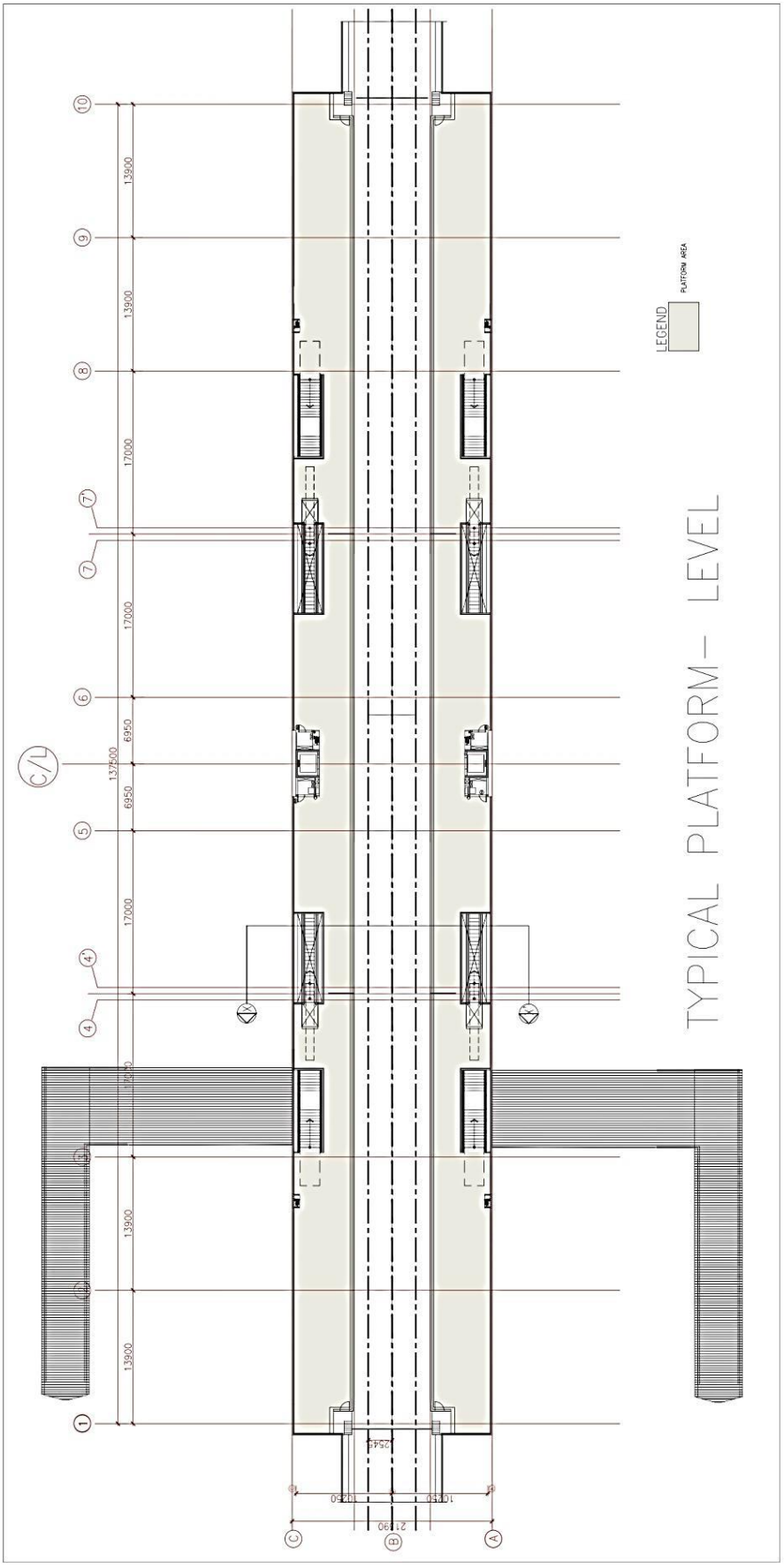
6.13 OPERATIONAL INTEGRATION

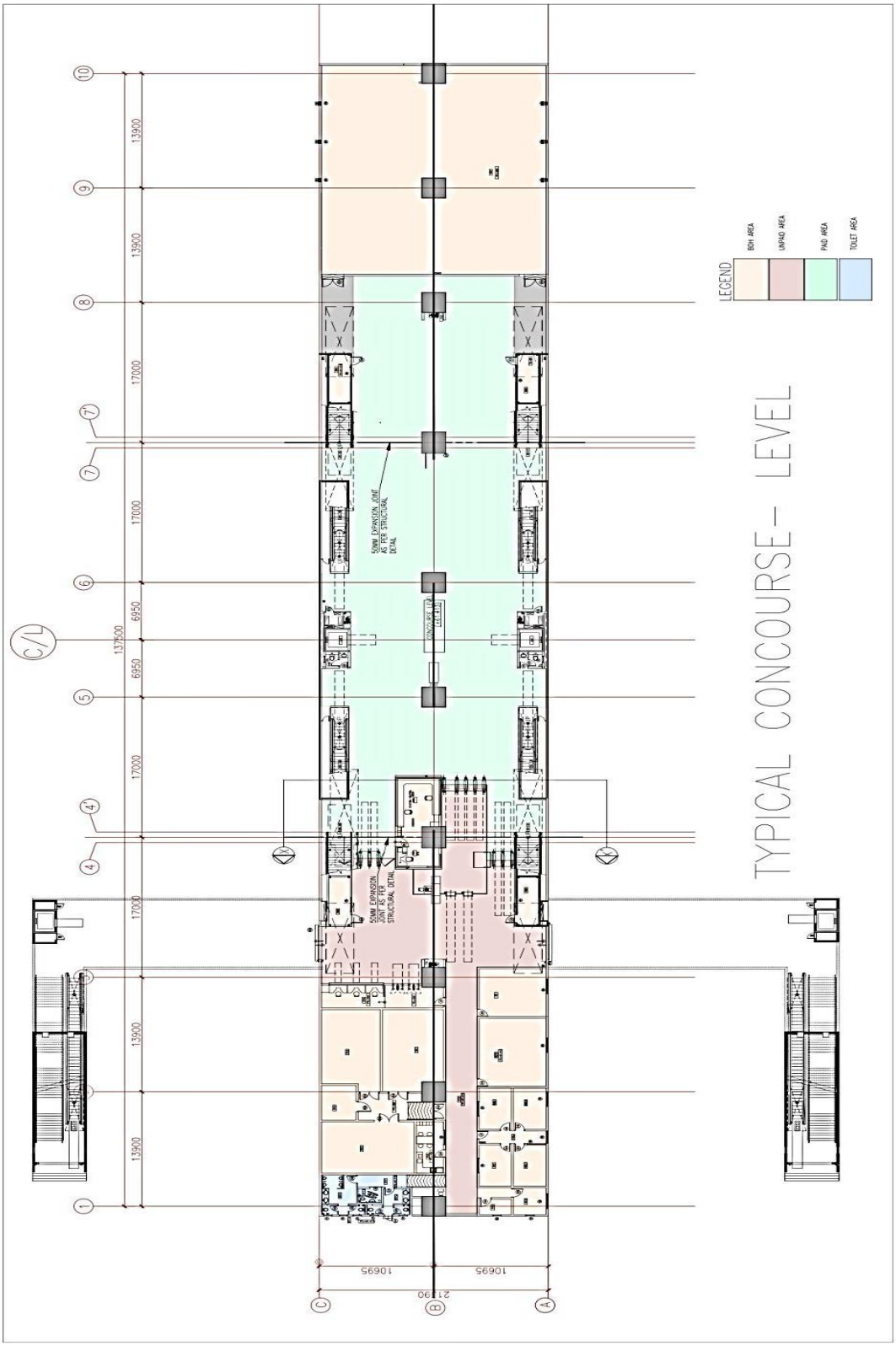
Integration at operational level will be required to synchronize the timings of the MRTS services and the bus service. For an efficient interchange, walking and waiting time at these stations will need to be minimized. Introduction of common ticketing and their availability at convenient locations will be necessary to ensure forecast patronage of the system. 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.

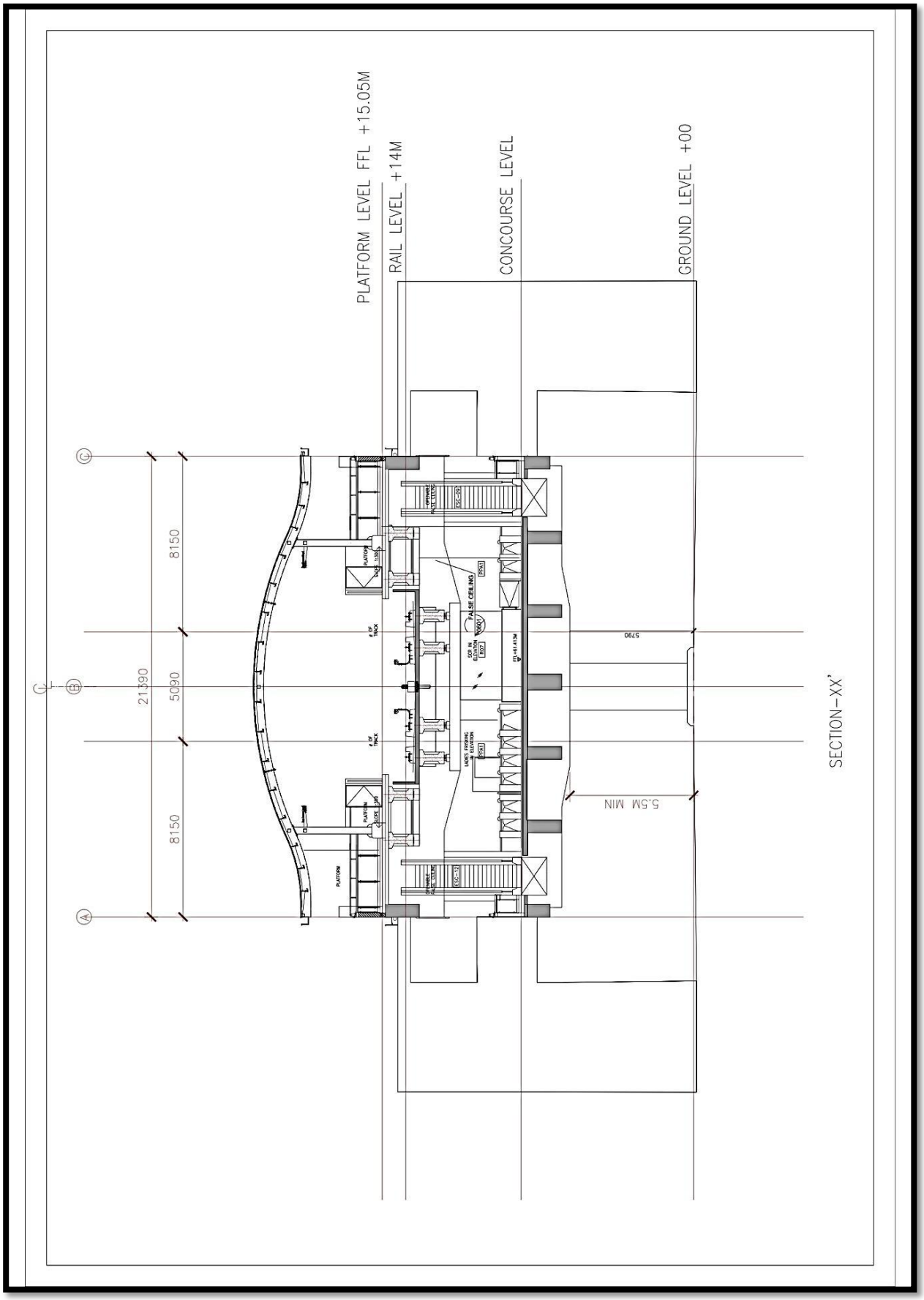
TYPICAL ELEVATED STATION



TYPICAL GROUND– LEVEL


TYPICAL PLATFORM– LEVEL
LEGEND
PLATFORM AREA
C/L
13900
17000
6950
137500
25540
21930


TYPICAL CONCOURSE– LEVEL
LEGEND
BOH AREA
UNPAID AREA
PAID AREA
TOILET AREA
50MM EXPANSION JOINT AS PER STRUCTURAL DETAIL
C/L
10695
10695
21190


PLATFORM LEVEL FFL +15.05M
RAIL LEVEL +14M
CONCOURSE LEVEL
GROUND LEVEL +00
8150
5090
8150
21390
5790
5.5M MIN
SECTION–XX'

Chapter - 7

Train Operation Plan



7.1 Operation Philosophy

7.2 Stations

7.3 Train Operation Plan: Salient Features

7.4 Traffic Demand

7.5 Train Formation

7.6 Train Operation Plan

7.7 Train Frequency

7.8 Hourly Train Operation Plan

7.9 Vehicle Kilometer

7.10 Year Wise Rake Requirement

7.11 Cost Estimate



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

1. North-South Corridor: APMC to Mahatma Mandir

S. No	Station Name	Chainage (m)	Inter Distance Between Two Stations.	Station Type	Remarks
	Dead End	-1615			Already Operational
1	APMC	0		Elevated	
2	Jivraj	950	950	Elevated	
3	Rajiv Nagar	1800	850	Elevated	
4	Shreyash	3170	1370	Elevated	
5	Paldi	4524	1354	Elevated	
6	Gandhigram Railway Station	5970	1446	Elevated	
7	Old High Court	7045	1075	Elevated	
8	Ushmanpura	8078	1033	Elevated	
9	Vijay Nagar	9575	1497	Elevated	
10	New Vadaj	10867	1292	Elevated	
11	Ranip	12197	1330	Elevated	
12	Sabarmati Railway Station	12965	768	Elevated	
13	AEC	13906	941	Elevated	
14	Sabarmati	15265	1359	Elevated	
15	Motera Stadium	16661.70	1396.695	Elevated	
16	Koteshwar Road	17598.80	937.11	Elevated	
17	Vishwakarma	19017.00	1418.20	Elevated	

S. No	Station Name	Chainage (m)	Inter Distance Between Two Stations.	Station Type	Remarks
	College				Already under Construction
18	Tapovan Circle	19994.45	977.45	Elevated	
19	Narmada Canal	20900.00	905.55	Elevated	
20	Koba Circle	22050.63	1150.63	Elevated	
21	Juna Koba	23056.45	1005.82	Elevated	
22	Koba Gaam	24066.45	1010.00	Elevated	
23	GNLU	24977.57	911.12	Elevated	
24	Raysan	26413.75	1436.18	Elevated	
25	Randesan	27786.89	1373.14	Elevated	
26	Dholakuva Circle	28943.26	1156.37	Elevated	
27	Infocity	30334.00	1390.74	Elevated	
28	Sector - 1	31600.00	1266.00	Elevated	
29	Sector 10A	32850.00	1250.00	Elevated	
30	Sachivalaya	34041.26	1191.26	Elevated	
31	Akshardham	35170.00	1128.74	Elevated	
32	Juna Sachivalaya	36069.00	899.00	Elevated	
33	Sector - 16	37161.35	1092.35	Elevated	
34	Sector - 24	38199.01	1037.66	Elevated	
35	Mahatma Mandir	39399.64	1200.63	Elevated	
	DEAD END	39499.64	100.00		

2. Koteshwar Road - Airport Metro Corridor

S. No	Station Name	Chainage (m)	Inter Distance Between Two Stations.	Station Type	Remarks
0	Koteshwar	-389.954		Elevated	Already under Construction
	End of under construction section and start of this DPR Corridor	0.00			Present DPR under study
1	Koteshwar Prachin Mandir	2394.93	2394.93	Elevated	
2	Sabarmati River	3041.57	646.64	Elevated	
3	Sardarnagar	4545.22	1503.65	Elevated	
4	Airport	6218.61	1673.39	Underground	
	DEAD END	6333.61	115.00		

3. GNLU to GIFT

S. No	Station Name	Chainage (m)	Inter Distance Between Two Stations.	Station Type	Remarks
	DEAD END	-405.00			Already under Construction
1	GNLU	0.00	405.00	Elevated	
2	PDPU	1749.00	1749.00	Elevated	
3	Gift City	4605.86	2856.86	Elevated	
	End of under Construction section and start of this DPR Corridor	4982.69			Present DPR under study (Will be constructed in first phase)
4	Gift City House	5908.95	1303.09	Elevated	
5	Gujarat Biotechnology University	7132.68	1223.72	Elevated	
6	Shahpur	7864.29	731.61	Elevated	
7	Ratanpur	9400.00	1535.71	Elevated	Present DPR under study (Will be constructed in second phase)
8	Lavarpur	10820.00	1420.00	Elevated	
9	GIFT	12071.00	1251.00	Elevated	
	Dead End	12187.42	116.42		

Note: Second Phase of GIFT City extension shall be operation from 2031.

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: 30 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 2027, 2031, 2041 and 2051 for the purpose of planning are indicated in Attachment I/A, I/B, I/C, I/D 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)

Capacity AW3 (@ 8 passengers per square meter of standee area)

Driving Motor Car (DMC) - 315 (43 seated + 272 standing)
Trailer Car (TC) - 342 (50 seated + 292 standing)
3 Car Train - 972 (136 seated + 836 standing)

7.6 TRAIN OPERATION PLAN

Train Operation is planned in such a manner that trains originating from APMC will alternatively terminate at Mahatma Mandir Terminal Station and Shahpur/GIFT terminal Station. This operation will result in half of originating headway in common section of APMC to GNLU (Y type operation). Shuttle operation is planned for Koteshwar road to Airport Station at headway of 12 minutes from the year 2027 to 2051.

It is to be noted that Corridor proposed from GNLU to GIFT will fully operate in 2031 and in year 2027 only GNLU to Shahpur section will came in operation.

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 ' for the year 2027, 2031, 2041 and 2051 are given below:

TABLE 7.2 Rake Requirement

Sections	Year	Headway (min)	No. of Rakes operational in APMC to Motera (Phase-I)	Total No of Rakes Ordered in Phase-II Corridor	Rake Consist	No. of Rakes required	Additional Rakes Required	Max. PHPDT Demand	PHPDT Capacity Available
APMC to GNLU	2027	6	14	10	3-car	30	6	4572	7640* (9720#)
GNLU to Mahatma Mandir and GNLU to Shahpur		12						1763	3820* (4860#)
Koteshwar Road to Airport		12	N/A	N/A		4	4	1269	3820* (4860#)
APMC to Mahatma Mandir	2031	6	37		3-car	31	Nil	5128	7640* (9720#)
GNLU to Mahatma Mandir and GNLU to GIFT		12						2346	3820* (4860#)
Koteshwar Road to Airport		12				4		1662	3820* (4860#)
APMC to Mahatma Mandir	2041	4.5	46		3-car	42	Nil	7757	10187* (12960#)
GNLU to Mahatma Mandir and GNLU to GIFT		9						5105	5093* (6480#)

Sections	Year	Headway (min)	No. of Rakes operational in APMC to Motera (Phase-I)	Total No of Rakes Ordered in Phase-II Corridor	Rake Consist	No. of Rakes required	Additional Rakes Required	Max. PHPDT Demand	PHPDT Capacity Available
Koteshwar Road to Airport		12				4		2164	3820* (4860#)
APMC to Mahatma Mandir	2051	4.15	54		3-car	44	Nil	8956	11046* (14053#)
GNLU to Mahatma Mandir and to GIFT		8.3						5733	5523* (7027#)
Koteshwar Road to Airport		12				4		2719	3820* (4860#)

7.7 TRAIN FREQUENCY

TABLE 7.5 Train Frequency Corridors

Section	2027		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 GNLU	6 min	10 to 30 min	6 min	10 to 30 min	4.5 min	6 to 20 min	4.15 min	6 to 20 min
GNLU to Mahatma Mandir and GNLU to Shahpur	12 min	16 to 40 min	12 min	16 to 40 min	9 min	12 to 40 min	8.3 min	12 to 40 min
Koteshwar Road to Airport	12 min	16 to 40 min	12 min	16 to 40 min	12 min	16 to 40 min	12 min	16 to 40 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 1.1,2.1, 3.1,4.1** for 'APMC to GNLU' Section and **Table 1.2, 2.2, 3.2, 4.2** for 'GNLU to Shapur/GIFT' and 'GNLU to Mahatma Mandir' and Section and **Table 1.3, 2.3, 3.3, 4.4** for 'Koteshwar Road to Airport' Section respectively for years 2027, 2031, 2041 and 2051 enclosed as **Attachment II.**

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 4.1** enclosed as **Attachment III**.

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 IV.**

Requirements of coaches is calculated based on following assumptions-

Assumptions –

(i) Train Composition planned as under

3 car Train Composition (67% Powering)	**: DMC +TC +DMC**
Train Carrying Capacity of 3 Car Train (@6 passengers per square meter of standee area)	: 764 passengers @6 standee/sqm
Train Carrying Capacity of 3 Car Train (@8 passengers per square meter of standee area	: 972 passengers @ 8 standee/sqm

(ii) Coach requirement has been calculated based on headway during peak hours.

(iii) Traffic reserve is taken as one train to cater to failure of train on line and to make up for operational time list.

(iv) Repair and maintenance reserve has been estimated as 8 to 10 % of total requirement (Bare).

(v) The calculated number of bare rakes in fraction is rounded off to next higher number.

(vi) Schedule speed is taken as: 30 kmph

(vii) Total Turn round time is taken as 6 min at terminal stations.

7.11 COST ESTIMATE

The estimated cost per coach at Jan 2019 Price level exclusive of taxes and duties may be assumed as INR 8.0 Crores per Coach. Total 18 additional cars are required in year 2027 for extension of North-South Corridor in Phase-II ((APMC - Motera Stadium) to Mahatma Mandir and GNLU to Shahpur and total 12 cars are required for Koteshwar Road to Airport section in Ahmedabad Metro Rail Network. Hence budget provision for total 30 Cars of ₹ 240 Crores (approx.) is to be kept in the Estimate for Rolling stock.

Annexure-1A

PHPDT Demand and Capacity Chart

Ahmedabad Metro

Year:	2027	
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	APMC to GNLU
Headway (min)	12	GNLU to Mahatma Mandir and GNLU to Shahpur
Headway (min)	12	Shuttle Operation in Koteshwar to Airport

S.N	FROM	TO	FROM	TO	FROM	TO	PHPDT Demand Phase-1 and Phase-2 Line	PHPDT Phase-2 Line and New LinE	PHPDT Airport New Line	Train carrying capacity @ 6p/sqm of standee area	Train carrying capacity @ 8p/sqm of standee area	Train carrying capacity @ 6p/sqm of standee area	Train carrying capacity @ 8p/sqm of standee area	Train carrying capacity @ 6p/sqm of standee area	Train carrying capacity @ 8p/sqm of standee area
	Phase-1 and Phase 2 Line		Phase-2 Line and New Line		Airport Line Shuttle Operation					Phase-1 and Phase 2 Line		Phase-2 Line and New Line		Airport Line Shuttle Operation	
1	APMC	Jivraj					382			7640	9720				
2	Jivraj	Rajiv nagar					826			7640	9720				
3	Rajiv nagar	Shreyash					924			7640	9720				
4	Shreyash	Paldi					1013			7640	9720				
5	Paldi	Gandhigram rly stn					1311			7640	9720				
6	Gandhigram rly stn	Old high court					1651			7640	9720				
7	Old high court	Ushmanpura					4065			7640	9720				
8	Ushmanpura	Vijay nagar					4072		----------	7640	9720				
9	Vijay nagar	New vadaj					**4172**		----------	7640	9720				
10	New vadaj	Ranip					4081		----------	7640	9720				
11	Ranip	Sabarmati Rly stn					3908		----------	7640	9720				
12	Sabarmati Rly stn	AEC					3754		----------	7640	9720				
13	AEC	Sabarmati					3691		----------	7640	9720				
14	Sabarmati	Motera Stadium					3544		----------	7640	9720				
15	Motera Stadium	Koteshwar Road					3266			7640	9720				
16	Koteshwar Road	Vishvakarma College			Koteshwar	Koteshwar Prachin Mandir	2490		**1269**	7640	9720			3820	4860
17	Vishvakarma College	Tapovan Circle			Koteshwar Prachin Mandir	Sabarmati River	2473		1246	7640	9720			3820	4860
18	Tapovan Circle	Narmada Canal			Sabarmati River	Sardarnagar	2406		1225	7640	9720			3820	4860
19	Narmada Canal	Koba Circle			Sardarnagar	Airport	2406		1161	7640	9720			3820	4860
20	Koba Circle	Juna Koba					2403			7640	9720				
21	Juna Koba	Koba Gaam					2403			7640	9720				
22	Koba Gaam	GNLU					2399			7640	9720				
23	GNLU	Raysan	GNLU	PDPU			915	**1763**		7640	9720	3820	4860		
24	Raysan	Randesan	PDPU	GIFT City (Existing)			904	1578		3820	4860	3820	4860		
25	Randesan	Dholakuva Circle	GIFT City (Existing)	GIFT City House			888	1214		3820	4860	3820	4860		
26	Dholakuva Circle	Infocity	GIFT City House	Gujarat Biotechnology University			833	295		3820	4860	3820	4860		
27	Infocity	Sector 1	Gujarat Biotechnology Un	Shahpur			817	7		3820	4860	3820	4860		
28	Sector 1	Sector 10A					804			3820	4860				
29	Sector 10A	Sachivalaya					724			3820	4860				
30	Sachivalaya	Akshardham					569			3820	4860				
31	Akshardham	Juna Sachivalaya					485			3820	4860				
32	Juna Sachivalaya	Sector 16					436			3820	4860				
33	Sector 16	Sector 24					329			3820	4860				
34	Sector 24	Mahatma Mandir					195			3820	4860				

Note: APMC to Motera is existing section of Phase-I Corridor where 3-Car Trains are operating. Under Phase-II Project of Ahmedabad Metro-Motera to Mahatma Mandir and GNLU to Gift City sections are under construction. Two new corridors are proposed for DPR Preperation, one is from Koteshwar to Airport and other is from Gift City to Shahpur

Annexure-1B

PHPDT Demand and Capacity Chart

Ahmedabad Metro

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)	6 APMC to GNLU
Headway (min)	12 GNLU to Mahatma Mandir and GNLU to GIFT
Headway (min)	12 Shuttle Operation in Koteshwar to Airport

S.N	FROM	TO	FROM	TO	FROM	TO	PHPDT Demand Phase-1 and Phase-2 Line	PHPDT Phase-2 Line and New LinE	PHPDT Airport New Line	Train carrying capacity @ 6p/sqm of standee area	Train carrying capacity @ 8p/sqm of standee area	Train carrying capacity @ 6p/sqm of standee area	Train carrying capacity @ 8p/sqm of standee area	Train carrying capacity @ 6p/sqm of standee area	Train carrying capacity @ 8p/sqm of standee area
	Phase-1 and Phase 2 Line		Phase-2 Line and New Line		Airport Line Shuttle Operation					Phase-1 and Phase 2 Line		Phase-2 Line and New Line		Airport Line Shuttle Operation	
1	APMC	Jivraj					421			7640	9720				
2	Jivraj	Rajiv nagar					930			7640	9720				
3	Rajiv nagar	Shreyash					1,036			7640	9720				
4	Shreyash	Paldi					1,134			7640	9720				
5	Paldi	Gandhigram rly stn					1,465			7640	9720				
6	Gandhigram rly stn	Old high court					1,830			7640	9720				
7	Old high court	Ushmanpura					4,989			7640	9720				
8	Ushmanpura	Vijay nagar					5,003		----------	7640	9720				
9	Vijay nagar	New vadaj					5,128		----------	7640	9720				
10	New vadaj	Ranip					5,066		----------	7640	9720				
11	Ranip	Sabarmati Rly stn					4,906		----------	7640	9720				
12	Sabarmati Rly stn	AEC					4,705		----------	7640	9720				
13	AEC	Sabarmati					4,650		----------	7640	9720				
14	Sabarmati	Motera Stadium					4,515		----------	7640	9720				
15	Motera Stadium	Koteshwar Road					4,241			7640	9720				
16	Koteshwar Road	Vishvakarma College			Koteshwar	Koteshwar Prachin Mandir	3,166		1,662	7640	9720			3820	4860
17	Vishvakarma College	Tapovan Circle			Koteshwar Prachin Mandir	Sabarmati River	3,147		1,637	7640	9720			3820	4860
18	Tapovan Circle	Narmada Canal			Sabarmati River	Sardarnagar	3,070		1,614	7640	9720			3820	4860
19	Narmada Canal	Koba Circle			Sardarnagar	Airport	3,073		1,539	7640	9720			3820	4860
20	Koba Circle	Juna Koba					3,075			7640	9720				
21	Juna Koba	Koba Gaam					3,076			7640	9720				
22	Koba Gaam	GNLU					3,071			7640	9720				
23	GNLU	Raysan	GNLU	PDPU			1,110	2346		7640	9720	3820	4860		
24	Raysan	Randesan	PDPU	GIFT City (Existing)			1097	2156		3820	4860	3820	4860		
25	Randesan	Dholakuva Circle	GIFT City (Existing)	GIFT City House			1077	1752		3820	4860	3820	4860		
26	Dholakuva Circle	Infocity	GIFT City House	Gujarat Biotechnology University			1006	714		3820	4860	3820	4860		
27	Infocity	Sector 1	Gujarat Biotechnology Un	Shahpur			989	391		3820	4860	3820	4860		
28	Sector 1	Sector 10A	Shahpur	Ratanpur			973	385		3820	4860	3820	4860		
29	Sector 10A	Sachivalaya	Ratanpur	Lavarpur			876	382		3820	4860	3820	4860		
30	Sachivalaya	Akshardham	Lavarpur	GIFT			693	366		3820	4860	3820	4860		
31	Akshardham	Juna Sachivalaya					591			3820	4860				
32	Juna Sachivalaya	Sector 16					532			3820	4860				
33	Sector 16	Sector 24					398			3820	4860				
34	Sector 24	Mahatma Mandir					227			3820	4860				

Note: APMC to Motera is existing section of Phase-I Corridor where 3-Car Trains are operating. Under Phase-II Project of Ahmedabad Metro-Motera to Mahatma Mandir and GNLU to Gift City sections are under construction. Two new corridors are proposed for DPR Preperation, one is from Koteshwar to Airport and other is from Gift City to Gift.

Annexure-1C

PHPDT Demand and Capacity Chart

Ahmedabad Metro

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)	4.5 APMC to GNLU
Headway (min)	9 GNLU to Mahatma Mandir and GNLU to GIFT
Headway (min)	12 Shuttle Operation in Koteshwar to Airport

S.N	FROM	TO	FROM	TO	FROM	TO	PHPDT Demand Phase-1 and Phase-2 Line	PHPDT Phase-2 Line and New LinE	PHPDT Airport New Line	Train carrying capacity @ 6p/sqm of standee area	Train carrying capacity @ 8p/sqm of standee area	Train carrying capacity @ 6p/sqm of standee area	Train carrying capacity @ 8p/sqm of standee area	Train carrying capacity @ 6p/sqm of standee area	Train carrying capacity @ 8p/sqm of standee area
	Phase-1 and Phase 2 Line		Phase-2 Line and New Line		Airport Line Shuttle Operation					Phase-1 and Phase 2 Line		Phase-2 Line and New Line		Airport Line Shuttle Operation	
1	APMC	Jivraj					560			10187	12960				
2	Jivraj	Rajiv nagar					1281			10187	12960				
3	Rajiv nagar	Shreyash					1417			10187	12960				
4	Shreyash	Paldi					1552			10187	12960				
5	Paldi	Gandhigram rly stn					2024			10187	12960				
6	Gandhigram rly stn	Old high court					2423			10187	12960				
7	Old high court	Ushmanpura					7457			10187	12960				
8	Ushmanpura	Vijay nagar					7503		----------	10187	12960				
9	Vijay nagar	New vadaj					7726		----------	10187	12960				
10	New vadaj	Ranip					**7757**		----------	10187	12960				
11	Ranip	Sabarmati Rly stn					7634		----------	10187	12960				
12	Sabarmati Rly stn	AEC					7467		----------	10187	12960				
13	AEC	Sabarmati					7431		----------	10187	12960				
14	Sabarmati	Motera Stadium					7340		----------	10187	12960				
15	Motera Stadium	Koteshwar Road					7145			10187	12960				
16	Koteshwar Road	Vishvakarma College			Koteshwar	Koteshwar Prachin Mandir	6039		**2164**	10187	12960			3820	4860
17	Vishvakarma College	Tapovan Circle			Koteshwar Prachin Mandir	Sabarmati River	6033		2127	10187	12960			3820	4860
18	Tapovan Circle	Narmada Canal			Sabarmati River	Sardarnagar	5956		2101	10187	12960			3820	4860
19	Narmada Canal	Koba Circle			Sardarnagar	Airport	5972		1987	10187	12960			3820	4860
20	Koba Circle	Juna Koba					6000			10187	12960				
21	Juna Koba	Koba Gaam					6004			10187	12960				
22	Koba Gaam	GNLU					6003			10187	12960				
23	GNLU	Raysan	GNLU	PDPU			1754	**5,105**		10187	12960	5093	6480		
24	Raysan	Randesan	PDPU	GIFT City (Existing)			1735	4,918		5093	6480	5093	6480		
25	Randesan	Dholakuva Circle	GIFT City (Existing)	GIFT City House			1700	3,995		5093	6480	5093	6480		
26	Dholakuva Circle	Infocity	GIFT City House	Gujarat Biotechnology University			1585	1,565		5093	6480	5093	6480		
27	Infocity	Sector 1	Gujarat Biotechnology Un	Shahpur			1560	853		5093	6480	5093	6480		
28	Sector 1	Sector 10A	Shahpur	Ratanpur			1537	848		5093	6480	5093	6480		
29	Sector 10A	Sachivalaya	Ratanpur	Lavarpur			1389	844		5093	6480	5093	6480		
30	Sachivalaya	Akshardham	Lavarpur	GIFT			1105	827		5093	6480	5093	6480		
31	Akshardham	Juna Sachivalaya					944			5093	6480				
32	Juna Sachivalaya	Sector 16					855			5093	6480				
33	Sector 16	Sector 24					639			5093	6480				
34	Sector 24	Mahatma Mandir					370			5093	6480				

Annexure-1D

PHPDT Demand and Capacity Chart

Ahmedabad Metro

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)	4.15 APMC to GNLU
Headway (min)	8.3 GNLU to Mahatma Mandir and GNLU to GIFT
Headway (min)	12 Shuttle Operation in Koteshwar to Airport

S.N	FROM	TO	FROM	TO	FROM	TO	PHPDT Demand Phase-1 and Phase-2 Line	PHPDT Phase-2 Line and New LinE	PHPDT Airport New Line	Train carrying capacity @ 6p/sqm of standee area	Train carrying capacity @ 8p/sqm of standee area	Train carrying capacity @ 6p/sqm of standee area	Train carrying capacity @ 8p/sqm of standee area	Train carrying capacity @ 6p/sqm of standee area	Train carrying capacity @ 8p/sqm of standee area
	Phase-1 and Phase 2 Line		Phase-2 Line and New Line		Airport Line Shuttle Operation					Phase-1 and Phase 2 Line		Phase-2 Line and New Line		Airport Line Shuttle Operation	
1	APMC	Jivraj					616			11046	14053				
2	Jivraj	Rajiv nagar					1426			11046	14053				
3	Rajiv nagar	Shreyash					1574			11046	14053				
4	Shreyash	Paldi					1723			11046	14053				
5	Paldi	Gandhigram rly stn					2251			11046	14053				
6	Gandhigram rly stn	Old high court					2691			11046	14053				
7	Old high court	Ushmanpura					8553			11046	14053				
8	Ushmanpura	Vijay nagar					8614		----------	11046	14053				
9	Vijay nagar	New vadaj					8881		----------	11046	14053				
10	New vadaj	Ranip					**8956**		----------	11046	14053				
11	Ranip	Sabarmati Rly stn					8850		----------	11046	14053				
12	Sabarmati Rly stn	AEC					8684		----------	11046	14053				
13	AEC	Sabarmati					8657		----------	11046	14053				
14	Sabarmati	Motera Stadium					8573		----------	11046	14053				
15	Motera Stadium	Koteshwar Road					8398			11046	14053				
16	Koteshwar Road	Vishvakarma College			Koteshwar	Koteshwar Prachin Mandir	6998		**2719**	11046	14053			3820	4860
17	Vishvakarma College	Tapovan Circle			Koteshwar Prachin Mandir	Sabarmati River	6992		2658	11046	14053			3820	4860
18	Tapovan Circle	Narmada Canal			Sabarmati River	Sardarnagar	6897		2618	11046	14053			3820	4860
19	Narmada Canal	Koba Circle			Sardarnagar	Airport	6916		2436	11046	14053			3820	4860
20	Koba Circle	Juna Koba					6951			11046	14053				
21	Juna Koba	Koba Gaam					6955			11046	14053				
22	Koba Gaam	GNLU					6953			11046	14053				
23	GNLU	Raysan	GNLU	PDPU			2181	**5733**		11046	14053	5523	7027		
24	Raysan	Randesan	PDPU	GIFT City (Existing)			2159	5459		5523	7027	5523	7027		
25	Randesan	Dholakuva Circle	GIFT City (Existing)	GIFT City House			2119	4434		5523	7027	5523	7027		
26	Dholakuva Circle	Infocity	GIFT City House	Gujarat Biotechnology University			1978	1739		5523	7027	5523	7027		
27	Infocity	Sector 1	Gujarat Biotechnology Un	Shahpur			1951	952		5523	7027	5523	7027		
28	Sector 1	Sector 10A	Shahpur	Ratanpur			1928	946		5523	7027	5523	7027		
29	Sector 10A	Sachivalaya	Ratanpur	Lavarpur			1746	942		5523	7027	5523	7027		
30	Sachivalaya	Akshardham	Lavarpur	GIFT			1387	923		5523	7027	5523	7027		
31	Akshardham	Juna Sachivalaya					1189			5523	7027				
32	Juna Sachivalaya	Sector 16					1079			5523	7027				
33	Sector 16	Sector 24					816			5523	7027				
34	Sector 24	Mahatma Mandir					458			5523	7027				

Attachment II

TABLE 1.1

HOURLY TRAIN OPERATION PLAN
APMC to GNLU

Year: 2027
Configuration: 3-Car
Headway(min): 6

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**	**10**	**10**
9 to 10	**6**	**10**	**10**
10 to 11	**6**	**10**	**10**
11 to12	10	6	6
12 to 13	20	3	3
13 to 14	24	3	3
14 to 15	24	3	3
15 to 16	20	3	3
16 to 17	10	6	6
17 to 18	**6**	**10**	**10**
18 to 19	**6**	**10**	**10**
19 to 20	**6**	**10**	**10**
20 to 21	10	6	6
21 to 22	20	3	3
22 to 23	24	3	3
23 to 24	30	2	2
Total No. of train trips per direction per day		**110**	**110**

TABLE 1.2			
HOURLY TRAIN OPERATION PLAN GNLU to Mahatma Mandir and GNLU to Shahpur			
Year:	2027		
Configuration:	3-Car		
Headway(min):	12		
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	**12**	**5**	**5**
9 to 10	**12**	**5**	**5**
10 to 11	**12**	**5**	**5**
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	3	3
16 to 17	16	4	4
17 to 18	**12**	**5**	**5**
18 to 19	**12**	**5**	**5**
19 to 20	**12**	**5**	**5**
20 to 21	16	4	4
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		**68**	**68**

TABLE 1.3

HOURLY TRAIN OPERATION PLAN
Shuttle-Koteshwar to Airport

Year:	**2027**
Configuration:	**3-Car**
Headway(min):	**12**

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	**12**	**5**	**5**
9 to 10	**12**	**5**	**5**
10 to 11	**12**	**5**	**5**
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	3	3
16 to 17	16	4	4
17 to 18	**12**	**5**	**5**
18 to 19	**12**	**5**	**5**
19 to 20	**12**	**5**	**5**
20 to 21	16	4	4
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		**68**	**68**

TABLE 2.1

HOURLY TRAIN OPERATION PLAN
APMC to GNLU

Year:	**2031**
Configuration:	**3-Car**
Headway(min):	**6**

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	24	3	3
6 to 7	20	3	3
7 to 8	10	6	6
8 to 9	**6**	**10**	**10**
9 to 10	**6**	**10**	**10**
10 to 11	**6**	**10**	**10**
11 to12	10	6	6
12 to 13	20	3	3
13 to 14	24	3	3
14 to 15	24	3	3
15 to 16	20	3	3
16 to 17	10	6	6
17 to 18	**6**	**10**	**10**
18 to 19	**6**	**10**	**10**
19 to 20	**6**	**10**	**10**
20 to 21	10	6	6
21 to 22	20	3	3
22 to 23	24	3	3
23 to 24	30	2	2
Total No. of train trips per direction per day		**110**	**110**

TABLE 2.2

HOURLY TRAIN OPERATION PLAN
GNLU to Mahatma Mandir and GNLU to Shahpur

Year:	**2031**
Configuration:	**3-Car**
Headway(min):	**12**

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	**12**	**5**	**5**
9 to 10	**12**	**5**	**5**
10 to 11	**12**	**5**	**5**
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	3	3
16 to 17	16	4	4
17 to 18	**12**	**5**	**5**
18 to 19	**12**	**5**	**5**
19 to 20	**12**	**5**	**5**
20 to 21	16	4	4
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		**68**	**68**

TABLE 2.3
HOURLY TRAIN OPERATION PLAN
Shuttle-Koteshwar to Airport

Year:	**2031**
Configuration:	**3-Car**
Headway(min):	**12**

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	**12**	**5**	**5**
9 to 10	**12**	**5**	**5**
10 to 11	**12**	**5**	**5**
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	3	3
16 to 17	16	4	4
17 to 18	**12**	**5**	**5**
18 to 19	**12**	**5**	**5**
19 to 20	**12**	**5**	**5**
20 to 21	16	4	4
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		**68**	**68**

TABLE 3.1 HOURLY TRAIN OPERATION PLAN APMC to GNLU			
Year:	2041		
Configuration:	3-Car		
Headway(min):	4.5		
Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	16	4	4
6 to 7	12	5	5
7 to 8	6	10	10
8 to 9	**4.5**	**14**	**14**
9 to 10	**4.5**	**14**	**14**
10 to 11	**4.5**	**14**	**14**
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	**4.5**	**14**	**14**
18 to 19	**4.5**	**14**	**14**
19 to 20	**4.5**	**14**	**14**
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		**163**	**163**

TABLE 3.2

HOURLY TRAIN OPERATION PLAN
GNLU to Mahatma Mandir and GNLU to Shahpur

Year:	**2041**
Configuration:	**3-Car**
Headway(min):	**9**

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	**9**	**7**	**7**
9 to 10	**9**	**7**	**7**
10 to 11	**9**	**7**	**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	**9**	**7**	**7**
18 to 19	**9**	**7**	**7**
19 to 20	**9**	**7**	**7**
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		**84**	**84**

TABLE 3.3

HOURLY TRAIN OPERATION PLAN
Shuttle-Koteshwar to Airport

Year:	**2041**
Configuration:	**3-Car**
Headway(min):	**12**

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	**12**	**5**	**5**
9 to 10	**12**	**5**	**5**
10 to 11	**12**	**5**	**5**
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	3	3
16 to 17	16	4	4
17 to 18	**12**	**5**	**5**
18 to 19	**12**	**5**	**5**
19 to 20	**12**	**5**	**5**
20 to 21	16	4	4
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		**68**	**68**

TABLE 4.1

HOURLY TRAIN OPERATION PLAN
APMC to GNLU

Year:	**2051**
Configuration:	**3-Car**
Headway(min):	**4.15**

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	16	4	4
6 to 7	12	5	5
7 to 8	6	10	10
8 to 9	**4.15**	**15**	**15**
9 to 10	**4.15**	**15**	**15**
10 to 11	**4.15**	**15**	**15**
11 to12	6	10	10
12 to 13	12	5	5
13 to 14	16	4	4
14 to 15	16	4	4
15 to 16	12	5	5
16 to 17	6	10	10
17 to 18	**4.15**	**15**	**15**
18 to 19	**4.15**	**15**	**15**
19 to 20	**4.15**	**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 4.2

HOURLY TRAIN OPERATION PLAN
GNLU to Mahatma Mandir and GNLU to Shahpur

Year:	**2051**
Configuration:	**3-Car**
Headway(min):	**8.3**

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	**8.3**	**8**	**8**
9 to 10	**8.3**	**8**	**8**
10 to 11	**8.3**	**8**	**8**
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	**8.3**	**8**	**8**
18 to 19	**8.3**	**8**	**8**
19 to 20	**8.3**	**8**	**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		**90**	**90**

TABLE 4.3 HOURLY TRAIN OPERATION PLAN Shuttle-Koteshwar to Airport			
Year:	2051		
Configuration:	3-Car		
Headway(min):	12		
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	**12**	**5**	**5**
9 to 10	**12**	**5**	**5**
10 to 11	**12**	**5**	**5**
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	3	3
16 to 17	16	4	4
17 to 18	**12**	**5**	**5**
18 to 19	**12**	**5**	**5**
19 to 20	**12**	**5**	**5**
20 to 21	16	4	4
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		**68**	**68**

Attachment-III

TABLE 4.1

Vehicle Kilometer

Ahmedabad Metro

Year	2027				2031				2041				2051			
Section	APMC to GNLU	GNLU to Shahpur	GNLU to Mahatma Mandir	Koteshwar to Airport	APMC to GNLU	GNLU to GIFT	GNLU to Mahatma Mandir	Koteshwar to Airport	APMC to GNLU	GNLU to GIFT	GNLU to Mahatma Mandir	Koteshwar to Airport	APMC to GNLU	GNLU to GIFT	GNLU to Mahatma Mandir	Koteshwar to Airport
Section Length	24.98	7.86	14.41	6.22	24.98	12.07	14.41	6.22	24.98	12.07	14.41	6.22	24.98	12.07	14.41	6.22
Number of Trains per day	110	68	68	68	110	68	68	68	163	84	84	68	169	90	90	68
Daily Train -KM	5496	1069	1960	846	5496	1642	1960	846	8143	2028	2421	846	8443	2173	2594	846
No of working Days in a year	340	340	340	340	340	340	340	340	340	340	340	340	340	340	340	340
Yearly Train -KM (10^3)	1869	363	666	288	1869	558	666	288	2769	689	823	288	2871	739	882	288

Attachment-IV

Rake Requirement for Ahmedabad Metro Project

Year 2027

	Section	Distance (kms)	Schedule Speed in kmph	Headway (min)	Run time (min)	Turn round time (min)	Any other time to be considered* (min)	Total round time+any other time	Total round trip time (min)	Rake Requirement							Total No of Cars Availablein PH-I (APMC-Motera) and ordered in PH-II	Additional Cars Required
										Bare	Bare	Traffic Reserve	R&M	Total No of Rakes	No. of Cars per rake	No. of Cars		
Y Type Operation	APMC to Mahatma Mandir	39.40	30	12	78.80	6.0	0	6.0	163.60	13.63	14	1	2	17	3	51	72	18
	APMC to Sahahpur	32.80	30	12	65.60	6.0	0	6.0	137.20	11.43	12	0	1	13	3	39		
Shuttle Operation	Koteshwar to Airport	6.22	30	12	12.44	6.0	0	6.0	30.88	2.57	3	0	1	4	3	12	Nil	12
									Total No of Rakes					34		102		

Above operation results in:

Section	Effective Headway	Required No of Rakes	No of Car	Avalilable Cars	Additional cars required
APMC to GNLU	6.00	30	90	72	18
GNLU to Shahpur	12.00				
GNLU to Mahatma Mandir	12.00				
Koteshwar to Airport	12.00	4	12	0	12

	Year 2031																		
	Section	Distance (kms)	Schedule Speed in kmph	Headway (min)	Run time (min)	Turn round time (min)	Any other time to be considered* (min)	Total round time+any other time	Total round trip time (min)	Rake Requirement							Total No of Cars proposed in DPR of March '2019	Additional Cars Required
										Bare	Bare	Traffic Reserve	R&M	Total No of Rakes	No. of Cars per rake	No. of Cars		
Y Type Operation	APMC to Mahatma Mandir	39.40	30	12	78.80	6.0	0	6.0	163.60	13.63	14	1	2	17	3	51	111	No additional Requirement
	APMC to GIFT	37.04	30	12	74.08	6.0	0	6.0	154.16	12.85	13	0	1	14	3	42		
Shuttle Operation	Koteshwar to Airport	6.22	30	12	12.44	6.0	0	6.0	30.88	2.57	3	0	1	4	3	12		
									Total Additional No of Rakes					35		105		

Above operation results in:

Section	Effective Headway	Required No of Rakes	No of Car	Total No of Cars proposed in DPR of March '2019	Additional cars required
APMC to GNLU	6.00	31	93	111	No additional Requirement
GNLU to GIF	12.00				
GNLU to Mahatma Mandir	12.00				
Koteshwar to Airport	12.00	4	12		

	Year 2041																	
	Section	Distance (kms)	Schedule Speed in kmph	Headway (min)	Run time (min)	Turn round time (min)	Any other time to be considered* (min)	Total round time+any other time	Total round trip time (min)	Rake Requirement							Total No of Cars proposed in DPR of March '2019	Additional Cars Required
										Bare	Bare	Traffic Reserve	R&M	Total No of Rakes	No. of Cars per rake	No. of Cars		
Y Type Operation	APMC to Mahatma Mandir	39.40	30	9	78.80	6.0	0	6.0	163.60	18.18	19	1	2	22	3	66	138	No additional Requirements
	APMC to GIFT	37.04	30	9	74.08	6.0	0	6.0	154.16	17.13	18	0	2	20	3	60		
Shuttle Operation	Koteshwar to Airport	6.22	30	12	12.44	6.0	0	6.0	30.88	2.57	3	0	1	4	3	12		
									Total Additional No of Rakes					46		138		

Above operation results in:

Section	Effective Headway	Required No of Rakes	No of Car	Total No of Cars proposed in DPR of March '2019	Additional cars required
APMC to GNLU	4.50	42	126	138	No additional Requirements
GNLU to GIF	9.00				
GNLU to Mahatma Mandir	9.00				
Koteshwar to Airport	12.00	4	12		

	Year 2051																	
	Section	Distance (kms)	Schedule Speed in kmph	Headway (min)	Run time (min)	Turn round time (min)	Any other time to be considered* (min)	Total round time+any other time	Total round trip time (min)	Rake Requirement							Total No of Cars proposed in DPR of March '2019	Additional Cars Required
										Bare	Bare	Traffic Reserve	R&M	Total No of Rakes	No. of Cars per rake	No. of Cars		
Y Type Operation	APMC to Mahatma Mandir	39.40	30	8.3	78.80	6.0	0	6.0	163.60	19.71	20	1	2	23	3	69	162	No additional requirements
	APMC to GIFT	37.04	30	8.3	74.08	6.0	0	6.0	154.16	18.57	19	0	2	21	3	63		
Shuttle Operation	Koteshwar to Airport	6.22	30	12	12.44	6.0	0	6.0	30.88	2.57	3	0	1	4	3	12		
									Total Additional No of Rakes					48		144		

Above operation results in:

Section	Effective Headway	Required No of Rakes	No of Car	Total No of Cars proposed in DPR of March '2019	Additional cars required
APMC to GNLU	4.15	44	132	162	No additional requirements
GNLU to GIF	8.30				
GNLU to Mahatma Mandir	8.30				
Koteshwar to Airport	12.00	4	12		

Chapter - 8

Rolling Stock



8.1 Introduction

8.2 Optimization of Coach Size

8.3 Passenger Carrying Capacity

8.4 Weight

8.5 Performance Parameters

8.6 Coach Design and Basic Parameters

8.7 Selection of Technology



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 for a Medium Rail Transit System (MRTS).

Following important criteria is proposed for selection of rolling stock:

- Passenger comfort & safety
- Proven equipment with high reliability
- Energy efficiency
- Light weight equipment and coach body
- High rate of acceleration and deceleration
- Optimized scheduled speed
- Flexibility to meet increase in traffic demand
- Aesthetically pleasing Interior and Exterior
- Low Life cycle cost
- Flexibility to meet increase in traffic demand
- Anti-telescopic
- Traction: 750V DC Third Rail
- SOD, KE. and Signalling system of the proposed corridor shall be kept same as the operational corridor of Phase-1 in Ahmedabad Metro.

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. The low life cycle cost is achieved by the way of reduced scheduled and unscheduled maintenance and high reliability of the sub-systems.

8.2 OPTIMIZATION OF COACH SIZE

The following optimum size of the coach, as opted for this corridor, 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)/Motor Car (MC)	21.34 m	2.9 m	3.9 m

**Maximum length of coach over couplers/buffers = 23 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.
Following train composition is recommended:

3-car Train: DMC + TC + DMC
Table 9.2 and 9.3 shows the carrying capacity of Rail Vehicles with standing passenger @ 6 passengers per sqm of standee area and @ 8 passengers per sqm of standee area respectively.

Table 8.2: Carrying Capacity of Rail Vehicles (Normal @6 Person/sqm of standee area)

	Driving Motor car	Trailer car / Motor car	3 Car Train
Seated	43	50	136
Standing	204	220	628
Total	247	270	764

Table 8.3: Carrying Capacity of Rail Vehicles (Crush@8 Person/sqm of standee area)

	Driving Motor car	Trailer car / Motor car	3 Car Train
Seated	43	50	136
Standing	272	292	836
Total	315	342	972

8.4 WEIGHT

The weights of driving motor car and trailer car have been estimated as in Table 8.4,

Table 8.4: Weight of Rail Vehicles (TONNES)

3 car train	Gross Weight
DMC+TC+DMC	126T
Per Axle Load (max.)	16T

8.5 PERFORMANCE PARAMETERS

8.5.1 Motorisation of 67% for all categories of Metro Rolling Stock.

8.5.2 The recommended performance parameters are:

Item	Values
Minimum Design Average Acceleration rate for fully loaded(seating plus standees @8 persons per sqm)train on level tangent track shall be as under: 0 to 40 kmph 0 to 60 kmph 0 to 80 kmph	 $1.0 m/s^2$ $0.6 m/s^2$ $0.3 m/s^2$
Minimum Operational Average Acceleration rate for (seating plus standees @6 persons/sq.m) loaded on level tangent track shall be as under: 0 to 35 kmph 0 to 60 kmph 0 to 80 kmph	 $1.20 m/s^2$ $0.65 m/s^2$ $0.35 m/s^2$
Service braking rate from 80 kmph to standstill for fully loaded(seating plus standees @8 persons per sqm) train on level tangent track:	$1.0 m/s^2$
Service braking rate from 80 kmph to standstill for fully loaded(seating plus standees @6 persons per sqm) train on level tangent track:	$1.1 m/s^2$
Emergency braking rate from 80 kmph to 0 kmph for fully loaded train on level tangent track:	$1.3 m/s^2$
Jerk rate (maximum)	$0.75 m/s^2$

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

8.7.1 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-.

8.7.2 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 car-body.

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.

8.7.3 Bogies

Bolster less lightweight fabricated bogies with steel/helical coil springs in primary suspension 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 levels of the cars constant irrespective of passenger loading unlike those with coil spring. Asymmetrical Air spring in secondary suspension are essential for reducing wheel Flange & Rail Gauge Face wear which helps in greatly reducing down time of Rolling Stock for re-profiling and change of wheels. 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 rubber/ helical spring. A smooth curving performance with better ride index is being ensured by provision of above type of bogies.

8.7.4 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
(vi) 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.

8.7.5 Propulsion System Technology

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

The brush less 3 phase induction motors has now replaced the D.C. Series motors in traction applications. The induction motor, for the same power output, is smaller and lighter in weight and ideally suited for rail based Medium Rail Transit applications. The motor tractive effort and speed is regulated by 'Variable Voltage and Variable frequency' (VVVF) 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 Third Rail D.C voltage is stepped up through a converter and supply voltage to DC link, which feeds Inverter operated with Pulse Width Modulation (PWM) control technology and using Insulated Gate Bipolar Transistors (IGBT). Thus three-phase variable voltage variable frequency output drives the traction motors for propulsion.

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

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

8.7.6 Interior and Gangways

Passenger capacity of a car is maximized in a Metro System by providing longitudinal seats for seating and utilizing the remaining space for standing passenger. Therefore, all the equipments are mounted on the under frame for maximum space utilization.

The gangways are designed to give a wider comfortable standing space during peak hours along with easy and faster passenger movement especially in case of emergency.

8.7.7 Passenger Doors

For swift flow 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. Automatic door mechanism is envisaged from consideration of passenger safety. Passenger doors are controlled electrically. Electrically controlled door operating mechanism has been preferred over pneumatically operated door to avoid cases of air leakage and sluggish operation of doors.

Anti-Drag system should be incorporated in door design for safety of passengers.

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.



Figure 8.1 : Interior view

8.7.8 Air–conditioning

With heavy passenger loading for standee area and doors being closed from consideration of safety and with windows being sealed type to avoid transmission of noise, air conditioning of coaches has been considered essential. Each coach shall be provided with two air conditioning units capable of cooling, heating and dehumidifying and thus automatically controlling interior temperature throughout the passenger area at 25°C with 65% RH all the times under varying ambient conditions up to full load. For emergency situations such as power failure or both AC failures etc., ventilation provision supplied from battery will be made. Provision shall be made to shut off the fresh air intake and re-circulate the internal air of the coach, during an emergency condition, such as fire outside the train causing excessive heat and smoke to be drawn in to the coach. The coefficient of performance should be at least 2.5.

8.7.9 Cab Layout and Emergency Detrainment Door.

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

8.7.10 Communication

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

Public Address and Passenger Information Display System is provided in the car so that passengers are continuously advised of the next stoppage station, final

destination station, interchange station, emergency situations if any, and other messages. The rolling stock is provided with Talk Back Units inside the cars, which permit duplex conversation between passengers and the drivers in case of any emergency

8.7.11 Noise and Vibration

The trains will pass through heavily populated urban area. The noise and vibration for a metro railway becomes an important criterion from public acceptance view point. The source of noise is (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 recommended: -

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

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

8.7.12 Passenger Safety Features

(i) ATO/UTO

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

(ii) Fire

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

Two fire extinguishers per car in saloon area and one fire extinguisher per cab to be provided. All materials used for construction of metro shall comply with international standards EN 45545 for fire and smoke.

Fresh air intake to the saloon area of the car shall have smoke detection system to prevent entry of external smoke into the saloon area.

(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. In general, the parameters under EN15227 and EN 12663 should be followed.

(iv) Gangways

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



Gangways

8.7.13 Condition & Health Monitoring System

Nowadays, IoT based artificial intelligence enables support, condition & health monitoring system for maintenance of infrastructure including Rolling Stock to reduce the human intervention and expenditure on maintenance are available. Few of them are highlighted as under:

i. Axle Hot Box detection system to identify locations the axle bearing temperature of all passing trains and generate alerts.
ii. Rail Check system to detect rail fractures, missing fasteners from track, etc.
iii. CCD monitoring system
iv. Car Scanner to detect the missing component and measure the wear of wheel, brake block, disc etc.

8.7.14 Reliability, Availability Maintainability and Safety

The metro rail system is to be developed with a high degree of reliability, availability, maintainability and safety to run the trains under ATP/ATO. The optimization of the system design with respect to RAMS must be planned and form an integrated element of the project from its inception throughout the lifecycle. The RAMS process shall conform to internationally accepted standards.

Based on the Train operation plan it is to propose to keep the Mean distance between failure (MDBF) target as 100000 Km. However, final figures shall be opted based on the accumulated km of per train per year.

8.7.15 Comprehensive Maintenance of Rolling Stock

A comprehensive maintenance of Rolling stock by the Rolling Stock contractor may also be explored, where designated land for depot shall be provided by MRA and Rolling Stock contractor will construct and maintain the infrastructure required for train maintenance and operation including DCC, Auto Wash Plant, all other M&Ps. Signaling, Track and other facilities of depot will be provided and maintain by MRA.

Chapter – 9

Depot



9 1 Corridor

9 2 Depot- Cum- Workshop

9 3 Maintenance Philosophy

9 4 Rolling Stock Maintenance Needs

9.5 Year-Wise Planning Of Maintenance Facility Setup at Depot cum Workshop

9.6 Requirement of Maintenance/Inspection Lines for Depot-Cum-Workshop

9.7 Inspection Requirement at Depot

9.8 Design of Depot- Cum- Workshop Facilities

9.9 Car Delivery Area

9.10 Operational Features

9.11 Infrastructure Facilities

9.12 List of Buildings & List of Plants & Equipments at Depot-Cum-Workshop



Chapter – 9

DEPOT

9.1 CORRIDOR: Ahmedabad Metro Rail Network Phase-II comprises of following corridors:

Table - 9.1

S. No.	Corridor	Route length(Km)
1	(APMC to Motera Stadium) to Mahatma Mandir	39.39
2	GNLU to Gift	12.071
3	Koteshwar Road to Airport Metro (Phase-IIA)	6.22

9.2 DEPOT – CUM – WORKSHOP

9.2.1 It is proposed to use one depot- cum- workshop with following functions at Gyaspur Depot 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.
(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, taking in consideration the passenger load of 2027, 2031, 2041 & 2051 respectively.

TABLE - 9.2

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	Check and testing of all sub-assemblies (Electrical + Mechanical). Overhaul of pneumatic valves, Compressor. Condition	Workshop

Type of Schedule	Interval	Work Content	Locations
	approx.) whichever is earlier	based maintenance of sub-systems to bring them to original condition. 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 kilometres 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-9.3

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-9.4

Sections	Year	No. of Rakes operational in APMC to Motera (Phase-I)	Total No of Rakes Ordered in Phase-II Corridor	Rake Consist	No. of Rakes required	Additional Rakes Required	Additional No of Cars Required
APMC to GNLU	2027	14	10	3-car	30	6	18
GNLU to Mahatma Mandir and GNLU to Shahpur							
Koteshwar Road to Airport		N/A	N/A		4	4	12
Sections	**Year**	**Total No of Rakes Proposed in DPR for Ahmedabad Phase-II Metro Rail Corridor March'2019**		**Rake Consist**	**No. of Rakes required**	**Additional Rakes Required**	**Additional No of Cars Required**
APMC to Mahatma Mandir	2031	37		3-car	31	Nil	Nil
GNLU to Mahatma Mandir and GNLU to GIFT							
Koteshwar Road to Airport					4		
APMC to Mahatma Mandir	2041	46		3-car	42	Nil	Nil
GNLU to Mahatma Mandir 3and GNLU to GIFT							
Koteshwar Road to Airport					4		
APMC to Mahatma Mandir	2051	54		3-car	44	Nil	Nil
GNLU to Mahatma Mandir and to GIFT							
Koteshwar Road to Airport					4		

(ii) Requirement of Stabling Lines (SBL), Inspection Lines (IBL) and Workshop Lines (WSL) in the Depot -cum -Workshop.

Stabling and Inspection lines

Table-9.5

Year	Total No. of Rakes required	SBLs				IBLs			
		Total SBLs required for rakes of Phase-I & Phase-II as per DPR March 2019	Total SBLs Available as on Date at Gyaspur Depot	Provision of SBLs in Indroda Circle as per DPR March 2019	Additional SBL required	Total IBLs required for rakes of Phase-I & Phase-II as per DPR March 2019	Total IBLs Available as on Date at Gyaspur Depot	Provision of IBLs in Indroda Circle as per DPR March 2019	Additional IBL required
2027	34	14 lines x two train of 3-car are required in the year 2021.	20 Lines X Two Trains of 3-Car	6 Lines X Two Trains of 3-Car	No Additional Requirement as planned SBLs will Cater the Requirement of Phase-2B Corridor.	One bay of 3 lines each with two trains of 3-cars in the year 2021.	One bay of 3 lines each with two trains of 3-cars.	One bay of 2 lines each with two trains of 3- cars are planned for future requirement.	No Additional Requirement as planned IBLs will Cater the Requirement of Phase-2B Corridor.
2031	35	17 lines x two train of 3-car		4 Lines X Two Trains of 3-Car		No additional requirements, existing One bay of 3 lines each with two trains of 3-cars are sufficient.			
2041	46	21 lines x two train of 3-car		Nil		No additional requirements, existing One bay of 3 lines each with two trains of 3-cars are sufficient.			
2051	48	24 lines x two train of 3-car		3 Lines X Two Trains of 3-Car		Additional, one bay of 2 lines would be required for the year 2051.			

Workshop lines

Table-9.6

Year	Total No. of Rakes required	Total No of WSLs required for rakes of Phase-I & Phase-II in DPR March 2019	Total WSLs Available as on Date at Gyaspur Depot	Total No of Additional WSL required
2027	34	Two bays of 2 lines each with two trains of 3-cars is to be required in the year 2021.	4 lines x two train of 3-car are available till date.	No Additional requirement. Planned 4 WSLs are sufficient to Cater the requirement of Phase 2B Corridor
2031	35	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.		
2041	46	No Additional Bay is required.		
2051	48			

Note: No Workshop Lines are planned in Indroda Circle

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:

The length of 3- Car train would be 69 mts. For the design of the stabling lines in the depot and terminal stations or elsewhere (as may be required), following approximates dimensions have been taken in consideration, however final dimensions shall be decided based on actual site conditions/ area available at the time of design finalization of depot:

Total length of Stabling lines = 168m.

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 168 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 168 m X 16 m size (one bay of 2 lines) 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:

(a) 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 Aluminium 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. 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.

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. Plant and Machinery

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.

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.

Chapter - 10

Power Supply Arrangements



10.1 Power Requirements

10.2 Need for High Reliability of Power Supply

10.3 Sources of Power Supply

10.4 750V DC Third Rail Current Collection System

10.5 Auxiliary Supply Arrangements for Stations

10.6 Rating of Major Equipment

10.7 MV/LV System

10.8 Standby Diesel Generator (DG) Sets

10.9 Solar Photo Voltaic (PV) Power System

10.10 Sewage Treatment System Using Integrated Constructed Wetlands(ICW)

10.11 Supervisory Control and Data Acquisition (SCADA) System

10.12 Energy Saving Measures

10.13 Electric Power Tariff



Chapter 10

POWER SUPPLY ARRANGEMENTS

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, firefighting, 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 Current Collector – 60KWh/1000 GTKM as per MoHUA guideline for 750 V DC system.

(ii) Elevated/at –grade station auxiliary load – initially 250 kVA, which will increase to 315kVA in the year 2051.

(iii) Underground station auxiliary load – initially 1500 kVA, which will increase to 2000kVA 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 2027, 2031, 2041 and 2051 are summarized in table 10.1 below:-

Table 10.1 Power Demand Estimation (MVA)

S No		Load	Year			
			2027	2031	2041	2051
1.	**Phase – II Extension A**: From 'Koteswar Road' To 'Sardar Vallabhbhai International Airport'. Total 04 Stations, comprising of 03 Elevated Stations & 01 Underground Station, 6.33 km	Headway (min)	12.0	12.0	12.0	12.0
		Traction Power	0.79	0.79	0.79	0.79
		Auxiliary Power	2.37	2.37	2.67	3.10
		Total Power Demand	**3.16**	**3.16**	**3.46**	**3.89**
2.	**Phase – II Extension B**: From 'Gift City (Existing)' To 'Shahpur Metro'	**Load**	**Year**			
			2027	**2031**	**2041**	**2051**
		Headway (min)	12.0	12.0	9.0	8.30
		Traction Power	0.42	0.42	0.56	0.61

S No		Load	Year			
			2027	2031	2041	2051
	comprising of 3 Elevated Stations,3.33 km	Auxiliary Power	0.79	0.79	0.88	0.99
		Total Power Demand	**1.21**	**1.21**	**1.44**	**1.60**
3.	**Phase – II Extension C**: From 'Shahpur' to 'Gift' comprising of 3 Elevated Stations, 4.32 km	**Load**	**Year**			
			2027	**2031**	**2041**	**2051**
		Headway (min)	Not Applicable	12.0	9.0	8.30
		Traction Power	Not Applicable	0.54	0.72	0.79
		Auxiliary Power	Not Applicable	0.79	0.89	0.99
		Total Power Demand	Not Applicable	**1.33**	**1.61**	**1.78**
4	**Grand Total Power Demand**		**4.37**	**5.70**	**6.51**	**7.27**

The detailed calculations of power demand estimation are attached at Annexure 10.1A, 101B & 10.1C.

10.2 Need for High Reliability of Power Supply

The proposed Ahmedabad metro system is being designed to handle about 2,719 & 5,773 passengers per direction during peak hours when trains are expected to run at 12 minutes & 10.3 minutes intervals in 2051 for Koteswar Road to Sardar Vallabhbhai International Airport & Metro corridor inside Gift City, respectively based on Train Operation Plan. Incidences of any power interruption, apart from affecting train running, will cause congestion at stations. Interruption of power at night is likely to cause alarm and increased risk to traveling public. Lack of illumination at stations, non-visibility of appropriate signages, disruption of operation of lifts and escalators is likely to cause confusion, anxiety and ire in commuters, whose tolerance level are low on account of stress. Effect on signal and communication may affect train operation and passenger safety as well. Therefore, uninterrupted power supply is mandatory for efficient metro operations.

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

10.3 Sources of Power Supply

In the previous DPR of Phase – II Network (extension of North-South Corridor from Motera Stadium to Mahatma Mandir and its two Spurs from Koteshwar Road to Airport

& from GNLU to Gift City) of Ahmedabad Metro prepared by DMRC in the Year 2018, it was suggested that any two of the three proposed RSS may be constructed to meet the Power Supply (Traction as well as Auxiliary) Requirements of the above mentioned Phase – II Network.

Based upon the inputs received from Ahmedabad Metro through, following Receiving Substations are being constructed:-

Table 10.2 RSSs Under Construction for Phase – II of Ahmedabad Metro

Corridor	Location of RSS of Metro Authority	Proposed Capacity of 132 / 33kV Transformer
Phase – II (Under Construction): From Motera Stadium to Mahatma Mandir, Including 'Spur From GNLU to Gift City'	Indroda Depot	30 / 40 MVA (ONAN / ONAF)
	Koba Gaam	30 / 40 MVA (ONAN / ONAF)

Power demand of the under construction Motera Stadium to Mahatma Mandir is proposed to be fed from upcoming Indroda Depot RSS & Koba Gaam RSS of GMRC's Network which have sufficient capacities of Transformer to cater to additional demand as per the Train Operation plan (Chapter 7: Train Operation Plan) up to 2051, which would arise due to the proposed Koteshwar to Sardar Vallabhbhai International Airport (Phase – II Extension B)&Metro corridor inside Gift City (Phase – II Extension B & Phase – II Extension C).

However, final decision regarding the augmentation of the capacities at existing RSS or /and construction of a new RSS may be reviewed based on the Electrical load along with associated parameters assessed on the basis of detailed simulation studies to be carried out at the detailed design stage and depending up on the availability of Power & availability of Spare Bays in the Grid Substations.

Table 10.3A: Power Demand projections for the upcoming 02 nos. RSSs in Phase – II of Ahmedabad Metro (Under Construction)

Corridor	Input Source	Peak demand in Scenario 1: Normal Feed (i.e., All RSS are in service		Peak demand in Scenario 2 : (n-1) Feed (i.e., the adjacent RSS is Out of Service)	
		Year (2027)	Year (2051)	Year (2027)	Year (2051)
Phase – II (Under Construction): From Motera Stadium to	**Koba Gaam RSS** (Presently Under Construction) **Capacity: 30/40 MVA**	**Normal Feed Scenario,** Considering both RSS **i.e.,**		**(N-1) Feed Scenario**, considering	

Corridor	Input Source	Peak demand in Scenario 1: Normal Feed (i.e., All RSS are in service		Peak demand in Scenario 2 : (n-1) Feed (i.e., the adjacent RSS is Out of Service)	
		Year (2027)	Year (2051)	Year (2027)	Year (2051)
Mahatma Mandir, **Including 'Spur From GNLU to Gift City'** **Excluding 'Phase – II extension A, B & C'** (as brought out in Table 10.1 above)	(as communicated by Ahmedabad Metro)	**Koba Gaam & Indroda RSS** are **'In Service'.**		**Indroda RSS** to be **'Out of Service'.**	
	Traction Load	2.09	3.02	4.54	6.56
	Auxiliary Load	2.36	2.98	6.04	7.61
	Sub-Total	**4.45**	**6.00**	**10.58**	**14.17**
	Indroda Depot RSS (Presently Under Construction) **Capacity: 30/40 MVA** (as communicated by Ahmedabad Metro)	**Normal Feed Scenario,** Considering both RSS **i.e., Koba Gaam & Indroda RSS** are **'In Service'.**		**(N-1) Feed Scenario**, considering **Koba Gaam RSS** to be **'Out of Service'.**	
	Traction Load	2.45	3.54	4.54	6.56
	Auxiliary Load	3.68	4.63	6.04	7.61
	Sub-total	**6.13**	**8.17**	**10.58**	**14.17**

Table 10.3 B: Power Demand projections for the upcoming 02 nos. RSSs in Phase – II along with Phase – II Extensions A, B & C of Ahmedabad Metro

Corridor	Input Source	Peak demand in Scenario 1: Normal Feed (i.e., All RSS are in service		Peak demand in Scenario 2 : (n-1) Feed (i.e., the adjacent RSS is Out of Service)	
		Year (2027)	Year (2051)	Year (2027)	Year (2051)
Phase – II (Under Construction): From 'Motera Stadium' to 'Mahatma Mandir' **Including 'Spur From GNLU to Gift City'** **Phase – II Extension A**: From 'Koteshwar' to 'Sardar Vallabhbhai	**Koba Gaam RSS** (Presently Under Construction) **Capacity: 30/40 MVA** (as communicated by Ahmedabad Metro)	**Normal Feed Scenario,** Considering both RSS **i.e., Koba Gaam & Indroda RSS** are **'In Service'.**		**(N-1) Feed Scenario**, considering **Indroda RSS** to be **'Out of Service'.**	
	Traction Load	2.88	3.81	5.75	8.73
	Auxiliary Load	4.72	6.07	9.19	12.68
	Sub-Total	**7.60**	**9.88**	**14.94**	**21.41**

Corridor	Input Source	Peak demand in Scenario 1: Normal Feed (i.e., All RSS are in service		Peak demand in Scenario 2 : (n-1) Feed (i.e., the adjacent RSS is Out of Service)	
		Year (2027)	Year (2051)	Year (2027)	Year (2051)
International Airport' **Phase – II Extension B:** From 'Gift City (Existing)' To 'Shahpur Metro' **Phase – II Extension C:** From 'Shahpur' To 'Gift'	**Indroda Depot RSS** (Presently Under Construction) **Capacity: 30/40 MVA** (as communicated by Ahmedabad Metro)	**Normal Feed Scenario,** Considering both RSS **i.e., Koba Gaam & Indroda RSS** are **'In Service'.**		**(N-1) Feed Scenario**, considering **Koba Gaam RSS** to be **'Out of Service'.**	
	Traction Load	2.87	4.92	5.75	8.73
	Auxiliary Load	4.47	6.61	9.19	12.68
	Sub-total	**7.34**	**11.53**	**14.94**	**21.41**

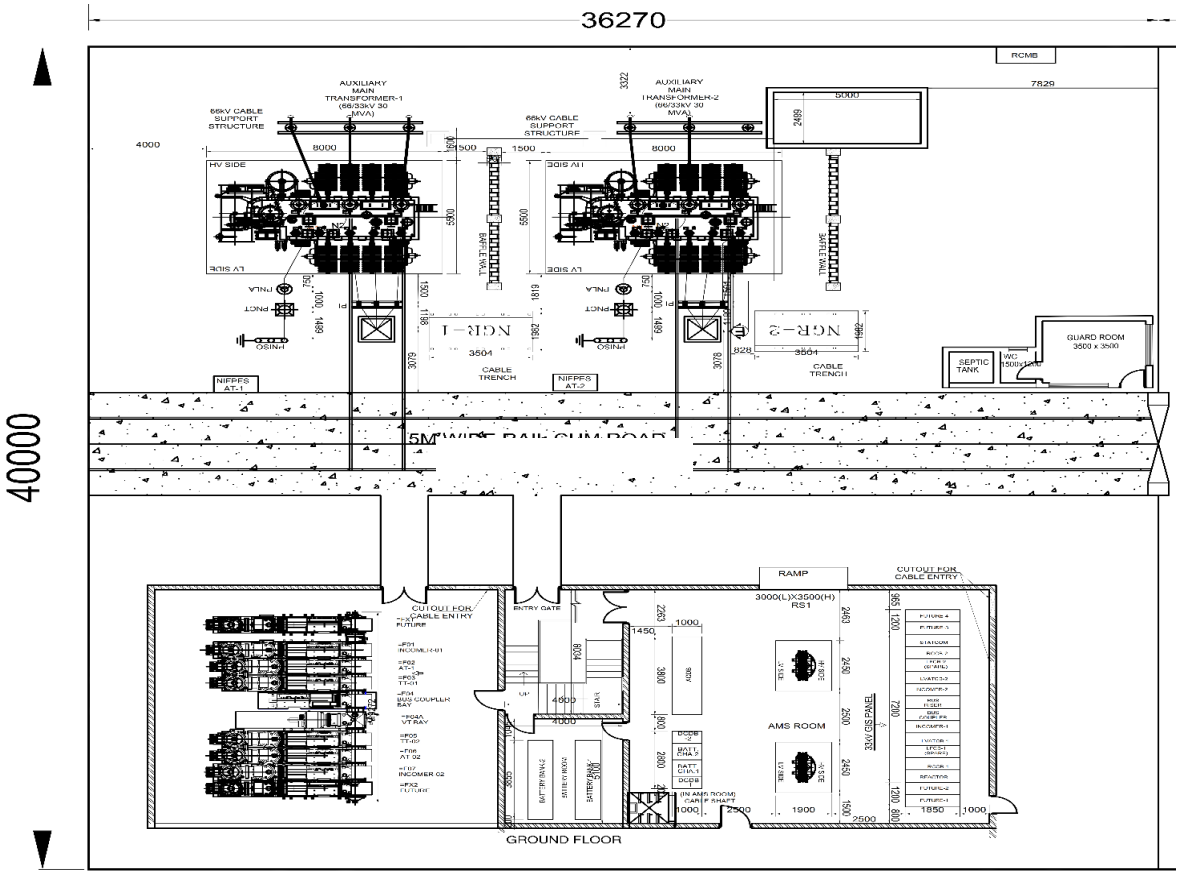


Figure 10.1: Layout of a Typical Receiving Substation equipped with High Voltage Gas Insulated Switchgear (GIS)

The 132kV / 66kV power supply from Grid Substation (GSS) is stepped down to 33 kV level at each of the RSS of Metro Authority. The 33kV power is then distributed further along the alignment through separate 33kV Ring main cable network for feeding the TSS and ASS at the Metro Stations for meeting the Traction and Auxiliary load requirements. These 33 kV cables are laid in dedicated ducts/cable brackets along the viaduct.

In case of tripping of One RSS on fault or input supply failure, train services can be maintained by feed extension from other RSS. 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.



Figure 10.2: Photograph of a Typical Air Insulated Receiving Substation (AIS)



Figure 10.3: Photograph of a Typical High Voltage Gas Insulated Switchgear

10.4 750 V DC Traction System

10.4.1 Traction Sub-stations (33kV/750V DC)

33kV (AC) /750V (DC)Traction Sub-Stations (TSS) are required to be set up for feeding 750V (DC) Traction Power supply to the Third rail of Traction Power System. In order to cater to the Traction load as per train operation plan, it is envisaged to provide Traction Sub-Stations (TSS) at each of the alternate metro station. The Traction Sub-Stations (TSS) and Auxiliary Sub-Stations (ASS) are normally located within the Metro Station building itself either at the Concourse or Platform or Ground level (inside a room), depending upon the Design and Space availability.

Each TSS shall be provided with 2 nos. Transformer-rectifier (each of 2.5 MVA Capacity)for feeding traction load with space provisions for accommodating an additional Transformer-rectifier to meet the future traction load requirements as and when the cars per train composition is increased or headway is reduced. The capacity of the Transformer-rectifiers to be finalized at the detail design stage.

At the Metro Station on which, TSS is not being provided at present and only ASS has been planned, then in above such metro stations, adequate space for installation of 2 nos. Transformer-rectifier be planned to meet the future traction load requirements as and when the cars per train composition is increased or headway is reduced. The capacity of the Transformer-rectifiers to be finalized at the detail design stage.

Self-cooled, Cast Resin dry type Transformer-rectifier are proposed, which are 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.

Possibility for provisions of 'Regenerative Energy Recovery System' may be explored at the Detail Design Stage.

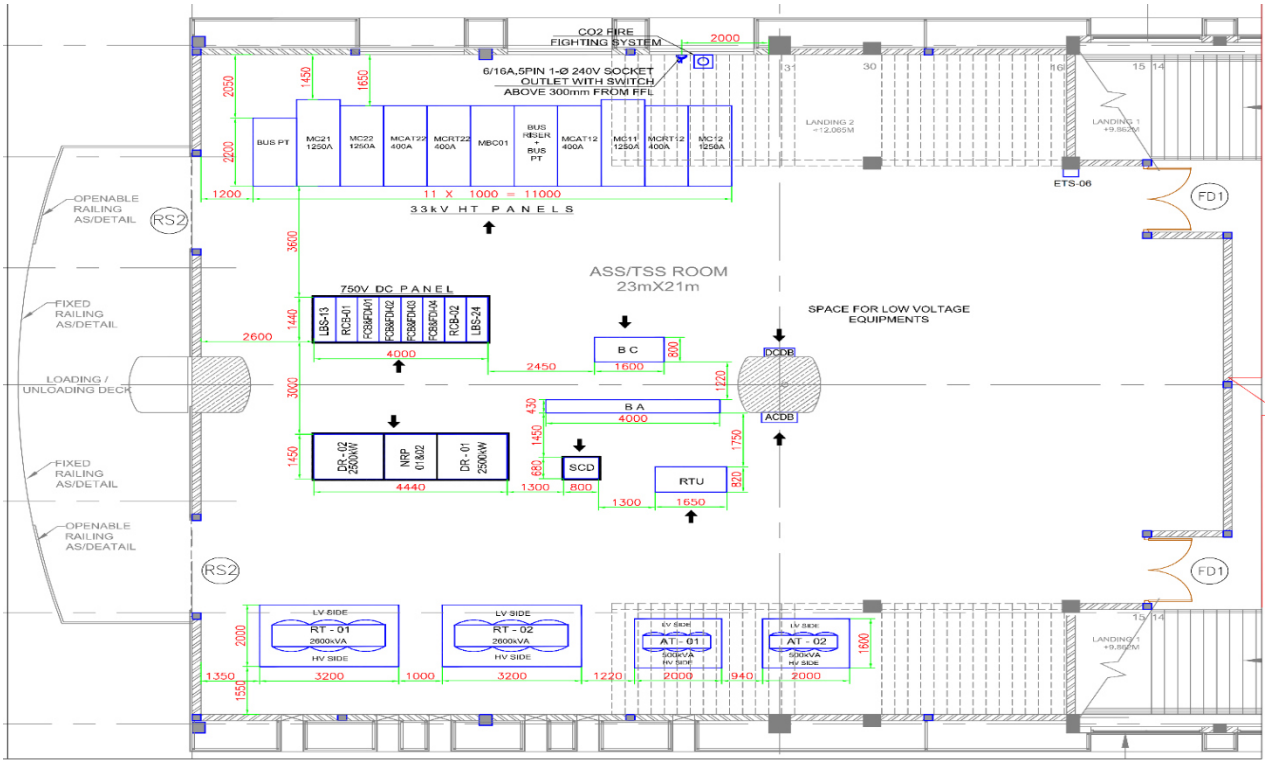


Figure 10.4: TYPICAL LAYOUT OF TSS & ASS (Combined)

10.4.2 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).

Adequate protection measures are required to be taken to ensure proper drainage of water on the viaduct so that the Third Rail and the Running Rails do not get affected due to accumulation of water on viaduct.

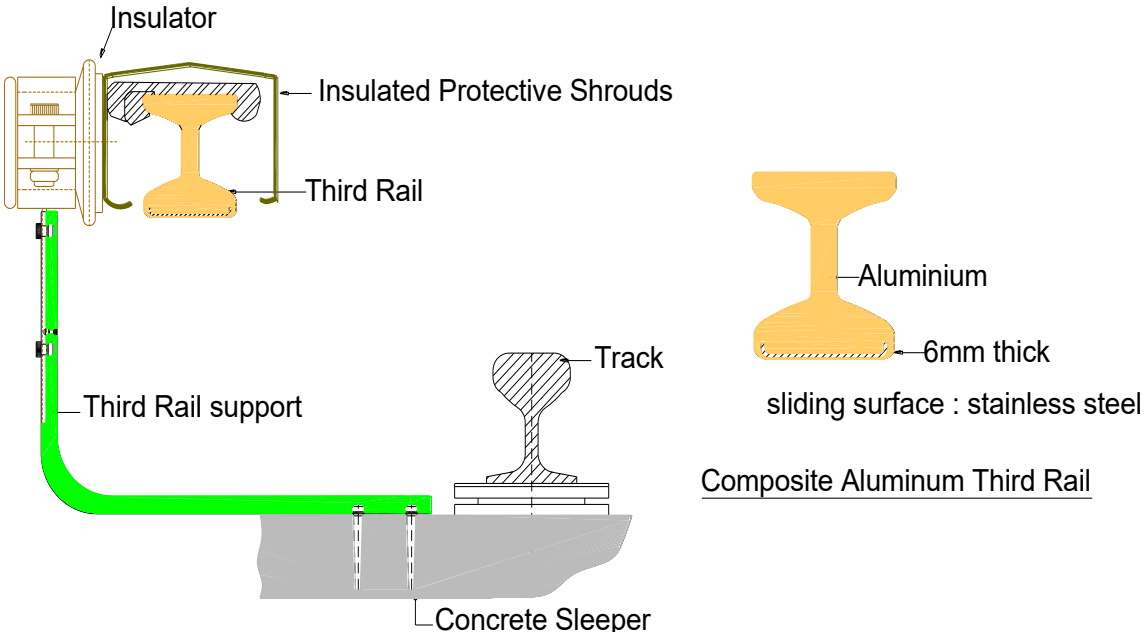


Figure 10.5: Depot Third Rail Current Collection System

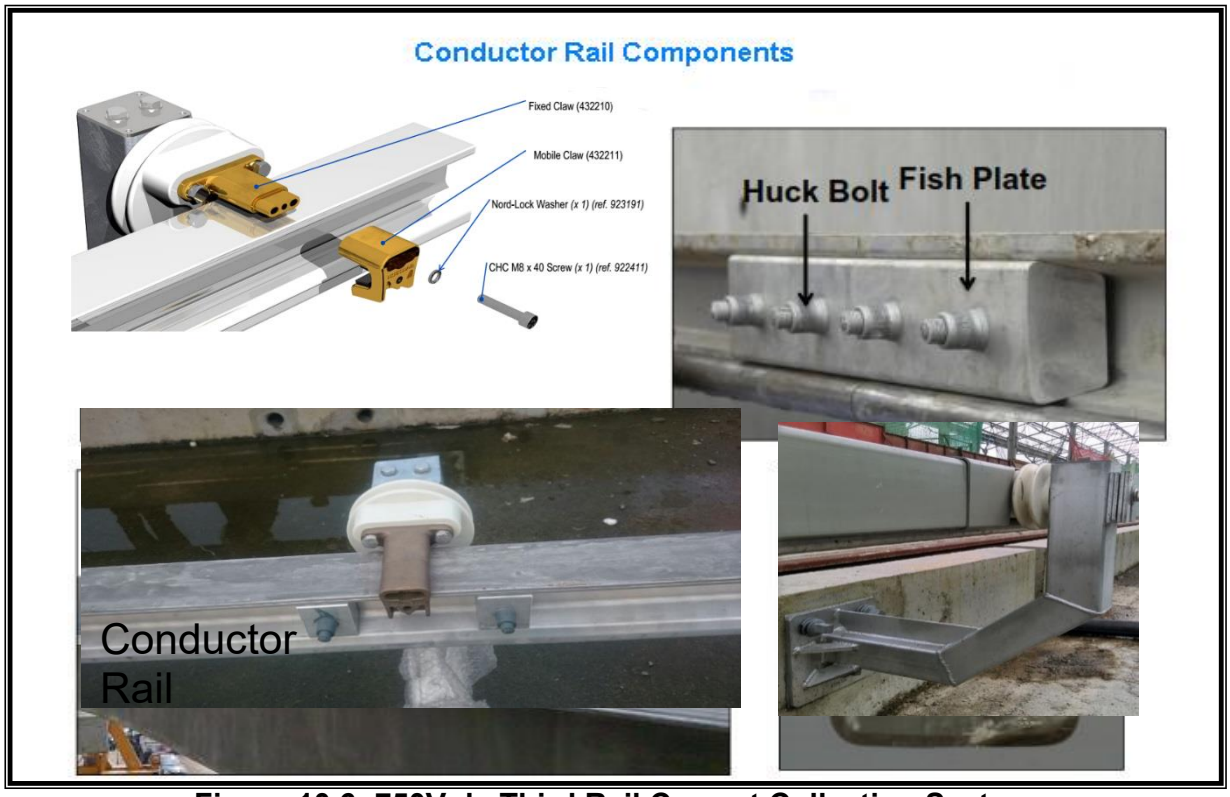


Figure 10.6: 750V dc Third Rail Current Collection System

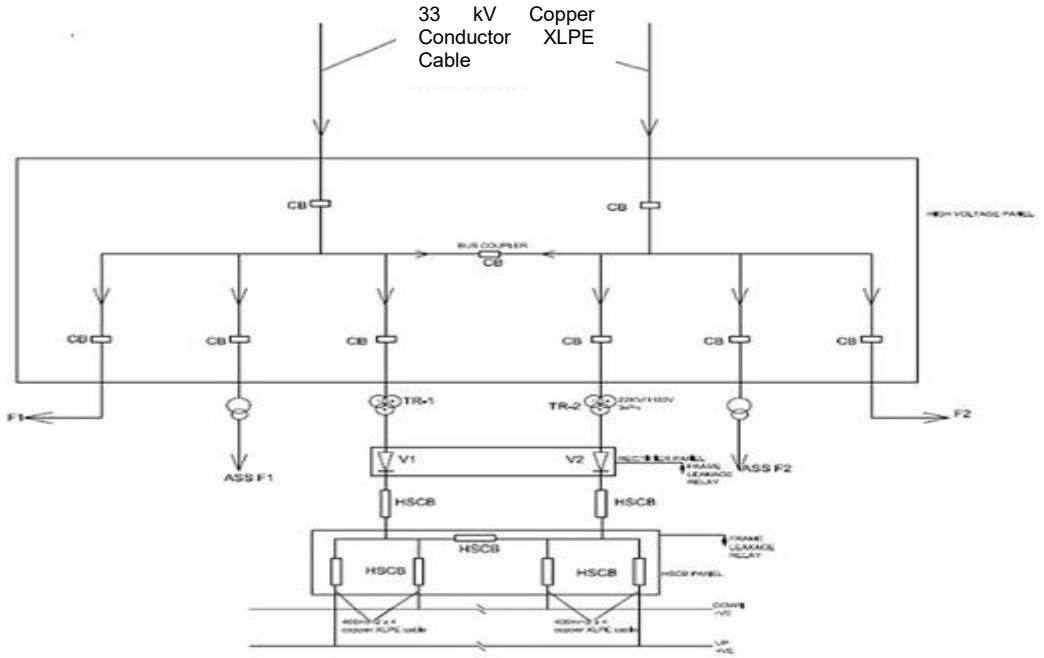


Figure 10.7: Schematic Diagram of DC Traction Substation (TSS) at Metro Stations

10.4.3 Mainline DC Return Current & Stray Current and Protection of DC traction system

Main Line Return Current

Floating system (i.e. Traction system with floating negative) is to be adopted for all sections except depot area. Under this system, Electrical isolation of the running rail from the earth shall be ensured through appropriate insulation (wherever required). The running rails shall be connected to the Negative Return Panel at TSS through cables for providing path to the Return Current.

The running rails shall be adequately insulated as per EN50122-2.

A provision shall be made to earth the running rail (i.e. negative bus) in case of rail potential being higher than limits prescribed 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 (TSS).

Proper scheme / systems for return current management and its monitoring be ensured at the detail design stage.

Stray current management and its monitoring:

Stray current cable shall be provided along the viaduct. Stray current cables 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 cables are preferably of aluminum. Stray current cable can never be used as a general earth. In addition, provisions shall be made for continuous monitoring of the stray current as per EN-50122 at multiple locations through SCADA system.

Concept of DC Stray Current Corrosion

In DC Traction systems, bulk of return current finds its path back to the Traction Sub-station (TSS) 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. Itis 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 nearest traction sub-station.

The DC stray currents cause metal detraction in watery electrolytes as per the following chemical reactions: -

- Stray current enters in the metal
  $2H_2O + 2e^- \rightarrow H_2 + 2OH^-$ (development of Hydrogen gas)
- Stray current exits from metal
  $Fe \rightarrow Fe^{2+} + 2e^-$ (Fe^{2+} ions migrate away from the metal)

That is how, DC stray currents cause corrosion of metallic structure where it leaves the metal. This is shown in figure 10.8. Pitting and general form of corrosion are most often encountered on DC Electrified Railways.

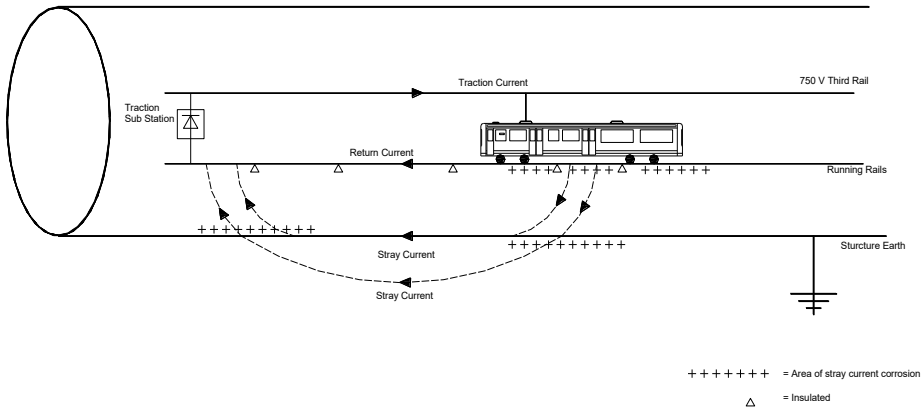


Figure 10.8: DC Traction System: Stray Current Corrosion Concept

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.

Measures for Protection against Stray Current Corrosion

Suitable measures are required to suppress the stray currents as well as the presence of high touch potentials. Safety of personnel is to be given preference. Following measures are normally required to restrict the Stray currents:-

(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

Proper scheme / systems for Stray current Management (including suppression and monitoring of Stray currents) to provide proper protection from Stray current be ensured at the detail design stage.

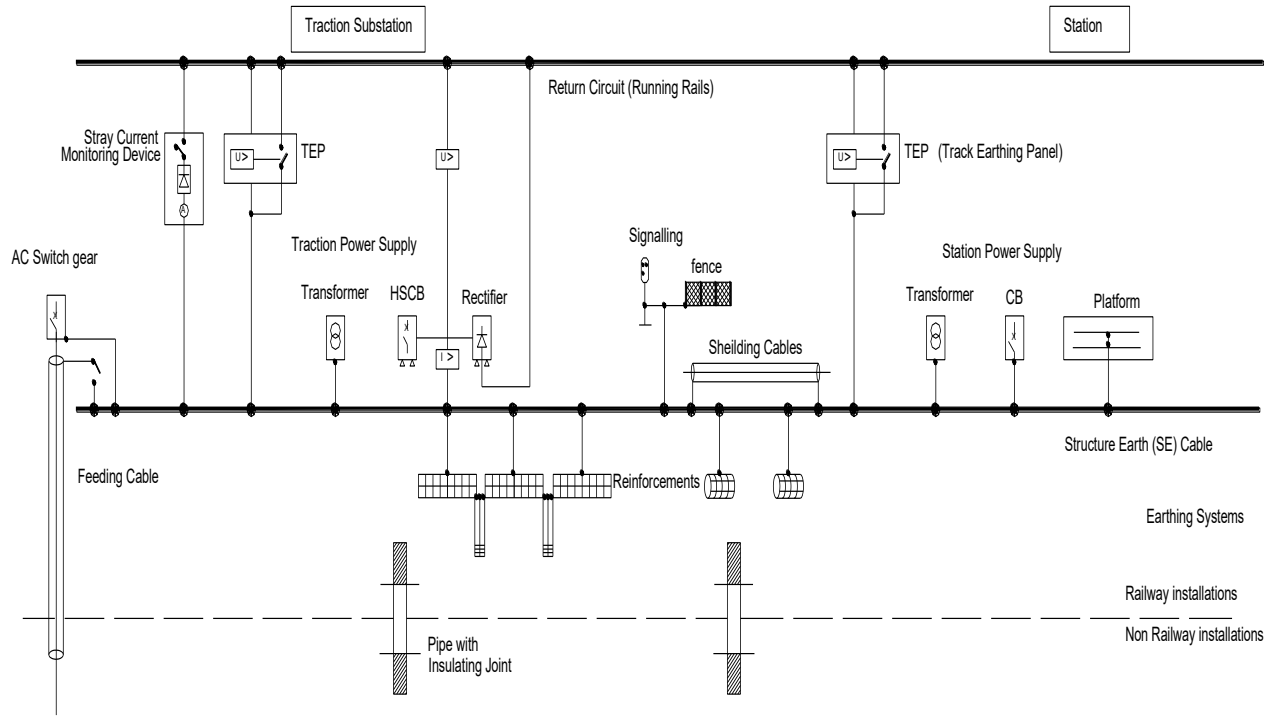


Figure 10.9: Basic Diagram for Earthing, Bonding and Stray Current Protection Measures

Protection of DC traction system:

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.

10.4.4 Earthing & Bonding for AC supplies

The Earthing & Bonding system for AC Power Supply System shall be maintained distinct and isolated from the DC system for the Main line.

Proper Earthing & Bonding at the Receiving Substations (RSS), Metro stations, Depots, Auxiliary Substation (ASS) shall be ensured, 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.
4. Structural Earth(SE)Conductor:

SE conductor of appropriate cross section preferably ACSR shall be provided along the viaduct on up and down lines and to the places (wherever required) for the Earthing and Bonding to ensure safety, and all the metallic parts of equipment, cable sheath, viaduct reinforcement, signal post etc. shall be connected to SE conductor.

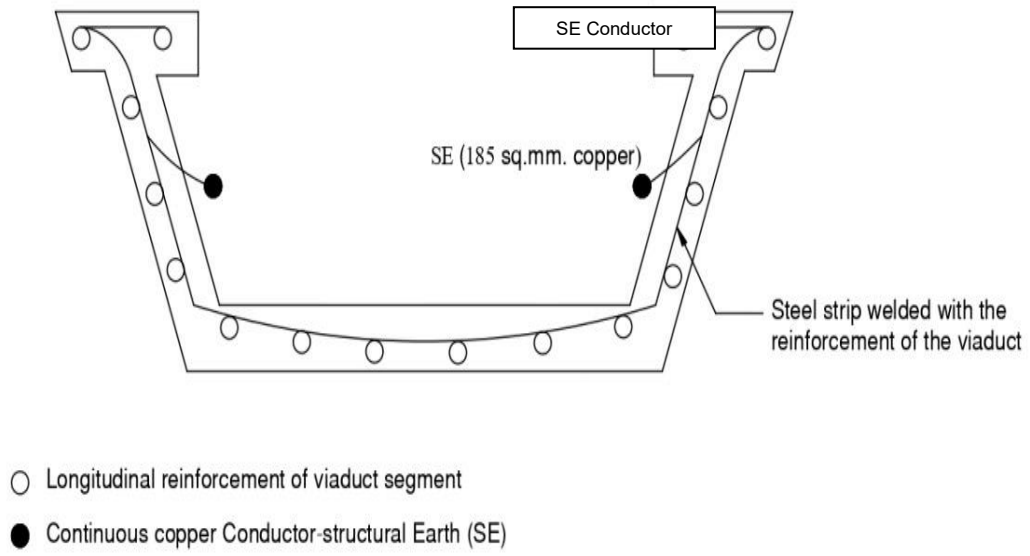


Figure 10.10: Connection of SE Conductor to Steel Reinforcement of Viaduct Segment

5. 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.

10.4.5 Depot

1. Traction Power Supply System in the Depot shall be an Earthed System, wherein, the Running Rail inside the Depots shall be connected to the earthed system.
2. A separate TSS shall be provided for meeting the Traction Power Supply requirements of the depot.
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).

10.4.6 Electromagnetic Interference / Electromagnetic Compatibility (EMI /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, SCADA, Lifts, Escalators, 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, SCADA, Lifts, Escalators, E&M system etc.) shall comply with the EMI / EMC requirements of international standards viz. EN50121, EN50123, IEC61000 series etc. A detailed EMI / EMC Plan will be required to be developed and implemented duly involving all stake holders.

10.5 Auxiliary Supply Arrangements for Stations

Auxiliary sub-stations (ASS) are envisaged to be provided at each station. The ASS will be located at Concourse 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 315 kVA for elevated/at-grade stations and 2000kVA for Underground station. Accordingly, two dry type cast resin transformers (33/0.415kV) of 315kVAand 2000kVAcapacity (one transformer as standby) are proposed to be installed at the elevated stations& Underground station respectively.



Figure 10.11: Typical Indoor Auxiliary Sub-station

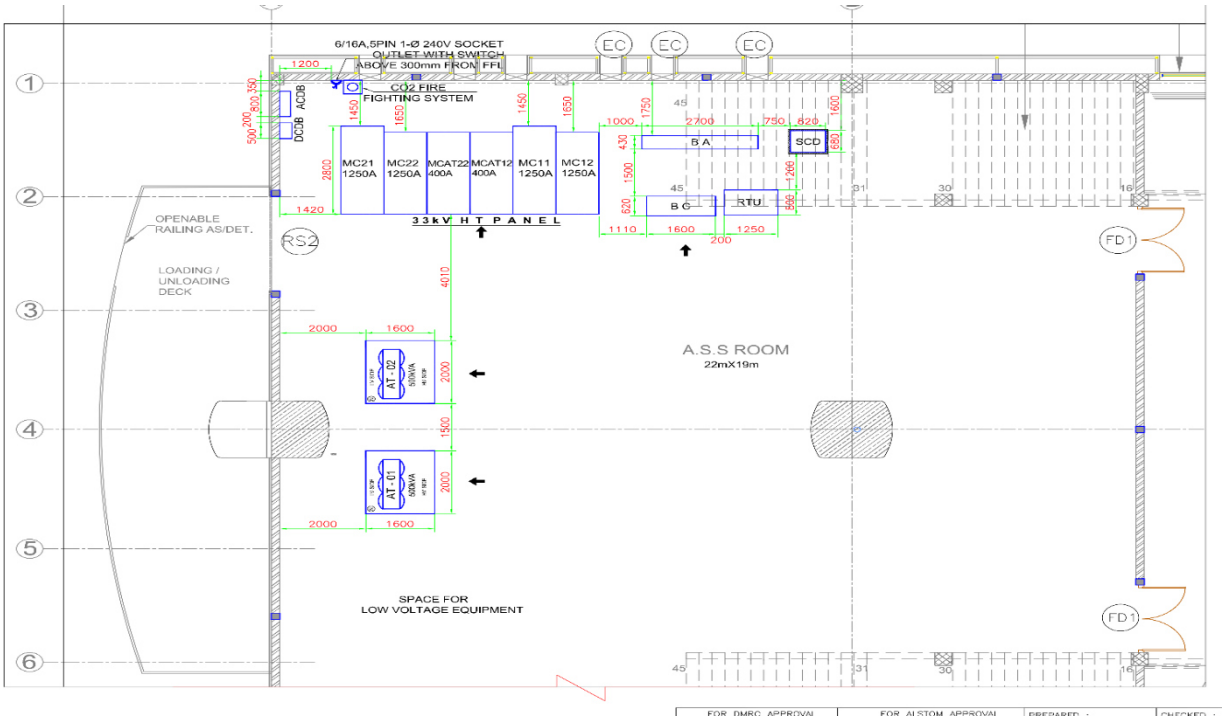


Figure 10.12: Typical Layout of ASS

10.6 Rating of Major Equipment

Traction transformer-rectifier set (33kV/750 V DC) shall be of 2.5 MVA with overload requirement of 150% for 2 hours with four intermittent equally spaced overloads of 300% for 1 minute. The Traction Transformer Rectifier set shall produce 750V DC nominal output voltage with 12-pulse rectification so as to minimize the ripple content in the output dc voltage. The IEC 850 international standard envisages the minimum and maximum voltages of 500V and 900V respectively for 750V DC Traction system and therefore, the dc equipment shall be capable of giving desired performance in this voltage range.

33kV (240 sq. mm. Copper) 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 shall be used for Elevated section and FRLSZH cable shall be used for Underground section.

Adequate no. of 750 V DC Single-phase XLPE insulated cables (300 sq. mm. Copper) shall be required for feeding Traction Power from TSS to Third Rail and to ensure the Return current from the running rail to the TSS.

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 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.

Common UPS shall be provided at elevated station(s) by S&T Department, which will feed the requirements of S&T Loads as well as E&M Loads.

Similarly, common UPS shall be provided at underground station(s) by Electrical Department, which will feed the requirements of S&T Loads as well as Electrical Loads.

The Capacity of the UPS for meeting emergent Electrical load requirement is likely to be20 KVA at Elevated station and 40 KVA at underground stations. However, the capacities may be finalized at the stage of detailed design keeping in view the S&T load requirements.

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 180kVA capacity at the elevated stations and 380kVA capacity at underground station to cater to the following essential services:

(i) Essential lighting
(ii) Signaling & telecommunications
(iii) Fire fighting system
(iv) Lift operation
(v) Fare collection system

Silent type DG sets with low noise levels are proposed, which do not require a separate room for installation.

10.9 Solar Photo Voltaic (PV) Power system

Solar PV power system are proposed to be installed at various sites in RESCO (Renewable Energy Service Company) model at Stations and Depots, for which adequate and necessary provision in the design of roofs may be planned by Metro Rail Authority.



Figure 10.13: 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. Constructed Wetlands 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 Thiruvananthapuram 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 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 12.89 million units in initial years (2027), which will be about 21.28 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 132kv or 66 kV) plus nominal administrative Charges i.e. on a no profit no loss basis. The power tariff of Gujarat Electricity Regulatory Commission for the Metro Traction for FY 2023-24 is demand charges Rs.335 per kW and energy charges Rs 3.55 per Unit. It is proposed that Government of Gujarat takes necessary steps to fix power tariff for 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 Municipal Corporation should not levy any municipal taxes on Electricity for Ahmedabad Metro.

- 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.

Phase – II Extension A: From 'Koteswar Road' To 'Sardar Vallabhbhai International Airport					Annexure 10.1A (Power)	
POWER REQUIREMENT			**YEAR**			
S.No.	**Particulars**	**Unit**	**2027**	**2031**	**2041**	**2051**
A	**Traction Power Requirements**	1	2	3	4	5
1	Train Configuration (3 - Car)	(DMC+TC+DMC)	3	3	3	3
2	Passenger Weight (65 kg per Passenger)	T	63.18	63.18	63.18	63.18
3	Train Tare Weight	T	126	126	126	126
4	Total Train Weight	T	189.18	189.18	189.18	189.18
5	Section Length	km	6.33	6.33	6.33	6.33
6	Headway	mts	12.00	12.00	12.00	12.00
7	Specific Energy Consumption	KWhr/ 1000 GTKM	60	60	60	60
8	No. of Trains/hr in both directions	Nos.	10	10	10	10
9	Total Traction Power Requirement	MW	0.72	0.72	0.72	0.72
	Total Traction Power Requirement (MVA) assuming 5% energy losses and 0.95 pf	**MVA**	**0.79**	**0.79**	**0.79**	**0.79**
B	**Aux. Power Requirements**					
1	Elevated/at-grade Station Power Consumption	MVA	0.25	0.25	0.28	0.315
2	Underground station Power Consumption	MVA	1.50	1.50	1.70	2.00
3	Mid-Shaft Power Consumption	MVA	0.63	0.63	0.63	0.63
4	No. of Elevated/at-grade Stations	Nos.	3	3	3	3
5	No. of Underground stations	No.	1	1	1	1
6	No. of Mid-Shaft	No.	0	0	0	0
7	Total Aux Power Requirement	MVA	2.25	2.25	2.54	2.95
8	Total Aux. Power Requirement (MVA) assuming 5% energy losses	**MVA**	**2.36**	**2.36**	**2.67**	**3.09**
C (A+B)	**Total Traction & Aux. Power Requirement (MVA)**	**MVA**	**3.16**	**3.16**	**3.46**	**3.89**
Note: The requirement of PD load is not consided in estimation of power calculation.						

Phase – II Extension A: From 'Koteswar Road' To 'Sardar Vallabhbhai International Airport					**Annexure 10.1A (Energy)**

ENERGY CONSUMPTION			**YEAR**			
S.No.	**Year**	**Unit**	**2027**	**2031**	**2041**	**2051**
A	**Traction Energy**	1	2	3	4	5
1	Section Length	km	6.33	6.33	6.33	6.33
2	No. of Trains per direction in a day*	No.	68	68	68	68
3	Weight of Train & Passenger	T	189.2	189.2	189.2	189.2
4	Specific Energy Consumption	KWH/ 1000 GTKM	60	60	60	60
	Yearly Traction Energy consumption with 365 days working	million units	3.57	3.57	3.57	3.57
B	**Station Aux. Energy**					
1	Elevated/at-grade Station	MVA	0.25	0.25	0.28	0.315
2	Underground Station	MVA	1.50	1.50	1.70	2.00
3	No. of Eevated/at-grade Stations	No.	3	3	3	3
4	No. of Underground Stations	No.	1	1	1	1
5	Total Aux. Power Requirement	MVA	2.25	2.25	2.54	2.95
6	Total Aux. Power Requirement (MVA) assuming 5% energy losses and 0.85 pf for Aux. loads	MVA	**2.78**	**2.78**	**3.14**	**3.64**
7	Diversity Factor of Aux. loads		0.40	0.40	0.40	0.40
8	Yearly Aux. Energy Consumption 20 hrs/day and 365 days working (million units)	**million units**	**5.58**	**5.58**	**6.30**	**7.31**
C (A+B)	**Net Annual Energy Consumption (Traction & Aux.)**	**million units**	**9.15**	**9.15**	**9.87**	**10.88**

Note: The requirement of PD load is not consided in energy calculation.

Phase – II Extension B: From 'Gift City (Existing)' To 'Shahpur Metro'					Annexure 10.1B (Power)	
POWER REQUIREMENT			**YEAR**			
S.No.	**Particulars**	**Unit**	**2027**	**2031**	**2041**	**2051**
A	**Traction Power Requirements**	1	2	3	4	5
1	Train Configuration (3 - Car)	(DMC+TC+DMC)	3	3	3	3
2	Passenger Weight (65 kg per Passenger)	T	63.18	63.18	63.18	63.18
3	Train Tare Weight	T	126	126	126	126
4	Total Train Weight	T	189.18	189.18	189.18	189.18
5	Section Length	km	3.33	3.33	3.33	3.33
6	Headway	mts	12.00	12.00	9.00	8.30
7	Specific Energy Consumption	KWhr/ 1000 GTKM	60	60	60	60
8	No. of Trains/hr in both directions	Nos.	10	10	13	14
9	Total Traction Power Requirement	MW	0.38	0.38	0.50	0.55
	Total Traction Power Requirement (MVA) assuming 5% energy losses and 0.95 pf	**MVA**	**0.42**	**0.42**	**0.56**	**0.60**
B	**Aux. Power Requirements**					
1	Elevated/at-grade Station Power Consumption	MVA	0.25	0.25	0.28	0.315
2	No. of Elevated/at-grade Stations	Nos.	3	3	3	3
3	Total Aux Power Requirement	MVA	0.75	0.75	0.84	0.95
4	Total Aux. Power Requirement (MVA) assuming 5% energy losses	**MVA**	**0.79**	**0.79**	**0.88**	**0.99**
C (A+B)	**Total Traction & Aux. Power Requirement (MVA)**	**MVA**	**1.21**	**1.21**	**1.44**	**1.60**
Note: The requirement of PD load is not consided in estimation of power calculation.						

Phase – II Extension B: From 'Gift City (Existing)' To 'Shahpur Metro'						Annexure 10.1B (Energy)
ENERGY CONSUMPTION			**YEAR**			
S.No.	**Year**	**Unit**	**2027**	**2031**	**2041**	**2051**
A	**Traction Energy**	1	2	3	4	5
1	Section Length	km	3.33	3.33	3.33	3.33
2	No. of Trains per direction in a day*	No.	68	68	84	90
3	Weight of Train & Passenger	T	189.2	189.2	189.2	189.2
4	Specific Energy Consumption	KWH/ 1000 GTKM	60	60	60	60
	Yearly Traction Energy consumption with 365 days working	million units	1.88	1.88	2.32	2.48
B	**Station Aux. Energy**					
1	Elevated/at-grade Station	MVA	0.25	0.25	0.28	0.315
2	No. of Eevated/at-grade Stations	No.	3	3	3	3
3	Total Aux. Power Requirement	MVA	0.75	0.75	0.84	0.95
4	Diversity Factor of Aux. loads		0.40	0.40	0.40	0.40
5	Yearly Aux. Energy Consumption 20 hrs/day and 365 days working (million units)	**million units**	**1.86**	**1.86**	**2.08**	**2.35**
C (A+B)	**Net Annual Energy Consumption (Traction & Aux.)**	**million units**	**3.74**	**3.74**	**4.40**	**4.83**

Note: The requirement of PD load is not consided in energy calculation.

Phase – II Extension C: From 'Shahpur' To 'Gift'					Annexure 10.1C (Power)	
POWER REQUIREMENT			**YEAR**			
S.No.	**Particulars**	**Unit**	**2027**	**2031**	**2041**	**2051**
A	**Traction Power Requirements**	1	2	3	4	5
1	Train Configuration (3 - Car)	(DMC+TC+DMC)	3	3	3	3
2	Passenger Weight (65 kg per Passenger)	T	63.18	63.18	63.18	63.18
3	Train Tare Weight	T	126	126	126	126
4	Total Train Weight	T	189.18	189.18	189.18	189.18
5	Section Length	km	0.00	4.32	4.32	4.32
6	Headway	mts	0.00	12.00	9.00	8.30
7	Specific Energy Consumption	KWhr/ 1000 GTKM	60	60	60	60
8	No. of Trains/hr in both directions	Nos.	0	10	13	14
9	Total Traction Power Requirement	MW	0.00	0.49	0.65	0.71
	Total Traction Power Requirement (MVA) assuming 5% energy losses and 0.95 pf	**MVA**	**0.00**	**0.54**	**0.72**	**0.78**
B	**Aux. Power Requirements**					
1	Elevated/at-grade Station Power Consumption	MVA	0.25	0.25	0.28	0.315
2	No. of Elevated/at-grade Stations	Nos.	0	3	3	3
3	Total Aux Power Requirement	MVA	0.00	0.75	0.84	0.95
4	Total Aux. Power Requirement (MVA) assuming 5% energy losses	**MVA**	**0.00**	**0.79**	**0.88**	**0.99**
C (A+B)	**Total Traction & Aux. Power Requirement (MVA)**	**MVA**	**0.00**	**1.33**	**1.61**	**1.78**
Note: The requirement of PD load is not consided in estimation of power calculation.						

Phase – II Extension C: From 'Shahpur' To 'Gift'					Annexure 10.1C (Energy)	
ENERGY CONSUMPTION			**YEAR**			
S.No.	**Year**	**Unit**	**2027**	**2031**	**2041**	**2051**
A	**Traction Energy**	1	2	3	4	5
1	Section Length	km	0.00	4.32	4.32	4.32
2	No. of Trains per direction in a day*	No.	0	68	84	90
3	Weight of Train & Passenger	T	189.2	189.2	189.2	189.2
4	Specific Energy Consumption	KWH/ 1000 GTKM	60	60	60	60
	Yearly Traction Energy consumption with 365 days working	million units	0.00	2.44	3.01	3.22
B	**Station Aux. Energy**					
1	Elevated/at-grade Station	MVA	0.25	0.25	0.28	0.315
2	No. of Eevated/at-grade Stations	No.	0	3	3	3
3	Total Aux. Power Requirement	MVA	0.00	0.75	0.84	0.95
4	Diversity Factor of Aux. loads		0.40	0.40	0.40	0.40
5	Yearly Aux. Energy Consumption 20 hrs/day and 365 days working (million units)	**million units**	**0.00**	**1.86**	**2.08**	**2.35**
C (A+B)	**Net Annual Energy Consumption (Traction & Aux.)**	**million units**	**0.00**	**4.30**	**5.09**	**5.57**
Note: The requirement of PD load is not consided in energy calculation.						

Phase – II (Under Construction): From Motera Stadium to GNLU					Annexure 10.1 D1 (Power)	
POWER REQUIREMENT			**YEAR**			
S.No.	**Particulars**	**Unit**	**2027**	**2031**	**2041**	**2051**
A	**Traction Power Requirements**	1	2	3	4	5
1	Train Configuration (3 - Car)	(DMC+TC+DMC)	3	3	3	3
2	Passenger Weight (65 kg per Passenger)	T	63.18	63.18	63.18	63.18
3	Train Tare Weight	T	126	126	126	126
4	Total Train Weight	T	189.18	189.18	189.18	189.18
5	Section Length	km	8.32	8.32	8.32	8.32
6	Headway	mts	6.00	6.00	4.50	4.15
7	Specific Energy Consumption	KWhr/ 1000 GTKM	60	60	60	60
8	No. of Trains/hr in both directions	Nos.	20	20	27	29
9	Total Traction Power Requirement	MW	1.89	1.89	2.52	2.73
	Total Traction Power Requirement (MVA) assuming 5% energy losses and 0.95 pf	**MVA**	**2.09**	**2.09**	**2.78**	**3.02**
B	**Aux. Power Requirements**					
1	Elevated/at-grade Station Power Consumption	MVA	0.25	0.25	0.28	0.315
2	Underground station Power Consumption	MVA	1.50	1.50	1.70	2.00
3	Mid-Shaft Power Consumption	MVA	0.63	0.63	0.63	0.63
4	No. of Elevated/at-grade Stations	Nos.	9	9	9	9
5	No. of Underground stations	No.	0	0	0	0
6	No. of Mid-Shaft	No.	0	0	0	0
7	Total Aux Power Requirement	MVA	2.25	2.25	2.52	2.84
8	Total Aux. Power Requirement (MVA) assuming 5% energy losses	**MVA**	**2.36**	**2.36**	**2.65**	**2.98**
C (A+B)	**Total Traction & Aux. Power Requirement (MVA)**	**MVA**	**4.45**	**4.45**	**5.43**	**5.99**
Note: The requirement of PD load is not consided in estimation of power calculation.						

Phase – II (Under Construction): From Motera Stadium to GNLU						Annexure 10.1 D1 (Energy)
ENERGY CONSUMPTION			**YEAR**			
S.No.	**Year**	**Unit**	**2027**	**2031**	**2041**	**2051**
A	**Traction Energy**	1	2	3	4	5
1	Section Length	km	8.32	8.32	8.32	8.32
2	No. of Trains per direction in a day*	No.	110	110	163	169
3	Weight of Train & Passenger	T	189.2	189.2	189.2	189.2
4	Specific Energy Consumption	KWH/ 1000 GTKM	60	60	60	60
	Yearly Traction Energy consumption with 365 days working	million units	7.58	7.58	11.23	11.65
B	**Station Aux. Energy**					
1	Elevated/at-grade Station	MVA	0.25	0.25	0.28	0.315
2	Underground Station	MVA	1.50	1.50	1.70	2.00
3	No. of Eevated/at-grade Stations	No.	9	9	9	9
4	No. of Underground Stations	No.	0	0	0	0
5	Total Aux. Power Requirement	MVA	2.25	2.25	2.52	2.84
6	Total Aux. Power Requirement (MVA) assuming 5% energy losses and 0.85 pf for Aux. loads	MVA	**2.78**	**2.78**	**3.11**	**3.50**
7	Diversity Factor of Aux. loads		0.40	0.40	0.40	0.40
8	Yearly Aux. Energy Consumption 20 hrs/day and 365 days working (million units)	**million units**	**5.58**	**5.58**	**6.25**	**7.04**
C (A+B)	**Net Annual Energy Consumption (Traction & Aux.)**	**million units**	**13.16**	**13.16**	**17.49**	**18.68**
Note: The requirement of PD load is not consided in energy calculation.						

Phase – II (Under Construction): From GNLU to Mahatma Mandir					Annexure 10.1 D2 (Power)	
POWER REQUIREMENT			**YEAR**			
S.No.	**Particulars**	**Unit**	**2027**	**2031**	**2041**	**2051**
A	**Traction Power Requirements**	1	2	3	4	5
1	Train Configuration (3 - Car)	(DMC+TC+DMC)	3	3	3	3
2	Passenger Weight (65 kg per Passenger)	T	63.18	63.18	63.18	63.18
3	Train Tare Weight	T	126	126	126	126
4	Total Train Weight	T	189.18	189.18	189.18	189.18
5	Section Length	km	14.52	14.52	14.52	14.52
6	Headway	mts	12.00	12.00	9.00	8.30
7	Specific Energy Consumption	KWhr/ 1000 GTKM	60	60	60	60
8	No. of Trains/hr in both directions	Nos.	10	10	13	14
9	Total Traction Power Requirement	MW	1.65	1.65	2.20	2.38
	Total Traction Power Requirement (MVA) assuming 5% energy losses and 0.95 pf	**MVA**	**1.82**	**1.82**	**2.43**	**2.63**
B	**Aux. Power Requirements**					
1	Elevated/at-grade Station Power Consumption	MVA	0.25	0.25	0.28	0.315
2	Underground station Power Consumption	MVA	1.50	1.50	1.70	2.00
3	Mid-Shaft Power Consumption	MVA	0.63	0.63	0.63	0.63
4	No. of Elevated/at-grade Stations	Nos.	12	12	12	12
5	No. of Underground stations	No.	0	0	0	0
6	No. of Mid-Shaft	No.	0	0	0	0
7	Total Aux Power Requirement	MVA	3.00	3.00	3.36	3.78
8	Total Aux. Power Requirement (MVA) assuming 5% energy losses	**MVA**	**3.15**	**3.15**	**3.53**	**3.97**
C (A+B)	**Total Traction & Aux. Power Requirement (MVA)**	**MVA**	**4.97**	**4.97**	**5.96**	**6.60**
Note: The requirement of PD load is not consided in estimation of power calculation.						

Phase – II (Under Construction): From GNLU to Mahatma Mandir						Annexure 10.1 D2 (Energy)
ENERGY CONSUMPTION			**YEAR**			
S.No.	**Year**	**Unit**	**2027**	**2031**	**2041**	**2051**
A	**Traction Energy**	1	2	3	4	5
1	Section Length	km	14.52	14.52	14.52	14.52
2	No. of Trains per direction in a day*	No.	68	68	84	90
3	Weight of Train & Passenger	T	189.2	189.2	189.2	189.2
4	Specific Energy Consumption	KWH/ 1000 GTKM	60	60	60	60
	Yearly Traction Energy consumption with 365 days working	million units	8.18	8.18	10.11	10.83
B	**Station Aux. Energy**					
1	Elevated/at-grade Station	MVA	0.25	0.25	0.28	0.315
2	Underground Station	MVA	1.50	1.50	1.70	2.00
3	No. of Eevated/at-grade Stations	No.	12	12	12	12
4	No. of Underground Stations	No.	0	0	0	0
5	Total Aux. Power Requirement	MVA	3.00	3.00	3.36	3.78
6	Total Aux. Power Requirement (MVA) assuming 5% energy losses and 0.85 pf for Aux. loads	MVA	**3.71**	**3.71**	**4.15**	**4.67**
7	Diversity Factor of Aux. loads		0.40	0.40	0.40	0.40
8	Yearly Aux. Energy Consumption 20 hrs/day and 365 days working (million units)	**million units**	**7.45**	**7.45**	**8.34**	**9.38**
C (A+B)	**Net Annual Energy Consumption (Traction & Aux.)**	**million units**	**15.63**	**15.63**	**18.45**	**20.21**

Note: The requirement of PD load is not consided in energy calculation.

					Annexure 10.1 D3 (Power)	
Phase – II (Under Construction): Spur From GNLU to Gift City						
POWER REQUIREMENT			**YEAR**			
S.No.	**Particulars**	**Unit**	**2027**	**2031**	**2041**	**2051**
A	**Traction Power Requirements**	1	2	3	4	5
1	Train Configuration (3 - Car)	(DMC+TC+DMC)	3	3	3	3
2	Passenger Weight (65 kg per Passenger)	T	63.18	63.18	63.18	63.18
3	Train Tare Weight	T	126	126	126	126
4	Total Train Weight	T	189.18	189.18	189.18	189.18
5	Section Length	km	5.01	5.01	5.01	5.01
6	Headway	mts	12.00	12.00	9.00	8.30
7	Specific Energy Consumption	KWhr/ 1000 GTKM	60	60	60	60
8	No. of Trains/hr in both directions	Nos.	10	10	13	14
9	Total Traction Power Requirement	MW	0.57	0.57	0.76	0.82
	Total Traction Power Requirement (MVA) assuming 5% energy losses and 0.95 pf	**MVA**	**0.63**	**0.63**	**0.84**	**0.91**
B	**Aux. Power Requirements**					
1	Elevated/at-grade Station Power Consumption	MVA	0.25	0.25	0.28	0.315
2	Underground station Power Consumption	MVA	1.50	1.50	1.70	2.00
3	Mid-Shaft Power Consumption	MVA	0.63	0.63	0.63	0.63
4	No. of Elevated/at-grade Stations	Nos.	2	2	2	2
5	No. of Underground stations	No.	0	0	0	0
6	No. of Mid-Shaft	No.	0	0	0	0
7	Total Aux Power Requirement	MVA	0.50	0.50	0.56	0.63
8	Total Aux. Power Requirement (MVA) assuming 5% energy losses	**MVA**	**0.53**	**0.53**	**0.59**	**0.66**
C (A+B)	**Total Traction & Aux. Power Requirement (MVA)**	**MVA**	**1.15**	**1.15**	**1.43**	**1.57**

Note: The requirement of PD load is not consided in estimation of power calculation.

Annexure 10.1 D3 (Energy)

ENERGY CONSUMPTION			YEAR			
S.No.	**Year**	**Unit**	**2027**	**2031**	**2041**	**2051**
A	**Traction Energy**	1	2	3	4	5
1	Section Length	km	5.01	5.01	5.01	5.01
2	No. of Trains per direction in a day*	No.	68	68	84	90
3	Weight of Train & Passenger	T	189.2	189.2	189.2	189.2
4	Specific Energy Consumption	KWH/ 1000 GTKM	60	60	60	60
	Yearly Traction Energy consumption with 365 days working	million units	2.82	2.82	3.49	3.74
B	**Station Aux. Energy**					
1	Elevated/at-grade Station	MVA	0.25	0.25	0.28	0.315
2	Underground Station	MVA	1.50	1.50	1.70	2.00
3	No. of Eevated/at-grade Stations	No.	2	2	2	2
4	No. of Underground Stations	No.	0	0	0	0
5	Total Aux. Power Requirement	MVA	0.50	0.50	0.56	0.63
6	Total Aux. Power Requirement (MVA) assuming 5% energy losses and 0.85 pf for Aux. loads	MVA	**0.62**	**0.62**	**0.69**	**0.78**
7	Diversity Factor of Aux. loads		0.40	0.40	0.40	0.40
8	Yearly Aux. Energy Consumption 20 hrs/day and 365 days working (million units)	**million units**	**1.24**	**1.24**	**1.39**	**1.56**
C (A+B)	**Net Annual Energy Consumption (Traction & Aux.)**	**million units**	**4.06**	**4.06**	**4.88**	**5.30**

Note: The requirement of PD load is not consided in energy calculation.

Phase – II (Under Construction)			Annexure 10.1 D (D1+D2+D3) (Power)			
POWER REQUIREMENT			**YEAR**			
S.No.	**Section of Corridor**	**Load**	**2027**	**2031**	**2041**	**2051**
1	From Motera Stadium to GNLU	Traction (MVA)	2.09	2.09	2.78	3.02
		Auxiliary (MVA)	2.36	2.36	2.65	2.98
		Sub- Total (MVA)	**4.45**	**4.45**	**5.43**	**5.99**
2	From GNLU to Mahatma Mandir	Traction (MVA)	1.82	1.82	2.43	2.63
		Auxiliary (MVA)	3.15	3.15	3.53	3.97
		Sub- Total (MVA)	**4.97**	**4.97**	**5.96**	**6.60**
3	Spur From GNLU to Gift City	Traction (MVA)	0.63	0.63	0.84	0.91
		Auxiliary (MVA)	0.53	0.53	0.59	0.66
		Sub- Total (MVA)	**1.15**	**1.15**	**1.43**	**1.57**
Grand Total		Traction (MVA)	4.54	4.54	6.05	6.56
		Auxiliary (MVA)	6.04	6.04	6.76	7.61
		Total (MVA)	**10.57**	**10.57**	**12.81**	**14.17**
Note: The requirement of PD load is not consided in estimation of power calculation.						

Annexure 10.1 E (A+B+C+D)
(Power)

Phase – II (Under Construction): From Motera Stadium to Mahatma Mandir Including 'Spur From GNLU to Gift City'

Phase – II ExtensionA: From 'Koteshwar to Sardar Vallabhbhai International Airport'

Phase – II ExtensionB: From 'Gift City (Existing)' To 'Shahpur Metro'

Phase – II ExtensionC: From 'Shahpur' To 'Gift'

POWER REQUIREMENT			YEAR			
Ref. Annexure	**Section of Corridor**	**Load**	**2027**	**2031**	**2041**	**2051**
Annexure - 10.1 A	Phase – II Extension A: From 'Koteswar Road' To 'Sardar Vallabhbhai International Airport	Traction (MVA)	0.79	0.79	0.79	0.79
		Auxiliary (MVA)	2.36	2.36	2.67	3.09
		Sub- Total (MVA)	**3.16**	**3.16**	**3.46**	**3.89**
Annexure - 10.1 B	Phase – II Extension B: From 'Gift City (Existing)' To 'Shahpur Metro'	Traction (MVA)	0.42	0.42	0.56	0.60
		Auxiliary (MVA)	0.79	0.79	0.88	0.99
		Sub- Total (MVA)	**1.21**	**1.21**	**1.44**	**1.60**
Annexure - 10.1 C	Phase – II Extension C: From 'Shahpur' To 'Gift'	Traction (MVA)	0.00	0.54	0.72	0.78
		Auxiliary (MVA)	0.00	0.79	0.88	0.99
		Sub- Total (MVA)	**0.00**	**1.33**	**1.61**	**1.78**
Annexure - 10.1 D	Phase – II (Under Construction): From Motera Stadium to Mahatma Mandir, Including 'Spur From GNLU to Gift City'	Traction (MVA)	4.54	4.54	6.05	6.56
		Auxiliary (MVA)	6.04	6.04	6.76	7.61
		Sub- Total (MVA)	**10.57**	**10.57**	**12.81**	**14.17**
Grand Total		Traction (MVA)	5.75	6.29	8.12	8.74
		Auxiliary (MVA)	9.19	9.98	11.19	12.68
		Total (MVA)	**14.94**	**16.27**	**19.32**	**21.43**

Note: The requirement of PD load is not consided in estimation of power calculation.

Chapter - 11

Signalling & Train Control System



11.1 Introduction

11.2 Signalling System & PSG

11.3 Overview of Signalling System

11.4 System Description and Specifications

11.5 Signalling Mode of Operation

11.6 Half Height Integrated Platform Gate (PG)

11.7 Centralized Traffic Control (CTC)

11.8 Back Up of the OCC (BCC)

11.9 Standards

11.10 Space Requirement For Signalling Installations

11.11 Maintenance Philosophy For Signalling Systems



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 efficient Train Control, ensuring safety in train movements. It assists in the optimization of rail infrastructure investment and the running of efficient train services on the network.

This Chapter provides the main design features of the Signalling and train control system for the operation of the Ahmedabad Phase-II metro corridor extension mentioned below taking into account the proven and advanced system being used worldwide. The corridor is: -

a) Inside Gift City to Gift City Station

The Proposed Corridor mentioned above is planned to be operated at 90 Km/hr as it is an extension of the corridor.

Koteswar Prachin Mandir and GNLU stations shall be interchange stations as in the existing scenario and Gyaspur Depot shall be used for the Phase II corridor of Ahmedabad Metro Rail Corridor. As per design requirements, the Signalling System shall be designed at a 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 service.
The proposed Signalling system design for the metro line corridor isas under:

- Continuous Automatic Train Control System (CATC)
- Driverless Train Operation (DTO)
- Automatic Train Operation System (ATO)
- Automatic Train Protection (ATP) System
- Communication-Based Train Control (CBTC) based Automatic Train Control (ATC) System
- Onboard Equipment for Cab Signalling
- Fall-Back Block System along with Track Vacancy Detection System
- Interlocking device
- Trackside Radio equipment
- Electric Point Machine

- Trackside Signals
- Automatic Train Supervision (ATS) based Centralized Traffic Control System
- Optical Fiber Based Backbone Network (Redundant)
- Power Supply of Signalling
- Cable for Signalling
- Half Height Integrated Platform Screen Gate for Elevated stations (PG System) and Full Height Platform Gate for Under-ground stations

11.3 OVERVIEW OF SIGNALLING SYSTEM& PSG

It is expected to carry a 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 the following basic principles of the Signalling System: -

- The Train Control and Monitoring shall be ensured from the Centralized Traffic Control System located at the Operation Control Centre (OCC). OCC equipment shall be connected to the station equipment room through an 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 the safe side or more restrictive state. In such case, the Signalling System shall authorise the movement of trains in normal and degraded operations.
- Equipment shall be connected through Electronic Interlocking (to Station Equipment Room) by secure links to ensure the safe movement of train.
- Provide a 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 the brake in case of disregard of signal/warning by the driver.
- Provide safety and enforce speed limits on the sections having permanent and temporary speed restrictions.
- Improve capacity with safer and smoother operations. The driver will have a 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 the System status of trackside and train-borne equipment and enabling preventive maintenance.
- To avoid any accident at the platform, an 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 the Passenger Screen Gate System.

- Signalling and 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 Trackside and Train.

Radio for CBTC shall work in License free ISM band (2.4/ 5.8 GHz) to support-

- For Radio communication, Station/ Wayside Radio Antenna towers will be used for wayside to Train antenna (mounted on train roof). Tower design & strength shall be properly designed to cater strong winds possibility at the installed location.

Wireless communication system shall be used for communication between the wayside and train borne CBTC system.

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), DTO (Driverless Train Operation) and ATS (Automatic Train Supervision) sub-systems.

The Train-Borne Automatic Train Control System will consist of Automatic Train Operation (ATO), Driverless Train Operation (DTO) and Automatic Train Protection (ATP). This will work on the 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 and 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 and 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, and 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 Driverless Train Operation (DTO)

In this mode, the train shall operate driverless (with a crew member onboard), it shall operate under the supervision and control of ATP function. This shall be operated with attendant under fully automated operation (GoA-3) as defined in IEC 62290-12006.

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

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

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

In DTO 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.

11.4.5 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.

11.4.6 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.

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

“Restricted Manual (RM) Mode” means a driving mode where train is driven manually and is subjected to automatic train protection in respect of maximum speed limit only.

RM/ROS mode shall be available only when Onboard ATC in operation. If the Onboard ATC does not receive ATP information, the train shall be manually driven by

the 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.

11.4.8 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, Onboard ATC power supply is shut down.

11.4.9 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.

11.4.10 Track Vacancy Detection

Primary mode for track vacancy detection system on main line may be through Radio Ranging Method and for secondary detection, Axle Counter is used. Secondary detection system shall be used for non-CBTC trains/vehicles, fall back operations of CBTC.

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 is 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

11.4.11 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.

11.4.12 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.

11.4.13 Point Machines

Non-Trailable Electrical Point Machine capable of operating with 3-phase, 50 Hz. 380V AC will be used on mainline.

11.4.14 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. Existing Test track shall be used.

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 six Modes are

mentioned as under: -

a) Restricted Manual (RM) Mode.
b) Driverless Train Operation (DTO) Mode
c) Automatic Train Protection (ATP) Mode
d) Automatic Train Operation (ATO) Mode
e) Run on Sight Mode (ROS) Mode
f) 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 1.5/1.7 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 Door (ASD), Platform End Doors (PED), Emergency Escape Doors (EED) and Fixed Screens (FS) 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 the structure and architecture of the station and operationally with the 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.

11.7.1 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 requirements, 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:

- TheSignallingtechnicalroom:40m2
- Themaintenanceroom:30m2
- Thepowersupplyroom:50m2

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 extension metro network also.

11.8 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 extension metro network also.

- The OCC, normally on-line and used by the Operators to control the Metro Line traffic. Operation & Maintenance Control,
- The BCC, is 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.

11.9 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 centralized 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.
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.
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, PG System 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 Height(1.5/1.7 mtrs) 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 implemented for EMC.
Train Working under emergency	Running on site with line side signal with speed automatically restricted upto 25 Kmph.
Environmental Conditions	Air-conditioners for all equipment rooms.

Description	Standards
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 undertaken in the central laboratory/ manufacturer's premises.

11.10 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.

11.11 MAINTENANCE PHILOSOPHY FOR SIGNALLING SYSTEMS

The philosophy of continuous monitoring of system status and preventive & and corrective maintenance of Signalling 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 & Automatic Fare Collection Systems



12.0 Telecommunication System

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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 the operational and administrative requirements of the metro network.

12.2 OVERVIEW

The Telecommunication facilities proposed are helpful in meeting the requirements for the 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,
- Cables for Telecommunications etc.

12.3 TELECOMMUNICATION SYSTEM AND TRANSMISSION MEDIA

12.3.1 Fiber 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 in the corridor along the track as per commercial requirement for revenue if existing corridor has similar provision.

12.3.2 Gigabit Ethernet Network (WAN)

A totally IP Based High Capacity, highly reliable and fault-tolerant, MPLS Ethernet Network can be provided. 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 as existing. 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 the Centralized Management and Control facility of all equipment used in line, if sufficient no. of ports are not available in the existing scenario for the extension station. 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 equipment's and lower level stations. 1+1 or N:1 protection switching functions are provided for the synchronous signal outputs.

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, and Holdover Clock. The existing Master Clock system at OCC can be extended to provide the signal to the new Line.

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. The station exchanges will be connected to the existing 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 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 TETRA International standard.

All the new stations 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 TETRA 400 Mhz band, depending on frequency availability& frequency spots already in use. The existing TETRA System can be augmented or a new TETRA System with Inter System Interface to existing TETRA System can be provided. 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, Base Stations shall be required at average distance of 4 Kms based on radio survey. Also, repeater's will be required based on the RF survey for the radio communication.

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 amplifiers 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 Centralized 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.

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 existing 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 existing OCC on the Video Wall. At OCC (or Security Control Room at OCC), a Large Video Wall for CCTV shall be provided by using the existing 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 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 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 technology used shall be as far as possible the existing Operational Line's technology, so as to ensure seamless integration. Wherever the available capacity permits, the existing Central Master Clock, Servers, etc shall be used for a most cost-effective solution. The decision to augment existing systems or to install new systems, shall have to be taken based on the most economical solution at the time of actual procurement. 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 Fiber system as the main bearer for bulk of the Telecommunication network
Telephone Exchange	PABX of minimum 30 ports is to be provided at all Stations, an Exchange of 60 Ports to be provided at Terminal Station
Train Radio System	TETRA based communication between motorman of moving cars, stations, maintenance personnel and central

System	Standards
	control.
Train Destination Indicator System	LED based boards with adequate visibility on Elevated and LED Panels in concourse to be provided at convenient location at all stations to provide bilingual visual indication of the status of the running trains, and also special messages in emergencies.
Centralized clock System	Accurate display of time through a synchronization system of slave clocks driven from a GPS master clock at the OCC and sub – master clock in station. This shall also be used for synchronization other systems.
Passenger Announcement System	Passenger Announcement System covering all platform and concourse areas with local as well as Central Announcement.
Redundancy (Major System)	Redundancy in RF Coverage, Path Redundancy for Optical Fiber 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 Telecommunication equipment’s 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 equipment's 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 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 stations inside GIFT City House to GIFT station MRTS corridor. 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 worldwide accepted systems for Metro environment.

The proposed ticketing system shall be of Contact less Card/ Single Journey Ticket (SJT) 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/ SJT based AFC system is similar to magnetic ticket based AFC system, but Contactless system proves cheaper due to reduced maintenance, less wear and tear and less prone to dusty environment.

In light of new guidelines, itis proposed that AFC components for all stations may be installed using Project Cost .

For reference of new Guidelines, Directive letter has been annexed as **Annexure-II.**

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 (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 ticket 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 ISSUING MACHINE (TIM) & SELF-SERVICE TICKETING KIOSKS

The self-service ticket kiosks and TIM 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 Issuing Machines (Automatic Ticket Issuing Machines) are proposed. The TIM'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 Tickets for single journey
2. Add Value in Smart card by paying money using Bank Notes or through Credit Card /Debit card /pre-Paid card/ UPI.
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 ticket 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 minimizes the number of times the station staffs need to replenish the machines with change.

12.17.2 Physical

The TIM'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 TIM rooms as required by the station architecture. Separate tamper-proof coin boxes and note vaults shall be provided.

Minimum 2 TIM 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)-QR code as per existing Line.
- 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) to support National Common Mobility Card (NCMC) 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 QR code on mobile/ paper QR code. QR code on mobile will be the most preferred media as it has no cost of ticket media.

Choice of SJT/CSC media shall take into considerations the mandatory interoperability on existing Operational Line.

12.18.2 Ticket Reader/Add Value Machine/ Cashless Smart Machine (CSM)

These machines will be used:

- to know the Card/ media balance,
- 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.
- as cashless Smart Machine to add value directly through UPI, etc.

12.18.3 Swing Barrier (For Manual Entry/ Exit without Ticket media)- *Optional*

Swing Barrier (1 No. at each access) will be used for Entry & Exit within Paid & Unpaid area mainly for the O&M Staff. AFC Reader shall be provided on this Gate also to keep into account the number of passers through this gate.

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 or by E-SAM encoded in the equipment. The SAM/E-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. If existing CC has available capacity then the same can be used after a due diligence of cost vs service life availability vs a competitive bid CC. The CC is connected to Station Computer and equipment's 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 SJT, CSC and transaction information received from the Station Computer Systems.

c) The CC shall hold and download SJT 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 SJT, 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

With the integration of new corridor with existing network, network will get modified. Trains will operate from GIFT City House to GIFT station MRTS corridor.

The AFC equipment required at various locations of New MRTS Corridor (till year 2051)are tabulated at **Annexure-1** for projection years 2027, 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

Standards	Description
Fare media	a) Single Journey Ticket – QR code on mobile/ paper QR code or other contactless media. 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 the 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.

Standards	Description
Ticket office machine(TOM/ EFO)	Manned Ticked Office Machines shall be installed in the station for selling cards / SJT to the passengers. Also, TIM's shall be provided for Automatic Ticket Issuing.
Ticket Readers	Ticket Reader shall be installed near EFO for passengers to check information stored in the card/ media.
Portable ticket decoder(PTD)	PTD will be used to check the card/ media during travel
UPS	Common UPS of S&T system will be utilized.
Maintenance philosophy	Being fully Contactless system, the manpower requirement for maintenance is much less compared to a system with magnetic tickets. However, adequate facilities are 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 modes 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 at least the smart card-based fare products should be inter-operable by means of NCMC standards.

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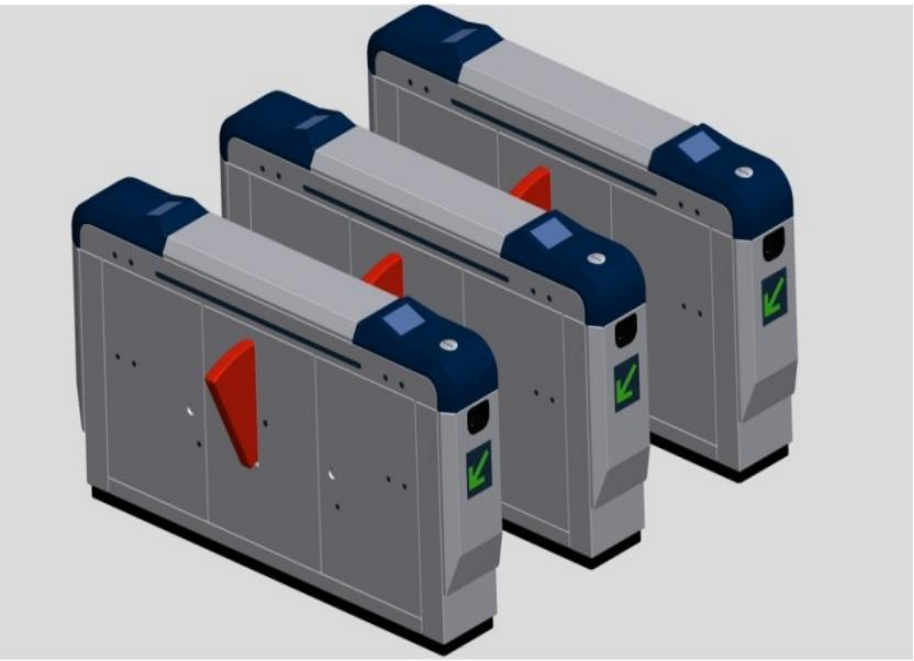


Fig 12.1 Entry/Exit Gates

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 Issuing machine



Fig. 12.3 Ticket Reader/Add Value Machine/ Cashless Smart Machine

ANNEXURE -1

(A) AFC Equipment's for GIFT City House to GIFT station (Projection for 2027)

Both UP & DN Direction (GNLU to GF-III)											
Station No.	**Station Name**	**Boarding**	**Alighting**	**Peak Minute Boarding**	**Peak Minute Alighting**	**Entry Gate**	**Exit Gate**	**TOM**	**EFO**	**TR**	**TVM**
1	GIFT City House	761	924	13	15	2	2	2	2	4	2
2	Gujarat Biotechnology University	236	289	4	5	2	2	2	2	4	2
3	Shahpur	7	6	0	0	2	2	2	2	4	2

(B) AFC Equipment's for GIFT City House to GIFT station (Projection for 2031)

Both UP & DN Direction (GNLU to GF-III)											
Station No.	**Station Name**	**Boarding**	**Alighting**	**Peak Minute Boarding**	**Peak Minute Alighting**	**Entry Gate**	**Exit Gate**	**TOM**	**EFO**	**TR**	**TVM**
1	GIFT City House	881	1,067	15	18	2	2	2	2	4	2
2	Gujarat Biotechnology University	276	337	5	6	2	2	2	2	4	2
3	Shahpur	8	7	0	0	2	2	2	2	4	2
4	Ratanpur	5	4	0	0	2	2	2	2	4	2
5	Lavarpur	19	16	0	0	2	2	2	2	4	2
6	GIFT	316	366	5	6	2	2	2	2	4	2

(C) AFC Equipment's for GIFT City House to GIFT station (Projection for 2041)

Both UP & DN Direction (GNLU to GF-III)											
Station No.	**Station Name**	**Boarding**	**Alighting**	**Peak Minute Boarding**	**Peak Minute Alighting**	**Entry Gate**	**Exit Gate**	**TOM**	**EFO**	**TR**	**TVM**
1	GIFT City House	2,034	2,466	34	41	2	2	2	2	4	2
2	Gujarat Biotechnology University	617	754	10	13	2	2	2	2	4	2
3	Shahpur	9	7	0	0	2	2	2	2	4	2
4	Ratanpur	5	4	0	0	2	2	2	2	4	2
5	Lavarpur	21	17	0	0	2	2	2	2	4	2
6	GIFT	708	827	12	14	2	2	2	2	4	2

(D) AFC Equipment's for GIFT City House to GIFT station (Projection for 2051)

Both UP & DN Direction (GNLU to GF-III)											
Station No.	**Station Name**	**Boarding**	**Alighting**	**Peak Minute Boarding**	**Peak Minute Alighting**	**Entry Gate**	**Exit Gate**	**TOM**	**EFO**	**TR**	**TVM**
1	GIFT City House	2,258	2,737	38	46	2	2	2	2	4	2
2	Gujarat Biotechnology University	684	836	11	14	2	2	2	2	4	2
3	Shahpur	10	8	0	0	2	2	2	2	4	2
4	Ratanpur	5	4	0	0	2	2	2	2	4	2
5	Lavarpur	23	19	0	0	2	2	2	2	4	2
6	GIFT	792	923	13	15	2	2	2	2	4	2

Assumptions:

1. Each station has two access: Two Entry and Two Exit
2. Minimum AFC equipment's at a station with two access:
    - 2 Entry Gates,
    - 2 Exit Gates,
    - 2 Ticket Office Machine (TOM)
    - 2 Excess Fare Office
    - 4 Ticket Reader/ AVM/ CSM
    - 2 Ticket Issuing Machine
3. Minimum Field Throughput of Gate is 25 Passengers per Minute based on passenger behavior.
4. 50% Passengers will use Single Journey Ticket & 50% Passengers will use Smart Card.

Annexure-II

F.No. K-14011/08/2017-MRTS-Coord
Government of India
Ministry of Housing & Urban Affairs
MRTS-Coord Desk

Room No.310B, Nirman Bhawan,
Dated the 03rd October, 2023.

To,

The MDs of All Metro/RRTS companies
(As per list attached)

Subject : Implementation of AFC system in Metro Rail Corporations- guidelines regarding.

Madam/Sir,

It is observed that the Metro/RRTS companies are sharing a large portion of their operational revenues towards fulfilling obligations under AFC system being implemented under Public Private Partnership(PPP). This in turn affects their ability to meet operational expenditure and capabilities of repayment of loans.

2. Considering the above scenario, the following directives are being issued for compliance/implementation by Metro/RRTS Companies with immediate effect:

(i) Henceforth, the AFC system will not be installed under PPP model. The AFC system should be installed using the Project Cost and no contract with the Acquirer bank should be made for revenue sharing model. However, MDR charges can be paid as per prevailing guidelines;

(ii) Advertising space or ATM space can be offered in the Tender Document itself to reduce the Bid Price after due analysis and diligence;

(iii) Only those Financial Institutions having necessary permissions by Reserve Bank of India for issue of new NCMC cards should be appointed as Acquirer under the contract;

(iv) There should not be any condition in the Tender Documents, which prohibits other Banks from issuance of NCMC cards in the Metro/RRTS premises;

(v) All NCMC cards should be accepted to achieve the objective of One Nation One card;

(vi) Nationalized Banks will be given space to sell the NCMC cards at Metro Stations free of cost for a period of one year from the date of launch of NCMC Cards. The size and area ,of space may be decided by metro/RRTS companies as per availability of space. In case of space constraints, it should be on first come first serve basis.

(vii) During top up of cards, full amount is to be credited. Transaction charges, if any, is to be borne by the Metro/RRTS Companies; and

(viii) Fee for issue of New Card shall not exceed Rs.50/- only as being charged in DMRC.

3. All the Metro/RRTs Companies are requested to take immediate appropriate action as per the directives mentioned above under intimation to this Ministry.

Yours faithfully,

3/X/23

(Yogesh Antil)
Director(MRTS-I)
Tele:011-23062782

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19	The Managing Director, Mumbai Metro One Pvt, Ltd., Metro Corporate Centre, Four Bungalows, Andheri(W), Mumbai - 400 053 E.Mail: shubhodoy.mukherjee@relianceada.com	20	The Managing Director, L&T Metro Rail (Hyderabad) Limited, Hyderabad Metro Rail Administrative Building, Uppal Main Road, Nagole Hyderabad – 500 039 E.Mail: kvb.reddy@ltmetro.com
21	The Managing Director, Andhra Pradesh Metro Rail Corporation Ltd (APMRC) Flat No.503, Vinayghar Apartments, Brindhavan colony, Labbipet, Vijayawada, Andhra Pradesh – 520 010. Email - apmetrorail@gmail.com	22	The Managing Director, Haryana Mass Rapid Transport Corporation Limited (HMRTC). C-3, HSVP Complex, Sector 6, Panchkula - 134109 Email - mdhmrtc@gmail.com

Chapter -13

Disabled Friendly Features



13.1 Introduction

13.2 Content

13.3 Rail Transport

13.4 Information Signs & Announcements

13.5 Metro Railway Stations

13.6 Information Systems

13.7 General and Accessible Toilets

13.8 Drinking Water Units

13.9 Visual Contrasts

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13.11 Alerting Systems

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13.16 Street Design

13.17 Traffic Signals

13.18 Subway & Foot Over Bridge

13.19 Alighting and Boarding Areas

13.20 Approach

13.21 Car Park



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, 2016. 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.

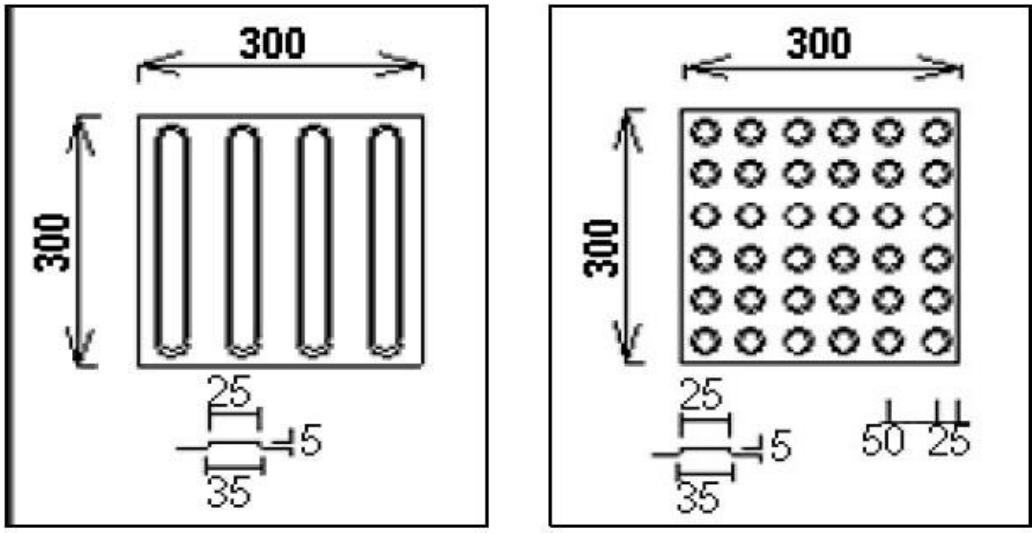


Fig. 13.3 - Guiding paver



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:
  - Critical Surfaces (walls, ceiling and floor),
  - Signage and background sign frame/ wall,
  - Step edges and risers/ treads on steps,
  - Handrails and background walls,
  - Doors and surrounding walls,
  - Switches/ sockets and background wall,
  - Toilet fixtures and critical surfaces in toilet.

- Barriers and hazards should be highlighted by incorporating colours and luminance contrast.

13.10 EMERGENCY EGRESS/EVACUATION

- Placement (accessibility) and visibility of such devices is very important. The following is to be considered for the installation of such alarm devices; fire alarm boxes, emergency call buttons and lit panels should be installed between heights of 800mm and 1000mm from the furnished floor surface. These should be adequately contrasted from the background wall and should be labelled with raised letters and should also be in Braille.

- A pre-recorded message, alerting an emergency to the control room or reception should be installed in the telephone and this should be accessible by a ‘hotkey’ on the phone keypad. This ‘hotkey’ should be distinct from the rest of the keypad.

13.11 ALERTING SYSTEMS

- In emergency situations, it is critical that people are quickly alerted to the situation at hand, for persons with disability the following needs to be considered.

- Consider having audible alarms with ‘voice instructions’ that can help guide them to the nearest emergency exit. As an alternative to the pre-recorded messages, these alarms may be connected to the central control room for on-the-spot broadcasts.

- Non-auditory alarms (visual or sensory) to alert persons with hearing

impairments should be installed at visible locations in all areas that the passengers may use (including toilet areas, etc).

Non-auditory alarms include:

- Flashing beacons
- Vibrating pillows and vibrating beds.
- Pagers or mobile phones that give out a vibrating alarm along with a flashing light (these may be issued to persons with vision or hearing impairments at the time of check-in or boarding the vehicle.)

13.12 WRITTEN EVACUATION PROCEDURE

A written evacuation procedure that details the egress plan for people with disability should be installed behind the entrance door in the accessible rest rooms. The evacuation procedure should be detailed in large print letters that contrast strongly against the background. Where possible, it should also incorporate raised letters and Braille. The evacuation route should be displayed on a high contrast tactile map for benefit of persons with vision impairments.

13.13 EMERGENCY EVACUATION ROUTE

- Designate routes that are at least 1200mm wide, to ensure that a person using a wheelchair and a non disabled person are able to pass each other along the route. The route should be free of any steps or sudden changes in level and should be kept free from obstacles such as furniture, coolers, AC units and flower pots.

- Use Exit signage along the route. Orientation and direction signs should be installed frequently along the evacuation route and these should preferably be internally illuminated. The exit door signage should also be internally illuminated.

- A ‘way guidance lighting system’ consisting of low mounted LED strips to outline the exit route (with frequent illuminated direction indicators along the route) should be installed along the entire length of the evacuation route. Way guidance systems allow persons with vision impairments to walk significantly faster than traditional overhead emergency lighting. Moreover, emergency exit lights in green color and directional signals mounted near the floor have been found to be useful for all people in cases where a lot of smoke is present.

13.14 WAY GUIDANCE SYSTEM

- Luminance on the floor should be 1lux minimum provided on along the centre line of the route and on stairs.
- Install clear illuminated sign above exit and also directional signage along the route.
- The directional exit signs with arrows indicating the way to the escape route

should be provided at a height of 500mm from the floor level on the wall and should be internally illuminated by electric light connected to corridor circuits.

13.15 FIRE RESISTANT DOORS

- Fire resistant doors and doors used along the emergency evacuation route are generally heavy and the force required to open these is much higher than 25 Newtons, making it difficult for people with disability to negotiate these doors independently. There are, however, magnetic and other types of door holders available that can be connected to fire alarms so that they will hold the doors open normally but will release the doors when the fire alarm is activated.

13.16 STREET DESIGN

(a) Footpath (Sidewalk)

Footpaths should be regarded as a transportation system which is connected and continuous, just like roadways and railways. They should not be sporadically placed where ever convenient, but instead should be provided consistently between all major attractions, trip generators, and other locations where people walk.

Footpath should:

- Be along the entire length of the road;
- Have height of a standard public step riser i.e. 150 mm maximum;
- Be at least 1800 mm wide;
- Have non-slip surface;
- Have tactile guiding paver for persons with visual impairments;
- Preferably have well defined edges of paths and routes by use of different colours and textures;
- Have no obstacles or projections along the pathway. If this is unavoidable, there should be clear headroom of at least 2200 mm from the floor level;
- The minimum 1.8m (width) x 2.2m (Height) Walking Zone should be clear of all obstructions – both horizontally and vertically.

Footpath should have:

- Have kerb ramps where ever a person is expected to walk into or off the pathway; and
- Have tactile warning paver installed next to all entry and exit points from the footpath.

(b) Kerb Ramp

- Kerb should be dropped, to be flush with walk way, at a gradient no greater than 1:10 on both sides of necessary and convenient crossing points. Width should not be less than 1200mm. If width (X) is less than 1200mm, then slope of the flared side shall not exceed 1:12.

- Floor tactile paving- Guiding & Warning paver shall be provided to guide persons with vision impairment so that a person with vision impairment does not accidentally walk onto the road.
- Finishes shall have non-slip surface with a texture traversable by a wheel chair.

(c) Road Intersections

- Pedestrian crossings should be equipped with traffic control signal.
- Traffic islands to reduce the length of the crossing are recommended for the safety of all road users.
- Warning pavers should be provided to indicate the position of pedestrian crossings for the benefit of people with visual impairments.
- Table tops (raised road level to the sidewalk height) are helpful in reducing the speed of traffic approaching the intersection

(d) Median/Pedestrian Refuge

Raised islands in crossings should:

- Cut through and level with the street; or
- Have kerb ramps on both the sides and have a level area of not less than 1500 mm long in the middle; and
- A coloured tactile marking strip at least 600 mm wide should mark the beginning and end of a median/ pedestrian refuge to guide pedestrian with visual impairments to its location.

13.17 TRAFFIC SIGNALS

- Pedestrian traffic lights should be provided with clearly audible signals for the benefit of pedestrians with visual impairments;
- Acoustic devices should be installed on a pole at the point of origin of crossing and not at the point of destination;
- The installation of two adjacent acoustic devices such as beepers is not recommended in order to avoid disorientation;
- The time interval allowed for crossing should be programmed according to the slowest crossing persons; and
- Acoustical signals encourage safer crossing behaviour among children as well.

13.20 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 APPROACHS

- 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 & Social Impact Assessment



14.1 Environment Impact Assessment

14.2 Project Description

14.3 Objectives of the EIA Study

14.4 Approach & Methodology

14.5 Policy, Legal and Administrative Framework

14.6 Description of the Environment

14.7 Anticipated Impacts and Mitigation Measures

14.8 Social Impact Assessment



CHAPTER - 14

ENVIRONMENT AND SOCIAL IMPACT ASSESSMENT

14.1 ENVIRONMENT IMPACT ASSESSMENT

This section deals with the Environmental Impact Assessment of proposed metro corridor from **from Gift City existing station to inside the Gift City at Ahmedabad**. The EIA study comprises of information on bio-physical and socio-cultural environment of the project influence area, as available in literature, gathered through stakeholders' consultations and through primary survey. Based on project particulars and the existing environmental conditions, potential impacts have been assessed on the bio-physical and socio-cultural environment. An environmental management plan has been suggested with cost estimates to mitigate the adverse impacts.

14.2 PROJECT DESCRIPTION

Delhi Metro Rail Corporation (DMRC) has been entrusted by the Gujarat Metro Rail Corporation (GMRC) Limited for preparation of Detailed Project Report of metro corridor from Gift City existing station to inside the Gift City at Ahmedabad. The proposed metro corridor will be developed in two phases. The Phase-I of the metro covers 3.331 km with 3 stations from GIFT City House to Shahpur and Phase-II of the metro covers 4.323 km with 3 stations from Shahpur to GIFT. Total length of the metro corridor is **7.654 km**. 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 this corridor and it is proposed to utilize Gyaspur Depot of Phase-I. The total alignment in this corridor will be elevated except the section near airport, which will be underground.

Station Location: The sequence of stations along with their respective Chainage is presented in **Table 14-1** and **Table 14-2** below:

Table 14-1 Proposed Metro Stations between GIFT City to Shahpur (Phase-I)

S. No.	Stations	Chainage (m)	Inter Station Distance (m)	Remarks
0	**GIFT City**			**Existing Station**
	Dead End	4982.685		
1	GIFT City House	5908.952	926.267	Elevated
2	Gujarat Biotechnology University	7132.675	1223.723	Elevated
3	Shahpur	7864.286	731.611	Elevated
	Dead End	8314.286	450.000	

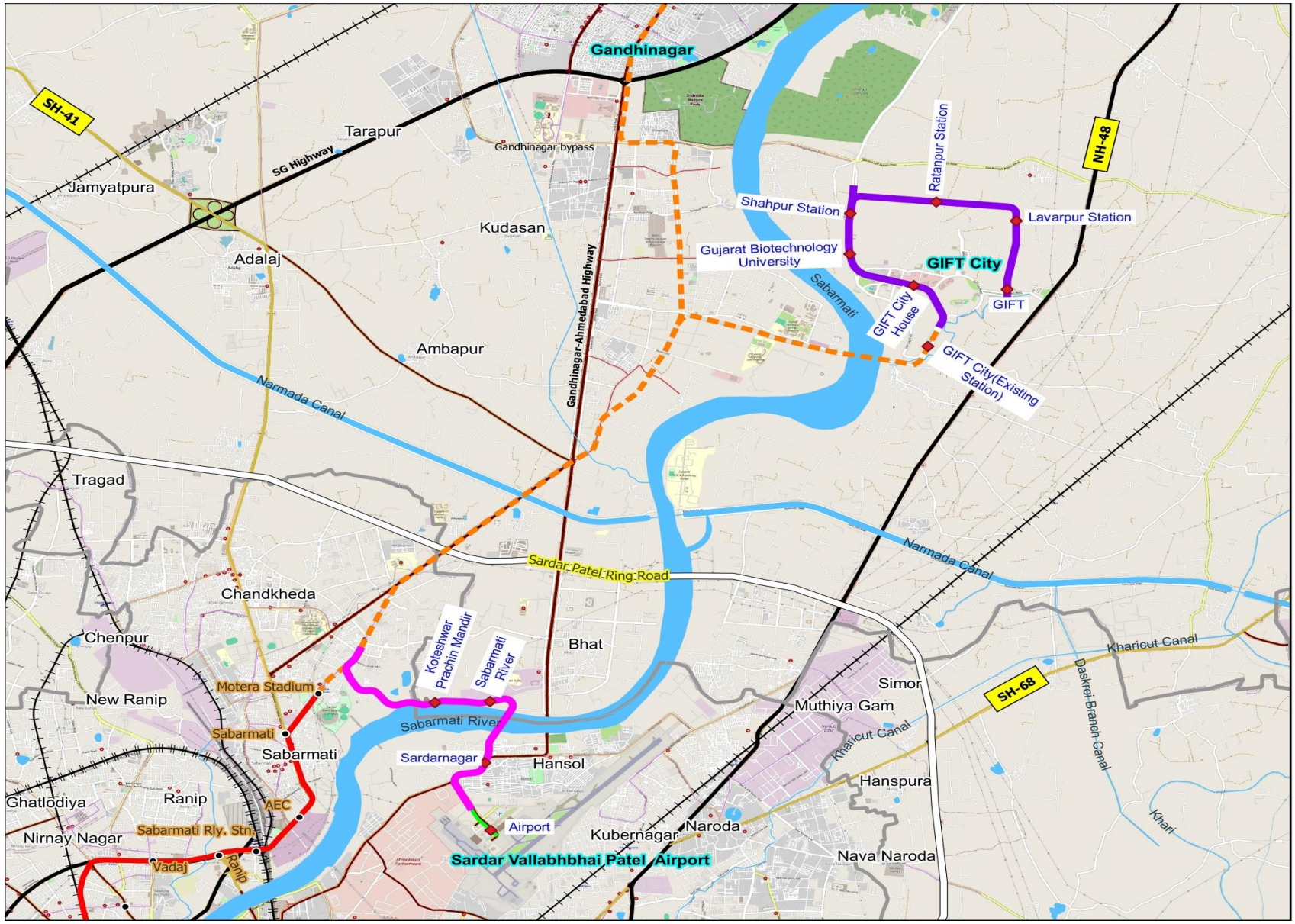


Figure 14.1 – Index Map Showing the Proposed Metro Corridor of Gift City

Table 14-2 Proposed Metro Stations between Shahpur to GIFT (Phase-II)

S. No.	Stations	Chainage (m)	Inter Station Distance (m)	Remarks
0	Shahpur	7864.286		Elevated
1	Ratanpur	9400.000	1535.714	Elevated
2	Lavarpur	10820.000	1420.000	Elevated
3	GIFT	12071.000	1251.000	Elevated
	Dead End	12187.417	116.417	



Photographs of the Proposed Metro Corridor

14.3 OBJECTIVES OF THE EIA STUDY

The objective of the EIA study was to establish present environmental conditions along the project corridor through available data / information supported by field studies / environmental monitoring, to predict the impacts on relevant environmental attributes due to the construction & operation of the proposed project; to recommend adequate mitigation measures to avoid/ minimize / compensate adverse impacts and suggest mitigation measures to make the project environmentally sound and sustainable.

Environmental Impact Assessment has been carried out in accordance with the Government of India Guidelines and as per the requirement of DMRC.

14.4 APPROACH & METHODOLOGY

- **Reconnaissance Survey:** A reconnaissance survey has been conducted by the environmental specialists along the project corridor. Location of protected areas (National Parks, Wildlife Sanctuaries, Conservation Reserves), Forests, Archeological Monuments etc. surface water bodies; environmental sensitive receptors (educational institutions, religious structures, medical facilities etc.) along the alignment were identified. Locations for environmental monitoring / sampling were also identified at this stage.
- **Secondary Data Collection & Review:** Secondary data such as Survey of India Toposheets, Forest Working Plans, booklet of Central Ground Water Board, details of Archaeological Monuments etc. have been collected from various secondary sources. Further, secondary data, which are relevant to understand the baseline as pertaining to physical and biological environments has been collected and reviewed.
- **Baseline Environmental Monitoring:** The secondary data collected has been appropriately supplemented by generating primary data through field study and monitoring. The field monitoring for Ambient Air Quality, Ambient Noise Level, Surface Water Quality, Ground Water Quality and Soil Quality will be carried out in October 2023 (Post-monsoon Season) as per the guidelines of CPCB & BIS and requirement of the MoEFCC by NABL Accredited laboratory.
- **Prediction of Impacts & Mitigation Measures:** Potential positive and negative impacts on land environment, air environment, noise, water environment and biological environment has been assessed for construction and operation phase. Mitigation measures have been suggested to reduce potentially significant adverse environmental impacts to acceptable levels.
- **Environment Management Plan:** The EMP envisages the plans for the proper implementation of mitigation measures to reduce the adverse impacts arising due to the project activities. Institutional set up for implementation of the EMP including institutional strengthening and training has been recommended. Environmental Monitoring Program during construction and operation phase has been suggested and the expenditures for environmental protection measures and budget for implementation of the EMP have been provided.

14.5 POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

14.5.1 Constitutional Provisions

The Constitution of India, in Article 48, of Directive Principles of the State, states that “the state shall endeavor to protect and improve the environment and to safeguard forests and wildlife of the country”. Further Article 51-A (g), of fundamental duties, emphasizes that, “It shall be the duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures”. These two provisions of the constitution are the guiding principles for the environmental legislations in India.

14.5.2 Applicable Environmental Legislations

The development of proposed metro corridor is associated with various adverse environmental impacts. Construction and operational activities of project fall under

the preview of various environmental regulations promulgated from time to time by Government of India and State Government. The Environmental Acts, Rules, Notification and Amendments applicable to the project include the following:

- Environment (Protection) Act and Rules, 1986
- EIA Notification, 14th September 2006 and its subsequent amendment
- Air (Prevention & Control of Pollution) Act, 1981
- Water (Prevention & Control of Pollution) Act, 1974
- Forest (Conservation) Act, 1980 and its amendments
- Forest (Conservation) Rules, 2022 (Published on 28.06.2022)
- Wildlife (Protection) Act, 1972
- Wildlife (Protection) Amendment Act, 2002, 2006
- Solid Waste Management Rules, 2016 and amendments
- Construction and Demolition Waste Management Rules, 2016
- The Hazardous and Other Waste (Management and Transboundary Movement) Rules, 2016
- Disposal of Fly Ash Notification 2009 and its amendments on 25th January 2016
- MoEFCC Office Memorandum (File No. 22-13/2019-IA.III) dated 28th August 2019 regarding Fly Ash Notification and subsequent amendments
- IS Codes & CPCB Guidelines for monitoring & analysis of air, water, soil etc.
- National Ambient Air Quality Standards, 16th November 2009
- Noise Pollution (Regulation & Control) Rules, 2003 and its amendments
- Ancient Monuments and Archaeological Sites and Remains (Amendment and Validation) Act, 2010
- Any of the applicable Acts. Rules and Guidelines (as applicable)

14.5.3 Clearances Required

a) Environment Clearance

As per the Environmental Impact Assessment (EIA) Notification, 14th September 2006 and its subsequent amendments, Rail based mass rapid transport system is not listed in the “SCHEDULE” appended to the EIA Notification which provides a detailed list of projects requiring prior Environmental Clearance from MoEFCC. Therefore, development of this metro corridor does not come under the purview of EIA Notification 2006 and **environmental clearance is not required** for the proposed development.

b) Forest Clearance

The alignment of the proposed metro corridor is not passing through any forest area. Therefore, as per Forest Conservation Act, 1980 and its subsequent amendments thereafter, **forest clearance is not required**. However, tree felling permission is to be taken from the competent authority.

c) Wildlife Clearance

The project is not passing through any Protected Areas and their Eco-sesintive zone. **Wildlife clearance is not required** for the project.

d) Clearances to be obtained by the Contractor

Apart from the clearances for the overall project work, the contractor, before starting the construction work, has to obtain required Clearances / NOCs listed in **Table 14-3** for operating his equipment and carrying out construction work.

Table 14-3 Clearances required to be obtained by the Contractor

S. No.	Type of Clearance Required	Statutory Authority	Statute under which Clearance is Required
1.	Consent for Establishment of Casting yard, Batching Plant etc.	• Gujarat Pollution Control Board (GPCB)	• Air (Prevention and Control of Pollution) Act, 1981 • Water (Prevention and Control of Pollution) Act, 1974 • The Noise Pollution (Regulation and Control) Rules, 2000
2.	Consent for Operation of Casting Yard, Batching Plant etc.		
3.	Permission for withdrawal of groundwater for construction	▪ Central Ground Water Authority, ▪ State Ground Water Board	• Environment (Protection) Act, 1986 • Ground Water Rules, 2002
4.	Permission for extraction of sand from river bed	• Department of Mines & Geology, Government of Gujarat	• Environment (Protection) Act, 1986
5.	Opening of New Borrow Areas / Quarry	• GPCB • District Collector	• Environment (Protection) Act, 1986 • Air (Prevention and Control of Pollution) Act, 1981 • Minor Mineral and Concession Rules, 2015
6.	New Quarry and its operation (if any)	• Department of Mines & Geology, Government of Gujarat • District Level Environment Impact Assessment Authority (DEIAA)	• Environment (Protection) Act, 1986 • The Mines Act. 1952 • Mines and Minerals (Development and Regulation) Amendment Act, 2015 • The Explosive Act, 1884 • Air (Prevention and Control of Pollution) Act, 1981 • Water (Prevention and Control of Pollution) Act, 1974
7.	Location and layout of workers camp, & equipment and storage yards	• Gujarat Pollution Control Board	• Environment (Protection) Act, 1986; • Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016
8.	Discharges from labour camp	• Gujarat Pollution Control Board	• Water (Prevention and Control of Pollution) Act, 1974
9.	Storage, handling and transport of hazardous materials	• Gujarat Pollution Control Board	• Hazardous and Other Waste (Management and Trans-boundary Movement) Rules, 2016

S. No.	Type of Clearance Required	Statutory Authority	Statute under which Clearance is Required
10.	PUC Certificate for all construction vehicles and all machineries	• Transport Department of Govt. of Gujarat	• The Motor Vehicle Act 1988 • The Motor Vehicles (Amendment) Bill, 2015 • The Central Motor Vehicles Rules, 1989
11.	Installation of DG Set (Consent to Establish)	• Gujarat Pollution Control Board	• Air (Prevention and Control of Pollution) Act, 1981 • The Noise Pollution (Regulation and Control) Rules, 2000
12.	Operation of DG Set (Consent to Operate)		
13.	Engagement of Labour Labour License	• Labour Commissioner (Ministry of Labour and Employment)	• The Building and Other Construction workers (Regulation of Employment and Conditions of Service) Act 1996 • Contract Labour (Regulation and Abolition) Act 1970 along with Rules, 1971
14.	Engagement of Labour Social Security Labour Welfare Wages	• Labour Commissioner (Ministry of Labour and Employment)	• The Employees' Provident Fund & Miscellaneous Provisions (Amendment) Act, 1996 • The Personal Injuries (Compensation Insurance) Act, 1963 • The Inter-State Migrant Workmen (Regulation of Employment and Conditions of Service) Act, 1979 • Equal Remuneration Act, 1976 • The Payment of Wages (Amendment) Act, 2005 • The Minimum Wages Act, 1948 • The Minimum Wages (Central) Rules, 1950

14.6 DESCRIPTION OF THE ENVIRONMENT

14.6.1 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. The proposed metro alignment is located in the Ahmedabad city which is in flat terrain.

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.

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:

Table 14-4 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

Age	Formation	Thickness (m)	Lithology
			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 intertrappean beds.		

14.6.2 Seismicity

As per Seismic Map of India (as per IS: 1893, Part I, 2002); the proposed metro alignment is situated in the **Zone III** (having moderate seismic intensity) and has a moderate risk of potential damage due to earthquake.

14.6.3 Drainage

River Sabarmati is the principal river of the study area. 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. 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.

14.6.4 Climate & Meteorology

The climate of the district is characterised 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.

Past meteorological data of IMD Observatory at Ahmedabad which is deemed to be representative for the study area has been collected for the period of 1981-2010 to establish the baseline climatic conditions of the study area. The key parameters of collected meteorological data have been summarized in **Table 14-5**.

Table 14-5 Summaries of Climatological Data (Year 1981-2010)

Parameter	IST	IMD Ahmedabad	
		Monthly Range	Annual Mean/Total
Mean Daily Maximum Temperature (°C)		28.1 (Jan) – 41.6 (May)	34.4
Mean Daily Minimum Temperature (°C)		12.4 (Jan) – 27.5 (Jun)	21.0
Relative Humidity (%)	0830	50 (Mar) – 87 (Aug)	67
	1730	20 (Apr) – 72 (Aug)	41
Total Rainfall (mm)		0.6 (Mar) – 291.2 (Jul)	750.9
Wind Speed (km/h)		4.7 (Nov) – 12.3 (Jun)	7.8

Source: Climatological Data of Ahmedabad, Indian Meteorological Department (1981-2010)

Temperature: Past climatic data show that May is the hottest month with the mean daily maximum temperature 41.6°C. January is recorded to be the coldest month with the mean daily minimum temperature 12.4°C. Due to rapid urbanization, industrialization and climate change, the State faced heat wave in every year with high intensity and frequent episodes. In May 2010, Ahmedabad faced a deadly heat wave with peak temperatures of over 46°C causing a spike in illness and death.

Rainfall & Relative Humidity: The average monthly rainfall, number of rainy days, mean wind speed and relative humidity at Ahmedabad is provided in **Table 14-6** and shown in **Figure 14.2**.

Table 14-6 Monthly Rainfall, Wind Speed and Relative Humidity (IMD Ahmedabad)

Months	Monthly Rainfall (mm)	No of Rainy Days	Mean Wind Speed (kmph)	Relative Humidity (%)	
				0830 Hours	1730 Hours
January	1.0	0.1	6.2	63	35
February	0.8	0.1	6.4	56	26
March	0.6	0.0	7.1	50	21
April	2.4	0.4	8.3	56	20
May	7.0	0.6	11.3	65	25
June	80.0	3.9	12.3	74	44
July	291.2	11.5	10.7	85	69
August	266.2	10.7	9.1	87	72
September	86.8	5.0	7.4	82	60
October	11.7	0.8	4.8	65	41
November	2.3	0.4	4.7	57	36
December	1.0	0.2	5.4	61	37
Total	**751.0**	**33.7**	**7.8**	**67**	**41**

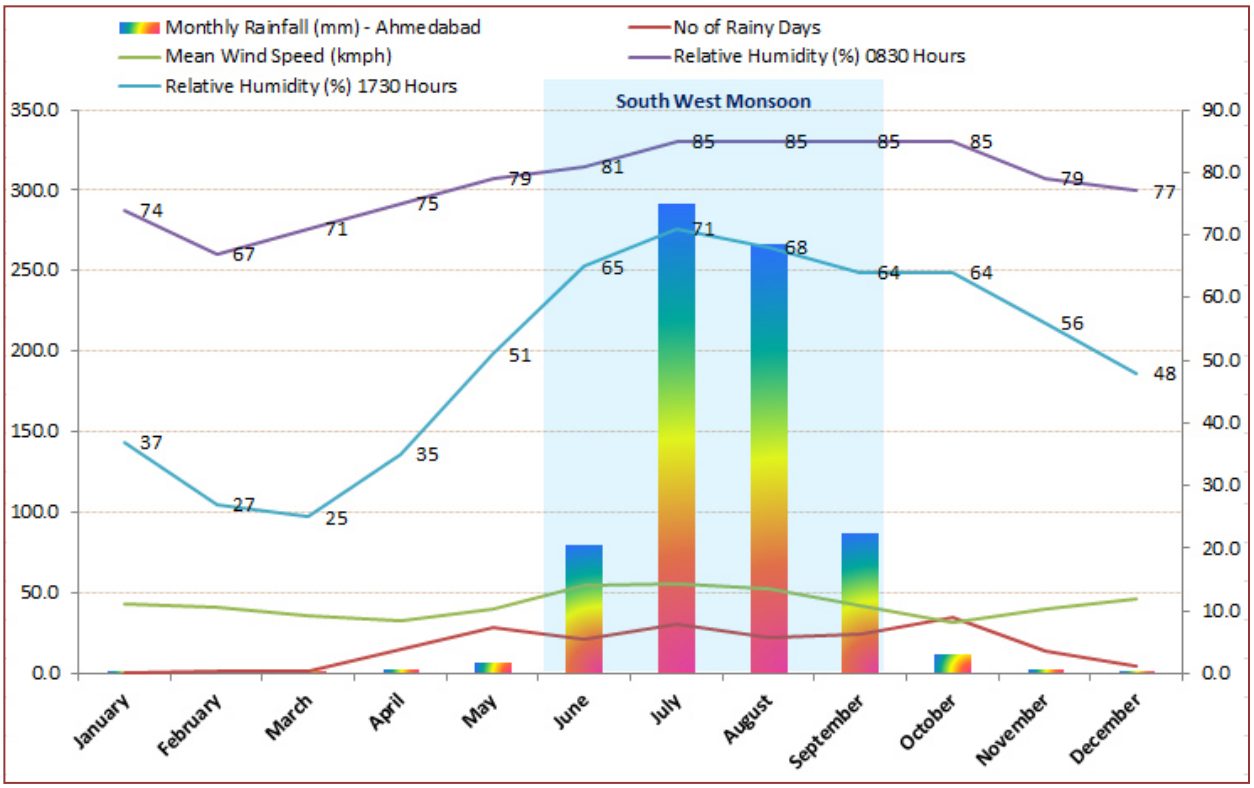


Figure 14.2 Monthly Rainfall, Rainy Days, Wind Speed and Relative Humidity of Ahmedabad IMD

The annual mean rainfall in the study area is 750.9 mm during the year 1981 to 2010. Historical data shows that heavy rains occur in the month of July due to SW monsoon. The southwest monsoon contributes around 96.5 percent of the annual rainfall. The northeast monsoon yields around 3.2 percent rainfall and the balance of around 0.3 percent results from the pre-monsoon and winter shower.

14.6.5 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).

14.6.6 Groundwater Quality as per Secondary Source

Central Ground Water Board, Ahmedabad has monitored water samples collected during May 2019, for basic parameters determining pH, EC, TDS, CO3, HCO3, Cl, NO3, SO4, F, Ca, Mg, TH, Alkalinity, Na, K, SAR and heavy metals. Maximum range distribution of few parameters observed during analysis is presented in **Table 14-7** and **Table 14-8.**

Table 14-7 Ground Water Analysis Results (May 2019)

District	EC in µmhos/ cm		Cl in mg/l		NO_3 in mg/l		F in mg/l	
	Max	Min	Max	Min	Max	Min	Max	Min
Ahmedabad	20,980	679	6000	50	**1058**	2.12	5.00	0.52
Permissible Limit as per IS 10500:2012	-		1,000		45		1.5	

Source: Groundwater Year Book 2019-20, Gujarat State, Regional Office Data Centre, CGWB, West Central Region, Ahmedabad, March – 2021

Table 14-8 Ground Water Analysis Results (May 2019)

District	CR in ppm		Fe in ppm		Mn in ppm		Cu in ppm		Zn in ppm	
	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
Ahmedabad	0.012	0.000	0.135	0.006	0.286	0.001	0.010	0.000	0.288	0.009
Permissible Limit as per IS 10500:2012	0.05		0.3		0.3		0.05		15	

Source: Groundwater Year Book 2019-20, Gujarat State, Regional Office Data Centre, CGWB, West Central Region, Ahmedabad, March – 2021

14.6.7 Ground Water Category

As per "Dynamic Ground Water Resource Estimation-2013", the assessment units (talukas) are divided into different categories adopting criteria such as stage of ground water development, significant long term water level decline trend during pre-monsoon and post-monsoon etc. As per the CGWA classification, ground water category of the Talukas through which the proposed metro alignment is passing is **semi critical** and **over exploited** Taluka wise classification is presented in **Table 14-9.**

Table 14-9 Classification of Ground Water based on the CGWA Classification

List of Non-Notified Areas		
S. No	**Sub District**	**Area Type Category**
State: Gujarat [1]		
District: AHMEDABAD		
1	Daskroi	Semi Critical
District: GANDHINAGAR		
1	Gandhinagar	Over Exploited

Source: http://cgwa-noc.gov.in/Sub/Report/AreaType/AreaType.aspx

14.6.8 Ecological Environment

Flora – The major species found in the study area among trees are Azadirachta indica, Mangifera indica, Acacia Arabica, Prosopis juliflora, Tectona grandis. Shrubs include Capparis sepiaria, Zizyphus Mauritiana. Herbaceous flora is Calotropis procera, Withania somnifera, Achyranthes aspera, Tridax. Main grasses are Cenchrus ciliaris, Aristida, Eragrostis, Saccharum spontaneum, Diehanthium, Cynodon dactylon etc.

Trees within Metro Corridor: Tree survey was carried out 5 m on either side of the centerline along the proposed alignment. Tree with Girth at Breast Height (GBH) 30 cm have been counted. A total of **195 trees** are located along the alignment including station area which are likely to be felled. Girth wise details of trees are given in **Table 14-10**.

Table 14-10 Details of Tree Enumeration along the Metro Corridor

Sl. No.	Name of Tree		Girth Class (cm)						
	Local Name	Scientific Name	0-30	31-60	61-90	91-120	121-150	> 150	Total
1	Aam	Mangifera indica	0	0	2	0	1	0	3
2	Babul	Acacia nilotica	15	24	31	0	5	0	75
3	Bordi	ZiZyphus nummularia	0	14	5	0	1	0	20
4	Foxtail palm	Wodyetia bifurcata	0	62	0	0	0	0	62
5	Khijado	Prosopis cineraria	0	0	0	0	9	0	9
6	Neem	Azadirachta indica	0	10	8	0	0	8	26
	Total		**15**	**110**	**46**	**0**	**16**	**8**	**195**

Source: Tree enumeration carriedout by ICT Pvt. Ltd.

Fauna - The fauna of study area are mainly comprises of Jungle Cat, Fox, Monkey, Common Mongoose, Peacock, Owl, King Fisher, Dove, Black Drongo, Pigeon, Indian Cobra, Branded Krait, and Garden Lizard etc.

Avifauna - Due to proximity to rivers, many birds species are observed near to the project area. Some of the species are Great Cormorant (Phalacrocorax carbo), Little Cormorant (P niger), Oriental Darter (Anhinga malanogastor), Indian Pond Heron (Ardeola grayil), Cattle Egret (Bubulcus ibis) , Western Reef Egret (Egretta gularis), Little Egret (E. garzetta) etc.

Protected Areas - The metro corridor does not pass through any Protected Areas (National Parks, Wildlife Sanctuaries or Conservation Reserves).

14.6.9 Sensitive Receptors

There are 10 sensitive receptors along the proposed metro corridor (Koteshwar Road to Airport), out of which, 2 are educational institutions and remaining 8 are religious places. Chainage wise list of sensitive receptors along with distance from the proposed center line of the metro route is given in **Table 14-11**.

Table 14-11 List of Sensitive Receptors along the Metro Corridor

S. N.	Name	Type	Distance* (m)	Side
1	Goga Maharaj temple	Educational	20	LHS
2	Aganvadi Kendra	Educational	21	LHS
3	Gujarat Biotechnology University	Religious	45	RHS

Source: Field survey carriedout by ICT Pvt. Ltd





View of Sensitive Receptors along Gift City Metro Corridor

14.6.10 Socio-cultural Environment

The proposed metro alignment in Ahmedabad city is not passing through or near any historical or archaeological monument or heritage site.

14.7 ANTICIPATED IMPACTS AND MITIGATION MEASURES

A summary of the potential environmental impacts during construction and operation phases along with recommended mitigation measures is summarized in **Table 14-12**.

Table 14-12 Summary of Anticipated Impacts and Recommended Mitigation Measures

Area	Impacts	Mitigation Measures
Construction Phase		
Topography and geology	• Entire alignment is elevated, alignment on flat terrain, hence insignificant impact	• The materials shall be procured from nearest available source • Borrow pits will be allowed at only pre-

Area	Impacts	Mitigation Measures
	• Disturbance on geological setting due to quarrying • Borrow pits resulting in water accumulation & breeding of vector disease.	identified locations. • Borrow pits will be restricted to 1 m depth followed by resurfacing of pits. • The materials will be procured from approved and licensed quarries. • Suitable seismic design of the structures will be adopted to mitigate the earthquake impacts. • Stabilization measures for slope shall be as per recommendation of Geotechnical investigation report.
Soil	• Disruption & loss of productive top soil from agricultural fields due to borrow pits • Loosening of top soil & loss of vegetative cover along the metro corridor due to excavation & back filling which will lead to enhanced soil erosion. • Run off from unprotected excavated areas can result in excessive soil erosion.	• 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 • Top soils (15 cm) will be conserved and used for plantation. • Accidental spills of lubricants/oil will be avoided by adherence to good practices. • Restrict site clearing within ROW. • Careful planning, timing of cut and fill operations and re-vegetation shall be done to minimize soil erosion. • Construction works leading to soil erosion will be stopped during monsoon • If any additional muck is generated, which can not be utilized, contractor has to identify muck dumping sites and prepare muck disposal plan duly approved by Supervision Consultant and DMRC.
Land use	• No major change in land use as mostly elevated following the existing road median. Minor changes in existing land use pattern at stations area etc. • Generation of solid waste/construction waste in the form of construction spoils from construction sites.	• Earth material generated during construction will be reused. • Construction debris will be disposed of in suitable pre-identified disposal sites as per Construction • Construction camp will be provided to avoid indiscriminate settlement of construction workers.

Area	Impacts	Mitigation Measures
Air quality	• Deterioration of air quality due to fugitive dusts emission from construction activities and vehicular movement • Deterioration of air quality due to gaseous emissions from construction equipment & vehicular traffic. • Deterioration of air quality due to emission from Batching plant and Casting yard	• Regular maintenance of machinery and equipment. • Contractor to submit PUC certificates for all vehicles / equipment / machinery used for the project and maintain a record of the same during the contract period. • Batching plant, hot mix plant and casting yards at downwind (1km) direction from the nearest settlement. • These plants shall be used after obtaining Consent To Establish & Consent To Operate from GPCB • Only Crushers licensed by the GPCB shall be used • Hot mix plant should be fitted with dust extraction unit and must have at-least 6 m stack height for the discharge of its scrubbed flue gases. • Crusher Plant should have a combination of dry and wet type control system to minimize the impact on air quality. • DG sets with stacks of adequate height and use of low sulphur diesel as fuel. • LPG should be used as fuel source in construction camps instead of wood. • Contractor to prepare traffic management and dust suppression plan duly approved by the Supervision Consultant
Noise level	• Increase in noise level due to construction activities like operation of construction equipment & vehicular traffic.	• All equipment to be timely serviced and properly maintained. • Construction equipment and machinery to be fitted with silencers and maintained properly. • Only IS approved equipment shall be used for construction activities. • Near educational institution, noisy construction activities shall be carried out after closing of the institute and in the weekends / holidays only. • Manage smooth traffic flow to avoid traffic jams and honking. • Honking restrictions near sensitive areas. • Noise limits from construction activity shall not exceed 85-90 dB(A) at a distance of 11 m from its source. • Provide PPEs to workers. • Conduct Noise monitoring as per Environmental Monitoring Program.
Vibration	• Generated from construction	• This would be a short-term activity and

Area	Impacts	Mitigation Measures
	machinery which may lead to potential annoyance or interference with vibration sensitive activities.	effort will be made to avoid piling operations during night between 11.00 pm to 5.00 am in the vicinity of residential areas. • Use of low vibration generating construction equipments, • Mounting of under frame equipments on anti-vibration pad, • Staggering of construction activities at site.
Water use	• Impact on the local water sources due to use of construction water.	• 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 • Approval will be taken from State / Central Ground Water Board in case ground water is extracted for the project
Water quality	• Increase of sediment load in the run off from construction sites and increase in turbidity in receiving streams/water bodies. • Water pollution due to sewage from construction camps.	• Silt fencing will be provided near water bodies to reduce sediment load. • Oil interceptor to stop and separate the floating oils. • Proper sanitation facilities will be provided in construction camp to prevent health related problems. • Muck shall not be allowed to confluence with any water course. Controlled water should be used for curing as per environmental monitoring program.
Flora & Fauna	• Felling of **195 trees** along the metro route • Disturbance to nesting of birds	• Trees to be removed only after approval of competent authority. • Tree falling outside construction zone will be saved. • 10 times of the trees cut shall be planted on the available space of the metro corridor and station areas

Area	Impacts	Mitigation Measures
		• Maintenance of plantation shall be done for 5 years. • Provision of LPG in construction camp as fuel source to avoid tree cutting. • Incidence of wildlife roaming in the areas may be reported to Forest Department, if any.
Construction camp	• Influx of construction work-force & suppliers who are likely to construct temporary tents in the vicinity. • Likely sanitation & health hazards & other impacts on the surrounding environment due to inflow of construction labourers.	• Construction camp shall be located 500m away habitation from 200m away from water bodies. No camps will be located inside river bed. • Construction camps with adequate potable water supply, sanitation & primary health facilities and fuel for cooking will be provided to accommodate construction workers. • It will be ensured that the construction workers are provided fuel for cooking to avoid cutting of trees from the adjoining areas. • Domestic as well as the sanitary wastes from construction camps will be managed as per Solid Waste Management Rules, 2016. • Land taken for construction camp and other temporary facility should be restored to its original conditions after completion of work.
Occupational health & safety	• Health & safety related problems to construction workers due to inadequate health & safety measures.	• Adequate safety measures complying to the occupational safety manuals will be adopted to prevent accidents/hazards to the construction workers • Periodic health check-up of construction workers will be done. • PPE to be provided to labors.
Road safety	• Increase on incidence of road accidents due to disruptions caused in existing traffic movements during construction of metro line.	• Proper traffic diversion and management will be ensured during construction at the interactions and construction areas. • Use of adequate signage to ensure traffic management and safety
Operation Phase		
Land use and Encroachment	• Change of land use by squatter/ encroachment within ROW and induced development outside the ROW.	• Planning agencies and Collector/ Revenue Officer will be made involved for controlled development and prohibiting squatter/ encroachment within ROW.
Water Supply and Sanitation	• Increased water demand for drinking, toilets, cleaning and	• Arrangement of water will have to be made at each station separately without affecting

Area	Impacts	Mitigation Measures
	also for other purpose like air conditioning.	the demand of existing wusers. The water demand may be met through purpose-built tube wells after due permission from CGWA. • All urinals in toilets will have automatic flushing through sensing devices. Flushing WC proposed to be low water consumption type.
Air quality	• Minor air pollution due to vehicular emission from increased road traffic and congestion.	• Adequate parking and traffic circulation at station locations to facilitate smooth traffic flow. • Monitoring of air quality at specified locations will be conducted.
Noise level	• Noise pollution due to operational equipment and at parking areas	• Monitoring of noise level at specified representative locations will be conducted. • Adequate plantation with suitable species in available space will result in partial noise attenuation.
Vibration	• 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 • 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
Waste management	• Increased waste generation due to operation of stations • Change of lubricants, cleaning and repair processes, in the maintenance and workshop for maintenance of rolling stock can lead to Oil spillage leading to Oil Pollution.	• Adequate number of colored bins (green and blue) separate for bio-degradable and non-biodegradable are proposed to be provided at the strategic locations within the stations. • Solid waste shall be handed over to authorities for final disposl as per Solid Waste Management Rules 2016 • Hazardous waste may be stored at designated areas by obtaining authorization from concerned authority and handed over to authorised recyclers

14.7.1 Environmental Management Plan

EMP has been prepared addressing the following issues:

a) Stage wise (pre-construction stage, construction stage & operation stage) environmental management measures;

b) Environmental Monitoring Program during construction and operation phase including performance indicator, monitoring schedule (parameters, locations, frequency of monitoring & institutional responsibility) and reporting system;

c) Institutional set up identified for implementation of the EMP including institutional capacity building

d) Budget for implementation of EMP

Environment Monitoring Program: For each of the environmental condition indicator, the monitoring program specifies:

- Parameters to be monitored
- Location of the monitoring sites
- Frequency and duration of monitoring
- Institutional responsibilities for implementation and supervision
- Detailed Environmental Monitoring Program is provided in EIA report.

Institutional Arrangement: Gujarat Metro Rail Corporation (GMRC) is responsible for implementation of all the mitigation and management measures suggested in EMP through Contractor and also make sure that the statutory requirements are not violated during the pre-construction, construction and operation stages of the project.

Environmental Budget: The budgetary provision for the implementation of the environmental management plan of the metro corridor can be categorized in to two types and is presented below:

- Activities of the Environmental Management Plan to be implemented by the Contractor under civil works contracts
- Activities of the Environmental Management Plan to be implemented by the Project Proponent

A capital cost provision of about **Rs. 3.88 Crore** has been kept towards implementation of environmental management plan. A summary of the environmental budget is presented in **Table 14-13**.

Table 14-13 Summary of Environmental Budget

S. No.	Description of items	To be implemented by	Amount (Rs.)
A.	Mitigation Cost including Compensatory Tree Plantation	Contractor	3,35,33,000
B.	Environmental Monitoring during Construction & Operation Phases		30,34,000
C.	Enhancement Measures		20,00,000
		Subtotal (A+B+C)	**3,85,67,000**
D.	Training & mobilization of DMRC staff and Contractor staff	Project Proponent	2,50,000
		Subtotal D	**2,50,000**
		Grand Total (A+B+C+D)	**3,88,17,000**
			Rs. 3.88 Cr.

Note: * 1) Construction period is assumed to be 4 years
2) Monitoring in Operation Phase is assumed to be conducted every 3 years for 15 years.
3) Any other statutory fees such as NOCs (under Air, Water Act etc.) are not included in this EMP budget."

14.8 SOCIAL IMPACT ASSESSMENT

The intensity of traffic on Indian roads in general and particularly in Indian cities has increased into manifolds, thus, rendering inadequate existing road capacity to contain the increased volume of traffic. To cope up with this challenge the Gujarat Metro Rail Corporation (GMRC), a Government of Gujarat Undertaking has assigned Delhi Metro Rail Corporation (DMRC) to take up the development a metro connectivity to Gift City existing station to inside the Gift City at Ahmedabad.

The Phase-I of the metro covers 3.331 km with 3 stations from GIFT City House to Shahpur and Phase-II of the metro covers 4.323 km with 3 stations from Shahpur to GIFT City.

Keeping in view, the importance of the proposed Metro line which will provide people's friendly urban transport for an emerging and aspirational Ahmedabad and also spur economic activities and accelerate expansion of urban city cluster to improve the lives of local people, Intercontinental Consultants and Technocrats Pvt. Ltd. (ICT) have been appointed as Consultants by Delhi Metro Rail Corporation Limited (DMRC) to carry out Environment Impact Assessment (EIA) and Social Impact Assessment (SIA) study as part of the preparation of DPR for proposed metro connectivity to Gift city at Ahmedabad.

The study of social impact assessment is meant to determine the magnitude of actual and potential impact on the population due to construction of proposed Metro line at Gift City. This study is to determine the major social impact issues, identify the potential hotspots and define the magnitude of actual and potential impacts. The present exercise will explore the impact on the population as well as on the properties.

It needs to be mentioned that the present report considered only those persons as affected persons (APs), whose structures, lands and livelihood are to be affected due to the construction of the Metro line.

14.8.1 Need for Social Impact Assessment

The loss of private assets resulting in loss of income and displacement makes social impact assessment an important input in project design while initiating and implementing developmental interventions. An understanding of the issues related to social, economic and cultural factors of the affected people is critical in the formulation of an appropriate rehabilitation plan. A detailed social impact assessment (SIA), therefore, needs to be carried out to make project design responsive to social development concerns. SIA also helps in enhancing the project benefits to poor and vulnerable people while minimizing or mitigating concerns, risks and adverse impacts

14.8.2 Objective of the Study

The main objective of the study is to ensure that the project addresses the adverse impacts on the livelihood of the people and that nobody is left worse off after implementing resettlement plan and those affected have access to project benefits, during project construction as well as operation stage.

The report aims to highlight the social problems and suggests general and typical mitigation measures to alleviate social problems of the project-affected people such as loss of livelihood, displacement and loss of access to community facilities through development of metro corridor and other facilities. The specific objectives of the SIA are as follows

- To carry out a socio-economic, cultural and political/institutional analysis to identify the project stakeholders and social issues associated with the project;
- To assess the extent of asset loss and undertake the census of potential project affected people;
- To document people perceptions through stakeholder's consultation as part of participatory planning for proposing a proper mitigation plan and minimizing the impacts.

14.8.3 Scope of the Study

The study began with the identification of social issues and stakeholders and communities, including socially and economically disadvantaged communities. The focus of SIA is on identifying local population likely to be affected by the project either directly or indirectly and undertake census survey. The scope of the study in particular included the following:

- Identifying key social issues associated with the proposed project and specifies the project's social development outcomes;
- Assessing potential social and economic impacts both during the construction phase and in the operation phase;
- Social screening of various project components and likely impacts in terms of land taking (loss of houses, livelihood, etc.), and resultant involuntary resettlement and provide inputs (in terms of magnitude of impacts and likely costs for mitigation) in preparing appropriate mitigation plans;
- Based on the assessment of potential social and economic impacts establish criteria that will assist in the formulation of strategies; to the extent possible maximize project benefits to the local population and minimize adverse impacts of the project interventions on the affected communities;
- Inform, consult and carry out dialogues with the project stakeholders on matters relating to project design, objectives, and implementation and provide specific recommendations to avoid/minimize high social risks;
- Identify likely loss of community assets (e.g. school, community assets) including the religious structures and common property resources (e.g. forest, grazing land) the impacts of their loss on the local population;

14.8.4 Methodology

In accordance with the scope of services of the Delhi Metro Rail Corporation (DMRC) has been entrusted by the Gujarat Metro Rail Corporation (GMRC), the Consultants will carry out SIA study of the proposed metro corridor covers 3.331 km with 3 stations from GIFT City House to Shahpur and Phase-II of the metro covers 4.323 km with 3 stations from Shahpur to GIFT.

Approach and methodology mainly consist of quantitative and qualitative tools and techniques. The tasks to be undertaken for the study are as indicated below

14.8.4.1 Collection and Review of Project Literature and Legal Policy Provisions

This phase intends to familiarize with the concerned and important stakeholders to identify and collect the available literature and to scope the activities. This involved following activities:

a. Discussions with Project Implementing authorities and other concerned
b. Collection of available relevant project literature. Consultations were held with concerned revenue officials to establish the ownership of land. Literature review and consultations formed the basis for identification of key.
c. Relevant national and state legislation and regulations were reviewed.

14.8.4.2 Rapid Reconnaissance Survey to Familiarize Field Activities

In addition to review and consultations, rapid preliminary field visits were conducted as part of ground truthing exercise. It provided the elementary idea about field research preparation and also helped for pilot testing of questionnaires and checklists

14.8.5 Census and Socio – Economic Household Survey

The social team conducted a census study within 5 m on either side of the proposed central line of the metro line, while in the location of proposed metro station the survey will be carried out up to 20 m, either side of the centerline. In order to identify and establish the legal entitlement of the property, a 100 % census survey method and 25% socio- economic survey of affected families is required to attain a representative database. The aim of the baseline socio-economic survey is to determine distribution of socio-economic groups on the map, analysis of social structure and income resources of the PAPs, inventories of the resources which the PAP use as well as the data on the system of economic production.

The data collected through different sources were used to identify structures coming within proposed ROW. The analysis of data also includes comprehensive examination of people's assets, important cultural or religious sites, and common property resources. The process includes collecting details of owner or occupant of the structure, its type and usage and dimensions. A structured and semi-structured format is generally used to collect all the relevant information on project PAPs and their structures.

14.8.6 Stakeholders Consultations

Consultative procedures have been a critical but important front in the entire social assessment process. Public consultations in social impact assessment facilitate to make a rapport with the stakeholders in the project influence area and provide basic inputs. In this regard, the social assessment ensures the involvement of local communities through participatory planning. The structured consultations endorse and integrate important resettlement issues in the project cycle.

The consultations were undertaken with various stakeholders at micro levels for sharing the information about the alignments and construction of Metro line. The

issues and concern likely to be emerged from construction of metro line were discussed and suggestions made by the participants were recorded. The range of discussion includes perception, attitude, benefit, problem and suggestions on social, economic, engineering viability of the project.

Almost all stakeholders' meeting, be it individual consultation or group consultation, were conducted along the project corridor, however, the presence of local people in a group in the local vicinity was scanty due to continuous heavy rain during consultations. The details of consultations are as follows:

Table 14-14 Location wise Details of Stakeholders Consultations

S. No.	Date of Consultation	Locations	Category of People and No. of Participants
1	06th Feb 2024	Lavapur Village	Local Persons (2)
2	06th Feb 2024	Ratanpur Village	Local Persons (4)
3	06th Feb 2024	Ratanpur Village	Local Persons (4)
4	06th Feb 2024	Shahpur Village	Farmers (7)
5	06th Feb 2024	Gift City	Construction Workers (4)

- **Snap shot of stakeholders Consultation**



Consultation at Lavapur Village



Consultation at Ratanpur Village



Consultation at Ratanpur Village



Consultation at Shahpur Village



Consultation at GIFT City

Issues Discussed

The social team explained the need and procedural details of GIFT City metro line to the participants in terms of its length, characteristics of the elevated Corridor and details of proposed station in the way. For a better understanding about the metro line the social team also explained in detail the proposed alignment and impact on population due to construction of metro line. The main issues, discussed during the consultation are as follows:

- The land requirements for the construction of entry/exit and metro station and depot and the probable impacts to the population along the metro line.
- The project's efforts at minimizing land acquisition and promoting safety measures.
- The broad principles and R & R mechanisms as per LARR Act-2013
- The present traffic condition and improvement due to Construction of metro corridor thereafter.
- Employment generation to the local people during construction of metro line and during operation
- Improvement in riding quality and easy access to desired destination.
- Influx of tourist
- Saving in the travel time and travel cost
- Increase in business opportunities in station area.
- Other issues highlighting the benefits of metro corridor

14.8.7 Social Impact Evaluation, Land Acquisition and Resettlement Impacts

This report will assess the social impacts and land acquisition requirement for construction of Metro line proposed for connecting at GIFT City. The chapter on Social impact assessment deals with affected persons, who are losing either their structures or land, due to project implementation. The detail of project impact summary is briefed here.

14.8.8 Impact on Land

In order to minimize land acquisitions and to provide good accessibility form either direction, 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:

- 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)

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

Table 14-15 Summary of Permanent Land Requirement (All figures in Sq. m)

S. No.	Description	First Phase			Second Phase		
		Govt.	Pvt.	Total	Govt.	Pvt.	Total
1	Stations	0	2052	2052	0	2052	2052
2	Running Section	0	0	0	0	1067	1067
3	Depot/Stabling Yard	0	0	0	0	0	0
4	Staff Quarters	0	0	0	0	0	0
5	Office Complex & OCC	0	0	0	0	0	0
6	RSS	0	0	0	0	0	0
	Total	**0**	**2052**	**2052**	**0**	**3119**	**3119**
Total (Pvt.) = 0.2052 ha (First Phase); 0.3119 ha (Second Phase)							

14.8.9 Impact and Identification of Structures

Census of all the structures lying within 10 m (5 m either side from the centerline) and 40 m in station area (20 m either side of the centerline) has been undertaken to assess the project impact on the population for displacement, resettlement and rehabilitation. Generally side of the service lane and median of the main road has been proposed for metro line to avoid the large scale demolition of properties and involuntary resettlement of the people.

A total number of 6 private residential structures within proposed RoW, might be impacted are shown in **Table 14-16**.

Table 14-16 Impact on Structures along the Project Route

Sl. No.	Category of Structure	Type of Private Property	No. of Affected Structures	Area (Sq. mtr.)
1	Semi pucca	Residential	3	73
2	Pucca	Residential	2	91
3	Temporary	Residential	1	45
Total			**6**	**209**

Photographs of Private Structures likely to be impacted








14.8.10 Likely Loss of Government/ Community Structures

No Government/ Community structures are getting affected.

14.8.11 Impact on Religious Property

No Religious structures are getting affected.

14.8.12 Project Impacted PAFs/PAPs

The acquisition of private land and the affected structures by the project are indicators of impact on the social environment. To estimate the exact number of

impacted persons at this stage is not possible. However, the exact figures of likely to be affected persons, who are losing their residential structures, are 6 in number comprising of 47 PAPs

Table 14-17 Project Impacted PAFs/PAPs

Sl. No.	Side	Name of Head of the Households	Occupation	Impact Category	No. of family members (PAPs)		
					Male	Female	Total
1	Left	Mahendra Bhai Juga Bhai	Farmer	Residential	3	3	6
2	Left	Shadaji	Farmer	Residential	4	6	10
3	Left	Dinesh Ji	Farmer	Residential	2	3	5
4	Left	Kalaji Jiva ji	Farmer	Residential	4	3	7
5	Right	Pratapji	Farmer	Residential	4	5	9
6	Right	Kalaji Shankar ji	Farmer	Residential	4	6	10
				Total	**21**	**26**	**47**

14.8.13 Socio-economic Profile of Affected Families

The purpose of social assessment survey was to create a broad database of the affected properties as well as the project-affected persons (PAPs) in order to understand the social profile of the project-affected area. It helps to appraise the positive as well as negative change in the life style of the communities in the project influence area due to an external intervention in the form of construction of metro corridor. The social profile of the affected population has been outlined in the following table:

Table 14-18 Socio-economic Profile of Affected Families

Sl. No.	Side	Name of the Affected Households	Age	Religious	Social	Literacy	Monthly Income (Rs.)	Family
1	Left	Mahendra Bhai Juga Bhai	45	Hindu	OBC	10th Pass	12000	Joint
2	Left	Shadaji	60	Hindu	OBC	10th Pass	15000	Joint
3	Left	Dinesh Ji	47	Hindu	OBC	12th Pass	25000	Joint
4	Left	Kalaji Jiva ji	45	Hindu	OBC	Elementary	30000	Joint
5	Right	Pratapji	60	Hindu	OBC	Elementary	15000	Joint
6	Right	Kalaji Shankar ji	75	Hindu	OBC	Elementary	15000	Joint

14.8.14 Assessment of Livelihood Losses

The proposed construction of metro line has no impact on livelihood directly or indirectly.

14.8.15 Positive Impact and Benefits of Metro Corridor

Consultative process with the potential stakeholders is a critical but important front in the entire social assessment process. It facilitates to make a rapport with the stakeholders in the project influence area and get basic inputs and perception of people regarding the project. .

- The issues, concern and benefits likely to be emerged from construction of metro line were discussed and perception of the people were recorded. The range of discussion includes perception, attitude, benefit, problem, suggestions recommendation and solution on social, economic, engineering viability of the project. Almost all the people and group consulted were having positive framework on project implementation. They welcomed the project and ascertained that it will be a boon for the population accessing Gujarat and tourist coming to visit Ahmedabad and other tourist places. The positive impact and benefits of the projects are as follows:
- This proposed metro corridor will enhance connectivity and reduce travel time.
- It will provide better accessibility to the students coming to Gift city, an educational hub, for career making.
- The emergence of a modern and planned city cluster will attract people, investments, trade, and tourism like never before. This will be a truly transformational project implemented using the principles of 5Ts (teamwork, technology, transparency, transformation and time-limit).
- The foremost benefit of construction of proposed metro line up to Airport is that it will create enormous investment opportunities within Gujarat. Besides, it will help Gujarat in Job creation, Tourism development, Exports and trade, Boost in the real estate market and Connectivity is the crucial key of Ahmedabad Airport etc.
- It’s no secret that the Gujarat government is determined to make Ahmedabad a futuristic business hub filled with numerous technologically advanced development projects and the proposed project is one of them
- Equipped with state-of-art facilities, the metro rail project will not only offer world-class, people friendly urban transport for an emerging and aspirational Ahmedabad but also spur economic activities and accelerate expansion of urban city cluster covering Gujarat.
- Transportation and connectivity are of the most domineering aspects of developing cities and is necessary for ensuring the growth of urban areas. The perplexing, perpetual and complex concerns in present Cosmopolis are sluggish traffic movement and jamming. The introduction of metro corridor will certainly play pivotal role in reducing sluggish traffic movement in Ahmedabad and other connecting cities.
- Local communities will have greater access to public infrastructure and increased mobility through enhanced transport facilities

14.8.16 Legal Policy Framework

The policy framework and entitlement for the program are based on national laws: The Land Acquisition & Rehabilitation and Resettlement Act-2013

The proposed policy Framework is committed to ensure that the livelihoods of project-affected persons are at least restored to pre-project levels, with the opportunity to improve on living standards where possible. The policy addresses the following adverse impacts associated with construction of metro line:

- Loss of land and other privately-owned assets
- Adverse impacts on subsistence/livelihood or income-earning capacity
- Collective adverse impacts on groups (e.g., through the loss of business resources and assets)
- To mitigate unforeseen effects on communities and promote general upliftment, rehabilitation and support measures will be extended to include households of the defined vulnerable social categories who may be adversely affected by construction of metro line.

14.8.17 Estimated Social Cost

The budget is an indicative of outlays for the different expenditure categories. These costs will be updated and adjusted to the inflation rate as the project continues and in respect of more specific information such as additional number of project affected people during the implementation, unit cost will be updated if the findings of the district level committee on market value assessment justify it.

The estimated social cost for the project which includes land acquisition cost, structures cost and contingency is prepared as per the Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act-2013. The social/resettlement cost estimate for this project includes:

14.8.18 Compensation for Land

In case of land acquisition the amount of compensation to be determined is that of the value of the land as decided by the Collector +100 percent Solatium+12 percent additional market value from the date of notification to taking over the possession or award whichever is higher. Market value of land as mentioned under section 26 of LARRA Act- 2013 needs to be multiplied by the radial factor (based on the distance of project from urban area as notified by the appropriate government- e.g multiplication of 2 in Rural area and Multiplication of 1 in Urban area) plus value of assets attached to land or building (mentioned in Section 29 of LARRA Act-2013) Plus Solatium (solatium includes 100% market value multiplied by 2 plus value of assets in Rural area and multiplied by 1 in urban area)

Example: Rural Area: If the Market value of land is Rs. 200, the final award will be Rs.200 x2 +Solatium (100 % of Market Value x 2) =400+400=800 or 4 times of Market Value, i.e., Rs.200x4=Rs.800

Urban Area: If the Market value of land is Rs. 500, the final award will be Rs.500 x1 +Solatium (100 % of Market Value x 1) =500+500=1000 or 2 times of Market Value, i.e., Rs.500x2=Rs.1000.

14.8.19 Compensation for Structures

The identified structures to be affected are in general temporary construction and are mostly projected area. There are no cases of displacement of any private structures. Hence, structures cost has been calculated on lump sum basis to meet the replacement value of the affected properties.

14.8.20 Total Social Cost

The table below summarizes the resettlement cost of the project:

Table 14-19 Estimated Social Cost

Sl. No.	Item	Unit Rate	Unit Rate (Rs./Structure)	Quantity	Estimated Budget (Rs.)
1	Cost of the Structures	Lump sum	25,000	6	1,50,000
2	RAP Implementation Consultant	Lump sum	5,00,000	1	5,00,000
	Total				**6,50,000**

Note- Land cost is not included

Chapter - 15

Security Measures for a Metro System



15.1 Introduction

15.2 Necessity of Security

15.3 Three Pillars of Security

15.4 Phases of Security

15.5 Responsibilities and Partnerships

15.6 Proposed Provisions for Security System



Chapter – 15

SECURITY MEASURES FOR A METRO SYSTEM

15.1 INTRODUCTION

Metro is emerging as the most favoured mode of urban transportation system. The inherent characteristics of metro system make it an ideal target for terrorists and miscreants. Metro systems are typically open and dynamic systems which carry thousands of commuters. Moreover the high cost of infrastructure, its economic impotence, being the life line of city high news value, fear & panic and 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 GMRC 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.

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.

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.

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 GMRC.

6. Bomb Blanket at least one per station and Depots.

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. 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.

15.7 COST

A lump-sum provision of Rs. 47 lakh plus taxes per station is kept in cost estimates, in accordance with “Report on Benchmarking for Cost Estimation of Metro Rail Projects” by M/o Housing & Urban Affairs, February 2019, suitably escalated to January 2024 price level.

Chapter - 16

Disaster Management Measures



16.1 Introduction

16.2 Need for Disaster Management Measures

16.3 Objectives

16.4 List of Serious Incidents requiring use of Provisions of the Disaster Management Measures

16.5 Provisions under Disaster Management Act, 2005

16.6 Provisions at Metro Stations/ Other Installations

16.7 Preparedness for Disaster Management



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 GMRC 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 GMRC 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) GMRC 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

17.2 Need for Multimodal Integration

17.3 Multi Modal Integration at Corridor Level

17.4 Multi Modal Integration at Station Area Level

17.5 Station Area Design



Chapter - 17

MULTI MODAL TRAFFIC INTEGRATION AT METRO STATIONS

17.1 INTRODUCTION

Public transport is like a tree, with a large trunk that feeds into smaller branches, and ultimately, twigs. Inter-city railways represent the trunks; high capacity urban, suburban and underground rail systems represent the major branches; metrolite, monorails, urban tramways, bus rapid transit systems and city bus systems represent the smaller branches, etc., down to smaller capacity public sharing autos and taxi transport systems for the twigs.

Multimodal integration planning refers to considerations for various modes and the interconnections between them. Integration means that whatever modes or types of transport (rail, road, NMT, etc.) are involved they all operate as one 'seamless' entity - for the benefit of the fare paying customer. This is achieved by planning services so that where a change of vehicle is required passengers can enjoy easy to use, pleasant and sheltered interchange facilities plus short waits for the next service. Furthermore, just as when a motorist buys fuel they do so once for the whole journey so with passenger transport the passenger should be able to benefit from through 'one purchase' ticketing for the whole journey.

17.2 NEED FOR MULTIMODAL INTEGRATION

Multimodal Integration ensures the smooth movement of commuters by various transportation modes like buses, IPT, private vehicles, NMT in such a way that efficiency is achieved in terms of time, cost, comfort, safety and accessibility. A successful multimodal integration can result in increased demand for public transportation by optimizing travel cost and time and allow seamless interchange between the various modes. 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.

In public transport group there are Mini Buses (20 seaters), and large buses (50 seaters) and Chartered Buses hired by schools and private offices. Auto Rickshaw (3-seater), Vikram and Grameen Sewa (large-shared 3 wheelers-6-seater) & Tata Magic (4-wheel light passenger vehicle which can carry 8-10 persons at a time) which are Intermediate Public Transport (IPT) Modes. In the personalized transport modes, there are Bicycles, Two wheelers and Cars of all possible sizes.

A chaotic situation is observed when all the above-mentioned transport vehicles are seen jostling to each other for space for moving forward. More pathetic conditions are seen at the Road Intersections. The solution lies in showcasing a workable arrangement of co-existence through identification of good points of each mode and then utilize the same to get the attention and embedding it in public psyche.

Multimodal Integration consists of combining and coordinating the operation of varied transport modes in order to offer continuous and door-to-door services. Intermodal facilities are infrastructures where people who use public transit can shift between different modes of transport. These infrastructures are especially planned to allow for the operation of at least two transport modes at the same time.

The approach to be adopted while planning for multi modal integration is to focus on last mile connectivity and ensure seamless travel from door to door. Importance of last mile connectivity becomes crucial for the success of a public transport system. A well connected, integrated network of footpath, cycle and bus feeder system acts as complimentary modes to generate ridership of mass transit system.

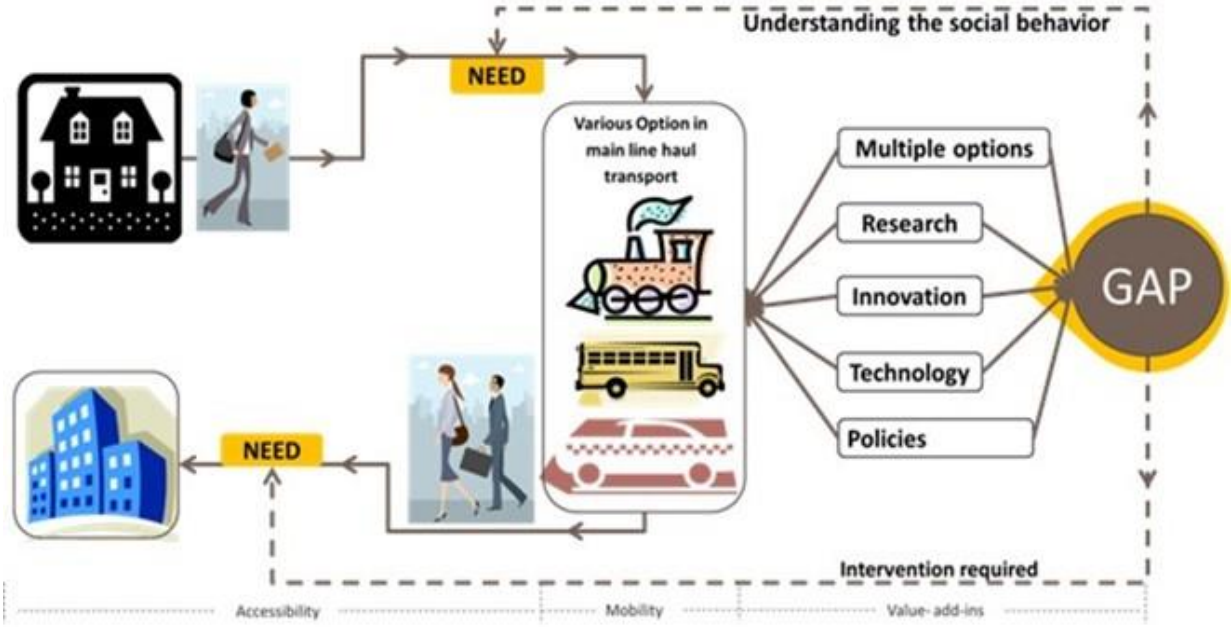


Fig. 17.1 Approach for Multimodal Integration

17.2.1 Last Mile Connectivity

Last mile connectivity services enable commuters to easily plug in or transfer to main transit line at the start or at the end of their trips. They complement rapid transit services by offering commuters the complete trip they require. The quality of the last mile to a great extent influences transit ridership and the choice opted by users. The three key parameters to be considered while planning for multi modal integration is presented below:

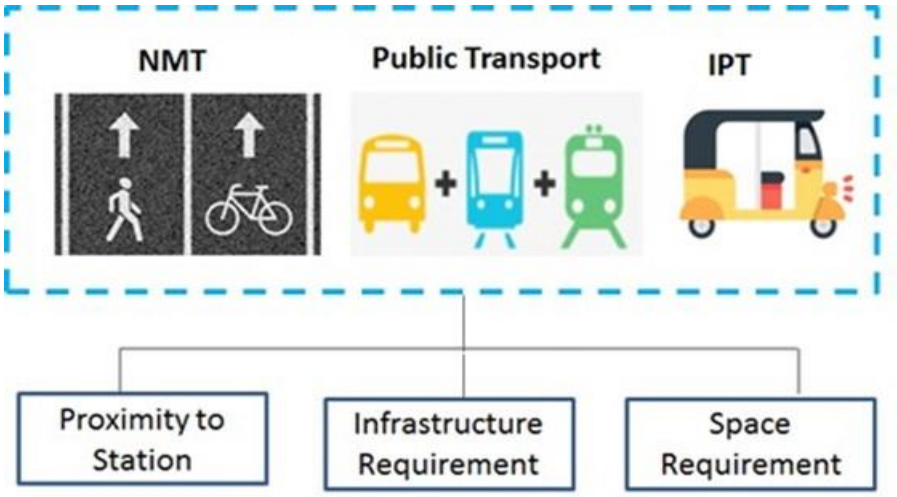


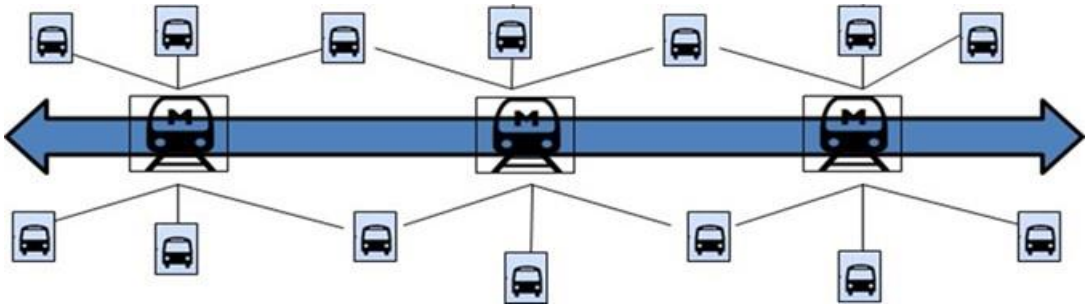
Fig. 17.2 Key Parameters to be Considered for Multimodal Integration

Last mile connectivity ensures ease of availability of mode and options reduce time and cost incurred in the last mile, ease of changing the mode and ease of walking/ cycling to and from stops or stations.

17.3 MULTI MODAL INTEGRATION AT CORRIDOR LEVEL

17.3.1 Feeder Services

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 modes. Feeder system ideally consists of buses/ mini buses/ shared autos operating within certain frequency in small loop routes, providing connectivity between trip generating/attracting areas and the linear network of metro.



The parameters to be considered for feeder service is as explained below:

- **Frequency**: The frequency of feeder buses should be in sync with metro timings and be at Ideally 5—10 min
- **Connectivity**: The feeder routes should connect nearest residential, commercial and activity centres to metro station based on Hub and Spokes model
- **Influence Areas/ Catchment for Metro**: Assess the catchment area around the metro station around a radius of 3-4kilometres and identify major trip generation points in the vicinity

- Assessment of areas that are poorly connected by existing bus routes to the metro station
- **Bus Type**: Shuttle buses, mini vans, battery operated vehicles etc.

Ahmedabad has a good bus transport service. However, an attempt should be made to rationalize the existing routes in order to improve the efficiency of public transport system and reduce the overlap with the proposed metro corridor. The existing PT routes should act as a feeder to the metro system and thereby improve the last mile connectivity.

The methodology followed to rationalize the existing PT/ IPT routes is explained below:

- To map and analyse public transport route structure plying along the proposed and proposed metro corridor
- Assess which sectors within the catchment area are poorly connected by existing bus routes to the metro station.

17.3.2 Pedestrian Network

The provision of a pedestrian-friendly infrastructure at station access, on roads leading to transit stops is of utmost importance to enhance efficiency of rapid transportation system. There is a need to improve the pedestrian network in the city as majority of roads lack pedestrian facilities. For construction of a new pedestrian network within the catchment area of proposed metro, following parameters should be considered:

- Land use distribution
- Important landmarks
- Missing pedestrian infrastructure links within the catchment area.



This should be followed by identification of major residential areas and major destinations within the surrounding of the proposed metro network. The network is 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.

There should be a pedestrian network along the existing roads within the catchment areas of 500 m from the proposed metro alignment. The footpath width on the main corridor to be kept between 1.5 to 3 m and on the side streets to be minimum 1.5 m and maximum height of 150mm from the finished road surface. Pedestrian pathways should be upgraded through adequate infrastructure like width, paved surface, ease of crossing, universal accessibility, continuity and aesthetic improvements. This will create pedestrian friendly environment and encourage people to use the footpaths.

17.3.3 NMT and 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. Along with having vehicular and pedestrian network along all vertical and horizontal networks, provision of cycle lane or non-motorized lane is necessary to boost use of sustainable and non-motorized modes. To facilitate use of cycles as 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. A cycling network is incomplete without facilitating docking stations at places beyond metro stations.

PBS has to be segregated from main carriageway and to accommodate the same along the metro corridor land needs to be acquired. Also docking stations has to be proposed at stations which cannot be accommodated in the existing scenario due to non-availability of extra land parcels. Hence it is suggested that the proposal of cycle track to be incorporated in future proposals of road widening along the metro corridor and its catchment area so as to improve the last mile connectivity.

17.4 MULTI MODAL INTEGRATION AT STATION AREA LEVEL

Multimodal integration at station areas is crucial as it aims at seamless integration of modes at metro stations. It is generally an 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. Thus, station area planning and design should ensure integration with public transport (PT), intermediate public transport (IPT) and NMT provisions.

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 stations with seating area with self-explanatory signage’s and symbols. Purpose of a station area plan is to make last mile more accessible.

The basic design principles to be followed for station design are presented below.

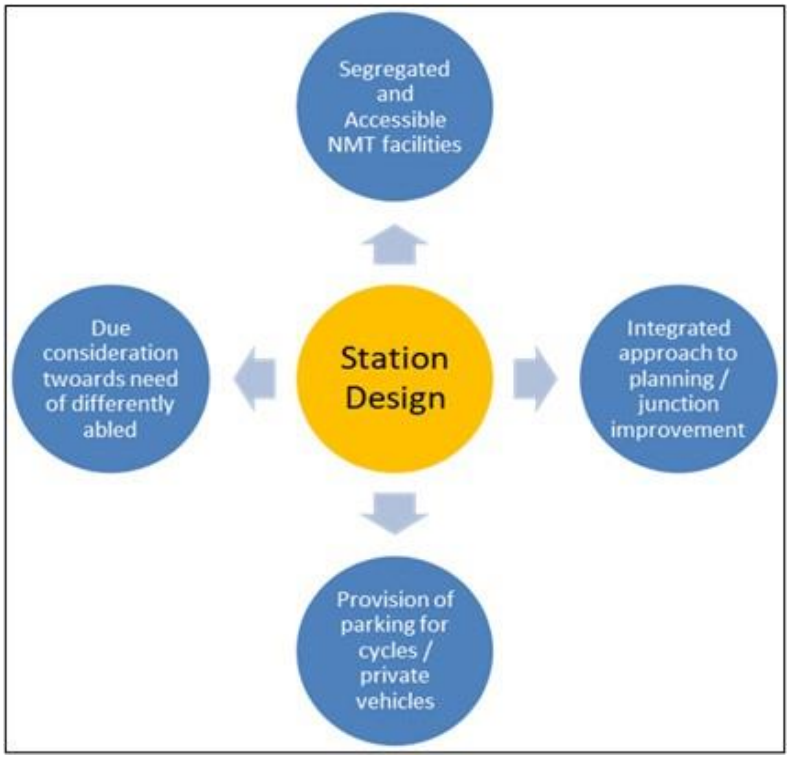


Fig. 17.3 Design Principles for Intermodal Integration at Metro Station Area

17.4.1 Standard Practices and Guidelines

In order to carry out station area level design for multi modal integration, the standard practices and guidelines were referred to guide the design process. As a part of which, IRC and UTTIPEC guidelines and reference documents including: Street Design Guidelines, Street Design Checklist and MRTS Connectivity and Multimodal Integration – Checklist, were referred.

The elements that constitute an integrated station area level design including sidewalks, transit stops, cycle docks, travel lanes etc. all vie for space within the limited available space. Hence, the judicious allocation of space as per their characteristic requirements is of utmost importance.

Footpath or sidewalk, provided on both edges of the street, should be walkable, clean and safe for pedestrians. It should be free from encroachments, parking and utility obstructions. In furtherance, it should be continuous and should ensure universal accessibility. As a standard practice, universal accessibility features (like barrier free designs) are required for all elements like sidewalks, crossings, public spaces and amenities.

Modal interchange facilities have also been specified to ensure seamless connectivity to the metro users while also ensuring accessibility to the mobility impaired. The bus stop locations should be within 50m level walk from the station exits. Pick-up & drop-off should be located without interfering with barrier-free movement of exiting pedestrians and movement of non-motorized vehicles.

Further, the location and quality of facilities outside the station premises including NMT and IPT facilities should be within the Multi-Functional Zones. Adequate Information maps and boards including Way finding Maps, Bus information and timetable, IPT stands/pick-up & drop-off zones etc. should be present in the station premises to aid metro users.

A conceptual design of intermodal integration at elevated metro station based on requirements is shown in figure below:

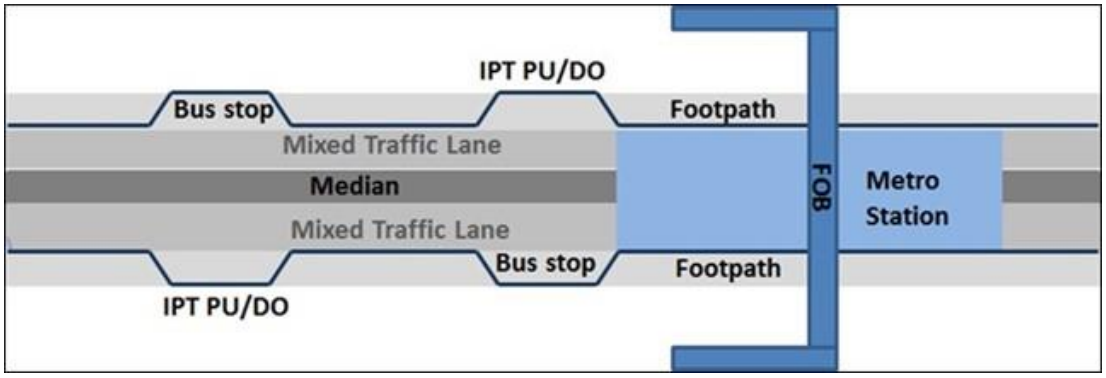


Fig. 17.4 Conceptual Design for Intermodal Integration at Metro Station Area

As per the design, provision of passenger access and egress are located at the entry and exit of metro station for easy accessibility. Two lane divided road with footpath on each side is proposed for most of the stretch along the metro alignment. Bus stops and IPT pick up/ drop off are proposed near the station.

17.5 STATION AREA DESIGN

The purpose of developing station area plans is to make last mile more accessible and integrated. This would ensure integration between the various modes present in the city. Moreover, adequate facilities for non-motorized modes including pedestrian are also required to ensure a smooth transit experience.

Station area planning and design was carried out in lieu of the standard design practices. Every station area unit was designed as per contextual constraints and demands. A typical station area planning took into consideration three integral components besides the mandatory station provisions, which are:

- Bus stops
- IPT pick-up and drop-off provisions and
- Footpath provisions

A complete station area planning is envisaged as an integrated design consisting of the above-mentioned components. While designing the vehicular movement around the station area, the location of the trees has also been considered to avoid tree cutting. A multi-modal integration plan incorporating the various elements for all stations along the corridor is presented in the images to follow.

As can be seen from the figures below, station area plans incorporate the infrastructure provisions for PT, IPT and Footpath, so as to provide a seamless connectivity for metro users. Adequate footpath provision of width ranging from 2.0 m to 3.0 m depending on the availability of the land has been ensured at all station area.

The bus stops have been designed to accommodate two buses and with a width of 3.0 m and length of 45 m. In addition to the provision for bus stops, pick-up and drop-off points have also been designed near the station areas. For all pick-up and drop-off spaces designed near the station modules, around 2.5 m width has been maintained. The distance between the bus station and pick up/ drop off points is kept at minimum 25 m for the vehicles to maneuver.

However, in case of land constraints at station areas, priority is given to provision of PT infrastructure than the IPT pick-up and drop-off points, wherein the latter is accommodated slightly further away from the station area locations.

Provision of passenger access and egress area should ideally be located at the entry and exit of metro station for easy accessibility. The design caters to the above-mentioned aspects pertaining to PT, IPT and NMT facilities to ensure integration between the modes and the metro. The above-mentioned facilities and infrastructure provisions have been designed for all entry/ exit points of the metro stations. The designs have been developed such that, the integration with all mentioned facets have been achieved.



Fig. 17.5 Typical Multimodal Integration Plan for Proposed Gujarat Biotechnology University Station at GIFT City

Chapter - 18

Cost Estimates



18.1 Introduction

18.2 Civil Engineering Works

18.3 Depot

18.4 Utility Diversions, Environmental Protection, Miscellaneous other Works

18.5 Rehabilitation and Resettlement

18.6 Traction and Power Supply

18.7 Signalling and Telecommunication Works

18.8 Automatic Fare Collection

18.9 Rolling Stock

18.10 Security

18.11 Multimodal Traffic Integration

18.12 General Charges and Contingences

18.13 Capital Cost Estimates



Chapter – 18

COST ESTIMATES

18.1 INTRODUCTION

Project Cost estimates for Ahmedabad Metro Phase-II B corridor 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 January 2024 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 published in “Report on Benchmarking for Cost Estimation of Metro Rail Projects” by M/o Housing & Urban Affairs, February 2019, duly escalated to January 2024 price level. 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 estimate separately.

The overall Capital Cost of this corridor from GIFT City to Shahpur under First Phase and Shahpur to GIFT under Second Phase at January 2024 price level has been tabulated hereunder.

Table 18.1 – Details of Capital Cost

Sr. No.	Name of the corridor	Capital Cost (Rs. Crore)	Taxes & Duties (Rs. Crore)	Total (Rs. Crore)
1	GIFT City to Shahpur (First Phase)	754.62	137.31	891.93
2	Shahpur to GIFT (Second Phase)	626.22	108.93	735.15
	Total at January 2024 level	1380.84	246.24	1627.08

Note: GIFT City to GIFT corridor is proposed to be implemented under two phases. First phase consisting first three stations is proposed to be implemented by 2029 and second phase consisting of remaining three stations is proposed to be implemented by 2033. Accordingly, cost for the two phases have been shown above separately.

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.

Private land for MRTS project shall be acquired by GMRC/ 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.26.60 Crore per hectare after suitably escalating the rates taken in Ahmedabad Metro Phase-II DPR. Similarly average rate for govt. land has been taken as Rs. 11.08 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.

18.2.2 Formation and Alignment

Elevated: For elevated viaduct, the rates adopted are based on “Report on Benchmarking for Cost Estimation of Metro Rail Projects” by M/o Housing & Urban Affairs, February 2019, duly escalated to January 2024 price level. Cost of viaduct length for station has been included in elevated section.

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, Signaling & Telecommunication works, Automatic fare collection installations, etc. have been summed up in the cost estimates.

Rates have been arrived on the basis of "Report on Benchmarking for Cost Estimation of Metro Rail Projects" by M/o Housing & Urban Affairs, February 2019, duly escalated to January 2024 price level.

18.2.4 Permanent way

For elevated alignment, ballast-less track, and for depot, ballasted track is proposed. Rates adopted are based on "Report on Benchmarking for Cost Estimation of Metro Rail Projects" by M/o Housing & Urban Affairs, February 2019, duly escalated to January 2024 price level.

18.3 DEPOT

No separate depot proposed for this spur. Existing Gyaspur depot and under implementation Stabling Yard at Indroda Circle shall be serving this extension i.e. GIFT city (Phase-II B) corridor. Provision has been made for miscellaneous work like plant & machinery or civil work.

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. Rates given in "Report on Benchmarking for Cost Estimation of Metro Rail Projects" by M/o Housing & Urban Affairs, February 2019, reduced to 50% in view of greenfield project. The same has been duly escalated to January 2024 price level.

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 have been made in the cost estimates based on "Report on Benchmarking for Cost Estimation of Metro Rail Projects" by M/o Housing & Urban Affairs, February 2019, duly escalated to January 2024 price level. Provision for Staff Quarters for O&M Wing have not been made in the cost estimates being a small spur of main line.

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 for elevated/at-grade section (Depot augmentation).

Rates provided are based on “Report on Benchmarking for Cost Estimation of Metro Rail Projects” by M/o Housing & Urban Affairs, February 2019, duly escalated to January 2024 price level.

18.7 SIGNALLING AND TELECOMMUNICATION WORKS

Rates adopted are based on “Report on Benchmarking for Cost Estimation of Metro Rail Projects” by M/o Housing & Urban Affairs, February 2019, duly escalated to January 2024 price level.

18.8 AUTOMATIC FARE COLLECTION

Adopted rates are based on “Report on Benchmarking for Cost Estimation of Metro Rail Projects” by M/o Housing & Urban Affairs, February 2019, duly escalated to January 2024 price level.

18.9 ROLLING STOCK

Adopted rates are based on “Report on Benchmarking for Cost Estimation of Metro Rail Projects” by M/o Housing & Urban Affairs, February 2019, duly escalated to January 2024 price level.

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 based on “Report on Benchmarking for Cost Estimation of Metro Rail Projects” by M/o Housing & Urban Affairs, February 2019, duly escalated to January 2024 price level.

18.11 MULTIMODAL TRAFFIC INTEGRATION

A lump sum provision of Rs. 3.83 Crore plus taxes per station has been made based on “Report on Benchmarking for Cost Estimation of Metro Rail Projects” by M/o Housing & Urban Affairs, February 2019, duly escalated to January 2024 price level, 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, except cost of land and general charges.

18.13 CAPITAL COST ESTIMATES

18.13.1 GIFT City to Shahpur (First Phase)

The overall Capital Cost for the first phase of Ahmedabad Phase-II B at January 2024 price level works out to **Rs. 754.62 Crores** excluding applicable Taxes & Duties of **Rs. 137.31 crores** as tabulated hereunder.

Table 18.2 - Capital Cost Estimate

Total length = 3.332 km (Entirely Elevated)
Total Stations = 3 (All Elevated)

January 2024 level

S. No.	Item	Unit	Rate	Qty.	Amount (Rs. in Cr.)
				Without taxes	
1.0	**Land**				
1.1	Permanent				
a	Government	ha	11.08	0.0000	0.00
b	Private	ha	26.60	0.2052	5.46
1.2	Temporary Land (@5% pa for 4 years)				
a	Government	Ha.	2.22	2.20	4.87
1.3	**R & R incl. Hutments etc.**	R. Km.	4.89	3.332	16.29
	Subtotal (1)				**26.62**
2.0	**Alignment and Formation**				
2.1	Elevated section (viaduct) including in station portion (Including Cost of Rain Water Harvesting)	R. Km.	47.22	3.332	157.34
	Subtotal (2)				**157.34**
3.0	**Station Buildings**				
3.1	Elevated stations (including finishes)	Each			
a	Civil works excluding viaduct in station portion	Each	33.18	3	99.54
b	EM works including lifts and escalators	Each	10.21	3	30.63
3.2	Providing Platform Screen Doors (PSD) at all stations	Per Station	3.83	3	11.49
	Subtotal (3)				**141.66**

S. No.	Item	Unit	Rate	Qty.	Amount (Rs. in Cr.)
				Without taxes	
4.0	**Augmentation of Depot, Admin Building and OCC**				
a	Civil works	LS			5.00
b	E&M and M&P works	LS			5.00
	Subtotal (4)				**10.00**
5.0	**P-Way**				
5.1	Ballast less track	R. Km.	8.42	3.332	28.06
5.2	Ballasted track for Depot, At Grade Section	T. Km.	4.98	0.20	1.00
	Subtotal (5)				**29.05**
6.0	**750 v DC Third Rail**				
6.1	Elevated Section	R.Km.	14.04	3.332	46.78
6.2	Depot	T.Km.	3.83	0.20	0.77
6.3	Catenary Maintenance Vehicle	Each	8.93	0	0.00
6.4	RSS cum TSS	Each	31.91	0	0.00
	Subtotal (6)				**47.55**
7.0	**Signalling and Telecom.**				
7.1	**Signalling**				
	Main line including OCC/BCC	R.Km.	5.62	3.332	18.73
	Depot including DCC	T.Km.	4.08	0.2	0.82
	On Board Equipment	Per Train	2.17	6	13.02
7.2	**Telecom**				
	Station	Per Station	5.74	3	17.22
	Depot	Per Depot	4.47	1	4.47
7.3	**Automatic Fare Collection(AFC) system**	Per Station	4.47	3	13.41
	Subtotal (7)				**67.66**
8.0	**Shifting of Miscellaneous Utilities**				
a	Civil and EM works	R. Km.	3.83	3.332	12.76
	Subtotal (8)				**12.76**
9.0	**Rolling Stock (2.9 m wide Coaches)**	Each	10.21	18	183.78
	Subtotal (9)				**183.78**
10.0	**Capital expenditure on security**	Per Station	0.47	3	1.41
	Subtotal (10)				**1.41**
11.0	**Staff quarter for O & M**				
a	Civil works	R.Km.	2.16	0.000	0.00
b	EM works etc	R.Km.	0.54	0.000	0.00
	Sub Total (11)				**0.00**

S. No.	Item	Unit	Rate	Qty.	Amount (Rs. in Cr.)
				Without taxes	
12.0	**Multimodal Integration and Last mile connectivity**				
a	Multimodal Integration and Last mile connectivity	Per Station	3.83	3	11.49
	Sub Total (12)				**11.49**
13.0	**Total of all items except Land**				**678.99**
14.0	**Total Tax and Duties**				**137.31**
15.0	**Total of all items including taxes and duties excluding land**				**816.30**
16.0	**General Charges incl. Design charges @ 5 % on all items except land**				**40.81**
17.0	**Continegencies @ 3 % on all items except land and G. Charges**				**24.49**
18.0	**Gross Total**				**881.60**
	Cost without land			**=**	**881.60**
	Cost including land			**=**	**891.93**

Table 18.3 - Details of Taxes and Duties

Basic Customs duty =	8.2500	%
CGST Customs Duty=	9.7425	%
SGST Customs Duty=	9.7425	%
Total Customs Duty=	**27.7350**	%
General IGST=	18	%
General CGST =	9	%
General SGST =	9	%

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	157.34		28.32	**28.32**
2	**Station Buildings**				
	Elevated station-Civil works	99.54		17.92	**17.92**
	Elevated station-EM works	30.63	1.70	4.41	**6.11**
3	**Depot**				
	Civil works	5.00	0.28	0.72	**1.00**
	EM works	5.00	0.28	0.72	**1.00**
4	**P-Way**	29.05	1.61	4.18	**5.79**
5	**Traction & Power Supply**	47.55	5.27	5.14	**10.41**
6	**Signalling and Telecom.**				
a	Signalling	32.56	4.52	2.93	**7.45**
b	Telecom	21.69	3.01	1.95	**4.96**

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.)	
c	AFC	13.41	1.86	1.21	**3.07**
7	**PSD**	11.49	1.59	1.03	**2.63**
8	**R & R hutments**	16.29		2.93	**2.93**
9	**Misc. Utilities, Staff Quarters and Security**				
	Civil works	19.25	0.00	3.46	**3.46**
	EM works	6.42	0.00	1.15	**1.15**
10	**Rolling stock**	183.78	20.39	19.85	**40.24**
11	**Rent on Temporary Land**	4.87		0.88	**0.88**
	Total	**683.86**	**40.51**	**96.81**	**137.31**
	Total Taxes & Duties				**137.31**
Rate of Taxes & Duties on Total cost without Taxes & Duties					**20.08%**
Total Central GST & Basic Customs duty					74.68
Total State GST					62.63
Total Taxes & Duties					**137.31**

18.13.2 Shahpur to GIFT (Second Phase)

The overall Capital Cost for the second phase of Ahmedabad Phase-II B at January 2024 price level works out to **Rs. 626.22 Crores** excluding applicable Taxes & Duties of **Rs. 108.93 crores** as tabulated hereunder.

Table 18.4 - Capital Cost Estimate

Total length = 4.253 km (Entirely Elevated)

Total Stations = 3 (All Elevated)

January 2024 level

S. No.	Item	Unit	Rate	Qty.	Amount (Rs. in Cr.)
				Without taxes	
1.0	**Land**				
1.1	Permanent				
a	Government	ha	11.08	0.0000	0.00
b	Private	ha	26.60	0.3119	8.30
1.2	Temporary Land (@5% pa for 4 years)				
a	Government	Ha.	2.22	2.20	4.87
1.3	**R & R incl. Hutments etc.**	R. Km.	4.89	4.253	20.79
	Subtotal (1)				**33.96**
2.0	**Alignment and Formation**				

S. No.	Item	Unit	Rate	Qty.	Amount (Rs. in Cr.)
				Without taxes	
2.1	Elevated section (viaduct) including in station portion (Including Cost of Rain Water Harvesting)	R. Km.	47.22	4.253	200.83
	Subtotal (2)				**200.83**
3.0	**Station Buildings**				
3.1	Elevated stations (including finishes)	Each			
a	Civil works excluding viaduct in station portion	Each	33.18	3	99.54
b	EM works including lifts and escalators	Each	10.21	3	30.63
3.2	Providing Platform Screen Doors (PSD) at all stations	Per Station	3.83	3	11.49
	Subtotal (3)				**141.66**
4.0	**Augmentation of Depot, Admin Building and OCC**				
a	Civil works	LS			5.00
b	E&M and M&P works	LS			5.00
	Subtotal (4)				**10.00**
5.0	**P-Way**				
5.1	Ballast less track	R. Km.	8.42	4.253	35.81
5.2	Ballasted track for Depot, At Grade Section	T. Km.	4.98	0.20	1.00
	Subtotal (5)				**36.81**
6.0	**750 v DC Third Rail**				
6.1	Elevated Section	R.Km.	14.04	4.253	59.71
6.2	Depot	T.Km.	3.83	0.20	0.77
6.3	Catenary Maintenance Vehicle	Each	8.93	0	0.00
6.4	RSS cum TSS	Each	31.91	0	0.00
	Subtotal (6)				**60.48**
7.0	**Signalling and Telecom.**				
7.1	**Signalling**				
	Main line including OCC/BCC	R.Km.	5.62	4.253	23.90
	Depot including DCC	T.Km.	4.08	0.2	0.82
	On Board Equipment	Per Train	2.17	0	0.00
7.2	**Telecom**				
	Station	Per Station	5.74	3	17.22
	Depot	Per Depot	4.47	1	4.47
7.3	**Automatic Fare Collection(AFC) system**	Per Station	4.47	3	13.41
	Subtotal (7)				**59.82**

S. No.	Item	Unit	Rate	Qty.	Amount (Rs. in Cr.)
				Without taxes	
8.0	**Shifting of Miscellaneous Utilities**				
a	Civil and EM works	R. Km.	3.83	4.253	16.29
	Subtotal (8)				**16.29**
9.0	**Rolling Stock (2.9 m wide Coaches)**	Each	10.21	0	0.00
	Subtotal (9)				**0.00**
10.0	**Capital expenditure on security**	Per Station	0.47	3	1.41
	Subtotal (10)				**1.41**
11.0	**Staff quarter for O & M**				
a	Civil works	R.Km.	2.16	0.000	0.00
b	EM works etc	R.Km.	0.54	0.000	0.00
	Sub Total (11)				**0.00**
12.0	**Multimodal Integration and Last mile connectivity**				
a	Multimodal Integration and Last mile connectivity	Per Station	3.83	3	11.49
	Sub Total (12)				**11.49**
13.0	**Total of all items except Land**				**559.57**
14.0	**Total Tax and Duties**				**108.93**
15.0	**Total of all items including taxes and duties excluding land**				**668.50**
16.0	**General Charges incl. Design charges @ 5 % on all items except land**				**33.43**
17.0	**Continegencies @ 3 % on all items except land and G. Charges**				**20.06**
18.0	**Gross Total**				**721.98**
			Cost without land	**=**	**721.98**
			Cost including land	**=**	**735.15**

Table 18.5 - Details of Taxes and Duties

Basic Customs duty =	8.2500	%
CGST Customs Duty=	9.7425	%
SGST Customs Duty=	9.7425	%
Total Customs Duty=	**27.7350**	%
General IGST=	18	%
General CGST =	9	%
General SGST =	9	%

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	200.83		36.15	**36.15**
2	**Station Buildings**				
	Elevated station-Civil works	99.54		17.92	**17.92**
	Elevated station-EM works	30.63	1.70	4.41	**6.11**
3	**Depot**				
	Civil works	5.00	0.28	0.72	**1.00**
	EM works	5.00	0.28	0.72	**1.00**
4	**P-Way**	36.81	2.04	5.30	**7.34**
5	**Traction & Power Supply**	60.48	6.71	6.53	**13.24**
6	**Signalling and Telecom.**				
a	Signalling	24.72	3.43	2.22	**5.65**
b	Telecom	21.69	3.01	1.95	**4.96**
c	AFC	13.41	1.86	1.21	**3.07**
7	**PSD**	11.49	1.59	1.03	**2.63**
8	**R & R hutments**	20.79		3.74	**3.74**
9	**Misc. Utilities, Staff Quarters and Security**				
	Civil works	21.89	0.00	3.94	**3.94**
	EM works	7.30	0.00	1.31	**1.31**
10	**Rolling stock**	0.00	0.00	0.00	**0.00**
11	**Rent on Temporary Land**	4.87		0.88	**0.88**
	Total	**564.44**	**20.89**	**88.04**	**108.93**
	Total Taxes & Duties				**108.93**
Rate of Taxes & Duties on Total cost without Taxes & Duties					**19.30%**
Total Central GST & Basic Customs duty					57.57
Total State GST					51.36
Total Taxes & Duties					**108.93**

Chapter - 19

Financing Options, Fare Structure, Financial Viability and Non-Fare Box Revenue



19.1 Introduction

19.2 Costs

19.3 Operation & Maintenance (O&M) Costs

19.4 Revenues

19.5 Financial Internal Rate of Return (FIRR)

19.6 Financing Options

19.7 Alternative Models of Financing

19.8 Recommendations



CHAPTER – 19

FINANCING OPTIONS, FARE STRUCTURE AND FINANCIAL VIABILITY

19.1 INTRODUCTION

The Gift City Extension Metro corridor is proposed to be constructed in two phases:

Phase I: From Gift City to Shahpur. The construction of the corridor is expected to commence from July 2025 and complete by June 2029. The revenue operation is scheduled to commence on 01-07-2029.

Phase II: From Shahpur to Gift City. The construction of the corridor is expected to commence from July 2029 and complete by June 2033. The revenue operation of the phase is scheduled to commence on 01-07-2033.

The route length of the metro system and estimated cost are placed in table 19.1 as under:

Table 19.1 Cost Details

Name of Corridor	Length (km)	Price level	Estimated cost without Land & taxes (Rs/Crore)	Estimated cost with land cost (Rs/Crore)	Estimated cost with all taxes & land cost (Rs/Crore)
Phase I: From Gift City to Shahpur	3.332	Jan-24	726.70	754.62	891.93
		July-25	781.88	809.80	957.53
Phase II: From Shahpur to Gift City	4.253	Jan-24	590.59	626.21	735.14
		July-29	772.37	807.99	950.45

19.2 COSTS

19.2.1 Investment Cost

The completion cost with taxes & duties have been calculated by taking escalation factor @ 5% p.a. on all items except land. The effective Customs Duty (CD) rate under project import scheme, post GST, works out to 27.735% {Basic CD @ 7.5%, IGST @ 18% and Cess @ 10%} on the imported portions. The GST rate on supply of works contract services has been considered @ 18% (CGST & SGST @ 9% each).

The total completion costs duly escalated and shown in the table 19.2 below have been taken as the initial investment.

Table 19.2 A Year –wise Investment (Completion Cost) of Phase I

Rs./ Cr.

Financial Year	Completion Cost including all Taxes & Land Cost
2025-26 (9 Months)	151.36
2026-27	305.62
2027-28	320.26
2028-29	217.55
2029-30 (3 Months)	55.84
Total	**1050.64**

Table 19.2 B Year –wise Investment (Completion Cost) of Phase II

Rs./ Cr.

Financial Year	Completion Cost including all Taxes & Land Cost
2029-30 (9 Months)	151.67
2030-31	303.48
2031-32	317.88
2032-33	214.09
2033-34 (3 Months)	54.95
Total	**1,042.08**

19.2.2 Additional Investment

No additional investment on account of additional coaches has been considered during the analysis period of 30 years.

19.3 OPERATION & MAINTENANCE (O&M) COSTS

19.3.1 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 & consumables and,
(iii) Energy costs

The requirement of staff has been assumed @ 15 persons per kilometre with average salary of Rs.15 Lakhs per annum at July 2029 level. The escalation factor used for staff costs is 9% per annum to provide for both escalation and growth in salaries. The average rate of electricity of Rs.6.00 per unit has been used for computation of energy cost. The annual maintenance cost and other expenses are assumed as Rs.1.50 Crores per Km for elevated section and Rs.2.25 Crores per Km

for underground section. The O&M cost (excluding staff cost) has been obtained by providing an escalation of 5% per annum.
The O&M costs have been tabulated in Table 19.3 as below:

Table 19.3A Operation and Maintenance Costs of Phase I

Rs. In Crore

Sl. No.	YEAR			Staff	Maintenance Expenses	Energy	Total
1	2029	-	2030	5.62	4.90	2.19	12.71
2	2030	-	2031	8.17	6.86	3.06	18.10
3	2031	-	2032	8.91	7.21	3.22	19.33
4	2032	-	2033	9.71	7.57	3.38	20.65
5	2033	-	2034	10.58	7.95	3.55	22.07
6	2034	-	2035	11.54	8.34	3.72	23.60
7	2035	-	2036	12.57	8.76	3.91	25.24
8	2036	-	2037	13.70	9.20	4.10	27.01
9	2037	-	2038	14.94	9.66	4.31	28.91
10	2038	-	2039	16.28	10.14	4.53	30.95
11	2039	-	2040	17.75	10.65	4.75	33.15
12	2040	-	2041	19.35	11.18	4.99	35.51
13	2041	-	2042	21.09	11.74	6.16	38.99
14	2042	-	2043	22.98	12.33	6.47	41.78
15	2043	-	2044	25.05	12.94	6.79	44.79
16	2044	-	2045	27.31	13.59	7.13	48.03
17	2045	-	2046	29.77	14.27	7.49	51.53
18	2046	-	2047	32.44	14.98	7.87	55.29
19	2047	-	2048	35.36	15.73	8.26	59.35
20	2048	-	2049	38.55	16.52	8.67	63.74
21	2049	-	2050	42.02	17.34	9.11	68.47
22	2050	-	2051	45.80	18.21	9.56	73.57
23	2051	-	2052	49.92	19.12	11.02	80.06
24	2052	-	2053	54.41	20.08	11.57	86.06
25	2053	-	2054	59.31	21.08	12.15	92.54
26	2054	-	2055	64.65	22.14	12.76	99.54
	Total			**697.78**	**332.49**	**170.71**	**1200.97**

Table 19.3 B Operation and Maintenance Costs of Phase II

Rs. In Crore

Sl. No.	YEAR			Staff	Maintenance Expenses	Energy	Total
1	2033	-	2034	10.13	7.61	3.06	20.80
2	2034	-	2035	14.72	10.65	4.28	29.65
3	2035	-	2036	16.05	11.18	4.49	31.73
4	2036	-	2037	17.49	11.74	4.72	33.95
5	2037	-	2038	19.07	12.33	4.96	36.35
6	2038	-	2039	20.78	12.95	5.20	38.93
7	2039	-	2040	22.65	13.59	5.46	41.71
8	2040	-	2041	24.69	14.27	5.74	44.70

Sl. No.	YEAR			Staff	Maintenance Expenses	Energy	Total
9	2041	-	2042	26.92	14.99	7.13	49.03
10	2042	-	2043	29.34	15.74	7.49	52.56
11	2043	-	2044	31.98	16.52	7.86	56.36
12	2044	-	2045	34.86	17.35	8.25	60.46
13	2045	-	2046	37.99	18.22	8.67	64.88
14	2046	-	2047	41.41	19.13	9.10	69.64
15	2047	-	2048	45.14	20.08	9.56	74.78
16	2048	-	2049	49.20	21.09	10.03	80.32
17	2049	-	2050	53.63	22.14	10.53	86.31
18	2050	-	2051	58.46	23.25	11.06	92.77
19	2051	-	2052	63.72	24.41	12.71	100.84
20	2052	-	2053	69.45	25.63	13.34	108.43
21	2053	-	2054	75.70	26.91	14.01	116.63
22	2054	-	2055	82.52	28.26	14.71	125.49
	Total			**845.90**	**388.03**	**182.87**	**1416.30**

19.3.2 Depreciation

Depreciation, being non cash expenditure, has not been considered for the purpose of computation of FIRR.

19.3.3 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 used in the system, it is expected that only 50% of the Signalling and Telecom equipments and 25% of electrical equipments would require replacement after 20 years of ROD. Based on this assumption, cost of replacement of these equipments has been provided in the 20th and 21st year of operation in following Table 19.4 below:

Table 19.4A Phase-I

Year	Replacement Cost
2049-50	128.17
2050-51	134.58
Total	**262.75**

Table 19.4B Phase-II

Year	Replacement Cost
2053-54	154.51
2054-55	162.24
Total	**316.75**

19.4 REVENUES

The Revenue mainly consists of fare box collection and other incomes from property business, advertisement, parking etc.

19.4.1 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.

19.4.2 Traffic

a. The projected ridership year wise figures are as indicated in table 19.5 as below: -

Table 19.5 Projected Ridership

Year	Trips per day (lakhs)
2027-28	0.22
2029-30	0.28
2031-32	0.33
2041-42	0.74
2051-52	0.82

b. Trip Distribution

The trip distribution amongst various fare slab is placed in Table 19.6 below: -

Table 19.6: Trip Distribution

Year/Distance in Km	0-2 km	2-5 km	5-12 km	12-21 km	21-32 km	21-32 km
2027	0.30%	2.39%	6.59%	17.95%	60.61%	12.16%
2031	0.24%	2.89%	7.34%	15.80%	53.12%	20.61%
2041	0.16%	2.72%	7.08%	15.94%	53.50%	20.60%
2051	0.18%	2.80%	7.06%	15.92%	53.44%	20.60%

19.4.3 Fare Structure

The following fare structure considered during traffic survey and ridership projections; have being used as base fare for calculation of Fare box revenue of the project. The Fare box revenue has been calculated by using an escalation factor @14% once in every two years on the base fare structure considering the average trend in the Consumer Price Index (CPI) and input costs of operation. While estimating revenue, it is presumed that 30% of the commuters will be using smart card and therefore 10% additional discount on smart card travellers has been considered. The fare structure assumed for the Year 2029 with an escalation @ 14% once in two years on the base fare structure as per the proposed fare slabs is shown in the Table 19.7 below:

Table 19.7 Fare Structure

Distance	Fare in 2024	Fare in 2029
0-2 Km	10	14
2-5 Km	20	28
5-12 Km	30	42
12-21 Km	40	56
21-32 Km	50	69
More than 32 Km	60	83

19.4.4 Other sources of revenues

19.4.4.1 Property Business: Revenues from Property Business and advertisement have been estimated at 10% of the fare box revenues during operations. Apart from development of property on metro stations and depot it is possible to raise resources through leasing of parking rights at stations, advertisement on trains and tickets, advertisements within stations and parking lots, advertisements on viaducts, columns and other metro structures, co-branding and naming rights to corporate, film shootings and special events on metro premises.

19.5 FINANCIAL INTERNAL RATE OF RETURN (FIRR)

The Financial Internal Rate of Return (FIRR) has been calculated for 30 years business cycle from start of Phase-I, and is placed in table 19.8. Separate FIRR for complete cycle of Phase-II has not been shown.

Table 19.8: FIRR

Figures in cr. (Rs.)

YEAR	Completion Cost	Replacement Cost	Fare Box Revenue	Non-Fare Box Revenue	Total Revenue	Running Exp	Net Cash Flow
25 - 26	151						-151
26 - 27	306						-306
27 - 28	320						-320
28 - 29	218						-218
29 - 30	208		45	5	50	13	-170
30 - 31	303		68	7	75	18	-247
31 - 32	318		82	8	90	19	-247
32 - 33	214		89	9	98	21	-137
33 - 34	55		110	11	121	43	23
34 - 35			119	12	131	53	78
35 - 36			147	15	161	57	104
36 - 37			159	16	175	61	114
37 - 38			198	20	218	65	152
38 - 39			215	21	236	70	166
39 - 40			265	27	292	75	217
40 - 41			288	29	317	80	236
41 - 42			356	36	392	88	304
42 - 43		-	360	36	396	94	301
43 - 44			416	42	457	101	356
44 - 45			420	42	462	108	354
45 - 46			484	48	532	116	416
46 - 47			489	49	538	125	413
47 - 48			562	56	619	134	484
48 - 49			568	57	625	144	481
49 - 50		128	656	66	721	155	439
50 - 51		135	663	66	729	166	428
51 - 52			763	76	840	181	659
52 - 53			771	77	848	194	654
53 - 54		155	887	89	976	209	612
54 - 55		162	896	90	986	225	599
Total	**2093**	**580**	**10076**	**1008**	**11083**	**2617**	**8.58%**

The various sensitivities with regard to increase/decrease in capital costs, O&M costs and fare-box revenues are placed in table 19.9 below.

Table 19.9: FIRR Sensitivity

Capital Cost			
10% increase in capital cost	**20% increase in capital cost**	**10% decrease in capital cost**	**20% decrease in capital cost**
7.87%	7.24%	9.37%	10.30%
REVENUE			
20% decrease in Fare Box revenue	**10% decrease in Fare Box revenue**	**10% increase in Fare Box revenue**	**20% increase in Fare Box revenue**
6.47%	7.58%	9.48%	10.31%
O&M COSTS			
10% increase in O&M cost		**10% decrease in O&M cost**	
8.31%		8.83%	

These sensitivities have been carried out independently for each factor.

19.6 FINANCING OPTIONS

19.6.1 Objectives of Funding: - The objective of funding of metro systems is not necessarily enabling the availability of funds for construction but coupled with the objective of financial closure are other concerns, which are of no less importance: -

- Ensuring low project cost
- Ensuring debt funds at low rates of interest
- Creating self-sustainable system in the long run by
  - Low infrastructure maintenance costs
  - Longer life span
  - Setting fares which minimise dependence on subsidies
- Recovering returns from both direct and indirect beneficiaries

Rail based mass transit systems are characterised by heavy capital investments coupled with long gestation period leading to low financial rates of return although the economic benefits to the society are immense. Such systems generate externalities, which do not get captured in monetary terms and, therefore, do not flow back to the system. However, experience all over the world reveals that both construction and operations of metro are highly subsidised. Therefore, government involvement in the funding of metro systems is a foregone conclusion. Singapore Metro had a 100% capital contribution from the Government, Hong Kong Metro had 78% for the first three lines and 66% for the later 2 lines. The Delhi, Chennai, Bengaluru, Mumbai Line-3 metros are funded with a mixture of equity and debt by GOI & concerned State Governments.

19.6.2 Since the governing objective of setting up these systems is social, the fares have to be set at levels which are publicly and politically acceptable thus setting in the vicious cycle of deficits leading to a fallback on subsidies/government support.

19.7 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 (SPV) under the Government Control (Delhi Metro Rail Corporation (DMRC) /Bangalore Metro Rail Corporation (BMRC))

(ii) Design, Build, Finance, Operate & Transfer (DBFOT)

i) SPV model

It is assumed that the funding of the corridor would be on similar lines as per the funding patterns of already running lines of Gujarat Metro. Besides, land including R&R should be made available free from all encumbrances by the State Government Authorities when the project starts. Accordingly, the funding pattern under SPV model assumed is placed in table 19.10 as under: -

Table 19.10A: Funding pattern SPV Model Phase I

Sources of Funds	Amount (Rs/Crore)	% contribution
Equity from Govt. of India	145.52	**15.34%**
Subordinate debt for Central Taxes by Govt. of India	44.20	**4.66%**
Equity from Government of Gujarat	145.52	**15.34%**
Subordinate debt for Central Taxes by Govt. of Gujarat	44.20	**4.66%**
PTA against Bilateral/Multilateral Loan	569.15	**60.00%**
Sub Total	**948.59**	**100.00%**
Land Cost to be borne by Govt. of Gujarat	27.92	
State Taxes to be borne by Govt. of Gujarat	74.13	
Project Completion Cost	**1050.64**	
Interest during construction (IDC) on Bilateral/ Multilateral Loan	16.71	
Completion Cost including IDC	**1067.55**	

The funding plan proposed under SPV model in Table 19.10A is graphically presented as under:

Funding pattern on SPV model Phase I

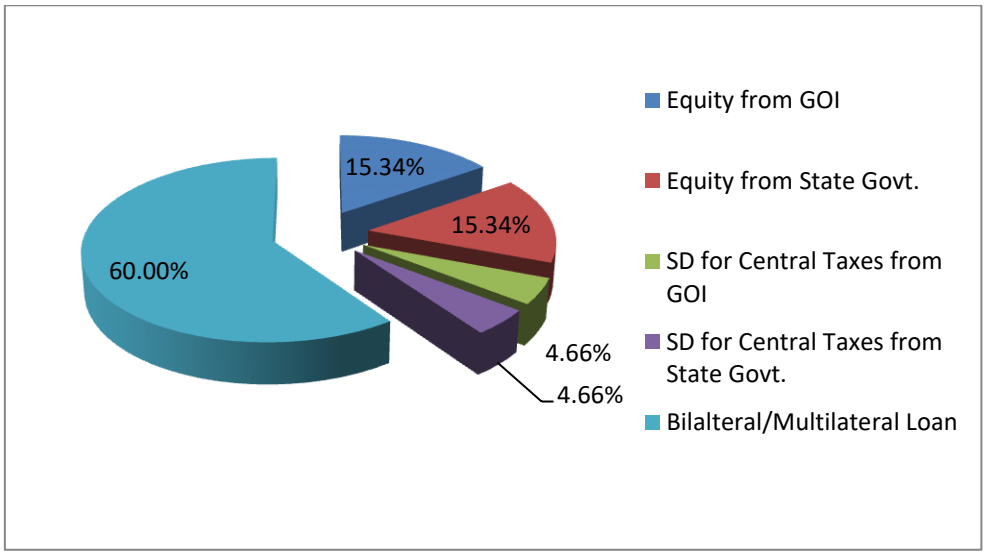
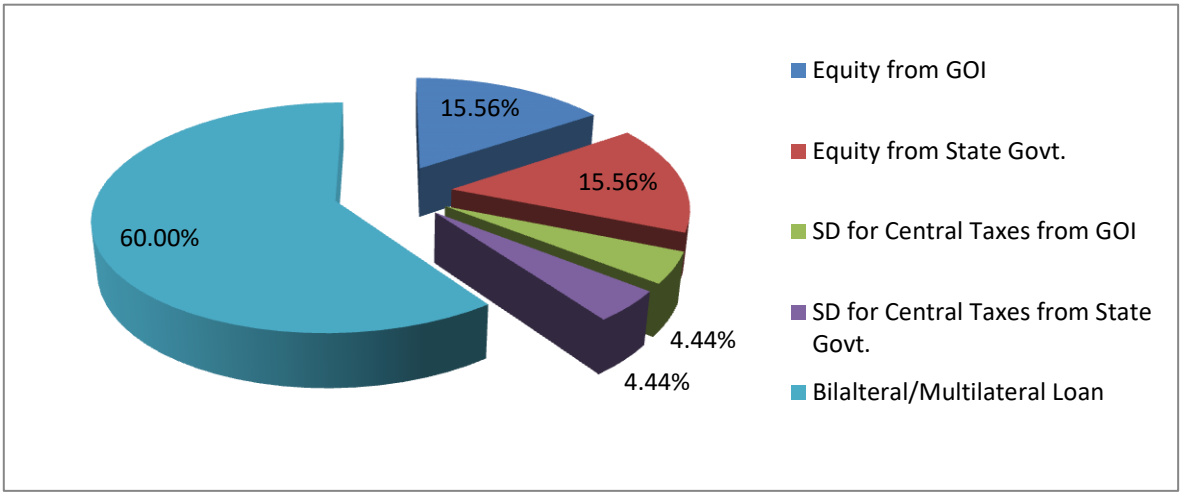


Table 19.10 B: Funding pattern SPV Model Phase II

Sources of Funds	Amount (Rs/Crore)	% contribution
Equity from Govt. of India	145.10	**15.56%**
Subordinate debt for Central Taxes by Govt. of India	41.41	**4.44%**
Equity from Government of Gujarat	145.10	**15.56%**
Subordinate debt for Central Taxes by Govt. of Gujarat	41.41	**4.44%**
PTA against Bilateral/Multilateral Loan	559.54	**60.00%**
Sub Total	**932.56**	**100.00%**
Land Cost to be borne by Govt. of Gujarat	35.62	
State Taxes to be borne by Govt. of Gujarat	73.90	
Project Completion Cost	**1042.08**	
Interest during construction (IDC) on Bilateral/Multilateral Loan	16.42	
Completion Cost including IDC	**1058.76**	

The funding plan proposed under SPV model in Table 19.10B is graphically presented as under:

Funding patter on SPV model Phase II



ii) Design-Build-Finance-Operate-Transfer (DBFOT) Model:-

In this model, the private firm will be responsible for designing, building, financing, operating and maintaining the entire project for the period of concession. Ownership of the Project shall be transferred to Government after the concession period. Apart from equity contribution from the promoters, it is assumed that the funding for the project shall be achieved through market borrowings. The rate of interest on market borrowings is assumed at 12% p.a. The Metro Rail being a social sector project, not many private parties are likely to bid for such a project. Besides, the private operator may demand assured rate of return on its equity, which is in the range of 20% p.a. to 22% p.a. (pre-tax) or a comfort of guaranteed ridership, sweeteners in the form of huge parcels of land free of cost for commercial exploitations. Viability Gap Funding (VGF) shall be required from Govt. of India as well as Govt. of Gujarat to ensure an Equity IRR of approx. **16%** for the Concessionaire. The funding pattern under the above model has been worked out with a pre-tax Equity Internal Rate of Return (EIRR) @ 16% is shown in the table 19.11 below:

Table 19.11 Funding pattern under DBFOT model (both phases)

Particulars	Amount (Rs/Crore)	% of contribution
VGF by GOI	376.23	20.00%
VGF by Govt. of Gujarat	392.20	20.85%
Equity by Concessionaire	370.91	19.72%
Concessionaire's Debt	741.81	39.43%
Sub-Total (A)	**1881.15**	**100.00%**
Land including R&R by State Government	63.54	
State Taxes by State Government	148.03	
Sub-Total (B)	**2092.72**	
Interest during construction (IDC) on Debt	358.52	
Total including IDC	**2451.24**	

The total fund to be contributed by GOI & GoG, excluding bilateral/multilateral loan, is shown in Table 19.12 below under SPV and BOT mode.

Table 19.12 *Rs. In crore*

Particulars	SPV Model	DBFOT
GOI	376.23	376.23
Govt. of Gujarat	587.80	603.77
Total	**964.03**	**980.00**

19.8 RECOMMENDATIONS

The project is operationally viable as the FIRR for a period of 30 years period including construction period with all the taxes is **8.58%**. However, FIRR is not the only criteria to take up the metro project. As per Metro Rail Policy 2017, issued by the Ministry of Housing and Urban Affairs, 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. Considering the positive FIRR as well as social considerations of requirement of reliable public transport, the project is recommended for its implementation.

From Table 19.12, it is evident that the VGF required to be contributed by GOI & GoG for executing the project through a DBFOT operator is higher as compared to the SPV model. The fund requirement under DBFOT model has been made with the assumption of 16% pre-tax EIRR. However, the DBFOT operator may expect the pre-tax EIRR of at least 20%, in such a situation, the VGF amount will only increase further. Therefore, it is recommended to implement the project through SPV model as per the funding pattern shown in Table 19.10.

YEAR		Completion Cost	Additional Cost	Replacement Cost	Fare Box Revenue	Non Fare Box Revenue	Total Revenue	Running Exp	Net Cash Flow	Completion Cost	Phase I													Completion Cost	Phase II												
											Equity from GoI	SD for CT from GOI	SD for Land by SG	Equity by SG	SD for CT from State Govt.	SD for ST from State Govt.	Cash Availability	External Loan	Cummulative Loan	IDC	Repayment	Balance Loan	Interest		Equity from GoI	SD for CT from GOI	SD for Land by SG	Equity by SG	SD for CT from State Govt.	SD for ST from State Govt.	Cash Availability	External Loan	Cummulative Loan	IDC	Repayment	Balance Loan	Interest	Cash Balance
2025	2026	151							-151	-151	36	11	9.31	36	11	19	-29	29	29	0	0	29											-	-	-	-		-
2026	2027	306							-306	-306	36	11	9.31	36	11	19	-183	183	212	2	2	212											-	-	-	-		-
2027	2028	320							-320	-320	36	11	9.31	36	11	19	-198	198	409	5	5	409											-	-	-	-		-
2028	2029	218							-218	-218	36	11		36	11	19	-104	104	513	7	7	513											-	-	-	-		-
2029	2030	208			45	5	50	13	-170	-56							-56	56	569	2	2	569	6	-152	36.27	10.35	11.87	36.27	10.35	18.47	-28.07	28.07	28.07	0.21	0.21	28.07	-	30.75
2030	2031	303			68	7	75	18	-247													569	9	-303	36.27	10.35	11.87	36.27	10.35	18.47	-179.87	179.87	207.94	2.13	2.13	207.94	-	48.06
2031	2032	318			82	8	90	19	-247													569	9	-318	36.27	10.35	11.87	36.27	10.35	18.47	-194.28	194.28	402.22	4.96	4.96	402.22	-	62.09
2032	2033	214	-		89	9	98	21	-137													569	9	-214	36.27	10.35		36.27	10.35	18.47	-102.36	102.36	504.58	7.01	7.01	504.58	-	68.45
2033	2034	55			110	11	121	43	23													569	9	-55							-54.95	54.95	559.54	2.11	2.11	559.54	6.29	62.99
2034	2035				119	12	131	53	78													569	9										559.54			559.54	8.39	60.81
2035	2036				147	15	161	57	104												28	541	8										559.54		-	559.54	8.39	59.23
2036	2037				159	16	175	61	114												28	512	8										559.54		-	559.54	8.39	69.44
2037	2038				198	20	218	65	152												28	484	7										559.54		-	559.54	8.39	107.95
2038	2039				215	21	236	70	166												28	455	7										559.54		-	559.54	8.39	122.32
2039	2040				265	27	292	75	217												28	427	7										559.54		27.98	531.56	8.18	145.69
2040	2041				288	29	317	80	236												28	398	6										559.54		27.98	503.58	7.76	166.08
2041	2042				356	36	392	88	304												28	370	6										559.54		27.98	475.61	7.34	233.97
2042	2043		-		360	36	396	94	301												28	341	5										559.54		27.98	447.63	6.92	232.63
2043	2044				416	42	457	101	356												28	313	5										559.54		27.98	419.65	6.50	288.34
2044	2045				420	42	462	108	354												28	285	4										559.54		27.98	391.68	6.08	286.68
2045	2046				484	48	532	116	416												28	256	4										559.54		27.98	363.70	5.67	349.74
2046	2047				489	49	538	125	413												28	228	4										559.54		27.98	335.72	5.25	347.68
2047	2048				562	56	619	134	484												28	199	3										559.54		27.98	307.75	4.83	419.97
2048	2049				568	57	625	144	481												28	171	3										559.54		27.98	279.77	4.41	417.42
2049	2050			128	656	66	721	155	439												28	142	2										559.54		27.98	251.79	3.99	375.77
2050	2051			135	663	66	729	166	428												28	114	2										559.54		27.98	223.81	3.57	366.27
2051	2052				763	76	840	181	659												28	85	1										559.54		27.98	195.84	3.15	597.64
2052	2053		-		771	77	848	194	654												28	57	1										559.54		27.98	167.86	2.73	593.77
2053	2054			155	887	89	976	209	612												28	28	1										559.54		27.98	139.88	2.31	552.67
2054	2055			162	896	90	986	225	599												28	-0	0										559.54		27.98	111.91	1.89	540.24
Total		2,093	-	580	10,076	1,008	11,083	2,617	5,794	-1,051	146	44	28	146	44	74	-569	569	1,732	17	586		134	-1,042	145.10	41.42	35.62	145.10	41.42	73.90	-559.54	559.54	13,452.63	16.42	464.05	9,647.78	128.83	6,606.64
									8.58%																												

Chapter - 20

Economic Appraisal



20.1 Introduction

20.2 Assessment Methodology

20.3 Values Adopted for Some Important Variables

20.4 Economic Benefits

20.5 Construction Cost

20.6 Economic Performance Indicators

20.7 Sensitivity Analysis

20.8 Quantified Benefits



Chapter – 20

ECONOMIC APPRAISAL

20.1 INTRODUCTION

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

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

In highway construction projects, 'without' is taken as "base case" and 'with' implies 'alternative case'. In 'alternative case' a portion of traffic on the road is diverted to a new road which is estimated first. Then the difference between maintenance & construction cost for 'base case' and for 'alternative case' which is known as relative road agency cost (RAC) is derived. Difference between road user cost for 'base case' and of 'alternative case' is also derived which is known as relative road user cost (RUC). Difference between RAC and RUC calculated for each year generates net benefit stream. Economic indicators (EIRR, BC Ratio, NPV) are the obtained.

In metro projects, same principal is followed but procedure is slightly different. Here, diverted traffic is nothing but the passengers shifted from road based modes to metro. Travel time saving is the difference between time which would be taking on metro and road based transports for same distance. Fuel cost saving is the difference between the cost of the fuel burnt on road based modes by the shifted passengers and the energy cost of running the metro rail which is a part of the maintenance cost. Thus, benefits are directly obtained by correlating with them with the passenger km (ridership and average trip length is multiplied to get passenger km). As is done in highway projects, net benefit is obtained by subtracting the cost of the project (incurred for construction (capital) and maintenance (recurring) costs for the metro line) from the benefits derived from pass km savings in each year. The net benefit value which would be negative during initial years becomes positive as years pass. Internal rate of return and benefit cost ratio are derived from the stream.

The sources from where economic savings occur are identified first. Although there are many kinds of primary, secondary and tertiary benefits, only the quantifiable components can be taken to measure the benefits. These components are quantified by linking with the number of passengers shifted and the passenger km saved by the trips which are shifted from road/ rail based modes to metro. It may be observed that first three (no 3-5, given in the table below) are direct benefits due to shifting of trips to metro, but other secondary benefit components are due to decongestion effect on the road, reduction of emission, accident, saving of fuel and time by remaining road passengers and road maintenance cost.

Cost components are first estimated applying market values then distributed year wise after applying escalation factors. Tax components are also added for arriving at real completion cost. For financial analysis these exercises are necessary, but for economic analysis all additional cost components are to be removed.

Values of Benefit components are mostly Economic values except fuel and vehicle maintenance cost which are estimated from market cost. Economic factors as per Appraisal Guidelines for Metro Rail Project Proposals, 2017; which are used for each cost/ benefit component are also given in the table below. Overall economic value of benefit components is 95.66% of the actual estimated value whereas overall economic value of cost components is 84.98% of the actual estimated cost.

Table 20.1 Summary of Estimated EIRR

S. No.	Cost/ Benefit Components	Economic Factors*
1	Construction Cost	83%
2	Maintenance Cost	87%
3	Annual Time Cost Saved by Metro Passengers	100%
4	Annual Fuel Cost Saved by Metro Passengers	90%
5	Annual Vehicle Operating Cost Saved by Metro Passengers	90%
6	Emission Saving Cost	100%
7	Accident Cost Saving	90%
8	Annual Time Cost Saved by Road Passengers	100%
9	Annual Fuel Cost Saved by Road Passengers	90%
10	Annual Infra Structure Maintenance Cost	87%

** As per Appraisal Guidelines for Metro Rail Project Proposals, 2017*

20.2 ASSESSMENT METHODOLOGY

Economic appraisal for the study 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, wherever applicable. In favour 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. The net cost of

the project leading to appropriately discounted net present value and benefit ratio are assessed along with the Economic Internal Rate of Return to assess economic viability of the project. The adopted framework for economic analysis is shown in the following figure.

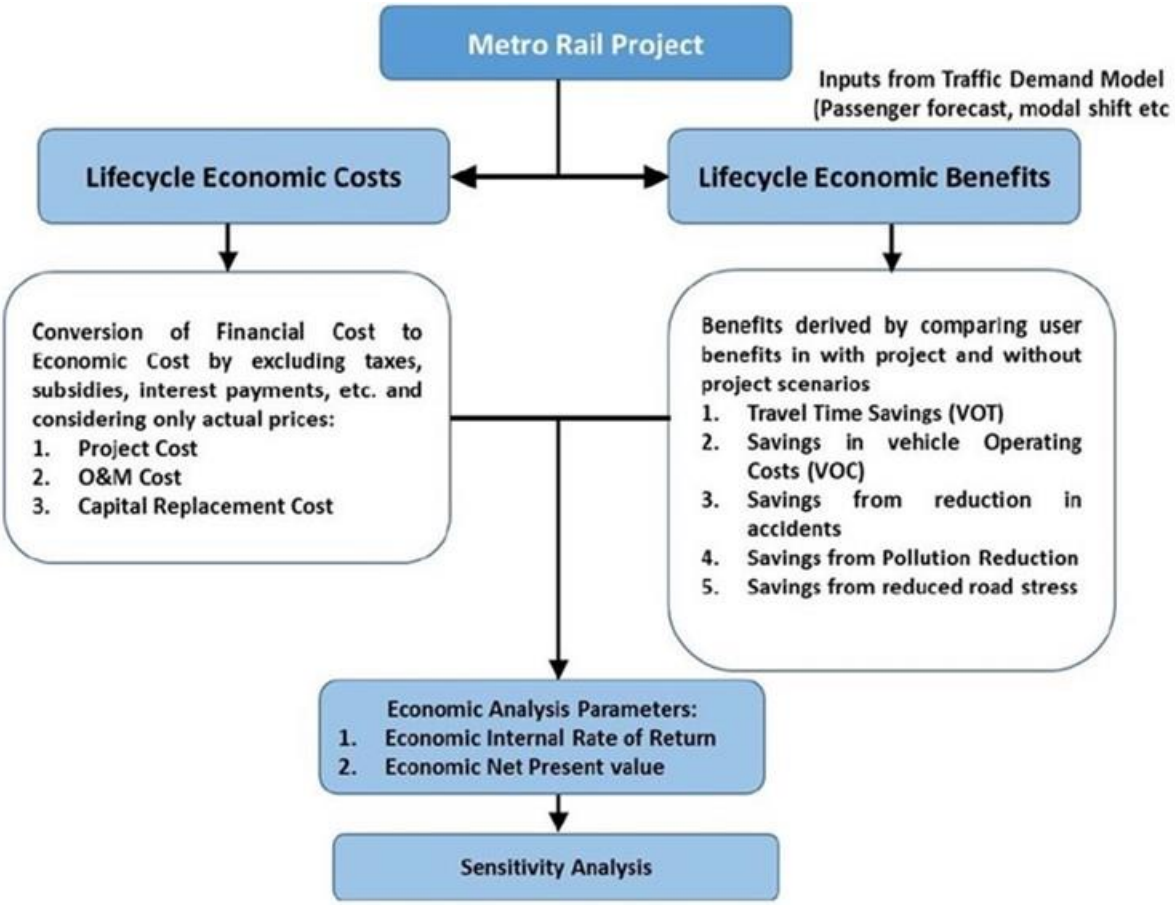


Figure 20.1 Analytical Framework for Economic Appraisal

20.3 VALUES ADOPTED FOR SOME IMPORTANT VARIABLES

Benefit components are converted (by applying appropriate unit cost) to money values (Rs.). Derivation procedures of some of the values used for economic analysis are shown in the table below.

Table 20.2 Values Adopted for Some Important Variables

S. No.	Important Variables	Values
1	Value of travel time is estimated from the weighted average income of the population for base year 2021. https://timesofindia.indiatimes.com/city/ahmedabad/gujarats-per-capita-income-is-2-76l-indias-1-72l-cag/articleshow/99130620.cms	Rs. 1.92/min
2	Vehicle Operating Cost per km (Derived from Life Cycle Cost of different passenger vehicles)	Table 20.3
3	Emission (gm/km as per CPCB and UK Norms) Emission	Table 20.4

	Saving Cost (adopted for Indian conditions in Rs/tonne).	
4	Fuel prices used (Rs./ltr or Rs./kg)	Table 20.5
5	Accident Rate (No of fatal and all accidents per one Cr. km).	Table 20.6
6	Fuel Consumption of vehicles at a given speed is derived from Road User Cost Study Model (CRRI-2010)	Figure 20.1
7	Infra Structure Maintenance Cost is derived from published values on annual expenditure on roads and traffic and annual vehicle-km	Rs. 1Cr./ vehicle- km
8	Average Journey Time Saved for average trip length (km) journey after Shifting (Derived from modal split -Table 20.8 and speed and delay survey)	13.35 min

Table 20.3 Vehicle Operating Cost (2023) in Rs.

Cost per Vehicle-km	Bus	Four Wheeler (Large)	Four Wheeler (Small)	Two Wheeler	Three Wheeler (Auto)	Mini Bus
Maintenance Cost	13.76	9.77	6.94	1.53	2.89	8.37
Capital Cost	9.61	5.34	2.67	0.24	0.72	6.87
Vehicle Operating Cost (VOC)	23.37	15.11	9.61	1.77	3.61	15.23

Table 20.4 Vehicle Emission (gm/lit.) 2011-2021 (CPCB) and Treatment Costs (As per Appraisal Guidelines for Metro Rail Project Proposals, MoHUA)

Vehicle Type	CO	HC	NO_X	PM	CO	CO_2
Bus	3.72	0.16	6.53	0.24	3.72	787.72
Two Wheeler-2 Stroke	1.4	1.32	0.08	0.05	1.4	24.99
Two Wheeler-4 Stroke	1.4	0.7	0.3	0.05	1.4	28.58
Mini Bus	2.48	0.83	8.26	0.58	2.48	358.98
Four Wheeler (Small)	1.39	0.15	0.12	0.02	1.39	139.51
Four Wheeler (Large)	0.58	0.05	0.45	0.05	0.58	156.55
Tata Magic	1.24	0.17	0.58	0.17	1.24	160
Three Wheeler (Auto)	2.45	0.75	0.12	0.08	2.45	77.89
Treatment Cost (Rs./tonne)	1,00,000					500

Table 20.5 Fuel Prices Used

Fuel Type	Fuel Prices in Rs. (As on 19.02.2024)
Petrol (Rs./l)	96.42
Diesel (Rs./l)	92.17
CNG (Rs./kg)	77.59

Table 20.6 Unit Cost of Accident in 2004 (As per Appraisal Guidelines for MRPs, MoHUA)

Type of Accident	Cost (Rs.) *	Accident Rate per Year **
Fatal accidents	4,37,342	372
All other type of accidents	64,256	924

*Source: * Appraisal Guidelines for Metro Rail Project Proposals, MoHUA. ** Road Accidents in India 2021 by Govt. of India, Ministry of Road Transport and Highways, Transport Research Wing, New Delhi*

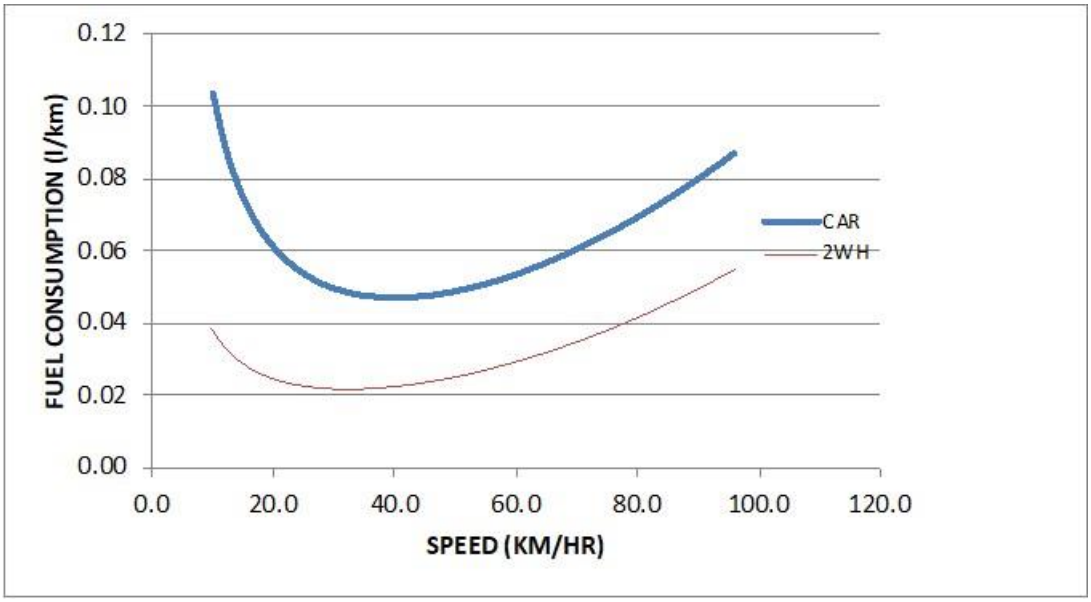


Figure 20.2 Fuel Consumption at Different Speed for Car and Two Wheeler

Table 20.7 Traffic Summary Used for Economic Analysis

Particulars	2029	2031	2041	2051
Total Motorised Trips/ Day (for catchment area)	4,35,103	4,47,382	5,00,374	5,56,061
Total Boarding (Ridership)/ Day of Proposed Corridor	26,881	32,567	73,868	82,054
Average Trip Length (km) of Proposed Corridor	24.87	25.23	25.33	25.31
Metro Passenger-km of Proposed Corridor	6,68,601	8,21,665	18,71,076	20,76,787

Table 20.8 Estimated Mode Share in the Study Area in 2023

Particulars	2027
Bus	11.93%
Car/ Taxi	20.69%
Auto Rickshaw	8.62%
Two Wheeler	51.28%
Share Auto	3.69%
Metro	3.78%

20.4 ECONOMIC BENEFITS

For deriving the values of economic indicators (EIRR, NPV, BCR), cost and benefit stream table is constructed in terms of money value. Socio-Economic Benefits are first quantified and converted in to money cost. All Benefit component values (economic) accrued between the years 2029-2054 are shown in figure below which shows that benefits are mainly coming from saving of travel time by proposed metro system and road passengers (57.74%), fuel saving cost (10.35%), vehicle maintenance cost (23.01%) and Environmental benefit from emission reduction, accident reduction and road maintenance cost (altogether) is 8.91%.

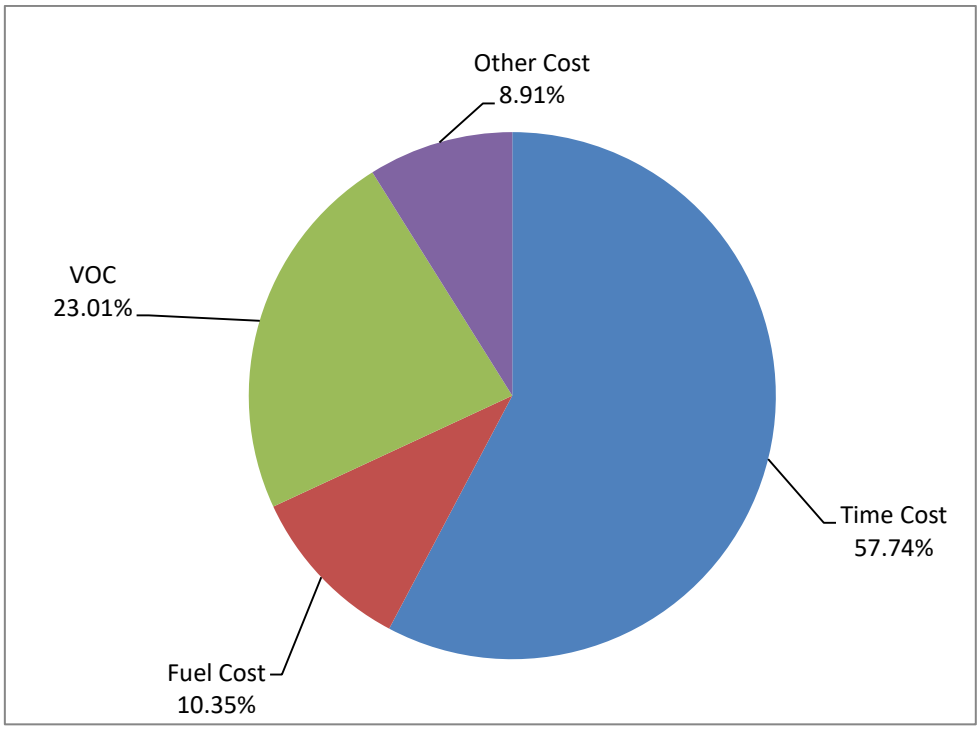


Figure 20.3 Percentage Share of Accrued Economic Benefits

Benefits are obtained directly from the projected passenger km saved for the horizon years (shown in the table above) and the values for other years are interpolated and extrapolated on the basis of projected traffic. Benefit Components Stream for proposed line is shown in the table below.

Table 20.9 Component-wise Different Economic Benefit Value in Rs. Crore

From	To	Annual Travel Time Cost Save	Annual Vehicle Operating Cost Save by Metro Passengers	Annual Fuel Cost Save by Metro Passengers	Annual Emission Cost Saving	Annual Accident Cost Saving	Annual Fuel Cost Save by Road Passengers	Annual Infrastructure Cost Saving	Total Benefits
2029	2030	45.67	33.85	24.62	2.47	4.38	4.78	6.47	122.24
2030	2031	65.70	51.60	27.49	2.85	5.00	4.98	7.48	165.11
2031	2032	95.98	50.24	34.11	3.29	6.35	5.77	9.94	205.68
2032	2033	108.68	55.12	37.24	3.75	7.16	5.76	11.33	229.05
2033	2034	123.11	60.48	40.66	4.28	8.08	5.75	12.91	255.28
2034	2035	139.52	66.36	44.39	4.88	9.12	5.75	14.71	284.72
2035	2036	158.17	72.81	48.46	5.56	10.29	5.74	16.76	317.79
2036	2037	179.37	79.89	52.91	6.33	11.61	5.73	19.10	354.94
2037	2038	203.48	87.66	57.76	7.22	13.09	5.72	21.77	396.71
2038	2039	230.90	96.18	63.06	8.22	14.77	5.71	24.81	443.67
2039	2040	262.10	105.53	68.85	9.37	16.67	5.70	28.28	496.50
2040	2041	297.59	115.79	75.17	10.68	18.80	5.70	32.22	555.95
2041	2042	337.97	167.05	73.86	12.17	19.09	5.12	31.95	647.21
2042	2043	370.41	177.26	75.81	12.91	20.05	5.23	33.90	695.58
2043	2044	405.98	188.09	77.82	13.70	21.05	5.35	35.97	747.96
2044	2045	444.97	199.58	79.87	14.54	22.11	5.47	38.17	804.71
2045	2046	487.71	211.77	81.98	15.43	23.22	5.59	40.50	866.21
2046	2047	534.57	224.71	84.15	16.37	24.38	5.72	42.97	932.88
2047	2048	585.95	238.44	86.38	17.37	25.60	5.85	45.60	1005.18
2048	2049	642.27	253.01	88.66	18.43	26.88	5.98	48.39	1083.62
2049	2050	704.03	268.46	91.00	19.56	28.23	6.11	51.34	1168.74
2050	2051	771.73	284.87	93.41	20.75	29.65	6.25	54.48	1261.14
2051	2052	845.97	302.27	95.88	22.02	31.13	6.39	57.81	1361.47
2052	2053	923.80	320.74	102.38	23.37	32.76	6.94	61.34	1471.32
2053	2054	1008.82	340.33	109.32	24.79	34.46	7.54	65.09	1590.35
2054	2055	1101.67	361.12	116.73	26.31	36.26	8.19	69.06	1719.34

20.5 CONSTRUCTION COST

Total cost of construction (Completion cost) is derived after considering cost of all major components such as relocation and rehabilitation (RR), civil construction, stations, cable infrastructure, signaling and telecommunication, power traction line, man power etc. (Recurring cost) includes energy cost, maintenance cost, and operation cost. These costs are inclusive of central tax and yearly escalation cost applied on fixed cost. Analysis period is taken from 2025-26 to 2054-55 out of which 8 years (2025-26 to 2029-30) are marked as construction period. During the years 2048-50 and 2052-54 replacement cost will again be required for repairing and replacement. Operation is expected to start in 2029-30 (5th Year). To obtain economic value of cost, all taxes and escalation factors are removed from the completion cost. Reduction factor (completion to economic) is derived as 84.98%. While estimating the cost, design charges are kept as 5% and contingency charges are kept as 3%. Cost stream generated for both options are shown in the table below.

Table 20.10 Estimated Completion and Recurring Cost in Rs. Crore

From	To	Completion Cost		Economic Cost	
		Capital Cost	Maintenance Cost	Capital Cost	Maintenance Cost
2025	2026	151	0	126	0
2026	2027	306	0	254	0
2027	2028	320	0	266	0
2028	2029	218	0	181	0
2029	2030	208	13	172	11
2030	2031	303	18	252	16
2031	2032	318	19	264	17
2032	2033	214	21	178	18
2033	2034	55	43	46	37
2034	2035	0	53	0	46
2035	2036	0	57	0	50
2036	2037	0	61	0	53
2037	2038	0	65	0	57
2038	2039	0	70	0	61
2039	2040	0	75	0	65
2040	2041	0	80	0	70
2041	2042	0	88	0	77
2042	2043	0	94	0	82
2043	2044	0	101	0	88
2044	2045	0	108	0	94
2045	2046	0	116	0	101
2046	2047	0	125	0	109
2047	2048	0	134	0	117
2048	2049	0	144	0	125
2049	2050	128	155	106	135
2050	2051	135	166	112	145
2051	2052	0	181	0	157
2052	2053	0	194	0	169
2053	2054	155	209	128	182

From	To	Completion Cost		Economic Cost	
		Capital Cost	Maintenance Cost	Capital Cost	Maintenance Cost
2054	2055	162	225	135	196

20.6 ECONOMIC PERFORMANCE INDICATORS

After generating the cost and benefit stream tables, values of economic indicators are derived and are given in the table below. Project period is 2025 to 2054. On the basis of economic cost, EIRR is 17.61%, B/C Ratio is 4.27 and NPV is Rs. 1,348 Cr. As per the Appraisal Guidelines for Metro Rail Project Proposals, a project is considered viable when the ENPV is 14% or above.

Table 20.11 Economic Indicator Values (on 2054-55)

Economic Indicators	Economic Price
Total cumulative cost	4,495
Total cumulative benefit	19,183
Benefit Cost Ratio	4.27
NPV	1,348
EIRR	**17.61%**

20.7 SENSITIVITY ANALYSIS

Sensitivity test on EIRR and B/C ratios was carried out and the output is given in the table below. Year 2054-55 is taken for the year of comparison. Sensitivity analysis with probable contingencies has been carried out. Calculated EIRR for all these conditions are show in the table below.

Table 20.12 Sensitivity of EIRR

Sensitivity		Parameter		
Traffic	Cost	EIRR	B/C Ratio	Cost (Rs. Cr.)
0%	0%	17.61%	4.27	4495
-10%	0%	16.98%	4.03	4495
-15%	0%	16.65%	3.92	4495
0%	10%	16.16%	3.82	5024
0%	15%	15.51%	3.63	5288
-10%	10%	15.54%	3.61	5024
-15%	15%	14.59%	3.33	5288

20.8 QUANTIFIED BENEFITS

20.8.1 Environmental Benefits

Environmental Benefits monitory values are shown in previous tables. These benefits are estimated (in terms of quantity) first and then converted into money value. For brevity, only 5 year estimates are shown in the table below (Reduction of Vehicle gas

Emission). It is seen that in 2029, CO_2 gas emission saving will be 3.7 thousand ton. Other emissions are toxic gases which will also be reduced due to less emission from the vehicles.

Table 20.13 Environmental Benefits Quantified (Tonnes per Year)

Environmental Factors	2029	2031	2041	2051
CO	83.1	100.7	228.5	253.8
HC	33.3	40.3	91.4	101.5
NO_X	7.2	8.7	19.8	21.9
PM	1.8	2.2	5.0	5.6
SO_2	0.2	0.2	0.4	0.5
CO_2	3724.9	4512.8	10235.8	11370.1
Total Emission Saved	**3850.5**	**4664.9**	**10580.9**	**11753.4**

20.8.2 Travel Benefits

Quantified Travel Benefits are shown in the table below. It may be seen that in 2029, Time saving will be 0.22 Cr (1 Cr. =10 million) hours, fuel saving 2.95 thousand tons. Amount of travel in terms of road passenger vehicle-km reduced (due to shifting to Metro Rail) is 1.19 thousand vehicle km. Around 24 fatal accidents and 60 other accidents may also be avoided. Hence it is expected that there will be some improvement of the overall ambience of the city.

Table 20.14 Travel Benefits Quantified

Quantified Benefits in Horizon Years	2029	2031	2041	2051
Annual Time Saved by Metro Passengers (in Cr. Hr.)	0.22	0.46	1.05	1.63
Annual Fuel Saved by Metro Passengers (in thousand tons)	2.95	3.68	8.86	11.51
Daily vehicles reduced (off the road)	16,389	19,856	45,037	50,028
CO_2 reduced (in thousand tons)	3.72	4.51	10.24	11.37
Other gases reduced (in thousand tons)	0.13	0.15	0.35	0.38
Reduced No of Fatal Accidents in Year	24	28	58	58
Reduced No of Other Accidents in year	60	71	145	145
Daily Vehicle-km Reduced (in thousand km)	1.19	1.44	3.28	3.64

Chapter – 21

Transit Oriented Development (TOD) and Value Capture Finance (VCF)



21.1 Background

21.2 Objectives of TOD

21.3 Principles of TOD

21.4 Approach for TOD Implementation

21.5 Potential of TOD and VCF in Ahmedabad Metro Phase – II B Corridors



Chapter – 21

Transit Oriented Development (TOD) and Value Capture Finance (VCF)

21.1 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.

21.2 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.

21.3 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 21.1 and 21.2, for realizing the objectives of TOD.



Figure 21.1: TOD Principles

21.4 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 21.2: TOD Support Principles Tools

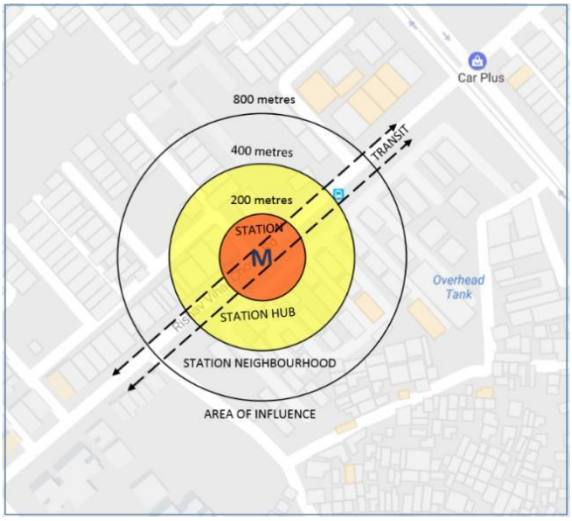


Figure 21.3: TOD Influence Zone

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 will follow 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 21.1 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 21.1. 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	Area/Project-based

S. No.	Value Capture Method	Frequency of Incidence	Scale of Intervention
		initiation	
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.

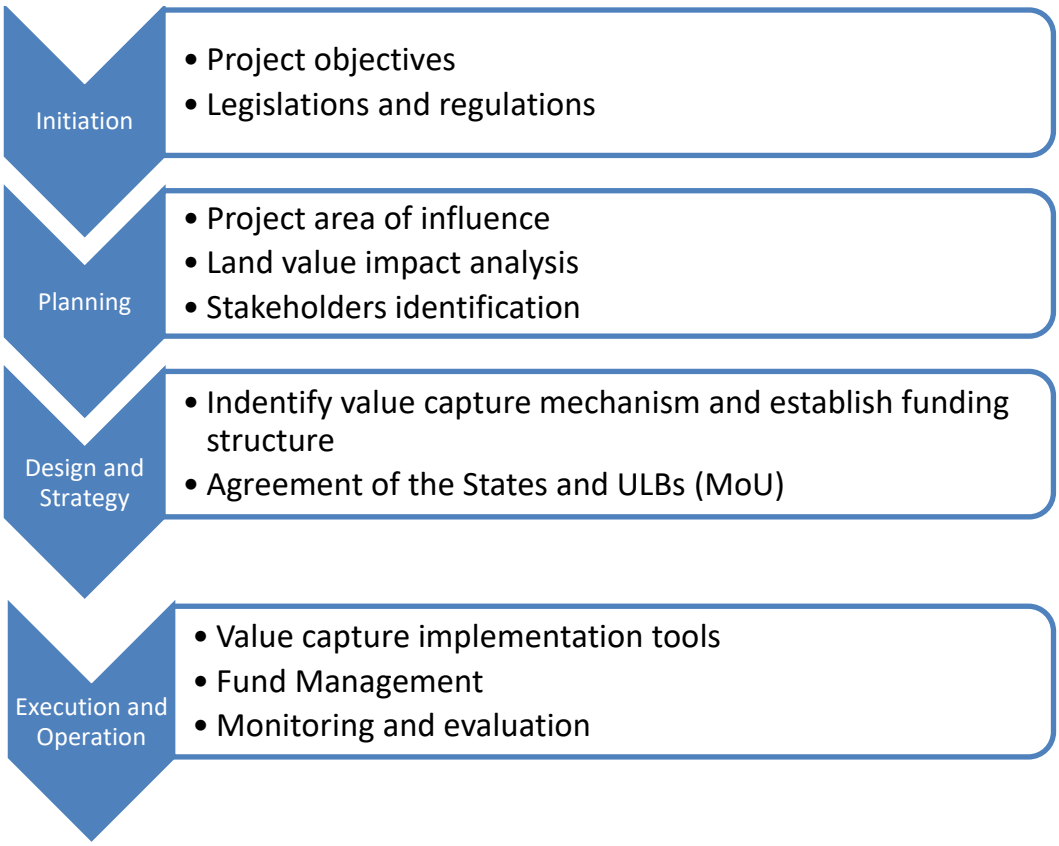


Figure 21.4: Steps Required for Project-based VCF

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 tax or one time betterment levy, development charges or impact fee5, transfer of development rights (TDRs), 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.

21.5 POTENTIAL OF TOD AND VCF IN AHMEDABAD METRO PHASE – II B CORRIDOR

GMRC may explore possibility of capturing land value by selling higher FSI in the corridor influence area. Further, various Value Capture Methods such as Land Value Tax, Fees for changing land use, Betterment levy, etc. as detailed in earlier paras may be adopted by GMRC as suitable for generating revenue. State TOD policy or guidelines, if any issued by Government of Gujarat (GoG) may be followed for Transit Oriented Development and Value Capture Financing.

Chapter – 22

Cyber Security



22.1 Introduction

22.2 Scope

22.3 Overview Of Domains Of Cyber Security

22.4 Data And Information Security

22.5 Physical Security

22.6 Identity, Access And Privilege Management

22.7 Application Security

22.8 Network & Infrastructure Security

22.9 Virtualization Security

22.10 Cyber Security Audit

22.11 Vulnerability Assessment

22.12 Governance



CHAPTER – 22

CYBER SECURITY

22.1 INTRODUCTION

Strong cyber security is an important component of Digital Strategy enabling the effective use of emerging technologies and ensuring confidence in the services.

Cyber Security is becoming more important as cyber risked contraire to evolve. It becoming more challenging due to increased thrust on distribution which increasing cyber connectivity.

Cyber security is a complex and multifaceted issue, where details relating to vulnerabilities, threat, risk, mitigation, or other factors are likely to be highlighted contextually to a specific organization and its operations.

22.2 SCOPE

The scope was designed to focus on metro-specific systems and cyber problems which could cause major (or exacerbate) disruption. Metro Rail system can be categorized into OT (Operation technology) system and IT (Information Technology) system.

- OT (Operation technology) system includes SCADA, CBTC, passenger information, maintenance management and other proprietary systems at the heart of metro operation.
- Information Technology (IT) systems includes corporate computer networks, fare collection system, payment systems and ERP which are not unique to metros and general in nature.

22.3 OVERVIEW OF DOMAINS OF CYBER SECURITY

Data Security - Protection of data from unauthorized, accidental or intentional modification, destruction, or disclosure.

Physical Security - It describes security measures that are designed to deny unauthorized access to facilities, equipment and resources and to protect personnel and property from any damage or harm.

Identity, Access and Privilege Management - It is about safeguarding data by protecting who has access to the systems; and what they are allowed to do.

Application Security - It involves suitable application security measures to protect

information of the organization which can be compromised or exposed if applications are not securely designed, developed, tested, configured and deployed.

Network and Infrastructure Security - It is used to manage and restrict access to the network, application security, email security, firewalls, antivirus, intrusion prevention systems, and VPNs (Virtual Private Network) etc.

Virtualization Security - It describes collective measures, procedures and processes that ensure the protection of a virtualized infrastructure / environment.

Governance - It describes various security measures to ensure timely identification, prioritization and remediation of the security risks. Further, it lists guidelines for continuous monitoring of the implemented cyber security processes.

22.4 DATA AND INFORMATION SECURITY

22.4.1 Background and Relevance

The purpose of Data and Information Security is to provide reasonable and appropriate safeguards to ensure the confidentiality, integrity, and availability of information assets by protecting those assets from unauthorized access, modification, destruction, or disclosure.

22.4.2 Data and Information Security Implementation Guidelines

22.4.2.1 Use of Virus Protection & Security Reminders

a) Licensed & Updated version of Antivirus/Internet Security software should be used in all supported IT/OT systems. CD/DVD/USB Flash drive of IT/OT systems should be scanned with the installed antivirus/internet security software before use.

b) Security reminders relevant to the IT/OT Systems released by the respective OEM/Government Cyber security agencies like CERT-IN, NTRO, NCIIPC etc. should be regularly checked and implemented.

22.4.2.2 Preventing Loss of Information

a) External/Remote connections for the information systems and assets should not be allowed for information exchange and transmission.

b) Data transmission ports such as USB must be disabled.

c) Approved password composition guideline must be followed while setting a password for any IT/OT system. IT/OT system passwords must not be shared with OEM/third party vendor. The system should forcefully ask to change the password after 60/90 days.

22.4.2.3 Default Sharing on System

No sharing of folder/files

22.4.2.4 Cryptography & Encryption Techniques

System owner must use encryption techniques to protect data and enforce confidentiality during transmission and storage

22.4.2.5 Public Mail and Collaboration Tools

Public mail such as Gmail, Yahoo etc. should strictly not be used for configuring system alerts, official purposes or official communication. Similarly, free cloud space like Google drive/Drop box should not be used for sharing of documents/data.

22.4.2.6 External Media and Printing Devices

External storage media (e.g. USB memory devices/readers, removable hard drives, SD, Compact Flash card, flash drives, key drives, read/rewritable CD/DVD, floppy disks, etc.) should be prohibited from connecting with official information systems. Instead of USB pen drive, HDD etc., network-based storage should be used for Data Backup.

22.4.2.7 Backup & Disaster Recovery

Backup plan, schedule and recovery procedures must be defined, implemented and updated as per the IT/OT system design. Data backup copies of all IT/OT systems should be taken at regular intervals & stored at safe and secure location (Disaster Recovery (DR) site) so that recovery to the most up-to-date state is possible. In addition, these is a provision to periodic restoration of backup to cross check backup.

22.4.2.8 Data Retention and Disposal

Data erasure from storage devices must be done prior to its transfer or destruction.

22.4.2.9 Third Party Access

a) In exceptional cases, Remote connection/USB access can be considered after approval of competent authority.

b) Internet connection should not be provided for OT system and it should be accessible using wired connection only.

c) Hardening standards for various IT and OT systems Hardware shall be formalized and periodic checks shall be performed to substantiate adherence to the same.

d) All systems should be configured to automatically lock the computer screen after 15 minutes of inactivity.

22.5 PHYSICAL SECURITY

22.5.1 Background and Relevance

Physical security describes security measures that are designed to deny unauthorized access to facilities, equipment and resources and to protect personnel and property from any damage or harm. Physical security is not only restricted to barriers or locks but has evolved with the use of access control measures, risk based or multifactor authentications, monitoring cameras, alarms, intrusion detectors, etc.

22.5.2 Physical Security Implementation Guidelines

22.5.2.1 Map and characteristics of physical facilities

Maps of facilities, their entry & exit points, deployment of IT/OT systems and people, list of authorized personnel permitted to access areas/ facility housing sensitive information systems/ devices, should be maintained.

22.5.2.2 Identity Badges

Photo identity cards should be issued to employees for identification and entry to the operational control center and IT/OT data centers.

22.5.2.3 Entry of Visitors &External Service Providers

Records for visitor entry (accompanied by authorized staff) such as name of visitor, time of visit, concerned person for visit, purpose of visit, address of the visitor, phone number of the visitor, ID proof presented, devices on-person, rack/device accessed, purpose of visit should be maintained.

22.5.2.4 Infrastructure Protection

Power and telecommunication lines into information processing facilities should be redundant, underground, where possible, or subject to adequate alternative protection. Network cabling should be protected from unauthorized interception or damage, for example by using conduit or by avoiding routes through public areas. Power cables and switching centers should be segregated from communication cables to prevent interference.

22.5.2.5 Guarding Facility

Background checks of all private guards manning the facility should be conducted prior to employment/ deployment. Details such as address verification, criminal records, past experience, references, family details, and medical records must be maintained as a minimum.

22.5.2.6 Vehicle Entry

Adequate security measures should be adopted at vehicle entry, exit and parking areas such as deploying physical barriers, manual inspection of vehicles, security lighting, video surveillance, deploying adequate security guards etc.

22.5.2.7 Monitoring & Surveillance

a) A mechanism must be established for 24/7 surveillance of all IT/OT facility areas inside the physical perimeter by use of technology such as closed-circuit TV.

b) Physical access to information assets and systems must be governed by employing techniques such as biometric access/smart cards etc.

22.5.2.8 Disposal of Equipment

a) Destruction and disposal of system/ hard drives/ memory devices/components should be performed by techniques such as removing magnets, hammering, degaussing, shredding, secure deletion etc.

b) Any equipment, being carried out of the facility for disposal, must be authorized by the competent authority concerned, under whom the equipment was deployed. Any modification or changes to the IT/OT infrastructure/physical security layout/ established procedure must be done post documented approval of competent authority.

22.5.2.9 Protection of Access Keys and Methodology

All access keys, cards, passwords, etc. for entry to any of the information systems

and networks shall be physically secured or subject to well-defined and strictly enforced security procedures.

22.5.2.10 Access to Restricted Areas:

Visitors requiring access to restricted areas must be accompanied by authorized personnel and visitor details must be maintained.

22.6 IDENTITY, ACCESS AND PRIVILEGE MANAGEMENT

22.6.1 Background and Relevance

Identity, access and privilege management is about safeguarding data by protecting who has access to the systems; and what they are allowed to do. Without specific attention on identification, access and privilege management of employees, information may be exposed outside the boundaries of an organization.

22.6.2 Identity, Access and Privilege Implementation Guidelines

22.6.2.1 User Access Management & Access Control

Details of users authorized by the competent authority to access information systems and devices must be maintained as per standard user access request form containing details such as name of person, location, designation, department, access level authorization, access requirement for applications, databases, files, information repositories etc. The department must enforce, govern and measure compliance with access control policy.

22.6.2.2 Review of User Privileges & Special Privileges

a) All user accounts must be reviewed periodically by the nominated person with the help of system activity logs, log-in attempts to access non-authorized resources, abuse of system privileges, frequent deletion of data by user etc.

b) Logs of all activity conducted via remote access should be captured & audited.

c) Allocation of special privileges must be strictly controlled and restricted to urgent operational cases. All special privileges must be issued for a pre-notified duration and should lapse post the specified period. All activity conducted with the use of special privileges must be monitored and logged.

22.6.2.3 Inactive Accounts

a) All user accounts which are inactive for 60/90 days should be disabled/deleted. All disabled accounts must be reactivated only post verification of the user by concerned system administrator.

b) The information pertaining to requests for user ID creation, user rights allocation, user rights modification, user password reset request and other instances of change or modification to user profile must be retained.

c) Closure of accounts as part of No dues process either on retirement or resignation/repatriation.

22.6.2.4 Unsuccessful Login Attempts

The user account must be disabled for a pre-defined limit post 3/5 unsuccessful log-in attempts. A random alpha numeric text CAPTCHA should be introduced post

second unsuccessful log-in attempt, if supported by system.

22.6.2.5 Ad-hoc Access to Systems

The authentication credentials of information systems which are disclosed to vendors for maintenance and support must be reset on a periodic basis or upon termination of maintenance activity.

22.6.2.6 Segregation of Duties

a) Separation of duties through assigned information system access authorizations should be documented & implemented. Different administrator accounts should be created for different roles.

b) All active sessions of a user should be terminated post 15 minutes of inactivity and should be activated only post re-authentication by specified mechanism.

22.6.2.7 Password Policy

a) Passwords must be encrypted when transmitting over an un-trusted communication network.

b) End user must be asked to follow the password generation guidelines.

c) Passwords must contain at least eight alphanumeric characters (except in the case of BIOS, if the same is not possible). Strong passwords contain combination of lower-case characters, upper case characters, numbers, Special characters (e.g. @#$%^&*() _+|~-=\` {}, []:";'<>/ etc.). All passwords are to be treated as case-sensitive.

d) Prevent users from using passwords shorter than a pre-defined length, or re-using previously used passwords.

e) Password communication must be on verified alternate channel such as official email.

f) Auto prompt option should be enabled/configured to change the system password after expiry of existing password.

g) There must exist an approved password recovery mechanism for all IT/OT systems, if supported by the system

h) Passwords must be changed within 60/90 days. Maximum password age should be configured to enforce the period of time (60/90 days) that a password can be used before the system forces the user to change it.

i) Passwords should never be written down or stored on-line without encryption. Do not reveal a password in email, chat, or other electronic communication. Do not reveal a password on questionnaires or security forms. Always decline the use of the "Remember Password" feature of applications.

22.7 APPLICATION SECURITY

22.7.1 Background and Relevance

Application security involves suitable security measures to protect information of the organization which can be compromised or exposed if applications are not securely designed, developed, tested, configured and deployed.

22.7.2 Application Security Implementation Guidelines

22.7.2.1 Application Security Process & Security Architecture

a) An updated document containing the list of authorized applications, their usage, custodian(s) assigned to each application, level of criticality, version implemented, number of installed instances, application license details, system environment etc. must be maintained.

b) The web software applications must be developed as per secure coding guidelines such as the Open Web Application Security Project (OWASP) guidelines. The applications must not have hardcoded passwords to connect to other databases and start services.

22.7.2.2 Application User Authentication & Session Management

a) Authorization of users should be based on centralized system rather than at an individual application level. Authorization and access to resources should be role based, rather than individual basis. Periodic review of authorization should be performed.

b) Applications should validate the data on the server-side and not on client-side. Applications should execute proper error handling so that errors will not provide detailed system information, deny service, impair security mechanisms, or crash the system.

c) Applications have secure session management to protect the sessions from unauthorized access, modification or hijacking. Sessions established by applications should be secured by using appropriate encryption technologies, especially when sensitive information is transferred using HTTPS/TLS protocols.

22.7.2.3 Input Validation & Error Handling

Ensure applications validate input properly and restrictively, allowing only those types of input that are known to be correct and Ensure applications execute proper error handling so that errors will not provide detailed system information, deny service, impair security mechanisms, or crash the system.

22.7.2.4 Application Change Control

a) Activity such as application maintenance, installation of critical changes, review of changes and post testing, responsibility of changes, document change requests amongst others must be documented with relevant details.

b) All the patches/updates for OS, database and third-party software should be downloaded from OEM sites only.

c) Restorable backup should be available before carrying out any system upgradation/maintenance activity.

22.7.2.5 Application Licensing

a) All the IT/OT systems must use only licensed version of software tools/utilities such as operating system, database, firmware, patches, drivers, and antivirus software etc.

b) License renewal procedure as agreed with OEM/third party must be followed.

22.8 NETWORK & INFRASTRUCTURE SECURITY

22.8.1 Background and Relevance

Network & Infrastructure Security includes managing and restricting access to the network, email security, firewalls, antivirus, intrusion prevention systems, SIEM and VPNs (Virtual Private Network) etc.

22.8.2 Network Security Implementation Guidelines

22.8.2.1 Network Diagram

Accurate mapping of the core components, connections and information of the network must be developed to build IT/OT system facility network diagram including network components such as routers, switches, firewall and computer systems, IP addresses, data flow routes, blacklisted or white listed systems/IP addresses, open/entry ports, subnet mask, administrative interface, zones, access control lists, network name amongst others.

22.8.2.2 Network Configuration

a) There must be documented standards/procedures for configuring network devices (e.g. routers, hubs, bridges, concentrators, switches, firewalls, IPS, IDS etc.), which cover - security architecture, device configuration, access control to network devices, vulnerability and patch management, changes to routing tables and settings in network devices and regular review of network device configuration and set-up.

b) Use of personal devices must be authorized by concerned personnel of the department, with documented forms maintained to reflect approvals and rejections. Security check of the personal device must be carried out prior to authorization for use in official premises.

22.8.2.3 LAN Security

All insecure access protocols such as TELNET must be disabled, and secure protocols such as SSH, SSL, or IP Security (IPSec) should be used. List of open ports and protocols must be approved by competent authority.

22.8.2.4 Security Zones & Network Traffic Segregation

a) Virtual LAN may be used by the departments to logically separate zones which deal with critical systems from the rest of the network after consulting with the OEM. VLAN configuration should be system wise and cross access must be prohibited.

b) Traffic flow filters, VLANs, network and host-based firewalls, application level filtering, proxies, content-based filtering etc. should be implemented for network traffic segregation.

22.8.2.5 Network Change Management

Changes required for the network must be tested/simulated before implementing in live environment. Appropriate permissions should be obtained before applying the patches and making any change in live environment.

22.8.2.6 Network Security & Security of IPv6 Devices

a) Firewalls should be placed between client and server subnets and before network admission of any new devices proper security scanning should be done. All Firewalls, servers etc. should be configured in HA mode.

b) A logging mechanism should be in place to record and maintain unauthorized attempts and authorized user activity. Logs must be maintained for a period of 60/90 days.

c) Firewall, IDS/IPS must be able to scan IPv6 traffic and enforce policies on the same.

22.8.2.7 Firmware Upgrade

Firmware upgrades must be regularly checked for network appliances. All upgrades must be installed post appropriate validation and testing in the development/testing environment, if available.

22.8.2.8 Default Device Credentials

The default credentials of network devices and information systems such as usernames, passwords, tokens should be changed prior to their deployment or first use.

22.9 VIRTUALIZATION SECURITY

22.9.1 Background and Relevance

Virtualization Security describes collective measures, procedures and processes that ensure the protection of a virtualized infrastructure / environment. The security of a virtualized environment largely depends on the individual security of each component, from the hypervisor (virtual machine manager) and host OS to the VMs, applications and storage.

22.9.2 Virtualization Implementation Guidelines

Evaluate the Need for Virtualization and the Risk Associated with it. A periodic risk assessment must be conducted to determine security risks arising out of data compromise, unauthorized access, virtual machine (VM) cloning, unexpected server behavior, lack of support, and lack of separation of duties, dormant virtual machines, information leakage, and limited functionality amongst others.

22.9.2.1 Strengthen Physical Access

All physical entry points to virtualized environments must be continuously monitored such as by deploying guards, CCTV, biometric access etc.

22.9.2.2 Segregation of Virtual Traffic

The traffic of virtualized environments must be segregated from rest of the network traffic in the organization by using separate switches, routers, virtual LANs etc.

22.9.2.3 Implement Defense-in-depth

Security zones must be created by type of usage (e.g. desktop vs server), development phase (e.g. development, testing and production), and sensitivity of data (e.g. classified data vs unclassified data).

22.9.2.4 Harden Virtualization Management Console

a) Root access via telnet must be restricted on all IT/OT systems.

b) NTP should be configured for time synchronization for logs.

c) Use of any default self-signed certificates for SSL communication must be prevented.

22.9.2.5 Vulnerability Information

A track of new vulnerabilities must be kept for operating systems or applications contained in virtual environments, through trusted National Vulnerability Database, notifications from CERT-In etc.

22.9.2.6 Logging and Monitoring

Logs must be regularly analyzed and monitored for any suspicious activity such as unauthorized access attempts, multiple failed login attempts, system lockout, critical file changes etc.

22.10 CYBER SECURITY AUDIT

To ensure compliance, frequent system audits are proposed in this Cyber Security policy.

The Audit frequency of these system audits is as follows:

Step-I: System Owner – Once in 6 months and submit report to IT/S&T department.

Step-II: S&T/IT Department – Once a year

Step-III: Third-Party (External) Auditor – Every 2 years

22.11 VULNERABILITY ASSESSMENT

Automation and introduction of new technologies in the sectors such as Metro, Regional rapid transit system and high-speed rail has created new vulnerabilities in cyber physical domain especially making IT/OT systems susceptible to cyber-attack. Therefore, vulnerability assessment of all new technologies are required to be carried out.

22.12 GOVERNANCE

22.12.1 Background and Relevance

Identifying, analyzing and responding to risk needs to occur throughout the information asset's lifecycle to ensure the optimum configuration and placement of Information Security controls.

Governance shall provide management direction and support for information security in accordance with business requirements and relevant laws and regulations. It shall provide oversight to ensure effective implementation of Cyber security policies and procedures across IT and OT systems.

22.12.2 Risk Management

a) An effective security governance requires a risk management process as a basis for identifying, implementing, evaluating, and maintaining appropriate controls required in order to adequately protect the information assets. Key policy directives that are to be implemented are as follows:

b) Design and implement risk management framework that details the mechanism to identify and classify the risks, define security incidents affecting the assets, assess the effectiveness of controls, perform risk value estimation, and manage & control

risks.

c) Risk assessment shall be conducted on periodic basis to identify risks across various business departments, new projects and corresponding business processes.

d) All the risks shall be maintained in a central risk register and tracked/monitored on periodic basis.

e) Prioritization of risks shall take place as per the defined risk assessment methodology.

22.12.3 Governance Structure

The Governance Structure establishes a management framework to ensure that information security is given oversight, managed, understood, communicated and implemented at the right level across IT and OT systems to meet compliance to set security rules.

The Governance structure consists of Strategic and Operational layers as illustrated below:

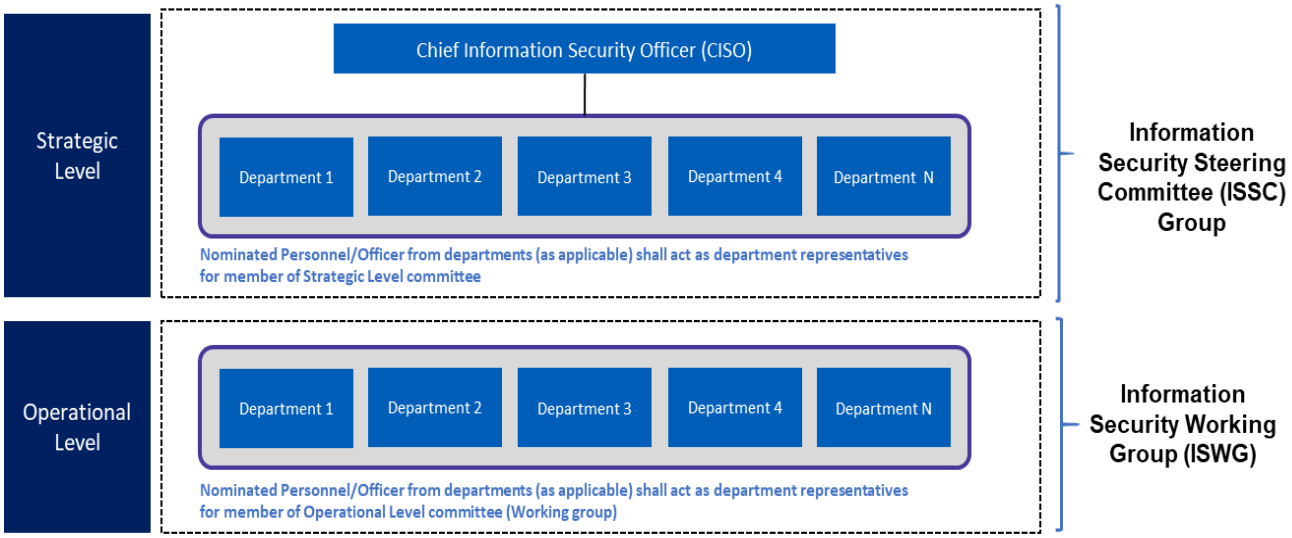


Fig. 22.1: Governance Structure

I. Chief Information Security Officer (CISO)

a) Accountability for oversight of the management of Information Security including the development, review, approval and implementation of Information Security Management System Policies.

b) Ensure that processes integrate information security management systems requirements through a set of policies and procedures.

c) Periodically communicate the importance of Cyber Security policy and its conformance to employees.

d) Review the policies, manuals and organization of information/cyber security standard.

e) Post consultation with committee members recommend cyber security policies and procedures for approvals from competent authorities.

f) Monitor through periodic meetings and reviews that the intended outcomes of Cyber Security policy implementation are achieved.

g) Identify emerging trends in the industry vertical (within which the organization is currently poised), in relation to information safety and security measures.

II. Information Security Steering Committee Group

a) Information Security Steering committee shall be chaired by Chief Information Security Officer (CISO) (with members including nominated personnel's/officer from different departments.

b) This group shall be responsible for overall governance and management of Cyber Security policy including risk evaluation and risk acceptance etc. along with budget related decisions.

III. Information Security Working Group

a) Working group shall contain nominated personnel/officer from different departments.

b) Representatives shall be responsible for implementation of Cyber Security policy.

Key policy directives that are to be implemented are as follows:

a) Establish an Information Security Governance Committee (ISG) with cross functional representation. This committee shall be responsible to provide independent oversight on the effective implementation of cyber security policy. The committee should be represented by senior nominated representatives from critical business functions.

b) A regularly meeting (i.e. at least quarterly) Information Security Governance Committee should be convened to monitor the risk and compliance posture of the organization.

c) The committee should ensure the policy's continued relevance, adequacy and effectiveness. Policy review should occur more frequently if significant business or regulatory change occurs.

d) Define and implement cyber security roles and responsibilities.

22.12.4 Key Performance Indicators

Information Security KPI's (Key Performance Indicators/measures) shall be formalized for the identified critical functions. Further, these Key Performance Indicator's (KPI's) shall be monitored and reported to Information Security Governance Committee on at least quarterly basis.

22.12.5 Information Security Exceptions

Key policy directives to implement information security exception management are as follows:

a) All the exceptions to the cyber security policy shall be documented by the respective business process teams and approved by department (Head of Department) and Chief Information Security Officer (CISO).

b) Central tracker for managing exceptions shall be maintained by the respective business departments.

c) All the exceptions shall be approved for a defined time period. There should be periodic monitoring of approved exceptions.

22.12.6 Legal and Regulatory requirements

Organization shall identify and implement appropriate controls to address legal and regulatory requirements applicable to Information Security. Key policy directives that are to be implemented are as follows:

a) Identify cyber security obligations arising from applicable laws, regulatory directives and contractual obligations.

b) All such requirements shall be documented and maintained in a central tracker with

the corresponding controls associated with each requirement. The specific controls and individual responsibilities to meet these requirements shall also be defined and documented.

c) Periodic review of these compliance shall be carried out.

22.12.7 Third Party Risk Management

Organization shall ensure that its Information Security requirements and obligations are reflected in its engagement of third-party suppliers. Key policy directives that are to be implemented are as follows:

a) Supplier risk management framework for third parties/suppliers shall be formalized.

b) Classification of supplier/third parties shall be performed basis the defined framework.

c) Compliance monitoring and audit of supplier/third party shall be conducted on periodic basis.

22.12.8 Change Management

Organization shall identify and implement appropriate controls to address changes to information security resources. Key policy directives that are to be implemented are as follows:

a) Defining a change classification methodology, framework and classifying changes such as Minor, Major and Emergency.

b) All the changes should be firstly tested in User Acceptance Testing (UAT) environment, followed by security testing and then moved on to production.

c) Change Management Board shall be established to review the changes and provide signoff.

Annexure A: Glossary & Abbreviations

S. No.	Term	Definition
1	AES	Advanced Encryption Standard, is a symmetric block data encryption technique.
2	AP	A wireless Access Point (AP) is a device that allows wireless devices to connect to a wired network using Wi-Fi, or related standards.
3	CAPTCHA	A computer program or system intended to distinguish human from machine input, typically as a way of thwarting spam and automated extraction of data from websites.
4	CCTV	Closed-circuit television, also known as video surveillance, is the use of video cameras to transmit a signal to a specific place, on a limited set of monitors
5	COBIT	Control Objectives for Information and Related Technology is a framework created by ISACA for information technology management and IT governance. It is a supporting toolset that allows managers to bridge the gap between control requirements, technical issues and business risks.
6	HTTP	Hyper Text Transfer Protocol is the underlying protocol used by the World Wide Web. HTTP defines how messages are formatted and transmitted, and what actions Web Servers and browsers should take in response to various commands.
7	HTTPS	Hyper Text Transfer Protocol Secure (HTTPS) is the secure version of HTTP, the protocol over which data is sent between your browser and the website that you are connected to. The 'S' at the end of HTTPS stands for 'Secure'. It means all communications between your browser and the website are encrypted.
8	IDS	Intrusion Detection systems - A class of networking products devoted to detecting attacks from hackers. Network-based intrusion detection systems examine the traffic on a network for signs of unauthorized access or attacks in progress, while host-based systems look at processes running on a local machine for activity and administrator has defined as "bad."
9	IP	Internet Protocol is the principal communications protocol in the Internet protocol suite for relaying datagrams across network boundaries. Its routing function enables internetworking, and essentially establishes the Internet.
10	IPS	Intrusion prevention systems IPS, also known as intrusion detection and prevention systems IDPS are network security appliances that monitor network and/or system activities for malicious activity. The main functions of intrusion prevention systems are to identify malicious activity, log information about this activity, attempt to block/stop it, and report it
11	IPsec	IP Security, a set of protocols developed by the IETF to support secure exchange of packets at the IP layer. IPsec has been deployed widely to implement Virtual Private Networks.
12	MAC	Media Access Control address is a hardware address that uniquely identifies each node of a network.

S. No.	Term	Definition
13	NAC	Network Access Control is an approach to computer network security that attempts to unify endpoint security technology (such as antivirus, host intrusion prevention, and vulnerability assessment), user or system authentication and network security enforcement
14	NTP	The Network Time Protocol is a networking protocol for clock synchronization between computer systems over packet-switched, variable-latency data networks
15	OEM	OEM (pronounced as separate letters) is short for original equipment manufacturer, which is a somewhat misleading term used to describe a company that has a special relationship with computer and IT producers. OEMs are manufacturers who resell another company's product under their own name and branding.
16	OT	Operational technology (OT) is hardware and software that detects or causes a change through the direct monitoring and/or control of physical devices, processes and events in the enterprise.
17	OWASP	The Open Web Application Security Project is an open-source web application security project. The OWASP community includes corporations, educational Departments, and individuals from around the world.
18	SHA 2	Secure hash algorithm SHA-2 is a set of cryptographic hash functions (SHA-224, SHA-256, SHA-384, SHA-512, SHA-512/224, and SHA-512/256) designed by the U.S. National Security Agency (NSA) and published in 2001 by the NIST as a U.S. Federal Information Processing Standard (FIPS).
19	SIEM	Security Information and Event Management (SIEM) provides real- time analysis of security alerts generated by network hardware and applications.
20	SNMP	Simple Network Management Protocol is an "Internet- standard protocol for managing devices on IP networks". It is used mostly in network management systems to monitor network-attached devices for conditions that warrant administrative attention
21	SSH	Secure Shell is a program to log into another computer over a network, to execute commands in a remote machine, and to move files from one machine to another. It provides strong authentication and secure communications over insecure channels.
22	SSID	Service set identifier is a case sensitive, 32 alphanumeric character unique identifier attached to the header of packets sent over a wireless local-area network that acts as a password when a device tries to connect to the basic service set a component of the IEEE 802.11 WLAN architecture.
23	SSL	SSL (Secure Sockets Layer) is a standard security protocol for establishing encrypted links between a web server and a browser in an online communication. The usage of SSL technology ensures that all data transmitted between the webserver and browser remains encrypted.

S. No.	Term	Definition
24	SSTP	Secure Socket Tunneling Protocol (SSTP) is a form of virtual private network (VPN) tunnel that provides a mechanism to transport PPP traffic through an SSL/TLS channel. SSL/TLS provides transport-level security with key negotiation, encryption and traffic integrity checking
25	TELNET	Telnet is a protocol used on the Internet or local area network to provide a bidirectional interactive text-oriented communication facility using a virtual terminal connection.
26	VLAN	A virtual LAN is any broad cast domain that is partitioned and isolated in a computer network at the data link layer. LAN is the abbreviation for local area network and in this context virtual refers to a physical object recreated and altered by additional logic.
27	VM	In computing, a virtual machine is an emulation of a computer system. Virtual machines are based on computer architectures and provide functionality of a physical computer. Their implementations may involve specialized hardware, software, or a combination.
28	VPN	Virtual private network is a network that is constructed by using public wires — usually the Internet — to connect to a private network, such as a company's internal network. There are a number of systems that enable to create networks using the Internet as the medium for transporting data. These systems use encryption and other security mechanisms to ensure that only authorized users can access the network and that the data cannot be intercepted.
29	WAF	A web application firewall is a form of firewall which controls input, output, and/or access from, to, or by an application or service. It operates by monitoring and potentially blocking the input, output, or system service calls which do not meet the configured policy of the firewall.
30	Wi-Fi	Wi-Fi is technology for radio wireless local area networking of devices based on the IEEE 802.11 standards
31	WLAN	A type of local-area network that uses high-frequency radio waves rather than wires to communicate between nodes.
32	WPA	WPA is a security technology for Wi-Fi wireless computer networks. WPA improves on the authentication and encryption features of WEP (Wired Equivalent Privacy).
33	WPA-2	Wi-Fi Protected Access 2, the follow on security method to WPA for wireless networks that provides stronger data protection and network access control. It provides enterprise and consumer Wi-Fi users with a high level of assurance that only authorized users can access their wireless networks.

Chapter - 23

Implementation Plan



23.1 Way Forward for Implementing Ahmedabad Metro Rail Project Phase-II B

23.2 Implementation on Delhi Metro/Chennai Metro Model

23.3 Organisational Set-Up of GMRC

23.4 Contracts

23.5 High Power Committee

23.6 Legal Cover for Ahmedabad Metro Phase-II B

23.7 Concessions from Government

23.8 Need for Dedicated Fund for Metro Projects



Chapter - 23

IMPLEMENTATION PLAN

23.1 WAY FORWARD FOR IMPLEMENTING AHMEDABAD METRO RAIL PROJECT PHASE-II B

On receipt of the Detailed Project Report, following action will be required for implementing the Ahmedabad Metro Phase-II B:

- 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 GMRC.
- 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.
- GMRC, 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 and II.
- 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 suggested corridor. 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.

23.2 IMPLEMENTATION ON DELHI METRO/CHENNAI METRO MODEL

GMRC has to take action for appointment of General Consultants for project management including preparation of tender documents. Till the General Consultants are in position, GMRC 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 23.1

Table 23.1 - Implementation Schedule through DMRC model

S. No.	Item of Work	Completion Period
1	Submission of Final DPR to State Govt.	D
2	Approval of DPR by State Government	D + 0.5 month
3	Submission of DPR for Approval of Ministry of Urban Development (MoUD).	D + 1 month
4	Appoint interim Consultant for preliminary works	D + 2 months
5	Approval of Project by Public Investment Board	D + 2 months
6	Sanction of Project by Government of India	D + 3 months
7	Appoint General Consultant	D + 9 months
8	Tendering, Execution of works and Procurement of equipments, coaches and installations	D + 48 months
9	Testing and Commissioning	D + 49 months
10	Revenue Operation	D + 49 months

Note: The above schedule is proposed for implementation of first phase of Phase-II B i.e. from GIFT City to Shahpur. Remaining section from Shahpur to GIFT is proposed to be implemented in second phase from 2029-2033.

23.3 ORGANISATIONAL SET-UP OF GMRC

GMRC has already implemented and operating Phase-I of Ahmedabad Metro. Presently GMRC is also implementing Ahmedabad Metro Phase-II, hence Phase-II B 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.

23.4 CONTRACTS

23.4.1 Civil Works

It is proposed to carry out the civil works through following construction contracts-

(a) Viaduct and Station Construction- Length of the corridor to be implemented in first phase is 3.33 km, accordingly it is suggested that one single contract package may be prepared for entire viaduct along with 3 stations included therein.

Architectural finishes, firefighting arrangements and general electrification, will form part of civil contracts.

23.4.2 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 (augmentation) and on main line.
- Design and installation of Signages.

23.4.3 Depot Contracts

The contracts are required for Civil and E&M works for augmentation of Gyaspur Depot and Indroda Circle stabling depot. One package for civil works will be for both locations.

The number of contracts for supply of Depot Equipment may be decided as and when the work is in progress.

23.5 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 GMRC. 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.

23.6 LEGAL COVER FOR AHMEDABAD METRO PHASE-II B

Construction of Ahmedabad Metro Phase-II B 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 B 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.

23.7 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, GMRC 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.

23.8 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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असाधारण
EXTRAORDINARY

भाग II—खण्ड 3—उप-खण्ड (ii)
PART II—Section 3—Sub-section (ii)

प्राधिकार से प्रकाशित
PUBLISHED BY AUTHORITY

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शहरी विकास मंत्रालय

(मैट्रो रेल प्रकोष्ठ)

अधिसूचना

नई दिल्ली, 7 सितम्बर, 2009

का.आ. 2279(अ).—केन्द्रीय सरकार, मैट्रो रेल (संशोधन) अधिनियम, 2009 (2009 का 34) की धारा 1 की उप-धारा (2) द्वारा प्रदत्त शक्तियों का प्रयोग करते हुए, 7 सितम्बर, 2009 को उस तारीख के रूप में नियत करती है, जिसको उक्त अधिनियम के उपबंध प्रवृत्त होंगे ।

[फा.सं. के-14011/40/2003-एमआरटीएस/मैट्रो]

विमल कुजूर, अवर सचिव

MINISTRY OF URBAN DEVELOPMENT

(Metro Rail Cell)

NOTIFICATION

New Delhi, the 7th September, 2009

S.O. 2279(E).—In exercise of the powers conferred by sub-section (2) of Section 1 of the Metro Railways (Amendment) Act, 2009 (34 of 2009) the Central Government hereby appoints the Seventh September, 2009 as the date on which the provisions of the said Act, shall come into force.

[F. No.K-14011/40/2003-MRTS/Metro]

BIMAL KUJUR, Under Secy.

3269 GI/2009

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The Gazette of India

असाधारण
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इस भाग में भिन्न पृष्ठ संख्या दी जाती है जिससे कि यह अलग संकलन के रूप में रखा जा सके।
Separate paging is given to this Part in order that it may be filed as a separate compilation.

MINISTRY OF LAW AND JUSTICE
(Legislative Department)

New Delhi, the 27th August, 2009/Bhadra 5, 1931 (Saka)

The following Act of Parliament received the assent of the President on the 26th August, 2009, and is hereby published for general information:—

THE METRO RAILWAYS (AMENDMENT) ACT, 2009

No. 34 OF 2009

[*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

Short title and commencement

1. (*1*) This Act may be called the Metro Railways (Amendment) Act, 2009.

(*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.".

Amendment of section 2.

7. In section 2 of the Delhi Metro Railway Act, in sub-section (*1*),—

(*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.

Amendment of section 6.

8. In section 6 of the Delhi Metro Railway Act, in sub-section (*2*), after clause (*b*), the following clauses shall be inserted, namely:—

"(*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;".

Amendment of section 7.

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:—

"(*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.

Substitution of new section for section 12.

10. For section 12 of the Delhi Metro Railway Act, the following section shall be substituted, namely:—

Annual report.

"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.".

Amendment of section 13.

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 23.

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 26.

13. In section 26 of the Delhi Metro Railway Act, in sub-section (*1*), the words "a small" shall be omitted.

Amendment of section 34.

14. In section 34 of the Delhi Metro Railway Act, for sub-section (*4*), the following sub-section shall be substituted, namely:—

"(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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GMGIPMRND—3842GI(S5)—28-8-2009.

Chapter - 24

Conclusions and Recommendations





Chapter – 24

CONCLUSIONS AND RECOMMENDATIONS

24.1 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 for extension of under construction GNLU to GIFT City corridor is proposed for implementation under two phases.

In first phase GIFT City (excluding) to Shahpur (3.33 km) at a completion cost of **Rs.1050.64 Crores** (including Cost of Land and all taxes & duties) to be made operational by July 2029 as recommended in implementation chapter. In addition to this, **Rs. 16.71 Crore** IDC for Loan is to be borne by GoG.

In second phase Shahpur (excluding) to GIFT (4.253 km) at a completion cost of **Rs.1042.08 Crores** (including Cost of Land and all taxes & duties) to be made operational by July 2033 as recommended in implementation chapter. In addition to this, **Rs. 16.42 Crore** IDC for Loan is to be borne by GoG.

24.2 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.

24.3 After examining the various options for execution of Ahmedabad Metro Project Phase-II B, it has been recommended that the project should be got executed through GMRC on SPV model as recommended in Chapter 19.

24.4 Fare structure considered during traffic survey and ridership projections have been used as base fare for calculation of FIRR of the project as mentioned in Chapter 19. Subsequently, for the purpose of assessing returns from the project, the fares have been revised every second year with an escalation of 14% every two years.

24.5 As in the case of Delhi Metro, the State Government should exempt/ reimburse the State Goods and Services Tax (SGST) to Ahmedabad Metro. However GMRC 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.

24.6 While the Financial Internal Rate of Return (FIRR) for the project (entire corridor from GIFT City (excluding) to GIFT i.e. first and second phase combined) has been assessed as 8.58% and the Economic Internal Rate of Return (EIRR) for same works out to 17.61%. Therefore, it is recommended for implementation.

APPENDIX



Appendix

DMRC's response to GMRC's observation on draft DPR of GIFT City vide letter dated 15th May 2024.

S. No.	Observation	Remarks
1.	Type of Rail: change from 880 grade to R260 grade required	Updated in Chapter 4 of Geometric Designing parameters and alignment description
2.	Augmentation of Gyaspur and Indrdoa depot: clarification on exact nature of augmentation required	The details of the augmentation of Depot have been mentioned in Chapter 9 of Depot.
3.	Casting yard land 2 ha. to be replaced with 5 ha.	Since this Corridor is planned to be constructed in two phases, hence the proposed 2 ha casting yard land is sufficient to cater for construction in each phase.
4.	Index to be checked with page no. and content name.	Page no. and Content is updated
5.	External agencies: (1) Army to be added in the DPR of Airport connectivity and (2) others external agencies to be deleted and GIFT City to be added in the DPR of GIFT City	GIFT city external agency has been updated in Chapter 5 Civil Engineering.
6.	Data for underground metro to be deleted from GIFT City DPR	Train Operation Plan is common for both Phase-ii A and Phase-ii B DPRs, as both the corridors are interrelated from the Operational point of view and common depot. Accordingly, Power Supply chapter is common in both the DPRs.
7.	Cl. 6.5 - airport underground station to be changed in GIFT City DPR	The index has been updated.
8.	Cl. 4.11- Koteshwar road to Airport corridor to be changed as per content in GIFT City DPR	The index has been updated.
9.	Koteshwar and Airport to be changed in GIFT City DPR	The index has been updated.

Gujarat Metro Rail Corporation (GMRC) Limited
(SPV of Govt. of India & Govt. of Gujarat)

GMRC LTD.
KARMAYOGI BHAVAN, GANDHINAGAR-382010
INWARD NO. - 915
DATE : 15/05/24

No. GMRC/Phase-IIA/C&P

Dated: 15.05.2024

Shri Pramit Kumar Garg
Director (Business Development),
Delhi Metro Rail Corporation Ltd.,
25, Ashoka Road, (Nr. Patel Chowk Metro Station)
New Delhi- 110001

Sub: Preparation of DPR for Metro connectivity to GIFT City and Sardar Vallabhbhai Patel International Airport- Compliance of observation and submission of final DPR

Ref: (1) DMRC's L/No. DMRC/Sr.GM/BD/99/GIFT CITY/2022-23/772, dated 28.03.2024
(2) DMRC's L/No. DMRC/Sr.GM/BD/99/GIFT CITY/2022-23/771, dated 28.03.2024

Dear Sir,

DMRC has submitted the draft DPR for Metro connectivity to GIFT City and Sardar Vallabhbhai Patel International Airport. Through email on 23.02.2024 and submitted hard copies of submission as per cl. No. 2.5 of the LoA vide above referred letters.

The draft DPRs have been reviewed and following observations are made:-

- **Type of Rail** : change from 880 grade to R260 grade required
- **Augmentation of Gyaspur and Indrdoa depot**: clarification on exact nature of augmentation required
- Casting yard land 2 ha. to be replaced with 5 ha.
- Index to be checked with page no. and content name.
- **External agencies:** (1) Army to be added in the DPR of Airport connectivity and (2) others external agencies to be deleted and GIFT City to be added in the DPR of GIFT City
- Data for underground metro to be deleted from GIFT City DPR
- Cl. 6.5 - airport underground station to be changed in GIFT City DPR
- Cl. 4.11- Koteshwar road to Airport corridor to be changed as per content in GIFT City DPR
- Koteshwar and Airport to be changed in GIFT City DPR

Now, it is requested to submit the final DPRs complying the above observations at the earliest.

Thanking you,

Yours sincerely,
15-5-24
(Ashutosh Rankawat)
Chief General Manager (P&D.)
For GMRC Ltd.

Registered Office : Block No. 1, First Floor, Karmayogi Bhavan, Sector-10/A, Gandhinagar - 382010.
Ph.: +91-79-23248572 **Fax :** +91-79-2324 8573 **Email :** info@gujaratmetrorail.com
Website : www.gujaratmetrorail.com CIN : U60200GJ2010SGC059407

DMRC's response to GMRC's observation on DPR of GIFT City vide email dated 14th August 2024

S. No.	Observation	Remarks
1.	Ch.21 first page- Heading of para no. 21.5 to be corrected from Phase II to Phase IIB	The same has been corrected.
2.	Ch.23 first page- Heading of para no. 23.1 to be corrected from Phase IIA to Phase IIB	The same has been corrected.
3.	To ensure all standards mentioned in the DPR should be of latest version	All standards is updated to Latest version.
4.	Table no.0.27 of FIRR data entry to be verify	Table no. 0.27 is updated.
5.	Ch.9 Depot- some tables contains on same page but header of table contains in between, to be verify	The same has been corrected.
6.	Para 9.12.1 to be recheck for Phase IIB requirement considering facilities available in the DPR of Phase I and Phase II. i.e augmentation requirement at Gyaspur or Indroda depot to be clearly mentioned.	Facilities requirement at Gyaspur and Indroda Circle Depot is mentioned in the Para 9.5, 9.6, Table 9.5 and Table 9.6.

RE: Submission of final DPR of GIFT City

From : ankur patel <ankur.patel@gujaratmetrorail.com> Wed, Aug 14, 2024 04:45 PM
Subject : RE: Submission of final DPR of GIFT City
To : Anjali Rai <anjali.20993@dmrc.org>
Cc : Sudhanshu Chaudhary <sudhanshu_2983@dmrc.org>, sandeep Gemawat <sandeep.4478@dmrc.org>, ashutosh@gujaratmetrorail.com, darshil shah <darshil.shah@gujaratmetrorail.com>

Dear Madam,
As per GIFT City DPR submitted vide trailing email, following observation are made:

1. Ch.21 first page- Heading of para no. 21.5 to be corrected from Phase II to Phase IIB
2. Ch.23 first page- Heading of para no. 23.1 to be corrected from Phase IIA to Phase IIB
3. To ensure all standards mentioned in the DPR should be of latest version
4. Table no.0.27 of FIRR data entry to be verify
5. Ch.9 Depot- some tables contains on same page but header of table contains in between, to be verify
6. Para 9.12.1 to be recheck for Phase IIB requirement considering facilities available in the DPR of Phase I and Phase II. i.e augmentation requirement at Gyaspur or Indroda depot to be clearly mentioned.

Thanks & Regards,
Ankur Patel,
Sr.DGM (Const.)
Gujarat Metro Rail Corporation (GMRC) Limited
Mob.7574000381

From: Anjali Rai [mailto:anjali.20993@dmrc.org]
Sent: 07 August 2024 12:54
To: Ankur Patel; Darshil Shah; Ashutosh Rankawat
Cc: Sudhanshu Chaudhary; sandeep Gemawat
Subject: Submission of final DPR of GIFT City

Dear Sir,

With reference to preparation of DPR for metro corridor from GIFT City to GIFT, final DPR is being submitted herewith after inclusion of all the observations made on the DPR.

The hardcopy of the DPR will be submitted subsequently.

Thanks and Regards,

Anjali Rai
Manager/CS
DMRC Ltd.
+9140481511

Disclaimer





DISCLAIMER

The information provided in this report is based on present site conditions and technology in the vogue. In case of any change in the site conditions, availability of land, upgradation in technology or any other reason, the same may be taken into consideration with due diligence and cost benefit analysis during detail design stage of project implementation and design should be modified accordingly.