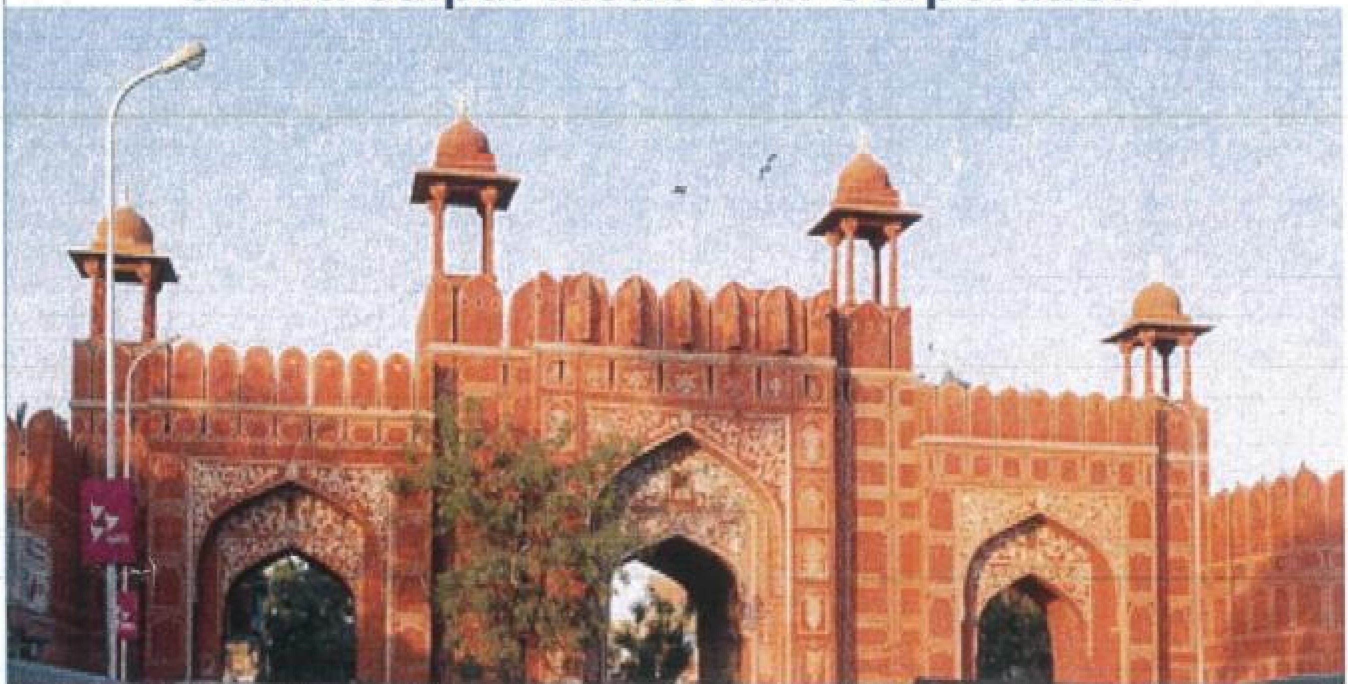
Detailed Project Report

Jaipur Metro (Phase-I)

Mansarovar to Badi Chaupar

Client: Jaipur Metro Rail Corporation



दिल्ली मेट्रो रेल कॉरपोरेशन लिमिटेड
DELHI METRO RAIL CORPORATION LTD.

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Salient Features

Jaipur Metro Project

SALIENT FEATURES

1. **Gauge (Nominal)** **1435 mm**

2. **Route Length (between dead ends)**

Description	Underground (km)	Elevated (km)	Total (km)
E-W Mansarovar to Badi Chaupar	2.789	9.278	12.067

3. **Number of stations**

Description	Underground	Elevated	Total
E-W Mansarovar to Badi Chaupar	3	8	11

4. **Traffic Forecast (in lakhs)**

Year	CORRIDOR	SECTIONAL LOAD (PHPDT)	DAILY RIDERS HIP (in lakhs)	AVERAG E LEAD (in km)
2014	Mansarovar-Badi Chaupar	11264	2.1	5.1
2021	Mansarovar-Badi Chaupar	16376	2.9	5.3
2031	Mansarovar-Badi Chaupar	27750	4.2	5.5

5. **Train Operation**

Capacity Provided for East-West corridor

Description	YEAR		
	2014	2021	2031
Cars/trains	4	4	4
Head way (Minutes)	6	4	2.5
Max. PHPDT Demand	11264	16376	27750
PHPDT Capacity Available	10340 (13160*)	15510 (19740*)	24816 (31584*)

* @ 8 persons per square meter of standee area

Year wise Rake Requirement

Corridor	Year	Headway (min)	No. of Rakes	Rake Consist	No. of Coaches
East-West corridor	2014	6	10	4 car	40
	2021	4	15	4 car	60
	2031	2.5	22	4 car	88

6. Speed

Designed Speed 80kmph

Scheduled speed 32 kmph

7. Traction Power Supply

a) Voltage 25 KV OHE

b) Power Demand (MVA)

Corridor		Year		
		2014	2021	2031
E-W Badi Chopar to Mansarovar.	Traction	4.1	6.2	9.5
	Auxiliary	10.7	12.4	14.1
	Total	**14.8**	18.6	**23.6**

c) Sub Stations

Sources of Power Supply

Corridor	Grid sub-station (with Input voltage)	Location of RSS of Metro Authority	Approx. length of cables
E-W Badi Chopar to Mansarovar.	Mansarovar GSS (220 / 132kV)	Depot at Mansarovar (132 / 33/25 kV)	0.5 km, 132kV (Double Circuit Cables).
	GIS substation, PWD Bungalow at Station Road near RSRTC bus stand. (132 / 33 kV).	Near Sindhi Camp Metro Station (132 / 33/25 kV)	0.5 km, 132kV (Double Circuit Cables).

d) SCADA system — Provided

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 4 coach unit - 1034 Passengers
e) Class of accommodation- One

9. Maintenance Facilities

Maintenance Depot for E-W Corridor - Mansarover Depot

10. Signalling, Telecommunication & Train Control

a) Type of Signalling — Cab signaling and continuous automatic train control with Automatic Train Protection (ATP)

b) Telecommunication
- i) Integrated System with Fibre Optic cable, SCADA, Train Radio, PA system etc.
- ii) Train information system, Control telephones and Centralized Clock System.

11. Fare Collection — Automatic Fare collection system with POM and Smart card etc.

12. Construction Methodology

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

13. Total Estimated Completion Cost (at April 2011 prices)

Corridor	Route Length (KMs)	Estimated Cost with Central Taxes at Apr-2011 price level	Completion cost (crore)
Mansarovar to Badi Chaupar (total in Phase-I)	**12.067**	**2677.00**	**3149.00**
Mansarovar to Chandpole (phase I A)	9.718	1792.00	2023.00
Chandpole to Badi Chaupar (Phase I B)	2.349	886.00	1126.00

14. Total Estimated Completion Cost of Phase-I (Both the corridor full with central taxes only) (Including escalation and central taxes only) — **Rs. 3149Crores**

15. Financial Indices

a) FIRR: Considering the 12.5 ha property development land from government.

Particulars	Cost including DMRC portion
FIRR	**8.24%**

b) EIRR

The EIRR in economic terms work out to be 18.6% for the project.

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Executive Summary

EXECUTIVE SUMMARY

0.1 INTRODUCTION

0.1.1 Jaipur, the 'symphony in pink', is the land of superlatives, where breathtaking beauty and rich art & culture blend superbly. It nestles amidst the Aravali ranges and is surrounded by rugged hills on three sides, each crowned by a formidable fort, while the city is studded with grand palaces, majestic mansions and gracefully landscaped gardens and parks. It is perhaps the first planned city of India, and was laid with great precision on the basis of principles of 'Shilp Shastra', the ancient Hindu treatise on architecture. The city was built in the form of a rectangle divided into blocks (Chowkries), with roads and avenues running parallel to the sides. In 1863 city of Jaipur was dressed in Pink to welcome Prince Albert, consort of Queen Victoria. The colour became an integral part of the city and it came to be known as 'The Pink City'.

After independence, Jaipur merged with the states of Jodhpur, Jaisalmer and Bikaner to become the greater Rajasthan in 1949. Under the State Re-Organization Act in 1956, Jaipur became the capital of the state of Rajasthan. Post independence, planned development of the city was taken up after the city became the capital of Rajasthan.

0.1.2 Though the city has grown into a modern metropolis and a throbbing commercial center, the city is a visitor's delight and caters to the needs of each form of tourism, ranging from historical, culture, adventure, sports, entertainment, shopping, business, conventions and conferences. Jaipur is also a renowned handicraft center and is also known for producing exquisite gold jewellery enamelled or inlaid with precious or semi-precious stones, blue pottery, carvings on wood, stone and ivory, block print and tie & dye textiles, leather articles, handmade paper, miniature painting etc.

0.1.3 **Location** - Jaipur city is located at an altitude of 431 m (above MSL) and at 26.92°N latitude & 75.82°E longitude. The geographical area of the city is 326 sq. kms. The city is bound by Sikar and Alwar districts on north, by Tonk, Ajmer and Sawai Madhopur districts on south, by Nagaur, Sikar, Ajmer districts on west and Dausa district in east. The climate of Jaipur city forms the part of the tropical summer land and therefore shows a significant variation in temperature. Climate of Jaipur is hot and dry.

0.1.4 Population

The total population of the study area in 2011 was 30,73,350. The decadal growth in Jaipur city is more than 100% in the past 3 decades. The decade wise population growth of Jaipur is given as **Table 0.1.**

Table 0.1
Decade wise population of Jaipur

S.No.	Year	Population	Percent rate of growth (%)
1	1951	304380	
2	1961	410376	3.0
3	1971	636768	4.5
4	1981	1015160	4.8
5	1991	1518235	4.1
6	2001	2324319	4.4
7	2011	3073350	3.2

Since 1961 the study area has registered an average rate of growth of around 4.45%. The estimated population figures of study area for the base year 2009, and the horizon years are given in **Table 0.2.**

Table 0.2
Estimated Population in Area of Study (lakh)

Region	2009	2011	2021	2031
Jaipur City	41.99	44.45	64.16	92.78

0.2 TRAFFIC DEMAND FORECAST

The 4-stage traffic model has been adopted to carry out transport demand forecast. This comprises trip generation, trip distribution, modal split and trip assignment

The traffic assignment was carried out with the three proposed alignments in place. The loading on the proposed metro alignments is presented in **Table 0.3**

Table 0.3 Summary of Transport Demand Projections

Year	CORRIDOR	SECTIONAL LOAD (PHPDT)	DAILY RIDERSHIP (in lakhs)	AVERAGE LEAD (in km)
2014	Mansarovar-Badi Chaupar	11264	2.1	5.1
2021	Mansarovar-Badi Chaupar	16376	2.9	5.3
2031	Mansarovar-Badi Chaupar	27750	4.2	5.5

The daily ridership on the east west corridor will be 2.10, 2.90 and 4.20 lakh in the year 2014, 2021and in 2031 respectively.

The maximum range of PHPDT on the East-West alignment in 2014 will be 11264 and by 2031 the maximum range of PHPDT is projected to be of the order of 27750.

0.3 NEED FOR METRO

A comprehensive transportation study for the city is already in progress. Possible options for a public mass transit system are :-

i). City Buses;

ii). Bus Rapid Transit Systems;

iii). Tramway system; and

iv). A Metro System (light or medium).

The city already has a bus system operated and maintained by Rajasthan Roadways and private operators. This is totally inadequate for the needs of the city. The Government is also contemplating to introduce Bus Rapid Transit Systems on certain selected routes. BRT has its own limitations and constraints. For one thing, the capacity of a BRT system can at best be only 10000 to 12000 PHPDT (Peak Hour Peak Direction Trips) and that of a tramway system about 8000 to 10000 PHPDT. The BRT takes away two lanes of the road for dedicated use pushing rest of the road vehicles crowded into the remaining road space. Therefore, unless the road widths are more than three lanes in each direction, BRT is not feasible and even then the non-bus riders will be put to tremendous inconvenience. In Delhi BRT has been a total failure. In the case of a Metro system, the road width is not encroached upon. If the Metro is elevated, only the central median of the road to a width of 2 to 3 m. is occupied for locating the columns carrying the rail deck. If the metro is underground, there is no encroachment at all on the road width.

Further a Metro will not cause any pollution, causes less vibration and noise, is safe and reliable. The energy needed for a passenger km. in the case of a metro is only 1/5th of the energy needed for road transport. A Light Metro will have a capacity of three lanes of BRT or 9 lanes of motor cars each way.

A tramway system shares the right of way with road vehicles and therefore reduces the available road width for other vehicles. Trams need more energy and has limited capacity. Trams have to wait at all road crossings for signals and therefore their speeds are low.

Therefore, wherever the travel demand is more than 10000 PHPDT, a Metro System is unavoidable. Any mass transit system should meet the needs of the city for the next 50 years or so and from this angle, the Metro should be the back bone for the Public Transport System, other modes being feeder services.

- **ADVANTAGES OF METRO SYSTEM**

- Requires 1/5th energy per passenger km compared to road-based system.
- Causes no air pollution in the city.
- Causes lesser noise level
- Occupies no road space, if underground and only about 2 metres width of the road, if elevated.
- Carries same amount of traffic as 5 lanes of bus traffic or 12 lanes of private motor cars (either way), if it is a light capacity system.
- Is more reliable, comfortable and safer than road based system
- Reduces journey time by anything between 50% and 75% depending on road conditions.

0.4 SYSTEM SELECTION

A. PERMANENT WAY

- **CHOICE OF GAUGE**

Standard Gauge (1435mm) is invariably used for metro railways world over due to its inherent advantages. During the last decade, 20 new metros have been constructed in various cities of the world. All these metros have gone in for Standard Gauge even though the national gauge for mainline railways in some of these countries was different from Standard Gauge. In India the national gauge is Broad Gauge (1676mm). Reasons for selection of Standard gauge are described in the Report.

- **TRACK STRUCTURE**

Track on Metro System 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 System 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. Ballastless track with continuous welded head-hardened rails has been proposed as mainline track in elevated and underground stretches. However for at-grade section and at depot the track structure shall be ballasted.

B. TRACTION SYSTEM

Keeping in view the ultimate traffic requirements, standardization, and other techno-economic considerations, 25 KV traction system is considered to be the best trade-off and hence, proposed for adoption on Jaipur Metro System.

C. SIGNALING AND TRAIN CONTROL

Metro carries large number of passengers at a very close headway requiring a very high level of safety enforcement and reliability. At the same time heavy investment in infrastructure and rolling stock necessitates optimization of its capacity to provide the best services to the public. These requirements of the metro are planned to be achieved by adopting ATP (Automatic Train Protection) and ATS (Automatic Train Supervision) signaling systems. Automatic Train Operation (ATO) will be added in future.

D. TELECOMMUNICATION

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

The telecommunication facilities proposed are helpful in meeting the requirements for

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

The proposed telecom system will cater to the following requirements:

- Train Traffic Control

- Assistance to Train Traffic Control
- Maintenance Control
- Emergency Control
- Station to station dedicated communication
- Telephone Exchange
- Passenger Announcement System and Passenger Information and Display System within the station and from Central Control to each station.
- Centralized Clock System
- Train Destination Indicator
- Instant on line Radio Communication between Central Control and Moving trains and maintenance personnel.
- Data Channels for Signaling, SCADA, Automatic Fare Collection, etc.

E. AUTOMATIC FARE COLLECTION

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

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

F. ROLLING STOCK

Rolling stock for Jaipur Metro has been selected based on the following criteria:

- Proven equipment with high reliability
- Passenger safety feature
- Energy efficiency
- Light weight equipment and coach body
- Optimized scheduled speed
- Aesthetically pleasing Interior and Exterior
- Low Life cycle cost
- Flexibility to meet increase in traffic demand
- 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.

The following optimum size of the coach has been chosen for this corridor as mentioned below in **Table 0.4.**

Table 0.4
Size of the coach

Descrption	Length	Width	Height
Driver Motor Car	21.64 m	2.9 m	3.9 m
Motor/Trailer car	21.34 m	2.9 m	3.9 m

0.5 CIVIL ENGINEERING

GEOMETRIC DESIGN NORMS

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.
Horizontal curves are provided with the following parameters given in **Table 0.5**.

Table 0.5

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

Elevated Sections

The viaducts carrying the tracks will have a vertical clearance of minimum 5.5 m above road level. For meeting this requirement with the 'Box' shaped pre-stressed concrete girders, the rail level will be about 9.8 m above the road level. However, at stations which are located above central median, the rail level will be 12.5 m above the road level with concourse at mezzanine. These levels will, however, vary marginally depending upon where the stations are located.

The track center on the elevated section is kept as 4.2m uniform through out the corridor to standardize the superstructure, except at few locations as detailed below:

- On curves below 300m Radius but upto 120m Radius 4.2m
- At scissors crossings 4.5m

- **Underground sections**

Rail level at midsection in tunneling portion shall be kept at least 12.0 m below the ground level so that a cover of 6m is available over the tunnels. At stations, the desirable depth of rail below ground level is 12.5m; Track centre in underground section to be constructed by Tunnel Boring Machine (TBM) is 13.05m to accommodate a 10m wide island platform. Track centre in underground section to be constructed by cut and cover method is 4.5m.

- **Gradients**

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

- **Design Speed**

The maximum sectional speed will be 80 km/h. However, the applied cant, and length of transition will be decided in relation to normal speeds at various locations, as determined by simulation studies of alignment, vertical profile and station locations.

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 80 kms. Horizontal alignment and vertical alignment are dictated to a large extent by the geometry of the road followed by the alignment.

- **Route Alignment**

East – West Corridor: Mansarovar to Badi Chaupar

From dead end (Ch.-1218.93m) of Mansarovar station to dead end of Badi Chaupar station (Ch. 10848.496m), the length of the corridor 2 is 12.067 km, out of which 2.789 km is under ground and remaining 9.278 km is elevated, including Switch Over

Ramp.Total 11 number of stations have been planned along this corridor out of which 8 are elevated and 3 are underground stations.

Alignment of E-W Corridor is placed at fig. 0.1.

- **Viaduct Structure**

  The proposed viaduct structure for the Jaipur Metro is Pre-cast segmental box girder, carrying two tracks supported on single pier located on the median of the road. Road clearance of 5.5 m is ensured below the viaduct structure. The foundation shall be pile foundation at most of the locations. Open foundations are possible at certain isolated locations. The superstructure shall be pre-cast segmental construction which will cause minimal inconvenience to the road users during the execution stage.

- **Station Locations & Planning**

  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 and the average spacing of stations is close to one km as possible.

- **Sequence of Stations**

  The sequence of stations along with their respective chainages, site and platform characteristics are presented in the **Table 0.6**:

Table 0.6
STATION LOCATION CHARACTERISTICS

S. No.	Name of Station	Chainage (in m)	Distance from previous station (in m)	Rail level (in m)	Ground Level (in m)	Platform type	Alignment
East – West Corridor Mansarovar to Bari Chaupar							
	Dead End	-1218.93	-	424.500	-		
1	Mansarovar	-659.363	559.567	424.500	410.943	Side	Elevated
2	New Aatish Market	795.520	1454.88	418.500	403.648	Side	Elevated
3	Vivek Vihar	1901.00	1105.48	426.400	412.889	Side	Elevated

S. No.	Name of Station	Chainage (in m)	Distance from previous station (in m)	Rail level (in m)	Ground Level (in m)	Platform type	Alignment
4	Shyam Nagar	2782.120	881.12	428.200	414.174	Side	Elevated
5	Ram Nagar	3529.256	741.136	438.000	417.400	Side	Elevated
6	Civil Lines	4615.296	1086.04	442.600	422.460	Side	Elevated
7	Railway Station	6198.422	1583.12	451.600	432.959	Side	Elevated
8	Sindhi Camp	7537.201	1338.77	451.000	438.057	Side	Elevated
9	Chand Pole	8323.248	786.04	431.250	999.000	Island	Underground
10	Choti Chaupar	9545.158	1221.91	427.000	440.647	Island	Underground
11	Badi Chaupar	10398.502	853.344	427.500	440.934	Side	Underground
	Dead End	10848.496	950.058	427.500	-		

Stations have been divided into two distinct areas, namely public and non-public (technical areas). The public area is further sub divided into unpaid and paid area. Provision for escalators are made at all stations in paid area from the beginning itself. Provision in civil structures at stations is being kept for providing lifts for disabled passengers in future.

Integration facilities at Metro stations include approach roads to the stations, circulation facilities, and pedestrian ways and circulation areas for various modes likely to come to important stations, including feeder buses. Parking for private vehicles has not been proposed in view of the scarcity of land along the alignment.

- **Geo Technical Investigations**

  Geotechnical investigation work at site was carried out to determine the existing subsoil strata, proposed type & depth of foundations and safe bearing capacity of foundations required for the proposed two Metro Corridors in Jaipur City based on the results of 35 bore holes. Core drilling was carried out by using rotary type of boring machine with diamond bits of N_X size. Casing of 100/150 mm dia was advanced up to the firm strata as per IS1892 (1979).The description of bore logs for bore holes drilled as per IS -5313.

  The top soil is generally silty sand with gravels having variable thickness. Weathered/hard rock at depth of 13 meter was met near Ajmer Puilya on East-West Corridor. The rock is metamorphic type quartz.

- **Utilities**

The proposed Metro alignment is passing along major arterial roads of the city road network, which are serving institutional, commercial and residential areas. A large number of surface and sub-surface utility services, viz. sewers, water-mains, storm water drains, telephone cables, electric poles, traffic signals, etc. are existing along the proposed alignment. Details of the existing utility services along the proposed alignment have been collected from the concerned authorities.

- **Land Requirement**

Since land is a scarce commodity especially in metropolitan areas, every effort has been made to keep land requirement to the barest minimum and acquisition of private property is minimal. Land is mainly required for Depots and route alignment on sharp bends, station buildings, platforms, entry/exit structures, traffic integration, power sub-stations, ventilation shafts, administrative buildings and temporary construction depots / work sites etc.
Abstract of land requirements for E-W Corridor is given in **Table 0.7**:

Table 0.7
Summary of Permanent Land Requirement (Ha)

SN	Description	E-W Corridor	
		Gov.	**Private**
1.	Stations	2.068	3.315
2.	Running Section	0.532	1.43
3.	RSS/TSS	0.61	
4.	Depots	11.19	
	Total	**14.4**	**4.745**

Total Land required for this corridor: 14.4 Ha (Govt.) + 4.745 Ha (Pvt.) = **19.145 Ha.**

0.6 Train Operation Plan

Any public transport system, particularly a Metro system, is made attractive by providing high frequency service both during peak and off-peak hours. For this purpose 4 Car trains with different headways of 3 minutes to 10 minutes has been examined. The frequency can be brought down to 3 minutes in future depending upon the demand. The detailed train operation plan is provided in the report.

Salient Features of the proposed trains' operation plan are:

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

- Make up time of 5-10% with 8-12% coasting.
- Scheduled speed for these corridors has been assumed as:
  East-West Corridor : 32 kmph

Requirement of coaches is calculated based on following assumptions:-

(i) Train Composition planned as under
DTC: Driving Trailer Car
MC : Motor Car
TC : Trailer Car
4 Car Train Composition : DTC + MC + MC+ DTC
Extendable to 6 car Train Composition : DTC + MC + TC + MC + MC+ DTC

Capacity

DTC	:	247 Passengers (Sitting-43, Crush Standing-204)
TC/MC	:	270 Passengers (Sitting-50, Crush Standing-220)
4 Car Train:		1034 Passengers (Sitting-186, Crush Standing-848)
6 Car Train:		1574 Passengers (Sitting-286, Crush Standing-1288)

(ii) Coach requirement has been calculated based on headway during peak hours.
(iii) Traffic reserve is taken as one train per section to cater to failure of train on line and to make up for operational time lost.
(iv) Repair and maintenance reserve has been estimated as 8 % of total requirement (Bare +Traffic Reserve) based on Intermediate Overhaul and Periodic Overhaul interval of 3 and 6 years respectively.
(v) The calculated number of rakes in fraction is rounded off to next higher number.

Total Reversal Time is taken as 6 min at terminal stations.

Based on Train formation and headway as decided above to meet Peak Hour Peak Direction Traffic Demand, Rake requirement has been calculated and tabulated below in **Table 0.8:**

Table 0.8

Corridor	Year	Headway (min)	No. of Rakes	Rake Consist	No. of Coaches
East-West corridor	2013	6	8	4 car	32
	2017	6	10	4 car	40
	2021	4	15	4 car	60
	2031	2.5	22	4 car	88

Total 32 coaches are required in the year 2013-14.

0.7 Power Requirements

Power supply is required for operation of Metro system for running of trains, station services (e.g. lighting, lifts, escalators, tunnel ventilation system, signaling & telecom, fire fighting etc) and workshops, depots & other maintenance infrastructure within premises of metro system. The major component of power supply is traction requirements for elevated sections and auxiliary requirements for Underground section.

The power requirements of a metro system are determined by peak-hour demands of power for traction and auxiliary applications. Broad estimation of auxiliary and traction power demand is made based on the following assumptions:-

(i) Specific energy consumption of rolling stock – 70KWh/1000 GTKM
(ii) Regeneration by rolling stock – 30%
(iii) Elevated station load – initially 200KW, which will increase to 300 KW in the year 2021
(iv) Underground Station load – initially 2000 kW, which will increase to 2250 kW in the year 2021

Keeping in view of the train operation plan and demand of auxiliary and traction power, power requirements projected for the year 2014, 2021 and 2031 are summarized in **Table 0.9** :-

Table 0.9 Power Demand Estimation (MVA)

Corridor		Year		
		2014	2021	2031
Badi Chopar to Mansarovar.	Traction	4.1	6.2	9.5
	Auxiliary	10.7	12.4	14.1
	Total	**14.8**	18.6	**23.6**

- **Sources of Power Supply**

The high voltage power supply network of Jaipur city has 220kV and 132kV network to cater to various types of demand in vicinity of the proposed corridor. 220/132 kV sub stations are located to the alignment of Corridors. Keeping in view the reliability requirements, two input sources of 132 kV Voltage level are normally considered for each corridor. As per the sequence of construction, the revenue operation of elevated sections of the two corridors will begin before the Underground sections are completed. The intersection of the two corridors will be at Sindhi Camp station (Underground station of N-S Corridor). Therefore, to achieve the desired reliability, two Receiving Sub Stations (132 / 33 / 25 kV) are proposed to be set up for E-W Corridor each. Based on the discussions with Rajasthan Rajya Vidyut Prasaran Nigam Limited (RVPN), it is proposed to avail power supply for traction as well as auxiliary services from the following grid sub-stations at 132kV voltage through cable feeders. Sources of Power Supply are given in **Table 0.10.**

Table 0.10 Sources of Power Supply

Corridor	Grid sub-station (with Input voltage)	Location of RSS of Metro Authority	Approx. length of cables
Mansarovar to Badi Chopar	Mansarovar GSS (220 / 132kV)	Depot at Mansarovar (132 / 33/25 kV)	0.5 km, 132kV (Double Circuit Cables).
	GIS substation, PWD Bungalow at Station Road near RSRTC bus stand. (132 / 33 kV).	Near Sindhi Camp Metro Station (132 / 33/25 kV)	0.5 km, 132kV (Double Circuit Cables).

- **Auxiliary Supply Arrangements for Stations & Depot**

  Auxiliary sub-stations (ASS) are envisaged to be provided at each station (3 ASS's for Underground stations and 1 ASS for elevated station) for stepping down 33 kV supply to 415 V for auxiliary applications. A separate ASS is required at depot. The ASS will be located at mezzanine or platform level inside a room. The auxiliary load requirements have been assessed at 200kW for elevated / at-grade stations which is likely to increase up to 300 KW in the year 2031 and 2000 kW for Underground Station which is likely to increase up to 2500 KW in the year 2031. In order to meet the requirement of auxiliary power two dry type cast resin transformers (33/0.415kV) of 500kVA capacity are proposed to be installed at the elevated stations (one transformer as standby) and one transformer of 1.6 MVA at each underground ASS. For Property Development within the footprints of the station, a provision to add third transformer at a later date may be kept at elevated station.

- **Standby Diesel Generator (DG) Sets**

  In the unlikely event of simultaneous tripping of all the input power sources or grid failure, the power supply to stations as well as to trains will be interrupted. It is, therefore, proposed to provide a standby DG set of 200 KVA capacity at the elevated stations and 2 X 1000/750 KVA at Underground stations to cater to the following essential services:

  (i) Essential lighting
  (ii) Signaling & telecommunications
  (iii) Fire fighting system
  (iv) Lift operation
  (v) Fare collection system
  (vi) Tunnel Ventilation (for Underground Stations)

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

0.8 VENTILATION AND AIR-CONDITIONING SYSTEM

The underground stations of the Metro Corridor are built in a confined space. A large number of passengers occupy concourse halls and the platforms, especially at the peak hours. The platform and concourse areas have a limited access from outside and do not have natural ventilation. It is therefore, essential to provide forced ventilation in the stations and inside the tunnel for the purpose of:

- Supplying fresh air for the physiological needs of passengers and the authority's staff;

- Removing body heat, obnoxious odours and harmful gases like carbon dioxide exhaled during breathing;
- Preventing concentration of moisture generated by body sweat and seepage of water in the sub-way;
- Removing large quantity of heat dissipated by the train equipment like traction motors, braking units, compressors mounted below the under-frame, lights and fans inside the coaches, A/c units etc.;
- Removing vapour and fumes from the battery and heat emitted by light fittings, water coolers, Escalators, Fare Gates etc. working in the stations;
- Removing heat from air conditioning plant and sub-station and other equipment, if provided inside the underground station.

This large quantity of heat generated in M.R.T. underground stations cannot be extracted by simple ventilation. It is, therefore, essential to provide mechanical cooling in order to remove the heat to the maximum possible extent. As the passengers stay in the stations only for short periods, a fair degree of comfort conditions, just short of discomfort are considered appropriate. In winter months it may not be necessary to cool the ventilating air as the heat generated within the station premises would be sufficient to maintain the comfort requirement.

0.9 MAINTENANCE DEPOTS

The depot planning is based on following assumptions:

i) There is no connectivity between North-South corridor and East-West corridor to transfer trains from one line to another else it would have reduced depot requirement in East-West corridor.

ii) Enough space is available at Bambana Nala and Mansarovar terminals for establishment of Depot-cum-workshop and a satellite depot respectively.

iii) Road transport shall be available for transporting heavy equipments for IOH/POH and heavy repairs from Mansarovar depot to Sitapura depot-cum-workshop and vice-versa.

iv) All inspection and workshop lines are designed to accommodate 6 car trains.

v) SBLs at terminal stations shall accommodate 6 car trains and SBLs within depots shall accommodate composite fleet of 4 car and 6 car trains.

It is proposed to establish a depot-cum-workshop at Sitapura Indl.Area and a small depot at Mansarovar with following distribution of activities.

Mansarovar

i) All minor inspections of East-West corridor

ii) All minor repairs

iii) Lifting of coaches for replacement of heavy components.

iv) Stabling of all the trains.

0.10 ENVIRONMENT IMPACT ASSESSMENT AND MANAGEMENT

A detailed Environmental Impact Assessment Study has been carried out along the proposed alignment. As a part of this study, comprehensive environmental baseline data was collected. 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. However, the project has some negative impacts especially during implementation of the project. An important environmental consideration of this project is that neither any forest area nor any plants/ trees of endangered species exist along the proposed alignment, though 1158 trees will need to be uprooted. A few residential/commercial structures are affected. To minimize the negative environmental impacts, an Environmental Management Plan has been drawn up.

0.11 COST ESTIMATES

CAPITAL COST ESTIMATE – E-W CORRIDOR

The capital cost of E-W corridor has been worked out as below:

Phase-I-Mansarovar to Badi Chopar (All inclusive Cost) .

Phase-IA-Part cost of Mansarovar to Chandpole (All inclusive Cost).

Phase-IB-Part cost of Chandpole to Badi Chopar (All inclusive Cost).

The overall capital cost for Phase I at April 2011price level, works out to Rs. **2399Crore**, excluding taxes and duties, but including general charges & design charges @ 7% on all items except land and 3% contingencies on all items.

The Capital Cost estimate for Phase-IA at April 2011price level, works out to **Rs. 1609Crore**, excluding taxes and duties, but including general charges & design charges @ 7% on all items except land and 3% contingencies on all items.
The Capital Cost estimate for Phase-IB at April 2011price level, works out to **Rs. 792Crore**, excluding taxes and duties, but including general charges & design charges @ 7% on all items except land and 3% contingencies on all items

TAXES AND DUTIES

The component of Import Duty, Excise Duty and VAT is not included in the Capital cost estimated. The estimated taxes and duties work out to Rs. 398 crore for Phase-I , Rs. 262crore for Phase-I A and Rs. 136 crore for Phase-I B for E-W corridor.

0.12 FINANCIAL VIABILITY, FARE STRUCTURE AND FINANCING OPTIONS

Investment Cost

For the purpose of calculating the Financial Internal Rate of Return (FIRR), the completion cost with central taxes have been calculated by taking escalation factor @5% PA. It has been assumed that Government of Rajasthan will exempt local taxes or reimburse the same. The impact of proposed Goods & Service Tax Act (GST) has not been considered in the calculation.

The construction work in respect of Phase-IA of 9.718 KMs from Mansarovar to Chandpole as already taken up and scheduled for commercial operation from 1st July-2013. However for the balance portion, the work willbe taken up inApril, 2012 and expected to be completed in the year 2016-17. The Revenue Opening Date (ROD) for this part has been assumed as 01.04.2017. The total completion costs duly escalated and shown in the table 12.2 have been taken as the initial investment. The cash flow of investments based on completion cost is separately is placed in Table –12.2 asbelow.

Table 0.11 Year wise Investment-With Central Taxes

(Figs in Rs/Crore)

F/Y	Estimated Cost at April 2011	Completion Cost for Phase-I	Completion Cost for Phase-I A	Completion Cost for Phase-I B
2010-11	46.00	46.00	46.00	0.00
2011-12	378.00	395.00	393.00	2.00
2012-13	632.00	693.00	596.00	97.00
2013-14	554.00	641.00	487.00	154.00
2014-15	369.00	449.00	287.00	162.00
2015-16	345.00	440.00	214.00	228.00
2016-17	177.00	237.00	0.00	235.00
2017-18	176.00	248.00	0.00	248.00
Total	2677.00	3149.00	2023.00	1126.00

12.2.1.2 Although the construction of Phase-IB from Chandpole to Badi Chaupar is expected to get over by 31st March 2017, the cash flow spills up to March 2018 on account of payment normally required to be made to the various contractors up to that period necessitated by contractual clauses.

Fare Structure

The fare structure of Delhi Metro was compared with the existing fare of Buses, Auto and other general modes of public transport in Jaipur and it was reported that the same is mostly coming at par of the Delhi Metro Fares structures as fixed by a fare fixation committee in 2009. The same, therefore have been assumed which have been duly escalated @10% for every two years and is placed in table 0.12.

Table 0.12: Fare Structure in 2013-14

Distance in km.	Metro Fare (Rs.)
0-2	9.00
2-4	12.00
4-6	14.00
6-9	18.00
9-12	19.00
12-15	21.00

Distance in km.	Metro Fare (Rs.)
15-18	23.00
18-21	25.00
21-24	26.00
24-27	27.00
27-31	28.00

Financial Internal Rate of Return (FIRR)

The Financial Internal Rate of Return (FIRR) with consideration that 12.5 ha of land will be provided by government for property development, obtained with the above revenues and costs for 35 years are placed in table 0.13: -

Table 0.13: FIRR (Cost with central taxes)

Particulars	Cost including DMRC portion
FIRR	**8.24%**

Financing Options

The objective of funding metro systems is not necessarily enabling the availability of funds for construction but coupled with the objective of financial closure are other concerns, which are of no less importance: -

- Ensuring low project cost
- Ensuring debt funds at low rates of interest
- Creating self sustainable system in the long run by
  - Low infrastructure maintenance costs
  - Longer life span
  - Setting fares which minimise dependence on subsidies
- Recovering returns from both direct and indirect beneficiaries

Rail based mass transit systems are characterised by heavy capital investments coupled with long gestation period leading to low financial rates of return although the economic benefits to the society are immense.

ALTERNATIVE MODELS OF FINANCING

The prominent models are: -

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

(ii) Public-Private Partnership (PPP) mode

- Built Operate and Transfer (BOT) model
- Other PPP Model

Table 0.14 - Funding pattern under EPC model

Particulars	Government of India		Government of Rajasthan		Total	
	%	Rs/Crore	%	Rs/Crore	%	Rs/Crore
Equity by GOI & GOR	15.00%	472.50	15.00%	472.50	30.00%	945.00
SD for land cost by GOR	0.00%	0.00	3.43%	108.00	3.43%	108.00
Additional SD for Central Taxes by GOI&GOR Equally	5.00%	157.50	5.00%	157.50	10.00%	315.00
JICA Loan /Market Borrowing/ debt from the State Govt.	0%	0%	56.57%	1781.00	56.57%	1781.00
Total	**20%**	**630.00**	**80%**	**2519.00**	**100.00%**	**3149.00**

0.13 ECONOMIC INTERNAL RATE OF RETURN

The cost and benefit streams for 30-year period in the economic prices have been worked out for both the phases of the project and presented in Annexure 13.1 of Chapter 13. The residual value of the metro facilities in last year has not been taken into account as benefit in these tables.

In the analysis, the 'with project' alternative of providing metro system is compared with the base option of 'without project (Do- nothing scenario)' alternative of using the existing transport facilities. This is to arrive the net economic benefits, which consist of reduction in vehicle operation cost and reduction in travel time. The total cost worked out on the above basis is then subtracted from the total benefits to estimate the net benefit of the project. This flow is then subjected to the process of discounting to work out the EIRR and ENPV on the project, to examine the viability of the Project in Economic terms. The results are given in Table 0.21.

Table 0.21: Results of Economic Analysis

Parameter	Results
EIRR (%)	18.6%

The EIRR for the proposed metro project is worked out to be 18.6%.

Sensitivity Analysis

A sensitivity analysis is carried out for the following scenarios;

- Increase in cost by 10%
- Decrease in benefits by 10%
- Combined scenario of Increase in cost by 10% and Decrease in benefits by 10%

The EIRR under these scenarios are given in Table 0.22.

Table 0.22 Results of Sensitivity Analysis

Sl. No.	Sensitivity	EIRR (%)	ENPV (Rs. in Crores @ 12% discount rate)
1	Normal Scenario	18.6.0%	5598
2	With increase in cost by 10%	17.6%	5066
3	With reduction in benefits by 10%	17.5%	4506
4	With 10% reduction in benefits and increase in cost by 10%	16.6%	3974

In the sensitivity analysis, the EIRR is found to be at 16.6%, under the combined scenario of increase in cost by 10% and decrease in benefits by 10%. Hence the project is found to be economically viable.

0.14 IMPLEMENTATION OF PROJECT

Implementation Schedule through DMRC on Deposit basis
Mansarover to Chandpole , Phase – 1A of East west corridor of Jaipur Metro

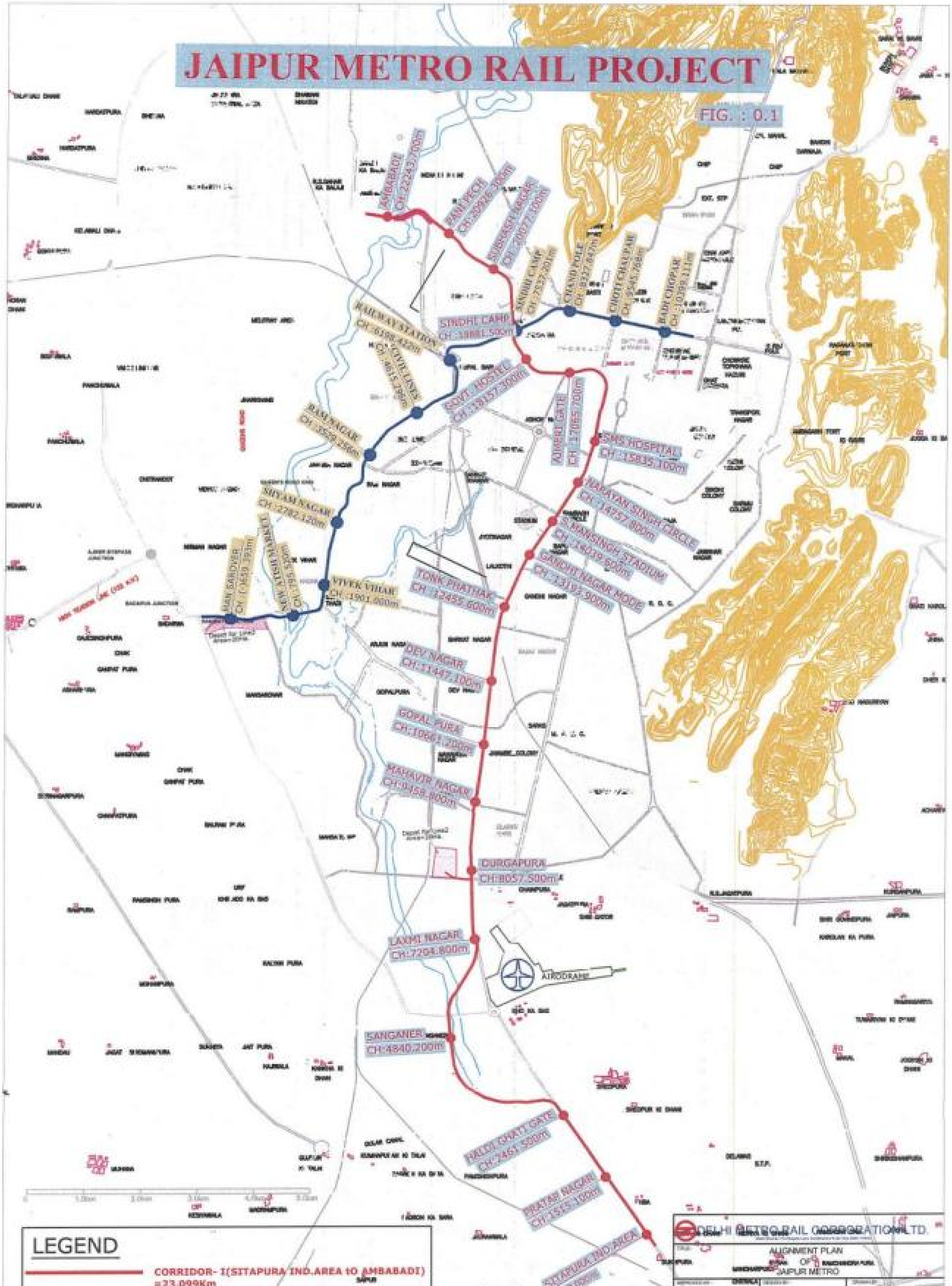
S. No.	Item of Work	Completion Date
1.	Submission of Final DPR to State Govt.	Submitted on 26.01.2010
2	Approval of DPR by State Government	Approved by State Govt. on 15.03.2011
3	Tendering, Execution of works and Procurement of equipments, coaches and installations	01.09.2010-15.04..2013

S. No.	Item of Work	Completion Date
4	Testing and Commissioning	15.04.2013-15.06.2013
5	Revenue Operation	30.06.2013

This corridor has to be commissioned in two stages i.e. one for the portion entrusted to DMRC and the second between Chandpole and Badi Chaupar. The above schedule is for Mansarovar- Chandpole portion. The commissioning of left over portion between Chandpole and Badi Chaupar may take about 5 years from the date agency is decided for its implementation. It is suggested that the agency for implementation of left over portion of phase I i.e Chandpole to Badi Chauparmay be decided by GoR at the earliest. To commission the entire Phase I corridor expeditiously, it is recommended that balance of phase I should also be got done through DMRC on the deposit terms or any other agency as EPC contract (with DMRC as GC) but with the same system and rolling stock as being planned for Phase IA under taken through DMRC.

0.15 CONCLUSIONS

After examining the various options for execution of Jaipur Metro Project, GoR has decided to execute East- West corridor as Phase-I on EPC Mode of which part 1A from Mansarovar to Chandpole of 9.718 Kms has been taken up through DMRC and the remaining part of this Phase Consisting of Chandpole to Badi Chauper is under process of award/execution. DMRC recommends this Phase Under EPC Mode with Equity funding by GoI and GoR equally as per DMRC /BMRC/CMRL Model..


JAIPUR METRO RAIL PROJECT
FIG. : 0.1
AMBABADI CH:22243.700m
PANI PECH CH:20926.300m
SUBHASH NAGAR CH:20077.100m
SINDHI CAMP CH:7532.200m
CHAND POLE CH:8937.847m
CHOTI CHAUPAR CH:9545.788m
BADI CHOPAR CH:10099.111m
RAILWAY STATION CH:6198.422m
SINDHI CAMP CH:18881.500m
CIVIL LINES
GOVT. HOSTEL CH:18157.300m
AJMERI GATE CH:17065.700m
RAM NAGAR CH:3550.288m
SMS HOSPITAL CH:15835.100m
NARAYAN SINGH CIRCLE CH:14757.800m
SHYAM NAGAR CH:2782.120m
S.MANSINGH STADIUM CH:14019.600m
GANDHI NAGAR MODE CH:13195.900m
MAN SAROVER
NEW ATISH MARKET
VIVEK VIHAR CH:1901.000m
TONK PHATHAK CH:12455.600m
DEV NAGAR CH:11447.100m
GOPAL PURA CH:10561.200m
MAHAVIR NAGAR CH:9458.800m
DURGAPURA CH:8057.500m
LAXMI NAGAR CH:7204.800m
AIRODRAM
SANGANER CH:4840.200m
HALDI GHATI GATE CH:2461.500m
PRATAP NAGAR CH:1515.100m
SITAPURA IND.AREA CH:0.000m
DELHI METRO RAIL CORPORATION LTD.
ALIGNMENT PLAN OF JAIPUR METRO
LEGEND
CORRIDOR- I(SITAPURA IND.AREA tO AMBABADI) =23.099Km
CORRIDOR- II(MANSAROVER to BADI CHOPAR) =12.067Km

Chapter 1

Introduction

1.1 Background
1.2 Study Area
1.3 Demographic Profile
1.4 Present Study

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

DPR for Jaipur Metro was last prepared and submitted in June 2011. The DPR contained the under-mentioned combinations of financing of two corridors:-

Combination – I: Funding under DMRC model (total cost including DMRC's portion of cost of Corridor-2)

Combination - II: Funding pattern under DMRC model (total cost excluding DMRC's portion of cost of Corridor-2)

Combination – III: Funding pattern under DMRC model (cost excluding Total cost of 9.718 km.)

Funding on BOT basis for under-mentioned two scenarios was also furnished:-

Scenario-1: **Cost excluding the work entrusted to DMRC (9.718 km) of Corridor-2 (only civil).**

Scenario-2: **Cost excluding the cost of Civil, S&T and Rolling Stock of the stretch entrusted to DMRC (9.718 km).**

The development of the Jaipur Metro is being done in two phases and accordingly, now JMRC has approached that two separate DPRs to be prepared for Phase-I (East-West Corridor) and Phase-II (North-South Corridor). A copy of letter No.F.7(C-3)JMRC/DPR/2011/4776, dt. 21/2/2012 is put up at Annex 1.1.

Route Length (between dead ends)

Phase-I	**Underground/km**	**Elevated/km**	**Total/km**
Mansarovar to Badi Chaupar (East-West Corridor)	2.789	9.278	12.067
Phase-II			
Sitapura to Ambabari	5.095	18.004	23.009

(North-South Corridor			
Total:	**7.884**	**27.282**	**35.166**

This DPR is prepared for E-W Corridor with funding pattern like Chennai,Bangalore and DMRC and the report is named as Phase-I Report.

The other Paras of Chapter as given in the previous Report, are also reiterated as under:-

1.1.1 Jaipur, the 'symphony in pink', is the land of superlatives, where breathtaking beauty and rich art & culture blend superbly. Until the eighteenth century, Amber served as the capital of the Kachwaha clan of the Rajputs. However, due to its inaccessible tract on the Aravalli hills, it was unable to meet the demands of a growing population. Sawai Jai Singh in 1727 decided to move his capital to the plains, 11 km south of Amber. Jaipur, situated in North - West part of India, was thus founded in 1727 AD and was named after its founder Sawai Jai Singh. Jaipur City was not only planned but its execution was also coordinated by Sawai JaiSingh II, in such a manner that a substantial part of the city developed up within seven years of its foundation. It nestles amidst the Aravali ranges and is surrounded by rugged hills on three sides, each crowned by a formidable fort, while the city is studded with grand palaces, majestic mansions and gracefully landscaped gardens and parks. It is perhaps the first planned city of India, and was laid with great precision on the basis of principles of 'Shilp Shastra', the ancient Hindu treatise on architecture. The city was built in the form of a rectangle divided into blocks (Chowkries), with roads and avenues running parallel to the sides. In 1863 city of Jaipur was dressed in Pink to welcome Prince Albert, consort of Queen Victoria. The colour became an integral part of the city and it came to be known as 'The Pink City'.

In 19^{th} and 20^{th} centuries the city's population spread beyond its walls. In 1922 Man Singh II, Jaipur's Maharaja ascended the throne and it was during his reign that civic buildings like the secretariat, schools, hospitals and other public buildings were built. The municipality was reorganized in 1926 and a new municipal act was prepared in 1929.

After independence, Jaipur merged with the states of Jodhpur, Jaisalmer and Bikaner to become the greater Rajasthan in 1949.Under the State Re-Organization Act in 1956, Jaipur became the capital of the state of Rajasthan. Post independence, planned development of the city was taken up after the city became the capital of Rajasthan

1.1.2 Though the city has grown into a modern metropolis and a throbbing commercial center, the city is a visitor's delight and caters to the needs of each form of tourism, ranging from historical, culture, adventure, sports, entertainment, shopping, business, conventions and conferences. Jaipur is also a renowned handicraft center and is also known for producing exquisite gold jewellery enamelled or inlaid with precious or semi-precious stones, blue pottery, carvings on wood, stone and ivory, block print and tie & dye textiles, leather articles, handmade paper, miniature painting etc.

1.1.3 Location - Jaipur city is located at an altitude of 431 m (above MSL) and at 26.92°N latitude & 75.82°E longitude. The geographical area of the city is 326 sq. kms. The city is bound by Sikar and Alwar districts on north, by Tonk, Ajmer and Sawai Madhopur districts on south, by Nagaur, Sikar, Ajmer districts on west and Dausa district in east. The climate of Jaipur city forms the part of the tropical summer land and therefore shows a significant variation in temperature. Climate of Jaipur is hot and dry.

1.1.4 SEISMIC ACTIVATY

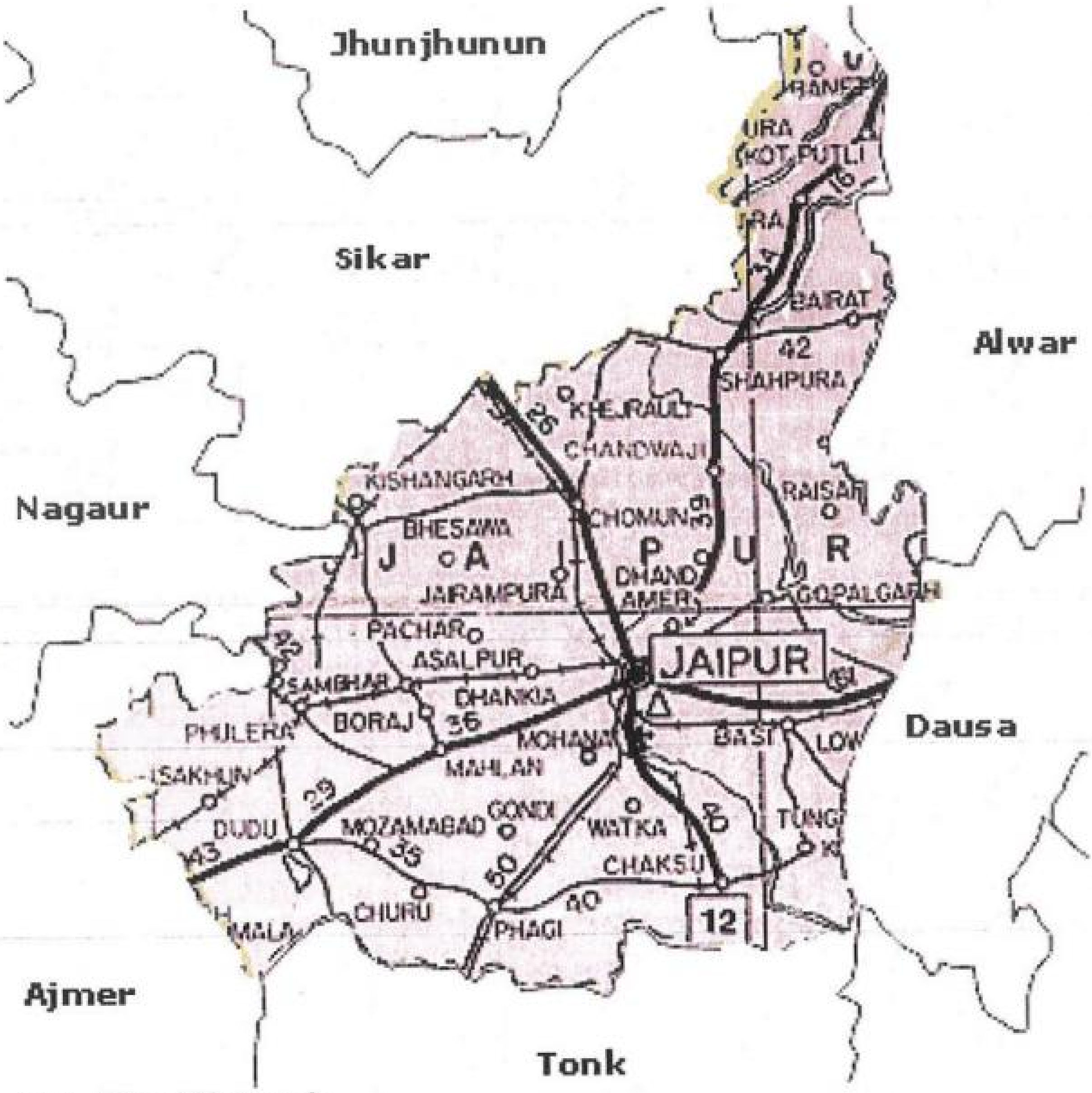
The city falls under zone-II which is classified as Low Damaged Risk Zone & is assigned zone factor of 0.10.

There has been no major earthquake in recent years in Jaipur City.

1.1.5 RAINFALL

No major river passes through the city of Jaipur. The average rain fall of the city is 620 mm.

Location of Jaipur City in Rajasthan State



1.1.6 Road Network

Jaipur city is well connected with other important cities of Rajasthan such as Ajmer, Udaipur, Jodhpur, Bikaner, Alwar, Bharatpur, Jaisalmer and other places of historical importance such as Agra, Gwalior, Khajuraho, Delhi, Chandigarh, Kolkata, Ahmedabad, Mumbai & Lucknow through road and rail linkages. The road network consists of National Highways, State Highways and Major & other Roads. Following National Highways pass through the city:

1 National Highway No. 8 (Delhi - Mumbai)

2 National Highway No. 11 (Agra - Bikaner)
3 National Highway No. 12 (Jaipur - Jabalpur)

1.1.7 Rail Network

Jaipur is the headquarters of the North Western Railway Zone of the Indian Railways. Jaipur is a major junction station.

Following are the three Broad Gauge routes passing through the city:

1 Delhi-Jaipur-Ahmedabad
2 Sawai Madhopur - Jaipur- Jodhpur
3 Agra – Jaipur

Jaipur at present is connected to Bikaner, Sri Ganganagar, via Sikar and Churu by Meter Gauge network shall also be connected by Broad Gauge after gauge conversion of Jaipur- Ringus- Sikar- Churu (MG to BG). The GC work of this section is sanctioned and is in progress.

1.1.8 Air Route

Jaipur has well connected domestic air links with all metropolitan & other important cities of India. The airport located at Sanganer has recently acquired the status of an international airport and offers direct flight to Muscat, Sharjah, Dubai and Bangkok.

1.2 STUDY AREA

The study area has been taken as the area comprising 94 internal and 10 external zones. The area are under the control of Jaipur Nagar Nigam and Jaipur Development Authority. The zone map is given in **Figure – 1.1.**

Ward map of JNN & JDA Area

In terms of share, 87% of the total population lives in the JNN area, of which 7% lives in the walled city. While the proportion of population living within the JNN has increased (primarily due to expansion in area), the proportion of population in the walled city has declined. This can be regarded as positive phenomena as the walled city is already very densely populated. The Walled City has a spatial extent of only 6.7 sq.km but houses nearly four lakh people. The 2001census shows that the population of the Walled City has declined from 1991. The reason for this is out movement of inhabitants from the area to new residential colonies being developed in the periphery in want of better living environment.

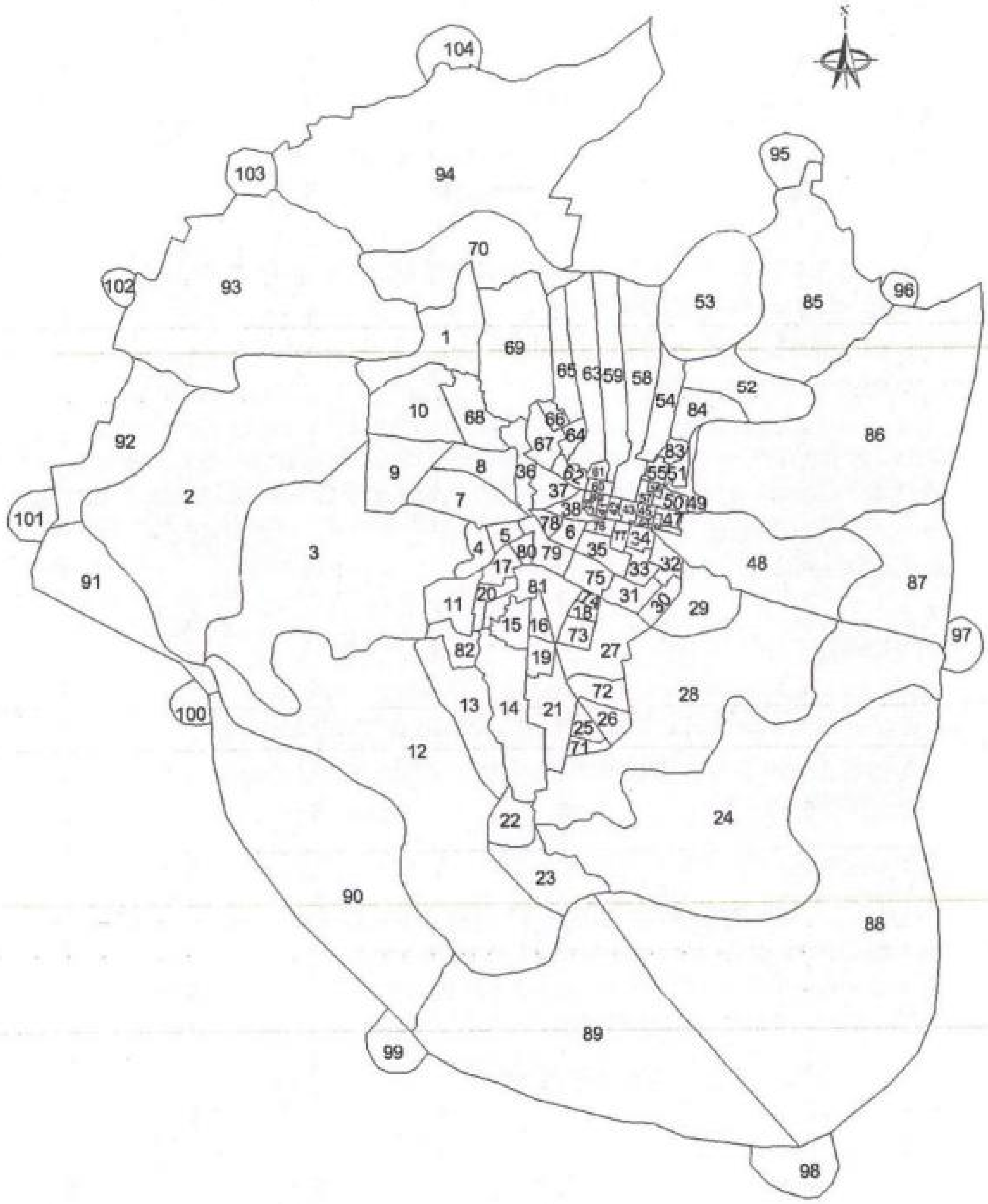


Figure – 1.1

1.3 DEMOGRAPHIC PROFILE

The total population of the study area in 2001 was 23,24,319. The decadal growth in Jaipur city is more than 100% in the past 3 decades. The decade wise population growth of Jaipur is given as Table 1.

Table 1
Decade wise population of Jaipur City

S.No.	Year	Population	Percent rate of growth (%)
1	1951	304380	
2	1961	410376	3.0
3	1971	636768	4.5
4	1981	1015160	4.8
5	1991	1518235	4.1
6	2001	2324319	4.4
7	2011	3073350	3.2

Since 1961 the study area has registered an average annual rate of growth of around 4.45%. The estimated population figures of study area for the base year **2009**, and the horizon years are given in Table 2.

Table 2
Estimated Population in Area of Study (lakh)

Region	2009	2011	2021	2031
Jaipur Urban Agglomeration	41.99	44.45	64.16	92.78

1.4 PRESENT STUDY

As already explained in the beginning of the Chapter, this Report is prepared as revision to earlier DPR submitted for Phase-I of Jaipur Metro. The need of a Metro system for a city is brought out in the subsequent paras.

1.4.1 Rapid industrialization and intense commercial developments in the past decades have resulted in steep rise in travel demand, putting Jaipur's transport infrastructure to stress. With the projected increase in the city's population, strengthening and augmenting the existing transport infrastructure has assumed urgency.

1.4.2 The present public transport system available for the city is not properly organized and is inadequate in terms of frequency & comfort. The fleet of about 250 buses is being operated under public transport system which connects the suburban areas to core area of the city. The private mini bus operators operate about 1800 buses mostly in city area. The private mini bus operators dominate and compete with public bus system. Their routes are in-efficiently rationalized and are not properly regulated with too many buses on some routes where as other routes have very less frequency.

The other transport facility available is Rickshaws. Cycle Rickshaws operates mostly inside walled city area for short trips and Auto Rickshaws operates in whole study area. The present bus transport system is insufficient to cater the need of city due to which the share of public transport has decreased from 26% to 19% in last decade. Commuters prefer to use personalized transport. The average annual growth rate of the vehicles in Jaipur is about 12% which is causing congestion on city roads.

The State Government has taken up the project of Bus Rapid Transport System (BRTS) under JNNURM scheme at a cost of Rs. 480.00 crores. Under BRTS project, pilot dedicated corridor has been developed from C-Zone bypass to Ambabari in a length of 7.1 km. Further, it has been reported that it is proposed to develop 45.0 km BRT corridor on wider road sections of the city. 400 new low floor modern buses are being procured for induction into city transport system. BRTS routes are being modified to act as feeder to Jaipur Metro.

Chapter 2

Traffic Forecast

CHAPTER 2

TRAFFIC FORECAST

2.0 TRANSPORT DEMAND FORECAST

2.1 TRAVEL CHARACTERISTICS

2.1.1. GENERAL

Two metro corridors with a combined length of 35.666 km have been identified for the city of Jaipur.

- The E-W line starts from Manasarovar and ends at Badi Chopar with a total length of 12.067 km.(Phase 1)
- The N-S line starts from Sitapura industrial area to Ambabari via SMS hospital with a total length of 23.099 km.(Phase 2)

This chapter covers the transport demand projections for above mentioned corridors and section and station loadings for the same.

2.1.2. TRANSPORT DEMAND MODELLING

Data Base

Detailed household surveys and various traffic surveys were carried out during the DPR study. A transport demand model was developed and the future OD-Matricies based on the projected population and employment was developed.

The network for the transport demand model including the metro alignments has been developed from the primary database.

The four-stage transport Demand Model involving Trip Generation, Trip distribution, Modal Split and Assignment has been used.

The basic functions included in the transportation study process are:

- Trip-end prediction or trip generation and attractions – i.e., the determination of the number of person trips leaving a zone irrespective of destination and the number of trips attracted to a zone, irrespective of origin.
- Trip distribution – the linking of the trip origins (generation) with their destinations (attraction).
- Modal split – the division of trips between public transport modes and different private modes
- Assignment – the allocation of trips between a pair of zones to the most likely route(s) on the network.
- Evaluation – assessing the effectiveness of the network in meeting the transport demand.

The details of the planning process as adopted for this study is shown in **Figure 2.1**.

2.1.3 ZONING

The entire study area has been delineated into 104 zones as shown in **Figure 2.2.** Among them 94 are the internal zones and the remaining zones (10 zones) are external zones. Detailed list of all these zones is given in the **Annexure 2.1.**

Summary of population projection and employment projections is presented in the **Table 2.1**.

Table 2.1 Population and Employment projection(Urban Agglomeration)

Description	Horizon Year			
	2009	2011	2021	2031
Population (in lakhs)	41.99	44.45	64.16	92.78
Employment (in lakhs)	14.69	15.55	22.44	32.47

These figures are based on the Census (2001) and projected for future in consultation with the city development authorities.

2.1.4 TRIP INFORMATION

The trip information obtained from the survey has been analyzed with respect to distribution of total trips by mode. The share of trips by various modes are presented in **Table 2.2 and Figure. 2.3.**

Table 2.2 Distribution of Trips (All modes)

Mode	Share
Walk	28%
Bicycle	5%
Car	9%
Two Wheeler	24%
Auto Rickshaw	5%
Taxi	8%
Public transport	21%
Total	100%

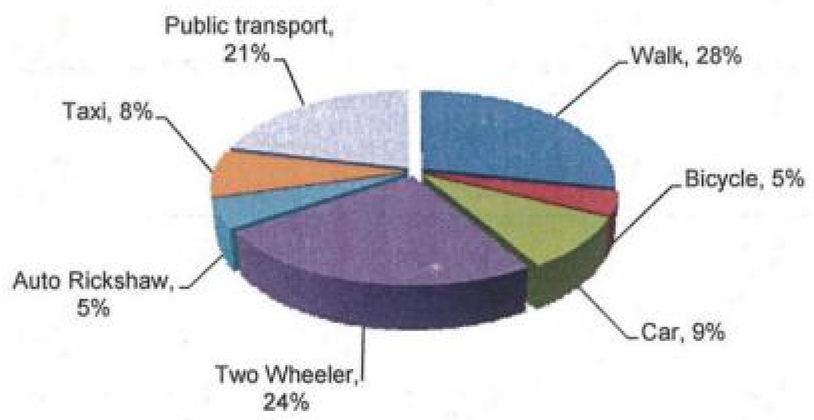


Figure 2.3. Mode Share (all modes)

Public transport trips constitute about only 21% of the total trips while Two-wheeler trips are 24 %, Auto trips 5%, Car trips constitutes 9% and taxi trips 8%.

2.2 TRANSPORT DEMAND MODEL AND PARAMETERS

2.2.1 MODEL DESCRIPTION

As stated earlier, the standard four stage Model constituting Trip generation, trip Distribution, Modal split and Assignment is used. Extensive household surveys and traffic surveys were carried out to develop the four stage model. The horizon year Origin-Destination (O – D) Matrices for private and public modes were developed using the Gravity Model. The parameters obtained from the Model have been used for the transport demand projections for the proposed alignments.

2.2.2 SPEED FLOW RELATIONSHIP

The speed flow curves were developed for different functional classes. Speed flow curves have been adjusted to take into account delays at junctions. These speed flow curves were converted into Bureau of Public Roads(BPR) functions and fed into the model as input in the highway network. The form of the BPR function is

$$T_C = T_0 * (1 + \alpha * (v/c)^{\wedge\beta})$$

Where

Tc – Congested Link Travel time

T0 – Link Free flow time

V - Link Volumes

C – Link Capacity

α and β – Calibrated Parameters

The BPR functions developed for different categories of roads is given in Table 2.3.

Table 2.3. BPR functions

Road way Class	Functional Characteristics	Directional Capacity	ALPHA	BETA

6	2L-2W-UD	1900	4.1	3.5
11	4L-2W-UD	3800	3.0	3.5
12	4L-2W-D	4500	3.3	3.0
15	6L-2W-D	6700	5.0	3.8

(Note: L: Lanes, 1w- One Way, UD- Undivided, D- Divided, 2W- Two way)

The initial free flow speeds taken for the assignment of public and private modes are summarized in **Table 2.4.**

Table 2.4 Free flow Speeds

Mode	**Free Flow Speed (kmph)**		
	2-lane	4-lane	6-lane
All modes	36	40	49

2.2.3 TRIP CATEGORIZATION

The passenger transport demand in terms of daily passenger trips has been broadly categorized as intra-city and inter-city trips. The inter-zonal trips are the most important, so far as transport system development is concerned. The trips were classified by different motorized modes including private, hired and public motorized vehicles.

2.2.4 TRIP GENERATION

The first of the sub-models in the study process is that which predicts the number of trips starting and ending in each zone. The techniques developed attempt to utilize the observed relationships between travel characteristics and the urban environment and are based on the assumption that 'trip making' is a function of three basic factors:

- Land use pattern and development in the study area,
- Socio-economic characteristics of the trip-making population of the study area, and

- Nature, extent and capabilities of the transportation system in the study area

Mathematically, trip generation can be expressed as:

Trips Generated = Function (socio-economic, locational etc. variables)

Various techniques for developing the trip generation sub-models are available and notable among them are:

- Regression Analysis
- Category Analysis or Cross Classification Analysis

A typical regression analysis for trip generation model is

$$G = A_o + \sum_{I=1}^{k} a_{ij}\, x_i$$

Where

G	=	No. Of trips (produced/attracted) in a zone for a specific purpose.
A_0	=	Constant term to be calibrated.
$a_o, a_1 \ldots\ldots a_K$	=	Coefficients to be determined by the regression analysis
$X_1, x_2.$	=	Zonal planning input factor (independent) variable)

The significance of the regression equation is tested on the basis of R^2 value and the t-statistics value (for each of the coefficients).

Typical inputs for trip generation sub-models are population, employment, vehicle ownership, household income, residential density, etc. These models are developed using standard computer programs.

Population is a major influencing factor for trip generation. As it is one of the major variables in the trip end models used for obtaining the future trip ends, it has an influence in the over all trip productions / attractions.

For the generation of trip generation sub-models, analysis has been carried out at zonal level utilizing regression analysis technique. The generalized form of the trip generation equation to be developed is as under: -

Y=A+BX

Where

Y=Trips produced or attracted

A=Constant term

B=Trip rate to be determined from least square Analysis

X=Independent variable e.g., population, employment, Vehicle ownership

The results of calibration of different models are given in **Table 2.5**

Table 2.5 Generation for Total Trips

	Co-off.
Intercept	98.71
X Variable	0.054

By using the above table the value of R^2 was found to be 0.65, T-value – 8.5, F-value-72.3 (**Assuming Population in zones as the variable**).

Table 2.6 Trip attraction for total trips

	Co-off.
Intercept	524.6
X Variable	0.134

By using above expression the value of R^2 was found to be 0.55, T value-6.6, F Value-43.24 (**Assuming Employment in zone as variable).**

The population and employment projection for the horizon years is presented in **Table 2.7** below:

Table 2.7 Population and employment projections

Year	Population (Lakhs)	Employment (Lakhs)
2009	41.99	14.69
2011	44.45	15.55
2021	64.16	22.44
2031	92.78	32.47

2.2.5 PER CAPITA TRIP RATE (PCTR)

Adopted Per Capita Trip Rate for base and horizon years i.e., 2009, 2014, 2021 and 2031 are as given in the **Table 2.8.**

Table 2.8 Adopted PCTR (Motorized) Value

Year	PCTR Value
2009	0.68
2014	0.71
2021	0.77
2031	0.85

2.2.6 TRIP DISTRIBUTION AND MODE CHOICE

A regular four stage transport model distributes the trip ends to the zones initially and then selects the choice of the mode. Trip distribution normally is carried out using the traditional gravity function. Many methods are available for mode choice including diversion curve, utility based logit model etc. The present study combines the trip distribution and mode choice to form a combined Trip Distribution and Modal Split phase using a conventional doubly constrained gravity model of the form:

$$T_{ijm} = r_i G_i s_j A_j F_{ijm}$$

Where T= number of inter zonal trips between zone i & j and by mode m
G= Total generation trip ends by zone
A= Total attraction trip ends by zone

i=Generation Zone
j= Attraction Zone
r,s=Balancing factors (constants)
Fijm= Deterrence function for mode m

Fijm= Km e-βcijm Cijm α --------------- Eqn 1

Where K= Constant Factor
C=Generalized Cost
β= Calibration Constant –Exponential function
α=Calibration Constant- Power function
Double Constraints are imposed by ensuring that

$$\sum_{Jm} T_{ij} = G_i \quad \text{and} \quad \sum_{\text{Im}} T_{ij} = A_i$$

The calibration includes estimation of parameters of the deterrence function is in the form of Gamma (Refer Eqn 1). The calibration process for combined trip distribution and mode choice is explained in flowchart as shown in **Figure 2.4**.

The cost of travel (C- generallised cost) between the zones has been estimated based on skims from the Highway and Public Transport assignment. The estimation of generallised cost for the base year is explained in the following section.

2.2.7 DETERENCE FUNCTIONS

Calibrated parameters for the Deterrence function by mode is given in **Table 2.9**

Table 2.9 Calibrated Deterrence Functions for Morning peak hour

	Morning Peak		
Mode	**K**	**ALPHA**	**BETA**
Two wheeler	0.92	-0.4	44.8
Car	7.9	0.4	26.8

Auto Rickshaw	3.3	1.73E-13	36.6
Taxi	4.5	-0.2	29.4
Public transport	4.7	0.2	49.8

2.2.8 TRIP ASSIGNMENT

2.2.8.1 Trip assignment is the process of allocating a given set of trip interchanges to a specific transportation system and is generally used to estimate the volume of travel on various links of the system to simulate present conditions for validation purposes and to use the same for horizon years for developing forecast scenarios. The process requires as input, a complete description of either the proposed or existing transportation system, and a matrix of inter-zonal trip movements. The output of the process is an estimate of the trips on each link of the transportation system, although the more sophisticated assignment techniques also include directional turning movements at intersections.

The purposes of trip assignment are:

1. To assess the deficiencies of the existing transportation system by assigning estimated future trips to the existing system – **Do Nothing Scenario**.
2. To evaluate the effects of limited improvements and extensions to the existing transportation system by assigning estimated trips to the network which included these improvements.
3. To develop system development priorities by assigning estimated future trips for intermediate years to the transportation system proposed for these years.
4. To test alternative transportation system proposals by systematic and readily acceptable procedures.
5. To provide design hours volumes and turning movements.

2.2.8.2 ASSIGNMENT PROCEDURE ADOPTED

The observed highway and public transport matrices were assigned on the network to check the validation across the screen lines. The assigned traffic volume has been compared with the observed traffic counts. The assignment is carried out in two stages with the assignment of Transit trips following the

Highway PCU Assignment. The highway assignment is the assignment of vehicles on Roads and this is carried out also in stages with commercial vehicles and buses taken as pre loads. The transit assignment is the assignment of commuters on a Public Transit network which comprises of buses, metros etc which are linked on to the zonal system via walk links. This methodology is presented in **Figure 2.5**.

2.2.8.3 PCU CONVERSION FACTOR

The results from the trip assignment, which is in terms of person trips, have to be converted to PCU trips for updating the link speeds. As the occupancy levels of the private modes are quite different from the road-based public transport modes, separate passenger to PCU conversion factors were derived for the two types of travel. The factors used for the study area are given in **Table 2.10**

Goods vehicles and other slow moving vehicles use the roads simultaneously. Thus the capacity comparison and speed modifications must take movement of these vehicles in mixed traffic conditions into account. Thus, after the person trips are converted to vehicles trips in terms of PCUs, the goods traffic factor is added to boost up the value to incorporate the mixed flow conditions because of goods vehicles and the slow moving vehicles.

TABLE 2.10 PCU CONVERSION FACTORS

	Modes	PCU Values
Private Vehicles& IPT	Two wheeler	0.75
	Car	1.0
	Auto rickshaw	2.0
	Taxi	1.0
Commer cial Vehicles	**Modes**	**PCU Values**
	Truck	2.2
	MAV	3.7
	LCV	1.4

(As per IRC 106: 1990)

2.3 TRANSPORT DEMAND PROJECTIONS

2.3.1 The proposed stations on the east west corridor and distance between the stations is given in **Table 2.11**

Table 2.11 : Inter -Station Distances on the Mansarovar to Badi Chopar Corridor

Station No	Station Name	Distance (in km)
1	Mansarovar	0
2	New aatish Market	1.454
3	Vivek Vihar	1.105
4	Shayam Nagar	0.881
5	Ram Nagar	0.747
6	Civil Lines	1.086
7	Railway Station	1.583
8	Sindhi Camp	1.338
9	Chand Pole	0.786
10	Choti Chopar	1.221
11	Badi Chopar	0.853

The Mansarovar to Badi Chopar corridor route length is 12.067 km with 11 stations. It may be noted that station spacing along the alignment varies from 0.718 km to 2.364 km.

2.3.2 SECTION LOADING

The traffic assignment was carried out with the two proposed alignments in place. The loading on the Mansarovar to Badi Chaupar corridor is presented in **Table 2.12**

Table 2.12 Summary of Transport Demand Projections

CORRIDOR	SECTIONAL LOAD	DAILY RIDERSHIP	DAILY PASSENGER KM	AVERAGE LEAD (Km)
2014				
Mansarovar to Badi Chaupar	11,264	2,10,420	10,73,142	5.1
2021				
Mansarovar to Badi Chaupar	16,376	2,93,175	15,53,828	5.3
2031				
Mansarovar to Badi Chaupar	27,750	4,21,614	23,18,877	5.5
2041				
Mansarovar to Badi Chaupar	29,169	4,43,175	24,37,463	5.5

The daily ridership on the east west corridor will be 2.1 lakhs in 2014 and in 2031, the ridership will be 4.2 lakhs passengers per day.

The maximum range of PHPDT on the East-West alignment in 2014 will be 11264 and by 2031 the maximum range of PHPDT is projected to be of the order of 27750. The section wise loading and PHPDT is presented in **Annexure 2.2.**

2.3.3 STATION LOADING

Peak hour station loading (two way boardings) for the two alignments are presented in **Table 2.12 .**

Table 2.12 Station Loading for Mansarovar to Badi Chopar Corridor

S. No.	STATION NAME	2014	2021	2031	2041
1	Mansarovar	6427	6643	10513	11051
2	New Aatish Market	978	1382	2381	2503
3	Vivek Vihar	941	1726	2787	2930
4	Shayam Nagar	1488	2383	3802	3996
5	Ram Nagar	1991	4668	8588	9027
6	Civil Lines	1518	2591	4239	4456
7	Railway Station	1443	1835	2512	2640
8	Sindhi Camp	2218	3991	4344	4566
9	Chand Pole	3694	3885	3971	4174
10	Chotti Chopar	1871	2399	2554	2685
11	Badi Chopar	811	1072	1155	1214

(Note: Numbers are total Boardings on both directions (Up and Down)

2.3.4 TRIP LENGTH FREQUENCY DISTRIBUTION

The trip length frequency distribution of the Metro trips is presented in **Annexure 2.3** it can be observed that the average trip length for the years 2014 and 2031 for East west corridor the trip length is 5.1 km in 2014 and increasing to 5.5 km in 2031.

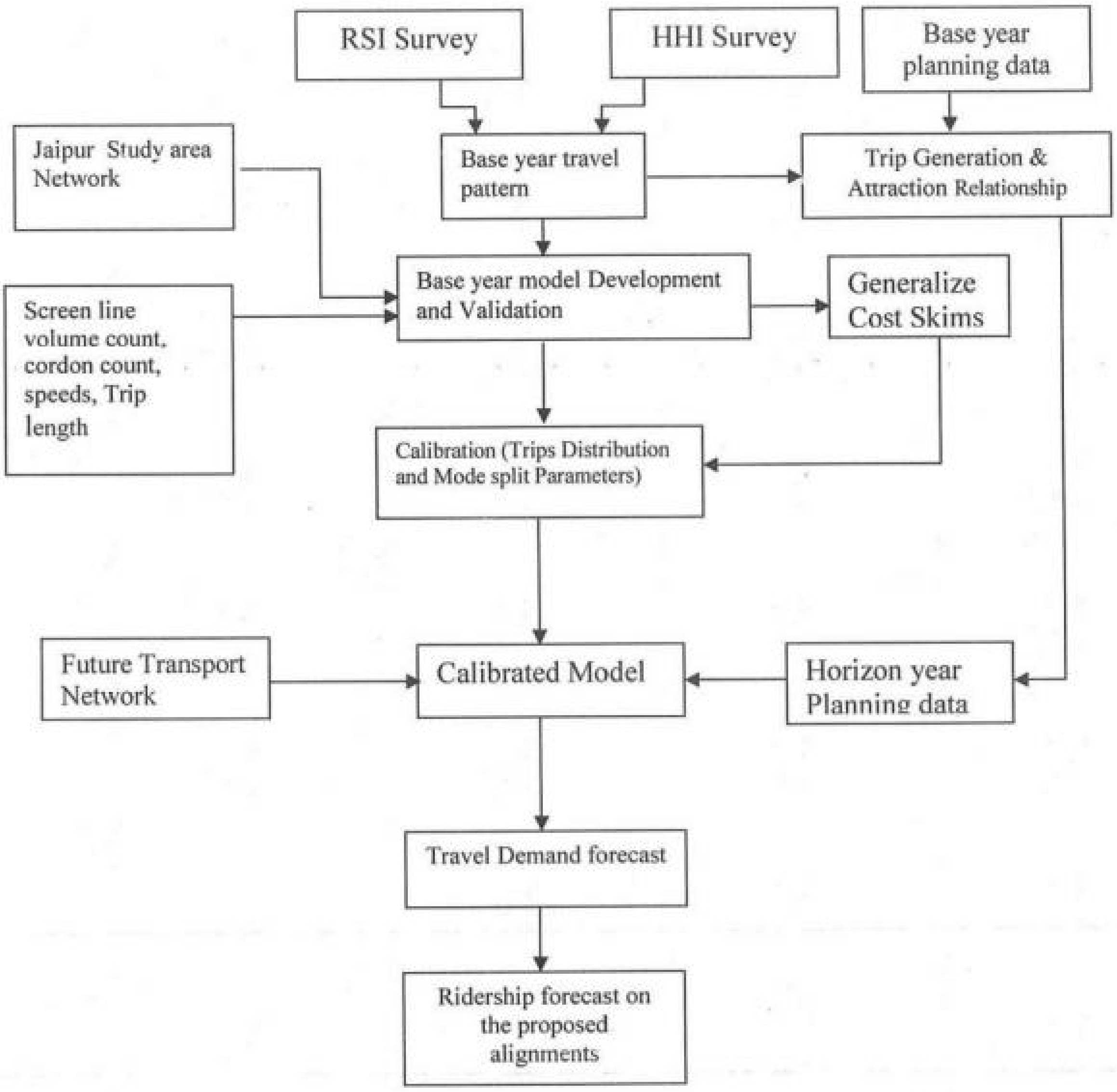


Figure 2.1: Modeling approach

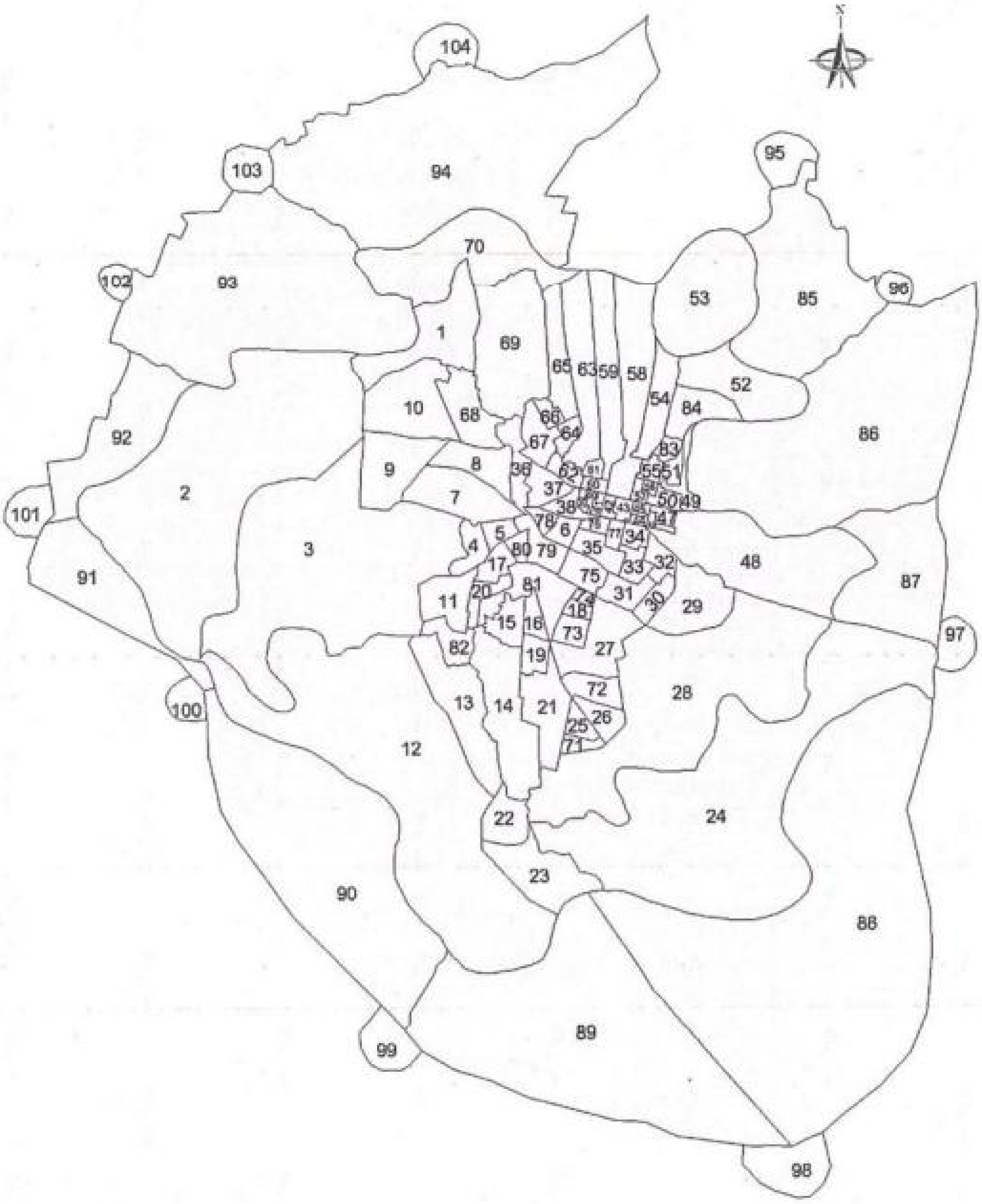


Figure 2.2: Zoning system

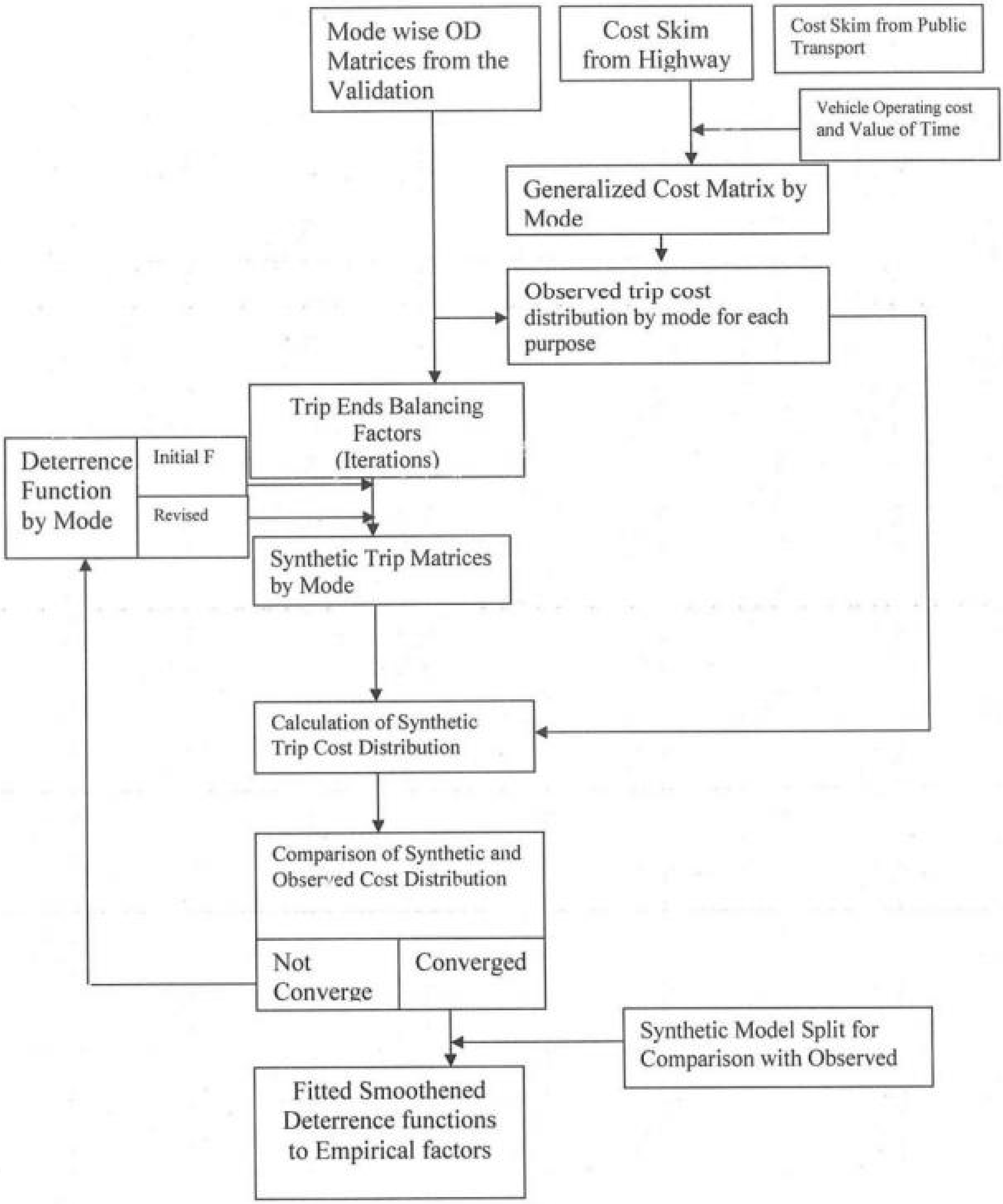


Figure 2.4: Calibration process

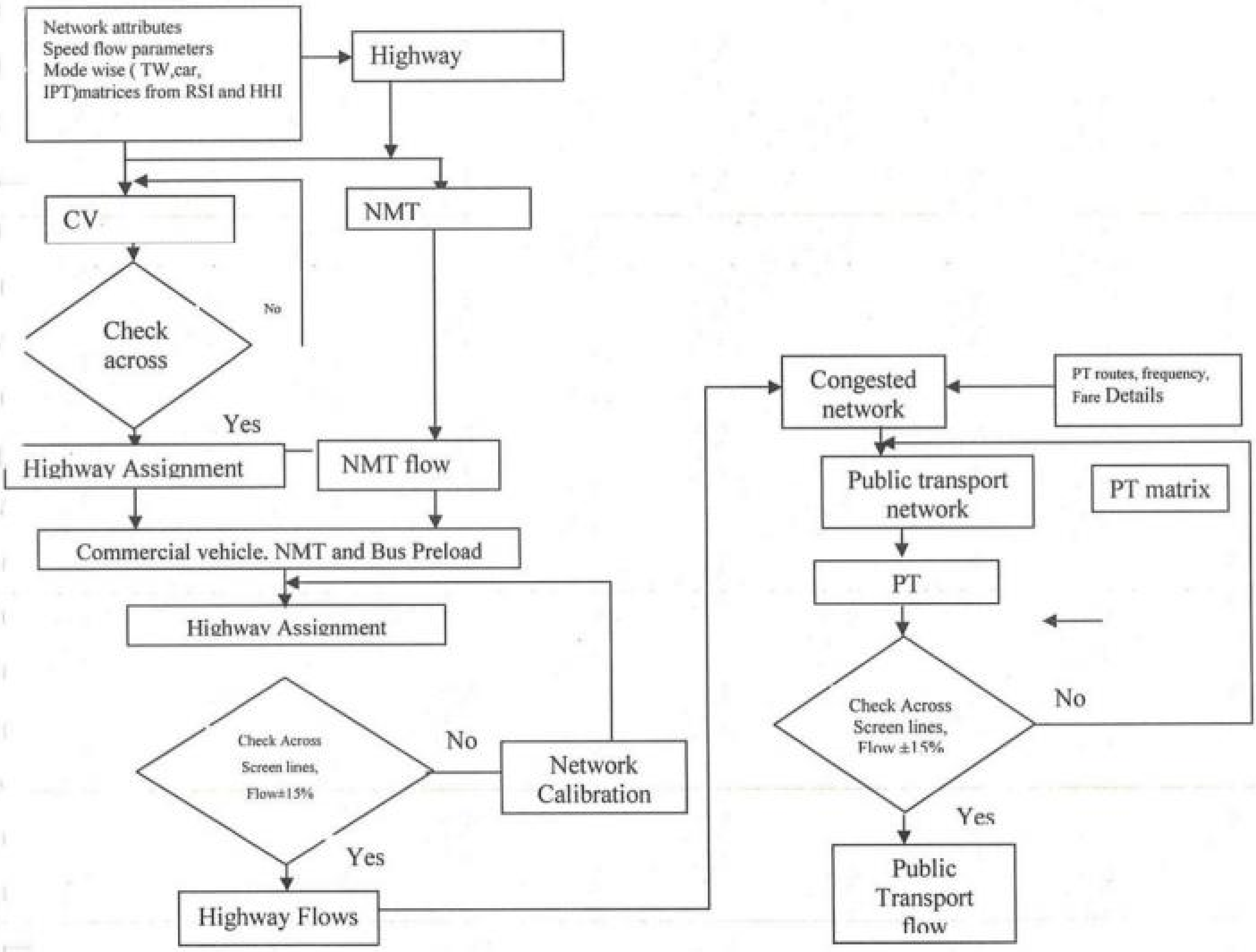


Figure 2.5. Trip Assignment

ANNEXURE -2.1
ZONE NUMBERS AND ZONE NAMES

Zone No.	Zone Name
1	Muralipura & Society
2	West Outer Zone
3	Vidhyut Nagar
4	Shanti Nagar
5	ESI Hospital Area
6	C-Scheme
7	NBC Army Area
8	Ram Mandir
9	Khatipura
10	Jhotwara Industrial Area
11	Shyam Nagar
12	Prathviraj Nagar
13	Mansarovar Colony
14	Triveni Nagar
15	Mahesh Nagar
16	SMS Stadium
17	Civil Lines
18	Gandhi nagar
19	Barkat Nagar North
20	Barkat Nagar South
21	Vasundhara Colony
22	Sanganeer
23	Sanganeer wards 11-19
24	East South Outer Area
25	Malviya Nagar South
26	Malviya Nagar North
27	University
28	Sawai Gator
29	Hills Beyond Jawahar
30	Jawahar Nagar
31	Raja Park
32	Janta Colony
33	Adarsh Nagar
34	Central jail

35	Rambagh Palace
36	Banipark West
37	Banipark East
38	Sansar Chandra Road
39	Walled City Area
40	Walled City Area
41	Walled City Area
42	Walled City Area
43	Walled City Area
44	Walled City Area
45	Walled City Area
46	Walled City Area
47	Walled City Area
48	Transport nagar
49	Laxmi Narayanpuri
50	Walled City Area
51	Basant Pura
52	Jal Mahal
53	Amer
54	Kagdiwala
55	Chandi ki Taksal
56	Walled City Area
57	Walled City Area
58	City Palace
59	Part Brahmpuri
60	Walled City Area
61	Walled City Area
62	Sikar House
63	Part Nahari Ka Naka
64	Bhatta Basti
65	Kacchi Basti
66	Shastri Nagar
67	Nehru Nagar
68	Ambabari
69	Vidhya Dhar Nagar
70	North Outer Area
71	Malviya Nagar South

72	Universit
73	Gandhi nagar
74	Gandhi nagar
75	Rambagh Palace
76	Rambagh Palace
77	Rambagh Palace
78	C-Scheme
79	C-Scheme
80	Civil Lines
81	Civil Lines
82	Shyam Nagar
83	Jal Mahal
84	Jal Mahal
85	Kukas, Chandwaji
86	Jamuva Ramgarh
87	Naila
88	Shivdaspura, Padampura
89	Chandlai, Chittoda, Knowledge city, Pahariya, Rohini Nagar Phase-2
90	Shivraj Colony, Rohini Nagar Phase-1, Renwal, Harsooliya, Narsi
91	Vatika Infotech city
92	Kalwad
93	Bhesawa, Jahota
94	Nindor, Nahargarh fort
95	Alwar district
96	Delhi, Haryana, Utter Pradesh
97	Dausa, Sawai Madhopur, Karauli districts of Rajasthan
98	Tonk, Bundi, Kota districts of Rajasthan, Madhya Pradesh
99	Ajmer, Bhilwara districts of Rajasthan
100	Rest of India
101	Nagur, Jodhpur districts of Rajasthan
102	Bikaner district
103	Rest of Rajasthan, Gujarat, Punjab
104	Sikar, Jhunjhunun, Churu districts of Rajasthan

ANNEXURE 2.2

Peak Hour Section Loadings – 2014- Mansarovar to Badi Chopar corridor

Station no	Station Name	Boarding	Alighting	Sectional loading	Station no	Station Name	Boarding	Alighting	Sectional loading
1	Mansarovar	6427	0	6427	11	Badi Chopar	811	0	811
2	New Aatish Market	759	249	6937	10	Choti Chopar	1021	132	1700
3	Vivek Vihar	810	294	7453	9	Chand Pole	788	565	1923
4	Shayam Nagar	1304	280	8477	8	Sindhi Camp	1220	504	2639
5	Ram Nagar	1787	341	9923	7	Railway Station	459	574	2524
6	Civil Lines	1321	349	10895	6	Civil Lines	197	301	2420
7	Railway Station	984	615	11264	5	Ram Nagar	204	253	2371
8	Sindhi Camp	998	4287	7975	4	Shayam Nagar	184	658	1897
9	Chand Pole	2906	1525	9356	3	Vivek Vihar	131	190	1838
10	Choti Chopar	850	1880	8326	2	New Aatish market	219	345	1712
11	Badi Chopar	0	8326	0	1	Mansarovar	0	1712	0

Peak Hour Section Loadings – 2021- Mansarovar to Badi Chopar corridor

Station no	Station Name	Boarding	Alighting	Sectional loading	Station no	Station Name	Boarding	Alighting	Sectional loading
1	Mansarovar	6643	0	6643	11	Badi Chopar	1072	0	1072
2	New Aatish Market	1022	312	7353	10	Choti Chopar	1237	145	2164
3	Vivek Vihar	1531	298	8586	9	Chand Pole	961	592	2533
4	Shayam Nagar	1988	389	10185	8	Sindhi Camp	1774	607	3700
5	Ram Nagar	4275	374	14086	7	Railway Station	478	745	3433
6	Civil Lines	2369	479	15976	6	Civil Lines	222	513	3142

7	Railway Station	1357	957	16376	5	Ram Nagar	393	357	3178
8	Sindhi Camp	2217	5006	13587	4	Shayam Nagar	395	953	2620
9	Chand Pole	2924	1978	14533	3	Vivek Vihar	195	505	2310
10	Choti Chopar	1162	2561	13134	2	New Aatish Market	360	599	2071
11	Badi Chopar	0	13134	0	1	Mansarovar	0	2071	0

Peak Hour Section Loadings – 2031- Mansarovar to Badi Chopar Corridor

Station no	Station Name	Boarding	Alighting	Sectional loading	Station no	Station Name	Boarding	Alighting	Sectional loading
1	Mansarovar	10513	0	10513	11	Badi Chopar	1155	0	1155
2	New Aatish market	1978	329	12162	10	Choti Cnopar	1383	153	2385
3	Vivek Vihar	2524	475	14211	9	Chand Pole	1024	647	2762
4	Shayam Nagar	3256	512	16955	8	Sindhi Camp	1967	751	3978
5	Ram Nagar	8027	487	24495	7	Railway Station	536	931	3583
6	Civil Lines	3985	853	27627	6	Civil Lines	254	559	3278
7	Railway Station	1976	1853	27750	5	Ram Nagar	561	388	3451
8	Sindhi Camp	2377	5947	24180	4	Shayam Nagar	546	1008	2989
9	Chand Pole	2947	3068	24059	3	Vivek Vihar	263	576	2676
10	Choti Chopar	1171	4385	20845	2	New Aatish market	403	704	2375
11	Badi Chopar	0	20845	0	1	Mansarovar	0	2375	0

Peak Hour Section Loadings – 2041- Mansarovar to Badi Chopar Corridor

Station no	Station Name	Boarding	Alighting	Sectional loading		Station no	Station Name	Boarding	Alighting	Sectional loading
1	Mansarovar	11051	0	11051		11	Badi Chopar	1214	0	1214
2	New Aatish market	2079	346	12784		10	Choti Chopar	1454	161	2507
3	Vivek Vihar	2653	499	14938		9	Chand Pole	1076	680	2903
4	Shayam Nagar	3423	538	17822		8	Sindhi Camp	2068	789	4181
5	Ram Nagar	8438	512	25748		7	Railway Station	563	979	3766
6	Civil Lines	4189	897	29040		6	Civil Lines	267	588	3446
7	Railway Station	2077	1948	29169		5	Ram Nagar	590	408	3627
8	Sindhi Camp	2499	6251	25417		4	Shayam Nagar	574	1060	3142
9	Chand Pole	3098	3225	25289		3	Vivek Vihar	276	605	2813
10	Choti Chopar	1231	4609	21911		2	New Aatish market	424	740	2496
11	Badi Chopar	0	21911	0		1	Mansarovar	0	2496	0

Annexure 2.3.

Mansarovar to Badi Chopar Corridor

Trip Length in KM	Trips-2014	Trips-2021	Trips -2031	Trips -2041
0-3	8176	10606	13571	14792
3-6	5219	7663	11220	11456
6-9	7507	9242	13491	14154
9-12	2478	5064	8564	8839

Chapter 3

Need for a Metro

3.1 Why a Metro?

3.2 Types of Metros and their Capacity

3.3 Advantages of a Metro System

CHAPTER 3

NEED FOR METRO

3.1 Why a Metro?

Public Transport System is an efficient user of space and energy, with reduced level of air and noise pollution. As the population of a city grows, share of public transport, road or rail-based, should increase. For a city with population of 1.0 million, the share of public transport should be about 40% - 45%. The percentage share of public transport should progressively increase with further growth in the city population, reaching a value of about 75% when the population of the city touches 5 million mark.

A comprehensive Mobility Plan for the city is already prepared. Possible options for a public mass transit system are:-

i). City Buses;

ii). Bus Rapid Transit Systems;

iii). Tramway system; and

iv). A Metro System (light or medium).

The city already has a bus system operated and maintained by Rajasthan Roadways and private operators. This is totally inadequate for the needs of the city. The Government is also contemplating to introduce Bus Rapid Transit Systems on certain selected routes. BRT has its own limitations and constraints. For one thing, the capacity of a BRT system can at best be only 10000 to 12000 PHPDT (Peak Hour Peak Direction Trips) and that of a tramway system about 8000 to 10000 PHPDT. The BRT takes away two lanes of the road for dedicated use pushing rest of the road vehicles crowded into the remaining road space. Therefore, unless the road widths are more than three lanes in each direction, BRT is not feasible and even then the non-bus riders will be put to tremendous inconvenience. In Delhi BRT has been a total failure. In the case of a Metro system, the road width is not encroached upon. If the Metro is elevated, only the central median of the road to a width of 2 to 3 m. is occupied for locating the columns carrying the rail deck. If the metro is underground, there is no encroachment at all on the road width.

Jaipur City, with its present population of 4.45million and employment of 15.55 lakh has a travel demand of 36 lakh passenger trips every day with 3.6 lakh trips performed during peak hour. With growing population and mega development plans coming up for the Port City, the travel demand is expected to grow steeply. With the growing economy and inadequate public transport services, the passengers shall shift to private modes, which is already evident from the high vehicle ownership trends in the region. This would not only aggravate the congestion on streets but also increase the pollution. Hence, it is essential to plan and provide for a Light to medium Metro System in Jaipur.

The peak traffic demand on East-West corridors of Jaipur Metro has been assessed 11264 in 2014 and this is likely to increase to 27750 PHPDT by the year 2031. Road accidents are on the rise. Therefore, it is not possible to introduce road based transport system all along the proposed metro corridors. Moreover, traveling time on the road will be much higher. Also, bus travel is not as comfortable as that of metro. There is an urgent need to introduce a Metro system to provide fast, safe and hastle free movement of the public in the city.

3.2 Types of metros and their capacity

Rail based mass transport in cities can be brought mainly under three categories:-

Mode		Carrying capacity (passengers/hour) phpdt
a)	Light Rail Metro System (LRTS)	Up to 25,000
b)	Medium Capacity Metro System	25,000-50,000
c)	Heavy Capacity Metro System	50,000-80,000

Since, the number of commuters to be dealt is relatively less in Medium Metro System, its trains consist of 3 Coaches (which can be increased to 6 Coaches in future) and other related infrastructure is also of a smaller size.

For medium capacity Metro systems, the train generally comprises 3 to 6 coaches with ultimate train headway of about 3 minutes. The other related infrastructure, e.g. civil works, stations, passenger-handling equipment etc. are also planned accordingly.

Heavy capacity metro systems have to deal with large traffic densities ranging from 50,000 to 80,000 phpdt. Accordingly, the trains have 6 to 9 coaches and other related infrastructure is also of large size. Beyond the traffic level of 80,000 phpdt, additional parallel lines are normally planned. The metro system being planned for Delhi is heavy capacity system.

In view of the present and projected PHPDT on the proposed corridor of Jaipur city, Medium Metro System is adequate for meeting the demand.

3.3 Advantages of a Metro system

Metro systems are superior to other modes because they provide higher carrying capacity, faster, smoother and safer travel, occupy less space, are non-polluting and energy-efficient. To summarise, a Metro system:

- (i) Requires 1/5th energy per passenger km compared to road-based system
- (ii) Causes no air pollution in the city
- (iii) Causes lesser noise level
- (iv) Occupies no road space if underground and only about 2 metres width of the road if elevated
- (v) Carries same amount of traffic as 5 lanes of bus traffic or 12 lanes of private motor cars (either way), if it is a light capacity system.
- (vi) Is more reliable, comfortable and safer than road based system
- (vii) Reduces journey time by anything between 50% and 75% depending on road conditions.
- (viii) Maximize growth of the Jaipur economy by enhancing its competitive position and facilitating future employment and population growth;
- (ix) Delivers a step change by opening a new era in the speed and quality of public transport service linking major growth locations in and around Jaipur area with the city centre and strategic employment areas;
- (x) Supports and facilitate the sustainable growth of Jaipur, recognizing the importance of its city centre to the future economy of the Jaipur city region;
- (xi) Improves the efficiency of the city's public transport and road networks;

(xii) Creates a system with the flexibility to adapt to development phased over several years;

(xiii) Promote quality of life through a safe and healthy built and natural environment;

(xiv) Increases overall public transport patronage on the corridors served and achieves a mode shift from the car;

(xv) Promotes equality of opportunity by improving accessibility to employment, goods and services;

(xvi) Improve the overall journey experience for passengers using the system by providing high quality information, better waiting and vehicle environments and enhanced safety and security;

(xvii) Assists in building vibrant, confident and cohesive communities in the city;

(xviii) Provides levels of segregation from traffic and public transport priority sufficient to ensure consistently high standards of punctuality and reliability;

(xix) Creates a system that is well integrated with the wider transport network and public real.

Chapter 4

System Selection

4.1 Permanent Way
4.2 Traction System
4.3 Signalling
4.4 Telecommunication
4.5 Rolling Stock

CHAPTER 4

SYSTEM SELECTION

4.1 PERMANENT WAY

4.1.1 Choice of Gauge

Based on extensive survey of the travel pattern in Jaipur City and discussions with the officials of the State Government and Jaipur Development Authority, DMRC has finalized two corridors as most eligible for introduction of a Metro System in the first phase. The brief detail of the E-W corridor is as under:

East-West corridor from Badi Chopar to Mansarovar, covering a length of 12.067 km with 11 stations (3 underground & 8 elevated).

The corridors will be Standard Gauge (1435 mm) for the following reasons :

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

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

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

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

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

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

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

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

4.1.2 TRACK STRUCTURE

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

GENERAL

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

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

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

Rail Section

Keeping in view the proposed axle load and the practices followed abroad, it is proposed to adopt UIC-60 (60 kg. /m) rail section. Since 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- 12-96. As these rails are not manufactured in India at present, these are to be imported. For the Depot lines, the grade of rails should be 880, which can be easily manufactured indigenously.

Ballastless Track on Viaducts

On the viaducts, it is proposed to adopt plinth type ballastless track structure with RCC derailment guards integrated with the plinths (shown in **Fig.4.1**). Further, it is proposed to adopt Vossloh-336 Fastenings System or any other equivalent/ better system (shown in **Fig.4.2**) or any other suitable system on both types of ballastless track structures, with a base-plate to base-plate spacing of 65 cm. on viaducts complying of performance criteria laid down by Railway Board vide letter Circular No. 2009/Proj/InAs/9/2, dated 02.05.2010. Most of the components of Vossloh-336 fastening system are now indigenously available. The toe load design for the clips is to be finalised at the detail design stage.

Ballast less Track in Depot

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

- Discretely supported on concrete/steel pedestal for inspection lines.
- Embedded rail type inside the Workshop.

- Plinth type for Washing Plant line.
- Normal Ballast less (as on viaduct) for Washing lines, Stabling and other running lines.

Turnouts

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

  i) On main lines, 1 in 9 type turnout with a lead radius of 300 metres and permissible speed on divergent track as 40 km/h (shown in **Fig.4.3**).

  ii) On Depot lines, 1 in 7 type turnout with a lead radius of 140metres and permissible speed on divergent track as 25 km/h (shown in **Fig.4.4**).

- The Scissors cross-overs on Main Lines (1 in 9 type) will be with a minimum track centre of 4.5 m (shown in **Fig.4.5**).
- The proposed specifications for turnouts are given below: -

  i) The turnouts should have fan-shaped layout throughout the turnout so as to have same sleepers/base-plates and slide chairs for both LH and RH turnouts.

  ii) The switches and crossings should be interchangeable between ballasted and ballastless turnouts (if required).

- The switch rail should be with thick web sections, having forged end near heel of switch for easy connection with lead rails, behind the heel of switch. The switches should have anti creep device at heel of switch for minimising the additional LWR forces transmitted from tongue rail to stock rail.
- The crossings should be made of cast manganese steel and with welded leg extensions. These crossings should be explosive hardened type for main lines and without surface hardening for Depot lines.
- The check rails should be with UIC-33 rail section without being directly connected to the running rails.

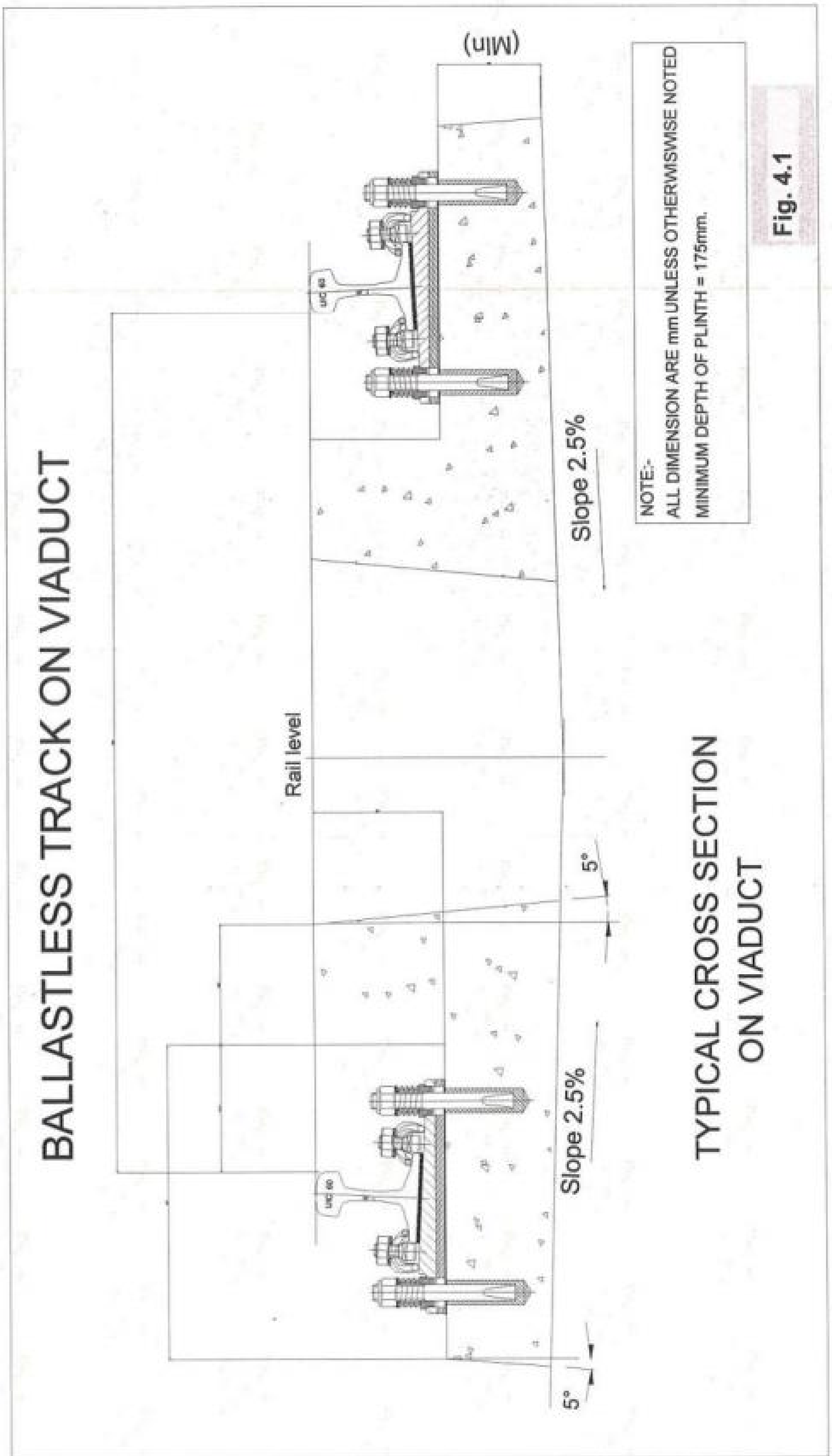
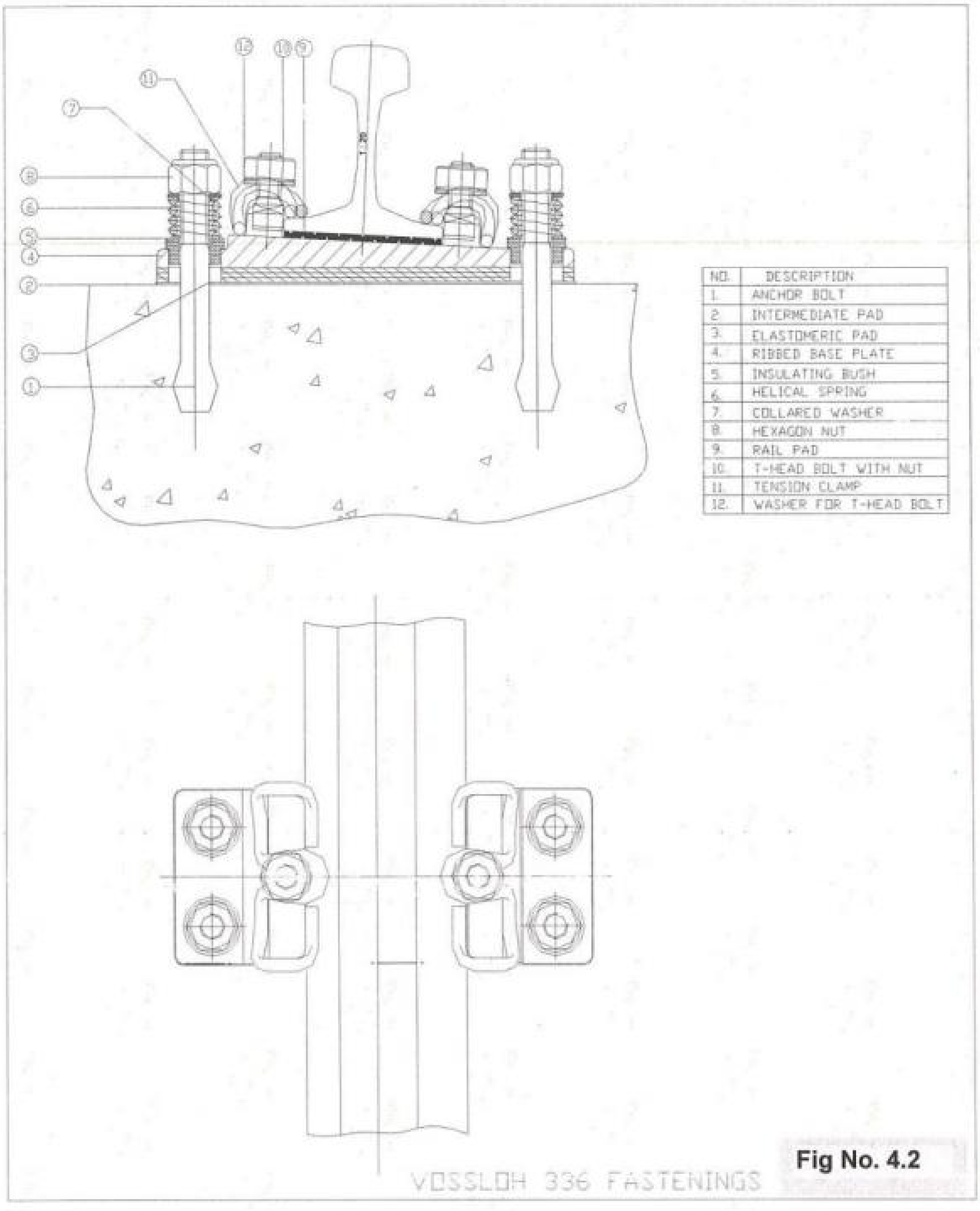

BALLASTLESS TRACK ON VIADUCT
(Min)
UIC 60
UIC 60
Rail level
Slope 2.5%
Slope 2.5%
5°
5°
TYPICAL CROSS SECTION
ON VIADUCT
NOTE:-
ALL DIMENSION ARE mm UNLESS OTHERWISWISE NOTED
MINIMUM DEPTH OF PLINTH = 175mm.

Fig. 4.1



NO.	DESCRIPTION
1.	ANCHOR BOLT
2.	INTERMEDIATE PAD
3.	ELASTOMERIC PAD
4.	RIBBED BASE PLATE
5.	INSULATING BUSH
6.	HELICAL SPRING
7.	COLLARED WASHER
8.	HEXAGON NUT
9.	RAIL PAD
10.	T-HEAD BOLT WITH NUT
11.	TENSION CLAMP
12.	WASHER FOR T-HEAD BOLT

Fig No. 4.2

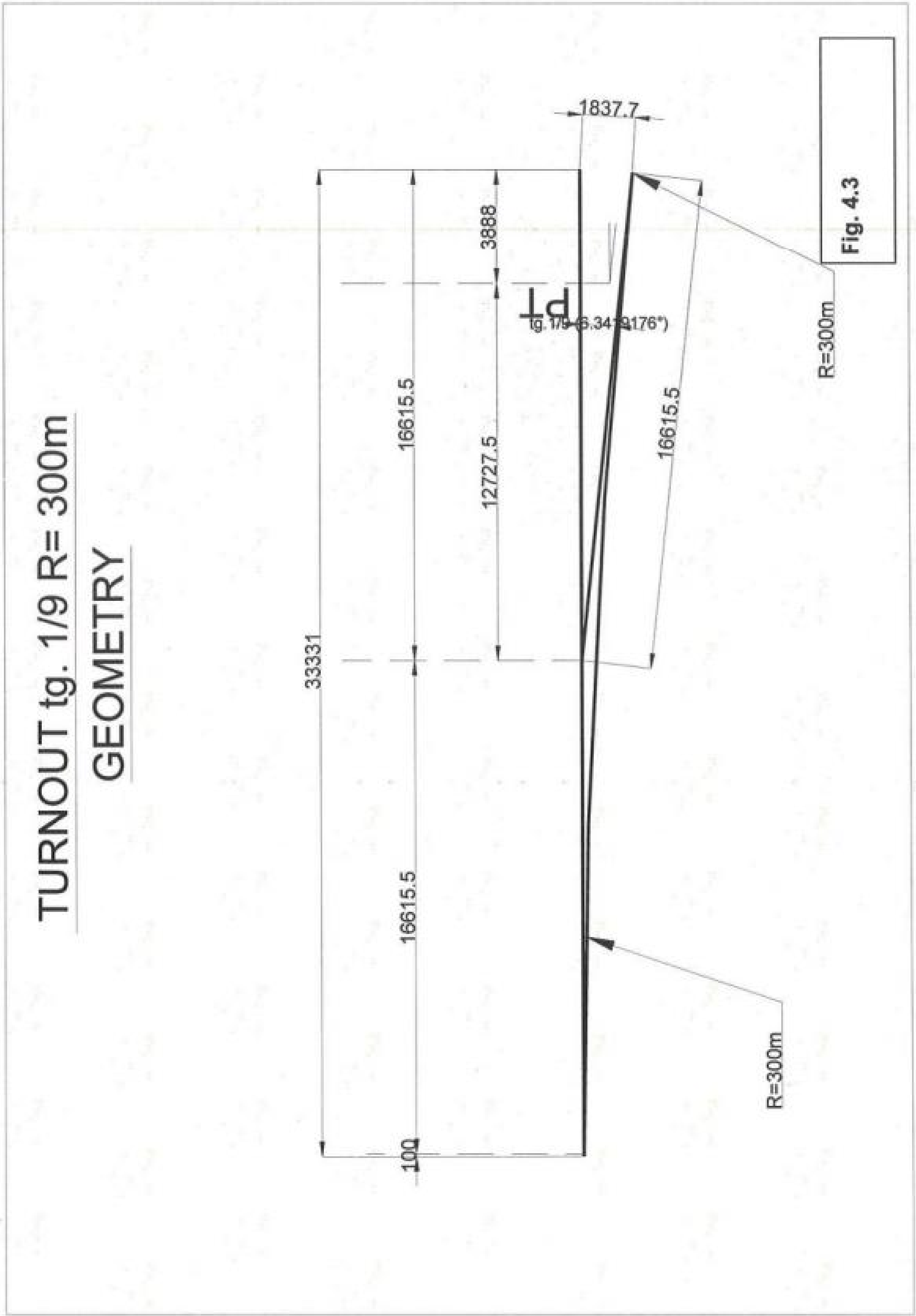

TURNOUT tg. 1/9 R= 300m
GEOMETRY
1837.7
3888
16615.5
12727.5
33331
16615.5
16615.5
100
R=300m
R=300m
PT

Fig. 4.3

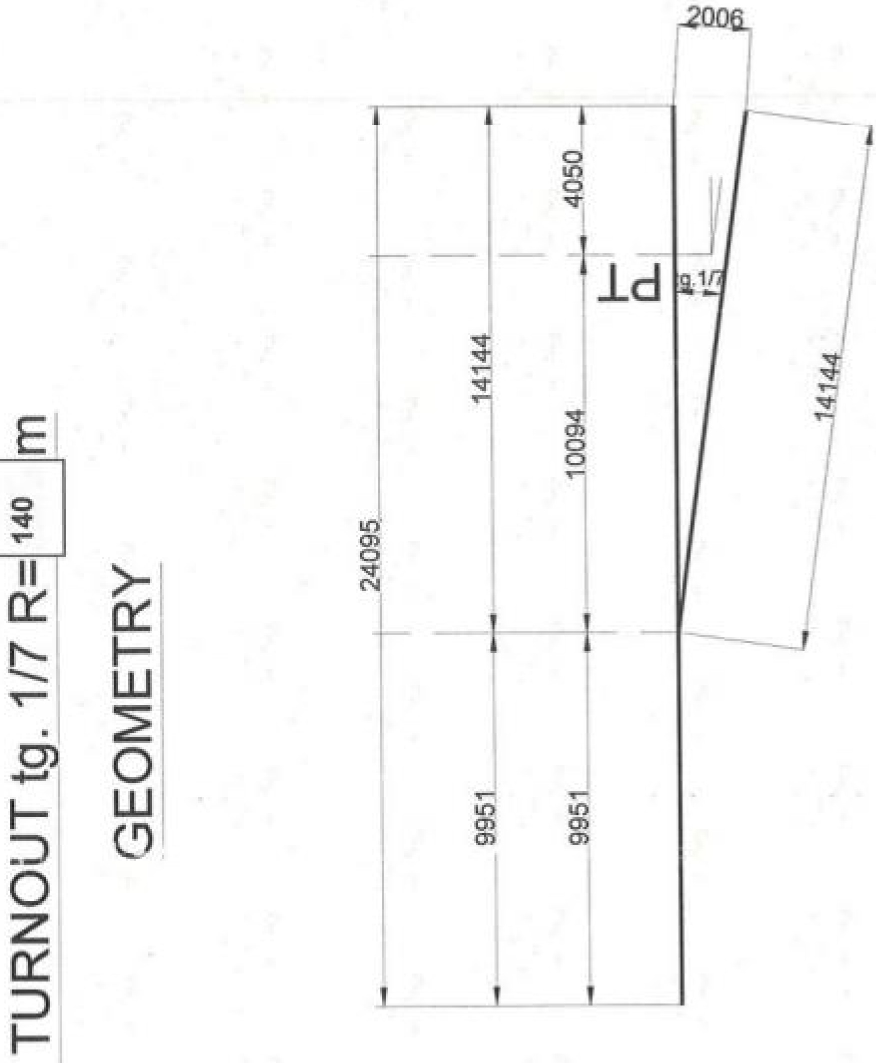

TURNOUT tg. 1/7 R= 140 m
GEOMETRY
2006
4050
PT
tg.1/7
14144
10094
24095
14144
9951
9951

Fig No. 4.4

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

AXLE SCHEME

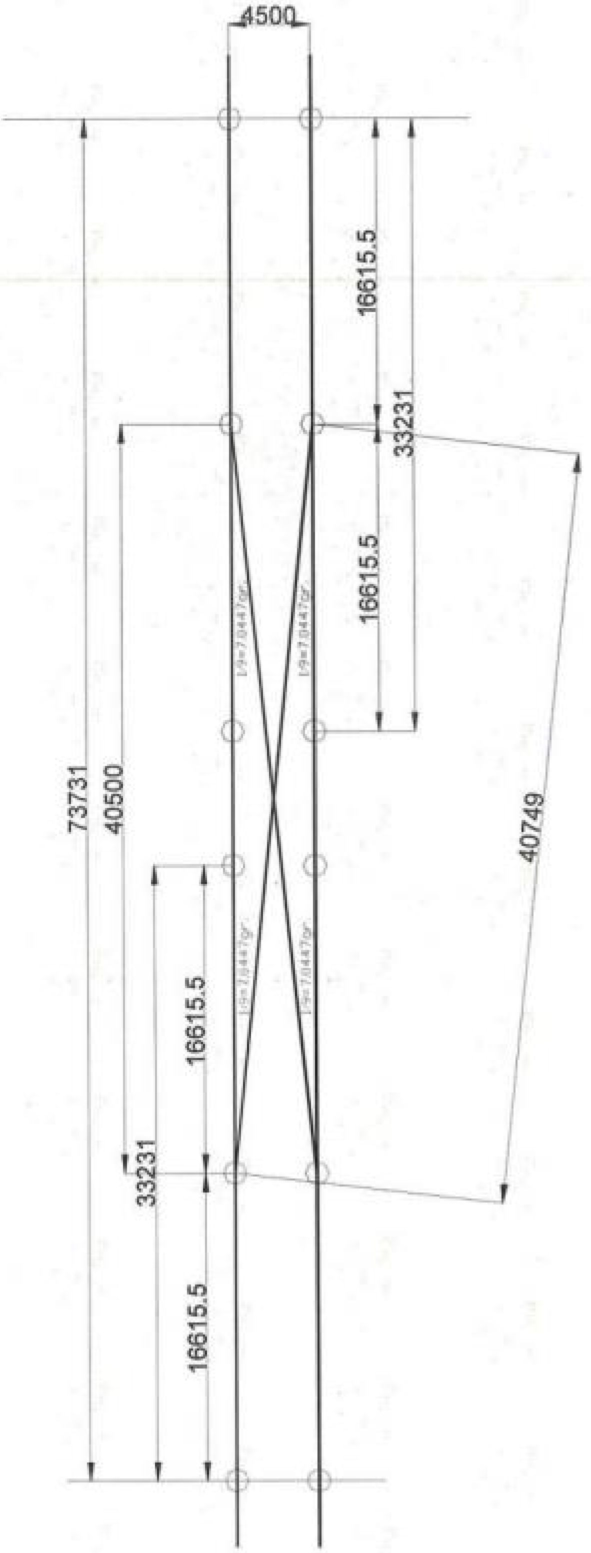


Fig No.4.5

Buffer Stops

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

4.1.3 Rail Structure Interaction

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

Welding

Flash Butt Welding Technique is to be used for welding of rails. Alumino-Thermic Welding is to be done only for those joints which cannot be welded by Flash Butt Welding Technique, such as joints at destressing locations and approach welds of switches & crossings. For minimising the population of Thermit welds, mobile (rail-cum-road or portable) Flash Butt Welding Plant will have to be deployed.

4.2 TRACTION SYSTEM

25 kv ac overhead traction system (OHE) has been proposed for both the North-South and East West corridors of Jaipur Metro.

4.3 SIGNALLING

4.3.1 Introduction

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

4.3.2 SIGNALLING AND TRAIN CONTROL

4.3.2.1 Overview

Metro carries large number of passengers at a very close headway requiring a very high level of safety enforcement and reliability. At the same time heavy investment in infrastructure and rolling stock necessitates optimization of its capacity to provide the best services to the public. These requirements of the metro are planned to be achieved by adopting 'Distance to go' ATP (Automatic Train Protection) and ATS (Automatic Train Supervision) sub-systems. This will:

- Provide high level of safety with trains running at close headway ensuring continuous safe train separation.
- Eliminate accidents due to driver passing Signal at Danger by continuous speed monitoring and automatic application of brake in case of disregard of signal / warning by the driver.
- Provide safety for protection of the Jaipur Metro Rail Asset.
- Provides safety and enforces speed limit on section having permanent and temporary speed restrictions.
- Improve capacity with safer and smoother operations. Driver will have continuous display of Target Speed / Distance to Go status 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 signaling and telecommunication equipment by monitoring system status of trackside and train born equipments and enabling preventive maintenance.

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

4.3.2.2 System Description and Specifications

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

a. Continuous Automatic Train Control

Continuous Automatic Train Control will consist of - ATP (Automatic Train Protection), ATO (Automatic Train Operation) and ATS (Automatic Train Supervision) sub-systems:

(i) Automatic Train Protection (ATP)

Automatic Train Protection is the primary function of the train control systems. This sub-system will be inherently capable of achieving the following objectives in a fail-safe manner. Line side signals will be provided at diverging routes (i.e. at points & crossings), which shall serve as backup signalling in case of failure of ATP system. However, in such cases, train speed will be automatically restricted to 25 kmph.

- Cab Signalling
- 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
- Authorization of opening of train doors on the correct side of train doors on the correct side of station platform.

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

(ii) Automatic Train Operation (ATO) - Future

This system will operate the trains automatically from station to station while remaining within the safety envelope of ATP & open the train doors. Driver will close the train doors and press a button when ready to depart. In conjunction with ATP/ ATS, ATO can control dwell time at stations and train running in accordance with headway/ timetable.

(iii) Automatic Train Supervision (ATS)

A train supervision system will be installed to facilitate the monitoring of train operation and also remote control of the station. The train supervision will log each train movement and display it on the workstations with each Traffic Controller at the OCC and on one workstation placed in the Station Control room (SCR) with each Station Controller.

The centralized system will be installed in the Operation Control Centre. The OCC will have a projection display panel showing a panoramic view showing the status of tracks, points, signals and the vehicles operating in the relevant section/ whole system. ATS will provide following main functionalities:

- Automatic Route setting
- Automatic Train Regulation
- Continuous Tracking of train position
- Display Panel & Workstation interface
- Adjustment of station dwell time
- Link to Passenger Information Display System for online information
- Computation of train schedules & Timetable

b. Interlocking System:

(i) Computer Based Interlocking (CBI)

At all stations with points and crossings, Computer Based Interlocking (CBI) will be provided for operation of points and crossings and setting of routes. It should cover the entire line and ensure that ;

- Conflicting routes cannot be set,
- Points are only moved, when all the safety conditions are met

- Signals only clear to proceed occur only when all the safety conditions are fulfilled

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. Control functions in external circuits will be provided both in the positive and negative wires. 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, relays, point operating machines, power supply etc.

(ii)Track Circuits

Audio Frequency Track Circuit will be used for vehicle detection and for transmission of data from track to train.

(iii) Point Machines

Non-Trail able Electrical Point Machine capable of operating with either 110V DC or 3-phase 380V AC will be used on main line. The depot point machine will preferably be trailable type.

c. Train Depot: Signalling

All depot lines except the one which is used for shunting and in the workshop shall be interlocked. A workstation shall be provided in the Depot Control Centre for electrical operation of the points, signals and routes of the depot yard. Audio Frequency Track Circuits will be used in the depot as well.
Computer based interlocking is recommended to be used for Depot lines so as to integrate the system with ATC in future.

4.3.3 Standards

The standards to be adopted for Signaling System are shown in **Table 4.1**.

TABLE 4.1

Description	Standards
▪ Interlocking	Computer based Interlocking adopted for station having switches and crossing. All related equipment as far as possible will be centralised in the equipment room at the station. The depot shall be interlocked except for lines mainly used for shunting, workshop/inspection shed areas.
▪ Operation of Points	With Direct current 110V D.C. point machines or 380 volts 3 phase, 50 Hz. AC point machines.
▪ Track Circuit	Audio frequency Track circuits on running section, test track and in depot.
▪ Signals at Stations with point & crossings	Line Side signals to protect the points (switches). LED type signals for reliability and reduced maintenance cost.
▪ UPS (uninterrupted power at stations as well as for OCC)	For Signalling and Telecommunications
▪ Train protection system	Automatic Train Protection system.
▪ 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.
▪ Redundancy for TP/ Train Describer.	Redundant Train borne equipment and ATS equipment at OCC.
▪ Cables	Outdoor cables will be steel armoured as far as possible.
▪ Fail Safe Principles	SIL-4 safety levels as per CENELEC standard for signal application.
▪ Immunity to External Interface.	All data transmission on telecom cables/OFC/Radio. All Signalling and telecom cables will be separated from power cables. CENELEC standards to be implemented for EMC.
▪ Train Working under emergency	Running on site with line side signal with speed

	automatically restricted between 15-25 kmph.
▪ Environmental Conditions	Air-conditioners for all equipment rooms.
▪ Maintenance philosophy	Philosophy of continuous monitoring of system status and preventive & corrective maintenance of Signalling equipments shall be followed. Card / module / sub-system level replacement shall be done in the field and repairs under taken in the central laboratory/ manufacturer's premises.

4.3.4 Space Requirement for Signaling Installations

Adequate space for proper installations of all Signaling 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 Signaling equipment shall be generally 60 sq m for UPS Room (common for signaling and telecom) and 50 sq m at interlocked station with points & 20 sq m at other stations for Signaling. These areas shall also cater to local storage and space for maintenance personnel to work. At the OCC and the Depot, the areas required shall be as per the final configuration of the equipments and network configuration keeping space for further expansion.

4.3.5 Maintenance Philosophy for Signaling Systems

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

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

4.3.6 Signaling Scheme Plan

Conceptual Signaling Scheme Plan for both the corridors of Jaipur Metro Rail Project is placed as **Annexure 4.1 & 4.2.**

4.4 TELECOMMUNICATION

4.4.1 INTRODUCTION

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

4.4.2 OVERVIEW

The telecommunication facilities proposed are helpful in meeting the requirements for

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

The proposed telecom system will cater to the following requirements:

- Train Traffic Control
- Assistance to Train Traffic Control
- Maintenance Control
- Automatic Fare Collection
- Security system
- Emergency Control
- Station to station dedicated communication
- Telephone Exchange
- Integrated Passenger Announcement System and Passenger Information and Display System within the station and from Central Control to each station.
- Centralised Clock System
- Train Destination Indicator
- Instant on line Radio Communication between Central Control and Moving Cars and maintenance personnel.
- Data Channels for Signalling, SCADA, Automatic Fare Collection etc.
- E&M SCADA is not envisaged as part of Telecomm System as such, hence catered to separately in DPR.

4.4.3 TELECOMMUNICATION SYSTEM AND TRANSMISSION MEDIA

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

The main bearer of the bulk of the telecommunication network is proposed with optical fibre cable system. Considering the channel requirement and keeping in view the future expansion requirements a minimum 48 Fibre optical fiber cable is proposed to be laid in ring configuration with path diversity.

SDH (minimum STM-16) based system shall be adopted with SDH nodes at every station and OCC . Access 2MB multiplexing system will be adopted for the lower level at each node, equipped for channel cards depending on the requirement of channels in the network. Further small routers and switches shall be provided for LAN network at stations. Alternatively a totally IP Based High Capacity, highly reliable and fault tolerant, Ethernet Network (MAN/LAN) can be provided in lieu of SDH/MUX.

ii) Telephone Exchange

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 shall be provided. The exchanges at Central Control and Depots shall be of larger sizes as per the actual number of users. 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. Alternatively only for non-operational (other than Direct Line Communication) a separate IP Based Phone System can be implemented.

iii) Mobile Radio Communication

Mobile Radio communication system having minimum 8 logical channels is proposed for on-line emergency communication between Motorman (Front end and Rear end) of moving train and the Central Control. The system shall be based on Digital Trunk Radio Technology to TETRA International standard. This system now is widely adopted for mobile radio communication in metro / rapid transit services abroad. All the stations and the OCC will be provided with fixed radio sets. Mobile communication facility for maintenance parties and Security Personnel will be provided with handheld sets. These persons will be able to communicate with each other as well as with central control.

The frequency band for operation of the system will be that for TETRA in 400/800 MHz band, depending on frequency availability. The system shall provide mobile radio communication between the motorman of the moving cars from any place and the Central Control .The motorman can also contact any station in the network through the central control, besides intimating the approaching trains about any emergency like accident, fire, line blocked etc., thus improving safety performance.

To provide adequate coverage, based on the RF site survey to be carried out during detailed Design stage, base stations for the system will be located at sites conveniently selected after detailed survey. Tentatively minimum 4 sites with 40 meter towers (tower base required 6x6 m clear space) with Base Stations shall be required along the North South Corridor at Haldi Ghati Area, Durgapura, Tonk Phatak, SMS Hospital and Ambabari in Elevated corridor and at least one Base Station shall be required at Subhash Nagar and Government Hostal for Underground section, feeding through Bi-directional Amplifiers and Leaky Coaxial Cables to the adjacent stations.

For the elevated portion of the East West Corridor, at least two Base Station with 40 m Towers shall be required at Sindhi Camp and Vivek Vihar Stations and for Underground Section, atleast one Base Station shall be required at Chotti Chopar feeding through Bi-directional Amplifiers and Leaky Coaxial Cables, the adjacent stations.

In addition to the TETRA Radio Coverage for the internal use of the Metro, the city is also likely to have Mobile Coverage from Private Operators.

In the elevated sections it is expected that coverage shall be available from the adjoining sites of the Mobile Operators. However, in the underground stations / tunnels, coverage needs to be specially extended by the Mobile Operators. To enable the Mobile Operators to do so, the Metro Authority will have to have an agreement with a group of Mobile Operators according to which Metro shall provide an Air-conditioned room (approx. 20 sq. m) at each underground station to the Mobile Operator Group. The Mobile Operators shall install all their repeater equipment in this room and then extend the coverage inside the tunnel by laying their own LCX cable in each tunnel and through antennas strategically placed in the concourse area. Further, for City Emergency Services like Police, the mobile operators shall also design their LCX network to support the police wireless coverage in the tunnels /station area. The detailed Agreement covering both the Mobile / Emergency Service Radio Coverage shall have to be finalised by the Metro Authority with the respective parties, at the time of implementation.

iv) Passenger Announcement System

The system shall be capable of announcements from the local station as well as from OCC. Announcements from Station level will have over-riding priority in case of emergency announcements. The System shall be linked to Signalling System for automatic train actuated announcements.

v) Passenger Information Display System

These shall be located at convenient locations at all stations to provide bilingual visual indication of the status of the running trains and will typically indicate information such as destination, arrival/departure time, and also special messages in emergencies. The boards shall be provided at all platforms and concourses of all stations. The System shall be integrated with the PA System and available from same MMI.

vi) Centralized Clock System

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

vii) Closed Circuit Television (CCTV) System

The CCTV system shall provide video surveillance and recording function for the operations to monitor each station. The monitoring shall be possible both locally at each station and remotely from the OCC.

The CCTV system backbone shall be based on IP technology and shall consist of a mix of Fixed Cameras and Pan/Tilt/Zoom (PTZ) Cameras. Cameras shall be located at areas where monitoring for security, safety and crowd control purpose is necessary.

viii) Network Monitoring and Management

For efficient and cost effective maintenance of the entire communication network, it is proposed to provide a network management system (NMS), 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.

4.4.4 Technology

The Technologies proposed to be adopted for telecommunication systems are shown in **Table 4.2** below:

TABLE 4.2

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

4.4.5 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 Signal & Telecom equipment shall be generally 30 sq.m each for Telecom Room and 50 sq.m. for UPS Room (common for signal, telecom and AFC). These areas shall also cater to local storage and space for maintenance personnel to work . At the OCC , the areas required shall be as per the final configuration of the equipment and network configuration keeping space for further expansion.

4.4.6 Maintenance Philosophy for Telecom systems

The philosophy of continuous monitoring of system status and preventive & corrective maintenance of Signalling and telecommunication equipments shall be followed as per the Operation and Maintenance Manual. 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 on the section. This lab will be equipped with appropriate diagnostic and test equipments to rectify the faults and undertake minor repairs. Cards / modules / equipment requiring major repairs as specified in suppliers documents shall be sent to manufacturer's workshop.

4.4.7 AUTOMATIC FARE COLLECTION

4.4.7.1 INTRODUCTION

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

For Multiple Journey, the Store Value Smart Card shall be utilized and for the Single Journey, the media shall be as utilized as Contactless Smart Token.

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

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

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

B) Automatic fare collection systems have the following advantages:

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

H. AFC systems are the worldwide accepted systems for LRT/Metro environment.

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

C) Choice of Control Gates

Retractable flap type Control Gates/Paddle Type Gates are proposed which offer high throughput, require less maintenance and are latest in modern metros internationally. Tripod turnstile type gates offer less throughput and require more maintenance and hence are not proposed.

D) Passenger Operated Machine

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

AFC equipment Requirement

AFC equipment tentative requirement is given in **Table 4.3.** The exact number and type shall depend on the final station layout and the traffic being catered to.

4.4.7.2 Technology

The technology proposed for AFC systems are as under:

TABLE 4.3

Standards	*Description*
• Fare media	a) Contactless smart card – For multiple journeys. b) Single Journey: Contactless smart token captured at exit gates.
• Gates	Computer controlled automatic gates at entry and exit. There will be following types of gates: • Entry • Exit • Reversible (if required as per final station layout) – can be set to entry or exit • Reversible Handicapped Gate -gate for disabled people.
• Station computer, Central computer and AFC Net work	All the fare collection equipment shall be connected in a local area network with a station server controlling the activities of all the machines. These station servers will be linked to the central computer situated in the operational control centre through the optic fibre communication channels. The centralised control of the system shall provide real time data of earnings, passenger flow analysis, blacklisting of specified cards etc.
• Ticket office machine (TOM/EFO)	Manned Ticket office machine shall be installed in the stations for selling tickets to the passengers. Also POM's shall be provided for Automatic Ticket Vending.
• Ticket reader and portable ticket decoder.	Ticket reader shall be installed near EFO for passengers to check information stored in the ticket.
• UPS (uninterrupted power at stations as well as for OCC).	**Common UPS of S&T system will be utilised.**

Entry/Exit Gates

Ticket Office Machine

4.4.7.3 AFC Equipment Requirement

AFC Equipment requirement for Jaipur Metro E-W Corridor based on Traffic Projection for 2014 is given in **Tables 4.5** :

TABLE 4.5

AFC Equipments Estimate for Jaipur Metropolitan Area (projection for 2014)

S.No.	Station	Hourly Boardin	Hourly Alightin	Peak Min Boardi	Peak Min alightin	Gate Entry	Exit Gate	Disabled	TOM	EFO	TR	TVM
	East West Corridor											
1	Mansarovar	6427	1707	129	34	4	2	1	6	2	4	2
2	New Aatish Nagar	759	312	15	6	2	2	1	2	2	4	2
3	ESI Hospital	810	294	16	6	2	2	1	2	2	4	2
4	Shyam Nagar	1304	280	26	6	2	2	1	2	2	4	2
5	Ram Nagar	1787	271	36	5	2	2	1	2	2	4	2
6	Civil lines	1314	349	26	7	2	2	1	2	2	4	2
7	Railway Station	984	615	20	12	2	2	1	2	2	4	2
8	Sindhi Camp	1220	4287	24	86	2	3	1	2	2	4	2
9	Chand Pole	2969	1525	59	31	2	2	1	3	2	4	2
10	Choti Chopar	1021	1880	20	38	2	2	1	2	2	4	2
11	Badi Chopar	811	8394	16	168	2	6	1	2	2	4	2
	Total					**24**	**26**	**11**	**27**	**22**	**44**	**22**

Assumptions:

1. Each station has only 2 access
2. Minimum AFC equipments at a station with "2 access- 1 for entry, 1 for exit":

   2 entry gates, 2 exit gates, 2 EFO, 2 TOM, 4 TR,2 TVM
3. One Disabled gate at each station.
4. Throughput of gate 30 passengers per minute, TOM 10 transactions per minutes.
5. 50 % passenger are assumed on Smart Card and 50% on single journey token.

4.5 ROLLING STOCK

4.5.1 Introduction

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

4.5.2 Optimization of Coach Size

The following optimum size of the coach has been chosen for this corridor as mentioned in **Table 4.6.**

Table 4.6

SIZE OF COACH

Particular	*Length*	*Width*	*Height*
Driving Trailer Car (DTC)	21.64m	2.9 m	3.9 m
Trailer Car (TC)/Motor Car (MC)	21.34 m	2.9m	3.9 m

Maximum Length of coach over couplers / buffers is 22.6 m.

4.5.3 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 and for evacuation from ends in emergency. Criteria for the calculation of standing passengers are 3 persons per square meter of standing floor area in normal state and 6 persons in crush state of peak hour.

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

Following train composition is recommended:

4-car Train : DTC+MC+MC+DTC

6-car Train : DTC+MC+TC+MC+MC+DTC

The passenger carrying capacity for Driving Trailer Car, Trailer Car and Motor Car and also of a train is given in **Table 4.7.**

Tabie 4.7

Carrying Capacity of MRV

	DTC		TC / MC		4-Car Train		6-Car Train	
	Normal	**Crush**	**Normal**	**Crush**	**Normal**	**Crush**	**Normal**	**Crush**
Seated	43	43	50	50	186	186	286	286
Standing	102	204	110	220	424	848	644	1288
Total	145	247	160	270	610	1034	930	1574

Normal- 3 persons/sqm of standee area

Crush - 6 persons/sqm of standee area

4.5.4 WEIGHT

The weight of motorcars and trailers has estimated as in **Table 4.8**, referring to the experiences in Delhi Metro. The average passenger weight has been taken as 65 kg.

Table 4.8

Weight of Medium Rail Vehicles (Tonnes)

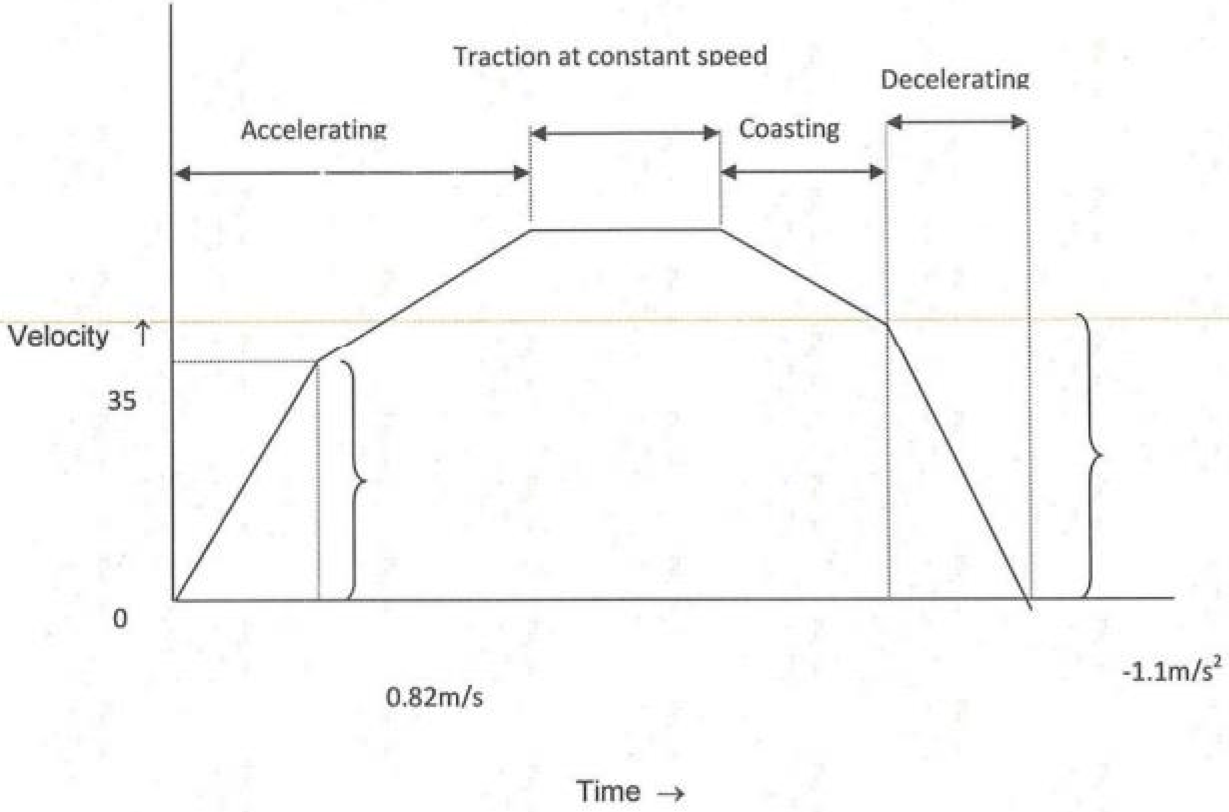
	DTC	TC	MC	4-Car Train	6-Car Train	8-Car Train
TARE(max)	39	39	39	156	234	312
Passenger						
Normal	9.425	10.4	10.4	39.65	60.45	81.25
Crush@6/sqm	16.055	17.55	17.55	67.21	102.31	137.41
Crush@8/sqm	20.475	22.295	22.295	85.583	130.22	174.85
Gross						
Normal	48.425	49.4	49.4	195.65	294.45	393.25
Crush@6/sqm	55.055	56.55	56.55	223.21	336.31	449.41
Crush@8/sqm	59.475	61.295	61.295	241.58	364.22	486.85
Axle Load Crush@6/sqm	13.764	14.138	14.138			
Axle Load Crush@8/sqm	14.869	15.324	15.324			

The axle load @ 6 persons/ sqm of standing area works out in the range of 13.764T to 14.138 T. Heavy rush of passenger, having 8 standees per sq. meter can be experienced occasionally. Hence, it will be advisable to design the coach with sufficient strength so that even with this overload, the design will not result in overstresses in the coach. Coach and bogie should therefore be designed for **16 T axle load**.

4.5.5 Performance Parameters

The recommended performance parameters are:

Maximum Design Speed	: 95 kmph
Maximum Operating Speed	: 85 kmph
Acceleration	: 0.82 m/s^2 +_ 5%
Deceleration	: 1.1 m/s^2 (normal brake)
	: 1.3 m/s^2 (Emergency brake)



Simplified velocity – time operation curve

4.5.6 Coach Design and Basic Parameters

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

- Proven equipment with high reliability.
- Passenger safety feature
- Energy efficiency
- Light weight equipment and coach body
- Optimized scheduled speed
- Aesthetically pleasing Interior and Exterior
- Low Life cycle cost
- Flexibility to meet increase in traffic demand
- 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.

4.5.7 Selection of Technology

1) Low Life Cycle Cost

The low life cycle cost is achieved by the way of reduced scheduled and unscheduled maintenance and high reliability of the sub-systems. It is possible to achieve these objectives by adopting suitable proven technologies. The selection of following Technologies has been adopted to ensure low life cycle cost:

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 as well corrosion repairs, which may have to be carried out up to 4-5 times during the service life of these coaches. It is now standard practice to adopt stainless steel or aluminium for car body.

The car bodies with aluminium require long and complex extruded sections which are still not manufactured in India. Therefore, aluminium car body has not been considered for use. Stainless steel sections are available in India and as such it is specified. No corrosion repair is necessary on these cars during their service life.

Stainless steel car body leads to energy saving due to its light weight. It also results in cost saving due to easy maintenance and reduction of repair cost from excellent anti-corrosive properties as well as on improvement of riding comfort and safety in case of a crash or fire.

3) Bogies

Bolster less lightweight bogies with rubber springs are now universally adopted in metro cars. These bogies require less maintenance and overhaul interval is also of the order of 4,20,000 km. The use of air spring at secondary stage is considered with a view to keep the floor level of the cars constant irrespective of passenger loading unlike those with coil spring. The 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 conical rubber spring. A smooth curving performance with better ride index is being ensured by provision of above type of bogies.

4) Braking System

The brake system shall consist of:

- An electro-pneumatic (EP) service friction brake.
- A fail safe, pneumatic friction emergency brake.
- A spring applied air-release parking brake
- An electric regenerative service brake
- Provision of smooth and continuous blending of EP and regenerative braking.

The regenerative braking will be the main brake power of the train and will regain the maximum possible energy and pump it back to the system and thus fully utilize the advantage of 3 phase technology .The regenerative braking should have air supplement control to bear the load of trailer car. 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.

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 brushless 3 phase induction motors has now replaced the D C series motors in traction applications. The induction motor, for the same power output, is smaller and lighter in weight and ideally suited for rail based Mass Rapid Transit applications. The motor tractive effort and speed is regulated by Variable Voltage and Variable Frequency control and can be programmed to suit the track profile and operating parameters. 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, 3 phase a.c. traction drive that are self ventilated, highly reliable, robust construction and back up by slip/ slid control have been recommended.

The AC catenary voltage is stepped down through a transformer and converted to DC voltage through convertor 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 3 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 fibre 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.

6) Interior and Gangways

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

Interior View

7) Passenger Doors

For swift evacuation of the passenger in short dwell period, four doors of adequate width, on each side of the coach have been considered. These doors shall be of such dimensions and location that all the passenger inside the train are able to evacuate with in least possible time without conflicting movement .As the alignment passes through elevated section at 10 to 12 meters above ground, automatic door closing mechanism is envisaged from consideration of passenger safety. Passenger doors are controlled electrically by a switch in Driver cab. Electrically controlled door operating mechanism has been preferred over pneumatically operated door to avoid cases of air leakage and sluggish operation of doors.

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

Passenger Doors

8) Air-conditioning

With heavy passenger loading of 6 persons/sqm for standee area and doors being closed from consideration of safety and with windows being sealed type to avoid transmission of noise, air conditioning of coaches has been considered essential. Each coach shall be provided with two air conditioning units capable of 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.

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.

An emergency door for easy detrainment of the passengers on the track has been provided at the centre of the front side of each cabin which has an easy operation with one handle type master controller.

Driving cab

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 conversation between passengers and the drivers in case of any emergency.

1) Noise and Vibration

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

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

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

2) Passenger Safety Features

(i) ATP

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

(ii) Fire

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

(iii) Emergency door

The rolling stock is provided with emergency evacuation facilities at several vehicles to ensure well-directed evacuation of passengers in case of any emergency including fire in the train.

(iv) Crash worthiness features

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

(v) Gangways

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

Gangways

Salient Features of Rolling Stock for Medium Rail Transit System is enclosed as **Annexure 4.3**.

Annexure 4.3

Salient Features of Rolling Stock for Medium Rail Transit System		
S.No.	**Parameter**	**Details**
1	**Gauge** (Nominal)	1435mm
2	**Traction system**	
2.1	Voltage	25 KV AC
2.2	Method of current collection	Overhead Current Collection System
3	**Train composition**	
3.1	4 car :	DTC + MC + MC + DTC
3.2	6 car:	DTC + MC + TC + MC + MC + DTC
3.3	8 car:	N.A.
4	**Coach Body**	Stainless Steel
5	**Coach Dimensions**	
5.1	Height	3.9 m
5.2	Width	2.9 m
5.3	Length over body (approx)	
	- Driving Trailer Car (DTC)	21.64 m
	- Trailer Car (TC)	21.34 m
	- Motor Car (MC)	21.34 m
	Maximum length of coach over couplers/buffers:	*22 to 22.6 m (depending upon Kinematic Envelop)*
5.4	Locked down Panto height (if applicable)	4048 mm
5.5	Floor height	1100mm
6	**Designed - Passenger Loading**	

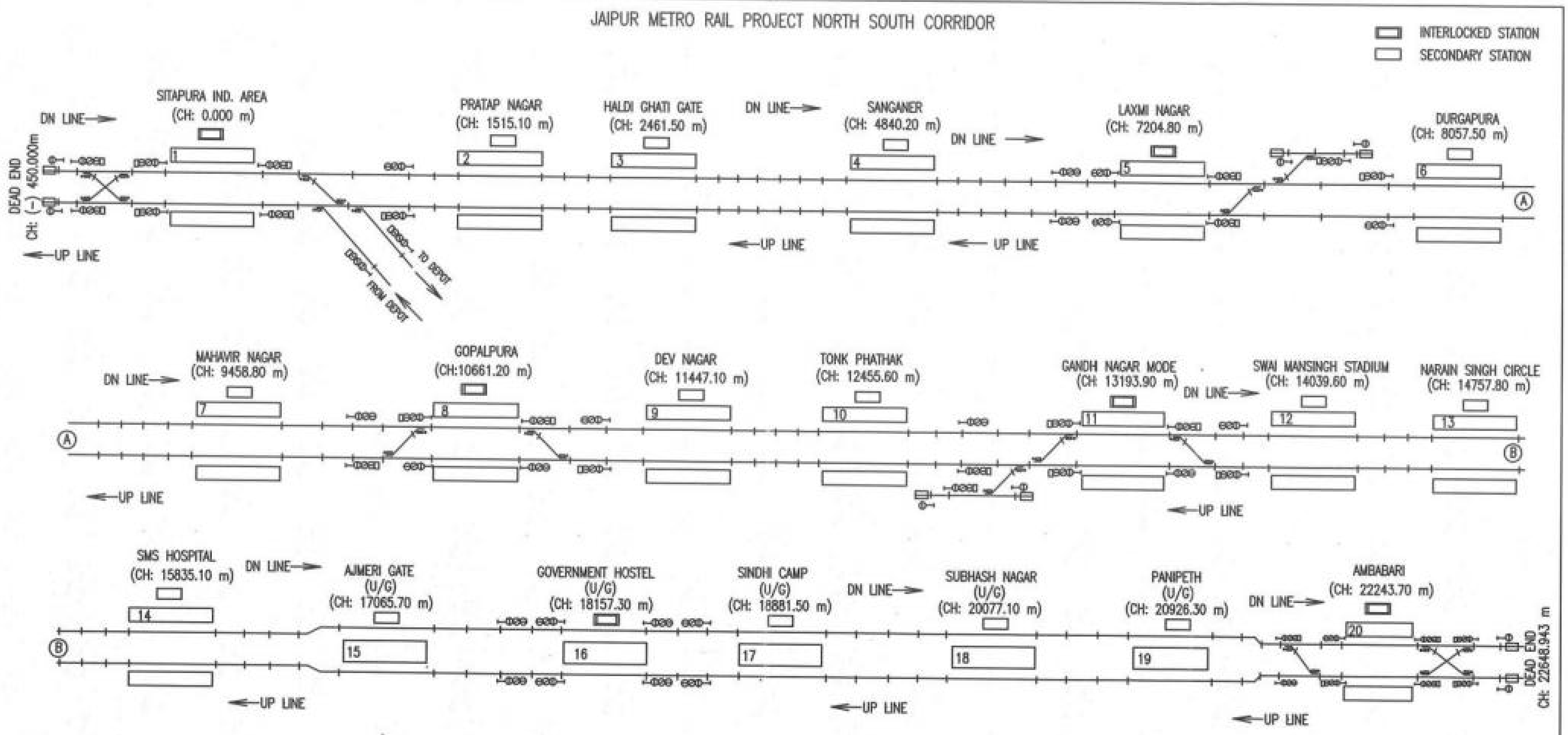
6.1	Design of Propulsion equipment	8 Passenger/ m^2
6.2	Design of Mechanical systems	10 Passenger/ m^2
7	**Carrying capacity- @ 6 standees/sqm**	
7.1	Coach carrying capacity	
	DTC	247 (seating - 43 ; standing - 204)
	TC	270 (seating - 50 ; standing - 220)
	MC	270 (seating - 50 ; standing - 220)
7.2	Train Carrying capacity	
	4 car train	1034 (seating - 186 ; standing - 848)
	6 car train	1574 (seating - 286 ; standing - 1288)
	8 car train	N.A.
8	**Weight (Tonnes)**	
8.1	Tare weight (maximum)	
	DTC	39
	TC	39
	MC	39
8.2	Passenger Weight in tons	@ 0.065 T per passenger
	DTC	16.055
	TC	17.55
	MC	17.55
8.3	Gross weight in tons	
	DTC	55.055
	TC	56.55
	MC	56.55
9	**Axle load(T)(@ 8 persons per sqm of standee area)**	15.32

	System should be designed for 16T axleload	
10	**Maximum Train Length (6 car)-Approximate**	136. m
11	**Speed**	
11.1	Maximum Design Speed	95 Kmph
11.2	Maximum Operating Speed	85 Kmph
12	**Wheel Profile**	**UIC 510-2**
13	**Noise Limits (ISO 3381 and 3058 - 2005)**	
13.1	Stationary (Elevated and at grade)	
13.1.1	Internal (cab and saloon)	L_{pAFmax} 65 dB(A)
13.1.2	External (at 7.5 mtr from centre line of track)	L_{pAFmax} 68 dB(A)
13.2	Running at 85 kmph (Elevated and at grade)	
13.2.1	Internal (cab and saloon)	$L_{pAeq,30}$ 72 dB(A)
13.2.2	External (at 7.5 mtr from centre line of track)	L_{pAFmax} 85 dB(A)
13.3	Stationary (Underground)	
13.3.1	Internal (cab and saloon)	L_{pAFmax} 72 dB(A)
14	**Traction Motors Ventilation**	**Self**
15	**Acceleration on level tangent trac**	**0.82 m/sec^2**
16	**Deacceleration on level tangent track**	**1.1 m/sec^2 (>1.3 m/sec^2 during emergency)**
17	**Type of Bogie**	**Fabricated**
18	**Secondary Suspension springs**	Air

19	**Brakes**	- An electro-pneumatic (EP) service friction brake - An electric regenerative service brake - Provision of smooth and continuous blending of EP and regenerative braking - A fail safe, pneumatic friction emergency brake - A spring applied air-release parking brake - The brake actuator shall operate a Wheel Disc Brake -Brake Electronic Control Unit (BECU) Independent for each bogie
20	**Coupler**	Auto
	Outer end of 2-car Unit (except DT cab front side)	Automatic coupler with mechanical, electrical & pneumatic coupling
	Front cab end of DT car	Automatic coupler with mechanical & pneumatic coupling but without electrical coupling head
	Between cars of same Unit	Semi-permanent couplers
21	**Detrainment Door**	Front
22	**Type of Doors**	Sliding
23	**Passenger Seats**	Stainless Steel
24	**Cooling**	
24.1	Transformer	Forced
24.2	CI & SIV	Self/Forced
24.3	TM	Self ventilated
25	**Control System**	Train based Monitor & Control System (TCMS/TIMS)
26	**Traction Motors**	3 phase VVVF controlled

27	**Temperature Rise Limits**	
27.1	Traction Motor	Temperature Index **minus** 70 deg C
27.2	CI & SIV	10 deg C temperature margin for Junction temperature
27.3	Transformer	IEC specified limit **minus** 20 deg C
28	**HVAC**	- Cooling, Heating & Humidifier (As required) - Automatic controlling of interior temperature throughout the passenger area at 25°C with 65% RH all the times under varying ambient conditions up to full load.
29	**PA/PIS including PSSS (CCTV)**	Required
30	**Passenger Surviellance**	Required
31	**Battery**	Lead Acid Maintenance free
32	**Headlight type**	LED
33	**Coasting**	8% (Run time with 8% coasting shall be the 'Run Time in All out mode **plus** 8%')
34	**Emergency Operating Conditions**	- One serviceable fully loaded 4-car train shall be capable of pushing a fully loaded defective 4-car train without parking brakes applied on all sections including section of 3% gradient up to next station. Thereafter, after passenger detrainment, the healthy train shall push

		the defective train till terminal station. - A 4-car or 6-car fully loaded train shall be capable of clearing the section with the traction motors of one 2-car unit cut out.
35	**Gradient (max)**	4%
36	**Insulated Mat on roof**	Required
37	**Average Cost per car exclusive of taxes and duties at Oct 2008 Price level in Rs. crore**	10



DELHI METRO RAIL CORPORATION LTD.
Metro Bhawan, Fire Brigade Lane, Barakhamba Road, New Delhi-110001.

SIGNALLING SCHEME PLAN No. DMRC/Sig.201/08)
Jaipur Metro Rail Project Corridor –1
Ref: P.Way Plan, vide DMRC/20/268/2003 dt 14.3.11
Drawn By Sctish Kumar JE/Sig | Date 18th Mar 2011

Chapter 5

Civil Engineering

CHAPTER 5

CIVIL ENGINEERING

5.1 GEOMETRIC DESIGN NORMS

5.1.1 General

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.

5.1.2 Horizontal Alignment

As far as possible, the alignment follows the existing roads. This leads to introduction of many horizontal curves. On consideration of desirable maximum cant of 110 mm and cant deficiency of 85 mm on Metro tracks, the safe speed on curves of radii of 400 m or more is 80 km/h. On elevated section use of curves with minimum radius of 120 m, having speed of 55 km/h shall be adopted. However in underground section desirable minimum radius of curve shall be 300 m for ease of working of Tunnel Boring Machine (TBM). However in exceptional situation on this project, curves of 200 m radius (safe speed of 55 km/h) have been adopted where New Austrian Tunneling Machine (NATM) shall be used.

For maximum permissible speed on curve with various radii, Table 5.1 may be referred.

5.1.3 Horizontal Curves

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

5.1.4 Transition Curves

The existing roads along which the metro is proposed have frequent curves. However, it is necessary to provide transition curves at both ends of the circular curves. 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. 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: either 25 m or Nil.
- Minimum curve length between two transition curves: 25 m

5.1.5 Vertical Alignment and Track Centre

(a) **Elevated Sections**

The viaducts carrying the tracks will have a vertical clearance of minimum 5.5 m above road level. For meeting this requirement with the

'Box' shaped pre-stressed concrete girders, the rail level will be about 9.8 m above the road level. However, at stations which are located above central median, the rail level will be 13.5 m above the road level with concourse at mezzanine. These levels will, however, vary marginally depending upon where the stations are located.

The track center on the elevated section is kept as 4.2 m uniform throughout the corridor to standardize the superstructure, except at few locations, wherever scissors crossovers are planned, it is kept 4.5 meter. Also in case of sharper than 120m centre to centre distance of tracks to be increased and special segments of adequate width to be casted.

(b) Underground sections

Rail level at midsection in tunneling portion shall be kept at least 12.0 m below the ground level. At stations, the desirable depth of rail below ground level is 12.5 m, so that station concourse can be located above the platforms.

Track center in underground sections are follows:

Sections where stations are to be constructed by cut & cover and running section by TBM to accommodate 12 m wide platform (for lesser width of platform, track center to be reduced.)	: 15.05 m
Sections where stations are to be constructed by NATM and running section by TBM to facilitate Construction of stations	: 22.00 m
Sections where stations as well as running sections both are to be constructed by cut and cover method	: 4.80 m

(c) Gradients

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

(d) Vertical Curves

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

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

5.1.6 Design Speed

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

Table 5.1

Cant, Permitted Speed & Minimum Transition Length for Curves

RADIUS	CANT	MAXIMUM PERMISSIBLE SPEED	MINIMUM DISTANCE BETWEEN ADJACENT TRACKS	
			UNDER GROUND	ELEVATED AND AT-GRADE
meters	mm	kmph	mm.	Mm
3000	15	80	3500	3650
2800	15	80	3500	3650
2400	20	80	3500	3650
2000	20	80	3500	3650
1600	25	80	3500	3650
1500	30	80	3500	3650
1200	35	80	3500	3650
1000	45	80	3500	3700
800	55	80	3550	3700

RADIUS	CANT	MAXIMUM PERMISSIBLE SPEED	MINIMUM DISTANCE BETWEEN ADJACENT TRACKS	
600	70	80	3550	3750
500	85	80	3600	3750
450	95	80	3600	3800
400	105	80	3650	3800
350	110	75	3650	3800
300	110	70	3700	3850
200	110	55	3800	3950
150*	110	45	4000	4050
150*	0	30	4000	4050
120*	110	40	4000	4150
120*	0	25	4000	4150

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

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

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

5.1.7 Station Locations

Stations have been located so as to serve major passenger destinations and to enable convenient integration with other modes of transport. However effort has also been made to propose station locations, such that inter station distances are as uniform as possible. The average spacing of stations is kept close to 1.0 km.

5.2 DESCRIPTION OF CORRIDORS

Two corridors have been recommended for Jaipur Metro Rail Project which are shown in Fig.5.1. out of these corridors east west corridor has been selected for implementation in phase 1.

5.3 East – West Corridor : Mansarovar to Badi Chaupar

From dead end (Ch-1218.93m)of Mansarovar station to dead end of Badi Chaupar station (Ch. 10848.496 m), the length of the corridor 2 is 12.067 km.

Total 11 number of stations have been planned along this corridor out of which 8 are elevated and 3 are underground stations.

This Corridor of Jaipur Metro Rail Project passes through the middle of Jaipur City and runs in East-West direction. It originates from Mansarovar in West and terminates at Badi Chaupar in East. It starts from Mansarovar and runs on the median of Gopalpura bye pass for a kilometer and then takes left turn after New Aatish Market station and runs on the median of New Sanganer Road, through Vivek Vihar and Shyam Nagar stations. As the road is narrow and kinky at the junction of New Sanganer Road and Ajmer Road, it leaves New Sanganer Road and after passing over built up area of Vaid Colony it enters Government land under dispute with Dhamani and passes over Sodala Thana.

Two lane elevated road coming from Ajmer side, ramp starting from BPCL petrol pump after crossing Queens Road meet with two lane elevated road ramp starting from HPCL petrol pump and attaining full height at Indian Oil Petrol pump at Sodala and forms Four lane Elevated Road . This four lane Elevated Road at level 1 meets Metro Rail of level 2 ahead of Sodala Thana. Here onward Elevated Road runs at level 1 and Metro at level 2

The four lane elevated road of level 1 after meeting with Metro of level 2 run on median of Ajmer Road passing through Civil Line station and there after it runs on left side of slip road with two lane elevated road on separate pier and metro on separate pier The two lane elevated road crosses underneath the Metro alignment and runs straight crossing railway track and reaches at the end of MI Road end of Ajmer Pullia. The Metro alignment after taking left turn reaches to Railway station. On right side of Ajmer Pullia another two lane elevated road runs up to ramp on MI road end matching with Ajmer Pullia. The Metro alignment has been so planned to cater to two new railway tracks as per request of Railway authorities

Here after alignment takes 'U' turn to follow Station Road up to Chandpole. From Chandpole to Badi Chaupar, alignment is underground and runs below the road. Switch Over Ramp has been provided between Sindhi Camp and Chandpole. Sindhi Camp will be an interchange station and Chandpole, Chotti Chaupar & Badi Chaupar are underground stations. Dead end is provided beyond Badi Chaupar. Overall length of alignment is 12.067 km from dead end to dead end, out of which 2.628 km is underground and remaining 9.439 km is elevated including length of SOR. Total 11 stations have been planned along the corridor; out of which 3 are underground and remaining 8 are elevated.

5.4 Reference Line

Center line of Mansarovar station has been taken as '-659.363m' for reckoning of chainage on Corridor. Chainage increases from Mansarovar station to Badi Chaupar station. Line from Mansarovar station to Badi Chaupar station has been named as "Up line" and from Badi Chaupar to Mansarovar station is named as "Down line".

5.5 Terminal Stations

5.5.1 Mansarovar station

The terminal station of corridor is Mansarovar station, with its center line at Ch. '-659.363m'. This station is elevated. At the end of this station, the train reversal facilities have been proposed by providing cross over at the rear end. The dead end of corridor is at Ch. (-) 1218.93 m. Reversal length can be used for night stabling of rakes during night.

Connection has also been provided from Mansarovar station to Mansarovar depot.

5.5.2 Badi Chaupar Terminal station

The terminal station at other end of corridor is Badi Chaupar station with its center line at Ch. 10398.502m. This station is underground. At the end of this station, the train reversal facilities have been proposed by providing cross overs at the rear end. The dead end of Corridor is at Ch. 10848.496 m. Stabling of rakes on reversal length of tracks during night has been planned on this terminal.

5.6 Route Alignment

To describe the alignment properly it has been divided in three sections as follows:

i. Elevated section km (-)1.218 to km 7.80

ii. Switch Over Ramp km 7.80 to km 8.22

iii Underground section km 8.22 to km 10.848

5.6.1 Elevated section km (-) 1.218 to km 7.80

From km (-) 1.218 to km 7.80 alignment has been kept on median of main road except from km 3.05 on New Sanganer Road to km 3.63 where it is passing over built up area of Vaid Colony and through Govt. land under dispute as New Sanganer Road beyond km 3.05 is narrow and kinky. In this section 26 nos of curves have been provided. Out of these curves, sharpest one is 90 m, which has occurred at 1 location, whereas flattest radius is 8500 m occurring at 1 location. Length of straights between two curves in this section is greater than 50 m at all locations and 52.97% alignment is curved.

Vertical alignment has been designed keeping in view 5.5 m clearance from road surface to bottom of the girder. It has been increased by about 3.5 m at station locations to accommodate concourse of stations. Ground profile in this section varies from highest level at Sindhi Camp i.e. 451.00 m from mean sea level (MSL) to 424.50 m from MSL at Mansarovar. Existing ground profile is generally falling or raising at the rate of 2 % gradient. Change of grade takes place at 22 locations. Steepest grade is 3.36 % which has been provided to bring alignment from elevated position to underground position. Flattest grade is level, which has been provided at stations. Longest length at same grade is from Ch. -260 to Ch. 160 which is 420 m long at 0 % gradient.

5.6.2 Switch Over Ramp km 7.80 to 8.22

Due to the alignment passing through very congested area and elevated alignment not being possible in the stretch via Chandpole, Chotti Chaupar and Badi Chaupar stations, alignment has been proposed underground from Chandpole to Badi Chaupar stations.

Switch Over Ramp or at grade ramp is required to switch over alignment from elevated position to underground position or vice versa. SOR has been planned between km 7.80 to km 8.22 on Station Road. Location of Switch over Ramp has been decided keeping in view the availability of road width, without creating hindrance to traffic flow on roads. About 10.50 m wide strip of road in a length of 420 m shall be required permanently. It has been planned with 3.38 % gradient to minimize the length of ramp.

5.6.3 Underground Section (km 8.22 to km 10.848)

Underground section can be further divided in to two sections

(a) Underground section by Tunnel Boring Machine (TBM)

(b) Underground section by Cut & Cover Method.

5.6.4 Underground section by TBM Method

Alignment attains underground position at km 8.50 at the end of Switch Over Ramp. It has been planned to construct underground section from km 8.50 to km 10.22 by TBM and therefore no curve of less than 300 m radius is planned. One curve of 300 m and other curve of 8500 m radius have been proposed. Efforts have been made to maintain radius as large as possible to facilitate smooth working of TBM as well as smooth riding of trains.

Vertical alignment has been designed keeping adequate cushion (about 6 m) over the tunnel.

Change of grade takes place at 4 locations. Steepest gradient provided in the section is 3.36 % which has been provided on entry of Chandpole station. Longest length at same grade is on level gradient that has been provided at three locations.

5.6.5 Underground section by Cut & Cover Method

From Ch. 8220.00 to Ch. 8253.00, Ch. 8393.00 to 8500.00 and Ch 10464.00 to 10848.00 in a total length of 475 m it is proposed to use Cut & Cover Method.

Only one curve of 120 m radius has been provided in this stretch.

Three stations have been planned in this stretch which shall be constructed by cut & cover method using Top Down Construction.

5.6.6 Horizontal Curves

While designing horizontal alignment, efforts have been made to keep alignment straight as far as possible. However it is not possible in case of elevated sections, where alignment has to follow central median of existing roads. Geometrics of existing roads at certain locations is too kinky that metro alignment cannot follow the same. Alignment at these locations has deviated from on road position to off road position to keep metro alignment geometry within stipulated norms.

Total 29 number of curve have been provided in this corridor. Over all 41.62 % alignment is on curves. Sharpest curve is 92.15 m, whereas flattest is 8505.525 m. Abstract and details of horizontal curves have been put on Table 5.8 and Table 5.9 respectively.

Table 5.8
Abstract of Horizontal Curves

S.No	Radius	Nos. of occurrences	Curve Length	% w.r.t. Total Curve Length
1	122.100	2	119.081	2.554
2	127.100	1	182.790	3.920
3	202.100	4	735.607	15.775
4	302.100	2	632.088	13.555
5	402.100	4	834.668	17.899

S.No	Radius	Nos. of occurrences	Curve Length	% w.r.t. Total Curve Length
6	502.100	1	103.498	2.220
7	602.100	3	549.614	11.786
8	602.250	1	117.520	2.520
9	702.100	3	515.771	11.061
10	1002.100	3	345.445	7.408
11	1202.100	1	150.798	3.234
12	2502.100	1	130.895	2.807
13	7002.100	1	77.643	1.665
14	8505.525	1	66.006	1.415
Total		**29**	**4663.184**	**100.00**

Table 5.9
Statement of Horizontal Curves

Curve No	Direction	Radius	Deflection Angle			Transition Length		Tangent Length	Curve Length	Total Curve Length
1	Right	602.250	6	21	0	35	35	50.911	31.746	101.746
2	Left	-202.100	22	12	2	50	50	64.740	28.308	128.308
3	Left	-202.100	45	46	46	55	55	113.074	106.479	216.479
4	Left	-202.100	43	55	6	55	55	109.221	99.913	209.913
5	Left	-202.100	63	46	44	55	55	153.616	169.968.	279.968
6	Left	-7002.100	0	23	14	15	15	31.155	32.309	62.369
7	Right	702.100	5	27	41	35	35	50.990	31.924	101.924
8	Left	-2502.100	1	1	26	15	15	29.856	26.712	56.712
9	Right	127.100	36	6	52	50	50	66.672	30.113	130.113
10	Left	-402.100	39	38	56	46	46	168.035	232.254	324.254
11	Right	402.100	15	41	52	46	46	78.458	64.167	156.157
12	Right	1002.100	7	11	33	25	25	75.483	100.798	150.798
13	Right	1202.100	2	44	51	20	20	38.827	37.643	77.643
14	Right	1002.100	4	30	38	25	25	51.967	53.895	130.895
15	Right	602.100	18	44	36	45	45	121.893	151.966	241.966
16	Right	602.100	9	17	35	40	40	68.944	57.657	137.657
17	Left	-602.100	11	40	15	40	40	81.546	82.644	162.644
18	Right	402.100	13	12	6	45	45	69.052	27.648	117.648
19	Left	-302.100	65	51	54	57.75	57.75	224.845	289.533	405.033
20	Left	-122.100	48	34	0	50	50	80.438	53.498	103.498
21	Right	122.100	136	19	2	50	50	263.864	159.242	279.242
22	Left	-402.100	24	56	38	46	46	111.983	129.055	227.055

Curve No	Direction	Radius	Deflection Angle			Transition Length		Tangent Length	Curve Length	Total Curve Length
23	Left	-702.100	4	51	16	30	30	44.762	29.485	89.485
24	Right	702.100	6	11	27	30	30	52.971	45.864	105.864
25	Left	-502.100	13	2	4	45	45	79.877	69.224	159.224
26	Left	-1002.100	8	27	0	35	35	91.533	112.790	182.790
27	Right	122.100	42	21	15	50	50	72.599	40.259	140.259
28	Right	302.100	12	48	26	50	50	58.938	17.528	117.520
29	Right	8505.525	0	20	37	15	15	33.003	36.006	66.006

5.7 Gradients

While designing vertical alignment, efforts have been made to keep grades as flatter as possible. However it is not possible in the stretches of corridor where profile of existing road has steep gradients. Stations have been planned on level gradient. Majority of grades are less than 1%. Flattest gradient is level, which has been provided on stations. Steeper gradients have been introduced where they are absolutely required. Change of grade takes place at 37 locations. Abstract of gradients and details of gradient have been put in Table 5.11 & 5.12 respectively.

Table 5.11
Abstract of Gradients

S.No.	Description	No. Occurrences	Lengths (m)	% w.r.t. Total Length
1	0-1	22	7306.538	60
2	>1-2	8	1974.462	16
3	>2-3	7	1683.000	14
4	>3-4	3	1103.000	10
Total		40	12067.000	100

Table 5.12
Statement of Gradients

S. No.	Chainage		Length	Rail Level		Gradient (%)	Remarks
	From	To		From	To		
1	-1218.930	-440.000	778.930	424.500	424.500	0.00	Level
2	-440.000	-140.000	300.000	424.500	418.700	-1.93	Fall
3	-140.000	162.000	302.000	418.700	419.00	0.10	Rise
4	162.000	420.000	258.000	418.900	412.800	-2.40	Fall
5	420.000	675.000	255.000	412.700	418.500	2.27	Rise
6	675.000	952.000	277.000	418.500	418.500	0.00	Level

S. No.	Chainage		Length	Rail Level		Gradient (%)	Remarks
	From	To		From	To		
7	952.000	1080.000	128.000	418.500	421.600	2.42	Rise
8	1080.000	1180.000	100.000	421.600	422.200	0.60	Rise
9	1180.000	1460.000	280.000	422.200	419.800	-0.86	Fall
10	1460.000	1780.000	320.000	419.800	426.400	2.06	Rise
11	1780.000	2030.000	250.000	426.400	426.400	0.00	Level
12	2030.000	2160.000	130.000	426.400	424.400	-1.54	Fall
13	2160.000	2420.000	260.000	424.400	424.000	-0.15	Fall
14	2420.000	2660.000	240.000	424.000	428.200	1.75	Rise
15	2660.000	3040.000	380.000	428.200	428.200	0.00	Level
16	3040.000	3360.000	320.000	428.200	438.000	3.06	Rise
17	3360.000	3850.000	490.000	438.000	438.000	0.00	Level
18	3850.000	4220.000	370.000	438.000	438.900	0.24	Rise
19	4220.000	4450.000	230.000	438.900	442.600	1.61	Rise
20	4450.000	4800.000	350.000	442.600	442.600	0.00	Level
21	4800.000	5120.000	320.000	442.600	444.700	0.66	Rise
22	5120.000	5360.000	240.000	444.700	447.000	0.96	Rise
23	5360.000	5572.000	212.000	447.000	451.400	2.08	Rise
24	5572.000	5770.000	198.000	451.400	444.300	-3.59	Fall
25	5770.000	6040.000	270.000	444.300	451.600	2.70	Rise
26	6040.000	6360.000	320.000	451.600	451.600	0.00	Level
27	6360.000	6600.000	240.000	451.600	444.500	-2.96	Fall
28	6600.000	6855.000	255.000	444.500	447.400	1.14	Rise
29	6855.000	7430.000	575.000	447.400	451.000	0.63	Rise
30	7430.000	7640.000	210.000	451.000	451.000	0.00	Level
31	7640.000	8225.000	585.000	451.000	431.250	-3.38	Fall
32	8225.000	8470.538	245.538	431.250	431.250	0.00	Level
33	8470.538	8720.000	249.462	431.250	426.500	-1.90	Fall
34	8720.000	8890.000	170.000	426.500	426.500	0.00	Level
35	8890.000	9150.000	260.000	426.500	424.000	-0.96	Fall
36	9150.000	9420.000	270.000	424.000	427.000	1.11	Rise
37	9420.000	9660.000	240.000	427.000	427.000	0.00	Level
38	9660.000	9960.000	300.000	427.000	424.000	-1.00	Fall
39	9960.000	10215.000	300.000	424.000	427.500	1.17	Rise
40	10260.000	11348.393	1088.393	427.500	427.500	0.00	Level

5.8 Break up of Alignment Length for East - West Corridor

Breakup of alignment length for the Corridor is given in **Table 5.12(A)**

Table 5.12(A)
Breakup of alignment length

S. No.	Description	Chainage(m)		Length(m)
		From	To	
1	Elevated	-1218.93	7800	9018
2	SWR	7800	8220	420
3	Underground (Cut & Cover)	8220	8500	280
4	Underground (TBM)	8500	10220	1720
5	Underground (Cut & Cover)	10220	10848	628
Alignment length (Total)				**12067**

5.9 Station Planning

5.9.1 RAIL LEVELS AND ALIGNMENT

In underground sections, the rail levels are generally about 14 m below the ground level governed by a ground clearance of 2 m and a station box of about 14 m depth. In the elevated section, rail level is generally about 13.5 m above ground in order to maintain a clearance of 5.50 m between the road and the station structure. In order to keep the land acquisition to minimum, alignment is planned generally in middle of the road (especially at stations in underground section) and a two-level station design has been proposed in both elevated and underground sections. Entry/exit structures to the proposed stations and traffic integration areas have been planned in the open space available.

5.9.2 PLATFORMS

All the underground stations have been planned with island platforms except Badi Chaupar station where side platforms have been planned. In the elevated section, stations have been planned with side platforms to avoid the viaduct structure from flaring in and out at stations, which obstructs the road traffic below. Care has been taken to locate stations on straight alignment. However, in some stations, site constraints have become the deciding criteria and a curve of 1000 m radius has been introduced.

5.9.3 SEQUENCE OF STATIONS

The sequence of stations along with their respective chainages, site and platform characteristics are presented in the Table 5.13:

Table 5.13
STATION LOCATION CHARACTERISTICS

S. No	Name of Station	Chainage (in m)	Distance from previous station (in m)	Rail level (in m)	Ground Level (in m)	Platform type	Alignment
East – West Corridor Mansarovar Depot to Bari Chaupar							
	Dead End	-1218.93	-	424.500	411.050		Elevated
1	Mansarovar	-659.363	559.567	424.500	410.943	Side	Elevated
2	New Aatish Market	795.520	2014.45	418.500	403.648	Side	Elevated
3	Vivek Vihar	1901.00	1454.883	426.400	412.889	Side	Elevated
4	Shyam Nagar	2782.120	1105.480	428.200	414.174	Side	Elevated
5	Ram Nagar	3529.256	881.120	438.000	417.400	Side	Elevated
6	Civil Lines	4615.296	741.136	442.600	422.460	Side	Elevated
7	Metro Railway Station	6198.422	1086.04	451.600	432.959	Side	Elevated
8	Sindhi Camp Station	7537.201	1583.126	451.000	438.057	Side	Elevated
9	Chand Pole	8323.248	786.04	431.250	999.000	Island	Under Ground
10	Choti Chaupar	9545.158	1221.910	427.000	440.647	Island	Under Ground
11	Badi Chaupar	10398.502	853.344	427.500	440.934	Side	Under Ground
	Dead End	10848.496	450.0	427.500	441.200		Under Ground

5.9.4 PLANNING AND DESIGN CRITERIA FOR STATIONS

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

2. The platform level has adequate 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 5.5 m under the concourse above the road intersection, allowing 3.5 m for the concourse height, about 1 m for concourse floor and 1.5 m for structure of tracks above the concourse. Further, the platforms are 1.09 m above the tracks. This would make the rail level in an elevated situation at least 13.5m above ground.

4. In the underground stations, platform level is determined by a critical clearance of 2.50 m above the station box, which would be 13.7 m high. Allowing about 80 cm for the box structure, 70 cm for rails /supporting

structure and 1.09 m for rail to platform ht, would make the platforms in an underground situation at least 13.5 m below ground.

5. 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.

6. 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.

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

8. Station entrances are located with particular reference to passenger catchment points and physical site constraints within the right-of-way allocated to the MRTS.

9. Office accommodation, operational areas and plant room space is required in the non-public areas at each station. The functions of such areas are given in Table 5.13.

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

11. The system is being designed to maximize its attraction to potential passengers and the following criteria have been observed:

    - Minimum distance of travel to and from the platform and between platforms for transfer between lines.
    - Adequate capacity for passenger movements.
    - Convenience, including good signage relating to circulation and orientation.
    - Safety and security, including a high level of protection against accidents.

12. Following requirements have been taken into account:

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

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

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

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

5.9.5 TYPICAL ELEVATED STATION

The station is generally located on the road median on central piers. Total length of the station is 140m. All the stations are two-level stations. The concourse is 140m under the station, with staircases leading from either side of the road. The maximum width of the station at concourse is 20.46 m and at the narrowest part is 16.5 m. Passenger facilities like ticketing, information etc. as well as operational areas are provided at the concourse level. Typically, the concourse is divided into public and non-public zones. The non-public zone or the restricted zone contains station operational areas such as Station Control Room, Station Master's Office, Waiting Room, Meeting Room, UPS & Battery Room, Signaling Room, Train Crew Room & Supervisor's Office, Security Room, Station Store Room, Staff Toilets, etc. The public zone is further divided into paid and unpaid areas. Auxiliary Service station is provided on the ground nearby as per availability of land.

One typical station of Civil Lines is falling between Ram Nagar and Metro Railway Station in East – West Corridor on Ajmer Road, here normal road runs at lowest level i.e. ground level, above it at level one Elevated BRTS Road runs, over it at level two Civil lines station will be constructed. The height of this station will be 20.14m from ground level approximately.

At Ramnagar station also the rail level is of the order of 20m due to interface with elevated road .Here one extra floor of area of about 3000Sq.m has been created below concourse for property development purpose.

Since the stations are in the middle of the road, minimum vertical clearance of 5.5 m has been provided under the concourse. Platforms are at a level of about 13.5 m from the road.

With respect to its spatial quality, an elevated Metro structure makes a great impact on the viewer as compared to an At-grade station. The positive dimension of this impact has been accentuated to enhance the acceptability of an elevated station and the above ground section of tracks. Structures that afford maximum transparency and are light looking have been envisaged. A slim and ultra-modern concrete form is proposed, as they would look both compatible and modern high-rise environment as well as the lesser-built, low-rise developments along some parts of the corridor.

Platform roofs, that can invariably make a structure look heavy, have been proposed to be of steel frame with aluminum cladding to achieve a light look. Platforms would be protected from the elements by providing an overhang of the roof and sidewalls would be avoided, thereby enhancing the transparent character of the station building. In order to allow unhindered traffic movement below the stations. Structure is supported on a central row of columns, which lies unobtrusively on the central verge.

5.9.6 Typical Underground Station

The typical underground station is a two-level station with platforms at the lower level and concourse on the upper level. Concourses are provided in such a manner that the total height of underground station, and hence the cost, is kept to the minimum. The upper level has, in addition to the concourse, all the passenger amenities, ECS plant rooms, electrical and S&T equipment rooms, station operation areas such as Station Control Room, Station Master's Office, Waiting Room, Meeting Room, UPS & Battery Room, Signaling & Train Crew Room, Train Crew Supervisor's Office, Security & Station Store Room, Staff Toilets, etc. Lower level has platforms, tracks, seepage sump, pump room and similar ancillary spaces beyond the platforms on either side.
Ventilation shafts, equipment hatch, entrances and chiller plants for ECS plant are above ground structures associated with the underground station and are being provided on the open spaces by the road side/ acquired land. Generally four entrances have been provided to the station, two at each end

(one each from either side of the road). Two emergency staircases are also being planned in the traffic islands. Other above ground structures is suitably located near the station.

Structure of the underground station is essentially a concrete box about 20 m wide, 14.6 m high and 140.00 m long with an intermediate slab. Sides of the box are made of 1.2 m thick RCC.

Table 5.14
STATION ACCOMMODATION

1. Station Control Room	2. Cleaner's Room
3. Station Master's Office	4. Security Room
5. Information & Enquiries	6. First Aid Room
7. Ticket Office	8. Miscellaneous Operations Room
9. Ticket Hall Supervisor & Excess Fare Collection (Passenger Office)	10. Platform Supervisor's Booth
11. Cash and Ticket Room	12. Traction Substation (alternate Stations)
13. Staff Area	14. Fire Tank and Pump Room
15. Staff Toilets	16. Commercial Outlets and Kiosks
17. Station Store Room	18. UPS and Battery Room

19. Refuse Store	20. Signaling / Communication Room
21. Public Toilets	22. Aaxilliary sub station
23. Electrical switch room	24. Environ control system plant room for under ground station
25. Tunnel ventilation system plant rooms (for underground station)	26. Insert gas room (for underground station)
27. Inert gas room (for underground station)	28. CDMA /Gas room (for underground station)
29. DB Panel room (for underground station)	30. Sewage/ seepage tanks and pump rooms (for underground station)
31. Chiller plant room (for underground station)	32. Pump room (for underground station)

5.9.7 PASSENGER AMENITIES

Passenger amenities such as ticketing counters/automatic ticket vending machines, ticketing gate, etc. are provided in the concourse. Uniform numbers of these facilities have been provided for system wide uniformity, although the requirement of the facilities actually varies from station to station. The same applies to provision of platform widths and staircase/escalators. Maximum capacity required at any station by the year 2031 for normal operation has been adopted for all stations. For this purpose, peak minute traffic is assumed to be 2% of the peak hour traffic. For checking the adequacy of platform area, stair widths and requirement additional of emergency evacuation stairs, a maximum accumulation of passengers in the station has been considered to be comprising waiting passengers at the platform (including two missed headways) and section load expected to be evacuated at the station in case of an emergency.

5.9.8 Concourse

Concourse forms the interface between street and platforms. In elevated stations, this is contained in a length of 70 - 80 m in the middle of the station. This is where all the passenger amenities are provided. The concourse contains automatic fare collection system in a manner that divides the concourse into distinct paid and unpaid areas. The 'unpaid area' is where passengers gain access to the system, obtain travel information and purchase tickets. On passing through the ticket gates, the passenger enters the 'paid area', which includes access to the platforms. The concourse is planned in such a way that maximum surveillance can be achieved by the ticket hall supervisor over ticket machines, automatic fare collection (AFC) gates, stairs and escalators. Ticket machines 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 AFCs.

5.9.9 Ticketing Gates

Ticketing gates' requirement has been calculated taking the gate capacity as 30 persons per minute per gate. Passenger forecast for the horizon year 2031 has been used to compute the maximum design capacity. At least two ticketing gates shall be provided at any station even if the design requirement is satisfied with only one gate. Uniform space has been provided in all stations where gates can be installed as and when required.

5.9.10 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 TIMS 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 TIMS 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 tickets or prepaid card, etc. Accordingly, the requirement of ticket counters has been calculated and the same provided for in the plans.

5.9.11 Platforms

A uniform platform width of 8 to 12 m wide is proposed for the underground stations. In elevated stations, 4.5m wide side platforms have been proposed. These platform widths also have been checked for holding capacity of the platform for worst-case scenario.

5.9.12 Stairs, Escalators and Lifts

Provision has been made for escalators in the paid area i.e. from concourse to platforms. On each platform, one escalator has been proposed. In addition, two staircases with a combined width of 6 m are provided on each platform connecting to the concourse. These stairs and escalator together provide an escape capacity adequate to evacuate maximum accumulated passengers in emergency from platforms to concourse in 5.5 minutes. Lifts have been provided one each on either platform, to provide access for elderly and disabled.

Since the rise to road from the concourse is about 8m, it is proposed to provide lifts in addition to stairs for vertical movement of passengers from street to concourse.

5.9.13 TRAFFIC INTEGRATION

5.9.13.1 Concept of Traffic Integration

The objective of an integrated transport system and traffic movement is to offer maximum advantage to commuters and society from traffic and planning consideration. Various modes of transport need to be integrated in a way that each mode supplements the other. A large proportion of MRTS users will come to and depart from various stations by public, hired and private modes, for which integration facilities need to be provided at stations to ensure quick and convenient transfers.

In order to ensure that entire MRTS function as an integrated network and provides efficient service to the commuter, the following steps have been identified:

- Suitable linkages are proposed so that various corridors of MRTS are integrated within themselves, with existing rail services and with road based modes.
- Facilities needed at various stations are planned in conformity with the type of linkages planned there.

  Traffic and transport integration facilities are provided for two different types of linkages:
- Feeder links to provide integration between various MRTS corridors and road based transport modes i.e. public, hired, and private vehicles.
- Walk links to provide access to the pedestrians.

5.9.13.2 Approach Adopted in Planning Traffic Integration Facilities

Integration facilities at MRTS stations include approach roads to the stations, circulation facilities, pedestrian ways and adequate circulation areas for various modes likely to come to important stations including feeder bus/mini-buses. Parking for private vehicles has been proposed close to the station entrances. The computer model employed for traffic demand projections provides also a breakup of station loads between passengers arriving by walk or by vehicular modes. The vehicular component has been further broken up among hired and private modes on station-to-station basis, by assessing the socio-economic profile of the catchment areas and the distance likely to be travelled by commuters before and after using the MRTS. In doing so, feeder buses being planned as part of the project as well as interchange with railways has been considered. In case at a particular station, suitable land is not available, effort has been made to provide equivalent space on the adjacent stations, assuming that park and ride commuters will shift to which ever station such a facility is available.

5.10 CIVIL STRUCTURES

5.10.1 Underground Construction

As in the underground section most of the area is either built-up or passing under Road, it is proposed to tunnel through Tunnel Boring Machine (TBM) or New Austrian Tunneling Method (NATM) in the overburden soil mass. This will reduce cost substantially and inconvenience to general public during construction. Tunnel excavation for a major part of this underground section is expected to be carried out by Tunnel Boring Machines. There is some smaller section along the underground part of the alignment where Cut & Cover method has been considered for construction after Switch Over Ramp (SOR). Tunnel boring machines (TBMs) capable of drilling in soft soil with a finished internal diameter of 5.6 m. can be successfully employed for boring tunnels through this stratum. The tunnels are proposed with a minimum soil cover of 6 m.

5.10.2 Underground Stations

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

5.10.3 Cut and Cover Method of Construction of Underground Stations

Cut and Cover mainly consists of following steps:

1. Diversion of utilities
2. Construction of support walls
3. Excavation between the support walls along with the installation of struts between the two walls to keep them in position.

4. Construction of tunnel/structure and removal of temporary struts.
5. Back filling and restoration of the surface

Utility Diversion:

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

Support Walls:

Most commonly used support wall is RCC Diaphragm Wall. The advantage of diaphragm wall is that the same can be used as part of permanent structure. The modern techniques are now available where water-stop can be inserted at the joints of two diaphragm wall panels to avoid seepage through the joints. It is also now possible to ensure the verticality of the diaphragm wall panels to avoid any infringement problem later on. Typically the diaphragm wall of 80 cm to 1 meter thickness is sufficient to do the cut and cover construction. The various advantages of diaphragm wall are as follows.

(a) It is rigid type of support system and therefore ensures the maximum safety against settlement to the adjacent structures.

(b) Can be used as part of the permanent structure and, therefore, considered economical.

(c) With diaphragm wall it is possible to construct an underground structure by top down method. In this method top slab is cast once the excavation is reached to the top slab level with rigid connections to the diaphragm wall which can be achieved by leaving couplers in the diaphragm wall reinforcement at appropriate level. This top slab then acts as strut between the two support walls and gives much more rigidity and safety to the construction. Excavation thereafter can be completed. This also helps in restoration of the surface faster without waiting for full structure to be completed.

The other support walls which can be used depending on the site conditions are as follows:

(a) **Sheet Piles** : 'Z'/ 'U' sheet piles cane be used as temporary support wall. This can be advantageous where it is possible to re-use the sheet pile again and again and therefore, economy can be achieved However the main concern remains, driving of sheet piles causes vibrations/noise to the adjacent buildings. This may sometimes lead to damage to the building and most of the time causes inconvenience to the occupants of the building. Situation becomes more critical if sensitive buildings are adjacent to the alignment like hospitals, schools, laboratories, etc. Silent pile driving equipments however are now available and can be used where such problems are anticipated.

(b) **Retaining Casing Piles:** This is suitable for situation where the cut and cover is to be done in partly soil and partly rock. The top soil retaining structure can be done with the help of Casing pile which is then grouted with cement slurry. This is considered suitable in case of shallow level, non-uniform, uneven nature of rock head surface which render the construction of sheet piles/diaphragm wall impracticable. These are suitable up to 7-meter depth. The common diameter used for such casing pile is 2.00-2.50 m dia.

(c) **Soldier Piles and Lagging**: Steel piles (H Section or I section) are driven into the ground at suitable interval (normally 1-1.5 m) centre-to-centre depending on the section and depth of excavation. The gap between two piles is covered with suitable lagging of timber planks/shot-creting /steel sheets/GI sheets during the process of excavation.

(d) **Secant Piles**: are cast-in-situ bored piles constructed contiguously to each other so that it forms a rigid continuous wall. This is considered an alternative to diaphragm wall where due to soil conditions it is not advisable to construct diaphragm wall from the consideration of settlement during the trenching operation. 800 to 1000 mm dia piles are commonly used. Two alternate soft piles are driven and cast in such a way that the new pile partly cuts into earlier constructed piles. This new pile is constructed with suitable reinforcement. With this, alternate soft and hard pile is constructed. This has got all the advantages of diaphragm wall. However, this wall cannot be used as part of permanent structure and permanent structure has to be constructed in- side of this temporary wall.

Anchors:

As an alternative to the struts, soil/rock anchors can be used to keep these support walls in position. This gives additional advantage as clear space is available between two support walls and progress of excavation & construction is much faster as compared to the case where large number of struts is provided which create hindrance to the movement of equipments and material & thus affects the progress adversely.

The combination of all the type of retaining walls, struts/anchors may be necessary for the project to suit the particular site. Based on the above broad principle, the support walls system for cut and cover shall be chosen for particular locations.

5.10.4 Elevated Section

Choice of Superstructure

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

The segmental construction has been chosen mainly due to the following advantages:

- Segmental construction is an efficient and economical method for a large range of span lengths and types of structures. Structures with sharp curves and variable super elevation can be easily accommodated.

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

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

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

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

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

5.10.5 Types of Superstructures for Elevated Section

1. Pre-cast segmental box girder using external unbounded tendon

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

Comparative advantages/disadvantages of the above two types are given below:

A. Precast Segmental Box Girder using External Unbonded Tendon.

This essentially consists of precast segmental construction with external prestressing and dry joints and is by far most preferred technique in fast track projects. In such construction the prestressing is placed outside the structural concrete (inside the box section) and protected with high density polyethylene tubes, which are grouted with special wax or cement. The match cast joints at the interface of two segments are provided with shear keys as in traditional segmental construction. However, epoxy is dispensed with because water tight seal at the segment joints is not required because tendons are laid externally & protected by special wax or cement.

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

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

- Simplified segment casting. There is no concern about alignment of tendons. Increased speed of construction.
- The elimination of the epoxy from the match-cast joints reduces costs and increases speed of construction further.
- Replacement of tendons in case of distress is possible and can be done in a safe and convenient manner.
- Facility for inspection and monitoring of tendons during the entire service life of the structure.

Precast Segmental Box Girder using internal tendon is also use.

B. Precast Segmental U-Channel Superstructure with Internal Pre-stressing.

The single U type of viaduct structure is also a precast segmental construction with internal pre-stressing and requires gluing and temporary pre-stressing of segments. The match cast joints at the interface of two segments are also provided with shear keys. The main advantages for this type of structural configuration of superstructure are:

1. Built in sound barrier.
2. Built in cable support and system function.
3. Possibility to lower the longitudinal profile by approximately 1m compared to conventional design.
4. Built in structural elements capable to maintain the trains on the bridge in case of derailment (a standard barrier design allow this)
5. Built in maintenance and evacuation path on either side of the track.

However, 'U' section has following disadvantages:

(i) Inefficient structure sections

(ii) Requires cross pre-stressing of pier segments

(iii) At X-over locations the girders are to be connected at slab level hence changing of bearing at later stage becomes very difficult.

(iv) Costly than Box girder.

5.11 CONSTRUCTION METHODOLOGY

For the elevated sections it is recommended to have pre-cast segmental construction for super structure for the viaduct. For stations also the superstructure is generally of pre-cast members. The pre-cast construction will have following advantages:-

- Reduction in construction period due to concurrent working for substructure and superstructure.
- For segmental, pre-cast element (of generally 3.0m length), transportation from construction depot to site is easy and economical.
- Minimum inconvenience is caused to the public utilizing the road as the superstructure launching is carried out through launching girder requiring narrow width of the road.
- As the pre-cast elements are cast on production line in a construction depot, very good quality can be ensured.
- The method is environment friendly as no concreting work is carried at site for the superstructure.

5.12 Pre-Cast Construction

Casting of Segments

For viaducts segmental pre-cast construction requires a casting yard. The construction depot will have facilities for casting beds, curing and stacking area, batching plant with storage facilities for aggregates and cement, site testing laboratories, reinforcement steel yard and fabrication yard etc. An area of about 2.5 Ha. To 3.0 Ha. is required for each construction depot.

For casting of segments both long line and short line method can be adopted. However the long line method is more suitable for spans curved in plan while short line method is good for straight spans. A high degree of accuracy is required for setting out the curves on long line method for which pre calculation of offsets is necessary. Match casting of segments is required in either method. The cast segments are cured on the bed as well as in stacking yard. Ends of the segments are to be made rough through sand blasting so that gluing of segments can be effective.

The cast segment will be transported on trailers and launched in position through launching girders.

Launching Scheme

Launching girder is specially designed for launching of segments. The suggested launching scheme is designed in such a way that initially the launching girder is erected on pier head at one end of the work. The segments are lifted in sequence and when the lifting is over, they are dry matched while hanging from the launching girder. After dry matching, the Segments are glued with epoxy and pre-stressed from one end. The girder is lowered on the temporary / permanent bearings after pre-stressing. The launching girder then moves over the launched span to next span and the sequences continue.

5.13 Structural System of Viaduct

Superstructure

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

Normally the Box Girder having a soffit width of about 4.0 m (approx) accommodates the two tracks situated at 4.2m center to center (c/c). The Box Girder superstructure for almost all the simply supported standard spans will be constructed by precast pre-stressed segmental construction with epoxy bonded joints.

The standard spans c/c of piers of simply supported spans constructed by precast segmental construction technique has been proposed as 28.0m. The usual segments shall be 3.0m in length except the Diaphragm segments, which shall be 2.0m each. The other spans (c/c of pier) comprises of 31.0 m, 25.0 m, 22.0 m, 19.0 m & 16.0 m, which shall be made by removing/adding usual segments of 3.0 m each from the center of the span.

The pier segment will be finalized based on simply supported span of 31.0m and the same will be also kept for all simply supported standard span.

For major crossing having spans greater than 31.0m, special continuous units normally of 3 span construction or steel girders have been envisaged.

All these continuous units (in case provided at obligatory location) will be constructed by cast-in-situ balanced cantilever construction technique.

Substructure

The viaduct superstructure will be supported on single cast-in-place RC pier. The shape of the pier follows the flow of forces. For the standard spans, the pier gradually widens at the top to support the bearing under the box webs.

At this preliminary design stage, the size of pier is found to be limited to 1.8m to 2.0 m diameter of circular shape for most of its height so that it occupies the minimum space at ground level where the alignment often follows the central verge of existing roads.

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

The longitudinal center to center spacing of elastomeric/pot bearing over a pier would be about 1.8 m. The space between the elastomeric bearings will be utilized for placing the lifting jack required for the replacement of elastomeric bearing. An outward slope of 1:200 will be provided at pier top for the drainage due to spilling of rainwater, if any. The transverse spacing between bearings would be 3.2 m (to be studied in more details).

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

Foundation Recommendation

Substratum consists of top 1 meter as filled up soil followed by sand, silty sand, silty sand mixed with gravel up to 25 meter depth. From Ajmer Puliya to Government Hostel weathered/hard rock beyond 12 meter depth was met.

Pile foundations have been recommended for the foundations as per the stratum encountered. Hence, pile foundations with varying pile depths depending on soil characteristic have to be provided on a case-by-case basis.

Deck – Simple Spans

Salient features of the precast segmental construction method technique as envisaged for the project under consideration are indicated below:
The superstructure shall be constructed "span by span" sequentially, starting at one end of a continuous stretch and finishing at the other end. Nos. of launching girders may be required so as to work on different stretches simultaneously to enable completion of the project in time.

The number of "breaks" in the stretch can be identified by Nos. of continuous units & stations.

The suggested method of erection will be detailed in drawings to be prepared, at the time of detailed design. The launching girder (or, more accurately, the "assembly truss") is capable of supporting the entire dead load of one span and transferring it to the temporary brackets attached to the pier. The governing weight of the segments will be of the order of 50t (to be finalized). The launching girder envisaged will be slightly longer than two span lengths. It must be able to negotiate curves in conjunction with temporary brackets.

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

Box girder segments shall be match cast at the casting yard before being transported to location and erected in position. Post-tensioned cables shall be threaded in-situ and tensioned from one end. It is emphasized that for precast segmental construction only one-end pre-stressing shall be used.

The pre-stressing steel and pre-stressing system steel accessories shall be subjected to an acceptance test prior to their actual use on the works. The tests for the system shall be as per FIP Recommendations as stipulated in the special specifications. Only multi-strand jacks shall be used for tensioning of cables. Direct and indirect force measurement device (e.g. Pressure Gauge) shall be attached in consultation with system manufacturer.

The Contractor shall be responsible for the proper handling, lifting, storing, transporting and erection of all segments so that they may be placed in the structure without damage. Segments shall be maintained in an upright position at all times and shall be stored, lifted and/or moved in a manner to prevent torsion and other undue stress. Members shall be lifted, hoisted or stored with lifting devices approved on the shop drawings.

Epoxy Bonded Joints and Shear Keys

A minimum compressive stress of 3 kg/sq cm shall be provided uniformly over the cross-section for the closure stress on the epoxied joint until the epoxy has set. The curing period for application of the compressive stress, method of mixing and application of epoxy and all related aspects including surface preparation shall be as per approved manufacturer's specifications.

The purpose of the epoxy joint, which is about 1mm on each mating surface, shall be to serve as lubricant during segment positioning, to provide waterproofing of the joints for durability in service conditions and to provide a seal to avoid cross-over of grout during grouting of one cable into other ducts.

The epoxy shall be special purpose and meet requirements of relevant provision of FIP (International Federation of Pre-stressed Concrete)

The temporary compressive stress during the curing period shall be applied by approved external temporary bar pre-stressing (such as Macalloy or Diwidag bar systems or approved equivalent).

5.14 Construction of Stations

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

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

5.14.1 Grade of Concrete

It is proposed to carry out construction work with design mix concrete through computerized automatic Batching Plants with following grade of concrete for various members as per design requirement/durability considerations.

i) Piles	-	M -35
ii) Pile cap and open foundation	-	M -35
iii) Piers	-	M -40
iv) All precast element for viaduct and station	-	M -45
v) Cantilever piers and portals	-	M -45
	-	M -60
vi) Other miscellaneous structure	-	M -30

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

5.14.2 Reinforcement and pre-stressed Steel

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

5.14.3 Road width required during construction

As most of the construction is to be carried out on the middle of the road, central two lanes including median will be required for construction activities. During piling and open foundation work, a width of about 9 m will be required for construction and the same will be barricaded. It is proposed that two lanes are provided for traffic on either side during construction by widening of roads, if necessary. In certain cases, one way traffic may be resorted to.
All these actions will require a minimum period of about 4 to 6 months. During this period, the implementing agency can go ahead with the following preliminary works:

i) Preliminary action for diversion of utility and preparation of estimates thereof.

ii) Reservation of land along the corridor, identification and survey for acquisition.

The JMRC has to take action for appointment of consultant for Project Management and proof checking including preparation of tender documents.

Simultaneously, action is also to be taken for detailed design for structures for elevated corridors.

5.15 GEO-TECHNICAL INVESTIGATIONS

5.15.1 Details of Bore Holes

Investigation Works

Geotechnical investigation work at site was carried out to determine the existing subsoil strata, proposed type & depth of foundations and safe bearing capacity of foundations required for the proposed two Metro Corridors in Jaipur City based on the results of 41 boreholes.

Boring in Soil and Rock

Core drilling was carried out by using rotary type of boring machine with diamond bits of N_X size. Casing of 100/150 mm dia. was advanced up to the firm strata as per IS1892 (1979).The description of bore logs for bore holes drilled as per IS -5313. The bore logs are as under:

Table: 5.15
Borehole Details

S. No.	Specified Locations	Bore Hole No.	Depth below ground level (m)
	East – West Corridor		
26	Saras Dairy Booth near Hotel Sahil, Ramganj)	BH - 02	30.00 m
27	Near ManakChowk Police Station, (Badi Chaupar)	BH - 03	30.00 m
28	Near Mandir Shree Chandra Krishna Ji, (Chandpole)	BH - 04	30.00 m
29	Near Shiv Mandir, (Chandpole)	BH -05	30.00 m
30	Near Mamta Hotel, (Sindhi Camp)	BH -06	30.00 m
31	Near Shaheed Smark, (Govt. Hostel)	BH -07	30.00 m
32	Near Corporate Park, (Ajmer Road)	BH -08	30.00 m
33	Near Rajdhani Gents Parlour (Ajmer Road)	BH -09	30.00 m
34	Near Sodala Police Staion	BH -10	30.00 m
35	Near Vikas Tour and Travals	BH -11	30.00 m
36	Near Jodhpur SweetsHome	Bh - 13	30.00 m

S. No.	Specified Locations	Bore Hole No.	Depth below ground level (m)
37	Near New Bus Stand, (Gopalpura By Pass)	BH -17	30.00 m
38	Near R.P.F. Thana, (Railway Station)	BH -18	30.00 m
39	Opp. All Saints International School, (Shyam Nagar New Sanaganer Road)	BH -19	30.00 m
40	Near New Aatish Market, New Sanganer Road	BH -20	30.00 m

5.15.2 Field Tests & Laboratory Tests

Standard Penetration Tests

The Standard Penetration Tests were conducted in exploratory bore hole at different depths as per the procedure stipulated in IS: 2131. Number of blows required for each 15 cm penetration up to 45 cm were recorded and the number of blows for later 30 cm penetration were counted as Standard Penetration Value (N).

Grain Size Analysis

The Grain Size Analysis of different samples collected from boreholes were done as per IS: 2720(part IV).

Atterberg's Limits

The liquid limit and plastic limit were conducted as per IS: 2720(part V) on soil samples.

Field Content Density and Moisture

The Undisturbed Soil Samples were tested for field density and moisture content as per IS: 2720(part II).

Specific Gravity

The soil samples were tested for specific gravity as per IS: 2720(part III).

Direct Shear Test

The undisturbed soil samples were tested for direct shear tests.

Chemical Analysis of Soil

Chemical analysis of soil samples were conducted for PH, Sulphates (ppm) and for Chloride (ppm).

Chemical Analysis of Water

Chemical analysis of soil samples were conducted for PH, Sulphates (ppm) and for Chloride (ppm).

Rock Test Analysis

Rock samples were collected from the bore holes and tested for water absorption, porosity, dry density and compressed strength (kg/cm^2).

5.15.3 RECOMMENDATIONS

The top soil is generally silty sand with gravels having variable thickness.
Weathered/hard rock at depth of 13 meter was met near Ajmer Puilya on East-West Corridor.
The rock is metamorphic type quartz

Sub soli/ Rock Profile:

Profile was drawn for each bore hole covered in the scope of geotechnical investigation.
Based on sub soil profile pile foundation have been considered for piers.

Foundation in soil:

A foundation must have an adequate depth to avoid adverse environmental influence.

Allowable Bearing pressure:

Considering the proposed structure and taking in to account "N" values are allowable settlement of 25 mm has been adopted.

5.16 UTILITY DIVERSIONS

5.16.1 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 chapters, 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 chapter:

- Existing utilities and planning for their diversion during construction, if necessary.
- Land acquisition necessary for the project both on permanent basis as well as temporary, including its break up between Government and private ownership.

5.16.2 Utility and Services

Large number of sub-surface, surface and over head utility services viz. sewers, water mains, storm water drains, telephone cables, OH electrical transmission lines, electric poles, traffic signals, etc. are existing along the proposed alignment. These utility services are essential and have to be maintained in working order during different stages of construction, by temporary/permanent diversions or by supporting in position. Since these may affect construction and project implementation time schedule/costs, for which necessary planning/action needs to be initiated in advance. Organizations / Departments with concerned utility services in Jaipur are mentioned in Table 5.16.

Table 5.16

UTILITY RESPONSIBILITY DEPARTMENTS

S No	ORGANIZATION/ DEPARTMENT	UTILITY SERVICES
1.	Jaipur Nagar Nigam Jaipur Development Authority	Surface water drains, nallahs, Sewerage and drainage conduits, sewerage treatment plants, pumping stations,
2	PHED Jaipur	Water mains and their service lines, including hydrants, water treatment plants, pumping stations, Gardens etc.
3	Public Works Deptt. (PWD) and JDA Jaipur	Road construction & maintenance of State highways, Municipals Roads etc.
4	Bharat Sanchar Nigam Ltd. (BSNL) Airtel, Tata Indicom, Reliance, MTS, Vodaphone.	Telecommunication cables, junction boxes, telephone posts, O.H. lines, etc.
5	Jaipur Traffic Police	Traffic signal posts, junction boxes and cable connections, etc.
6	District Revenue Office	Land Development & Housing etc.
7	Railway	Railway crossings, signals, railway bridges, etc.
8	RVVNL Jaipur	OH & Under Ground Electric cables and Electric poles

5.16.3 Sewer Lines, Strom Water Drains and Water Lines

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

5.16.4 Above Ground Utilities

Above ground utilities namely street light, poles, traffic signal posts, telecommunication posts, junction boxes, trees etc, are also required to be shifted and relocated suitably during construction of elevated viaduct. Since these will be interfering with the proposed alignment. Approximate numbers of affected lamp/telecom elect. Posts & boxes are indicated in Table 5.17:

Table 5.17
AFFECTED ABOVE GROUND SERVICES

Section	LP/EP	TSP	TP	DP	HT	TR	CD	Remarks
E-W Corridor	624	4	164	0	1	557	0	One span is infringing Alignment

LP- Light Post , EP - Electric Post, TSP - Traffic Signal Post, TP - Telephone Post, DP-high tension double poll, HT- high tension post , TR- trees , CD-civil works

5.17 LAND REQUIREMENT FOR CORRIDORS

5.17.1 Land Requirement for Major Components

Availability of land is one of the major prerequisites for a project in cities like Jaipur. As the Metro alignment has to be planned on set standards and parameters, it becomes difficult to follow the road alignment. Apart from alignment the various structures like stations, parking facilities, traction sub stations, communication towers, etc. require large plots of land. The land being scare, costly and acquisition being complex process, the alignment is so planned that barest minimum land acquisition is involved. Land is mainly required for,

- Metro Structure (including Route Alignment), Station Building, Platforms, Entry/Exit Structures, Traffic Integration Facilities, etc.
- Receiving/Traction Sub-stations
- Radio Towers
- Property Development.
- Temporary Construction Depots and work sites.
- Depot
- Switch Over Ramps.

5.17.2 Land Requirement for Elevated Stretches

For elevated section, single pier supporting the viaduct will be located on the middle of road so that the existing roads remain in use as usual. Accordingly, necessary permission for using such right-of-way will have to be obtained from the concerned authorities. Elevated stations are 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.

The normal viaduct structure of elevated Metro is about 10 m (edge to edge) wide. Ideally the required right of way is 10m. However, for reasons of safety a clean marginal distance / setback of about 5 m is necessary from either edge of the viaduct (or 10 m on both sides of the center line) wherein no structures are to be located. In stretches, where the elevated alignment has to be located away from road, a strip of 17m width (with consideration of 3.5m clearance on either side to reduce land width), is proposed for acquisition, it ensures road access and working space all along the viaduct for working of emergency equipments and fire brigade.

5.17.3 Land for Underground Stretches

No land at surface is required permanently for underground section, except for small areas for entry/exit structures, traffic integration and ventilation shafts at stations. These will be located either on footpath edge or in front marginal open setback of the building along the road. All the stations in underground stretch are planned with island platforms except Badi Chaupar on east - west corridor.

5.17.4 Land for Switch Over Ramps

Switch Over Ramps are required for transition from the underground to elevated section. The ramp covers a stretch at ground for the whole width of structure for two tracks (about 11 m including the protection works). The length of ramp above ground depends on the existing ground slope and the gradient provided on Metro alignment (normally 3% to 4%). Thus the ramp is to be located in an area where sufficient road width is available or in an open area.

5.17.5 Land for Stations

Provision of land for Traffic Integration has been made on those stations only, where space is available. It is proposed to provide traffic integration facilities at all the following Metro stations. Land for these facilities has been identified and is given in Table 5.18: Land plans for stations of line 1 are given in figure 5.10/1 to 5.10/20.Table 5.18

Table: 5.18

LAND FOR STATIONS & TRAFFIC INTEGRATION

PLOT NO.	AREA(m2)	TYPE OF PROPERTY	PURPOSE	OWNERSHIP
Corridor 2 : East - West Corridor				
Mansarovar	3391.44		ENTRY/EXITU/W TANK+ GEN ROOM	Private
New Aatish Market	9663.00		ENTRY/EXITU/W TANK+ GEN ROOM	Private
Vivek Vihar	6506.37	Shops	ENTRY/EXITU/W TANK+ GEN ROOM	Private
Shyam Nagar	872.43	Open	ENTRY/EXITU/W TANK+ GEN ROOM	Private
Ram Nagar	9463.43	Shops	ENTRY/EXITU/W TANK+ GEN ROOM	Private
Civil Line	3145.00	Open	ENTRY/EXITU/W TANK+ GEN ROOM	Private/Govt
Railway Station	3040.00	Open	ENTRY/EXITU/W TANK+ GEN ROOM	Railway
Sindhi Camp Station	1171.00		ENTRY/EXITU/W TANK+ GEN ROOM	Private/Govt
Chandpole	6045.00		ENTRY/EXITU/W TANK+ GEN ROOM	Private/Govt
Choti Chaupar	5270.00		ENTRY/EXITU/W TANK+ GEN ROOM	Govt
Badi Chaupar	5270.00		ENTRY/EXITU/W TANK+ GEN ROOM	Govt
Total	**53837.67**			

5.17.6 Land for Depot

11.19Ha area in Mansarovar adjacent to the alignment of Corridor 2 has been identified for locating full-fledged maintenance depot. Earth filling is to be done to bring the existing ground level to designed level.

A Central Control Tower Office for Movement control of trains between Mansarover and Chandpole on the patron of Rout Relay Interlocking shall also be constructed in Mansarover Depot.

A Training Center shall also be housed at Mansarover Depot for coaching staff in Latest Safety, Technical & Operational courses and also the new recruited staff for Metro Railway. The details of land requirement for depot are given in **Table 5.19.**

Table 5.19

Land requirement for Depots

S N	Plot No.	Location	Land Area (Ha)	Ownership
1.	2	Mansarovar	11.19	Government
		Total	**11.19**	

5.17.7 Land for Receiving /Traction Sub Station

The details of land requirement for RSS / TSS are given in Table

Table 5.20

Land Requirement for RSS/TSS

Corridor	Location	Land Area (Ha)	Ownership
East- West	Mansarovar	0.34	Government
	PWD Bungalow at Station Road (RSRTC Bus Stand)	0.27	Government
Total		**0.61**	

5.17.8 Land Requirement for Running Section

As indicated earlier, the ROW of the roads along which the alignment is planned is sufficiently wide except on Ajmer Road at end of New Sanganer Road; hence no land is required for acquisition except on this stretch as long as the alignment is straight and at the centre of the road. However, at curved portions, the alignment could not be kept at the center of the road and acquisition of certain land is inevitable in spite of introduction of sharper radius curves in elevated sections.

To the extent possible the Entry and Exit points of stations (underground and elevated) were planned on the foot paths wherever possible. But, for locating other station facilities such as chiller plants, ventilation shafts, underground water tanks, generator set room etc. and where entry & exit could not be accommodated on foot paths, land acquisition is proposed. The land required for alignment planning is given in table 5.21.

Table 5.21

Land Requirement Running Section

S.N.	PLOT NO.	LOCATION	DETAILS	AREA(m^2)	TYPE	OWNERSHIP
Corridor 2 (East - West Corridor)						
2.	2RS1	Mansarover to Shyam Nagar H.T. Line	Mansarover (Kisan Dharm Kanta)	1153.48		Private
			Gurjar Ki Thadi	599.96		Private
3.	2RS2	Shyam Nagar - Ram Nagar	Ram Nagar (Vaid Vatika to Sodala Thana)	6948.41		Private
4.		Government land at Sodala Police Station		220.00		Government
5.	2RS3	Sodala Police Thana to Barodiya Basti	Near Ajmer Puliya	1685 30		Private
6.		Ganpati Nagar Railway Colony		1800.00		Government
7.	2RS4	Railway station to Chandpole	Railway Station to Chandpole	3913.24		Private
8.		Land of Railway Department near by Railway Station		800.00		Government
9.		Land of Railway Department near by Railway Station		2500.00	Open	Government
			Total	**19620.39**		

5.17.9 Land for Construction Depot

The land for corridor-2, Stage-1 for different packages has been identified for locating Construction Depot. This land will be acquired on temporary basis during construction period. The details of land requirement for depot are given in Table 5.22.

Table 5.22

Land Requirement on Temporary Basis for Construction Depot

S. No.	Package No.	Package Details	Location	Land Area(Ha)	Ownership
CORRIDOR – 2					
1	C-1	Mansarover – Chandpole construction of 6.53km.viaduct excluding elevated stations	Near New Aatish Market	4.00	Government

2	C-2	Construction of Elevated road cum Metro on Ajmer Road between Prince Road & Ajmer Puliya	Near Bhankrota	4.00	**Government**
3	C-3 to C-7 except C-4	Construction of Chandpole UG Metro & Station, Elevated stations	Near New Aatish Market	0.50 Ha each(2 Ha)	Private & Government
			TOTAL	**10.00**	

5.17.10 Land required for Property Development

Identification of Sites for Property Development: To ensure fast implementation of the proposals and optimisation of earnings, the following criteria have been kept in view:

- Land plots to be close to the proposed MRTS corridor.
- Land plots should be vacant and owned preferably by a Government agency.
- Proposed usage to be in conformity with provisions of Development Plans of the city.
- Availability of adequate infrastructural support and optimum potential for commercial utilization and early high returns.

Methodology of Property Development: Process of property development requires land, labour, capital, entrepreneurship and management as major inputs. Following steps are involved in the process:

- To obtain land free from all encumbrances with a clear title.
- To obtain clearances of the concerned government and local authorities for proposed usage, ground coverage, FAR, height and other basic controls and availability of essential services like water supply, sewers, electric supply, approach roads, etc.
- To assess demand and optimum usage and expected returns.
- To prepare architectural plans/models and obtain sanctions of concerned authorities.
- To prepare construction plans, structural designs, etc. for implementation.
- To appoint executing agency and create supervising organization.
- To sell the developed property and realize the proceeds thereof.
- To allow the property on long-term lease.

Property development and its transfer can be under taken by MRTS either by themselves or in collaboration with a builder/developer. Since it involves not only heavy financial investment but also real estate expertise and risk, it is considered better to undertake this activity in collaboration with some established builder/developer of repute on pre-agreed terms regarding individual responsibilities and various related financial aspects.

Land for Property Development have been identified amounting to approx. 50 hectares *to support the project as a whole for both the phases,out of which 12.5 ha has been proposed to support this phase,* the details of the land already under possession of JMRC are as shown in Table 5.23 below. Rest of the estates are under various stages of transfer.

Table 5.23

Land identified for Property Development to support the Jaipur Metro (Both Phases)

S. No.	Location	Land area (m^2)	Ownership
1	Land situated at Agriculture farm, Durgapura	146880	Govt.
2	Land situated at Disawar, Mansarovar	22615	Govt.
3	Land of Vetenary hospital, New Colony	9660	Govt.
4	Land Situated at PWD Chowki Dev nagar, Tonk Road	5000	Govt.
5	Land Situated at PWD Chowki Jawahar nagar bye-pass Gandhi path Tiraha	2875	Govt.
6	RSRDC Land situated at Jawahar Nagar bye-pass Hot Mix plant	8970	Govt.
7	Land of Marketing Board, lal Kothi Subzi mandi	19505	Govt.
8	Land & Building at Sanjay Circle, Chandpole Bazar	4700	Govt.
	Total	**220205**	

Abstract of land requirements for E-W Corridor is given in Table 5.24.

Table 5.24

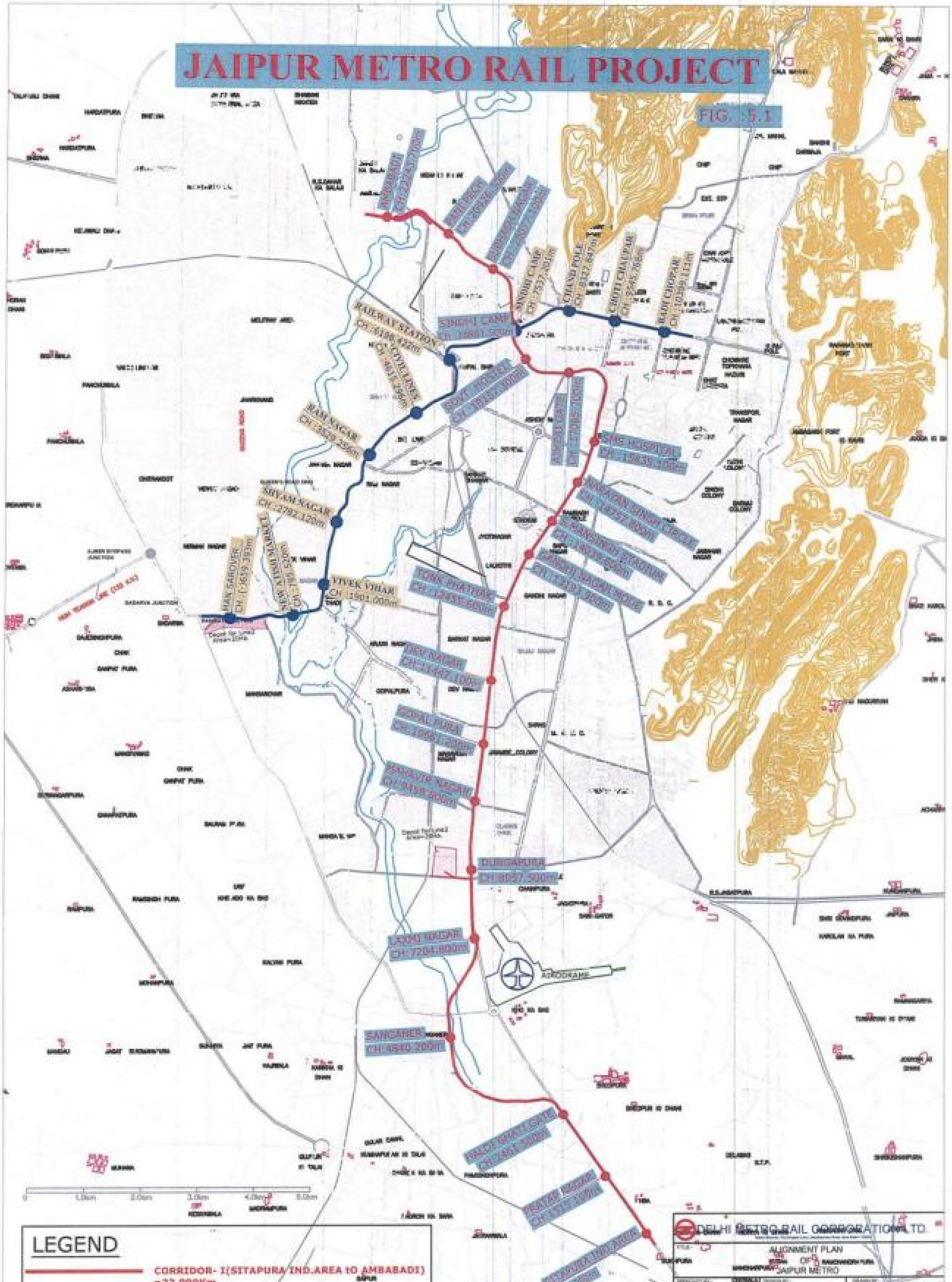
Summary of Permanent Land Requirement (Ha)

SN	Description	E-W Corridor	
		Gov.	Private
1.	Stations	2.068	3.315
2.	Running Section	0.532	1.43
3.	RSS/TSS	0.61	
4.	Depots	11.19	
	Total	**14.4**	**4.745**

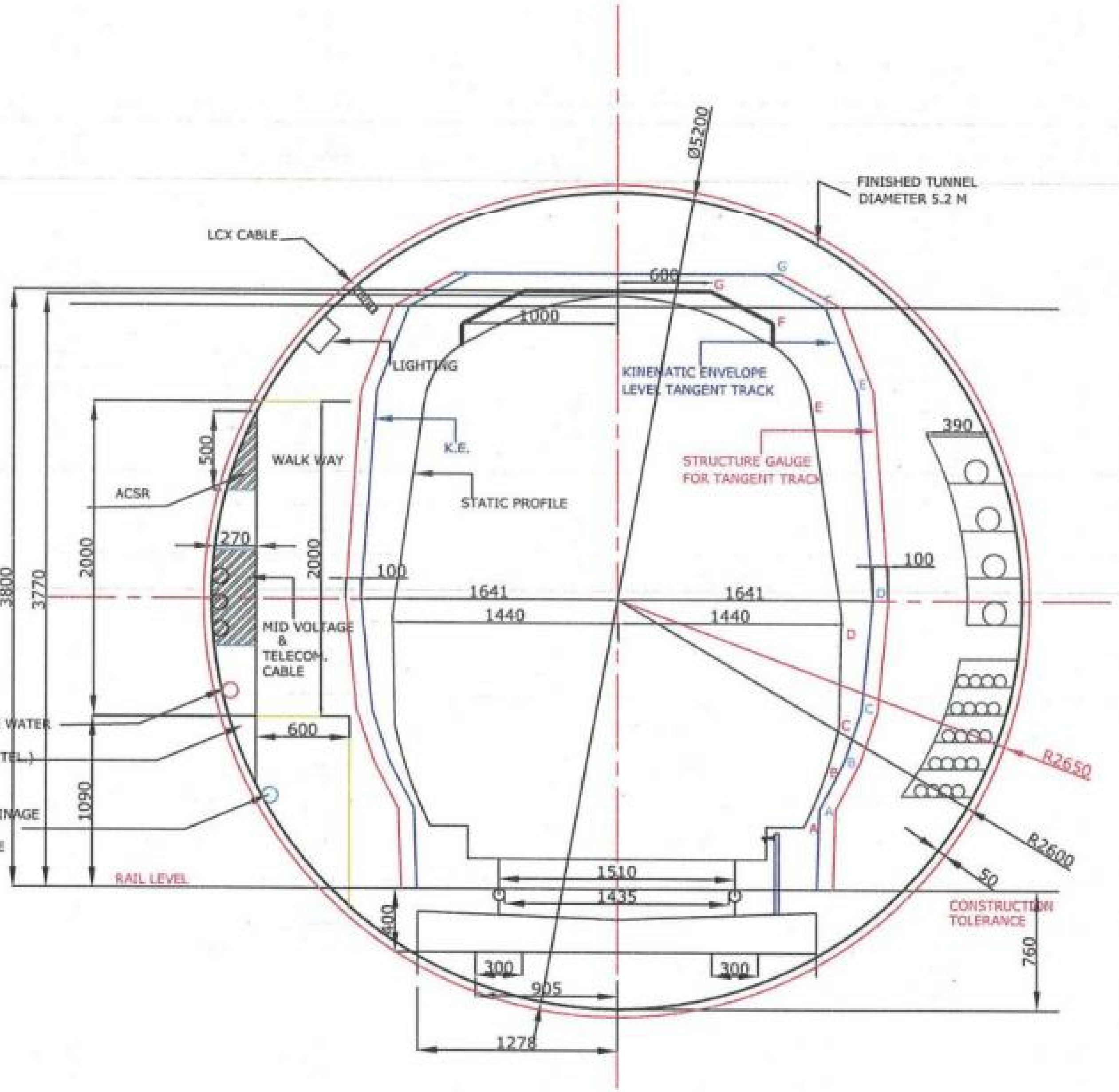
Total Land required : 19.145 Ha

5.22 Relocation / Resettlement

The project involves relocation of few shops, commercial cum residential buildings and hutments along the alignment. Compensation for relocation of these affected structures shall be paid and it has been considered in the project cost estimate. The alignment has been so chosen, that it remains mostly within the government land. However, at certain locations while negotiating the curves, the land acquisition became inevitable. It is proposed to invite bids from private developers to offer constructed tenements against TDR and cash components in their own land.


JAIPUR METRO RAIL PROJECT
FIG. 5.1
LEGEND
CORRIDOR- I(SITAPURA IND.AREA tO AMBABADI) =23.099Km
CORRIDOR- II(MANSAROVER to BADI CHOPAR) =12.067Km
SINDHI CAMP CH :1981.500m
RAILWAY STATION
RAM NAGAR CH :3529.256m
SHYAM NAGAR CH :2782.120m
VIVEK VIHAR CH :1901.000m
CHAND POLE
CHOTI CHAUPAR
BADI CHOPAR
SMS HOSPITAL
TONK PHATAK CH :12455.600m
DEV NAGAR
GOPAL PURA
MAHAVIR NAGAR
DURGAPURA CH:8057.500m
LAXMI NAGAR CH:7204.800m
AERODRAME
SANGANER CH:4840.200m
HALDI GHATI GATE
SITAPURA IND.AREA
DELHI METRO RAIL CORPORATION LTD.
ALIGNMENT PLAN OF JAIPUR METRO

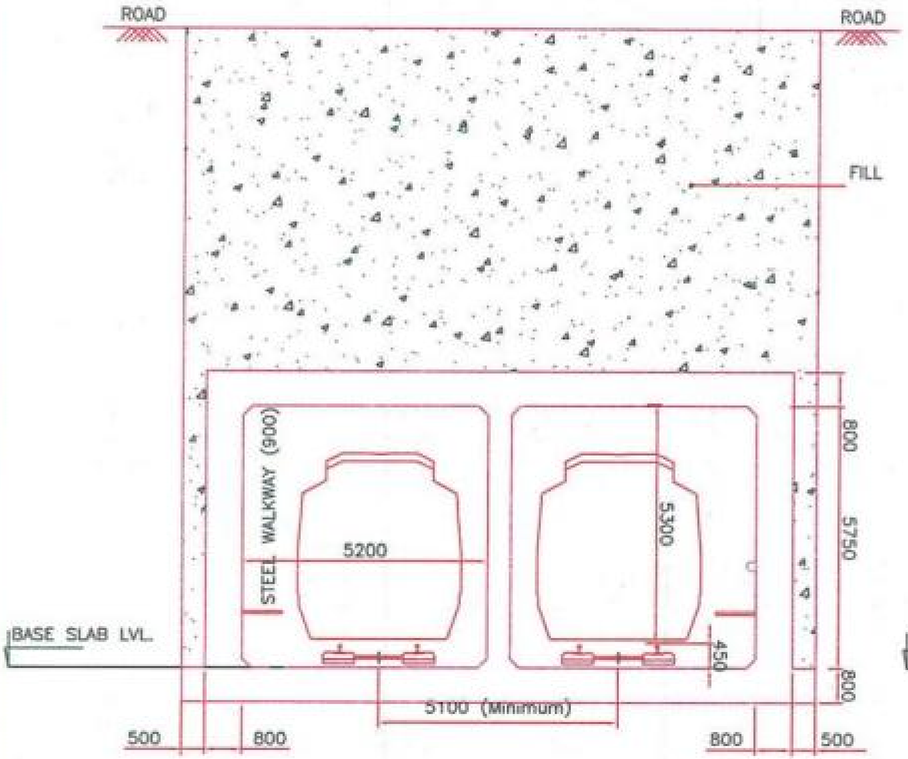
KINEMATIC ENVELOPE ON TANGENT TRACK
FOR JAIPUR METRO



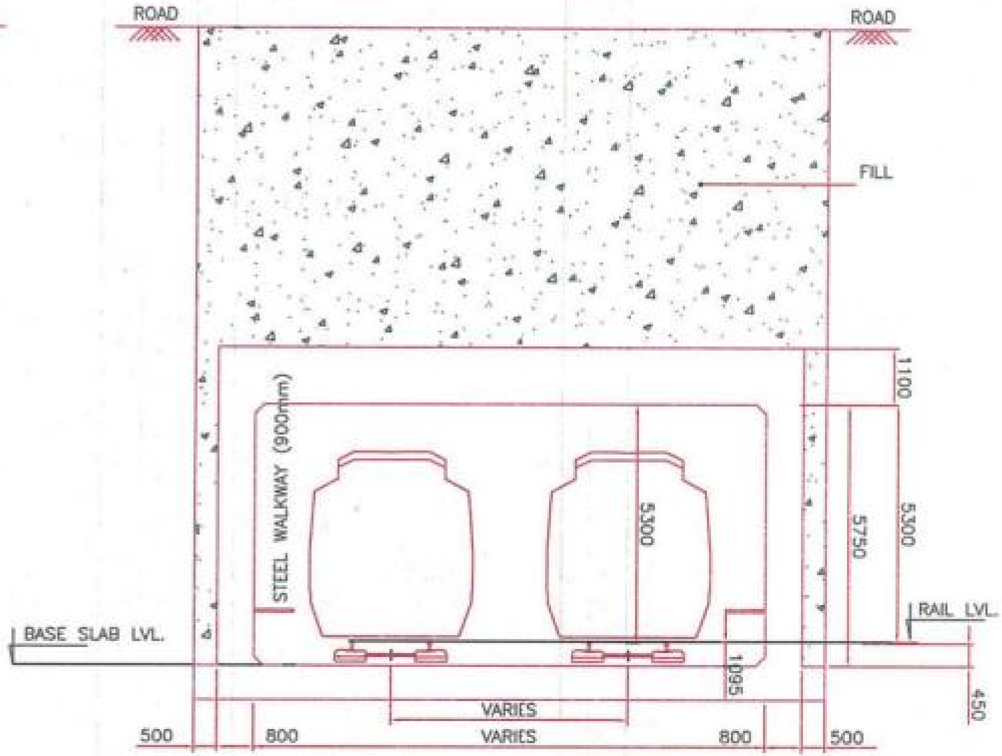
NOTE : All dimensions are in mm

Figure 5.2

DIA 5.2
FOR 1435 mm Gauge (SG)
FOR DFF TRACK



TYPICAL SECTIONAL DIMENSIONS OF TUNNEL
(AT LOCATION OTHER THAN CROSS OVER)



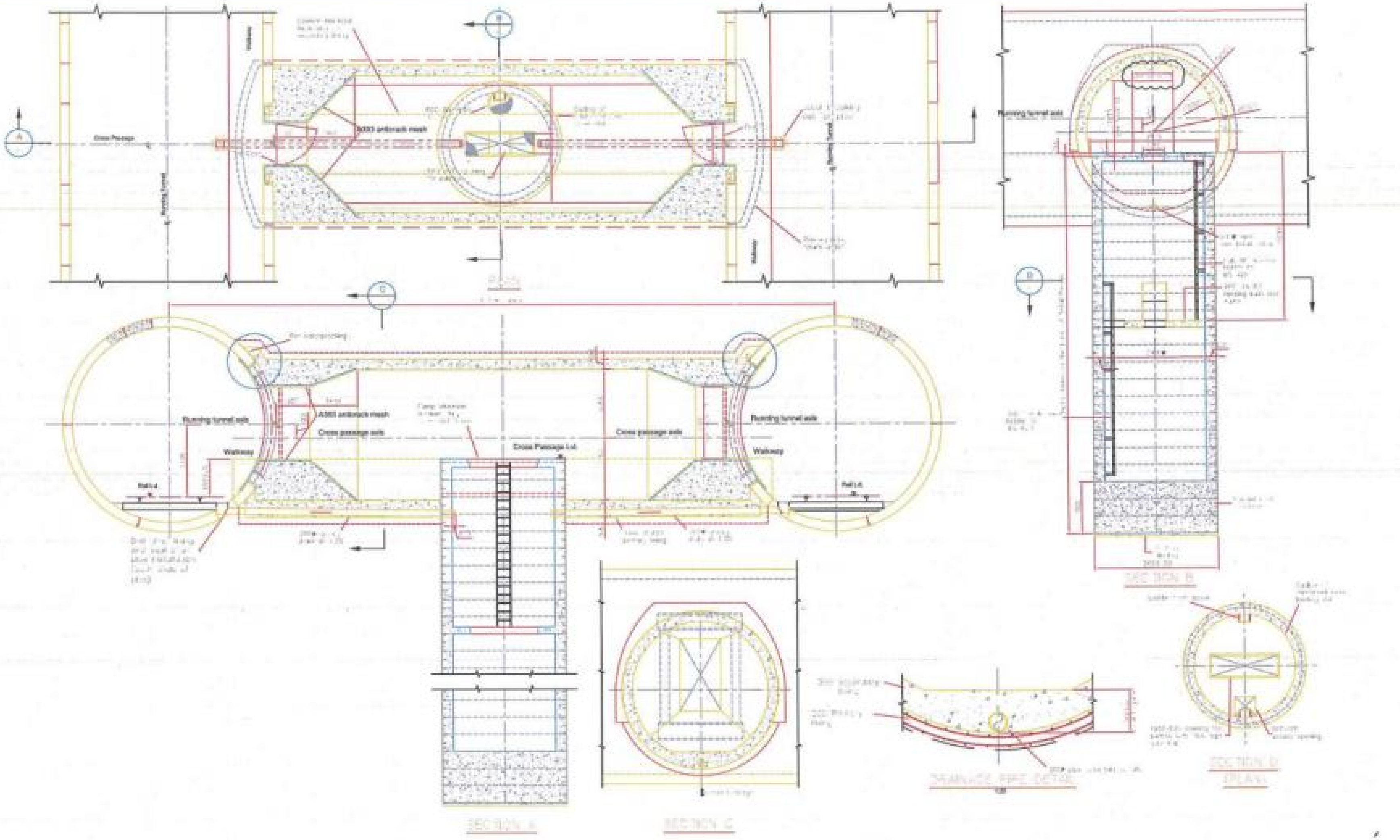
TYPICAL SECTIONAL DIMENSIONS OF TUNNEL
(AT CROSS OVER SECTION LOCATION)

NOTE :
Thickness of walls, slab & intermediate walls are indicative only.

TUNNEL

DIMENSIONS OF TUNNEL SECTION (TYPICAL SECTIONS)

Figure 5.3



CROSS PASSAGE WITH SUMP (TYPICAL SECTION)

Figure 5.4

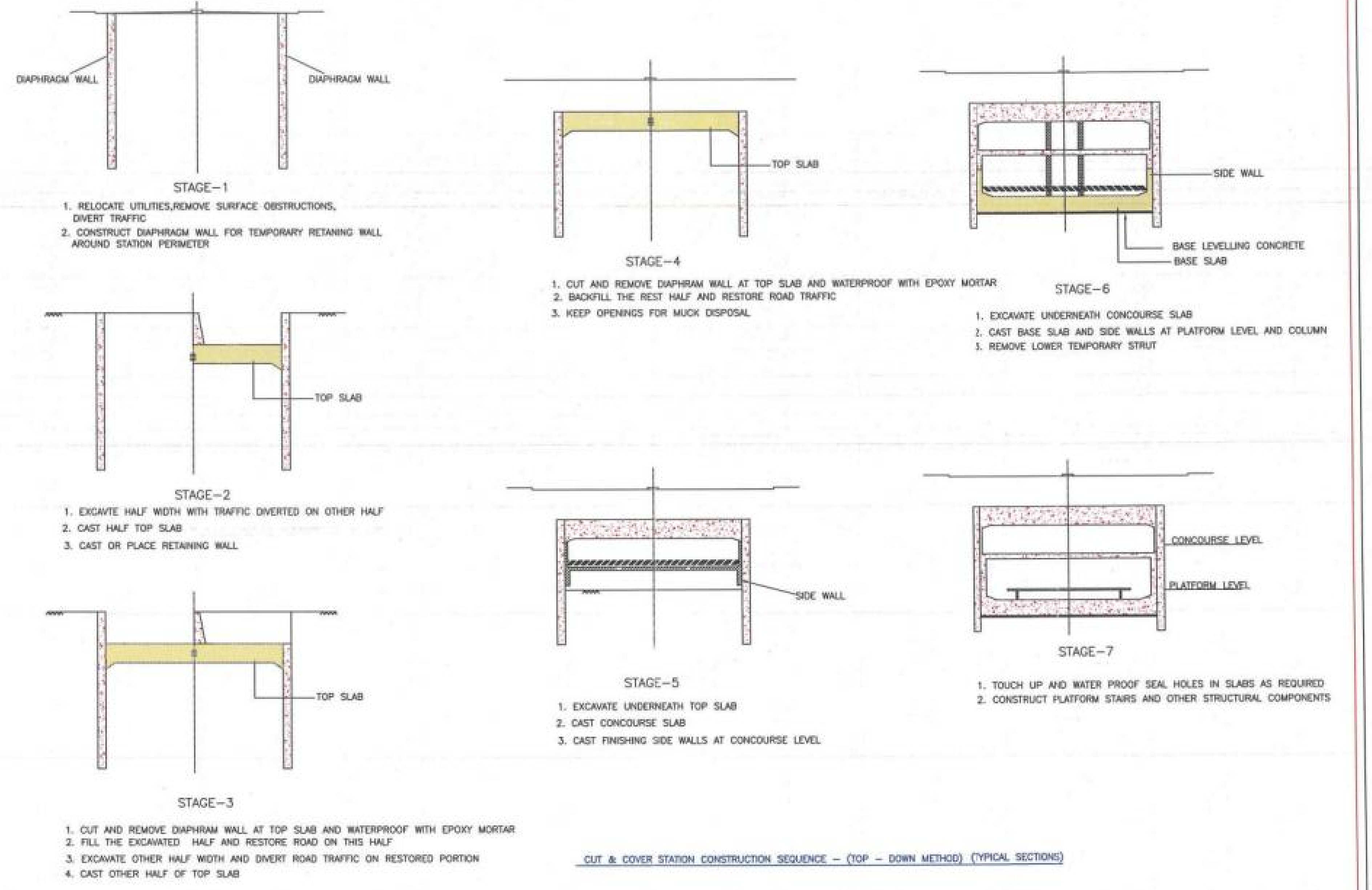
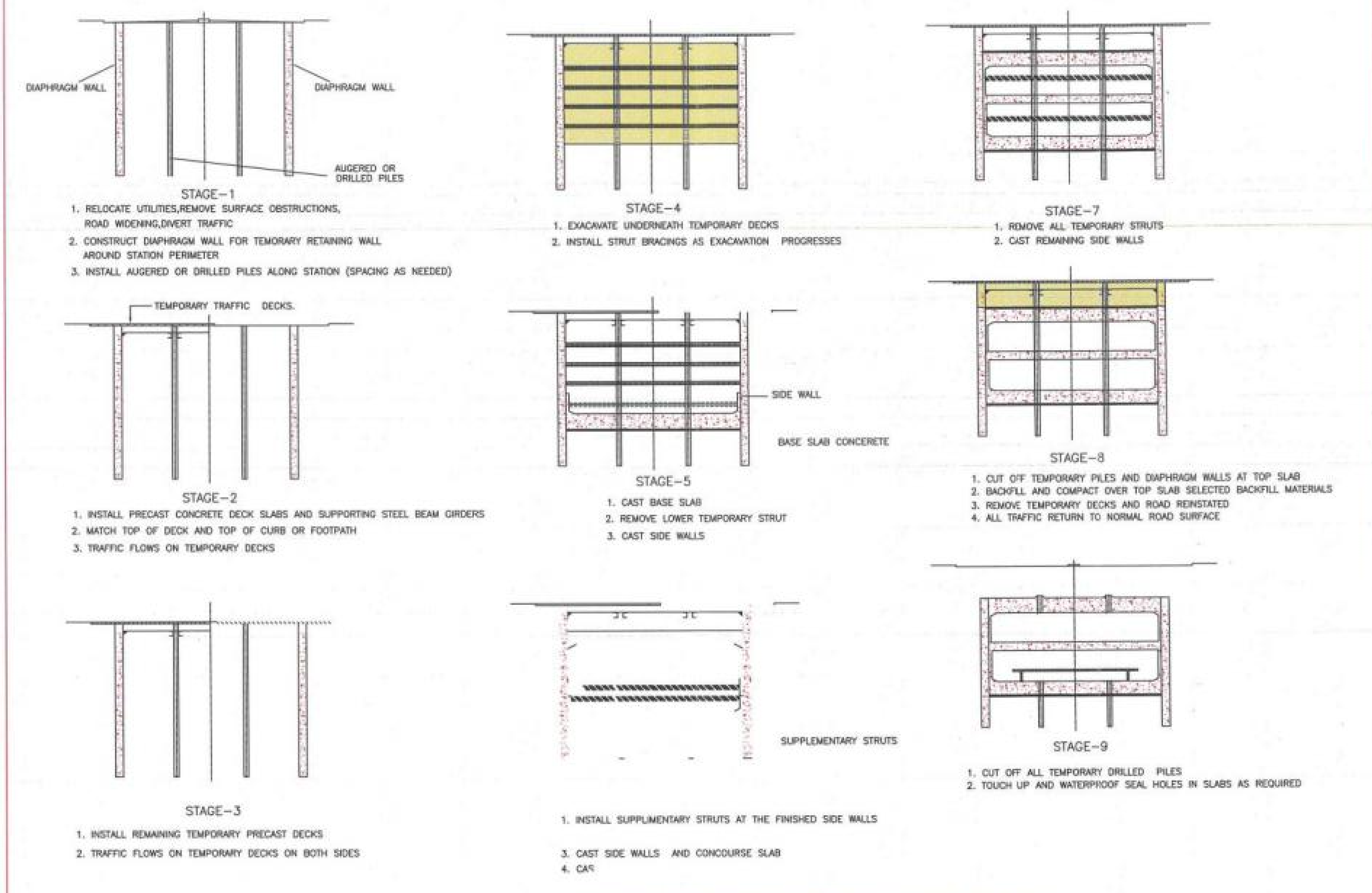
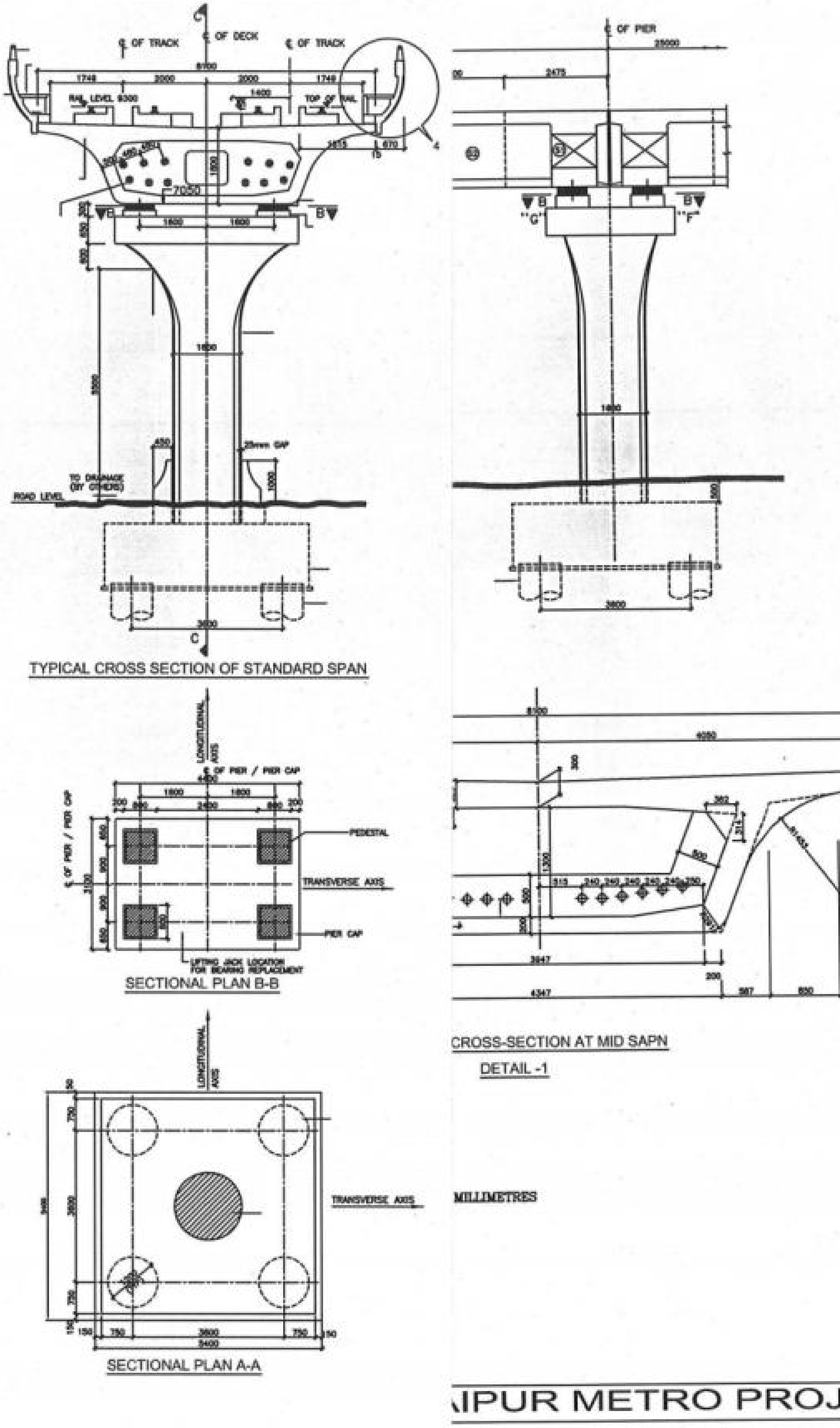

DIAPHRAGM WALL
DIAPHRAGM WALL
STAGE–1
1. RELOCATE UTILITIES,REMOVE SURFACE OBSTRUCTIONS, DIVERT TRAFFIC
2. CONSTRUCT DIAPHRAGM WALL FOR TEMPORARY RETANING WALL AROUND STATION PERIMETER
TOP SLAB
STAGE–2
1. EXCAVTE HALF WIDTH WITH TRAFFIC DIVERTED ON OTHER HALF
2. CAST HALF TOP SLAB
3. CAST OR PLACE RETAINING WALL
TOP SLAB
STAGE–3
1. CUT AND REMOVE DIAPHRAM WALL AT TOP SLAB AND WATERPROOF WITH EPOXY MORTAR
2. FILL THE EXCAVATED HALF AND RESTORE ROAD ON THIS HALF
3. EXCAVATE OTHER HALF WIDTH AND DIVERT ROAD TRAFFIC ON RESTORED PORTION
4. CAST OTHER HALF OF TOP SLAB
TOP SLAB
STAGE–4
1. CUT AND REMOVE DIAPHRAM WALL AT TOP SLAB AND WATERPROOF WITH EPOXY MORTAR
2. BACKFILL THE REST HALF AND RESTORE ROAD TRAFFIC
3. KEEP OPENINGS FOR MUCK DISPOSAL
SIDE WALL
STAGE–5
1. EXCAVATE UNDERNEATH TOP SLAB
2. CAST CONCOURSE SLAB
3. CAST FINISHING SIDE WALLS AT CONCOURSE LEVEL
SIDE WALL
BASE LEVELLING CONCRETE
BASE SLAB
STAGE–6
1. EXCAVATE UNDERNEATH CONCOURSE SLAB
2. CAST BASE SLAB AND SIDE WALLS AT PLATFORM LEVEL AND COLUMN
3. REMOVE LOWER TEMPORARY STRUT
CONCOURSE LEVEL
PLATFORM LEVEL
STAGE–7
1. TOUCH UP AND WATER PROOF SEAL HOLES IN SLABS AS REQUIRED
2. CONSTRUCT PLATFORM STAIRS AND OTHER STRUCTURAL COMPONENTS
CUT & COVER STATION CONSTRUCTION SEQUENCE – (TOP – DOWN METHOD) (TYPICAL SECTIONS)

Figure 5.5



CUT & COVER STATION CONSTRUCTION SEQUENCE – (BOTTOM – UP METHOD) (TYPICAL SECTIONS)

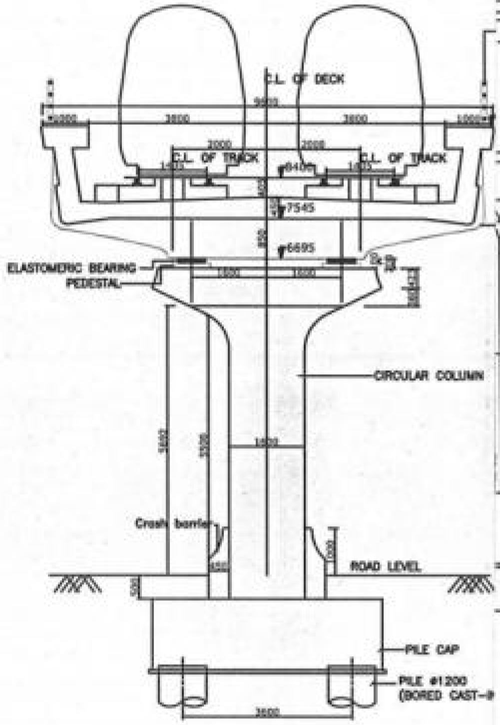
Figure 5.6



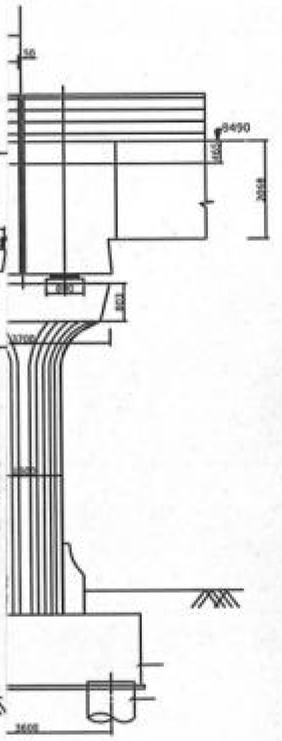
ıIPUR METRO PROJECT

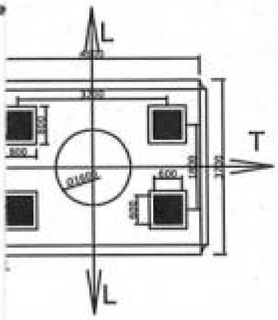
EMENT OF STANDARD SPAN BOX GIRDER WITH EXTERNAL PRESTRESSING

FIGURE-5.7

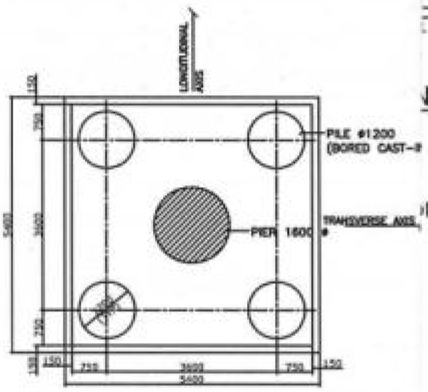


CROSS SECTION A-A





N FOR BED BLOCK



PLAN

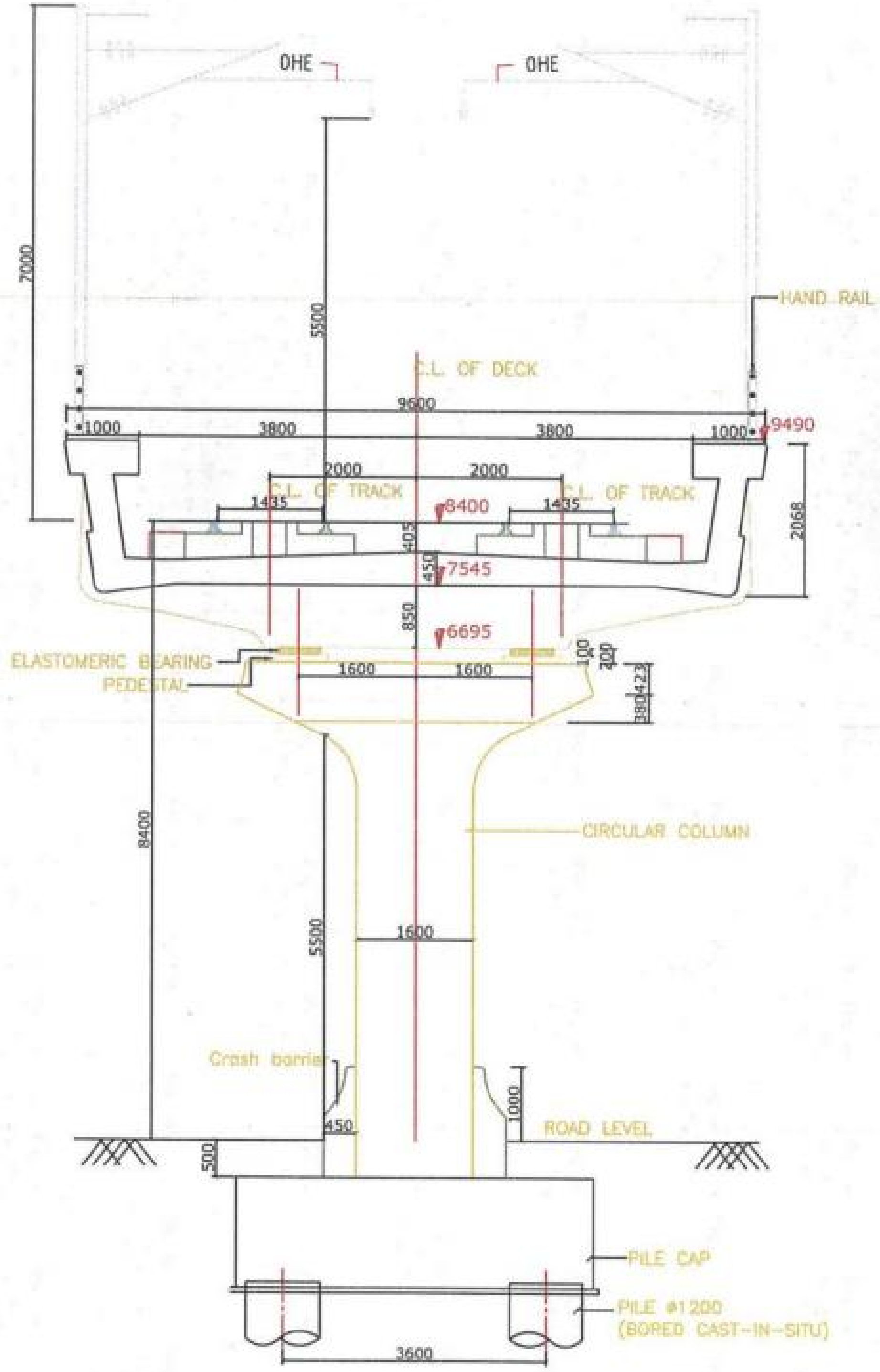
NS ARE IN MILLIMETRES

JAIPUR METRO PROJECT

RANGEMENT OF VIADUCT U-GIRDER WITH INTERNAL PRESTRESSING

FIGURE-5.8

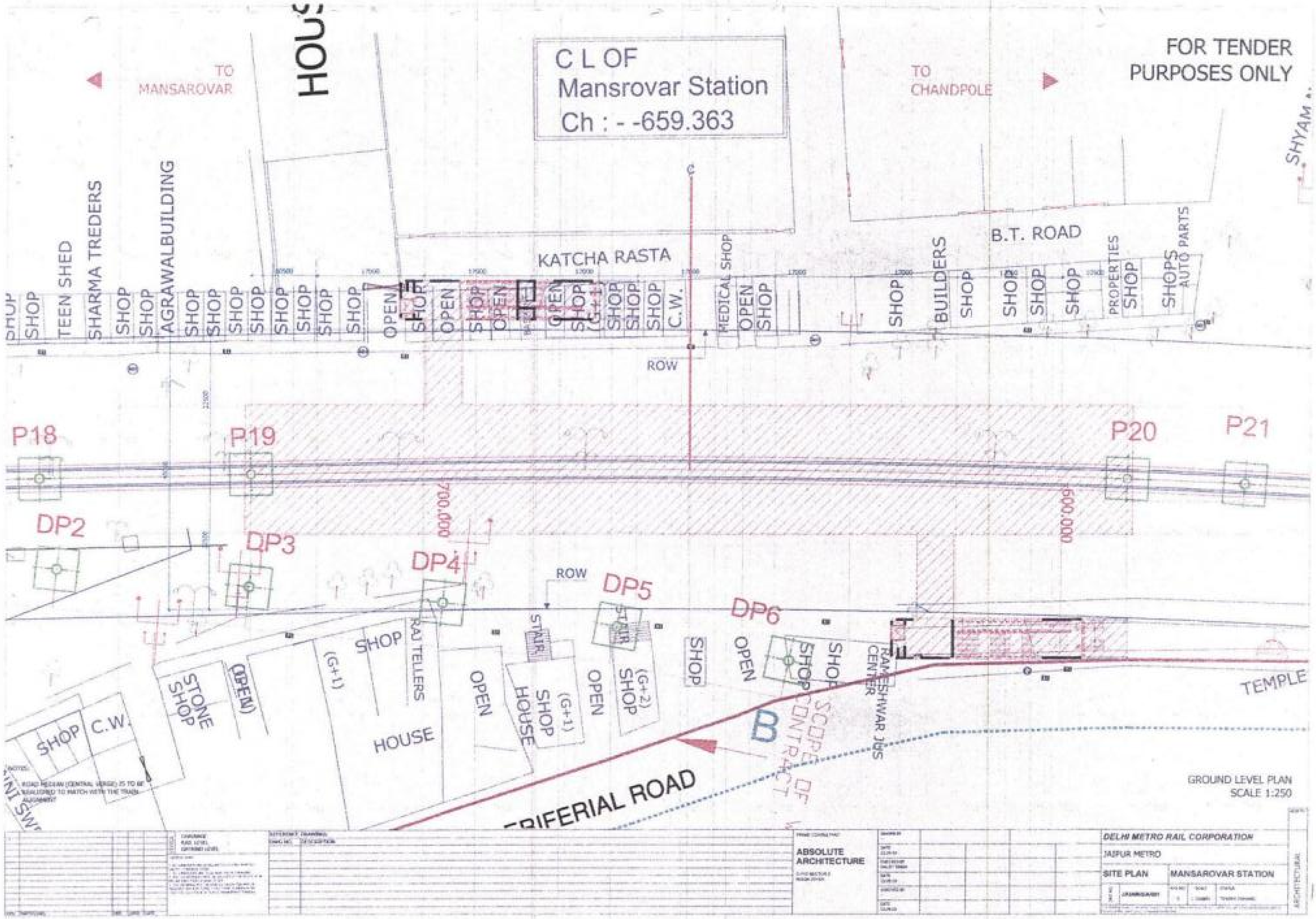
VIADUCT WITH 25 Kv. O H E

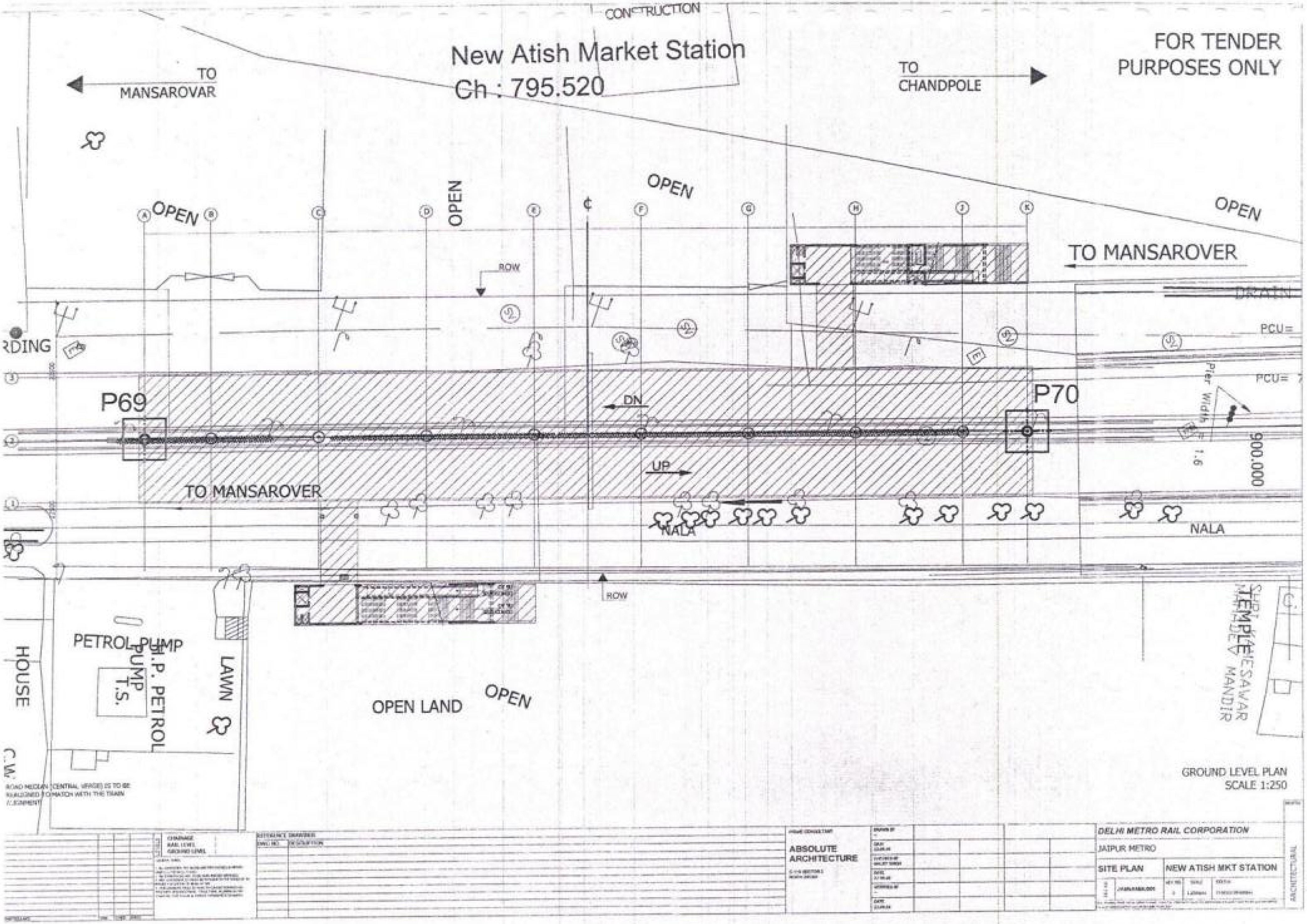


CROSS SECTION A-A

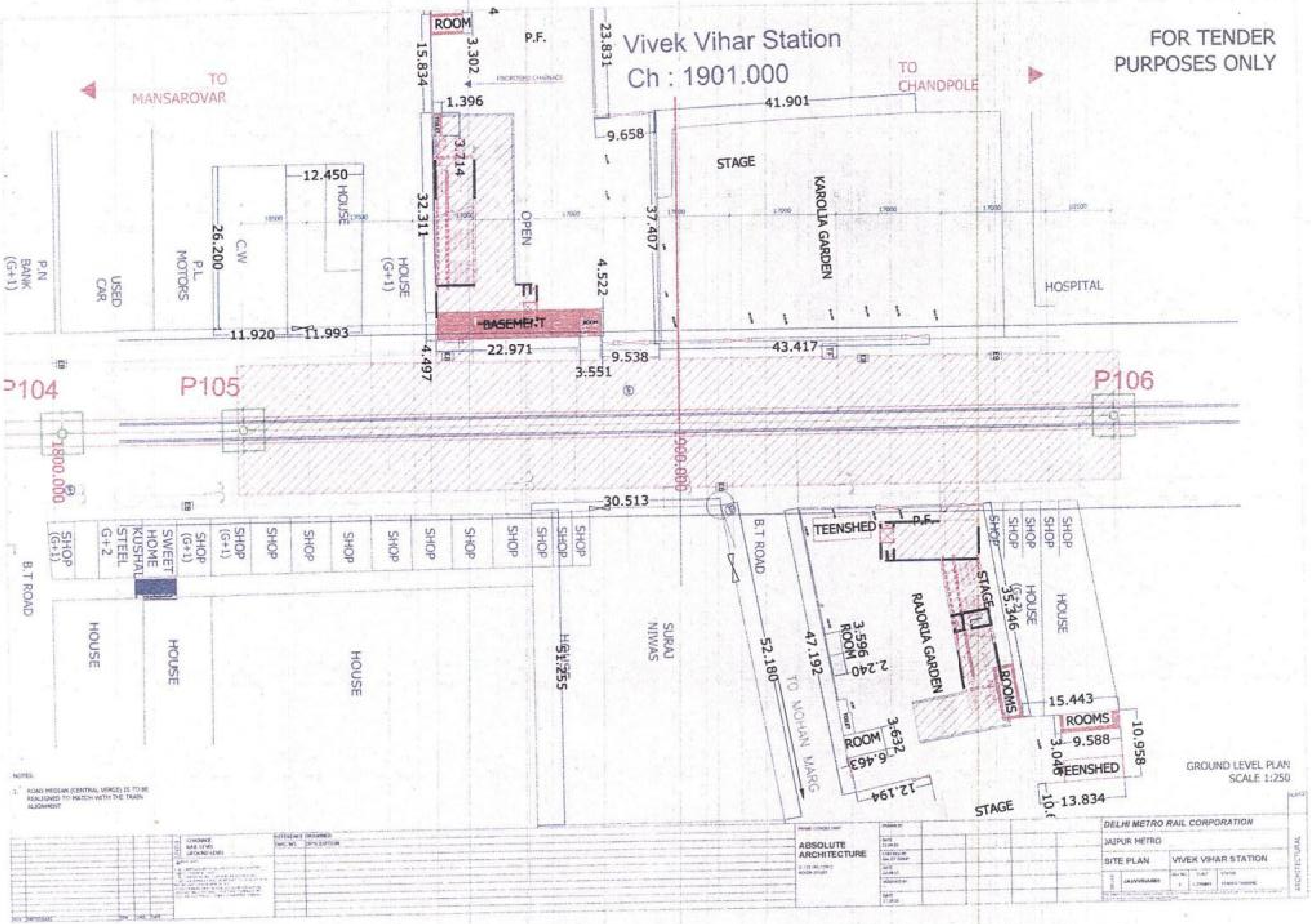
Fig.5.9

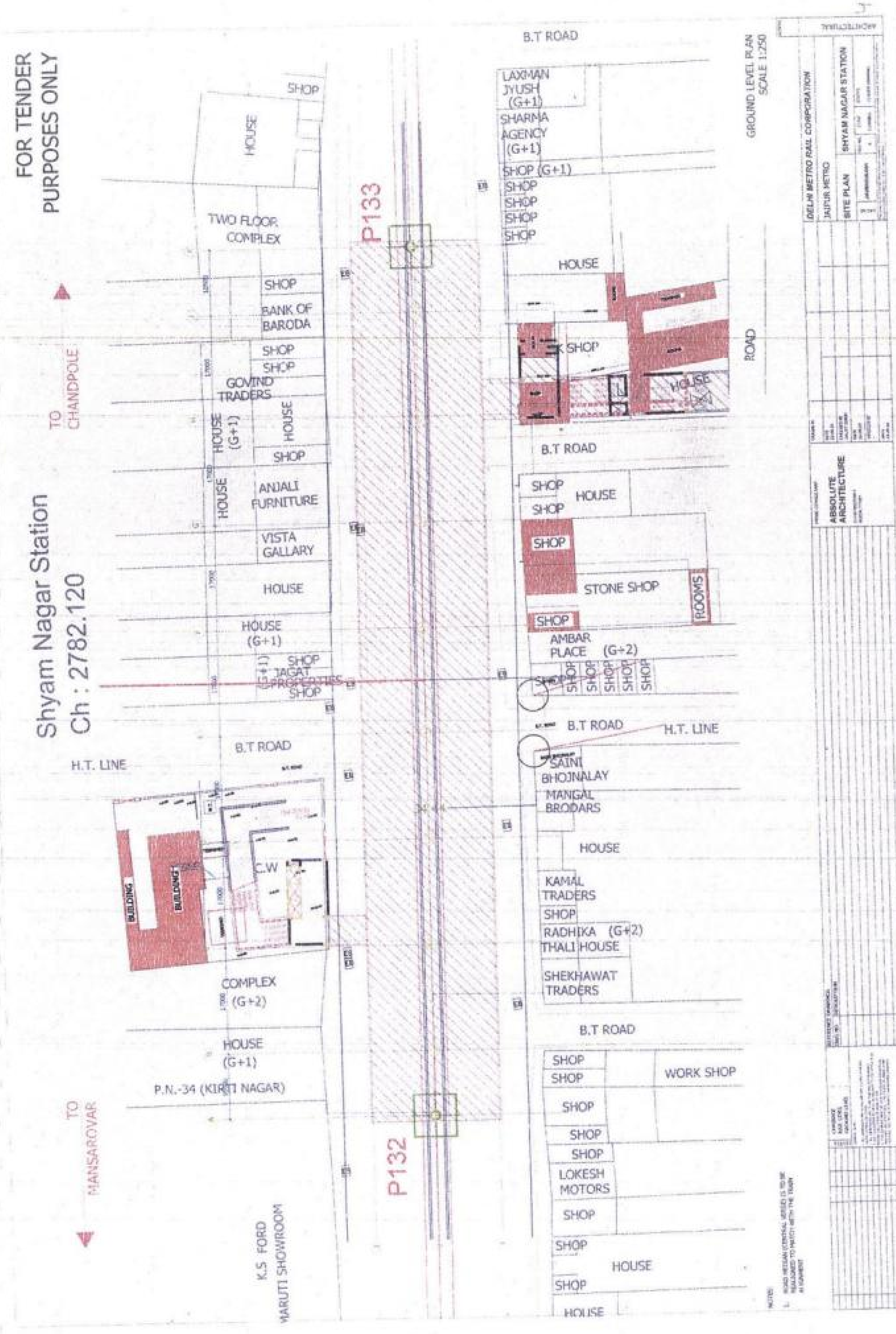
TYPICAL SECTION OF VIADUCT WITH U GIRDER


FOR TENDER PURPOSES ONLY
C L OF
Mansrovar Station
Ch : - -659.363
TO MANSAROVAR
TO CHANDPOLE
KATCHA RASTA
B.T. ROAD
ROW
TEEN SHED
SHARMA TREDERS
AGRAWALBUILDING
MEDICAL SHOP
BUILDERS
PROPERTIES SHOP
SHOPS AUTO PARTS
SHOP
OPEN
C.W.
P18
P19
P20
P21
DP2
DP3
DP4
DP5
DP6
700.000
600.000
STAIR
RAJ TELLERS
STONE SHOP
HOUSE
(G+1)
(G+2)
RAMESHWAR JUS CENTER
TEMPLE
SCOPE OF CONTRACT
B
ERIFERIAL ROAD
GROUND LEVEL PLAN
SCALE 1:250
DELHI METRO RAIL CORPORATION
JAIPUR METRO
SITE PLAN
MANSAROVAR STATION
ABSOLUTE ARCHITECTURE

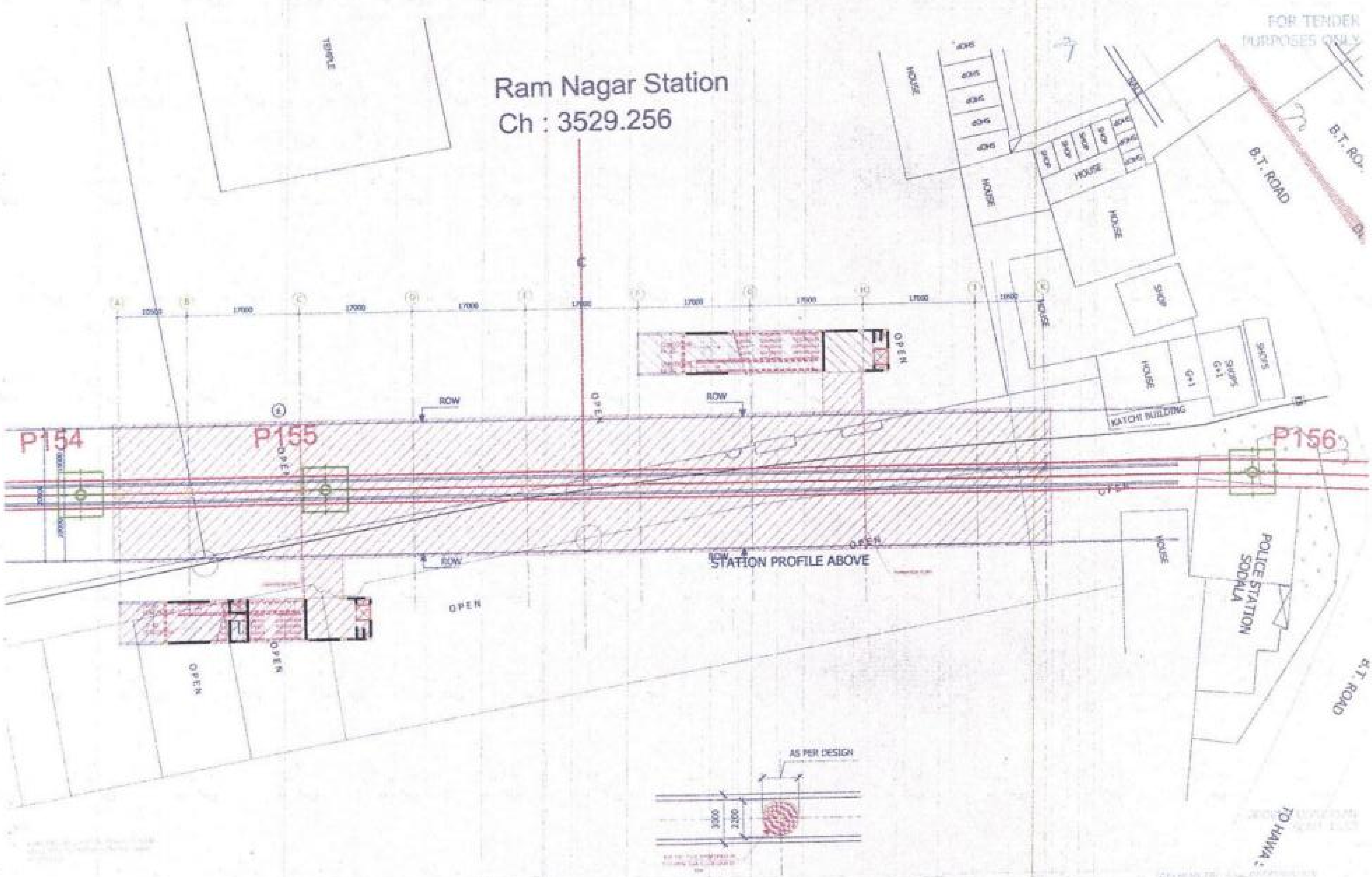


New Atish Market Station
Ch : 795.520
FOR TENDER PURPOSES ONLY
TO MANSAROVAR
TO CHANDPOLE
CONSTRUCTION
OPEN
OPEN
OPEN
OPEN
OPEN
TO MANSAROVER
TO MANSAROVER
DRAIN
PCU=
Pier Width 1.6
900.000
P69
P70
DN
UP
ROW
ROW
NALA
NALA
PETROL PUMP
H.P. PETROL PUMP
T.S.
LAWN
HOUSE
OPEN LAND
TEMPLE
SHRI KAMESAWAR MAHADEV MANDIR
GROUND LEVEL PLAN
SCALE 1:250
ROAD MEDIAN (CENTRAL VERGE) IS TO BE REALIGNED TO MATCH WITH THE TRAIN ALIGNMENT
ABSOLUTE ARCHITECTURE
DELHI METRO RAIL CORPORATION
JAIPUR METRO
SITE PLAN
NEW ATISH MKT STATION
ARCHITECTURAL


FOR TENDER PURPOSES ONLY
Vivek Vihar Station
Ch : 1901.000
TO MANSAROVAR
TO CHANDPOLE
ROOM
P.F.
OPEN
BASEMENT
STAGE
KAROLIA GARDEN
HOSPITAL
HOUSE
HOUSE (G+1)
C.W
P.L MOTORS
USED CAR
P.N BANK (G+1)
P104
P105
P106
1800.000
1900.000
SHOP
SHOP (G+1)
SWEET HOME
KUSHAL STEEL G+2
B.T ROAD
SURAJ NIWAS
TO MOHAN MARG
TEENSHED
RAJORIA GARDEN
ROOMS
HOUSE (G+2)
GROUND LEVEL PLAN
SCALE 1:250
NOTES:
ROAD MEDIAN (CENTRAL VERGE) IS TO BE REALIGNED TO MATCH WITH THE TRAIN ALIGNMENT
ABSOLUTE ARCHITECTURE
DELHI METRO RAIL CORPORATION
JAIPUR METRO
SITE PLAN
VIVEK VIHAR STATION
ARCHITECTURAL

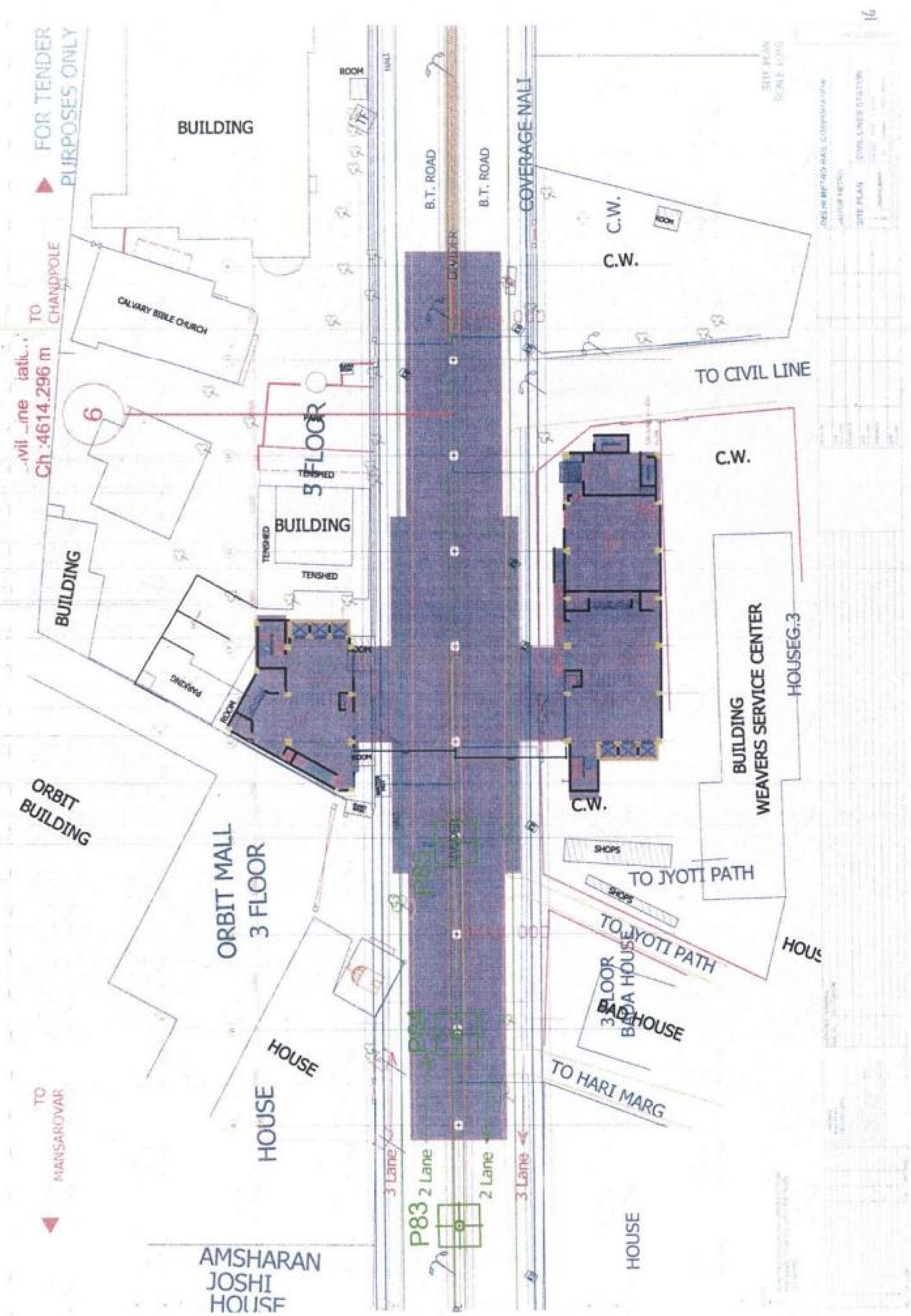


FOR TENDER PURPOSES ONLY
Shyam Nagar Station
Ch : 2782.120
TO CHANDPOLE
TO MANSAROVAR
P133
P132
B.T ROAD
LAXMAN JYUSH (G+1)
SHARMA AGENCY (G+1)
SHOP (G+1)
SHOP
SHOP
SHOP
SHOP
HOUSE
SHOP
TWO FLOOR COMPLEX
SHOP
BANK OF BARODA
SHOP
SHOP
GOVIND TRADERS
HOUSE (G+1)
HOUSE
SHOP
HOUSE
ANJALI FURNITURE
VISTA GALLARY
HOUSE
HOUSE (G+1)
SHOP
JAGAT PROPERTIES
SHOP
(G+1)
B.T ROAD
H.T. LINE
BUILDING
BUILDING
C.W
COMPLEX (G+2)
HOUSE (G+1)
P.N.-34 (KIRTI NAGAR)
K.S FORD
MARUTI SHOWROOM
K SHOP
HOUSE
B.T ROAD
SHOP
SHOP
HOUSE
SHOP
STONE SHOP
ROOMS
SHOP
AMBAR PLACE (G+2)
SHOP
SHOP
SHOP
SHOP
SHOP
SHOP
B.T ROAD
H.T. LINE
SAINI BHOJNALAY
MANGAL BRODARS
HOUSE
KAMAL TRADERS
SHOP
RADHIKA (G+2)
THALI HOUSE
SHEKHAWAT TRADERS
B.T ROAD
SHOP
SHOP
WORK SHOP
SHOP
SHOP
SHOP
LOKESH MOTORS
SHOP
SHOP
HOUSE
SHOP
HOUSE
ROAD
GROUND LEVEL PLAN SCALE 1:250
DELHI METRO RAIL CORPORATION
JAIPUR METRO
SITE PLAN
SHYAM NAGAR STATION
ABSOLUTE ARCHITECTURE
ARCHITECTURAL

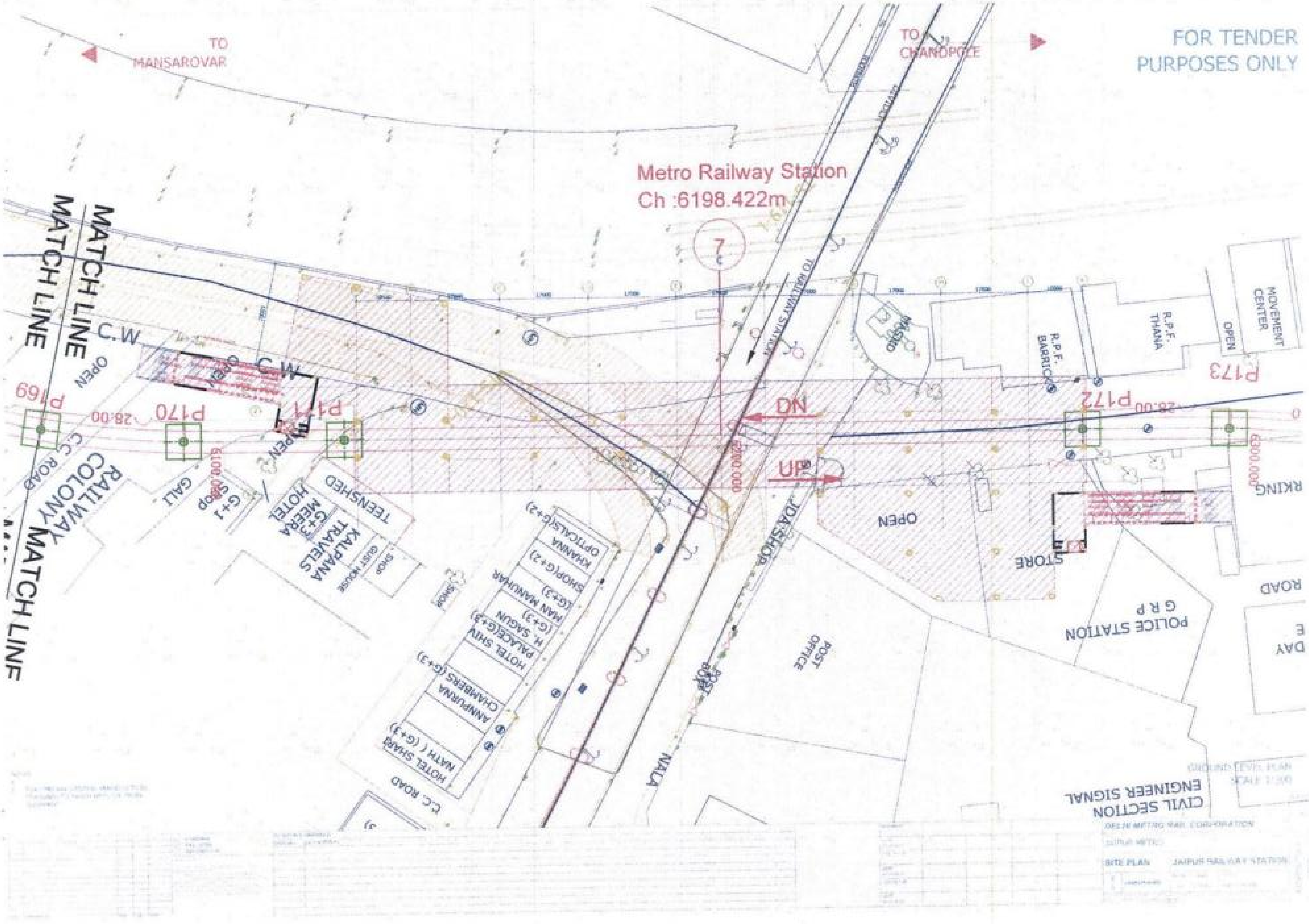


FOR TENDER PURPOSES ONLY
Ram Nagar Station
Ch : 3529.256
TEMPLE
B.T. ROAD
HOUSE
SHOP
SHOPS
SHOPS G+1
G+1
KATCHI BUILDING
POLICE STATION SODALA
P154
P155
P156
ROW
OPEN
STATION PROFILE ABOVE
AS PER DESIGN
3000
2200
TO HAWA
10500
17000

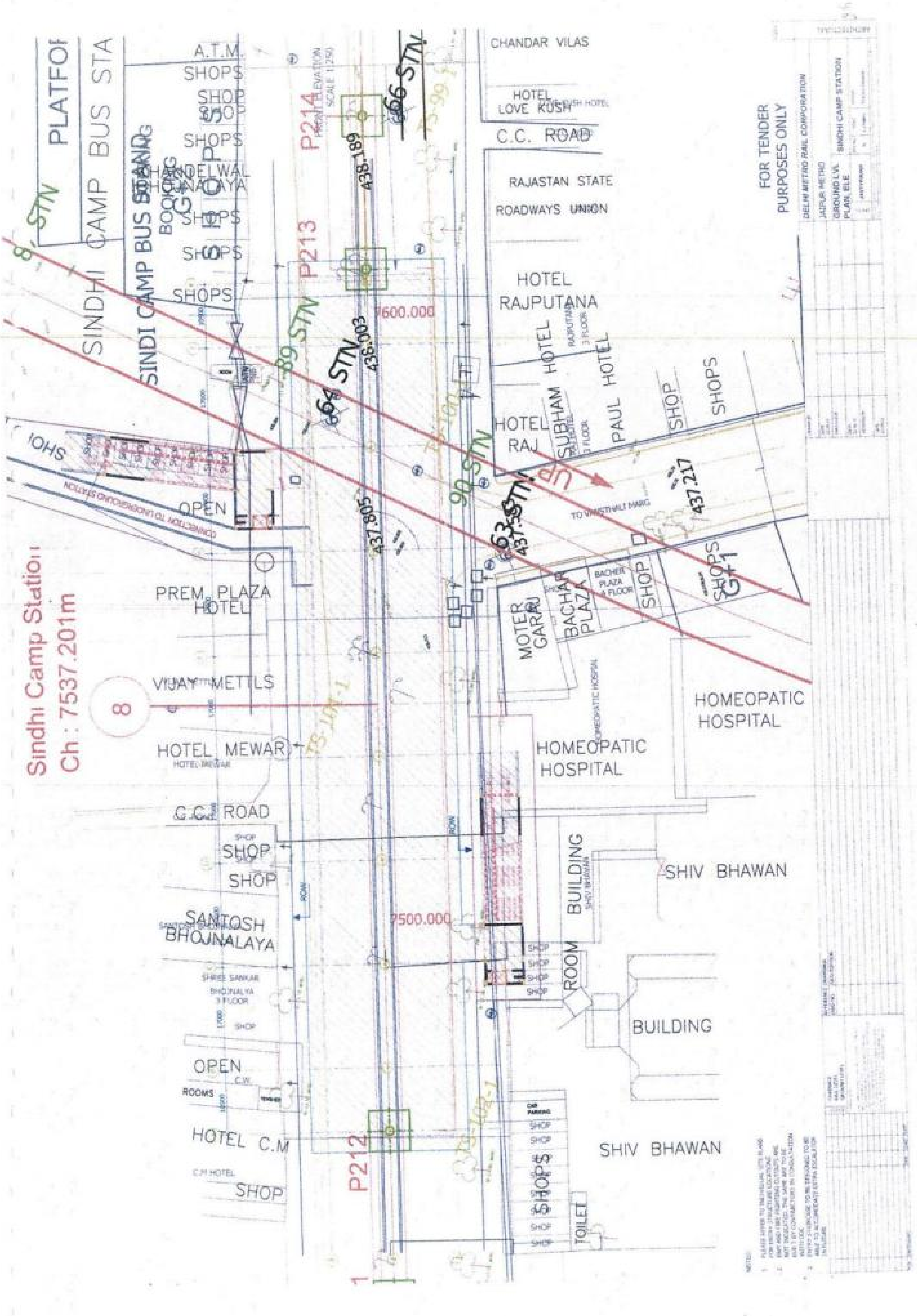
12



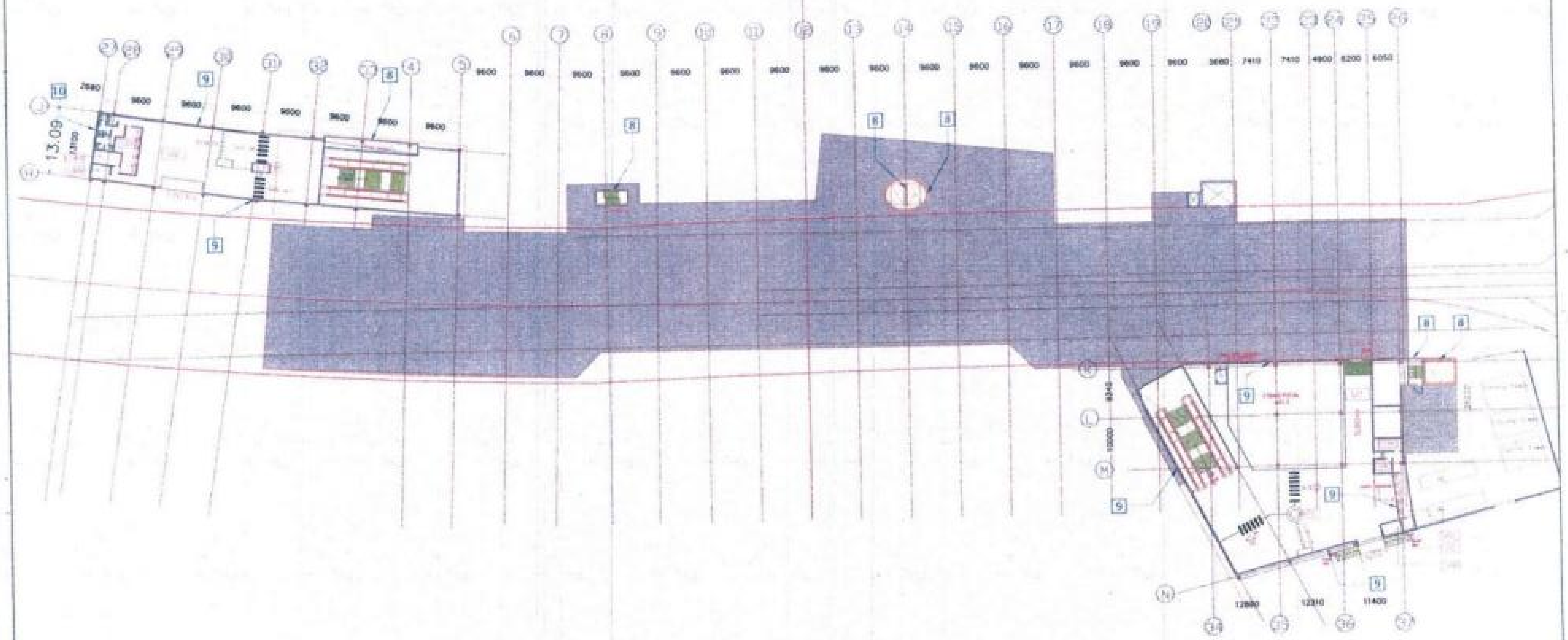
FOR TENDER PURPOSES ONLY
BUILDING
ROOM
B.T. ROAD
B.T. ROAD
COVERAGE NALI
DIVIDER
C.W.
C.W.
ROOM
CALVARY BIBLE CHURCH
TO CHANDPOLE
Ch:4614.296 m
6
TO CIVIL LINE
3 FLOOR
TENSHED
BUILDING
TENSHED
BUILDING
C.W.
BUILDING WEAVERS SERVICE CENTER
HOUSEG.3
PARKING
ORBIT BUILDING
ORBIT MALL 3 FLOOR
C.W.
SHOPS
TO JYOTI PATH
SHOPS
TO JYOTI PATH
HOUS
3 FLOOR BADA HOUSE
BADI HOUSE
P85
P84
HOUSE
TO HARI MARG
HOUSE
TO MANSAROVAR
3 Lane
2 Lane
2 Lane
3 Lane
P83
AMSHARAN JOSHI HOUSE
HOUSE



FOR TENDER
PURPOSES ONLY
TO
MANSAROVAR
TO
CHANDPOLE
Metro Railway Station
Ch :6198.422m
7
TO RAILWAY STATION
MOVEMENT CENTER
OPEN
R.P.F. THANA
R.P.F. BARRICK
MASJID
P173
P172
P171
P170
P169
28.00
6300.000
6200.000
6100.000
DN
UP
C.W
OPEN
MATCH LINE
MATCH LINE
MATCH LINE
C.C. ROAD
RAILWAY COLONY
GALI
G+1 SHOP
KALPANA TRAVELS
G+3 MEERA HOTEL
TEENSHED
GUST HOUSE
SHOP
KHANNA OPTICALS(G+2)
SHOP(G+2)
MAN MANUHAR (G+3)
H. SAGUN (G+3)
HOTEL SHIV PALACE(G+3)
ANNPURNA CHAMBERS (G+3)
HOTEL SHARI NATH ((G+3)
JDA SHOP
POST BOX
POST OFFICE
NALA
OPEN
STORE
POLICE STATION G R P
RKING
ROAD
DAY E
CIVIL SECTION ENGINEER SIGNAL
GROUND LEVEL PLAN
SITE PLAN
JAIPUR RAILWAY STATION



PLATFORM
SINDHI CAMP BUS STAND
SINDI CAMP BUS STAND
BOOKING
A.T.M.
SHOPS
SHOP
SHOP
SHOPS
KHANDELWAL BHOJNALAYA
SHOPS
SHOPS
SHOPS
CHANDAR VILAS
HOTEL LOVE KUSH
C.C. ROAD
RAJASTAN STATE ROADWAYS UNION
HOTEL RAJPUTANA
HOTEL RAJ
SUBHAM HOTEL
PAUL HOTEL
SHOP
SHOPS
TO VAISHALI MARG
P214
P213
P212
438.189
438.003
437.805
437.217
7600.000
7500.000
8 STN
89 STN
64 STN
66 STN
90 STN
63 STN
OPEN
CONNECTION TO UNDERGROUND STATION
PREM PLAZA HOTEL
Sindhi Camp Station
Ch : 7537.201m
8
VIJAY METTLS
HOTEL MEWAR
C.C. ROAD
SHOP
SHOP
SANTOSH BHOJNALAYA
SHREE SANKAR BHOJNALYA 3 FLOOR
SHOP
OPEN
ROOMS
HOTEL C.M
C.M HOTEL
SHOP
MOTER GARAJ
BACHAR PLAZA
BACHER PLAZA 3 FLOOR
SHOP
SHOPS G+1
HOMEOPATIC HOSPITAL
HOMEOPATIC HOSPITAL
BUILDING
SHIV BHAWAN
SHIV BHAWAN
SHOP
SHOP
SHOP
SHOP
ROOM
BUILDING
CAR PARKING
SHOP
SHOP
SHOPS
SHOP
SHOP
TOILET
SHIV BHAWAN
FOR TENDER PURPOSES ONLY
DELHI METRO RAIL CORPORATION
JAIPUR METRO
SINDHI CAMP STATION
GROUND LVL PLAN, ELE



WALL SCHEDULE

2	800 THK RCC, 400 CAVITY 200 THK CONCRETE BLOCK
3	800 THK RCC, 200 CAVITY & 200 THK CONC. BLOCK ON ONE SIDE
4	800 THK RCC
5	400 THK RCC, 200 CAVITY ? 200 THK CONC. BLOCK ON ONE SIDE
6	400 THK RCC
7	300 THK RCC
8	200 THK RCC
9	200 THK CONCRETE BLOCK
10	150 THK CONCRETE BLOCK

LEGEND

U1	STATION ENTRANCES & PASSAGEWAYS		
U2	CONCOURSE PUBLIC AREA		
U4	STATION MANAGER'S ROOM	1.40 X 2.70 M.	5.18 SQ.M.
U5W	TICKET OFFICE (TOM)	M.	31.8 SQ.M.
U5E	TICKET OFFICE (TOM)	M.	20.41 SQ.M.
U6	CASH & AUDIT RM.	2.34 X 2.46 M.	5.76 SQ.M.
U7E	CUSTOMER CARE (EFO)	M.	2.54 SQ.M.
U7W	CUSTOMER CARE (EFO)	3.2 X 1.5 M.	4.8 SQ.M.
U9E	SECURITY / POLICE ROOM	2.46 X 3.7 M.	9.10 SQ.M.
U9W	SECURITY / POLICE ROOM	2.7 X 3.6 M.	9.72 SQ.M.
U16E	STAFF MESS ROOM	5.5 x 2.37 M.	13.03 SQ.M.
U16W	STAFF MESS ROOM	2.6 X 5.3 M.	13.78 SQ.M.

Notes:_

1. Dimensions of RCC walls in their schedule a/were indicative only. Wall thickness may vary as per actual structure design. Minimum internal clearence shall be provd.
2. Wherever internal partition walls are indicated as RCC wall, it shall be madatory to follow the RCC wall of specified thickness.

NOTE
ESCALATOR PITS AND LIFT PITS SIZE TO BE AS PER MANUFACTURER'S SPECIFICATION AS FINALISED BY DMRC
ESCALATOR PITS AND LIFT PITS DRAINAGE TO BE AS PER S&H DRAWING

DELHI METRO RAIL CORPORATION LTD.

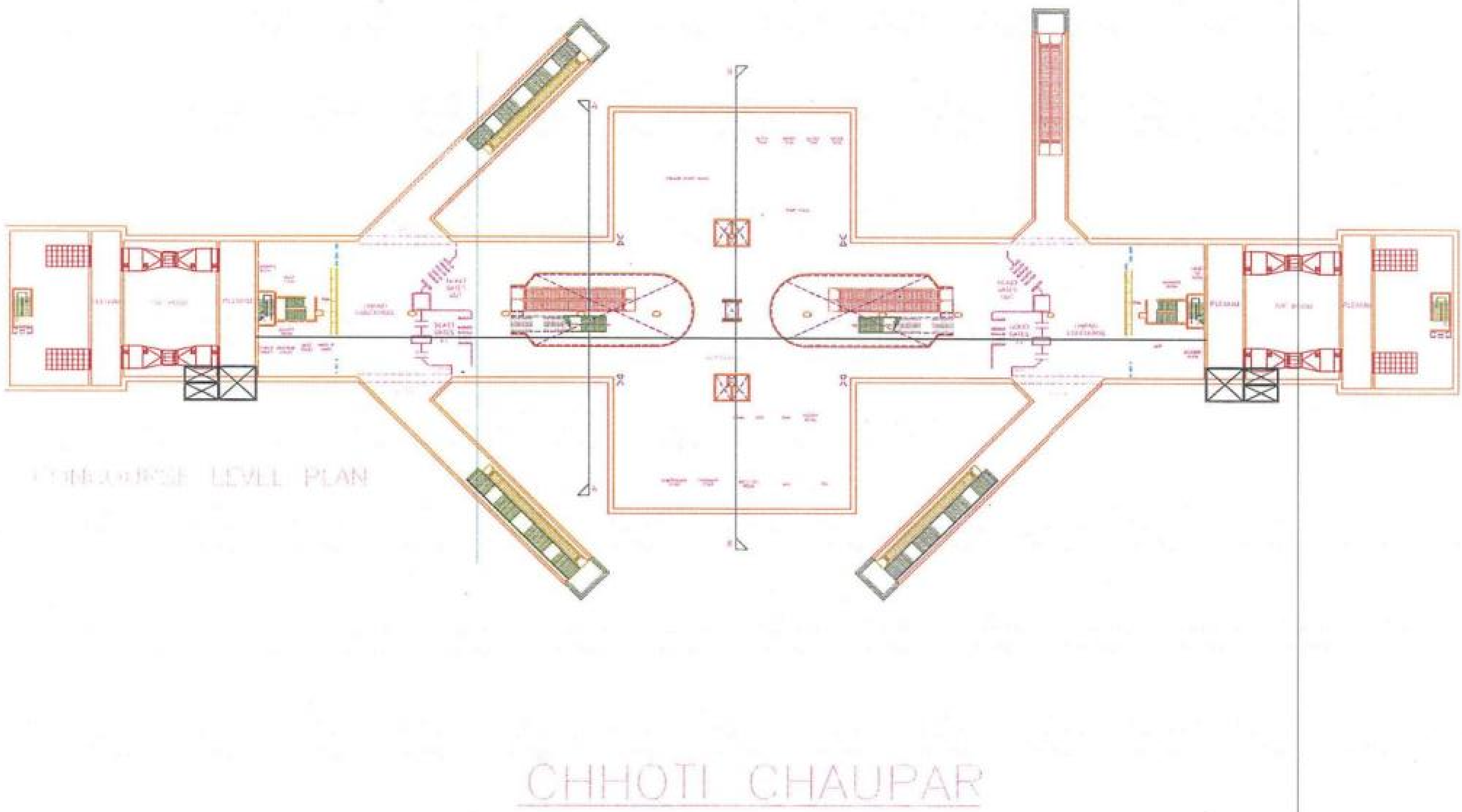
JAIPUR METRO

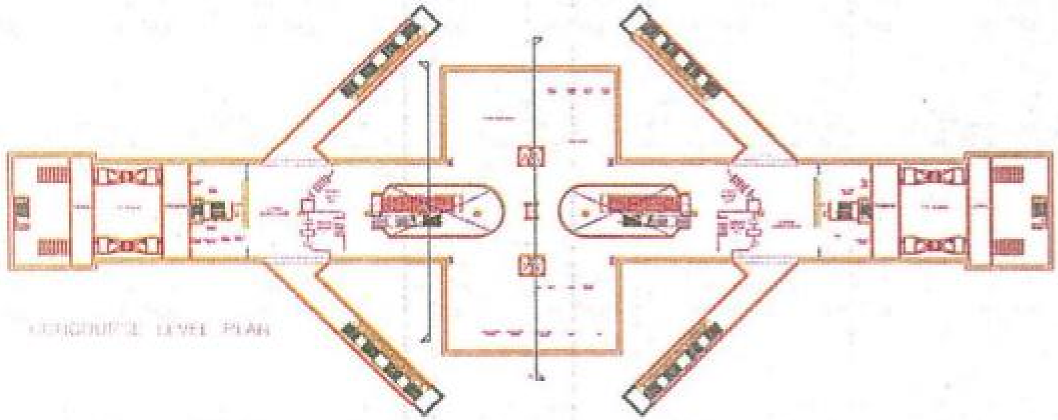
CHANDPOLE STATION

GROUND LEVEL PLAN

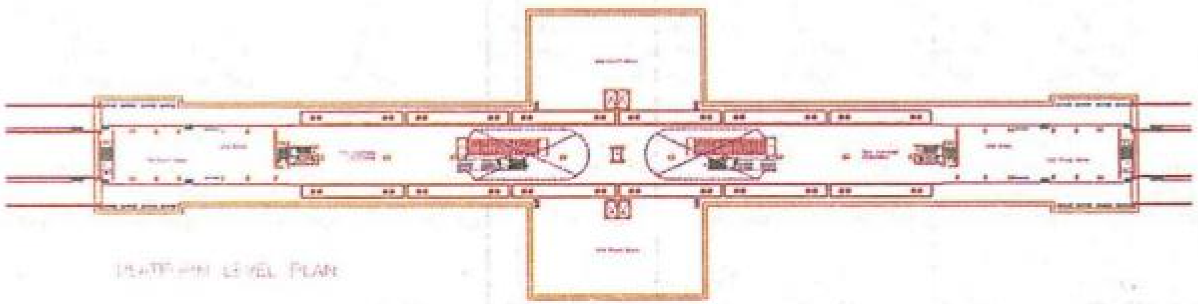
GENERAL ARRANGEMENT DRAWING

DMRC_12_CHP_JPR_1_1104_R1

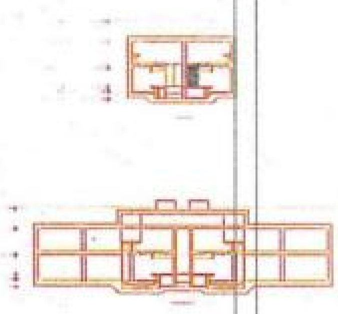

CONCOURSE LEVEL PLAN
CHHOTI CHAUPAR



CONCOURSE LEVEL PLAN



PLATFORM LEVEL PLAN



BADI CHAUPAR

Chapter 6

Train Operation Plan

6.1 Operation Philosophy
6.2 Stations
6.3 Train Operation Plan
6.4 Year wise rake Requirement

CHAPTER 6

TRAIN OPERATION PLAN

6.1 Operation Philosophy

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

- Selecting the most optimum frequency of Train services to meet sectional capacity requirement during peak hours on most of the sections.
- Economical & optimum train service frequency not only during peak period, but also during off-peak period.
- A short train consists of 4 coaches with high frequency service which can be increased to 6 Coaches to meet future requirements.
- Multi-tasking of train operation and maintenance staff.

6.2 Stations

List of stations for this corridor of Jaipur Metro is given below:

EAST-WEST CORRIDOR				
S. No	Name of Stations	Change (in m)	Inter – Station Distance (in km)	Remarks
	Dead End	(-)1218.930		
1	Mansarovar	(-)659.363	559.567	Elevated
2	New Aatish Market	795.520	1454.883	Elevated
3	Vivek Vihar	1901.000	1105.480	Elevated
4	Shyam Nagar	2782.120	881.120	Elevated
5	Ram Nagar	3529.256	747.136	Elevated
6	Civil Lines	4615.296	1086.040	Elevated
7	Railway Station	6198.422	1583.126	Elevated

EAST-WEST CORRIDOR				
S. No	**Name of Stations**	**Change (in m)**	**Inter – Station Distance (in km)**	**Remarks**
8	Sindhi Camp	7537.201	1338.779	Elevated
9	Chand Pole	8323.248	786.047	Underground
10	Choti Chopar	9545.158	1221.910	Underground
11	Badi Chopar	10398.502	853.344	Underground
	Dead End	10848.496	450.058	

6.3 Train Operation Plan

6.3.1 Salient Features

- Running of services for 19 hours of the day (5 AM to Midnight) with a station dwell time of 30 seconds,
- Make up time of 5-10% with 8-12% coasting.
- Scheduled speed for this corridors has been assumed as: 32 kmph

6.3.2 Traffic Demand

Peak hour peak direction traffic demands (PHPDT) for the Jaipur Metro ': East- West Corridor' for the year 2014, 2021 and 2031 for the purpose of planning are indicated in Attachment I/A2, B2 & C2 respectively.

6.3.3 Train formation

To meet the above projected traffic demand, the possibility of running trains with composition of 4 Car trains with different headways has been examined.

The basic details of train configuration selected for the Jaipur Metro Corridors are as under:

Composition

DTC : Driving Trailer Car

MC : Motor Car

TC : Trailer Car

4 Car Train Composition : DTC + MC + MC+ DTC

Extendable to 6 car Train Composition : DTC + MC + TC + MC + MC+ DTC

Capacity

DTC : 247 Passengers (Sitting-43, Crush Standing-204)

TC/MC : 270 Passengers (Sitting-50, Crush Standing-220)

4 Car Train: 1034 Passengers (Sitting-186, Crush Standing-848)

6 Car Train: 1574 Passengers (Sitting-286, Crush Standing-1288)

6.3.4 Train Operation Plan

Based on the projected PHPDT demand, train operation has been planned for Corridors for the year 2014, 2014 and 2031 as detailed below:

i) Year 2014 (Refer Attachment I/ A2)

East –West Corridor (Refer Attachment I/ A2)

- 6 min Headway with 4-car train.
- Available Peak Hour Peak Direction Capacity of 10340 @ 6 persons per square meter of standee area
- Available Peak Hour Peak Direction Capacity of 13160 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 11264 is in the Section between Railway Station and Sindhi Camp and the PHPDT demand in the section Civil Lines and Railway Station is 10895, demand in the remaining sections is in the range of 9923 to 6427 only. The planned capacity of 10340 (13160 under dense loading) is less than the PHPDT demand in two (zero, with dense loading capacity) sections out of ten sections.

ii) Year 2021 (Refer Attachment I/ B2)

East –West Corridor (Refer Attachment I/ B2)

- 4 min Headway with 4-car train.
- Available Peak Hour Peak Direction Capacity of 15510 @ 6 persons per square meter of standee area

- Available Peak Hour Peak Direction Capacity of 19740 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 16376 is in the Section between Railway Station and Sindhi Camp and the PHPDT demand in the section Civil Lines and Railway Station is 15976, demand in the remaining sections is in the range of 14533 to 6643 only. The planned capacity of 15510 (19740 under dense loading) is less than the PHPDT demand in two (zero, with dense loading capacity) sections out of ten sections.

iii) Year 2031 (Refer Attachment I/ C2)

East –West Corridor (Refer Attachment I/ C2)

- 2.5 min Headway with 4-car train.
- Available Peak Hour Peak Direction Capacity of 24816 @ 6 persons per square meter of standee area
- Available Peak Hour Peak Direction Capacity of 31584 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 27750 is in the Section between Railway Station and Sindhi Camp and the PHPDT demand in the section Civil Lines and Railway Station is 27627, demand in the remaining sections is in the range of 24495 to 10513 only. The planned capacity of 24816 (31584 under dense loading) is less than the PHPDT demand in two (zero, with dense loading capacity) sections out of ten sections.

In case of any mismatch in the capacity provided and the actual traffic, the capacity can be moderated suitably by either varying the rake composition or adjusting the Headway. The above Train Operation Plan is based on calculations on the basis of available traffic data.

As seen from above, based on traffic projections, requirement of 4-car trains is envisaged even in the Year 2031. However, the length of the train can be increased to 6-car and all infrastructure and maintenance facilities should be planned for 6-car trains.

The PHPDT capacity provided on this corridor in different years of operation is tabulated below:

Capacity Provided for East-West corridor

Corridor	YEAR		
East - West	**2014**	**2021**	**2031**
Cars/trains	4	4	4
Head way (Minutes)	6	4	2.5
Max. PHPDT Demand	11264	16376	27750
PHPDT Capacity Available	10340 (13160*)	15510 (19740*)	24816 (31584*)

* @ 8 persons per square meter of standee area

(a) Train frequency

Jaipur Metro Corridors

The train operation Jaipur Metro Corridor provides for the following train frequency:

Jaipur Metro	2014		2012		2031	
	Peak Hour h/w	Lean Hour h/w	Peak Hour h/w	Lean Hour h/w	Peak Hour h/w	Lean Hour h/w
East-West corridor	6min	8 to 15min	4min	6 to 15min	2.5min	5 to 15min

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

(b) Hourly Train Operation plan

The hourly distribution of daily transport capacity is presented **1.1A, 1.2A & 1.3A** for years 2014, 2021 & 2031 for East- West Corridor respectively and enclosed as Attachment II. Number of train trips per direction per day for E-W Corridor is worked out as 138 in the year 2014, 178 in the year 2021 and 240 in the year 2031 respectively. The directional splits for East- West Corridor is presented in **Table 2.2** enclosed as Attachment III.

(c) Vehicle Kilometer

Based on above planning, after considering maintenance period and assuming 340 days in service in a year, Vehicle Kilometers for Jaipur Metro East- West Corridor is given in **Table 3.2** enclosed as Attachment IV.

6.4 Year wise rake Requirement

Based on Train formation and headway as decided above to meet Peak Hour Peak Direction Traffic Demand, Rake requirement has been calculated and enclosed as Attachment V & has been tabulated below:

Corridor	Year	Headway (min)	No. of Rakes	Rake Consist	No. of Coaches
East-West corridor	**2014**	**6**	**10**	**4 car**	**40**
	2021	**4**	**15**	**4 car**	**60**
	2031	**2.5**	**22**	**4 car**	**88**

Requirements of coaches is calculated based on following assumptions:-

Assumptions -

(i) Train Composition planned as under

- 4 Car Train Composition : DTC-MC-MC-DTC
  Train Carrying Capacity of 4 Car Train: 1034 passengers
- Extendable to 6 car Train Composition : DTC + MC + TC + MC + MC+ DTC
  Train Carrying Capacity of 6 Car Train: 1574 passengers

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

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

(iv) Repair and maintenance reserve has been estimated as 8 % of total requirement (Bare +Traffic Reserve).

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

(vi) Schedule speed is taken as:

East – West corridor: 32 kmph

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

Attachment - I/A2

PHPDT Demand and Capacity Chart

Corridor II : East - West Corridor

Year:	2014
No. of Cars per Train:	4
Passenger Capacity @ 6 persons/sqm of a 4-Car Train:	1034
Passenger Capacity @ 8 persons/sqm of a 4-Car Train:	1316
Headway (min)	6

S.N	FROM	TO	Traffic Demand in PHPDT	Train carrying capacity @ 6p/sqm of standee area	Train carrying capacity @ 8p/sqm of standee area
1	Mansarovar	New Aatish Nagar	6427	10340	13160
2	New Aatish Nagar	Vivek Vihar	6937	10340	13160
3	Vivek Vihar	Shyam Nagar	7453	10340	13160
4	Shyam Nagar	Ram Nagar	8477	10340	13160
5	Ram Nagar	Civil Lines	9923	10340	13160
6	Civil Lines	Railway Station	10895	10340	13160
7	Railway Station	Sindhi Camp	11264	10340	13160
8	Sindhi Camp	Chand Pole	7975	10340	13160
9	Chand Pole	Choti Chopar	9356	10340	13160
10	Choti Chopar	Badi Chopar	8326	10340	13160

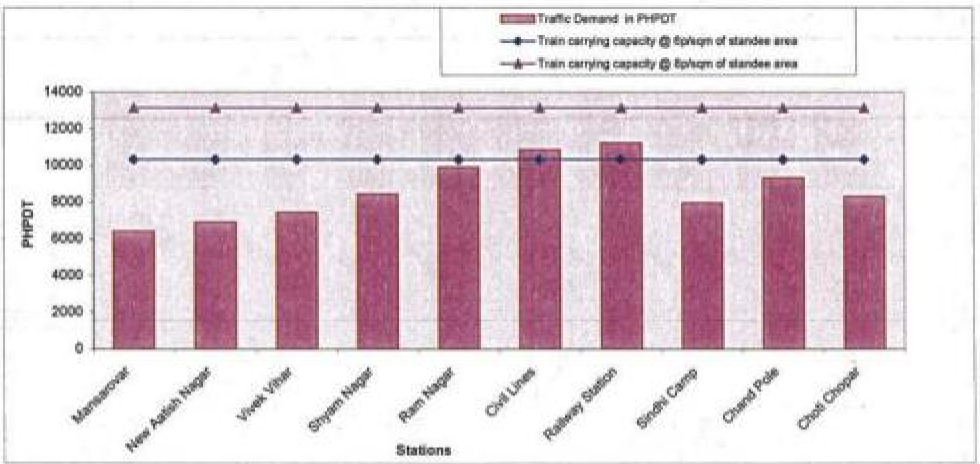


Fig 1.2

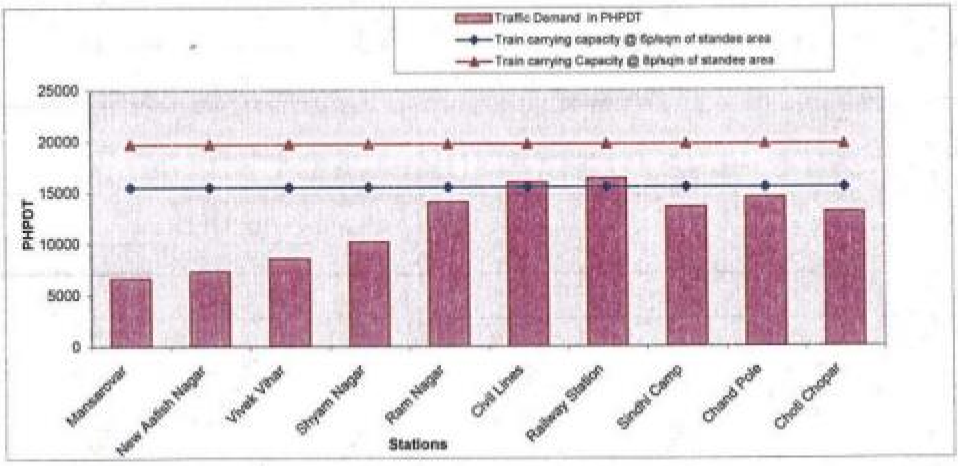
Attachment - I/B2

PHPDT Demand and Capacity Chart

Corridor II : East - West Corridor

Year:	2021
No. of Cars per Train:	4
Passenger Capacity @ 6 persons/sqm of a 4-Car Train:	1034
Passenger Capacity @ 8 persons/sqm of a 4-Car Train:	1316
Headway (min)	4

S.N	FROM	TO	Traffic Demand in PHPDT	Train carrying capacity @ 6p/sqm of standee area	Train carrying capacity @ 8p/sqm of standee area
1	Mansarovar	New Aatish Nagar	6643	15510	19740
2	New Aatish Nagar	Vivek Vihar	7353	15510	19740
3	Vivek Vihar	Shyam Nagar	8586	15510	19740
4	Shyam Nagar	Ram Nagar	10185	15510	19740
5	Ram Nagar	Civil Lines	14086	15510	19740
6	Civil Lines	Railway Station	15976	15510	19740
7	Railway Station	Sindhi Camp	16376	15510	19740
8	Sindhi Camp	Chand Pole	13587	15510	19740
9	Chand Pole	Choti Chopar	14533	15510	19740
10	Choti Chopar	Badi Chopar	13134	15510	19740



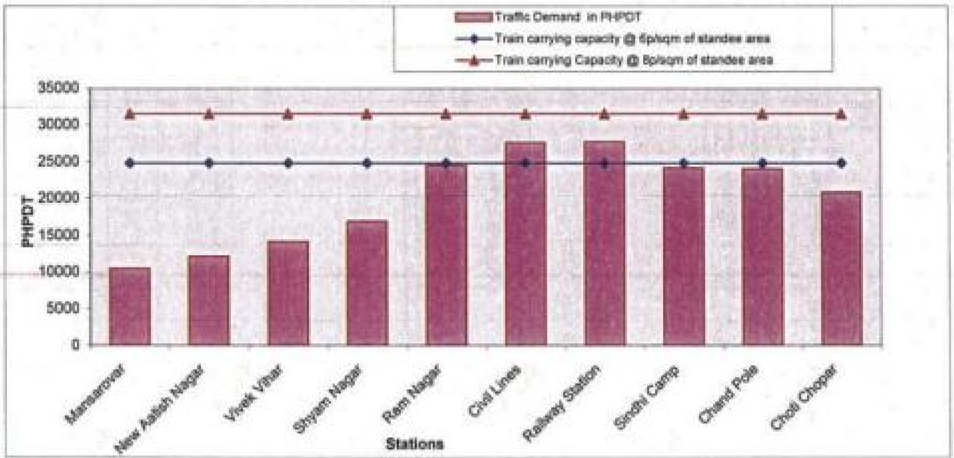
Attachment - I/C2

PHPDT Demand and Capacity Chart

Corridor II : East - West Corridor

Year:	2031
No. of Cars per Train:	4
Passenger Capacity @ 6 persons/sqm of a 4-Car Train:	1034
Passenger Capacity @ 8 persons/sqm of a 4-Car Train:	1316
Headway (min)	2.5

S.N	FROM	TO	Traffic Demand in PHPDT	Train carrying capacity @ 6p/sqm of standee area	Train carrying capacity @ 8p/sqm of standee area
1	Mansarovar	New Aatish Nagar	10513	24816	31584
2	New Aatish Nagar	Vivek Vihar	12162	24816	31584
3	Vivek Vihar	Shyam Nagar	14211	24816	31584
4	Shyam Nagar	Ram Nagar	16955	24816	31584
5	Ram Nagar	Civil Lines	24495	24816	31584
6	Civil Lines	Railway Station	27627	24816	31584
7	Railway Station	Sindhi Camp	27750	24816	31584
8	Sindhi Camp	Chand Pole	24180	24816	31584
9	Chand Pole	Choti Chopar	24059	24816	31584
10	Choti Chopar	Badi Chopar	20845	24816	31584



Corridor II : East - West Corridor, Year : 2014
Passenger Capacity @ 6 Persons/sqm in 4 Car Train: **1034** **Schedule Speed in Kmph= 32**

Section	Distance (kms)	Schedule Speed in kmph	Projected PHPDT Demand	Max. PHPDT Capacity Available	Headway (min)	Rake Requirement			Total No of Rakes	No. of Cars per rake	No. of Cars
						Bare	Traffic Reserve	R&M			
Corridor II : East - West Corridor	11.06	32.0	**11264**	10340	**6**	8	1	1	10	4	**40**
Total Turn Round Time(min)	**6**										

Corridor II : East - West Corridor, Year : 2021
Passenger Capacity @ 6 Persons/sqm in 4 Car Train: **1034** **Schedule Speed in Kmph= 32**

Section	Distance (kms)	Schedule Speed in kmph	Projected PHPDT Demand	Max. PHPDT Capacity Available	Headway (min)	Rake Requirement			Total No of Rakes	No. of Cars per rake	No. of Cars
						Bare	Traffic Reserve	R&M			
Corridor II : East - West Corridor	11.06	32.0	**16376**	15510	**4**	12	1	2	15	4	**60**
Total Turn Round Time(min)	**6**										

Corridor II : East - West Corridor, Year : 2031
Passenger Capacity @ 6 Persons/sqm in 4 Car Train: **1034** **Schedule Speed in Kmph= 32**

Section	Distance (kms)	Schedule Speed in kmph	Projected PHPDT Demand	Max. PHPDT Capacity Available	Headway (min)	Rake Requirement			Total No of Rakes	No. of Cars per rake	No. of Cars
						Bare	Traffic Reserve	R&M			
Corridor II : East - West Corridor	11.06	32.0	**27750**	24816	**2.5**	19	1	2	22	4	**88**
Total Turn Round Time(min)	**6**										

TABLE 1.1 A

Hourly Train Operation Plan for Corridor II : East - West Corridor

Year: 2014

Configuration: 4 Car

Headway(min): 6

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	12	5	5
6 to 7	10	6	6
7 to 8	8	8	7
8 to 9	**6**	**10**	**10**
9 to 10	**6**	**10**	**10**
10 to 11	**6**	**10**	**10**
11 to12	8	8	7
12 to 13	10	6	6
13 to 14	12	5	5
14 to 15	12	5	5
15 to 16	10	6	6
16 to 17	8	7	8
17 to 18	**6**	**10**	**10**
18 to 19	**6**	**10**	**10**
19 to 20	**6**	**10**	**10**
20 to 21	8	7	8
21 to 22	10	6	6
22 to 23	12	5	5
23 to 24	15	4	4
Total No. of train trips per direction per day		**138**	**138**

TABLE 1.2 A

Hourly Train Operation Plan for Corridor II : East - West Corridor

Year: 2021

Configuration: 4 Car

Headway(min): 4

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	12	5	5
6 to 7	10	6	6
7 to 8	6	10	10
8 to 9	4	**15**	**15**
9 to 10	4	**15**	**15**
10 to 11	4	**15**	**15**
11 to12	6	10	10
12 to 13	10	6	6
13 to 14	12	5	5
14 to 15	12	5	5
15 to 16	10	6	6
16 to 17	6	10	10
17 to 18	4	**15**	**15**
18 to 19	4	**15**	**15**
19 to 20	4	**15**	**15**
20 to 21	6	10	10
21 to 22	10	6	6
22 to 23	12	5	5
23 to 24	15	4	4
Total No. of train trips per direction per day		**178**	**178**

TABLE 1.2 A

Hourly Train Operation Plan for Corridor II : East - West Corridor

Year: 2031

Configuration: 4 Car

Headway(min): 2.5

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	12	5	5
6 to 7	10	6	6
7 to 8	5	12	12
8 to 9	**2.5**	**24**	**24**
9 to 10	**2.5**	**24**	**24**
10 to 11	**2.5**	**24**	**24**
11 to12	5	12	12
12 to 13	10	6	6
13 to 14	12	5	5
14 to 15	12	5	5
15 to 16	10	6	6
16 to 17	5	12	12
17 to 18	**2.5**	**24**	**24**
18 to 19	**2.5**	**24**	**24**
19 to 20	**2.5**	**24**	**24**
20 to 21	5	12	12
21 to 22	10	6	6
22 to 23	12	5	5
23 to 24	15	4	4
Total No. of train trips per direction per day		**240**	**240**

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JAIPUR METRO PROJECT

i) **East-West Corridor**

ii) **Route Length (Centre to Centre):**
East- West Corridor: 12.067 km

iii) **Number of Stations:**
East- West Corridor: 11

iv) **Average Interstation Distance:**
East- West Corridor: 1.106 km

v) **Gauge:** 1435 mm

vi) **Traction Power Supply**
i) Voltage: 25 KV AC
ii) Current Collection: Overhead Current Collection system

vii) **Rolling Stock:**

i) Coach Size:

Particular	*Length**	*Width*	*Height*
Driving Trailer Car (DTC)	21.64m	2.9 m	3.9 m
Trailer Car (TC)/Motor Car (MC)	21.34 m	2.9 m	3.9 m

Maximum length Coach over coupler/buffers = 22.6 m

ii) Passenger Carrying Capacity (Crush @ 6 person/sqm)

PARTICULAR	*SEATED*	*STANDING*	*TOTAL*
DTC	43	204	247
TC/MC	50	220	270
4-CAR	186	848	1034
6-CAR	286	1288	1574

Seating: Longitudinal

iii) Weight:

PARTICULAR	*TARE*	*PASSENGER*	*GROSS*
DTC	39	16.055	55.055
TC	39	17.55	56.55
MC	39	17.55	56.55
4-CAR	156	67.21	223.21
6-CAR	234	102.31	336.31

iv) Axle Load: To be designed for 16T

v) Max Acceleration: 0.82 m/s^2

vi) Max Deceleration: 1.1 m/s^2 (Normal Brake)
$>1.3 m/s^2$ (Emergency Brake)

vii) Maximum Design Speed: 95 kmph

viii) Maximum Operating Speed: 85 kmph

ix) Schedule Speed (as per train operation in following lines):

East- West Corridor: 32 kmph

x) Composition: 4-car = DTC+MC+MC+DTC
6-car = DTC+MC+TC+MC+MC+DTC

xi) Cost per car: Rs10.3 Crores exclusive of taxes and duties at May' 2010 Price Level.

xii) Capacity Provided & Rake Requirement:

S. No	Jaipur Metro Project	Year	Max. PHPDT Demand	PHPDT Capacity @6persons per sqm	Headway (min)	No. of Cars per rakes	No. of rakes	No. of coaches
1	East-West Corridor	2014	11264	10340 (13160)*	6	4	10	40
2	East-West Corridor	2021	16376	15510 (19740)*	4	4	15	60
3	East-West Corridor	2031	27750	24816 (31584)*	2.5	4	22	88

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

xiii) All Infrastructure and maintenance facilities to be planned for 6-Car trains.

Chapter 7

Power Supply Arrangements

CHAPTER 7

POWER SUPPLY ARRANGEMENTS

7.1 Power Requirements

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

(i) Specific energy consumption of rolling stock – 70KWh/1000 GTKM

(ii) Regeneration by rolling stock – 30%

(iii) Elevated station load – initially 200KW, which will increase to 300 KW in the year 2031

(iv) Underground Station load – initially 2000 kW, which will increase to 2500 kW in the year 2031

(v) Depot auxiliary load - initially 1000KW, which will increase to 2000 KW in the year 2031

Keeping in view of the train operation plan and demand of auxiliary and traction power, power requirements projected for the year 2014, 2021 and 2031 are summarized in table 7.1 below:-

Table 7.1 Power Demand Estimation (MVA)

Corridor		Year		
		2014	2021	2031
Badi Chopar to Mansarovar. [12.067 kms & 11 Stns. (3 U/G)].	Traction	4.1	6.2	9.5
	Auxiliary	10.7	12.4	14.1
	Total	14.8	18.6	23.6

Detailed calculations of power demand estimation are attached at **Annexure –7.1**

7.2 Need for High Reliability of Power Supply

The proposed Section of the Jaipur metro system is being designed to cater to about 27750 passengers per direction during peak hours when trains are expected to run at 2.5 minutes intervals in 2031. Incidences of any power interruption, apart from affecting train running, will cause congestion at stations. Interruption of power at night is likely to cause alarm and increased risk to traveling public. Lack of illumination at stations, non-visibility of appropriate signages, disruption of operation of lifts and escalators is likely to cause confusion, anxiety and ire in commuters, whose tolerance level are low on account of stress. Effect on signal and communication may affect train operation and passenger safety as well. Therefore, reliable and continuous 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 or 132kV from stable grid sub-stations and further transmission & distribution is done by the Metro Authority itself.

7.3 Sources of Power Supply

The high voltage power supply network of Jaipur city has 220kV and 132kV network to cater to various types of demand in vicinity of the proposed corridor. 220/132 kV sub stations are located to the alignment of Corridors. Keeping in view the reliability requirements, two input sources of 132 kV Voltage level are normally considered for each corridor. As per the sequence of construction, the revenue operation of elevated sections of the two corridors will begin before the Underground sections are completed. The intersection of the two corridors will be at Sindhi Camp station (Underground station of N-S Corridor). Therefore, to achieve the desired reliability, two Receiving Sub Stations (132 / 33 / 25 kV) are proposed to be set up for this Corridor. Based on the discussions with Rajasthan Rajya Vidyut Prasaran Nigam Limited (RVPN), it is proposed to avail power supply for traction as well as auxiliary services from the following grid sub-stations at 132kV voltage through cable feeders.

Table 7.2 Sources of Power Supply

Corridor	Grid sub-station (with Input voltage)	Location of RSS of Metro Authority	Approx. length of cables
Badi Chopar to Mansarovar.	Mansarovar GSS (220 / 132kV)	Depot at Mansarovar (132 / 33/25 kV)	0.5 km, 132kV (Double Circuit Cables).
	GIS sub station, PWD Bungalow at Station Road near RSRTC bus stand. (132 / 33 kV).	Near Sindhi Camp Metro Station (132 / 33/25 kV)	0.5 km, 132kV (Double Circuit Cables).

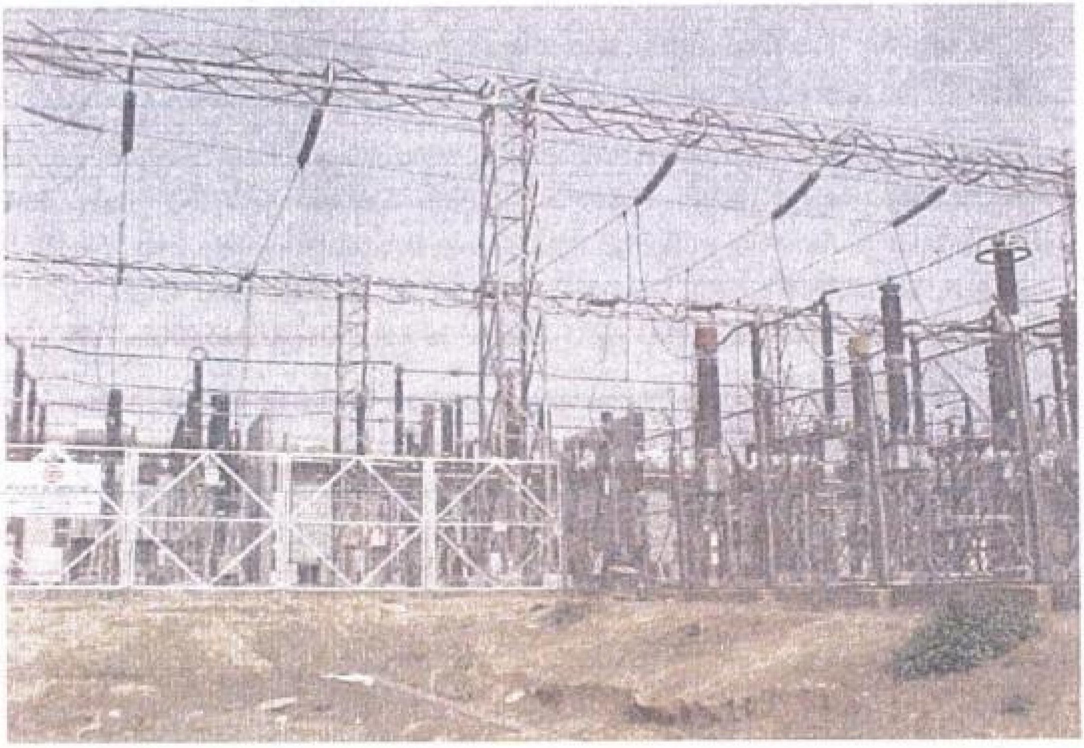
If the Jawahar circle GSS does not get commissioned by that time the 2X132 bays at mansarover GSS will be utilized with loop in loop out at RSS at Mansarover. The final distribution of load amongst the sub station will be decided depending upon the progress and requirements of construction.

Summary of expected power demand at various sources is given in Table – 7.3. Rajasthan Rajya Vidyut Prasaran Nigam Limited (RVPN) have confirmed availability of requisite power at their above sub-stations vide letter No RVPN/Dir (Tech.)/CE(PPM&R)/SE(D)/D.4149, dated:- 11.12.2009 and letter no.RVPN/Dir (Tech)/CE(PPM&R)/SE(D)/D.4211,dated:-16.12.2009(**Annexure – 7.2**).

Table 7.3 Power Demand Projection for various sources.

Corridor	Input Source / Receiving Sub Station (RSS)	Peak Demand – Normal (MVA)			Peak Demand – Emergency (MVA)		
		2014	**2021**	**2031**	**2014**	**2021**	**2031**
Badi Chopar to Mansarovar.	**At Mansarovar Depot**						
	Traction	2.3	3.5	5.1	4.1	6.2	9.5
	Auxiliary	3.0	3.8	4.5	10.7	12.4	14.1
	Total	5.3	7.2	9.5	14.8	18.6	23.6
	Near Sindhi Camp Metro Stn						
	Traction	1.8	2.7	4.4	4.1	6.2	9.5
	Auxiliary	7.7	8.6	9.6	10.7	12.4	14.1
	Total	9.5	11.3	14.0	14.8	18.6	23.6
	TOTAL (A + B)	**14.8**	**18.6**	**23.6**			

The 132 kV power supply will be stepped down to 25kV single phase for traction purpose at the RSS of Jaipur Metro and the 25kV traction supply will be fed to the OHE at viaduct through cable feeders. For feeding the auxiliary loads, the 132/33 kV power supply received will be stepped down to 33 kV or 33 kV supply will be directly availed and will be distributed along the alignment through 33kV Ring main cable network. These cables will be laid in dedicated ducts along the viaduct tunnel walls. If one RSS trips on fault or input supply failure, train services can be maintained from the other RSS. However, in case of total grid failure, all trains may come to a halt but station lighting & other essential services can be catered to by stand-by DG sets. Therefore, while the proposed scheme is expected to ensure adequate reliability, it would cater to emergency situations as well.



Typical High Voltage Receiving Sub-station

The 132kV cables will be laid through public pathways from Rajasthan Rajya Vidyut Prasaran Nigam Limited (RVPN) Grid Sub-stations to RSS of Metro Authority. For E-W corridor, RSS at Mansarovar depot and RSS near Sindhi Camp metro station shall be provided with 2nos. (one as standby) 132/25 kV, 15 MVA single phase traction Transformers for feeding Traction supply and 132/33

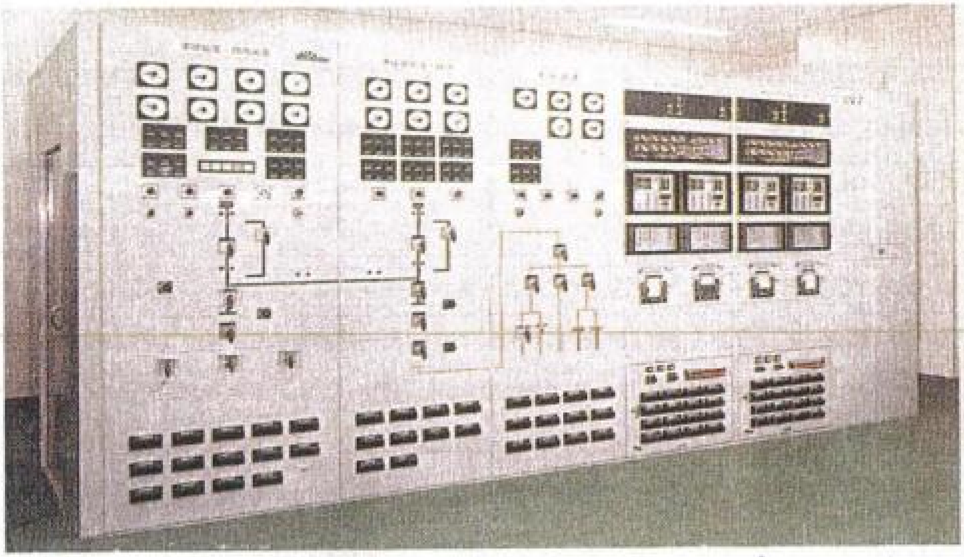
KV, 30 MVA three phase Transformers for feeding auxiliary loads. Interconnection will provide at 33KV & 25KV level to meet emergency requirement at sindhi camp in case of failure of two RSS of any one corridor .The capacity of transformers may be reviewed considering the load requirement/distribution of both the corridors at the time of detailed design.

Conventional Outdoor type 132 kV Switchgear is proposed for RSS's to be located in approx. 100 X 80 m (8000 sq. mtr.) land plot, as the availability of Land in this depot area may not be a constraint. The RSS near Sindhi Camp metro station, in case of difficulty in land acquisition, Gas Insulated Sub – stations (GIS) sub stations may be planned. Requirement of land for GIS will be approx. 90 X 40 m (3600 sq. m) but the cost of sub station works will increase by nearly Rs. 20 Crore per RSS.

In case 33 kV feeders are also utilized at PWD Bunglow, the price will be in addition to the estimated cost.

7.4 Auxiliary Supply Arrangements for Stations & Depot

Auxiliary sub-stations (ASS) are envisaged to be provided at each station (3 ASS's for Underground stations and 1 ASS for elevated station) for stepping down 33 kV supply to 415 V for auxiliary applications. A separate ASS is required at depot. The ASS will be located at mezzanine or platform level inside a room. The auxiliary load requirements have been assessed at 200kW for elevated / at-grade stations which is likely to increase up to 300 KW in the year 2031 and 2000 kW for Underground Station which is likely to increase up to 2500 KW in the year 2031. In order to meet the requirement of auxiliary power two dry type cast resin transformers (33/0.415kV) of 500kVA capacity are proposed to be installed at the elevated stations (one transformer as standby) and one transformer of 1.6 MVA at each underground ASS. For Property Development within the footprints of the station, a provision to add third transformer at a later date may be kept at elevated station.



Typical Indoor Auxiliary Sub-station

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

25kV ac traction currents produce alternating magnetic fields that cause voltages to be induced in any conductor running along the track. Booster Transformer and Return Conductor (BT/RC) System is proposed for EMI mitigation. Concrete structures of elevated viaducts are not good electrical earths and therefore, Earthing and Bonding of the traction system shall be in accordance with the latest standards EN50122-1, IEEE80 and other relevant standards. Two earth conductors –Overhead Protection Cable (OPC) and Buried Earth Conductor (BEC) are proposed to be laid along with elevated via duct and all the metallic structures, structural reinforcement, running rails etc will be connected to these conductors to form an equiv-potential surface & a least resistance path to the fault currents. The overhead protection cable will also provide protection against lightning to the 25kV OHE and the elevated viaduct. Similar arrangements have been adopted on Delhi Metro as well.

Detailed specification of equipment e.g. power cables, transformer, switchgear, E&M equipment etc shall be framed to reduce conducted or radiated emissions as per appropriate international standards. The Metro system as a whole (trains, signaling & telecomm, traction power supply, E&M system etc) shall comply with the EMC requirements of international standards viz. EN50121, EN50123, IEC61000 series etc. A detailed EMI/EMC plan will be required to be developed during project implementation stage.

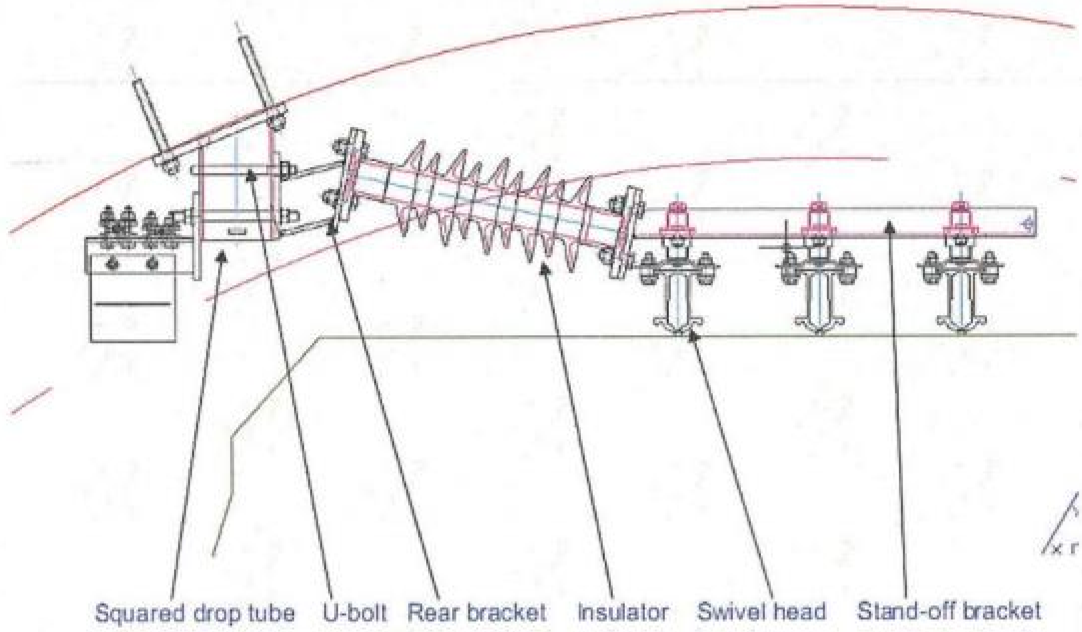
7.6 25 kV RIGID OHE SYSTEM.

The proposed 25kV Rigid OHE system in underground section is similar to the one installed in underground Metro Corridor of Delhi Metro. 25kV Rigid OHE system comprises a hollow Aluminum Conductor Rail of adequate cross section with 107 sq.mm copper contact wire held with elastic pinch. The Al conductor rail is supported by an insulator & cantilever arrangement attached to drop-down supports fixed to tunnel roof. The supports are located at every 10metre and there is no tension in the conductors and hence, no tensioning equipment in tunnel. The design of 25kv rigid OHE system shall be in accordance to electrical clearances & contact wire height as per IEC 60913, which is summarized below:

a) Contact wire height 4570mm

b) Structure to Live parts clearances...............270/170/150mm (Static/Dynamic/Absolute min dynamic)

c) Vehicle to Live parts clearances.................290/190/150mm (Static/Dynamic/Absolute min dynamic)



Definitive Design
25 KV ROCS Support

7.7 25kV Flexible Overhead Equipment (OHE) system

25kV ac flexible OHE system shall comprise 107 sqmm HD-copper contact wire and 65 sq.mm Cd-copper catenary wire. Return conductor (RC) shall be All Aluminum Conductor (AAC) of 233 sq.mm cross section. From safety considerations, Hydraulic type Anti-Tensioning Device (ATDs) are proposed on mainlines which does not require use of balance weight for tensioning of OHE conductors. Proven catenary fittings are proposed similar to DMRC system.

7.8 Rating of Major Equipment

25kV ac Overhead Equipment (OHE) shall comprise 107mm^2 HD-copper contact wire and 65 mm^2 Cd-copper catenary wire. Return conductor (RC) shall be All of OHE conductors.

Based on emergency demand expected at each RSS as shown in Table 7.3, and 2 nos. 132/25kV traction transformers of 15 MVA capacity and 2 nos. 30 MVA capacity Auxiliary transformers shall be provided at each RSS in E-W Corridor, being standard design (one to be in service and second one to serve as standby). The 132kV incoming cable shall be 3-phase single core XLPE insulated with 630 mm^2 Aluminum conductor to meet the normal & emergency loading requirements and fault level of the 132 kV supply.

33kV and 25kV switchgear shall be rated for 1250 A being standard design. 33kV cable ring network shall be adequately rated to transfer requisite auxiliary power during normal as well as emergency situations and accordingly 3 number of Single core 300 mm^2 FRLSOH Copper conductor cable XLPE insulated 33kV cable is proposed for ring main network due to underground section.

Adequate no. of cables are required for transfer of traction power from Metro's RSS to 25kV OHE. Single-phase XLPE insulated cables with 240mm^2 copper conductor are proposed for traction power. Based on current requirements, 2 cables are required for each of the two circuits to feed power to OHE.

The above capacities of transformers, switchgear, cables etc. have been worked out based on the conceptual design. Therefore, these may be required to be revised for better accuracy during design stage of project implementation.

7.9 Standby Diesel Generator (DG) Sets

In the unlikely event of simultaneous tripping of all the input power sources or grid failure, the power supply to stations as well as to trains will be interrupted. It is, therefore, proposed to provide a standby DG set of 200 KVA capacity at the elevated stations and 2 X 1000/750 KVA at Underground stations to cater to the following essential services:

(i) Essential lighting

(ii) Signaling & telecommunications

(iii) Fire fighting system

(iv) Lift operation

(v) Fare collection system

(vi) Tunnel Ventilation (for Underground Stations)

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

7.10 Supervisory Control and Data Acquisition (SCADA) System

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

Digital Protection Control System (DPCS) is proposed for providing data acquisition, data processing, overall protection control, interlocking, inter-tripping and monitoring of the entire power supply system consisting of 33kV ac switchgear, transformers, 25kV ac switchgear and associated electrical equipment. DPCS will utilize microprocessor-based fast-acting numerical relays & Programmable Logic Controllers (PLCs) with suitable interface with SCADA system.

7.11 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 Jaipur Metro includes the following energy saving features:

(i) Modern rolling stock with 3-phase VVVF drive and lightweight stainless steel coaches has been proposed, which has the benefits of low specific energy consumption and almost unity power factor.

(ii) Rolling stock has regeneration features and it is expected that 30% of total traction energy will be regenerated and fed back to 25kV ac OHE to be consumed by nearby trains.

(iii) Effective utilization of natural light is proposed. In addition, the lighting system of the stations will be provided with different circuits (33%, 66% & 100%) and the relevant circuits can be switched on based on the requirements (day or night, operation or maintenance hours etc).

(iv) Machine-room less type lifts with gearless drive have been proposed with 3-phase VVVF drive. These lifts are highly energy efficient.

(v) The proposed heavy-duty public services escalators will be provided with 3-phase VVVF drive, which is energy efficient & improves the power factor. Further, the escalators will be provided with infrared sensors to automatically reduce the speed (to idling speed) when not being used by passengers.

(vi) The latest state of art and energy efficient electrical equipment (e.g. transformers, motors, light fittings etc) have been incorporated in the system design.

(vii) Efficient energy management is possible with proposed modern SCADA system by way of maximum demand (MD) and power factor control.

7.12 Electric Power Requirement

The cost of electricity is a significant part of Operation & Maintenance (O&M) charges of the Metro System, which constitutes about 25 – 35% of total annual working cost. Therefore, it is the key element for the financial viability of the project. The annual energy consumption is assessed to about 45 million units in initial years (2014), which will increase to 66 Million Units by year 2031 for this corridor. 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 this Corridor should be at effective rate of purchase price (at 132 kV voltage level) plus nominal administrative charges i.e. on a no profit no loss basis. It is proposed that Government of Rajasthan take necessary steps to fix power tariff for Jaipur Metro at "No Profit No Loss" basis. Financial analysis has been carried out based on this tariff for the purpose of finalizing the DPR. Similar approach is being pursued for Delhi Metro.

					Annexure:-7.1	
POWER REQUIREMENTS	**JAIPUR METRO**					
	East - West - CORRIDOR					
	Badi Chopar to Mansarover					
	Year 2014		**Year 2021**		**Year 2031**	
Traction power requirements						
No of cars	4	(2MC+2DTC)	4	(2MC+2DTC)	4	(2MC+2DTC)
passenger weight	67.2	T	67.2	T	67.2	T
Train Tare weight	156.0	T	156.0	T	156.0	T
Total train weight	223.2	T	223.2	T	223.2	T
Section length	12.56	KM	12.56	KM	12.56	KM
Headway	**6**	mts	**4**	mts	**2.5**	mts
Specific Energy consumption	70	KWhr/1000GTKM	70	KWhr/1000GTKM	70	KWhr/1000GTKM
No. of trains/hr in both directions	20.00		30.00		48.00	
Peak traction power requirement	3.9	MW	5.9	MW	9.4	MW
Less Regeneration @ 30%	1.2	MW	1.8	MW	2.8	MW
Depot power requirements	1.0	MW	1.5	MW	2.0	MW
Total traction power requirement	3.7	MW	5.6	MW	8.6	MW
Total traction power requirement (MVA) assuming 5% energy losses and .95 pf	**4.1**	MVA	**6.2**	MVA	**9.5**	MVA
Station aux power requirements						
Elevated/at-grade station--power consumption	0.20	MW	0.25	MW	0.30	MW
Underground station--power consumption	2.00	MW	2.25	MW	2.50	MW
No. of elevated/at-grade stations	8		8		8	
No. of Underground stations	3		3		3	
Total Station Aux Power requirement	7.6	MW	8.8	MW	9.9	MW
Depot Aux power requirement	1.0	MW	1.3	MW	1.5	MW
Total Aux Power requirement	8.6	MW	10.0	MW	11.4	MW
Total aux power requirement (MVA) assuming 5% energy losses and .85 pf for aux loads	**10.6**	MVA	**12.4**	MVA	**14.1**	MVA
Total traction & aux power requirement (MVA)	**14.8**	MVA	**18.6**	MVA	**23.6**	MVA

Approximate Energy Consum| JAIPUR METRO

	East - West - CORRIDOR					
	Badi Chopar to Mansarover					
Year	**Year 2014**		**Year 2021**		**Year 2031**	
LENGTH (KM)	12.56	KM	12.56	KM	12.56	KM
No. of trains per direction in a day*	138		178		240	
WEIGHT OF TRAIN & PASSENGER	223.2	T	223.2	T	223.2	T
SFC (NET) with 30% regen	49	KWH/1000 GTKM	49	KWH/1000 GTKM	49	KWH/1000 GTKM
Yearly Traction Energy consumption with 365 days working with 30% regen	13.84	million units	17.85	million units	24.07	million units
Station aux power requirement						
Elevated/at-grade station	0.20	MW	0.25	MW	0.30	MW
U/G station	2.00	MW	2.25	MW	2.50	MW
no. of elevated/at-grade stations	8		8		8	
no. of U/G stations	3		3		3	
Total Station Aux Power requirement	7.6	MW	8.8	MW	9.9	MW
Depot Aux power requirement	1.0	MW	1.3	MW	1.5	MW
Total Aux Power requirement	8.6	MW	10.1	MW	11.4	MW
Total Aux power requirement (MVA) assuming 5% energy losses and .85 pf for aux loads	**10.6**	MVA	**12.4**	MVA	**14.1**	MVA
Diversity factor of aux loads	0.4		0.4		0.4	
Yearly Aux Energy consumption 20 hrs/day and 365 days working (million units)	31.02	million units	36.25	million units	41.12	million units
Net Annual Energy Consumption (Traction & Aux)	**44.9**	**million units**	**54.1**	**million units**	**65.2**	**million units**

Annexure – 7.2

Y.K. Raizada
DIRECTOR (TECHNICAL)

Rajasthan Rajya Vidyut Prasaran Nigam Ltd. (RVPN)
(A Successor Company of R.S.E.B.)
Vidyut Bhawan, Janpath, Jyoti Nagar, Jaipur-302 005

No. RVPN/Dir(Tech.)/CE(PPM&R)/SE(D)/ D. 4149 Jaipur, dated 11/12/09

The Executive Director (Electrical),
Delhi Metro Rail Corporation Ltd.,
Metro Bhawan, Fire Brigade Lane,
Barakhamba Road,
New Delhi-110 001.

Sub:- Jaipur Metro Rail Project - Power Supply requirement & sources.
Ref:- Your letter No. DMRC/Elec./Plg./Jaipur/09/30422 dt. 7.12.09.

Dear Sir,

Kindly refer our discussions on 10.12.09 in regard to various options for feeding power requirement of 35 MW and 20 MW for Corridor No. 1 & 2 respectively planned in the first phase for Jaipur Metro Rail Project.

In this regard, it is to state that normally for higher degree of reliability demand of 20 MW and above should be catered from 220 kV GSS. We propose to construct a 220 kV GIS station in Mansarover area. If, JMRC could provide a suitable piece of land at Mansarovar Depot, then we can construct a 220/132 kV GIS sub-station and provide required 132 kV bays to DMRC. In the process, you may save the cost of laying of 132 kV cable from our station. Otherwise, we shall provide power supply from our existing 132 kV GSS at Mansarovar and other places as under:

Corridor	Planned Metro Route	GSS close to the proposed alignments
Corridor-1	Durgapura to Ambabari via Kendriya Vidyalaya & SMS Hospital	Mansarovar Depot on 132 kV GSS Mansarovar.
Link Line	From SMS Hospital to Transport Nagar	01 No. 132 kV bay at 132/33 kV SMS stadium for supply of 8 to 10 MW supply.
Corridor-2	Badi Chopar to Mansarovar via Railway Station & Shyam Nagar	01 No. 132 kV bay at 132/33 kV GIS sub-station, PWD bunglow at Station Road near RSRTC bus stand.

Yours faithfully,

(Y.K.Raizada)
Director (Tech.)

Tel.: 0141-2740...(O), 27...(Res.) Fax: 0141-2740794 email: ...

Y.K. Raizada
DIRECTOR (TECHNICAL)

Rajasthan Rajya Vidyut Prasaran Nigam Ltd. (RVPN
(A Successor Company of R.S.E.B.)
Vidyut Bhawan, Janpath, Jyoti Nagar, Jaipur-302 005

No. RVPN/Dir(Tech.)/CE(PPM&R)/SE(D)/ D. 4211 Jaipur, dated 16/12/09

The Executive Director (Electrical),
Delhi Metro Rail Corporation Ltd.,
Metro Bhawan, Fire Brigade Lane,
Barakhamba Road,
New Delhi-110 001.

Sub:- Jaipur Metro Rail Project - Power Supply requirement & sources.
Ref:- This office letter No. RVPN/Dir(Tech.)/CE(PPM&R)/ SE(D)/ D.4149 dated 11.12.2009.

Dear Sir,

Further to my aforesaid letter, it is to intimate that in case we are provided a piece of land measuring about 3,000 sq.m near Jawahar Circle for 132 kV GIS sub-station, then we shall be in a position to provide 132 kV GIS bays from that station to Durgapura Depot of Jaipur Metro Rail otherwise 132 kV bays shall be provided from 132 kV GSS Mansarovar.

Regarding intermediates, in addition one No. 132 kV GIS feeder from each at SMS Stadium and PWD 132 kV GIS, additional bays can be provided at these stations at 33 kV voltage level as per requirement of Jaipur Metro Rail.

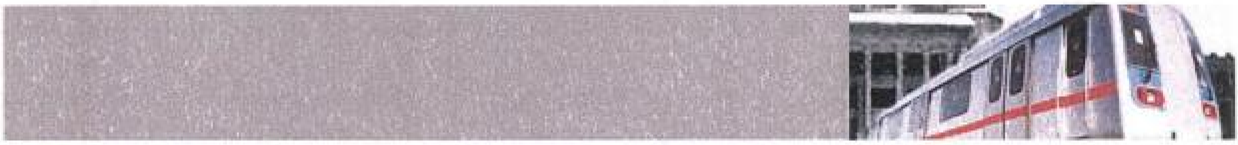
Yours faithfully,

(Y.K.Raizada)
Director (Tech.)

Tel. : 0141-2740827 (O), 2782068 (Res.) Fax : 0141-2740794 email : ppmrvpn@sancharnet.in

Chapter 8

Ventilation and Air-Conditioning System



CHAPTER 8

VENTILATION AND AIR-CONDITIONING SYSTEM

(For Jaipur Metro Underground Corridor)

8.1 Introduction:

This chapter covers the Ventilation and Air-conditioning (VAC) system requirements for the underground sections of the proposed Jaipur Metro alignment. It includes the following:

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

8.2 Alignment:

The East-West Corridor is having underground section of 2.789 km and includes 3 underground stations.

The MRTS alignment passes through the heart of the city. The underground section of East-West corridor starts from Badi Chopar and passes through Chotti Chopar and Chand Pole Metro Stations. The inter-station distances vary from 786 meters to 1221 meters.

8.3 Need for Ventilation and Air Conditioning

The underground stations of the Metro Corridor are built in a confined space. A large number of passengers occupy concourse halls and the platforms, especially at the peak hours. The platform and concourse areas have a limited access from outside and do not have natural ventilation. It is therefore, essential to provide forced ventilation in the stations and inside the tunnel for the purpose of:

- Supplying fresh air for the physiological needs of passengers and the authority's staff;
- Removing body heat, obnoxious odours and harmful gases like carbon dioxide exhaled during breathing;
- Preventing concentration of moisture generated by body sweat and seepage of water in the sub-way;
- Removing large quantity of heat dissipated by the train equipment like traction motors, braking units, compressors mounted below the under-frame, lights and fans inside the coaches, A/c units etc.;
- Removing vapour and fumes from the battery and heat emitted by light fittings, water coolers, Escalators, Fare Gates etc. working in the stations;
- Removing heat from air conditioning plant and sub-station and other equipment, if provided inside the underground station.

This large quantity of heat generated in M.R.T. underground stations cannot be extracted by simple ventilation. It is, therefore, essential to provide mechanical cooling in order to remove the heat to the maximum possible extent. As the passengers stay in the stations only for short periods, a fair degree of comfort conditions, just short of discomfort are considered appropriate. In winter months it may not be necessary to cool the ventilating air as the heat generated within the station premises would be sufficient to maintain the comfort requirement.

8.4 External Environment Conditions and Weather data

The design weather data from the ASHRAE handbooks have been used to arrive at the design criteria. For VAC system, it is suggested that 1% criteria would be acceptable on techno economic reasons. The climate pattern in Jaipur suggests that the summer and Monsoon season is generally between March to September. During the October and February months the weather generally has winter conditions

There is a critical need for maintaining desired Air – Quality (Environmental control) in public places like MRT stations. High content of suspended particles, Carbon Mono-oxide, Sulphur Dioxide etc. discharged in the air from moving traffic, industries, etc requires consideration of appropriate measures for air -pollution control in metro stations, while designing the VAC system.

8.5 Sub Soil Temperature

The temperature conditions of sub-soil play a vital role in the system design of the underground stations. It is proposed that water table surrounding the underground alignment shall be reviewed and is vital for facilitating adequate heat exchange between the tunnel structures and soil. The sub soil temperature of Jaipur is to be obtained/ measured.

8.6 Internal Design conditions in Underground Stations

With hot and humid ambient conditions of Jaipur during the summer and monsoon months, it is essential to maintain appropriate conditions in the underground stations in order to provide a 'comfort-like' and pollution-free environment. The plant capacity and design of VAC system needs to be optimized for the "Designed inside Conditions".

The Indian Standards & Codes, which pertain to office-buildings, commercial centers and other public utility buildings. The standards used for buildings are not directly applicable for the underground spaces, as the heat load gets added periodically with the arrival of the train.

The patrons will stay for much shorter durations in these underground stations, the comfort of a person depends on rapidity of dissipation of his body heat, which in turn depends on temperature, humidity and motion of air in contact with the body. Body heat gets dissipated is given out by the process of evaporation, convection and conduction. Evaporation prevails at high temperature. Greater proportion of heat is dissipated by evaporation from the skin, which gets promoted by low humidity of air. The movement of air determines the rate of dissipation of body heat in the form of sensible and latent heat.

There are different comfort indices recognized for this purpose 'Effective Temperature' criterion was used in selecting the comfort conditions in earlier metro systems, including the north-south section of Kolkata Metro) .In 'Effective Temperature' criterion, comfort is defined as the function of temperature and the air velocity experienced by a person. More recently a new index named RWI (Relative Warmth Index) has been adopted for metro designs worldwide and in Delhi Metro. This index depends upon the transient conditions of the metabolic rate and is evaluated based on the changes to the surrounding ambience of a person in a short period of about 6 to 8 minutes. It is assumed that during this period human body adjusts its metabolic activities. Therefore in a subway system where the train headway is expected to be six minutes or less, RWI is the preferred criterion.

8.7 Design parameters for VAC system

Based on the above, the following VAC system design parameters are assumed in the present report.

(1) Outside ambient conditions:

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

	1% Criteria
Summer :	41.10 DB, 21.3 WB
Monsoon:	32.0 DB, 27.9 WB

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

(2) Inside design conditions:

Platform areas	-	27 deg. C at 55 % RH
Concourse	-	28 deg. C at 60% RH

(3) Tunnel design conditions

Normal conditions	–	Max. DB 40 deg. C

Congested conditions -- Max. DB 45 deg. C

(4) Minimum fresh air - 10 % or 18 cmh / person

(in station public areas).

8.8 Design Concepts for VAC system

There are various VAC design concepts technically feasible in a subway system that can provide and maintain acceptable subway environment conditions under different requirement and constraints. These are: Open type; Closed type; platform screen doors etc. The experience available from the design of VAC system for Delhi Metro provides key guidelines for Jaipur Metro.

From the experience of DMRC, it can be concluded that with open shaft system the piston effects can be sufficient to maintain acceptable conditions inside the tunnel, as long as the ambient DB temperature is below 33^0 C. When the outside temperature is higher than 33^0 C the tunnel shafts should be closed to prevent any further exchange of air with atmosphere. The station premises (public areas) can be equipped with separate air-conditioning system during the summer and monsoon months to provide acceptable environment for patrons. There shall be provision of Trackway Exhaust System (TES) by which platform air can be re-circulated. The train cars reject substantial heat inside subway. When the trains dwell at the stations TES would capture a large portion of heat released by the train air conditioners mounted on the roof tops and under gear heat because of braking, before it is mixed with the platform environment.

8.9 Trackway Exhaust System (TES)

The TES is to be installed in the train ways of each station to directly capture heat rejected by the vehicle propulsion, braking, auxiliary and air conditioning systems as the train dwells in the station. The TES includes both an under platform exhaust (UPE) duct and an Over-trackway (OTE) exhaust duct. The TES uses ducts formed in the under platform void and over the trackway. Exhaust intakes are to be located to coincide with the train-borne heat sources.

Trackway Exhaust Fan

8.10 Ventilation and Air Conditioning of Ancillary Spaces

Ancillary spaces such as Staff Room, Equipment Room, will be mechanically ventilated or air conditioned in accordance with the desired air change rates and temperatures/humidity.

All ancillary areas that require 24-hour air conditioning will be provided with Fan Coil Units (FCUs) main Chilled Water plant for running during the revenue hours and with Air Cooled Chillers or standby AC units or VRV system for running during the non-revenue hours. Return air will be circulated through washable air filters.

Where fresh air is required it will be supplied to the indoor unit via a fresh air supply system, complete with filter, common to a group of ancillary areas.

8.11 Station Smoke Management System

The Trackway Exhaust and Concourse Smoke Extract Fans will be provided for smoke extract purposes from the public areas and will operate in various modes depending on the location of the fire. The control of this system in fire mode will be fail-safe. These exhaust fans will be provided with "essential" power supplies, with automatic changeover on loss of supply.

Down stand beams will be provided underneath the ceiling around floor openings for stairs and escalators, so that a smoke reservoir is formed on the ceiling. The smoke will be contained in this reservoir at ceiling level and exhausted to atmosphere. By controlling smoke in this manner, it is possible to maintain a relatively smoke clear layer above human head height and to protect the escape route, giving sufficient time for evacuation. The stations will be designed to accommodate the full smoke exhaust volumes and thus prevent the reservoir from completely filling with smoke. To provide an additional barrier against smoke migration, the overall smoke management system would be designed to provide a draught of fresh air through entrances and escape routes, to assist in protecting those routes from smoke.

8.12 System Components for VAC

The various components and equipment used in the VAC system are described in the following sections:

8.12.1 Station Air Conditioning

The platform and concourse areas will be air-conditioned using supply 'Air Handling Units' located in Environmental Control System (ECS) plant rooms throughout the station. Each platform will be served by at least two separate air handling units (AHU's) with the distribution systems combined along each platform to ensure coverage of all areas in the event of single equipment failure. Based on the initial estimation about 4 units of 25 cum/s each would be needed for the full system capacity.

Concourse Air Handling Unit

These air conditioning systems mix return air with a desired quantity of outside air. The outside air requirement is based on occupancy, with a minimum of 5 liters per second per person or 10% of circulated air volume, whichever is the greater. The provision of free cooling by a simple two-position economizer control system will be included, with the use of enthalpy sensors to determine the benefits of using return air or outside air. This will signal the control system to operate dampers between minimum and full fresh air, so as to minimize the enthalpy reduction needed to be achieved by the cooling coil. This mixture of outside and return air is then filtered by means of suitable filters and then cooled by a cooling coil before being distributed as supply air via high level insulated ductwork to diffusers, discharging the air into the serviced space in a controlled way to minimize draughts. Return air to the platform areas is extracted via the trackway exhaust system and either returned to the AHU'S or exhausted as required.

Water-cooled chiller units with screw compressors are recommended to be provided at each station, which are energy efficient. These units can be installed in a chiller plant room at surface level. Based on the initial concept design, the estimated capacity for a typical station would be around 900 TR, hence three units of 300TR (including one stand-bye) may be required for full system capacity (i.e. design PHPDT traffic requirement). During the detail design stage this estimated capacity might get marginally changed for individual station depending on the heat loads calculated through SES analysis.

Platform Air Handling Unit

8.12.2 Space Requirement for VAC System

The station air conditioning equipment plant rooms are normally located at each end of the concourse for the two level stations. The approximate area for air handling equipment room would be 800 sq. m at each end of the station. There shall be supply shafts and exhaust shafts of about $10m^2$ each at each end of the stations.

8.13 Control and monitoring Facilities

For the underground stations the control and monitoring of station services and systems such as station air-conditioning, ventilation to plant rooms, lighting, pumping systems, lifts & Escalators, etc shall be performed at Station Control Room (SCR). However, the operation and control of Tunnel Ventilation as well as Smoke Management system will normally be done through OCC. All these systems shall be equipped with automatic, manual, local and remote operation modes. The alarms and signals from the equipment at stations shall be transmitted to the OCC via communication network (such as FOTS).

There shall be an Auxiliary Power Controller at OCC who will be monitoring these services and systems. The command signals will be initiated at OCC and relayed upto the relevant equipment for operation. The feedback signal is received through SCADA whether the command is implemented or not. The control from OCC is generally performed using 'Mode Tables' for each system. This table defines the sequence of the desired equipment that needs to be operated based on the event. The abnormal conditions such as train congestion, emergency, fire in subway would be detected by various components and the emergency response thereto will be activated based on the mode tables. In the event that remote control is not possible due to any reason, the local control via SCR would be performed. The OCC will also be used for logging the alarm status, fault occurrences, and other maintenance related data for the above systems.

8.14 Codes and Standards

The concept VAC design is guided by the following codes and standards:

(a) SEDH – Subway Environment Design Handbook

(b) ASHRAE – Handbook, current series.

(c) CIBSE – relevant document.

(d) NFPA – 130, 2003 edition.

(e) ECBC- Energy Conservation Building Code

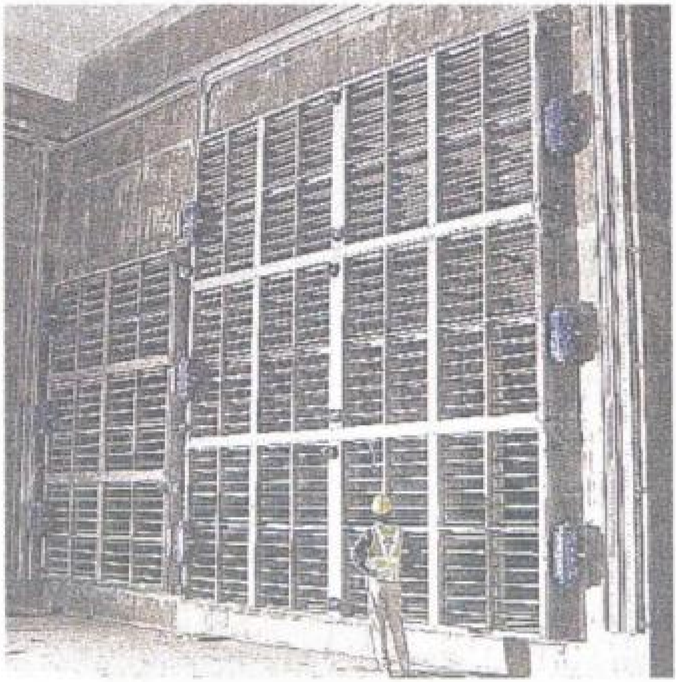
8.15 Design Concepts for TVS system

There are various TVS design concepts technically feasible in a subway system that can provide and maintain acceptable subway environment conditions under different requirement and constraints. These are: Open type; Closed type; Use of jet fans; use of mid-shafts; etc. The experience available from the design of TVS system for Delhi Metro also provides key guidelines.

From the experience of DMRC, it can be concluded that with open shaft system the piston effects can be sufficient to maintain acceptable conditions inside the tunnel, as long as the ambient DB temperature remains below 33^0 C. When the outside temperature is higher than 33^0 C the tunnel shafts should be closed to prevent any further exchange of air with atmosphere.

Under the normal train running the train heat generated inside the tunnel sections would be removed by the train piston action. It is envisaged that for the design outside conditions, it may not be necessary to provide forced ventilation using Tunnel Ventilations Fans for normal operating conditions. Two tunnel ventilation shafts would be provided at the end of the stations. These end-shafts at the stations also serve as Blast Relief Shafts i.e. the piston pressure is relieved to the atmosphere before the train reaches the station. All these shafts are connected to the tunnels through dampers. The dampers are kept open when the exchange of air with the atmosphere is permitted (Open Mode). For the Closed Mode system the shaft dampers can be in closed mode and the displaced air is dumped in the adjacent tunnel.

Generally each tunnel ventilation shaft is connected to a fan room in which there are two reversible tunnel ventilation fans (TVF) are installed with isolation dampers. These dampers are closed when the fan is not in operation. There is a bypass duct around the fan room, which acts as a pressure relief shaft when open during normal conditions, and enables the flow of air to bypass the TV fans, allowing air exchange between tunnel with flows generated by train movements. Dampers are also used to close the connections to tunnels and nozzles under different operating conditions. The details for the shaft sizes, airflow exchange with the atmosphere, fan capacities can be estimated in a more accurate manner with the help of Computer Simulations during the detailed design stage.



Tunnel Ventilation Dampers

8.16 Tunnel Ventilation Systems (TVS)

The TVS is provided in a Subway system essentially to carry out the following functions:

(a) Provide a tenable environment along the path of egress from a fire incident in enclosed stations and enclosed train ways.

(b) Produce airflow rates sufficient to prevent back layering of smoke in the path of egress within enclosed trainways.

(c) Be capable of reaching full operational mode within 180 seconds.

(d) Accommodate the maximum number of trains that could be between ventilation shafts during an emergency.

Tunnel Ventilation Fan

There are various operating modes (scenarios) for the Tunnel Ventilation system. These are described as under:

8.16.1 Normal Conditions

Normal condition is when the trains are operating to timetable throughout the system, at prescribed headways and dwell times, within given tolerances. The primary source of ventilation during normal conditions is generated by the movement of trains operating within the system and, in some cases, the trackway exhaust system.

During summer and the monsoon seasons, the system will be functioning essentially with the station air conditioning operating. The vent shafts to the surface will enable the tunnel heat to be removed due to train movements. The platform air captured by the trackway exhaust system shall be cooled and recirculated in the station. For less severe (i.e. cool) environmental conditions (or in the event of an AC system failure), station air conditioning will not be used and ventilation shafts will be open to atmosphere (open system) with the trackway exhaust system operating. For cold conditions, the closed system or open system mode may be used, but without any station air conditioning. System heating is achieved by the train heat released into the premises.

8.16.2 Congested Conditions

Congested conditions occur when delays cause disruption to the movement of trains. It is possible that the delays may result in the idling of a train in a tunnel section. Without forced ventilation, excessive tunnel temperatures may result reduced performance of coach air conditioners that may lead to passenger discomfort.

During congested operations, the tunnel ventilation system is operated to maintain a specific temperature in the vicinity of the car air conditioner condenser coils (i.e. allowing for thermal stratification). The open system congested ventilation shall be via a 'push-pull' effect where tunnel vent fans behind the train are operated in supply and tunnel vent fans ahead of the trains are operated in exhaust mode. Nozzles or booster (jet) fans will be used to direct air into the desired tunnel, if required.

8.16.3 Emergency Conditions

Emergency conditions are when smoke is generated in the tunnel or station trackway. In emergency conditions, the tunnel ventilation system would be set to operate to control the movement of smoke and provide a smoke-free path for evacuation of the passengers and for the fire fighting purposes. The ventilation system is operated in a 'push-pull' supply and exhaust mode with jet fans or nozzles driving tunnel flows such that the smoke is forced to move in one direction, enabling evacuation to take place in the opposite direction depending upon the location of Fire on the train.

8.17 Pressure Transients

The movement of trains within the underground system induces unsteady air motion in the tunnels and stations. Together with changes in cross section, this motion of air results in changes in air pressure within trains and for wayside locations. These changes in pressure or 'pressure transients' can be a source of passenger discomfort and can also be harmful to the wayside equipment and structures. Two types of transient phenomenon are generally to be examined:

a) Portal Entry and Exit Pressure Transients – As a train enters a portal, passengers will experience a rise in pressure from when the nose enters until the tail enters. After the tail enters the pressure drops. Similarly, as the nose exits a portal, pressure changes are experienced in the train. There are three locations of the portal one between SMS Hospital to Ajmeri Gate ,Pani Petch station to Ambabari and third between Chand Pole and Sindhi camp station.

b) Wayside Pressure Transients – As trains travel through the system they will pass structures, equipment and patrons on platforms. Equipment would include cross passage doors, lights, dampers, walkways etc. Pressures are positive for the approaching train and negative for retreating trains. Most rapid changes occur with the passage of the train nose and tail. The repetitive nature of these pressures may need to be considered when considering fatigue in the design of equipment.

The detailed analysis to assess the effect of pressure transients will be done during the design stage. For the portal entry/exits the effect of higher train speed may pose discomfort to the passengers. Although, based on the recent studies, it is assumed that a design train speed of 80 kmph would not be of major concern. The estimation of Way-side transients during design stage would be necessary to select design mechanical strength of the trackside fixtures, e.g. false ceilings, light fittings etc at the platform levels.

8.18 Tunnel Ventilation System

Tunnel ventilation fans will be installed in each of the fan rooms near vent shafts. There shall be two fans in a fan room at each end of the station. The fan capacity depends on the inter-station distances and may vary from 60 m^3/s to 100 m^3/s depending upon the length and cross section of the tunnel. The exact capacity will be obtained through the simulation during detailed design stage. If necessary, nozzle type structures made up of concrete or steel may also be constructed to achieve desired airflow and air velocity in the tunnel sections. Alternatively booster fans (jet fans) may be installed to direct the flow in the desired direction. These fans may also be used for emergency ventilation at crossover locations.

The trackway exhaust system will have three fans of each 21 cum/sec. for each platform. The connections to tunnels and shafts will be through damper units that may be either electrically or pneumatic actuated.

A comprehensive remote control and monitoring system for operation and control of tunnel ventilation system will be installed. The alarm and status signals from the equipment will be transmitted to operations control centers (OCC) through SCADA. The activation command for a group of equipment will be initiated from OCC by the controller. There shall be a mode table defining sequence of equipment operation for each event or scenario.

8.18.1 Space Requirement for Tunnel Ventilation System

The tunnel ventilation equipment plant room is normally located at each end of the concourse for the two level stations. The approximate area for tunnel ventilation fan room would be 600 sq. m. respectively at each end of the station. The tunnel vent shafts of approximately 20 sq. m. area will be constructed at each end of the stations. There shall be supply shaft and exhaust shafts of similar dimensions at the stations. For the underground stations with large inter station distances there may be necessity of constructing mid tunnel shaft. This will not be required for Jaipur Metro.

Chapter 9

Depot cum Workshops

CHAPTER 9

DEPOT CUM WORKSHOPS

9.1 Jaipur Metro System covers Sitapura – Ambabari section in N-S Corridor and Badi-Chopar to Mansarovar section in E-W corridor.

9.2 **Detail of Gauge and length**

Corridor (E-W)	Gauge(mm)	Route Length (KMs)
Badi-Chopar – Mansarovar	1435	12.067

9.3 The depot planning is based on following assumptions:

i) There is no connectivity between N-S Corridor and E-W corridor to transfer trains from one line to another else it would have reduced depot requirement in line 2.

ii) Enough space is available at Bambala Nala and Mansarover terminals for establishment of Depot-cum-workshop and a satellite depot respectively.

iii) Road transport shall be available for transporting heavy equipments for IOH/POH and heavy repairs from Mansarover depot to Bambala Nala depot-cum-workshop and vice-versa.

iv) All inspection and workshop lines are designed to accommodate 6- car trains.

v) SBLs at terminal stations shall accommodate 6 - car trains and SBLs within depots shall accommodate 6 – car trains.

9.4 It is proposed to establish a depot-cum-workshop at Bambana Nala and a small depot at Mansarover with following distribution of activities.All heavy maintenance of line 2 will also be performed at Bambana Nala depot.

Bambala Nala Depot

i) All minor inspection of E-W corridor

ii)All POH/IOH, heavy repair work of E-W corridor

iii) All POH/IOH & heavy repairs work of all equipments of all the trains of E-W corridor

Mansarover

i) All minor inspections of E-W corridor

ii) All minor repairs

iii) Lifting of coaches for replacement of heavy components.

iv) Stabling of all the trains of E-W corridor

9.5 In broad terms this chapter covers conceptual design on following aspects and will work as a guide for detailed design later:

- Layout of Stabling-shed, Inspection-shed, heavy repair, minor repairs, maintenance 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.

9.6 MAINTENANCE NEEDS TO ROLLING STOCK

- ➢ Monitoring of the performance of equipment by condition monitoring of key parameters. The concept is to evolve the need based maintenance regime, which can be suitably configured in the form of schedules like daily check, "A" checks, "B" type checks, "IOH" and "POH".
- ➢ Labour intensive procedures are kept to the minimum. Automation with state of the art machinery to ensure quality with reliability.
- ➢ Multi skilling of the Maintenance staff to ensure quality and productivity in their performance.
- ➢ Energy conservation is given due attention.

9.6.1 ROLLING STOCK MAINTENANCE NEEDS

i) Maintenance Schedule

The following maintenance schedule has been envisaged for conceptual design of depots assuming 485 kms for both lines running per train per day, taking in consideration the passenger load of 2014, 2021 and 2031 respectively. *

Type of Schedule	Interval	Work Content	Locations
Daily	Daily	Check on the train condition and function at every daily service completion. Interval cleaning/mopping of floor and walls with vacuum cleaner.	Stabling Lines
"A" Service Check	5,000 Km (10 days)	Detailed inspection and testing of sub - systems, under frame, replacement/topping up of oils & lubricants.	Inspection Bays
"B" Service Check	15,000 Km (30 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 Years)	Check and testing of all sub-assemblies (Electrical + Mechanical). Overhaul of pneumatic valves, Compressor. Condition based maintenance of sub-systems to bring them to original condition. Replacement of parts and rectification, trial run.	Workshop
Periodical Overhaul (POH)	840,000 Km,(6 Years)	Dismantling of all sub-assemblies, bogies suspension system, traction motor, gear, control equipment, air-conditioning units etc. Overhauling to bring them to original condition. Checking repair and replacement as necessary. Inspection and trial.	Workshop
Heavy Repairs	-	Changing of heavy item such as bogies, traction motor, axles, gear cases & axle boxes etc.	Workshop

ii) Washing Needs of Rolling Stock

Cleanliness of the trains is essential. Following schedules are recommended for environment of at Jaipur:

S.N.	Kind Inspection	Maint. Cycle	Time	Maintenance Place
1.	Outside cleaning (wet washing on automatic washing plant)	3 Days	10 mins.	Single Pass through Automatic washing plant of Depot
2.	Outside heavy Cleaning (wet washing on automatic washing plant and Front Face, Vestibule/Buffer area. Floor, walls inside/outside of cars and roof. Manually)	30 days	2 – 3 hrs.	(Automatic washing plant & cleaning & washing shed)

9.6.2 (i) Year-wise planning of maintenance facility setup at joint depot cum workshop of depot on East – West, Corridor at Mansarovar is tabulated below as per TOP:

Year	Headway		No. of Rakes		No. of Coaches	
	N-S	E-W	N-S	E-W	N-S	E-W
2014	5.0	6.0	21	10	84	40
2021	3.5	4.0	29	15	116	60
2031	3	2.5	33	22	132	88

(ii) Average earning/day/rake as per TOP

Year	N-S	E-W	Remarks
2014	520	486	• 'A' inspection frequency after every 10 days. • 'B' inspection after every 30 days.
2021	524	486	
2031	520	510	

(iii) Bare requirement of Stabling Lines

Year	2014	2021	2031
N-S	21	29	33
E-W	10	15	22
Total	31	44	55

(iv) Distribution of Stabling and Inspection and WSL Lines in N-S and E-W corridor depots

Year	No. of Trains	N-S Bambana Nala Depot			No. of Trains	E-W Mansarover Depot		
		SBLs	IBLs	WSLs		SBLs	IBLs	WSLs
2014	21	19 lines x 6-car	4 lines x 6-car (2 bays of 2 lines each)	4 lines	10	8 lines x 6-car	3 lines x 6-car (one bay)	2 lines
2021	29	27 lines x 6-car	-do-	-do-	15	13 lines x 6-car	-do-	-do-
2031	33	32 lines x 6-car	-do-	-do-	22	20 line x 6-car	-do-	-do-

*All the lines are planned for planned for 6-Car rakes.

9.7 Requirement of maintenance / Inspection lines for depot-cum-workshop at N-S corridor at Bambala Nala:

Schedule	Maintenance Requirement (No. of Cars)	Lines Needed
i) Year 2014 (Maximum no. of rake holding is (21X4)= 84 Cars)		
'A' Checks (5000 km) 10 days	(21X4) Cars = 84 Cars	2 Line x 6 cars (with Sunken Floor)
'B' Checks (15000 km) 30 days	(21X4) Cars = 84 Cars	1 Line x 6 cars (with Sunken Floor)
Unscheduled line & adjustment lines	For minor repairs, testing and after IOH/POH adjustments	1 Line x 6 cars (with sunken Floor)
Requirement		2 bays of 2 lines each with provision of space for additional bay of two lines for work load beyond 2021.
ii) Year 2021 (Maximum no. of rake holding is (29X4) = 116 Cars		
'A' Checks (5000 km) 10 days	(29X4) Cars = 116 Cars	2 Lines X 6 Cars (with sunken floor)
'B' Checks (15000 km) 30 days	(29X4) Cars = 116 Cars	1 Lines X 6 Cars (with sunken floor)
Unscheduled line & adjustment lines	For minor repairs, testing & adjustments post major repairs / IOH & POH	1 Line X 6 Cars (with sunken floor)
Requirement		2 bays of 3 lines each with provision of space for additional bay of two lines for work load beyond 2021.
(iii) Year 2031 (Maximum no. of rake holding is (33X4) = 132 Cars		

'A' Checks (5000 km) 10 days	(33X4) Cars = 132 Cars	2 Lines X 6 Cars (with sunken floor)
'B' Checks (15000 km) 30 days	(33X4) Cars = 132 Cars	1 Lines X 6 Cars (with sunken floor)
Unscheduled line & adjustment lines	For minor repairs, testing & adjustments post major repairs / IOH & POH	1 Line X 6 Cars (with sunken floor)
Requirement		2 bays of 2 lines each with provision of space for additional bay of two lines for work load beyond 2031.

9.7.1 Requirement of Maintenance / Inspection lines for depot at Mansarovar (E-W Corridor):

i) Year 2014 (Maximum no. of rake holding is 10 X 4 = 40 Cars)		
'A' Checks (5000 km) 8-10 days	(10 X 4) Cars = 40 Cars	1 Lines X 6 Cars (with sunken floor)
'B' Checks (15000 km) 30 days	(10 X 4) Cars = 40 Cars	1 Lines X 6 Cars (with sunken floor)
Unscheduled line and adjustment lines.	For minor repairs, testing and after IOH/POH	1 Line X 6 Cars with sunken floor.
Requirement		1 bay of 3 lines
ii) Year 2021 (Maximum no. of rake holding is 15 X 4 = 60 Cars)		
'A' Checks (5000 km) 10 days	(15 X 4) Cars = 60 Cars	1 Lines X 6 Cars (with sunken floor)
'B' Checks (15000 km) 30 days	(15 X 4) Cars = 60 Cars	1 Lines X 6 Cars (with sunken floor)
Unscheduled line and adjustment lines.	For minor repairs, testing and after IOH/POH	1-Line X 6 Cars (with sunken floor)
Requirement		1 bay of 3 lines with provision of future expansion
(iii) Year 2031 (Maximum no. of rake holding is (22X4) = 88 Cars		
'A' Checks (5000 km) 10 days	(22X4) Cars = 88 Cars	1 Lines X 6 Cars (with sunken floor)
'B' Checks (15000 km) 30 days	(22X4) Cars = 88 Cars	1 Lines X 6 Cars (with sunken floor)
Unscheduled line & adjustment lines	For minor repairs, testing & adjustments post major repairs / IOH & POH	1 Lines X 6 Cars (with sunken floor)
Requirement		1 bay of 3 lines with provision of future expansion

9.7.2 Following facilities shall be provided to carry out the inspection of the following sub-systems/equipments:

- Electronics; PA/PIS
- Mechanical components, couplers etc
- Batteries
- Air conditioner
- Brake modules
- Bogie
- Traction Motor
- Vehicle doors, windows and internal fittings
- Power system including converter, circuit breaker etc.

These activities shall be grouped into "A" checks. The minor scheduled inspections ("A" checks) shall be carried out during the day off peak and night. Since "B" checks take longer time, these cannot be completed in the off peak times. Certain inspection lines will be nominated for "A" checks. For "B" checks, separate line will be nominated where the rakes may be kept for long time.

One dedicated line in Depot-cum-workshop will be used for the adjustment and testing after the IOH and POH.

9.8 DESIGN OF DEPOT FACILITIES

As per advised dimensions of the Rolling Stock, the absolute length of 4-Car and 6 - car trains would be 89.4m (say 90m) and 135.6m respectively. However in the design of the Inspection shed, workshop lines and stabling lines at terminal stations, length of 6-car train is taken in consideration.

9.8.1 i) Stabling Lines at Depots at Mansarover:

S.No.	6-Car
1	Length of rake=**135.6m** (Say 136m)
2	Minimum length of SBL=136 (rake length) + 20m (for cross pathway, Signal and friction buffers) = **156 meters**

ii) Stabling lines are designed for 156m length to cater for safe gap from the friction buffer stops and the signaling interlocking needs. Looking to the car width of 2900 on SG, 5.0m "Track Centre" is proposed for all the stabling lines. Thus, space between stabling shall be sufficient to include 800mm wide paved 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 Sheds at Bambala & Mansarover

All IBLs are computed for 6 – Car trains

Length = [Cross path at end + space for friction buffer stop + Length of Rake + Cross path at end which keeps Gap from gate]

Length = 10.0m + 136.0m + 10.0m = 156m

At Mansarovar depot one bay of 3-lines of size 156 X 20 m shall be sufficient to take care of minor inspection load of trains in line II from the year 2014 to 2021.

Roof Inspection platforms and walk-ways for roof inspection supported on the columns shall be provided. There would be lighting below the rail level to facilitate the under frame inspection. Ramps of 1:8 slopes, 3 meter wide have been provided with sunken floor system for movement of material for the cars. Further, 5m 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. Each inspection line 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 have arrangement close by for cleaning of HVAC filter under high pressure water jet.

9.8.3 Depot at Mansarovar (E-W Corridor)

In addition to inspection bay as indicated in Para 8.2, there shall be a two-line workshop bay of size 156 X 21 m for lifting, replacement of heavy components like TMs, HVAC, Bogies, and axle provided with overhead cranes spanning the bay, pit jacks to facilitate 2-car unit should be provided & the lines shall be linked through turn-tables for transfer of Equipments. One of the line in the bay shall be provided with pits to facilitate undercarriage inspection and lowering undercarriage equipment. There shall be an array of rooms for testing of small components like pneumatic components, small motors, control equipments & machinery as indicated in annexure I and II. There shall be space for stacking of overhauled equipment and also for outgoing equipment of IOH/POH. The list of M&P is placed at Annexure II.

9.8.4 Workshop Line Requirements at depot-cum-workshop at Bambala Nala, Line-1:

Year	IOH	POH	Heavy Lifting	Wheel & Bogie Storage	Total	Remarks
2014	1	1	1	1	4	• Two bays of 2 WSL each with provision for expansion by one bay of 2 lines for future i.e. 2014-21. • All POH/IOH, heavy repairs of all the trains of both the corridors is concentrated here.
2021	2	1	2	1	6	
2031	-	-	-	-	6	

i. There shall be two Bays comprising of two lines each. Size of each workshop bay is proposed to be 156m x 21m. Two bays will be operational immediately and extension of III[rd] bay shall be complete by 2021. The unscheduled lifting and heavy repair line shall be fitted with jack system capable to lift the 2-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.

These lines are to be provided with pits at regular intervals for inspection of undercarriage with turn tables at the end. Each workshop bay shall be equipped with two 15T and 3T overhead cranes each spanning the entire length of the workshop bay.

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, Powers supply points and compressed air supply line shall be provided on each workshop column.

Workshop lines shall be inter-linked through turn tables, each suitable for movement of a train in AW0 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 that it does not affect the movement inside workshop.

There shall be walk-ways on columns for roof inspections, along the workshop lines,. These walk-ways 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 walk-way has to be ensured to avoid conflict in lifting and lowering of cars.

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.

The workshop shall cater to the IOH/POH and heavy repair requirement of all the trains of line-1 also.

ii. Workshop will have service building with array of rooms along its length. Total size is proposed to be 156 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 size 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.

iii. There shall be space for bogie/axle repair shop with necessary infrastructure for disassembly, overhaul, assembly and testing of mechanical components of bogie/axle. The repair shop shall be easily approachable from within the workshop for transportation of components.

Following equipment; repair/overhaul facilities are planned in the workshop and wheel repairs shop at the workshop:

1. Body furnishing
2. Bogie
3. Wheels
4. Traction Motors
5. Axle Box and Axle Bearing
6. Pantographs
7. Transformer, converter/inverter, circuit breaker
8. Battery
9. Air Compressor

10. Air-conditioner
11. Brake Equipment
12. Door actuators
13. Control and measuring equipments
14. Pneumatic equipment
15. Dampers and Springs
16. Couplers/Gangways
17. Coach Painting

9.9 Car Delivery Area

As the coaches are of standard gauge, these shall reach the Depot-cum Workshop by the road on trailers. To unload the coaches and bring them to the track, provision of space, along the side of shunting neck, has to be made for unloading of cars and other heavy materials. This area shall have an insulated track embedded in the floor facilitating the movement of road trawler, which brings in the cars. The length of the track embedded area shall be about 40m long. There should be enough space available for movement of heavy cranes for lifting of coaches. The unloading area should be easily accessible for heavy duty hydraulic trailers.

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 headway of main line is not affected. Simultaneous receipt and dispatch of trains from depot to main line is feasible in the present site scenario. Both of these activities will be done effectively without effecting the train operation on the main line. The stabling lines would be interlocked with the main line thereby induction of train from the stabling would be safe and without loss of time. The proposition for a transfer track on the incoming line as well as on the outgoing line to facilitate the movement of rake in the depot by Operation Control Centre (OCC) even though the further path inside the depot is not clear shall be explored in the detailed design stage depending on the actual availability of land.

An emergency line is also provided from which an emergency rescue vehicle may be dispatched to main line in the event of emergency if necessary.

9.11 Infrastructure Facilities

I. Inspection Shed

As indicated in paras 9.8.2 & 9.8.3

II. Stabling Lines in Depots

a) The requirement of lines shall be in accordance with the table indicated at 6.2 (IV). A part of 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 adjacent to stabling lines shall be provided with small room for keeping cleaning aids and for utilization by the contractor's staff.

III. Automatic Coach Washing Plants at Mansarover

Provision to be made for Rolling Stock exterior surfaces to be washed using a fully automated Train Washing System, with a throughput capacity of approximately ten trains per hour. The AWP shall be situated at such a convenient point on the incoming route so that incoming trains can be washed before entry the depot and undesirable movement/shunting over ingress and egress routes within the depot is avoided. Additional space for plant room for AWP system shall be earmarked along-side the washing apron as indicated at serial no. 6 of Annexure-I.

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 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 1000m in length covered & fenced is 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 6 Car train. In compliance to safety norms, the boundary of the track shall be completely fenced to prevent unauthorized tress passing 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 six car train 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 & 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. In the depots, other than at Bambana Nala, One auxiliary sub-station with DG set as standby is proposed to be provided.

VIII. Compressed Air Supply

Silent type compressor units shall be suitably installed inside the depots at convenient location for the supply of compressed air to workshop and Inspection sheds. Thus, the pneumatic pipeline shall run within the workshop and inspection bays as the case be lines should also 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 underground reserves.

X. Ancillary Workshop

This workshop will have a line at floor level with provision of pits. Arrangement for repairs of Shunters, Rail Road Vehicles and other ancillary vehicles will be provided. These vehicles will also be housed here itself. Heavy lifting works can be carried out in main workshop.

Ancillary workshop will be used for storing OHE/rigid OHE parts and their maintenance/repair for restoration of 25kV 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 vehicles and re-railing equipments.

   Since IOH/POH of equipments of line-2 has to be done at Bambana Nala, a lot of road transport will have to be utilized. Both the depots need to have enough space for parking of Road vehicles. Enough space will also have to be earmarked adjacent to workshops. Similarly provision of space for parking of re-railing equipments will have to be made close to the main exit gate of the Depots.

XIV. **Shed and Buildings**

The shed and buildings normally provided in the depot with their sizes and brief functions are indicated in Annexure-I. Some of these buildings are not depicted on the layout drawing. At the detailed design stage depending upon the land availability, the decision to locate these buildings can be taken. These can then be architecturally and functionally grouped.

XV. **Plant and Machinery**

(a) A separate building is planned for housing pit wheel lathe (PWL), approachable from workshop, inspection bay and stabling lines through rail and road for placement of cars for re-profiling of wheels within the depot along with space for depositing of scrap.

(b) Requirement of buildings and major plants and machinery, is given in Annexure III & IV for Mansarovar depots.

9.11.1 Following Safety features should be incorporated in the design of all the Maintenance Depots

I. 1.5 EOT cranes in the inspection bay should be interlocked with OHE in such a way that the cranes become operational only when OHE is isolated and grounded.

II. Red flasher lights should be installed along the inspection lines at conspicuous location to indicate the OHE is 'Live'.

III. Multi level wheel and TM stacking arrangement should be a inbuilt feature at the end of Workshop Lines.

IV. Pillars in the inspection bay & workshop should have provision for power sockets.

V. Placement of rakes from inspection/workshop lines on to washing lines for interior cleaning on their own power should be possible. Linking of OHE and its isolation at the cleaning area should be provided. Necessary requirements of safety should be kept in view.

VI. The roof inspection platform should have at least two open able doors to facilitate staff to go up the roof for cleaning of roof. Suitable safety interlock should be provided to ensure maintenance staff are enabled to climb on the roof inspection platform only after the OHE is isolated.

VII. Control Centre, PPIO & store depot must be close to Workshop.

VIII. 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.

IX. Provision of water hydrants should be done in workshops stabling yards also.

X. Compressed air points along with water taps should be available in interior of buildings for cleaning.

XI. Ventilation arrangement inside the inspection shed and workshop.

Both the depot-cum-workshop will have all the facilities shown above.

Annexure-I

List of Buildings at Depot at Mansarovar

Depot-cum-workshop at Mansarovar (Line-2):

S. No	Name of Building	Size	Brief Function
1.	Inspection Shed	156 x 20 m	Servicing of Cars for 10 days & 30 days inspection.
	Running repair shed	156 x 21 m	Lifting of cars for unit replacement of repaired bogies, wheels, under hung electric and mechanical equipments.
	Associated Sections	150 x 8 m	Rooms for carrying out the inspection & workshop activity.
2.	Stores Depot & Offices including Goods Platform with Ramp	40 x 25 m	i. Stocking of spares for regular & emergency requirement including consumable items. ii. This store caters for the requirement of depot for rolling stock & other disciplines. iii. To be provided with computerized inventory control. iv. Loading/Unloading of material received by road.
3.	Elect. Substation DG set room	20 x 15m	To cater for normal and emergency power supply for depot, workshop, service and all other ancillary buildings, essential power supply for essential loads and security light.
4.	Traction repair depot & E &M repair shop	80 x 20m (partly double storey)	Stabling and routine maintenance of shunting engine etc. & Traction maintenance depot. For maintenance of lifts/escalators and other General service works.
5.	Cycle / Scooter / Car Parking	80 x 6m 40 x 6m	i. Close to the depot entry. ii. Close to the stabling lines.
6.	Auto Coach washing plant	40 x 10m	For automatic washing of coaches. Washing apron is for collection of dripping water and its proper drainage.
7.	Washing apron for Interior Cleaning	110 x 6.5m	Heavy wet washing of rakes from inside, under frame, roof at 30 days interval.
8.	P.way office, store	80 x 20 m	i) For track maintenance of section and

S. No	Name of Building	Size	Brief Function
	& Workshop including Welding plant		depot. ii) To weld rails for construction period only. iii) To stable track Tamping machine.
9.	Security office & Time Office Garages (4 Nos.)	15 x 8m	For security personnel. For time punching For parking vehicle jeep, truck etc.
10.	Check Post (2 Nos.)	5 x 3m	For security check of incoming/outgoing staff material and coaches.
11.	Watch Tower (3nos)	3.5 x 2.5m	For security of the depot especially during nighttime.
12.	Depot control centre & Crew booking centre	25x20m (double storey)	To control movement of trains in and out of the depot & out of the depot & for crew booking.
13.	O.H raw water Tank	1,00,000 Ltrs. Capacity	Storage of water, capacity 1, 00,000 Ltrs each.
14.	Pump house Bore well	7.3 x 5.4 200 mm	Submersible type pump planned with 200 mm diameter bore well.
15.	Dangerous goods Store	15m x 10m	For Storage of paints, inflammables & Lubricants
16.	Traction 25/33kV sub station	15m x 10m	Traction Power Supply
17.	Waste Collection Bin	10m x 10m	Garbage dumping
18.	Repair shops for S & T	40 x 20m	For the AFC gates, Signaling and telecom equipment.
19.	Work shop Manager Office	30 x 20m	Office of Depot in charge
20.	ATP & ATO Room	10 x 8m	To keep equipments of ATP/ATO
21.	Waste Water Treatment Plant	12 x 6m	For treating the discharge waters of the depot and remove the oil, acids etc. before discharging into the river, with U/G tank.
22.	Canteen	150 sqm.	Canteen to cater staff of depot and workshop staff should be in a separate building with modern kitchen ware and facilities. Obligatory as per statuary requirements
23	Toilets (Gents) (Ladies)	10 x 7m 10 x 7m	These toilets shall be approachable both from workshop as well as from inspection bay and ladies toilet shall be completely insulated from gents toilet.

Annexure-II

List of Plants & Equipments at Mansarovar

S. No.	Equipment	Qty	Unit	Imp. / Ind.
1	Under floor Pit wheel lathe suitable for inside face to face turning,Chip crusher and conveyor for lathe on pit, Electric tractor for movement over under floor wheel lathe	1	Nos.	Imp
2	Mobile jacks 15T for lifting cars	8	Nos.	Imp
3	Pit jacks	4	Nos.	Imp
4	Re-railing equipment consisting of rail cum road vehicle and associated jack system etc	1	Set	Imp
5	Run through type Automatic Washing plant for Metro cars.	1	Nos.	Imp
6	Work lift platform	4	Nos.	Imp
7	Electric bogie tractor for pulling cars and bogies inside workshop	1	Nos.	Imp
8	Chemical cleaning tanks, ultrasonic cleaning tanks, etc	1	Set	Imp
9	Compressor for Inspection shed & shop air supply	2	Nos.	Ind
10	Travelling O/H crane Workshop 15 T:- 2 Nos; 3 T :- 2 Nos	2	Nos.	Ind
11	Mobile jib crane	2	Nos.	Ind
12	Mobile lifting table	2	Nos.	Ind
13	Carbody stands	8	Nos.	Ind
14	Bogie turn tables	2	Nos.	Ind
15	Underframe & Bogie blowing plant	1		Ind
16	AC filter cleaning machine	1	Nos.	Ind
17	Portable cleaning plant for rolling stock	1	Nos.	Ind
18	High-pressure washing pump for front and rear end cleaning of car	1	Nos.	Ind
19	Shot blast cleaner	1	Set	Ind
20	Axle shaft inspection station	1	Set	Ind
21	Industrial furniture	1	L.s.	Ind
22	Minor equipment and collective tools	-	Set	Ind
23	Induction heater	1	No.	Ind
24	Oven for the motors	1	No.	Ind
25	EMU battery charger	2	Nos.	Ind
26	Welding equipments (Mobile welding, oxyacetylene, fixed arc welding)	2	Set	Ind
27	Electric and pneumatic tools	-	Set	Ind
28	Measuring and testing equipment	-	Set	Ind
29	Tool kits	-	Nos.	Ind

S. No.	Equipment	Qty	Unit	Imp. / Ind.
30	Mobile safety steps	8	Nos.	Ind
31	Fork lift tractor	4	Nos.	Ind
32	Pallet trucks	4	Nos.	Ind
33	Diesel/battery Shunting Locomotive	1	Nos.	Ind
34	Road vehicles (pickup van/ truck)	2	Set	Ind
35	Miscellaneous office equipments	-	Nos.	Ind
36	Special jigs and fixtures and test benches for Rolling Stock			Ind
37	Battery operated rail-cum-road shunter with suitable coupler	2	Nos	Ind
38	Air Circulator	48	Nos.	Ind

Chapter 10

Environmental Impact Assessment & Management

CHAPTER 10

ENVIRONMENTAL IMPACT ASSESSMENT & MANAGEMENT

10.1 ENVIRONMENTAL BASELINE DATA

The main aim of the EIA study is to establish present environmental conditions along the proposed metro corridors; predict the impacts on relevant environmental attributes due to the construction and operation of the proposed project and recommend adequate mitigation measures to minimize/reduce adverse impacts. The study reveals the results and datas for both the phases and phase wise values and analysis will not have any material deviation. The different components of environment in which changes are likely to occur include water, land, air, ecology, noise, socio-economic issues, etc. The information presented in this section is drawn from various sources such as reports, field surveys and environment monitoring. Majority of data on water quality, vegetation, air and noise quality was collected during field studies in November 2009 to December 2009. This data has been utilized to assess the incremental impact, if any, due to the *project as a whole comprising both the phases of the project*. Collection and compilation of environmental baseline data is essential to assess the impact on the environment due to the project

10.1.1 Location and Physiography

Jaipur, also popularly known as the Pink City, is the capital of Rajasthan state, India. Jaipur is the former capital of the princely state of Jaipur. Founded on 18 November 1727 by Maharaja Sawai Jai Singh II, the ruler of Amber, the city today has a population of more than 3 million residents. It is also known as Paris of India.

Jaipur is the first well planned city of India, located in the desert lands of India, Rajasthan. The city which once had been the capital of the royalty now is the capital city of Rajasthan. The very structure of Jaipur resembles the taste of the Rajputs and the Royal families. In the present date, Jaipur is the major business centre for the natives of Rajasthan with all requisites of a metropolitan city.

The city is remarkable among pre-modern Indian cities for the width and regularity of its streets which are laid out into six sectors separated by broad streets 111 ft (34 m) wide. The urban quarters are further divided by networks of gridded streets. Five quarters wrap around the east, south, and west sides of a central palace quarter, with a sixth quarter immediately to the east. The Palace quarter encloses a sprawling palace complex (the Hawa Mahal, or palace of winds), formal gardens, and a small lake. Nahargarh Fort, where King Sawai Jai Singh II used to stay, crowns the hill in the northwest corner of the old city. Another noteworthy building is Observatory, Jantar Mantar.

Jaipur is located at 26.92°N latitude 75.82°E longitude. It has an average elevation of 431 metres.The district is situated in the eastern part of Rajasthan. It is bound in the north by Alwar, in South by Tonk, Ajmer and Sawai Madhopur. Nagaur, Sikar and Ajmer in the west and in east by Dausa district.

The major rivers passing through the Jaipur district are Banas and Banganga. Ground water resources to the extent of about 28.65 million cubic meter are available in the district. Although serious drought is rare, poor water management and exploitation of groundwater with extensive tube-well systems threatens agriculture in some areas.

Jaipur has a semi-arid climate. Although average rain fall is 620 mm, the rainfall is concentrated in the monsoon months between June and September. Temperatures remain relatively high throughout the year, with the summer months of April to early July having average daily temperatures of around 30°C. During the monsoon months there are frequent, heavy rains and thunderstorms, but flooding is not common. The winter months of November to February are mild and pleasant, with average temperatures in the 15-18°C range and little or no humidity. There are however occasional cold waves that lead to temperatures near freezing.

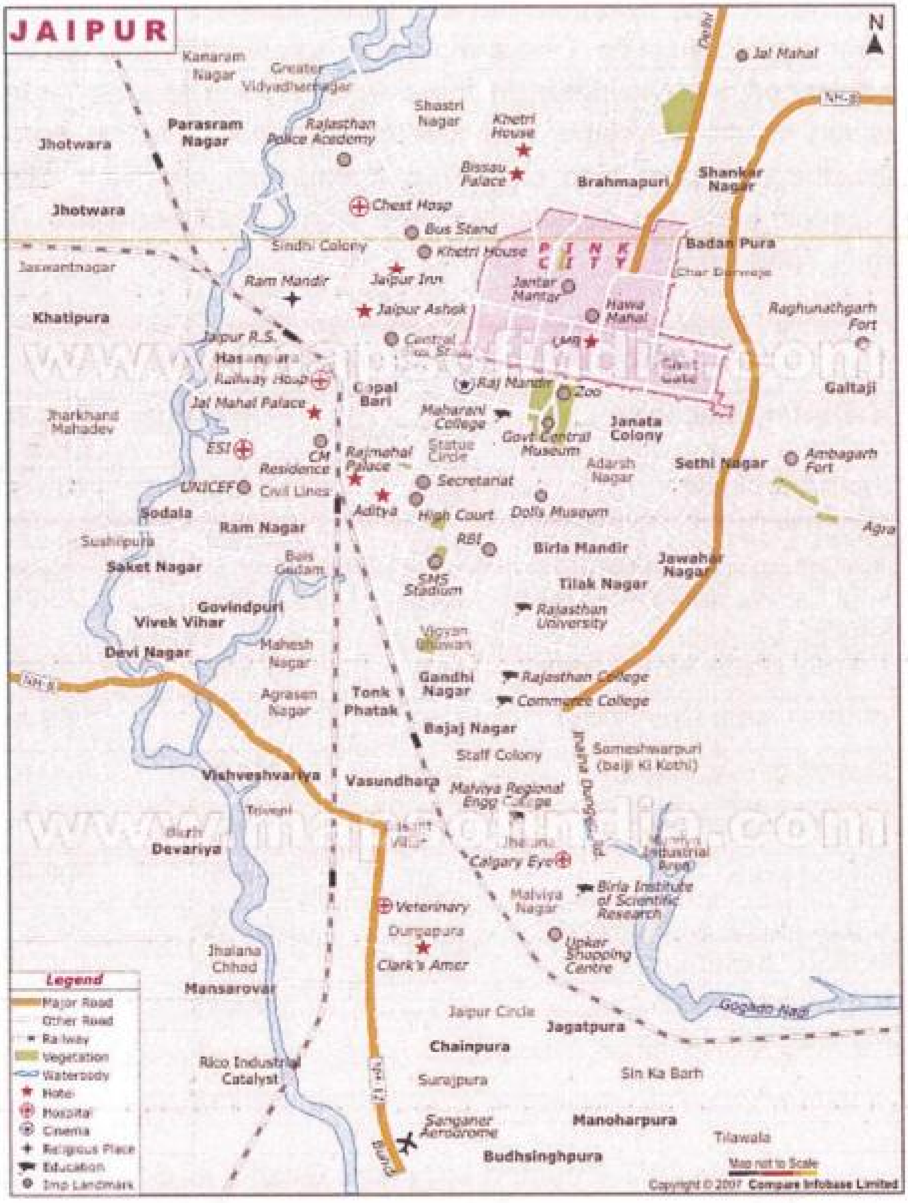
The meteorological condition prevailing at the project route during the study year is given below in table 10.1.

Table 10.1: Meteorological Data (IMD)

Parameters	Maximum	Minimum	Average
Temperature	45.4°C	5.0°C	30°C
Relative Humidity	61%	17%	50.66%
Wind Speed	28 kmph	0 kmph	14.9 kmph
Wind Direction	Predominant wind direction are NW and NE		
Rainfall	-	-	620 mm

Source: IMD, Jaipur

Fig.10.1. Map of Jaipur City



10.1.2 WATER AND SOIL

Groundwater samples were collected from deep tube wells in Complex / institutions along the proposed project route to understand the water quality. The ground water table in Jaipur is found to be varying from 80 ft to 250 ft. Samples of surface water of major nallas of the city in the vicinity of the alignment were taken. Water analysis was done for the physico-chemical and biological parameters as per norms.

For ground water, 10 representative samples were taken from sources along the alignments, which is summarized below in Table 10.2. The quality of the well water was inferred in comparison with the National Standards of Drinking Water Quality (IS: 10500, 1992). All the well water samples were colourless, odourless and with agreeable taste. One sample had high turbidity and the samples showed well-balanced pH. The chemical characteristics such as total hardness, chlorides, dissolved solids, sulphates and nitrates were within limits. Among the metals analyzed iron, copper, zinc, chromium, magnesium, cadmium, selenium, mercury and arsenic were not detected or were within stipulated limits. The results are given in Table 10.3.

Table 10.2: Ground water Sampling location

Code	Sampling Location	Corridor	Direction	Approx.Distance from Track (m)
GWQ1	Jawahar Circle	N-S	West	100 m
GWQ2	Saras Dairy	N-S	West	50 m
GWQ3	City Pulse, Narayan Singh Circle	N-S	East	150 m
GWQ4	Paliwal plaza Ajmeri gate	N-S	West	500 m
GWQ5	Sindhi Camp Bus Stand	N-S	West	250 m
GWQ6	Desert Inn Ambabari	N-S	North	400 m
GWQ7	Ranganj Choupad	E-W	North	500 m
GWQ8	Chand pole	E-W	North	600 m
GWQ9	Vesta Hotel, Nr.Railway station, Jaipur junction	E-W	South	50 m
GWQ10	Kapil Gyan peeth, Mansarover Jaipur	E-W	South	500 m

Table 10.3 Physico-chemical Quality of Groundwater

S.No	Parameters	Unit	GW Q1	GW Q2	G W Q3	GW Q4	GW Q5	GW Q6	GW Q7	GW Q8	GW Q9	GW Q10	GW Q11	Desirabl e limit
1.	Colour,	Haze n	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	5
2.	Odour	-	U/O	U/O	U/O	U/O	U/O	U/O	U/O	U/O	U/O	U/O	U/O	U/O
3.	Taste		Agreeable											
4.	Turbidity	NTU	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	5
5.	Ph	--	7.54	7.50	7.54	7.73	7.56	7.74	7.50	7.50	7.51	7.74	7.56	6.5-8.5
6.	Total Hardness as $CaCO_3$	mg/l	472	270	470	390	518	392	270	270	274	390	476	300

7.	Total Iron as Fe	mg/l	0.02	0.5	0.02	0.03	0.11	0.03	0.5	0.5	0.05	0.03	0.02	0.3
8.	Chloride as Cl	mg/l	872.9	969.9	869.7	914.9	916.3	961.9	892.6	899.3	719.8	915.6	873.9	250
9.	Residual Free Chlorine	mg/l	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	-
10	Total Dissolved Solids	mg/l	1,897	1,050	1,893	1,640	1,679	1648	1,050	1,050	1,058	1,643	1,902	500
11	Calcium as Ca	mg/l	80.40	56.00	80.00	68.00	240.00	68.80	56.00	56.00	42.4	68.00	81.20	75
12	Magnesium as Mg	mg/l	66.40	31.85	66.15	53.90	142.10	53.90	31.85	31.85	32.3	53.90	66.89	30
13	Copper as Cu	mg/l	<0.48	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05
14	Manganese as Mn	mg/l	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.1
15	Sulphate as SO_4	mg/l	20.68	26.09	20.50	25.38	28.08	25.44	26.09	26.09	26.18	25.41	20.76	200
16	Nitrate as NO_3	mg/l	5.89	6.25	5.81	1.35	4.47	1.45	6.25	6.25	6.40	1.41	5.96	45
17	Fluoride as F	mg/l	1.23	0.98	0.72	0.83	0.65	0.73	0.98	0.92	0.82	0.63	0.66	1
18	Phenolic Comp. as C_6H_5OH	mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.001
19	Selenium as Se	mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.05
20	Arsenic as As	mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.05
21	Zinc as Zn	mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	5.0
22	Chromium as Cr^{+6}	mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.05
23	Total Alkalinity as $CaCO_3$	mg/l	384	450	380	310	270	312	450	450	452	310	384	200
24.	Aluminum as Al	mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.03
25.	Boron as B	mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.1

BDL: Below Detectable Level, C/L; Colourless, U/O: odourless

Table 10.4 Physico-chemical Quality of Surface Water

Sl. No.	Parameters	Unit	Amanisha Nala	Ambabari ka nala	Jal Mahal Talab
1	Colour	Hazen	C/L	C/L	C/L
2	Odour	-	U/O	U/O	U/O
3	Turbidity	NTU	18	20	12
4	pH	--	7.7	7.8	7.2
5	Conductivity	uS/cm	720	680	460
6	Total Dissolve Solids	mg/l	520	510	320
7	Alkalinity as $CaCO_3$	mg/l	185	190	115
8	Total Hardness as $CaCo_3$	mg/l	171	182	101
9	Calcium as Ca	mg/l	42.0	48.0	24.0

Sl. No.	Parameters	Unit	Amanisha Nala	Ambabari ka nala	Jal Mahal Talab
10	Magnesium as Mg	mg/l	13.0	15.0	10.0
11	Sodium	mg/l	39.0	38.0	20.0
12	Potassium	mg/l	11.0	15.0	8.0
13	Bicarbonate	mg/l	230	232	140
14	Chloride as Cl	mg/l	52	59	32
15	Sulphate as SO_4	mg/l	26.0	25.0	26.0
16	Nitrate as NO_3	mg/l	4.0	3.6	3.80
17	Fluorides as F	mg/l	BDL	BDL	BDL
27	Phenolic compound as C_6H_5OH	mg/l	BDL	0.03	BDL
21	Cyanide	mg/l	BDL	BDL	BDL
22	Aluminium	mg/l	BDL	0.05	BDL
23	Arsenic	mg/l	BDL	BDL	BDL
18	Cadmium	mg/l	BDL	BDL	BDL
19	Chromium as Cr+6	mg/l	BDL	BDL	BDL
24	Iron	mg/l	0.2	0.2	0.05
20	Copper	mg/l	BDL	0.004	BDL
25	Lead	mg/l	BDL	BDL	BDL
26	Manganese	mg/l	BDL	BDL	BDL
27	Mercury	mg/l	BDL	BDL	BDL
28	Zinc	mg/l	1.9	1.4	0.9
29	Dissolve Oxygen	mg/l	3.4	3	6.4
30	BOD(3)days at27°C	mg/l	15.0	28.0	12.0
31	COD	mg/l	42.0	45.0	12.0
BDL: Below Detectable Level, C/L; Colourless, U/O: odourless					

The quality of the surface water is ccmpared to the Sewage waters for Navigation and controlled waste disposal. The results are given in Table 10.4. The pH and Dissolved oxygen are within the stipulated limits of navigational waters. There is no floating scum in the water surface.

Soil

The soil is poor in humus with organic carbon content less than 0.2 percent. Its water retaining capacity is very poor.

Four types of soil are found in Jaipur area.

1. Loamy Soil : It has low moisture content with normal fertility and found in majority in this area.
2. Clay Soil : This type of soil is blackish, greyish or dark brown in colour, having medium to heavy texture. The soil is less porous but highly fertile with almost balanced macro and micro-nutrients. It is found in Ramgarh area.

3. Sandy Soil : Sandy soil is very porous but not suitable for general type of vegetation. The colour varies from brown to grey and texture from fine to medium. It is found in Dudu and Phulera areas.
4. Sandy-loam Soil : This soil is semi-porous and fertile, it is generally yellowish brown with deep or light texture.

The proposed metro corridors mostly run through commercial area and a few patches have residential areas. Hence there is very little exposed soil along the route. However, soil samples were collected and analyzed and the results are presented in Table 10.5 and 10.6.

Table 10.5: Soil Type

Sr. No.	Location	Corridor	Soil texture	Sand (%)	Silt (%)	Clay (%)
1	Jawahar Circle	N-S	Sandy	66	25	09
2	MNIT Gate	N-S	Sandy	69	21	10
3	Garden of Indralok , Narayan Singh Circle	N-S	sandy	71	20	09
4	Ramnivas Garden Ajmeri gate	N-S	Sandy Loam	66	19	15
5	Banipark behind bus stand	N-S	Sandy Loam	59	25	16
6	Desert Inn Ambabari	N-S	Sandy	68	21	11
7	Ranganj Choupad	E-W	sandy	68	21	11
8	Chand pole	E-W	Sandy	68	19	13
9	Vesta Hotel, Nr. Railway station, Jaipur junction	E-W	Sandy Loam	59	25	16
10	Kapil Gyan peeth, Mansarover Jaipur	E-W	Sandy Loam	68	21	11

Table 10.6: Physicochemical Quality of Soil samples

Parameter	Unit	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Color	-	Yellow ish Brown	Yellow ish Brown	Yellow	Yellow Cream	Yellow Cream	Yellow	Yellow	Yellow	Yellow Cream	Yellow Cream
pH (1:2, W/V)		7.86	8.10	8.04	7.92	6.92	7.88	8.11	8.06	7.95	6.93
Conductivity	(μS/cm)	412	369	458	475	3.75	414	366	455	476	375
Cation Exchange capacity	(Meq/100Gm)	9.5	8.9	9.5	7.5	8..5	9.4	8.8	9.6	7.7	8..3
Moisture	%	5.36	4.58	3.58	5.27	5.27	5.33	4.54	3.55	5.26	5.27
Chlorides as Cl	%	0.025	0.021	0.026	0.035	0.035	0.026	0.027	0.023	0.034	0.035
Sulphate as SO_4	%	0.014	0.018	0.013	0.015	0.015	0.015	0.016	0.015	0.017	0.015
Total Carbonates	%	0.41	0.38	0.40	0.21	0.21	0.42	0.38	0.40	0.22	0.22
Total Organic Matter	%	0.42	0.37	0.40	0.22	0.22	0.40	0.38	0.40	0.21	0.21
Nitrogen as N	%	0.028	0.026	0.024	0.026	0.026	0.028	0.027	0.025	0.026	0.025
Phosphorus as P	%	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Potassium as K	%	0.311	0.242	0.233	0.244	0.249	0.318	0.247	0.236	0.245	0.244
Total Soluble solids	%	0.21	0.18	0.18	0.25	0.25	0.22	0.17	0.18	0.26	0.25
Zinc	Mg / Kg.	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Copper	Mg / Kg.	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Chromium	Mg / Kg.	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Cadmium	Mg / Kg.	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Nickel	Mg/Kg.	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Lead	Mg/Kg	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL

10.1.3 Green Cover

The proposed corridors do not pass through any reserve/protected forest in their entire length. Moreover, no forests are found in its indirect impact zone as well (7km radius). However, significant amounts of road side vegetation are observed in 20m band of metro corridor. There are over 601 trees along the N-S Corridor, about 557 trees for E-W Corridor.

Table : 10.7 Existing Vegetation Scenario : Flora

Common Name	:	Botanical Name
Aam	:	Magnifera indica
Babul	:	Acacia arabica
Bargad	:	Ficus bengalensis, Linn
Dhoak	:	Butea monosperma Lamk
Guggal	:	Ficus glomerata, Roxb
Khejari	:	Prosopis spicigera, Linn
Peepal	:	Ficus religisia
Neem	:	Azadirachta indica
Salar	:	Boswellia serrata
Bahera	:	Terminalia belerica
Dhaman	:	Grewic tilliafalia
Hingota	:	Balanites egyptiaca
Semal	:	Salamalia malabarica
Timru	:	Diospyros melanoxylon
Mustard	:	Brassica juncea

Source:- Medical & Herbal Farming, Mahveer Nagar,Jaipur

The main trees which were found in the vicinity of the corridor included Khejari, Castor, Roida(sheesham), Khair,Kair, Harsingar, lemon, pepal, Baniyan, ber, babool, neem, sirus,etc..

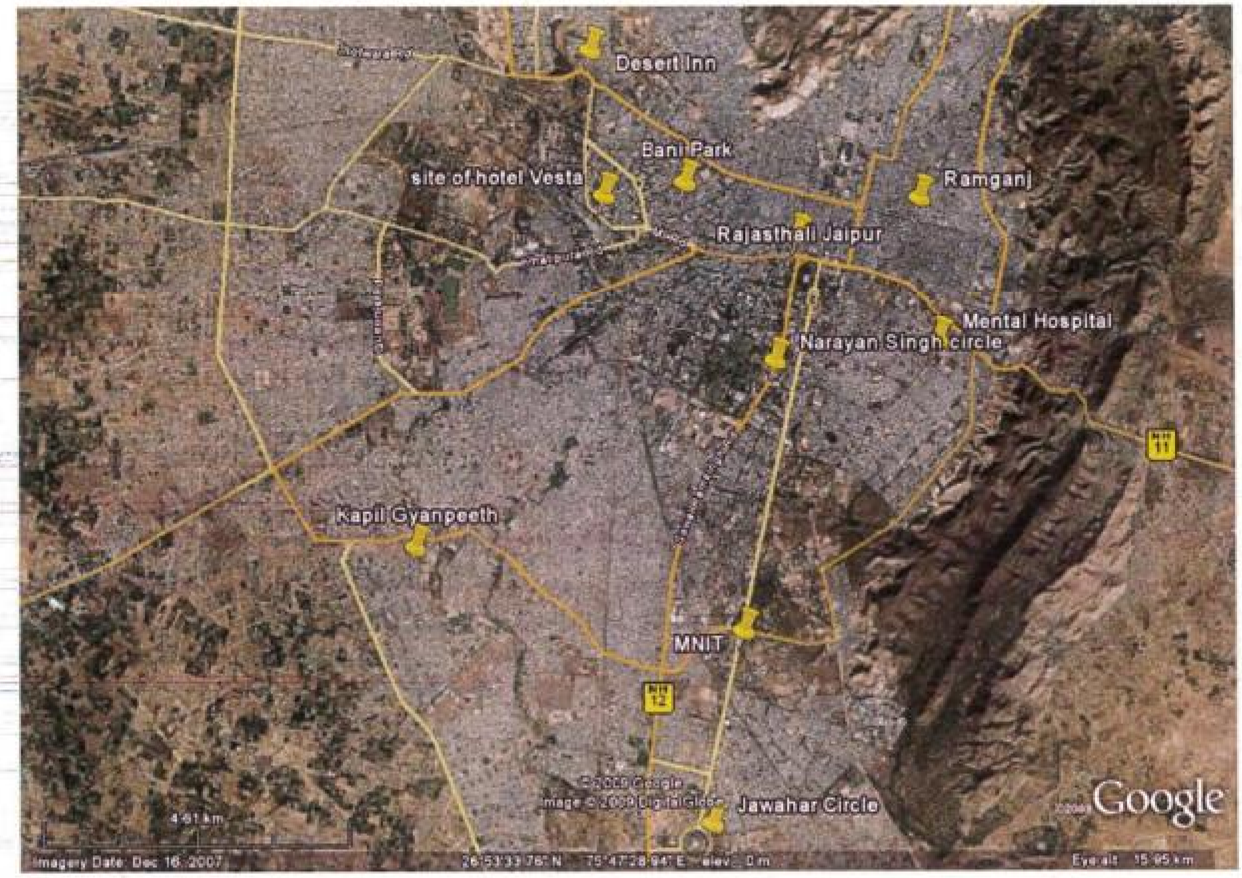
10.1.4 Air Quality

As part of the study, ambient air quality monitoring has been carried out by setting up ambient air quality monitoring stations at 10 locations for the parameters SPM, RPM, SO_2 and NO_x. The ambient air quality stations were selected taking into view traffic flow and strategic locations on the proposed metro rail route. Sampling was done during Dec 2009 at the 10 locations along the proposed alignment. The locations are given in Table 10.8.

Table-10.8 Details of Ambient Air Quality Monitoring Locations

Sr. No.	Name of Location/village	Corridor	Distance w.r.t. alignment
1	Jawahar Circle	N-S	100 m
2	MNIT Gate	N-S	50 m
3	Hanuman Temple, Narayan Singh Circle	N-S	150 m
4	Rajasthali, Ajmeri gate	N-S	500 m
5	Banipark behind bus stand	N-S	250 m
6	Desert Inn Ambabari	N-S	400 m
7	Ranganj Choupad	E-W	500 m
8	Chand pole	E-W	600 m
9	Site for Hotal Vesta Nr. Railway station, Jaipur junction	E-W	50 m
10	Kapil Gyan peeth, Mansarover Jaipur	E-W	500 m

Fig. 10.2 Ambient Air Quality Monitoring Locations



The results of air quality as monitored are given in Table 10.9.

Table 10.9 Air Quality

Standards (Concentration in µg/mg[3]) 24 hours**	98 Percentile Values (µg/mg[3])			
	SPM	RSPM	SO_2	NO_x
Industrial Area	500	150	120	120
Residential, Rural & Other Areas	200	100	80	80
Sensitive Areas	100	75	30	30
Ambient Air Quality Station Name	**SPM in µg/m3**	**RSPM**	**SO_2**	**NO_x**
Parking of Jawahar Circle	143.5	45.8	6.8	6.6
MNIT Gate	157.5	68.3	7.2	7.5
Hanuman Temple , Narayan Singh Circle	185.3	72.5	8.5	8.6
Rajasthali Ajmeri gate	188.7	72.3	8.8	9.6
Banipark behind bus stand	164.2	56.9	7.5	6.3
Desert Inn Ambabari	159.1	55.3	7.6	8.5
Ranganj Choupad	182.9	68.4	7.5	7.4
Chand pole	187.8	77.8	8.5	9.5
Ram Mandir, Nr. Railway station,. Jaipur junction	175.3	71.3	8.3	7.5
Kapil Gyan peeth, Mansarover Jaipur	156.3	64.3	7.4	6.3

Unit – µg/m³

** 24 hourly/ 8 hourly values should be met 98% of the time of the year. However 2% of the time it may exceed but not on two consecutive days

The following inferences can be drawn from the air quality monitoring of the city of Jaipur along the corridor route:

- Levels of SPM are on the higher side for the sensitive areas. However SPM in Ajmeri gate is highest and more than National Ambient Air Quality Standards. This is because of heavy traffic and congestion in the area. In the other areas also the SPM are higher due to heavy traffic. Chandpole is the busy area where one can see mixed residential and commercial land use.

- Levels of RSPM are also slightly high in the area of Chandpole because of heavy traffic and dust but within the permissible limit.
- Levels of SO_2 are well within the prescribed limits of NAAQS at all receptors.
- Levels of NO_X are also within prescribed limit.

10.1.7 SEISMICITY

The seismic hazard map of India was updated in 2000 by the Bureau of Indian Standards (BIS). Apart from the merging of Zones I and II, there are no major changes in the new hazard map with respect to the state of Rajasthan, as compared with the previous 1984 BIS map. Western parts of the districts of Barmer and Sirohi as well as northern sections of Alwar district lie in Zone IV, where the maximum intensity could reach VIII (MSK). The remaining areas of Barmer and Sirohi districts, as well as the districts of Bikaner, Jaisalmer and Sirohi lie in Zone III. The north-eastern districts of Jhunjhunu, Sikar, Bharatpur and the rest of Alwar also lie in Zone III. The maximum intensity expected in these areas would be around MSK VII. The rest of the state, including the capital, Jaipur, lie in Zone II, where the maximum intensity expected would be around MSK VI. It must be noted that BIS estimates the hazard, based in part, on previous known earthquakes. Since the earthquake database in India is still incomplete, especially with regards to earthquakes prior to the historical period (before 1800 A.D.), these zones offer a rough guide of the earthquake hazard in any particular region and need to be regularly updated

A light earthquake struck the Jaipur region in north-eastern Rajasthan on 24 December 2006 at 04:13 local time causing minor panic in the city of Jaipur. The earthquake had a magnitude of Mb=4.3 and was felt in parts of Jaipur and Jhunjhunu districts. Tremors from the earthquake were felt in many parts of Jaipur for up to 30-seconds. Shocks were distinctly felt in the city's Mansarovar and Sanganer areas. Minor hairline cracks developed in a building in the Bajaj Nagar-Malviya Nagar area of the city. Several people were woken up from their sleep and many ran outdoors. There was some anxiety in the city as many thought they had experienced tremors from a much larger earthquake elsewhere in the region. Peacocks were heard crying out restlessly following the tremor in the city's Bani Park area.

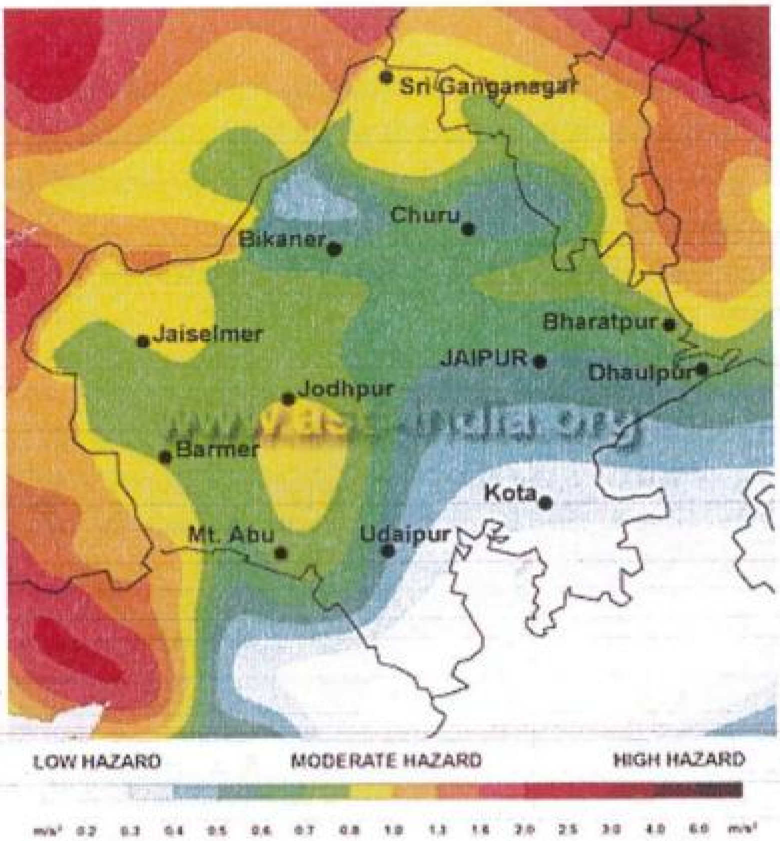


Fig. 10.3 GSHAP Hazard Map for Rajasthan

10.1.8 NOISE

Noise can be defined as unwanted sound in the wrong place at the wrong time. The highway noise prediction model used in this study (Lyons, 1973) is based on the principal: Noise is produced by traffic and is then attenuated by distance before it reaches the listener. The noise level can be well predicted using Lyons empirical model:

$$L = 10\log V - 15\log D + 30\log S + 10\log[\tanh(1.19*10^{-3})* VD/S] + 29$$

Where,

V= Volume of Traffic per hour (vehicles/hour)

S= Average vehicle speed (miles/hour)

D = Distance from centreline of road to sound receptor (feet)

L= Predicted noise level (dB)

Table 10.10

NOISE LEVEL RANGES AT DIFFERENT LOCATIONS

Location	Day						Night					
	L_{Max}	L_{Min}	L_{eq}	L10	L50	L90	L_{Max}	L_{Min}	L_{eq}	L10	L50	L90
Jawahar Circle	72.0	62.0	70.6	73.0	71.0	64.0	62.0	57.0	59.4	61.3	58.5	57.0
MNIT Gate	73.0	63.0	69.3	71.5	69.0	64.5	62.0	58.0	60.1	62.0	59.5	58.0
Garden of Indralok, Narayan Singh Circle	74.0	63.0	68.4	71.0	68.0	64.0	64.0	59.0	61.9	63.3	61.5	59.7
Ramnivas Garden Ajmeri gate	74.0	64.0	70.0	73.5	67.5	64.5	63.0	60.0	61.6	62.3	62.0	60.0
Banipark behind bus stand	73.0	62.0	70.6	73.0	71.0	64.0	62.0	57.0	59.4	61.3	58.5	57.0
Desert Inn Ambabadi	72.0	63.0	69.3	71.5	69.0	64.5	62.0	58.0	60.1	62.0	59.5	58.0
Ranganj Choupad	79.0	67.0	71.8	74.5	70.5	67.0	66.0	57.0	62.7	65.3	62.0	57.0
Chand Pole Gate	82.0	68.0	74.2	77.0	73.0	68.5	68.0	64.00	66.0	67.3	65.0	64.7
Ram Mandir, Nr. Railway station, Jaipur junction	79.0	66.0	72.2	75.0	71.0	66.5	66.0	62.00	64.0	65.3	63.0	62.7
Kapil Gyan peeth, Mansarover Jaipur	75.0	67.0	71.8	74.5	70.5	67.0	66.0	57.0	62.7	65.3	62.0	57.0

Source:- Field data collection

Noise levels were measured at 10 locations along the project alignment at 2.0 m away from the source as per standard practice. The noise level ranges are summarized in Table 10.10. It could be concluded that the noise levels recorded at various stations are 82db (day) and 68db (night).

Jaipur is no better, in fact the scenario in this capital city is nothing less than grim. According to observation three wheelers, trucks and motor cycles remain the chief source of noise pollution on Jaipur roads and is closely followed by generators in residential and commercial areas. 15 of the 46 residential locations surveyed have noise levels within the permissible range for 90% of the time in the day. But on the other hand there is an extreme situation in few locations where the noise levels are bit above the permissible levels round the clock. Even silence zones like hospital areas are alarmingly noisy. Areas around important hospitals like SMS Hospital have recorded sound levels above 70dB which is about 100 times that of levels permitted even in residential areas. Apart from this the major traffic corridors of the city cross even the critical 100dB mark in peak hours. The rise in noise levels in the last two decades can be well accounted for by the unprecedented rise in the vehicular population in the Jaipur district from about 1 lakh vehicles in 1971 to about 16 lakhs in 2008.

From the Table 10.10 it can be observed that the noise levels are well within the standards. The day noise level was found to be highest at Chand Pole Gate, which is one of the busiest intersections of the city.

10.2 SOCIO-ECONOMICS

The Jaipur region has an extent of 1464 sqkm that includes the walled city and the rest of Jaipur Nagar Nigam and rest of the area includes JDA area and the satellite towns & villages.

Table 10.11
Important Statistic (2001 Census)

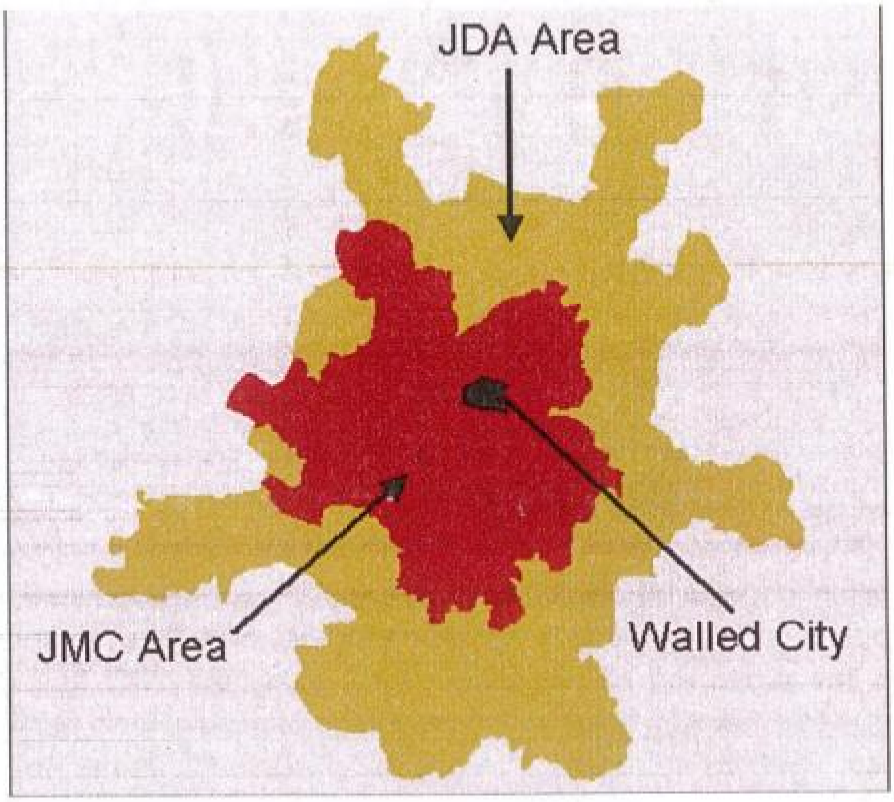
	POPULATION	
	RAJASTHAN	JAIPUR DISTRICT
Persons	5,64,73,122	52,52,388
Males	2,93,81,657	27,69,096
Females	2,70,91,465	24,83,292

Decimal Population Growth Rates	+28.33	+59.37
Density of Population (per Sq. Km)	165	373
Females per1,000 Males	922	875
Literate (Population in percentage)		
Persons	61.03	78.65
Males	76.46	86.96
Females	44.34	69.14

Source: Census of India-1991 and 2001.

The population of Jaipur city is 2324319 as per 2001 census. In terms of share, 87% of the total population lives in the JNN area, of which 7% lives in the walled city. While the proportion of population living within the JNN has increased (primarily due to expansion in area), the proportion of population in the walled city has declined. This can be regarded as positive phenomena as the walled city is already very densely populated. The Walled City has a spatial extent of only 6.7 sq.km but houses nearly four lakh people. The 2001 census shows that the population of the Walled City has declined from 1991. The reason for this is out movement of inhabitants from the area to new residential colonies being developed in the periphery in want of better living environment. The population in the rest of the JDA area does not show much growth from 0.347 million in1991 to 0.355 million in 2001 because JDA areas have been transferred to JNN. The rest of the JDA areas also includes 495 villages with nearly 0.2 million population. Rest of JDA areas accounted only for 18 % in 1991 and 13.2% in 2001 of the total population. Decrease in population of the rest of the JDA area in 2001 is due to the reconstitution of the municipal boundaries.

Figure 10.4 : Density of Population- Jaipur Region



Infrastructure

Rapid industrialization of the area in the last couple of decades led to high population growth since independence and has led to a high population density. In a recent international survey Jaipur was ranked the 7th best place to visit in Asia and in another poll it was ranked third among twelve major Indian cities.

Modern infrastructural facilities are developing fast, and in many cases surpass those of larger cities like Delhi and Calcutta. The city is expanding very quickly and has become a hot spot for development in Rajasthan. Jaipur International Airport is located at a satellite location of Sanganer and offer flights to Delhi, Mumbai, Ahmedabad, Bangalore, Kolkata and Guwahati along with sporadic services to International locations such as Muscat, Sharjah, Dubai & Bangkok.

Since 2000 Jaipur has become a centre for education. The city is very peaceful and many north Indian families prefer to send their offspring to Jaipur for higher and technical education. Jaipur has more than 60 engineering colleges, 40 business management institutes, 15 pharmacy institutes, 4 hotel management institutes, 3 medical colleges and 6 dental colleges. It also has 8 universities including Rajasthan University. Malaviya National Institute of Technology, Jaipur is one of the best technical institutes in India.

Jaipur has a well maintained road network with flyovers and traffic lights with closed circuit cameras. Police control room (PCR) vans are being equipped with GPS to monitor locations and help maintain law and order.

Jaipur boasts of International Living standards with well planned colonies of grid like patterns (sectors and blocks) and parks well maintained by JDA (Jaipur Development Authority). Two new colonies Anupam vihar and Abhinav vihar have been recently added to Jaipur by JDA. There are many shopping malls and Multiplex which offer a urban lifestyle to Jaipurites.

SMS Cricket stadium is also located here, which is a popular venue for many international matches and for Indian Premier League matches. Events like Jaipur Jewelry Show and Jaipur Literature Festival are offering a common platform for people not only from India but from other countries also, giving Jaipur a cosmopolitan image.

SMS Hospital, SDMH (Durlabhji Hospital) and Fortis Hospital are among the most famed hospitals of Jaipur. Apart from these, there are more than 40 small and midsized hospitals in the city. Old city of Jaipur is highly congested, whereas suburbs of Jaipur provide wide and free flowing roads. Tech Park built by Mahindra Group has already become operational.

Economy

48 large and medium scale units, 19544 small scale units are working in 19 industrial areas (Bagru, Bassi, Bais Godam, Bindyaka, Dudu, Hirawala, Jetpura, Jhotwara, Kaladera, Kanakpura, Kartarpura, Malviya Nagar, Phulera, Renwal, Sanganer, Shahpura, Sitapura, Sudarshanpur and Vishwakarma).

Jaipur district is a centre for both modern and traditional industries. The main industrial products include: acetylene gas, ACSR (Aluminum Conductor Steel Reinforced) cable, all-purpose flour (maida), atta flour, ball bearings, bottling of LPG, ceramics, pottery, cold roll strips, corrugated boxes, deoiled cakes, durries, dyeing and printing, edible oil, electronic items, engraving on brass items, ferrous and non-ferrous castings, gems and jewelry, general engineering and manufacturing, granite slabs and tiles, hand-made paper, handicraft items, halogen automobile headlamps, "hawai" chappals (sandals), household electrical appliances, HT steel strips, iodized salt, lamps, laminated springs for railways, marble statues, marble tiles & slabs, moulded plastic components for electronics, nitrochlorobenzene, oxygen gas, perfumes, pigments, plastic containers, P.P. multifilament yarn, PVC cables, PVC doors, PVC footwear, canvas shoes, Portland cement, readymade garments (clothing), re-roller products, semolina (suji), steel furniture, steel ingots, stone grits, synthetic leather, suits & shirts made of synthetic materials, tablets and capsules, two way radio and line, washing soap, wheat, woollen carpets, refined vegetable oil and vanaspati ghee heavy Steel fabrication, brass and lacquer work, enamel work, gems and jewellery, granite tiles, handlooms, marble statues, printed cloth and textiles, ready made garments, woollen and silk carpets.

Jaipur has been ranked 31 among the 50 Emerging Global Outsourcing cities. Genpact and Infosys have their BPO already established and running successfully. In fact Genpact has the fastest growing location in Jaipur. Real Estate business is flourishing well for the last 2–3 years. Some of the companies already present here include MICO, Coca Cola, IBM, Ericsson and NEI populary known as NBC Bearings.

Jaipur has regional office of Reserve Bank of India and many other prominent international banks. India's largest integrated IT SEZ Mahindra World City, planned by Jurong Consultant Singapore, covers nearly 3,000 acres (12 km^2) and is located on Jaipur Ajmer National Highway at a distance of 15 km from Jaipur and has already attracted major companies like Infosys, TCS, Wipro, Tech Mahindra, Truworth and Deutsche Bank.

India's one of its kind World Trade Park is also under construction in Malviya Nagar. It will be having luxury hotel, business halls, five screen multiplex, underwater restaurant and many showrooms of international brands. In coming years it will be the hub for modern business development in Jaipur.

An International standard Convention Centre, Golf course and film city on Jaipur Agra National highway are also being planned.

Tourism is a significant part of Jaipur's economy. Some of the world's best hotels are located here.

10.3 ENVIRONMENTAL IMPACTS

Based on the project particulars and existing environmental conditions potential impacts have been identified that are likely to result from the proposed metro rail project. The positive environmental impacts include reduction in traffic congestion, quick service and safety, less fuel consumption, reduction in air pollution, reduction of noise level.

Components of Impact Assessment

Construction and operational phase of the proposed project comprises various activities each of which may have an impact on environmental parameters. Various impacts during the construction and operation phase on the environment have been studied to estimate the impact on the environmental attributes and are discussed in the subsequent section. The probable impacts of each of these activities on various sectors of environment have been mentioned below under three headings:

- Impacts due to Project Location
- Impact due to project design;
- Impacts during Construction Phase
- Impacts during Operational Phase

All the potentially significant environmental impacts from the project are tabulated in Table 10.12:

Table 10.12
Potential Significant Environment Impacts

S. No.	Impacts	Negative Impact		Positive Impact		No Impact
		Short Term	Long Term	Short Term	Long Term	
A.	**Project Location**					
i.	Displacement of People					□
ii.	Change of land use		□			
iii.	Loss of trees/vegetation	□				
iv.	Shifting of utilities					□
v.	Impact on archeological property					□
B.	**Construction Phase**					
i.	Pressure on local infrastructure	□				
ii.	Impact on water Quality	□				
iii.	Impact on air quality including dust generation	□				
iv.	Noise pollution	□				

S. No.	Impacts	Negative Impact		Positive Impact		No Impact
		Short Term	Long Term	Short Term	Long Term	
v.	Traffic congestion and loss of access					□
vi.	Staking and disposal of construction material	□				
vii.	Public health and safety	□				
viii.	Social impact			□		□
C.	**Operational Phase**					
i.	Increase in Noise level		□			
ii.	Water Harvesting & Recharge					□
iii.	Induced Infrastructure development				□	
iv.	Quality of life/ Human use value				□	
v.	Job Opportunities				□	

10.3.1 Impact due to Project Location

Land-use changes: the alignment contains both elevated and underground section along the road. The metro alignment will change the landscape and the streetscape of the area. The project alignment is in zone-II (having moderate seismic intensity) of the seismic map of India (as per is: 1893, part-1, 2002), and therefore it will have very low risk of potential damage due to earthquake.

No significant impact on geology is anticipated from proposed construction of metro corridor activities except requirement of corridor building materials, which would be supplied from approved quarry sites located nearby.

Loss of trees: the proposed metro lines are in urban/ city area and will not pass through any forests. Hence no loss to forest is anticipated due to the project. However due to the proposed metro construction 1158 mature trees are likely to be lost. Trees are major assets in purifications of urban air, by utilizing CO_2 from atmosphere and releasing oxygen into the air. With removal of these trees the process for CO_2 conversion will get affected and the losses are reported below:

Total Number of Mature Trees	1158 nos.
Decrease in CO_2 absorption @ 21.8kg per year /tree for 8 years	201954.73 kg
Oxygen production @ 49kg per year /tree for 8 years	45392.85 kg

Average consumption of oxygen for a person is about 182 kg/ year. It means these trees will meet the requirement of about 1998 people round the year. The total value of these trees lost is Rs. 13.89 lacs as shown in table below.

Total Loss of trees (No.) :	1158
Average cost of one tree (Rs.) :	1200
Total Loss (Rs.) :	Rs. 13.89 lacs

Main species are Githithi, Babul, Neem, Peepal, Keekar, Pilkhan, Kakri, Chokar, Laspasia, Sahtut, Bargad, Gulmohar, Baikan, Rudrakash, Ashok etc. trees act as carbon sequestration. It is a carbon sink by removing the carbon and storing it as cellulose while releasing oxygen back into the air.

SHIFTING OF UTILITIES AND DRAINAGES: There will be shifting of existing water supply pipelines, electrical lines and drains. There are no major surface water body present in the proposed corridor except some drains and sewer system. But this will not affect construction and project implementation time schedule.

10.3.2 IMPACT DURING CONSTRUCTION PHASE

The impact during construction will be localized and short term with permanent changes in use of surrounding land as compared to the current conditions. Impact will be primarily related to the civil works and less intensive impact is expected during erection of the equipment and trial operation. The most likely negative impacts related to the construction works are given below:

- Pressure on local Infrastructure
- Soil erosion problems
- Solid Waste Generation
- Health risk at construction site,
- Traffic congestion and diversion problems,
- Excavated and Construction material Disposal problems,
- Water Contamination Problems
- Impact on Air Quality
- Impact on Noise Quality
- Displacement

PRESSURE ON LOCAL INFRASTRUCTURE: During the construction stage, there will be demand for basic amenities such as water, power, etc. for the construction labour along with the requirement of construction activities which will put pressure on the existing infrastructure. Considering the nature and the magnitude of the project, impact shall be short term and low in magnitude and are limited to construction phase only.

SOIL EROSION: Vegetation and top soil shall be disturbed during the construction stage due to excavation and movement of vehicles and equipment. The spillage of oil from machinery or cement residual from concrete mixer plants might contaminate the soil if not properly collected and disposed off. However, careful planning for the timing of cut and fills operations and re-vegetation would be done by the proponent.

SOLID WASTE GENERATION: Problems could arise from dumping of construction spoils (Concrete, bricks) waste materials (from contractor camps) etc. causing surface and ground water pollution. However, it is proposed to have ready mix concrete directly from batching plant for use at site. Batching plants will be located away from the site. Other construction material such as steel, bricks, etc. will be housed in a fenced stored yard. Balance material from these yards will be removed for use/disposal. Mitigation measures include careful planning, cleaning, redressing, landscaping and re-vegetation.

HEALTH RISK AT CONSTRUCTION SITE: since the project shall be confined to proposed corridor area, hence no health related impact is envisaged within the project influenced area during the construction stage. At the project site direct exposure to dust generation is likely to cause health related impact especially dust related diseases. This would be minimized by providing suitable respiratory personal protective equipments (PPE) such as nose mask with suitable filters etc.

TRAFFIC CONGESTION AND DIVERSION PROBLEMS: The project area has congested stretches where traffic movement is very slow and roads are very narrow. Moreover, encroachment and traffic load on the designated CW are heavy. Hence, traffic congestion during the construction phase will be a major issue. Suitable temporary segregation of traffic will be undertaken, in order to ease the load of traffic in the region. Also it will be appropriate to make these roads as one way for smooth operation of construction activities and traffic.

WATER CONTAMINATION PROBLEMS: Within the vicinity of project site no major / designated water body except one irrigation canal are present. Also since all construction related activities will primarily be confined to the enclosed corridor, hence no major impacts on the water bodies present in project influenced area are anticipated. Whatever impact due to accidental spills or due to bad construction practice, shall be short term and low in magnitude and confined to the construction period only.

IMPACT ON AIR QUALITY: Potential impacts on the air quality during the construction stage will be due to the fugitive dust and the exhaust gases generated in and around the construction site. These impacts will be short term. Proper siting, use of efficient machinery and schedule maintenance shall minimize such impacts.

IMPACT ON NOISE QUALITY: Noise is perceived as one of the most undesirable consequences of construction activity. Due to the various construction activities, there will be short-term noise impacts in the immediate vicinity of the project corridor. The impact will be felt more in the congested areas where utmost care has to be taken to reduce noise generation by using acoustic enclosures for noise producing machines.

SOCIAL IMPACT: the social impacts during the construction stage could result due to influx of migrant workers and associated induced development etc. This will ensure a rise in the consumption of consumer goods in the local area, which will tend to boost up the local economy. As local labours will be hired from the vicinity of the project site, initial conflict is not envisaged. As far as possible local labour within the project influenced area shall be utilized for the construction purpose and all the activities related to construction worker shall be confined to the project site only, hence no adverse social impacts are envisaged due to the proposed project.

10.3.3 IMPACT DURING OPERATION PHASE

During the operation phase, there would be impacts on the Water, Noise and refuse disposal problems with socio-economic impacts. The project may cause the following negative impacts during operation of the project due to the increase in the number of passengers and trains at the stations:

- Impact on Land Environment
- Noise pollution,
- Water supply and sanitation at Stations,
- Refuse disposal and sanitation, and
- Visual Issues

IMPACT ON LAND ENVIRONMENT: During the operation phase, the temporarily modified land use pattern such as temporary construction camps/tents would be dismantled. The metro corridor, after completion of its development, would consist of neat landscape with a pleasing outlook. As the metro corridor will pass through some congested stretches of residential/commercial areas, there would be increased scope for commercial, industrial and residential development along the project corridor. Squatter settlement and encroachment along the project metro corridor is very likely to take place unless proper controlled, restricted zoning measures are adopted.

NOISE POLLUTION: Main sources of noise are traction motors, cooling fans, wheel-rail interaction, electric generator and miscellaneous noise from rolling stock. Ambient noise in railways increases with train speed. Roughness of the contact surfaces of rail, wheel and train speeds are the factors which influences the magnitude of rail wheel noise. Maximum noise level has been estimated as 64 dB(A) including background noise level as 20 dB(A) inside the Metro. Noise level at a distance of 12.5m, 25m, and 50m from the alignment have been calculated similarly and these comes out to be 57.2, 54.2 and 45.2 dB(A) respectively.

IMPACT ON WATER SYSTEM: Public health facilities such as water supply, sanitation and toilets are very much needed at the stations. It has been recommended 45 litres per day water supply to persons working at stations. Persons working on each stations will be about 30. Thus water demand on one station works out to be about 11kld, out of them 7.5 kld wastewater will be generated at each station that will be treated in the treatment plant. Water should be treated before use upto WHO drinking water standards. Ground water shall be used for this purpose. In addition, water will be required for contractor's camps during construction.

10.3.4 BENEFICIAL IMPACTS OF THE PROPOSED PROJECT

The introduction of Metro project will yield benefits from non-tangible parameters such as saving due to vehicle operating costs and socio - economic benefits of bulk transport of goods, less travel time, better accessibility, integration of different modes of transport and low operational cost. Positive impacts have been listed under the following headings:

- Employment Opportunities,
- Benefits to Economy,

- Less Air Pollution,
- Quick Service and Safety,
- Less Fuel Consumption,
- Carbon Dioxide Reduction

10.4. SUMMARY OF IMPACTS AND MITIGATION MEASURES

A summary of the potential environmental impacts during construction and operation phase along with recommended mitigation measures is presented in matrix format in Table 10.13.

Table 10.13 Environmental Impacts and Mitigation Measures

Area	Impacts	Mitigation Measures
Construction Phase		
Topography & geology	• Change in existing profile of the land-use • Disturbance on geological setting due to quarrying.	• Suitable seismic design of the proposed corridor structures will be adopted to mitigate the earthquake impacts.
Soil	• Loosening of soil due to excavation, resulting increased soil erosion.	• Adequate drainage, embankment consolidation & slope stabilization will be taken along the road to avoid soil erosion.
Water use	• Impact on the local water sources due to use of construction water.	• Maximum rainwater harvesting and minimum use of existing water sources for construction will be ensured to minimize likely impacts on other users.
Water quality	• Increase of sediment load in the run off from construction sites • Water pollution due to sewage from construction camps.	• Sediment traps will be provided to reduce sediment load in construction wastewater. • Proper sanitation facilities will be provided in construction camps.
Air quality	• Deterioration of air quality due to fugitive dusts emission from construction activities and vehicular movement along unpaved roads. • Deterioration of air quality	• Construction materials will be stored in enclosed spaces to prevent fugitive emissions. • Truck carrying soil, sand and stone will be duly covered to avoid spilling. • Adequate dust suppression measures will be undertaken

Area	Impacts	Mitigation Measures
	due to gaseous emissions from construction equipment & vehicular traffic. • Deterioration of air quality due to emission from asphalt and hot mix plants.	to control fugitive dust. • Low emission construction equipment & vehicles will be used.
Noise level	• Increase in noise level due to operation of construction equipment & vehicular traffic.	• Protective gears such as ear plugs etc. will be provided to construction personnel exposed to high noise levels as preventive measure. • Low noise construction equipment will be used. • Construction activities carried out near residential area will be scheduled to the day time only so that minimum disturbances are caused to people.
Floral & fauna	• Loss of 1158 trees due to construction of proposed Metro corridors	• Preferential plantation of flowering trees with less timber & fruit value will be carried out. • Cooking fuel will be provided to construction workers to avoid cutting/felling of trees for fuel wood. • Compensatory trees cost of compensatory afforestation will be provided.
Rehabilitation & resettlement	• No Impact will take Place	Project affected persons will be re-habilitated.
Employment & trading opportunities	• The construction will improve the job opportunities	• Most of the construction laborers will be recruited from local areas to alleviate social tension of migration. • Some of the construction materials like stone chips & sand will be procured locally.
Operation Phase		

Area	Impacts	Mitigation Measures
Land-use & Encroachment	• Change of land use by squatter/ encroachment within ROW and induced development outside the ROW.	• Planning agencies and Collector/ Revenue Officer will be involved for controlled development and prohibiting squatter/ encroachment within ROW.
Drainage	• Filthy environment due to improper maintenance of drainage.	• Drainage system will be properly maintained.
Air quality	• The proposed project will provide a reduced vehicular emission load atmosphere	Positive Impact
Noise level	• Noise pollution due to operation phase of proposed Metro rail corridor	• Regular monitoring of noise level at specified locations will be conducted.
Access	• The proposed corridor will help to increase the accessibility of the project site	Positive Impact
Road safety	• Less vehicular movement will result to less accidental scenario	• Road signs, road markings, kerb paintings and road furniture like overhead gantry signs, roadway delineators etc. will be provided. • Adequate illumination will be provided at interchange locations • Periodical inspection of the corridor will be conducted to detect anomalies in pavement.

10.5 ENVIRONMENTAL MANAGEMENT PLAN

Based on the environmental baseline conditions, planned project activities and its impact assessed, the set of measures to be taken during implementation and operation to avoid, offset adverse environmental impacts or to reduce them to acceptable levels, together with the action which needs to be taken to be implemented are given in this section.

10.5.1 Mitigation Measures

Based on the project description, environmental baseline data and environmental impacts, it is proposed to prepare the environmental management plan for the following:

a) Compensation for loss of land
b) Compensation for loss of trees
c) Compensatory afforestation and fencing
d) Compensation for relocation / resettlement
e) Water supply and sanitation
f) Noise control
g) Vibration control

a) **Compensation for loss of land**: The cost of land for compensation is taken under the project cost.

b) **Compensation for loss of trees**: Compensation will be given for all trees which will be destroyed during construction activity.

c) **Compensatory afforestation**: According to survey, about 1158 trees are likely to be lost due to the project along the alignment. Ten times the number of trees is proposed to be planted. Hence a 9000 plants are required to be planted in the project area at a total cost of Rs. 13 lakh. It is presumed that government land will be provided for afforestation; hence no land cost will be involved. The recommended plant species for afforestation include Khejari, Castor, Roida(sheesham), Khair, Kair, Harsingar, lemon, pepal, ber, babool, neem, sirus,..gulmohar, arjun, papri, bottle brash, amla etc

d) **Compensation for relocation/resettlement:** The project involves relocation of shops, commercial cum residential buildings along the alignment. Compensation will be paid as per Government policy.

e) **Water supply and sanitation**: The public health facilities such as water supply sanitation and toilets are much needed at project location. Water should be treated before use upto WHO standards. In addition, water will be required for contractor's camps during construction for which additional arrangements have to be made in consultation with the Corporation of Jaipur. The collection and safe disposal of human wastes are among the most important problems of environmental health. During the operation phase, adequate water supply and sanitation facilities would be made available at all the stations. Properly designed rain water harvesting systems will be installed at all stations to conserve water.

f) **Noise**: There will be an increase in noise level in ambient air due to construction and operation of metro rail. The increase in levels is marginal; hence local population will not be adversely affected. However, the exposure of workers to high noise levels especially near engine, vent shaft, etc. need to be minimized. This can be achieved by job rotation, automation, protective devices, noise barriers, and soundproof compartments, control rooms, etc. The workers employed in high noise level area could be employed in low noise level areas. Automation of equipment and machineries, wherever possible should be done to avoid continuous exposure of workers to noise. At work places, where automation of machineries is not possible, the workers exposed to noise should be provided with protective devices. Special acoustic enclosures should be provided for individual noise generating equipments, wherever possible.

g) **Vibration control**: Vibration emanates from rail-wheel interaction and the same can be reduced by minimizing surface irregularities of wheel and rail, improving track geometry, providing elastic fastenings, and separation of rail seat assembly from the concrete plinth with insertion of resilient and shock absorbing pad.

10.6 ENVIRONMENTAL MONITORING PLAN

The environmental monitoring will be required for the construction and operational phases. The parameters to be monitored are water quality, air quality and noise level.

a) **Water quality**: Water quality parameters can be monitored one year before the construction, during the construction phase and also for one year after the completion of the project. Monitoring shall be carried out at least four times a year to cover seasonal variations. The parameters for monitoring will be pH, total dissolved solids, chlorides, nitrates, sulphates, total suspended solids, calcium, iron, fluoride, total alkalinity, oil and grease, etc. Locations for monitoring can be decided after the construction phase.

b) **Air quality and noise level:** Ambient air quality and noise level should be monitored one year before the construction, during the construction phase, and for one year after the completion of the project.

10.7 ENVIRONMENTAL MANAGEMENT SYSTEM

The environmental management system constitutes provision of an environmental division, which should be staffed by an environmental engineer/officer, an environmental assistant and two other assistants. The task assigned should include supervision and coordination of monitoring and implementation of environmental mitigation measures. An environmental advisor shall review progress of the division every year.

Chapter 11

Cost Estimates

CHAPTER 11

COST ESTIMATES

11.1 INTRODUCTION

Detailed cost estimates for E-W Corridor taken up as phase-I from Mansarovar – Badi Chaupar has been prepared covering civil, electrical, signaling and telecommunications works, rolling stock, environmental protection, rehabilitation, etc. considering 25 kV ac Overhead Traction System at April 2011price level. The Cost estimate for this corridor has been worked out for entire Phase-I as well as breakups for Phase-I A i.e Mansarovar to Chandpole and Phase-I B Chandpole to Badi Chaupar as described in para 11.2 of this chapter.

While preparing the capital cost estimates, various items have generally been grouped under three major heads on the basis of (i) route km length of alignment, (ii) number of units of that item, and (iii) item being an independent entity. All items related with alignment, whether elevated or at-grade or underground construction, permanent way, traction, Signalling & telecommunication, whether in main lines or in maintenance depot, have been estimated at rate per route km basis. Cost of station structures, other electrical services at these stations including Lifts & Escalators and Automatic Fare Collection (AFC) installations at all stations have been assessed in terms of each station as a unit. Similarly Rolling stock costs have been estimated in terms of number of units required. 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 accepted for Delhi Metro Phase-II. A suitable escalation factor has been applied to bring these costs to April 2011price level. However rate for elevated viaduct has been taken as per awarded rates for C1 contract of Jaipur metro and rates for underground section & station has been approximated according to the work awarded for DMRC's underground section from Central Secretariat to Mandi House. In some of the tenders, there is an element of taxes, which has been excluded for working out the project cost. However the details of taxes and duties are worked out separately.

The capital cost has been worked out for E-W Corridor and Depot at Mansarovar.

11.2 CAPITAL COST ESTIMATE – E-W CORRIDOR

The capital cost of E-W corridor has been worked out as below:

Phase-I-Mansarovar to Badi Chopar (All inclusive Cost) .

Phase-IA-Part cost of Mansarovar to Chandpole (All inclusive Cost).

Phase-IB-Part cost of Chandpole to Badi Chopar (All inclusive Cost).

The overall capital cost for Phase I at April 2011price level, works out to Rs. **2399Crore**, excluding taxes and duties, but including general charges & design charges @ 7% on all items except land and 3% contingencies on all items. The capital cost estimates are shown at **Table 11.2(a).**

The Capital Cost estimate for Phase-IA at April 2011price level, works out to **Rs. 1609Crore**, excluding taxes and duties, but including general charges & design charges @ 7% on all items except land and 3% contingencies on all items has been given in **Table 11.2(b).**

The Capital Cost estimate for Phase-IB at April 2011price level, works out to **Rs. 792Crore**, excluding taxes and duties, but including general charges & design charges @ 7% on all items except land and 3% contingencies on all items has been given in **Table 11.2(c).**

11.3 Land

i) Land requirements have been kept to the barest minimum & worked out on area basis. For underground and elevated alignment, no land is proposed to be acquired permanently, except small areas for locating entry/exit structures, traffic integration, etc. at stations, and wherever the alignment is off the road.

ii) Ground rent charges for 3 years @ 6% per year of the cost of land have been provided for temporarily land requirement, in the project cost estimates.

iii) A total land requirement for E-W corridor is 19.145ha out of which 14.400ha is government and 4.745ha is private land.

iv) It is envisaged that requirement of land remain same for underground and elevated options as no acquisition of land (except off the road locations) is proposed in running section of viaduct in case elevated sections. Requirement of land at station locations is increased marginally in case of underground sections as certain facilities such as DG set, Chilling Plant, Pump House and cooling Towers are required to be constructed at surface. Land required for depots and construction depots remains same in both the cases

v) Government of Rajasthan has proposed Property Development for funding the project after its commercial exploitation. However exact location of land shall be finalized and made available by them in due course. The property development shall be taken by the JMRC.

11.4 Formation, Alignment

i) **Underground section:-** The basis of rate is as accepted for Phase-II of Delhi Metro. A suitable escalation factor has been applied to bring these costs to April 2011price level. Costs are worked considering underground alignment to be done by Tunnel Boring Machines, except 220m lengths for each station, which is proposed to be done along with station work. All the stations are proposed to be constructed by cut & cover method.

ii) **Elevated Section:** Rates are based on the accepted rates of Phase-II of Delhi Metro, duly updated to April 2011price level. Cost of viaduct length for station has been included in elevated section. About 2 km length of viaduct will be double height for which no extra cost is provided. However, additional cost on this account to be charged to contingency.

11.5 Station Buildings

i) **Underground Stations:** Rates for underground stations are based on cost assessed for similar works for Delhi Metro Station works duly updated to April 2011price level. This work cover U.G. alignment, as well as, other civil electrical works like ventilation, air-conditioning, lifts & escalators, but does not cover P-way, O.H.E, signaling and interlocking works, AFC installations.

ii) **Elevated Stations:** Rates are based on accepted rates of Phase-II of Delhi Metro, duly updated to April 2011price level. The cost includes the general services at the stations but excludes the cost of viaduct, lifts & escalators, which have been considered separately under, respective items. One station is planned at double height. The extra cost on double height account to be charged to contingency.

11.6 Permanent Way

For elevated and underground sections, ballast-less track and for at-grade section and Depot ballasted track has been planned. Rates are based on accepted rates of Phase-II of Delhi Metro, duly updated to April 2011price level and duly corrected for the systems proposed for Jaipur Metro.

11.7 DEPOT

Car Maintenance Depot-cum-Workshop for E-W Corridor has been proposed at Mansarovar. Costs of depot have been worked out for various items of building, elevated structures, tracks, boundary wall & plants machinery etc.

11.8 UTILITY DIVERSIONS

The costs of utility diversions involved in the stretch have been considered separately and provided for in the estimate. In addition to sewer/drainage/water pipelines other important utilities works considered are road diversions, road restoration etc. Cost provision has been made on route km basis based on experience of Deihi Metro.

11.9 ENVIRONMENTAL IMPACT ASSESSMENT

Provision for environmental impacts of the proposed two Corridors of Jaipur Metro has been made to cover various protection works, additional compensatory measures, and compensation for loss of trees, compensatory afforestation and fencing, monitoring of water quality, air/noise pollution during construction, establishment of Environmental Division.

11.10 REHABILITATION & RESETTLEMENT

Provision towards compensation/rehabilitation of structure likely to be affected has been assessed. Sufficient provision is kept in the estimate to cover the cost of shifting of structures.

11.11 TRACTION & POWER SUPPLY

Provisions have been made to cover following subheads:

- OHE
- Receiving-cum-Traction Sub-stations including cables.
- ASS for elevated and at-grade stations.
- Service connection charges for Receiving Sub-stations.
- SCADA augmentation.
- Miscellaneous items e.g. illumination, lifting T&P, etc.

The rates adopted for various items are based on costs of works being done for Delhi Metro Phase-II, duly updated to April 2011 price level.

11.12 ELECTRICAL SERVICES AT STATIONS

These are included in estimated costs of stations. Cost of escalators for elevated stations have not been included in station costs, and therefore, are provided under electrical estimates & shown separately.

11.13 SIGNALLING & TELECOMMUNICATION WORKS

The rates adopted are based on assessment done considering rates of similar sub-system as accepted for Phase-II of Delhi Metro, duly updated to April 2011price level and TPWS works. These rates include escalation during manufacture & supply of equipment and their installation at site, but exclude CD and WT.

11.14 AUTOMATIC FARE COLLECTION

Adopted rates are based on assessment done considering rates of similar works in other metro projects, duly updated to April 2011price level. These rates exclude CD & WT, but include escalation during the period of equipment manufacture and their supply, including installation.

11.15 ROLLING STOCK

The estimated cost per coach at April 2011price level exclusive of taxes and duties has been taken as Rs. 8.5crores per coach.

11.16 TAXES AND DUTIES

The component of Import Duty, Excise Duty and VAT is not included in the Capital cost estimated. The estimated taxes and duties work out to Rs. 398 crore for Phase-I , Rs. 262crore for Phase-I A and Rs. 136 crore for Phase-I B for E-W Corridor (Table 11.3 a, b,& c)

Table 11.2 (a) : Capital Cost Estimate					
				April 2011 Prices	
	Mansarovar to Badi Chopar **(Phase I : All inclusive Cost).**				
	Total length = 12.067km, UG(C&C) =1.146 km, UG (TBM)=1.643 km, Elev =9.278 km				
	Total Station = 11 nos, UG = 3 nos., Elev = 8 nos				
S. No.	**Item**	**Unit**	**Rate**	**Qty.**	**Amount (Rs. in Cr.)**
				Without taxes	
1.0	**Land**				
a	Government Land	ha	0.00	14.4	0.00
b	Private Land	ha	20.00	4.745	94.90
c	Temporary Land (On Rent for 3 Years By GOR)	ha	0.90	10.00	9.00
1.1	Boundary	r km	0.71	1.97	1.40
	Sub Total (1)				**105.30**
2.0	**Alignment and Formation**				
2.1	Underground section by T.B.M excluding station length (220m each)	R. Km.	125.00	1.423	177.90
2.2	Underground section by Cut & Cover excluding Station length (220m each)	R. Km.	87.18	0.706	61.58
2.3	Elevated section including station length	R. Km.	21.25	9.278	197.16
2.4	Entry to depot	R. Km.	21.25	1.000	21.25
	Sub Total (2)				**457.88**
3.0	**Station Buildings**				
3.1	Underground Station(220 m length) incl. EM works, lifts, escalators, VAC etc.	Each			
a	Underground Station- Civil works	Each	114.39	3.000	343.16
b	Underground Station- EM works etc.	Each	52.07	3.000	156.20
3.2	Elevated stations	Each			

a	Type (A) way side- civil works	Each	11.12	4.000	44.46
b	Type (A) way side- EM works etc	Each	2.18	4.000	8.72
c	Type (B) Way side with signalling-civil works	Each	12.85	2.000	25.69
d	Type (B) Way side with signalling-EM works etc	Each	2.30	2.000	4.60
e	Type (C), Terminal station -civil works	Each	13.89	2.000	27.79
f	Type (c), Terminal station -EM works	Each	2.72	2.000	5.45
3.3	OCC bldg.				
a	OCC bldg.-civil works	LS	5.00	1.000	5.00
b	OCC bldg.-EM works etc	LS	2.00	1.000	2.00
c	Elevated Architectural finish-Civil works	Each	4.34	8.000	34.71
d	Training school at mansarowar Depot-civil works	LS	4.34	1.000	4.34
e	Training school at mansarowar Depot-EM works	LS	1.08	1.000	1.08
	Sub Total (3)				**663.21**
4.0	**Depot**				
a	Civil works	LS			65.08
b	EM works etc	LS			43.39
	Subtotal (4)				**108.47**
5.0	**P-Way**				
5.1	Ballastless track for elevated & underground Section	R. Km.	6.73	13.067	87.88
5.2	Ballasted track for at grade alignment in depot	R. Km.	2.06	5.000	10.30
	Subtotal (5)				**98.18**
6.0	**Traction & power supply incl. OHE, ASS etc. Excl. lifts & Escalators**				
6.1	UG Section	R.Km.	11.93	2.789	33.28
6.2	Elevated section	R.Km.	6.51	10.278	66.89
6.3	Lift for elevated stations	Each	0.18	32.000	5.90
6.4	Escalator for elevated stations	Each	0.69	32.000	22.21
	Subtotal (6)				**128.29**
7.0	**Signalling and Telecom.**				
7.1	Sig. & Telecom.	R. Km.	14.32	13.067	187.10
7.2	Automatic fare collection	Stn.			
a	Underground section	Each	2.71	3.000	8.14
b	Elevated stations	Each	2.71	8.000	21.69
	Sub Total (7)				**216.93**
8.0	**R & R incl. Hutments etc.**	LS			10.85
	Subtotal (8)				**10.85**

9.0	**Misc. Utilities, road works, other civil works such as median stn. signages Environmental protection**	R. Km.			
a	Civil works+EM works	R. Km.	2.71	12.048	32.67
	Subtotal (9)				**32.67**
10.0	**Rolling Stock**	Each	8.50	40.000	340.00
	Subtotal (10)				**340.00**
11.0	**Capital expenditure on security**	LS			
a	Civil works	LS			16.27
b	EM works etc	LS			5.42
	Subtotal (11)				**21.69**
12.0	**Total of all items except Land**				**2078.17**
13.0	**General Charges incl. Design charges @ 7 % on all items except land**				**145.47**
14.0	**Total of all items including G. Charges except land**				**2223.64**
15.0	**Contingencies @ 3 %**				**66.71**
16.0	**Gross Total**				**2290.35**
	Cost without land			=	**2290**
	Cost with land			=	**2399**

Table 11.2 (b) : Capital Cost Estimate
Mansarovar to Chandpole

(Phase I A: All inclusive Cost).

Total length = 9.718km, UG(C&C) =0.44km, Elev =9.278 km

Total Station = 9nos, UG = 1nos., Elev = 8 nos

S. No.	Item	Unit	Rate	Qty.	Amount (Rs. in Cr.)
				Without taxes	
1.0	**Land**				
a	Government Land	ha	0.00	13.35	0.00
b	Private Land	ha	20.00	4.75	94.90
c	Temporary Land (Government)	ha	5.00	10.00	9.00
1.1	Boundary	r km	0.71	1.97	1.40
	Subtotal (1)				**105.30**

2.0	**Alignment and Formation**				
2.1	Underground section by T.B.M excluding station length (220m each)	R. Km.	125.00	0.000	0.00
2.2	Underground section by Cut & Cover excluding Station length (220m each)	R. Km.	87.18	0.220	19.18
2.3	Elevated section including station length	R. Km.	21.25	9.278	197.16
2.4	Entry to depot	R. Km.	21.25	1.000	21.25
	Subtotal (2)				**237.59**
3.0	**Station Buildings**				
3.1	Underground Station(220 m length) incl. EM works, lifts, escalators, VAC etc.	Each			
a	Underground Station- Civil works	Each	114.39	1.000	114.39
b	Underground Station- EM works etc.	Each	52.07	1.000	52.07
3.2	Elevated stations	Each			
a	Type (A) way side- civil works	Each	11.12	4.000	44.48
b	Type (A) way side- EM works etc	Each	2.18	4.000	8.72
c	Type (B) Way side with signalling-civil works	Each	12.85	2.000	25.69
d	Type (B) Way side with signalling-EM works etc	Each	2.30	2.000	4.60
e	Type (C), Terminal station -civil works	Each	13.89	2.000	27.79
f	Type (c), Terminal station -EM works	Each	2.72	2.000	5.45
3.2	OCC bldg.				
a	OCC bldg.-civil works	LS	5.00	1.000	5.00
b	OCC bldg.-EM works etc	LS	2.00	1.000	2.00
c	Elevated Architectural finish-Civil works	Each	4.34	8.000	34.71
d	Training school at mansarowar Depot-civil works	LS	4.34	1.000	4.34
e	Training school at mansarowar Depot-EM works	LS	1.08	1.000	1.08
	Subtotal (3)				**330.32**
4.0	**Depot**				
a	Civil works	LS			65.08
b	EM works etc	LS			43.39
	Subtotal (4)				**108.47**
5.0	**P-Way**				
5.1	Ballastless track for elevated & underground Section	R. Km.	6.73	10.718	72.08
5.2	Ballasted track for at grade alignment in depot	R. Km.	2.06	5.000	10.30
	Subtotal (5)				**82.39**
6.0	**Traction & power supply incl. OHE, ASS etc. Excl. lifts & Escalators**				

6.1	UG Section	R.Km.	11.93	0.440	5.25
6.2	Elevated section	R.Km.	6.51	10.278	66.89
6.3	Lift for elevated stations	Each	0.18	32.000	5.90
6.4	Escalator for elevated stations	Each	0.69	32.000	22.21
	Subtotal (6)				**100.26**
7.0	**Signalling and Telecom.**				
7.1	Sig. & Telecom.	R. Km.	14.32	10.718	153.46
7.2	Automatic fare collection	Stn.			
a	Underground section	Each	2.71	1.000	2.71
b	Elevated stations	Each	2.71	8.000	21.69
	Subtotal (7)				**177.87**
8.0	**R & R incl. Hutments etc.**	LS			8.70
	Subtotal (8)				**8.70**
9.0	**Misc. Utilities, roadworks, other civil works such as median stn. signages Environmental protection**	R. Km.			
a	Civil works+EM works	R. Km.	2.71	9.718	26.35
	Subtotal (9)				**26.35**
10.0	**Rolling Stock**	Each	8.50	32.000	272.00
	Subtotal (10)				**272.00**
11.0	**Capital expenditure on security**	LS			
a	Civil works	LS			13.10
b	EM works etc	LS			4.36
	Subtotal (11)				**17.46**
12.0	**Total of all items except Land**				**1361.40**
13.0	**General Charges incl. Design charges @ 7 % on all items except land**				**95.30**
14.0	**Total of all items including G. Charges except land**				**1456.70**
15.0	**Continegencies @ 3 %**				**43.70**
16.0	**Gross Total**				**1500.40**
	Cost without land			**=**	**1500**
	Cost with land			**=**	**1609**

Table 11.2(c) : Capital Cost Estimate (Option III)					
				April 2011 Prices	
Chandpole to Badi Chopar **(Phase IB : All inclusive Cost).**					
Total length = 2.349km, UG(C&C) =0.706km, UG (TBM)=1.643 km,					

Total Station = 2nos, UG = 2nos.					
S. No.	**Item**	**Unit**	**Rate**	**Qty.**	**Amount (Rs. in Cr.)**
				Without taxes	
1.0	**Land**				
a	Government Land	ha	0.00	1.05	0.00
b	Private Land	ha	20.00	0.00	0.00
c	Temporary Land (Government)	ha	0.00	1.95	1.75
1.1	Boundary	r km	0.71	0.38	0.27
	Subtotal (1)				**2.02**
2.0	**Alignment and Formation**				
2.1	Underground section by T.B.M excluding station length (220m each)	R. Km.	125.00	1.42	177.88
2.2	Underground section by Cut & Cover excluding Station length (220m each)	R. Km.	87.18	0.49	42.37
	Subtotal (2)				**220.24**
3.0	**Station Buildings**				
3.1	Underground Station(220 m length) incl. EM works, lifts, escalators, VAC etc.	Each			
a	Underground Station- Civil works	Each	114.39	2.00	228.77
b	Underground Station- EM works etc.	Each	52.07	2.00	104.13
3.2	Elevated stations	Each	0.00		
	Subtotal (3)				**332.91**
4.0	**Depot**				
	Subtotal (4)				**0.00**
5.0	**P-Way**				
5.1	Ballastless track for elevated & underground Section	R. Km.	6.73	2.35	15.80
5.2	Ballasted track for at grade alignment in depot	R. Km.	2.06		
	Subtotal (5)				**15.80**

6.0	**Traction & power supply incl. OHE, ASS etc. Excl. lifts & Escalators**				
6.1	UG Section	R.Km.	11.93	2.35	28.03
	Subtotal (6)				**28.03**
7.0	**Signalling and Telecom.**				
7.1	Sig. & Telecom.	R. Km.	14.32	2.35	33.63
7.2	Automatic fare collection	Stn.			
a	Underground section	Each	2.71	2.00	5.42
b	Elevated stations	Each	2.71	0.00	0.00
	Subtotal (7)				**39.06**
8.0	**R & R incl. Hutments etc.**	LS			2.15
	Sub Total (8)				**2.15**
9.0	**Misc. Utilities, roadworks, other civil works such as median stn. signages Environmental protection**	R. Km.			
a	Civil works+EM works	R. Km.	2.71	2.35	6.37
	Subtotal (9)				**6.37**
10.0	**Rolling Stock**	Each	8.50	8.00	68.00
	Subtotal (10)				**68.00**
11.0	**Capital expenditure on security**	LS			
a	Civil works	LS			3.17
b	EM works etc	LS			1.06
	Subtotal (11)				**4.22**
12.0	**Total of all items except Land**				**716.77**
13.0	**General Charges incl. Design charges @ 7 % on all items except land**				**50.17**
14.0	**Total of all items including G. Charges except land**				**766.95**
15.0	**Contineqencies @ 3 %**				**23.01**
16.0	**Gross Total**				**789.96**
	Cost without land			=	**790**
	Cost with land			=	**792**

Table 11.3(a) : Details of Taxes and Duties

S. No.	Description	Total cost without Taxes & duties (Cr.)	Taxes and duties: custom duty (Cr.)	excise duty (Cr.)	VAT	Total taxes & duties (Cr.)
1	**Alignment & Formation**					
	Underground	239.48	15.05	12.09	16.18	**43.31**
	Elevated & entry to Depot	218.41		15.75	21.08	**36.83**
2	**Station Buildings**					
	Underground station-civil works	343.16	21.56	17.32	23.18	**62.07**
	Underground station-EM works	156.20	16.36	6.84	9.15	**32.35**
	Elevated station - civil works	137.00		9.88	13.22	**23.10**
	Elevated station-EM works	19.85	0.83	1.39	1.86	**4.08**
3	**Depot**					
	Civil works	65.08	4.09	3.28	4.40	**11.77**
	EM works	43.39	1.82	3.04	4.07	**8.92**
4	**P-Way**	98.18	16.45	1.72	2.30	**20.47**
5	**Traction & power supply**					
	Traction and power supply	100.17	8.39	5.26	7.04	**20.70**
	a) Lifts	5.90	0.74	0.21	0.28	**1.22**
	b) Esclators	22.21	4.65			**4.65**
6	**S and T Works**					
	S & T	187.10	31.35	3.85	5.16	**40.37**
	AFC	29.83	4.69	0.77	1.03	**6.48**
7	**R & R hutments**	10.85			1.36	**1.36**
8	**Misc.**					
	Civil works	24.50		1.77	2.36	**4.13**
	EM works	8.17		0.72	0.96	**1.67**
9	**Rolling stock**	340.00	62.67	2.73	3.66	**69.06**
10	**Security**					
	Civil works	16.27		1.17	1.57	**2.74**
	EM works	5.42		0.56	0.75	**1.31**
	Total	**2078.17**	**188.74**	**88.84**	**120.27**	**397.86**
	Total taxes & Duties					**398**

Table 11.3(b) : Details of Taxes and Duties

S. No.	Description	Total cost without Taxes & duties (Cr.)	Taxes and duties custom duty (Cr.)	excise duty (Cr.)	VAT	Total taxes & duties (Cr.)
1	**Alignment & Formation**					
	Underground	19.18	1.21	0.97	1.30	**3.47**
	Elevated & entry to Depot	218.41		15.75	21.08	**36.83**
2	**Station Buildings**					
	Underground station-civil works	114.39	7.19	5.77	7.73	**20.69**
	Underground station-EM works	52.07	5.45	2.28	3.05	**10.78**
	Elevated station - civil works	137.01		9.88	13.22	**23.10**
	Elevated station-EM works	19.85	0.83	1.39	1.86	**4.08**
3	**Depot**					
	Civil works	65.08	4.09	3.28	4.40	**11.77**
	EM works	43.39	1.82	3.04	4.07	**8.92**
4	**P-Way**	82.39	13.81	1.44	1.93	**17.18**
5	**Traction & power supply**					
	Traction and power supply	72.14	6.04	3.79	5.07	**14.91**
	a) Lifts	5.90	0.74	0.21	0.28	**1.22**
	b) Esclators	22.21	4.65			**4.65**
6	**S and T Works**					
	S & T	153.46	25.72	3.16	4.23	**33.11**
	AFC	24.41	3.63	0.63	0.84	**5.30**
7	**R & R hutments**	8.70			1.09	**1.09**
8	**Misc.**					
	Civil works	19.76		1.43	1.91	**3.33**
	EM works	6.59		0.58	0.77	**1.35**
9	**Rolling stock**	272.00	50.14	2.19	2.93	**55.25**
10	**Security**					
	Civil works	13.10		0.94	1.26	**2.21**
	EM works	4.36		0.45	0.60	**1.05**
	Total	**1361.40**	**125.60**	**57.67**	**78.28**	**261.56**
	Total taxes & Duties					**262**

Table 11.3(c) : Details of Taxes and Duties

S. No.	Description	Total cost without Taxes & duties (Cr.)	Taxes and duties custom duty (Cr.)	excise duty (Cr.)	VAT	Total taxes & duties (Cr.)
1	**Alignment & Formation**					
	Underground	220.24	13.84	11.12	14.88	**39.84**
2	**Station Buildings**					
	Underground station-civil works	228.77	14.38	11.55	15.46	**41.38**
	Underground station-EM works	104.13	10.91	4.56	6.10	**21.57**
3	**Depot**					**0.00**
4	**P-Way**	15.80	2.65	0.28	0.37	**3.29**
5	**Traction & power supply**					
	Traction and power supply	28.03	2.35	1.47	1.97	**5.79**
6	**S and T Works**					
	S & T	33.63	5.64	0.69	0.93	**7.26**
	AFC	5.42	0.85	0.14	0.19	**1.18**
7	**R & R hutments**	2.15			0.27	**0.27**
8	**Misc.**					
	Civil works	4.78		0.34	0.46	**0.81**
	EM works	1.59		0.14	0.19	**0.33**
9	**Rolling stock**	68.00	12.53	0.55	0.73	**13.81**
10	**Security**					
	Civil works	3.17		0.23	0.31	**0.53**
	EM works	1.06		0.11	0.15	**0.25**
	Total	**716.77**	**63.14**	**31.17**	**41.99**	**136.30**
	Total taxes & Duties					**136**

Chapter 12

Financing Options, Fare Structure and Financial Viability

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CHAPTER 12

FINANCING OPTIONS, FARE STRUCTURE AND FINANCIAL VIABILITY

12.1 INTRODUCTION

The Jaipur MetroPhase-I project, East west Corridor, consists of 12.067 Kms route length from Mansarovar to Badi Chaupar is proposed to be constructed with an estimated cost as per details are shown in table 12.1 below:-

Table 12.1(Rs./Crore)

Corridor	Route Length (KMs)	Estimated Cost with Central Taxes at Apr-2011 price level	Completion cost
Mansarovar to Badi Chaupar (total in Phase-I)	**12.067**	**2677.00**	**3149.00**
Mansarovar to Chandpole (phase I A)	9.718	1792.00	2023.00
Chandpole to Badi Chaupar (Phase I B)	2.349	885.00	1126.00

The estimated cost at April-2011 price level includes total amount of Rs.21.69 Crore as one-time charges of security personnel towards cost ofbarracks, hand held and door detector machine etc. However, the recurring cost towards salary and allowances of security personnel have not been taken into account in FIRR calculation.

12.2Costs

12.2.1 Investment Cost

12.2.1.1 For the purpose of calculating the Financial Internal Rate of Return (FIRR), the completion cost with central taxes have been calculated by taking escalation factor @5% PA. It has been assumed that Government of Rajasthan will exempt local taxes or reimburse the same. The impact of proposed Goods & Service Tax Act (GST) has not been considered in the calculation.

The construction work in respect of Phase-IA of 9.718 KMs from Mansarovar to Chandpole as already taken up and scheduled for commercial operation from 1st July-2013. However for the balance portion, the work willbe taken up inApril, 2012 and expected to be completed in the year 2016-17. The Revenue Opening Date (ROD) for this part has been assumed as 01.04.2017. The total completion costs duly escalated and shown in the table 12.2 have been taken as the initial investment. The cash flow of investments based on completion cost is separately is placed in Table – 12.2 asbelow.

Table 12.2Year wise Investment-With Central Taxes

(Figs in Rs/Crore)

F/Y	Estimated Cost at April 2011	Completion Cost for Phase-I	Completion Cost for Phase-I A	Completion Cost for Phase-I B
2010-11	46.00	46.00	46.00	0.00
2011-12	378.00	395.00	393.00	2.00
2012-13	632.00	693.00	596.00	97.00
2013-14	554.00	641.00	487.00	154.00
2014-15	369.00	449.00	287.00	162.00
2015-16	345.00	440.00	214.00	228.00
2016-17	177.00	237.00	0.00	235.00
2017-18	176.00	248.00	0.00	248.00
Total	2677.00	3149.00	2023.00	1126.00

12.2.1.2 Although the construction of Phase-IB from Chandpole to Badi Chaupar is expected to get over by 31st March 2017, the cash flow spills up to March 2018 on account of payment normally required to be made to the various contractors up to that period necessitated by contractual clauses.

12.2.1.3 The land cost is divided in initial 3years for Phase-IA and IB separately during which it is expected that the land acquisition work would be over and related payments would have to be released.

12.2.1.4 The escalation factor used is 5% p.a.

12.2.2 Additional Investment

Total investment provided in the FIRR calculation towards requirement of additional rolling stock duly escalated @5% PA is placed in table 12.3 as under: -

Table 12.3- Additional Investment towards Rolling Stock

(Rs/Crore)

With Taxes & Duties			
2021-22		2031-32	
No of Cars	Amount	No of Cars	Amount
20	367	28	838

12.2.3. Operation & Maintenance (O&M) Costs

12.2.3.1 The Operation & Maintenance costs can be divided into three major parts: -

(i) Staff costs

(ii) Maintenance cost which include expenditure towards upkeep and maintenance of the system and consumables& Misc. Office overheads.

(iii) Energy costs

The staff is assumed to be provided @ 35 persons per kilometre. The escalation factor used for staff costs is 9% per annum to provide for both escalation and growth in salaries. The staff cost has been worked out by considering pay scale wise O&M employees on roll as on 01.04.2011 and allowances as per DMRC rules.

The cost of other expenses is based on the actual O & M unit cost for the Delhi Metro Phase-II project. The rate of electricity assumed in the Delhi Metro study is about Rs. 2.30 per unit whereas at present in Jaipur the applicable rate is Rs. 3.63 per unit. The latter has been used for all calculations. The O&M cost (excluding staff cost) has been obtained by providing an escalation of 5% per annum towards energy cost, 5% towards Maintenance cost.

12.2.3.2 The O&M cost of phase I corridor has been tabulated in Table 12.4as below:

Table 12.4 Operation and Maintenance Costs

(Figs in Rs/Crore)

YEAR			Staff	Maintenance Expenses	Energy	Total
2013	-	2014	11.65	7.29	7.68	26.61
2014	-	2015	16.93	9.72	10.75	37.39
2015	-	2016	18.45	10.20	11.29	39.94
2016	-	2017	24.95	10.71	11.85	47.51
2017	-	2018	36.85	13.82	12.44	63.12
2018	-	2019	40.17	14.52	13.06	67.75

YEAR			Staff	Maintenance Expenses	Energy	Total
2019	-	2020	43.78	15.24	15.76	74.79
2020	-	2021	47.73	16.00	16.55	80.28
2021	-	2022	52.02	16.80	26.06	94.89
2022	-	2023	56.70	17.64	27.37	101.71
2023	-	2024	61.81	18.53	28.74	109.07
2024	-	2025	67.37	19.45	30.17	116.99
2025	-	2026	73.43	20.42	31.68	125.54
2026	-	2027	80.04	21.45	33.27	134.75
2027	-	2028	87.24	22.52	34.93	144.69
2028	-	2029	95.10	23.64	36.68	155.42
2029	-	2030	103.65	24.83	38.51	166.99
2030	-	2031	112.98	26.07	40.44	179.49
2031	-	2032	123.15	27.37	62.27	212.79
2032	-	2033	134.24	28.74	65.38	228.36
2033	-	2034	146.32	30.18	68.65	245.15
2034	-	2035	159.49	31.69	72.09	263.26
2035	-	2036	173.84	33.27	75.69	282.80
2036	-	2037	189.49	34.93	79.47	303.89
2037	-	2038	206.54	36.68	83.45	326.67
2038	-	2039	225.13	38.51	87.62	351.26
2039	-	2040	245.39	40.44	92.00	377.83
2040	-	2041	267.47	42.46	96.60	406.54
2041	-	2042	291.55	44.58	101.43	437.56
2042	-	2043	317.79	46.81	106.50	471.10
2043	-	2044	346.39	49.15	111.83	507.37
2044	-	2045	377.56	51.61	117.42	546.59

Depreciation

Although depreciation does not enter the FIRR calculation (not being a cash outflow) unless a specific depreciation reserve fund has been provided, in the present calculation, depreciation calculations are placed for purpose of record.

12.2.4 Replacement Cost

The replacement costs are provided for meeting the cost on account of replacement of equipment due to wear and tear. With the nature of equipment proposed to be provided, it is expected that only 50% of the Signalling and Telecom and 25% of electrical works would require replacement after 20 years. Further, 50% of the Signalling and Telecom and 25% of electrical works would require replacement after 30 years. These costs have been provided duly escalated @ 5% per annum.

12.3. Revenues

The Revenue of Jaipur metro mainly consists of fare box collection and other incomes from property development, advertisement, parking etc.

12.3.1 Fare box

The Fare box collection is the product of projected ridership per day and applicable fare structure based on trip distribution at different distance zones.

12.3.2 Traffic

12.3.2.1 (a) The projected ridership figures years are as indicated in table 12.5 as below: -

Table 12.5- Projected Ridership

Year	Trips per day (lakhs)
2013-14	1.21
2017-18	2.48
2021-22	2.93
2031-32	4.22
2041-42	4.43

(b) The growth rate for traffic is assumed at 5% Per Annum upto 2018-19,4.5% Per Annum from 2019-20 to 2028-29and thereafter @ 0.5% per annum.

12.3.2.2 Trip Distribution

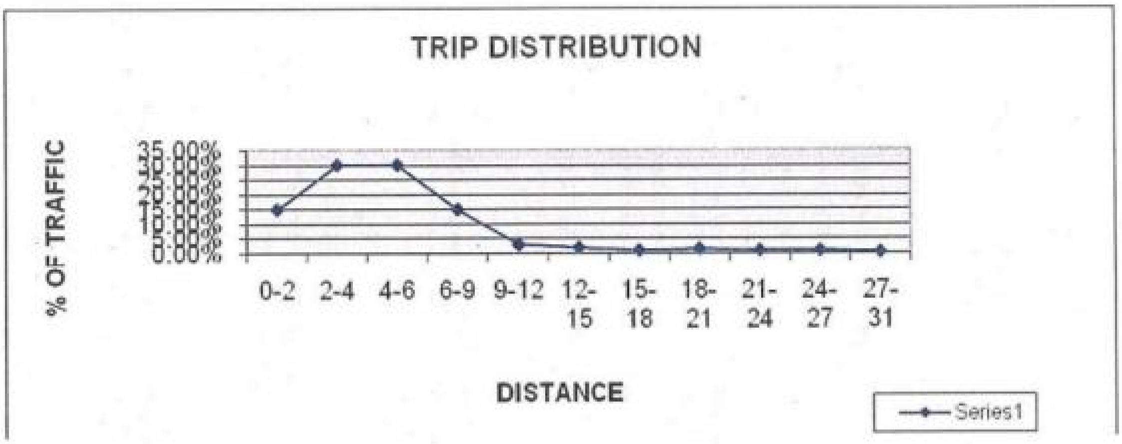
The trip distribution has been worked out by considering average lead of 5.35 KM and with an assumption that a passenger will travel in the network of Phase-I & Phase-II, which is placed in Table 12.6 below: -

Table 12.6- Trip Distribution

Distance in kms.	Percent distribution
0-2	15.00%
2-4	30.00%
4-6	30.00%
6-9	15.00%
9-12	3.00%
12-15	2.00%
15-18	1.00%
18-21	1.50%
21-24	1.00%
24-27	1.00%
27-31	0.50%
Total	**100.00%**

The graphic presentation of the same is placed below in Figure-12.1.

Figure 12.1 –Trip Distribution



12.3.2.3 Fare Structure

The fare structure of Delhi Metro was compared with the existing fare of Buses, Auto and other general modes of public transport in Jaipur and it was reported that the same is mostly coming at par of the Delhi Metro Fares structures as fixed by a fare fixation committee in 2009. The same, therefore have been assumedwhich have been duly escalated @10% for every two years and is placed in table 12.7.

Table 12.7- Fare Structure in 2013-14

Distance in kms.	Metro Fare (Rs.)
0-2	9.00
2-4	12.00
4-6	14.00
6-9	17.00
9-12	18.00
12-15	21.00
15-18	22.00
18-21	24.00
21-24	25.00
24-27	27.00
27-31	28.00

The above fare structure will remain unchanged during the first two years of operations. Comparison of Proposed Jaipur Metro Fare with Prevailing Fare Structure in different PT/IPT modes of Jaipur is given in the table below.

(Rs.)

Comparison of Proposed Jaipur Metro Fare with Prevailing Fare Structure in different PT/IPT modes of Jaipur					
Distance in K.M.	Auto Rickshaw Fare	Jaipur Buses (Non AC) Fare	Jaipur Buses (AC) Fare	Proposed Fare Structure in Jaipur Metro, if commissioned on date	Proposed Fare Structure in Jaipur Metro, if commissioned on 01.07.2013 or before in 2013.
0-2	13	6	10	8	9
2-4	29	6	10	10	12
4-6	45	10	15	12	14
6-9	69	10	15	15	17
9-12	93	10	20	16	18
12-15	117	12	20	19	21
15-18	141	12	25	20	22
18-21	165	12	25	21	24
21-24	189	12	30	22	25
24-27	213	18	30	24	27
27-31	237	18	30	25	28

From the above , it may be seen that the Metro Fare proposed are comparable to the existing fare structure for other modes in Jaipur and if need be, there is margin to increase the fares by about a rupee or two in the higher kilometre slab beyond 15-18 Km.

12.4 Other sources of revenues

Advertisement & Other revenuehave been taken as 10% of fare box revenue. It mainly includes the commercial earnings from rentals at Stations and Depot, leasing of parking rights at stations, advertisement on trains and tickets, advertisements within stations and parking lots, advertisements on viaducts, columns and other metro structures, co-branding rights to corporates, film shootings and special events on metro premises.

As per the details provided by JMRC, Jaipur Metro propose to put 12.50 hectors of lands for this Phase for exploitation for Real Estate Development with the involvement of established Developers. The property development models can be designed in a way that not only the upfront receipts but also the regular receipts in the development of lease rentals can be ensured to supplement the fare box collection and reduce the fare structure. No upfront revenue has been built up in this phase since the same has been planned to deploy parking lots at the Depot.

The SPV i.e., JMRC will give the land free of cost to the developer. The developer will bring equity to the extent of Rs.212 crore and the balance amount towards construction and upfront money planned for parking lots is to be arranged by the developer at the interest of 12% from Market as Debt. The estimated development cost will be Rs.850crore. It is assumed that the rental revenue will accrue to the developer from the FY 2016-17 which has been escalated @5% every year. Out of the estimated rental income, apart from meeting maintenance expenditure, the developer will repay the loan and interest. After meeting these obligations and retaining 15% return on his equity with an escalation @5% every year, the residual rental earnings will accrue to JMRC, which has been taken into account in the FIRR calculations.

The income from PD from standalone land parcel have been worked out based on the experience of DMRC by taking lease rent @ Rs.45/sq. ft., in 2013-14 construction cost of the development @ Rs.20,000/- per sq.mtr., maintenance charge of the development @ 20% of the lease rent income and FAR of 3 which is as per enclosed Table 12.17.11.

12.5 Financial Internal Rate of Return (FIRR)

12.5.1 The Financial Internal Rate of Return (FIRR) obtained with the above revenues and costs for 35 years ,including construction period, are placed in table 12.8: -

Table 12.8- FIRR: (Cost with central taxes)

Particulars	Cost including DMRC portion
FIRR	**8.24%**

12.5.2 The FIRR with central taxes is produced in Table 12.9

Table 12.9 –FIRR (Rs./Crore)

Year			Outflow					Inflow			Net Cash Flow
			Completion Cost	Addition al Cost	Running Expenses	Replace -ment costs	Total Costs	Fare Box Revenue	Revenue from PD, ADVT& others	Total Revenue	IRR
2010	-	2011	46				46		0	0	-46
2011	-	2012	395				395			0	-395
2012	-	2013	693				693			0	-693
2013	-	2014	641		26.61		668	68.00	6.80	74.8	-593
2014	-	2015	449		37.39		486	96.00	9.60	105.60	-381
2015	-	2016	440		39.94		480	110.00	11.00	121.00	-359
2016	-	2017	237		47.51		285	116.00	67.60	183.60	-101
2017	-	2018	248		63.12		311	167.00	-69.30	97.70	-213
2018	-	2019	0		67.75		68	175.00	-39.50	135.50	68
2019	-	2020	0	0	74.79		75	201.00	-6.90	194.10	119
2020	-	2021	0	0	80.28		80	210.00	27.00	237.00	157
2021	-	2022	0	367	94.89		462	243.00	66.30	309.30	-153
2022	-	2023	0	0	101.71		102	254.00	80.40	334.40	233

Year	Outflow					Inflow			Net Cash Flow
	Completion Cost	Additional Cost	Running Expenses	Replace-ment costs	Total Costs	Fare Box Revenue	Revenue from PD, ADVT& others	Total Revenue	IRR
2023 - 2024	0	0	109.07		109	295.00	98.50	393.50	284
2024 - 2025	0	0	116.99		117	308.00	114.80	422.80	306
2025 - 2026	0	0	125.54		126	354.00	133.40	487.40	362
2026 - 2027	0	0	134.75		135	370.00	150.00	520.00	385
2027 - 2028	0	0	144.69		145	427.00	170.70	597.70	453
2028 - 2029	0	0	155.42		155	446.00	188.60	634.60	479
2029 - 2030	0	0	166.99		167	491.00	209.10	700.10	533
2030 - 2031	0	0	179.49		179	494.00	225.40	719.40	540
2031 - 2032	0	838	212.79		1051	572.00	248.22	820.22	-230
2032 - 2033	0	0	228.36		228	575.00	316.50	891.50	663
2033 - 2034	0	0	245.15		245	633.00	336.30	969.30	724
2034 - 2035	0	0	263.26	447	710	636.00	349.60	985.60	275
2035 - 2036	0	0	282.80	380	663	708.00	370.80	1078.80	416
2036 - 2037	0	0	303.89		304	711.00	386.10	1097.10	793
2037 - 2038	0	0	326.67		327	785.00	409.50	1194.50	868
2038 - 2039	0	0	351.26		351	789.00	426.90	1215.90	865
2039 - 2040	0	0	377.83		378	878.00	452.80	1330.80	953
2040 - 2041	0	0	406.54		407	883.00	471.30	1354.30	948
2041 - 2042	0	0	437.56		438	973.00	499.30	1472.30	1035
2042 - 2043	0	0	471.10		471	978.00	520.80	1498.80	1028
2043 - 2044	0	0	507.37		507	1086.00	551.60	1637.60	1130
2044 - 2045	0	0	546.59		547	1091.00	574.10	1665.10	1119
Total	3149	1205	6728.1	827	11911	16123	7357	23480	8.24%

12.5.3 The various sensitivities with regard to increase/decrease in capital costs, O&M costs and revenues are placed in Table 12.10 below: -

Table 12.10 –FIRR Sensitivity

CAPITAL COSTS with Central Taxes			
10% increase in capital cost	20% increase in capital cost	10% decrease in capital cost	20% decrease in capital cost
7.86%	**7.50%**	**8.67%**	**9.16%**
REVENUE			
20% decrease in Fare Box/PDrevenue	10% decrease in Fare Box/PDrevenue	10% increase in Fare Box/PDrevenue	20% increase in Fare Box/PD revenue
5.29%	6.86%	9.48%	10.61%
O&M COSTS			
10% increase in O&M cost		10% decrease in O&M cost	
7.93%		8.55%	

These sensitivities have been carried out independently for each factor.

12.6Financing Options

Objectives of Funding: - The objective of funding metro systems is not necessarily enabling the availability of funds for construction but coupled with the objective of financial closure are other concerns, which are of no less importance: -

- Ensuring low project cost
- Ensuring debt funds at low rates of interest
- Creating self sustainable system in the long run by
    - Low infrastructure maintenance costs
    - Longer life span
    - Setting fares which minimise dependence on subsidies
- Recovering returns from both direct and indirect beneficiaries

Rail based mass transit systems are characterised by heavy capital investments coupled with long gestation period leading to low financial rates of return although the economic benefits to the society are immense. Such systems generate externalities, which do not get captured in monetary terms and, therefore, do not flow back to the system. However, experience all over the world reveals that both construction and operations of metro are highly subsidised. Government involvement in the funding of metro systems is a foregone conclusion. Singapore had a 100% capital contribution from the government, Hong Kong 78% for the first three lines and 66% for the later 2 lines.

12.6.1 ALTERNATIVE MODELS OF FINANCING

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

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

(ii) Public-Private Partnership (PPP) mode
- Built Operate and Transfer (BOT) model
- Other PPP Model

a) **DMRC/BMRC/CMRC pattern of Financing**: - A Special Purpose Vehicle (SPV) is set up for the implementation of the project and for its subsequent Operation & Maintenance. Under this arrangement Government of India and

Government of Rajasthan shall make equal equity contribution and run SPV as a commercial enterprise. As per the prevalent practice, Central Government may be willing to contribute 15% of the project cost as their equity contribution. An equal amount can be contributed by Government of Rajasthan aggregating the total equity to 30%. With the equal ownership of the SPV, both the governments nominate their representatives as members of the Board of Directors, which in turn select functional directors. Such a SPV has a benefit of independent management under the aegis of Indian Companies Act, 1956. Delhi Metro Rail Corporation is a shining example of success of such a SPV. Further the Government of India and the State Government contribute upto 5% eachof the total cost as Subordinated Debt against the Central taxes and duties. For the balance 60% funding requirement, options available are as follows: -

(i) Subordinate Debt:for Land- For Delhi Metro, land and rehabilitation and resettlement cost have been borne by GOI & GNCTD equally as interest free subordinate debt. Now, MOUD have changed the policy under which the cost of land for Bangalore and Chennai has been borne by Government of Karnataka and Tamilnadu as interest free subordinate debt. Similarly, the cost of Land amounting to Rs.108.00 Crore has to be contributed as interest free subordinate debt by Government of Rajasthan.Further the Government Land coming in this project has not been included in the total cost. This mezzanine financing is of extreme help in quickening the pace of land acquisition, since the compensation amount is released to evacuate instantaneously. The loan is of longer duration and becomes repayable only after other loans raised for the project is repaid.

(ii) Debt: - The balance cost is to be met through loans from various institutions namely JICA, Local borrowing, loans from ADB/World Bank and Suppliers Credit.

JICA Loan: - The total amount of loan required is Rs. 1781Crore. Overseas Development Loan from Japan International Cooperation Agency (JICA) can be availed of for metro rail projects with interest rate of 1.40% PA. The Under Ground portion, from Chandpole to Badi Chaupar, having completion cost of 1126 crores, can be taken up under the JICA funding with the other part of this phase. The loan is repayable in 30 years including moratorium period of

10 years. The loan is to be provided to Central Government which in turn releases the same to SPV under a Pass Through Assistance (PTA) mechanism. Normally, JICA agrees to fund for underground civil works, Electrical, Signalling &Telecom and Rolling Stock only. Since the loan will be in Japanese Yen any fluctuation in exchange rate at the time of repayment shall be borne by the Government of Rajasthan in line with recent guidelines of Department of Economic Affairs of Ministry of Finance, GOI. Alternatively, JICA can release the loan to the SPV for which a sovereign guarantee will be required from Central Government. Foreign exchange variation in such eventuality will be borne by the SPV. The State Government need to hedge the foreign currency fluctuation so minimise its loss. In either case loan shall be repaid by SPV from the income streams of metro operations.

Loan from Asian Development Bank (ADB)/World Bank: - The Loan shall be available from ADB/World Bank, but as per the experience its processing and approval normally takes 8-12 months. This may delay the implementation of the project resulting in avoidable increase in the completion cost.

Loan from Bank and Financial Institutions: - Funds can be arranged from Indian Financial Institutions like India Infrastructure Finance Company Limited (IIFCL), India Development Financing Corporation (IDFC), Life Insurance Corporation of India (LIC), IDBI Bank, ICICI Bank Ltd etc. These institutions are increasingly engaged to fund infrastructure projects subject to their commercial viability. There are many models available under which the funds can be arranged by these financial institutions with or without syndicating with other commercial banks. IIFCL e.g. fund 20% of the project cost and arrange balance through the syndication of commercial banks with a lead banker among the consortium of bankers. IIFCL also provide 100% funding for Metro Project subject to GOI guarantee. The loan can be given for a period of 20-30 years with interest rate ranging from 9.50% to 12% PA. The funding arrangement may require submission of central government guarantee as well. Since the rate of interest of these financial institutions is much higher than the interest rates of soft loan provided by JICA, Central Government and Government of Rajasthan shall have to bear the interest difference and provide suitable subsidy to the SPV.

Suppliers Credit: - Suppliers Credit is an established method to secure funding of imports. It is backed by EXIM banks of exporting countries and is often a much better instrument than bilateral aid. While bilateral aid ties the borrowing entity, Suppliers Credit can be used intelligently and effectively to spur competition in competitive international tendering method. In case of Rolling Stock, where market is truly competitive (unlike S&T) an attractive rate of interest for suppliers credit is possible. However, the supplier will load the amount of interest in cost of supply due to which the effective completion cost will be very high.

12.6.2 The funding pattern with Central Taxes assumed under this model (SPV) is placed in table 12.11as under: -

Table 12.11 - Funding pattern under EPC model

Particulars	Government of India		Government of Rajasthan		Total	
	%	Rs/Crore	%	Rs/Crore	%	Rs/Crore
Equity by GOI & GOR	15.00%	472.50	15.00%	472.50	30.00%	945.00
SD for land cost by GOR	0.00%	0.00	3.43%	108.00	3.43%	108.00
Additional SD for Central Taxes by GOI&GOR Equally	5.00%	157.50	5.00%	157.50	10.00%	315.00
JICA Loan /Market Borrowing/ debt from the State Govt.	0%	0%	56.57%	1781.00	56.57%	1781.00
Total	**20%**	**630.00**	**80%**	**2519.00**	**100.00%**	**3149.00**

12.6.3 Public Private Partnership: - Public Private Partnership (PPP) arrangements are steadily growing in use particularly in road, power, and telecom sectors which are more of commercial nature rather than in a social sector project. PPP models are arrayed across a spectrum ranging from BOT where the private sectors have total involvement to other tailor made models where both public and private sector assume separate responsibilities. BOT model is explained as under-

12.6.4 BOT Model: - In this model, the private firm will be responsible for financing, designing, building, operating and maintaining of the entire project. The contribution of Government of Rajasthan will be limited to cost of land only. Such a project become eligible for Viability Gap Funding (VGF) upto 20% from the Central Government provided the state government also contribute same or more amount towards the project. The metro being a social sector project not much private parties are available to bid for such a project. Besides quite expectedly the private operator may demand assured rate of return in the range of 14% to 16% or a comfort of guaranteed ridership

12.6.5 Since this Phase has already been taken up under EPC Mode and the equity from GoI is under active consideration, the project is recommended on DMRC/BMRC model.In case of projected revenue from PD is not materialised during the operation stage, revenue generation from the following sources need to be initiated by GOR: -

a) To allow increased FAR along the metro corridors.
b) Metro cess on the sale petrol and Diesel in the city.
c) Tax on the commercial vehicles entering to the Jaipur City.
d) Levy of additional charges on the new registration of vehicles.
e) To levy green cess on existing vehicles.

As reported by JMRC, the steps have already been initiated for Transit oriented development and revenue from additional FAR on the Metro corridor, revenue from additional stamp duty, Green Cess & registration charges on vehicles etc.

12.6.6 The detailed cash flow is shown as per the Table 12.18.1

12.6.7 The funding pattern assumed under DMRC/BMRC/CMRC model when the corridors are partly elevated and partly underground is depicted in the pie chart i.e., Figure 12.12 as under.

Figure 12.12 –Funding Pattern under EPC model

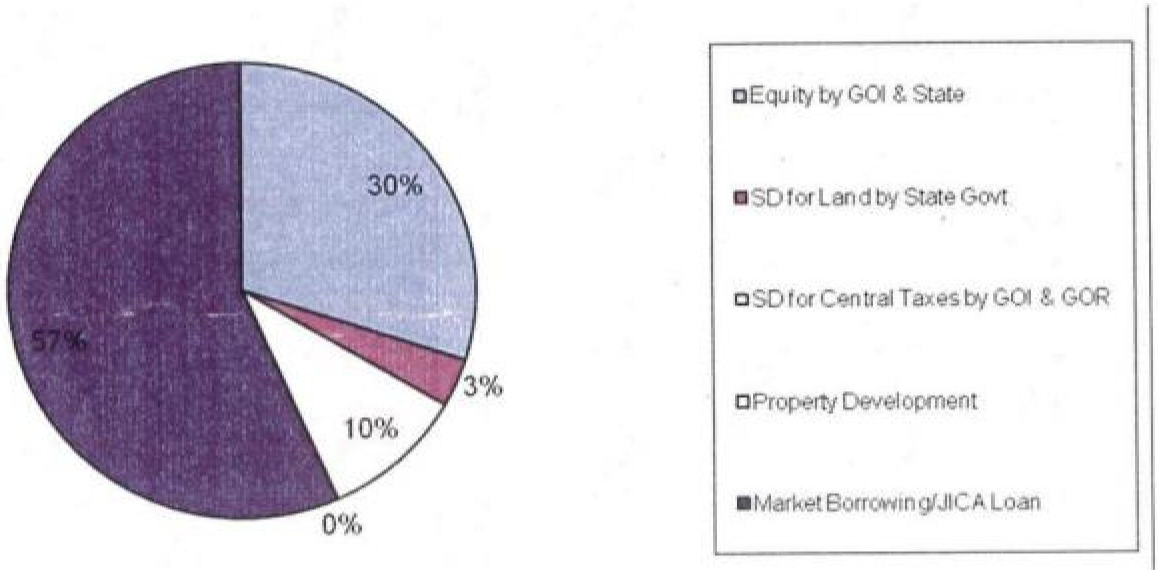


Table-12.18.1

	Jaipur Metro	(Corridor Mansarovar to Badi Chaupar)											WITH CENTRAL TAXES										
	CAPITAL COST-FIXED			2678														12.00%					
	CAPITAL COST - CURRENT			3149																			
	Year	Completion Cost	Additional Capital	Running Expenses	DEPRECIATION	REPLACEMENT	TOTAL COSTS	FARE BOX REVENUE	PD & ADVT	TOTAL REVENUE	NET CASH FLOW FOR	Funds other than loan i.e.	Availability of cash	Cumulative cash	Cum. Loan	Loan	REPAYMENT OF LOAN	IDC	Cumulative loan incl.	INTEREST	PROFIT BEFORE	CASH BALANCE	CUMULATIVE CASH
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	2010 - 2011	46					46		0	0	-46	376	330	330	0	0	0	0.00	0			330	330
2	2011 - 2012	395					395			0	-395	386	-9	321	0	0	0	0.00	0	0		-9	321
3	2012 - 2013	693					693			0	-693	228	-465	-144	144	144	0	8.64	153	0		-321	0
4	2013 - 2014	641		26.61	51.65		668	68.00	6.80	74.8	-593	189	-452	-596	596	452	0	45.44	650	0		48	48
5	2014 - 2015	449		37.39	103.30		486	96.00	9.60	105.60	-381	189	-260	-856	856	260	0	93.61	1004	0		68	116
6	2015 - 2016	440		39.94	103.30		480	110.00	11.00	121.00	-359	0	-440	-1296	1296	440	0	146.84	1591	0	-22	81	197
7	2016 - 2017	237		47.51	103.30		285	116.00	67.60	183.60	-101	0	-237	-1533	1533	237	0		1828	205	-172	-69	128
8	2017 - 2018	248		63.12	103.30		311	167.00	-69.30	97.70	-213	0	-248	-1781	1781	248	0		2075	219	-288	-185	-56
9	2018 - 2019	0		67.75	103.30		68	175.00	-39.50	135.50	68		0	-1781	1781	0	0		2075	249	-285	-181	-238
10	2019 - 2020	0	0	74.79	103.30		75	201.00	-6.90	194.10	119		0	-1781	1781	0	208		2075	249	-233	-338	-575
11	2020 - 2021	0	0	80.28	103.30		80	210.00	27.00	237.00	157		0	-1781	1781	0	208		1867	249	-196	-300	-876
12	2021 - 2022	0	367	94.89	114.32		462	243.00	66.30	309.30	-153		0	-1781	1781	0	208		1659	224	-124	-585	-1461
13	2022 - 2023	0	0	101.71	114.32		102	254.00	80.40	334.40	233		0	-1781	1781	0	208		1451	199	-81	-174	-1635
14	2023 - 2024	0	0	109.07	114.32		109	295.00	98.50	393.50	284		0	-1781	1781	0	208		1243	174	-4	-98	-1733
15	2024 - 2025	0	0	116.99	114.32		117	308.00	114.80	422.80	306		0	-1781	1781	0	208		1035	149	42	-51	-1784
16	2025 - 2026	0	0	125.54	114.32		126	354.00	133.40	487.40	362		0	-1781	1781	0	208		827	124	123	30	-1754
17	2026 - 2027	0	0	134.75	114.32		135	370.00	150.00	520.00	385		0	-1781	1781	0	208		619	99	172	78	-1677
18	2027 - 2028	0	0	144.69	114.32		145	427.00	170.70	597.70	453		0	-1781	1781	0	208		411	74	264	171	-1506
19	2028 - 2029	0	0	155.42	114.32		155	446.00	188.60	634.60	479		0	-1781	1781	0	203		203	49	316	227	-1279
20	2029 - 2030	0	0	166.99	114.32		167	491.00	209.10	700.10	533		0	-1781	1781	0	85		338	24	394	424	-855
21	2030 - 2031	0	0	179.49	114.32		179	494.00	225.40	719.40	540		0	-1781	1781	0	85		253	41	385	414	-441
22	2031 - 2032	0	838	212.79	139.46		1051	572.00	248.22	820.22	-230		0	-1781	1781	0	85		168	30	438	-346	-787
23	2032 - 2033	0	0	228.36	139.46		228	575.00	316.50	891.50	663		0	-1781	1781	0	85		83	20	504	558	-229
24	2033 - 2034	0	0	245.15	139.46		245	633.00	336.30	969.30	724		0	-1781	1781	0	85		-2	10	575	629	400
25	2034 - 2035	0	0	263.26	139.46	447	710	636.00	349.60	985.60	275		0	-1781	1781	0	0		0	0	583	276	676
26	2035 - 2036	0	0	282.80	139.46	380	663	708.00	370.80	1078.80	416		0	-1781	1781	0	0		0	0	657	416	1092
27	2036 - 2037	0	0	303.89	139.46		304	711.00	386.10	1097.10	793		0	-1781	1781	0	0		0	0	654	793	1885
28	2037 - 2038	0	0	326.67	139.46		327	785.00	409.50	1194.50	868		0	-1781	1781	0	0		0	0	728	868	2753
29	2038 - 2039	0	0	351.26	139.46		351	789.00	426.90	1215.90	865		0	-1781	1781	0	0		0	0	725	865	3618
30	2039 - 2040	0	0	377.83	139.46		378	878.00	452.80	1330.80	953		0	-1781	1781	0	0		0	0	814	953	4571
31	2040 - 2041	0	0	406.54	139.46		407	883.00	471.30	1354.30	948		0	-1781	1781	0	0		0	0	808	948	5518
32	2041 - 2042	0	0	437.56	139.46		438	973.00	499.30	1472.30	1035		0	-1781	1781	0	0		0	0	895	1035	6553
33	2042 - 2043	0	0	471.10	139.46		471	978.00	520.80	1498.80	1028		0	-1781	1781	0	0		0	0	888	1028	7581
34	2043 - 2044	0	0	507.37	139.46		507	1086.00	551.60	1637.60	1130		0	-1781	1781	0	0		0	0	991	1130	8711
35	2044 - 2045	0	0	546.59	139.46		547	1091.00	574.10	1665.10	1119		0	-1781	1781	0	0		0	0	979	1119	9829
	TOTAL	3149	1205	6728	3870	827	11909	16123	7357	23480	8.24%	1368				1781	2500	295	21607	2390	10530	9829	

REVENUE FROM PROPERY DEVELOPMENT PHASE-I

Table-12.18.2

Total Land available for Parking 0 Meter For PD say 100% 125000 Rent per SQ FT 45

others 125000 125000 interest 12% Rs/Crore Ar. PD in Sq. ft.

Area available in Sq. ft. 3,750,000 FAR 3 Construction cost= (@ 0.20 lakhs per Sqm 750.00 3,750,000.00

	Year	Construction cost of the Developer	Upfront Money to HMRC	Earning of Developer	Maintenance Expenditure	Developer's Equity	Developer s Market	IDC on Loan	Total Loan of the	Loan repayment	Bal Loan Amount	Interest on Loan	Return @14% + 5% escalation	Residual rental incoem to SPV
1	2010 - 2011	0	0				0	0	0		0		0	
2	2011 - 2012	0	0				0	0	0		0		0	
3	2012 - 2013	0	0				0	0	0		0		0	
4	2013 - 2014	188	0			71	117	7	124		124		-71	
5	2014 - 2015	197	0			71	243	22	265		265		-71	0
6	2015 - 2016	217			0	71	389	41	430	0	430	0	-71	0
7	2016 - 2017	249		70	14		638	70	708	0	708	0	0	56
8	2017 - 2018			98	20				0	47	661	85	32	-86
9	2018 - 2019			129	26				0	47	614	79	34	-57
10	2019 - 2020			163	33				0	47	567	74	36	-27
11	2020 - 2021			199	40				0	47	520	68	38	6
12	2021 - 2022			239	48				0	47	473	62	40	42
13	2022 - 2023			251	50				0	47	426	57	42	55
14	2023 - 2024			264	53				0	47	379	51	44	69
15	2024 - 2025			277	55				0	47	332	45	46	84
16	2025 - 2026			291	58				0	47	285	40	48	98
17	2026 - 2027			305	61				0	47	238	34	50	113
18	2027 - 2028			321	64				0	47	191	29	53	128
19	2028 - 2029			337	67				0	47	144	23	56	144
20	2029 - 2030			354	71				0	47	97	17	59	160
21	2030 - 2031			371	74				0	47	50	12	62	176
22	2031 - 2032			390	78				0	50	0	6	65	191
23	2032 - 2033			409	82				0			0	68	259
24	2033 - 2034			430	86				0				71	273
25	2034 - 2035			451	90				0				75	286
26	2035 - 2036			474	95				0				79	300
27	2036 - 2037			498	100				0				83	315
28	2037 - 2038			522	104				0				87	331
29	2038 - 2039			549	110				0				91	348
30	2039 - 2040			576	115				0				96	365
30	2040 - 2041			605	121				0				101	383
30	2041 - 2042			635	127				0				106	402
30	2042 - 2043			667	133				0				111	423
30	2043 - 2044			702	140				0				117	443
30	2044 - 2045			735	147				0				123	465
Total		850	0	11310	2262	212		140		708	6504	682	1701	5745

Chapter 13

Economic Analysis

CHAPTER 13

ECONOMIC ANALYSIS

13.1 The objective of the cost- benefit analysis is to identify and quantify the economic benefits and costs associated with the project (implementation of Metro from Mansarovar to Badi Chopar consist of 12.067 Kms route length) in phase-I and Sitapura to Ambabari 23.099 km for phase-II taken together, in order to select the optimum solution along with the economic viability in terms of its likely investment return potential.

The cost - benefit analysis is carried out by using the Discounted Cash Flow (DCF) technique to obtain the economic internal rate of return (EIRR %) and economic net present value (ENPV) for the proposed investments linked with the project. This is followed by a 'sensitivity analysis' carried out by increasing or decreasing the critical factors affecting the cost and benefit streams of the proposed project, in order to ascertain their effect on the economic feasibility indicators i.e. ENPV, EIRR.

13.2 Economic Analysis Approach

The economic appraisal of the metro system has been carried out within the broad framework of Social Cost -Benefit Analysis Technique. It is based on the incremental costs and benefits and involves comparison of project costs and benefits in economic terms under the "with" and "without" project scenario. In the analysis, the cost and benefit streams arising under the above project scenarios have been estimated in terms of market prices and economic values have been computed by converting the former using appropriate factors. The annual streams of project costs and benefit have been compared over the entire analysis period to estimate the net cost/ benefit and to calculate the economic viability of the project in terms of EIRR.

13.3 Analysis Period

The analysis period of the project is taken as 36 years from the base year 2009 as follows:

Base Year 2009

Construction period - 2012 to 2015 (4 years)

Project opening for traffic - 2016

End of the analysis period -2045

No. of operating years, considered for economic analysis - 30 years

Thus, 30 years of operation, in effect, from the start of operation i.e. 2017, has been considered for economic evaluation for the project.

13.4 Estimation of Costs

The project cost straeam comprises capital cost, operation and maintenance cost. Cost components considered for the purpose of this exercise include:

- Capital cost of infrastructure
- Operation and Maintenance cost of the system

The project cost (at Financial price) for Phase-I and Phase-II ie; Rs. 9732 crore (estimated cost with central taxes) is taken in the analysis. The Operation & Maintenance Cost (O & M cost) is assumed as 3% of the project cost/annum. This cost has been converted to economic price by applying a factor of 0.85.

The development of metro is proposed in five years. The proposed phasing of construction is explained in Table 13.1.

Table 13.1: Phasing of Construction

Year	Phasing	Cost (Rs. In Crores)	
		in Financial price	in economic price
2012	20%	1946	1654
2013	20%	1946	1654
2014	40%	3893	3309
2015	20%	1946	1654
Total	**100%**	**9732**	**8272**

13.5 Estimation of Benefits

The proposed metro will yield tangible and non-tangible savings due to equivalent reduction in road traffic and certain socio-economic benefits. Introduction of metro will result in reduction in number of buses, usage of private vehicles, air pollution and increase the speed of road-based vehicles. This, in turn, will result in significant social benefits due to reduction in fuel consumption, vehicle operating cost and travel time of passengers. Reduction in accidents, pollution and road maintenance costs are the other benefits to the society in general.

The benefit stream that has been evaluated and quantified includes:

Capital and operating cost (on present congestion norms) of carrying the total volume of passenger traffic by existing bus system and private vehicles in case the metro project is not taken up.
Savings in operating costs of all buses and other vehicles due to de-congestion including those that would continue to use the existing transport network even after the metro is introduced.

Savings in time of commuters using the metro over the existing transport modes because of faster speed of metro.

Savings in time of those passengers continuing on existing modes, because of reduced congestion on roads.

Savings in fuel consumption on account of less number of vehicles on road and decongestion effect with introduction of metro are included in those of vehicle operating cost.

Quantification of some of the social benefits has not been attempted because universally acceptable norms do not exist to facilitate such an exercise. However, it has been considered appropriate to highlight the same, as given below:

Reduction in accidents and pollution from vehicles
Reduced road stress
Better accessibility to facilities in the influence area
Economic stimulation in the micro region of the infrastructure
Increased business opportunities
Overall increased mobility
Facilitating better planning and up-gradation of influence area.
Improving the image of the city.

13.6 Transport Demand on Metro Corridor

At present mostly bus system is meeting the transport demand in the study area. Part of the demand is also met by IPT modes and private modes. As given in traffic chapter, the estimated transport demand on metro is given in Table 13.2.

Table 13.2 Transport Demand Forecast on the proposed metro corridors

ITEM	2014	2021	2031
Total Trips/ day (Lakh)	34.79	49.40	78.86
Trips on metro / day (Lakh)	5.32	7.79	10.98
Trips by other modes / day (Lakh)	29.47	41.62	67.88

13.7 Reduction in Traffic Congestion and Fuel Consumption

The traffic on the metro is expected to shift from buses, auto rickshaw, car, taxi and two wheeler. It has been estimated that the number of buses and other private modes are likely to decrease with the introduction of the metro corridors. This will save Rs. 417 Crores in the year 2016 towards the vehicle operating cost (VoC).

13.8 Passenger Time Saving

With the introduction of metro, there will be reduction in traffic congestion on the roads and correspondingly, there will be saving in time of commuters travelling by various modes of road transport. Similarly, metro System itself being faster than conventional road transport modes, will also lead to considerable saving in time of commuters travelling on metro. With the implementation of the project, the annual passenger time savings are estimated at Rs. 351 Crore for the year 2016.

13.9 Results of Economic Analysis

The cost and benefit streams for 30-year period in the economic prices have been worked out and presented in Annexure 1. The residual value of the metro facilities in last year has not been taken into account as benefit in these tables.

In the analysis, the 'with project' alternative of providing metro system is compared with the base option of 'without project (Do- nothing scenario)' alternative of using the existing transport facilities. This is to arrive the net economic benefits, which consist of reduction in vehicle operation cost and reduction in travel time. The total cost worked out on the above basis is then subtracted from the total benefits to estimate the net benefit of the project. This flow is then subjected to the process of discounting to work out the EIRR and ENPV on the project, to examine the viability of the Project in Economic terms. The results are given in Table 13.3.

Table13.3: Results of Economic Analysis

Parameter	Results
EIRR (%)	18.6%
ENPV (Rs. In crores @ 12% discount rate)	5598

The EIRR for the proposed metro project is worked out to be 18.6%.

13.10 Sensitivity Analysis

A sensitivity analysis is carried out for the following scenarios;
Increase in cost by 10%
Decrease in benefits by 10%
Combined scenario of Increase in cost by 10% and Decrease in benefits by 10%
The EIRR under these scenarios are given in Table 4. Details are presnted in Annexure 13.4.

Table 13.4 Results of Sensitivity Analysis

Sl. No.	Sensitivity	EIRR (%)	ENPV (Rs. in Crores @ 12% discount rate)
1	**Normal Scenario**	18.6%	5598
2	With increase in cost by 10%	17.6%	5066
3	With reduction in benefits by 10%	17.5%	4506
4	**With 10% reduction in benefits and increase in cost by 10%**	16.6%	3974

In the sensitivity analysis, the EIRR is found to be at 16.6%, under the combined scenario of increase in cost by 10% and decrease in benefits by 10%. Hence the project is found to be economically viable.

Annexure 13.1

Cost and Benefit Stream : Normal Scenario *(Units: Rs in Crores)*

YEAR	CAPITAL	Operation & Maintenance Cost	TOTAL COSTS	SAVINGS FROM		TOTAL SAVINGS	NET CASH FLOW
				TIME	VOC		
2012	-1654.44	0.00	-1654.44	0.00	0.00	0.00	-1654
2013	-1654.44	0.00	-1654.44	0.00	0.00	0.00	-1654
2014	-3308.88	0.00	-3308.88	0.00	0.00	0.00	-3309
2015	-1654.44	0.00	-1654.44	0.00	0.00	0.00	-1654
2016	0.00	-248.17	-248.17	416.88	351.34	768.22	520
2017	0.00	-248.17	-248.17	475.64	419.96	895.60	647
2018	0.00	-248.17	-248.17	534.41	488.58	1022.98	775
2019	0.00	-248.17	-248.17	593.17	557.19	1150.37	902
2020	0.00	-248.17	-248.17	651.94	625.81	1277.75	1030
2021	0.00	-248.17	-248.17	715.96	732.83	1448.78	1201
2022	0.00	-248.17	-248.17	1023.72	964.85	1988.58	1740
2023	0.00	-248.17	-248.17	1374.44	1196.88	2571.32	2323
2024	0.00	-248.17	-248.17	1725.15	1428.91	3154.05	2906
2025	0.00	-248.17	-248.17	2075.86	1660.93	3736.79	3489
2026	0.00	-248.17	-248.17	2426.57	1892.96	4319.53	4071
2027	0.00	-248.17	-248.17	2777.28	2124.99	4902.27	4654
2028	0.00	-248.17	-248.17	3127.99	2357.02	5485.01	5237
2029	0.00	-248.17	-248.17	3478.70	2589.04	6067.75	5820
2030	0.00	-248.17	-248.17	3829.41	2821.07	6650.48	6402
2031	0.00	-248.17	-248.17	4102.97	3053.10	7156.07	6908
2032	0.00	-248.17	-248.17	4144.00	3077.52	7221.52	6973
2033	0.00	-248.17	-248.17	4185.44	3102.14	7287.58	7039
2034	0.00	-248.17	-248.17	4227.29	3126.96	7354.25	7106
2035	0.00	-248.17	-248.17	4269.57	3151.97	7421.54	7173
2036	0.00	-248.17	-248.17	4312.26	3177.19	7489.45	7241
2037	0.00	-248.17	-248.17	4355.38	3202.61	7557.99	7310
2038	0.00	-248.17	-248.17	4398.94	3228.23	7627.17	7379
2039	0.00	-248.17	-248.17	4442.93	3254.06	7696.98	7449
2040	0.00	-248.17	-248.17	4487.36	3280.09	7767.44	7519
2041	0.00	-248.17	-248.17	4532.23	3306.33	7838.56	7590
2042	0.00	-248.17	-248.17	4577.55	3332.78	7910.33	7662
2043	0.00	-248.17	-248.17	4623.33	3359.44	7982.77	7735
2044	0.00	-248.17	-248.17	4669.56	3386.32	8055.88	7808
2045	0.00	-248.17	-248.17	4716.26	3413.41	8129.66	7881
Total	-8272.20	**-7444.98**	**-15717.18**	**91272.17**	**68664.51**	**159936.67**	**144219.49**
			IRR %				**18.6**
			ENPV (Rs. in Crores @ 12% discount rate)				**5598**

Chapter 14

Implementation Plan

CHAPTER 14

IMPLEMENTATION PLAN

14.1 WAY FORWARD FOR IMPLEMENTING JAIPUR METRO PROJECT

- Original DPR for Phase - I was approved by GoR and GoR had asked to prepare Revised DPR keeping the N - S corridor on Tonk Road and extend South end of N - S corridor up to Sitapura Industrial area.DPR was submitted to Government of Rajasthan in June 2011.

- Jaipur Metro Rail Corporation Ltd, the Special Purpose Vehicle (SPV) for implementing the project and for its subsequent Operation & Maintenance has already been set up and is functioning.

- Work of Stage - I from Mansarover to Chandpole excluding Signalling, Telecom and Rolling was assigned to DMRC as deposit work. However, subsequently, Government of Rajasthan (GOR) has entrusted the work of rolling stock, signaling & telecom works of line 2 also to DMRC for timely commissioning of this stretch. The work of this corridor on part stretch i.e. between Mansarovar and Chandpole are in full swing and this stretch is targeted for commissioning in June 2013.

- GoR has started this corridor on their own. However as indicated by JMRC, the proposal of funding this line on the model of Chennai , Bangalore and Kolkata is under active consideration of Government of India.Hence in compliance to the directions by Government of India , JMRC has requested DMRC to divide entire DPR of June 2011 in two portion as under.

  Phase I: DPR for East-West Corridor between Mansarovar and Chandpole

  Phase-II: DPR for North-South Corridor

- On receipt of Phase I DPR, following action will be required for further approvals of GoI

- Approval of GoR already exists for earlier DPR but formal approval of Phase-I, DPR now being submitted again be taken explaining the reasons behind such bifurcation of earlier DPR.

- The Phase I DPR to be forwarded to the Ministry of Urban Development (GOI), Planning Commission and Finance Ministry with the request for approving the Metro project and for financial participation through equity contribution in the SPV.

- Signing of an MOU between Rajasthan 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.

- The Metro Railways (Amendment) Act, 2009 has been extended to Jaipur Metro Rail also, vide The Gazette of India – Extraordinary/Part II-Section3-Sub-section(ii) No.76 New Delhi, Friday, January 14, 2011

- The loan portion of the funding will have to be tied up by State Government in consultation with the Government of India.

- The Government should freeze all developments along the corridors suggested. For any constructions within 50 m. of the proposed alignment a system of 'No Objection Certificate' should be introduced so that infructuous expenditure at a later stage is avoided.

14.2 INSTITUTIONAL ARRANGEMENTS

To enable Jaipur Metro project to be implemented without any loss of time and cost over-run, effective institutional arrangements would need to be set up. Details of these arrangements are explained below:

14.2.1 SPECIAL PURPOSE VEHICLE

Experience of implementing Delhi Metro project has shown that a Special Purpose Vehicle (SPV), vested with adequate powers, is an effective organizational arrangement to implement and subsequently operate and maintain a metro project. Rajasthan Government has already registered Jaipur Metro Rail Corporation Ltd for Jaipur Metro under the Companies Act, 1956. This SPV is a

PSU of the State Government. Since the equity for the project will be contributed by the State and the Central Governments, both these Governments should have Directors on its Board. The number of Directors from each Government can be mutually agreed upon between the Central and the State Governments. The Managing Director of JMRC should be the nominee of the State Government. In order to avoid delays usually associated with bureaucratic process of decision-making, the Board of Directors (BOD) of JMRC should be vested with full powers needed to implement the project. The BOD, in turn, should delegate adequate powers to the Managing Director to take all decisions in day-to-day matters.

14.2.2 Empowered Committee

The Government of Rajasthan has already set up an 'Empowered committee' under the Chairmanship of its Chief Seretary to monitor the project, before whom problems and obstacles encountered during execution of the project will be placed byJMRC duly assisted by PD for quick redressal through the Board of the JMRC, in case the board of JMRC is not authorized to address

14.2.3 Group of Ministers

Union Cabinet had set up an Empowered Group of Ministers (EGOM) to take decisions on behalf of the Cabinet on policy matters concerning Delhi Metro project. The Group of Ministers is chaired by the Home Minister. Other members of the EGOM are Minister of Urban Development and Poverty Alleviation, Minister of Railways, Minister of Finance and Company Affairs and Deputy Chairman Planning Commission. Chief Minister, Delhi and Lt. Governor, Delhi, are permanent invitees to all meetings of the EGOM. The EGOM meets whenever any problem requiring decision on behalf of the Union Cabinet is to be taken. It is suggested that the role of this EGOM should be enlarged to include Jaipur Metro. The Chief Minister, Rajasthan should be inducted as a member and should attend the meetings of EGOM whenever any issue concerning Jaipur Metro is to be deliberated upon.

14.3 IMPLEMENTATION

- JMRC has awarded work of part East-West corridor from Mansarover to Chandpole(All Works) to DMRC on deposit terms basis. The works are in full progress.
- JMRC has targeted to commission this portion by 30.06.2013.

A suggested project implementation schedule is given below. The proposed date of commissioning of the section with suggested dates of important milestones is given in Table 14.3.1 which saves one year in implementation.

Table 14.3.1
Implementation Schedule through DMRC on Deposit basis
Mansarover to Chandpole , Phase – 1A of East west corridor of Jaipur Metro

S. No.	Item of Work	Completion Date
1.	Submission of Final DPR to State Govt.	Submitted on 26.01.2010
2	Approval of DPR by State Government	Approved by State Govt. on 15.03.2011
3	Tendering, Execution of works and Procurement of equipments, coaches and installations	01.09.2010-15.04..2013
4	Testing and Commissioning	15.04.2013-15.06.2013
5	Revenue Operation	30.06.2013

This corridor has to be commissioned in two stages i.e. one for the portion entrusted to DMRC and the second between Chandpole and Badi Chaupar. The above schedule is for Mansarovar- Chandpole portion. The commissioning of left over portion between Chandpole and Badi Chaupar may take about 5 years from the date agency is decided for its implementation. It is suggested that the agency for implementation of left over portion of phase I i.e Chandpole to Badi Chauparmay be decided by GoR at the earliest. To commission the entire Phase I corridor expeditiously, it is recommended that balance of phase I should also be got done through DMRC on the deposit terms or any other agency as EPC contract (with DMRC as GC) but with the same system and rolling stock as being planned for Phase IA under taken through DMRC.

14.5 ORGANISATIONAL SET-UP OF JMRC

The JMRC Organization, as stated earlier, should be very lean but effective. It shall consist of a non-executive Chairman, a Managing Director with full Executive Powers (in Schedule 'A') and three Functional Directors (in Schedule 'B') including Director (Finance). All the three Functional Directors shall be full members of the Management Board. The Directors shall be assisted by Heads of Departments in each of the major disciplines and they in turn shall have Deputy HODs. The organization should be basically officer-oriented with only Personal Assistants and Technical Assistants attached to senior officers by eliminating unproductive layers of staff such as Peons, Clerks, etc. We strongly recommend that the total organizational strength is limited to 30 to 40 eliminating too many tiers to enable faster decision-making.

It is necessary for the JMRC officers to get exposed to the Metro technology and Metro culture through study tours of some of the selected foreign Metros and Delhi/Calcutta Metros.

Implementing a metro project in a congested metropolis is indeed a challenge. In sheer size, magnitude and technical complexity there are no parallels to metro projects. Further, these projects are to be carried out in difficult urban environment without dislocating city life, while at the same time preserving the environment. The project involves integration of a number of complex technical systems. Some of these technologies used in these systems are totally new to e country each one of which is a major project by itself. Interfacing various system contracts is a difficult and highly skilled exercise. Side by side, timely and adequate funds have to be assured for implementation and lands, without encumbrances, have to be taken possession of in time. Clearances from the local authorities have to be taken which includes permission to cut trees, diversion of utilities, management of road traffic, etc., all of which will call for an efficient and competent project implementing agency.

Metro projects cannot be executed the way Government agencies execute projects in this country. Timely completion is very important to safeguard the financial viability. Competent and skilled technical personal to man such an organization are difficult to mobilize. In fact such experienced persons are not readily available in the country. Being a rail based project, for most of the systems such as rolling stock, signaling, telecommunication, traction power supply, etc., persons with railway background would be necessary. As systems & construction technology used in metro are much more advanced and sophisticated than the one used in Railways as these have to suit dense urban areas, Metro experience will enable faster & smoother execution and thus is desirable & therefore should be preferred.

14.5.1 DMRC has set up a project office at Jaipur having strength of about 50 to take up the implementation of the stage-I at site with back up support of Delhi office for all system designs, tendering as we are handling the Delhi Metro Project.

14.5.2 Jaipur Metro Rail Corporation role will be primarily to arrange funds and obtain necessary Government and other clearances for which Board of Directors supported by 4 to 6 officers & staff only will be required during construction of Phase I. Land acquisition will be done by JDA.

14.6 CONTRACTS

14.6.1 Civil Works

Elevated viaduct will be part design and built basis while the elevated stations will be constructed on design and built basis .Underground section will be constructed based on the design and built basis.

Corridor No. 2 In stage-1 (Mansarover to Chandpole) is already under implementation with two packages for the elevated viaduct, three packages for the elevated stations, one package for depot and one package for the underground section including Chandpole station.

Architectural finishes, fire fighting arrangements and general electrification, will form part of civil contracts.

14.6.2 System Contracts

- Design, construct and installation for Traction and Power Supply.
- Design, construct and installation of Signal and Telecommunication works.
- Design, construct and installation of lifts.
- Design, construct and installation of escalators.
- Design, construct and commissioning of Automatic Fare Collection System.

- Design and supply of rolling stock.
- Installation of track in Depot and on main line.
- Design and installation of Signages.

14.6.3 Depot Contracts

The contracts are required for Civil and E&M works .Each depot will have one package for civil works.

The number of contracts for supply of Depot Equipment may be decided as and when the work is in progress.

14.7 LEGAL FRAMEWORK

Metro rail projects are undertaken in congested urban environment. Metro lines have, therefore, to pass through heavily built-up areas. As vacant land for laying these lines is seldom available, they have to be constructed either as elevated or underground. When elevated, the metro lines are generally located along the medians of the existing roads to obviate the need for acquiring land. Even in such cases, land is to be acquired for siting station buildings, traffic integration areas, etc. After construction of a metro line is complete, it has to be certified as 'safe', by a statutory authority before it can be opened for public carriage of passengers. For operation and maintenance of a metro line, several crucial issues having legal implications need to be taken care of. These include continued monitoring of safety of train operations, security of metro properties, maintaining law and order within metro premises, enquiries into accidents involving metro trains whenever they happen, deciding the extent of compensation payable for damages/injuries/casualties arising out of such accidents, laying down passenger fares and their subsequent revision etc. There has, therefore, to be a proper legal frame-work to take care of such problems encountered during construction as well as operation of metro rail lines. Hence there is a need for a legislation to give legal cover to Jaipur Metro.

Construction of Jaipur Metro has commenced. Parliament has passed and notified an Act named as The Metro Railways (Amendment) Act 2009. To provide the legal cover to the construction of Jaipur Metro. Metro Act has been extended to Jaipur Metro Rail also; vide The Gazett of India – Extraordinary/Part II-Section3-Sub-section (ii) No.76 New Delhi, Friday, January 14, 2011

14.8 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.

14.8.1 The State Government have exempted the Rajasthan Value Added Tax (VAT) &entry Tax to Jaipur Metro. It should also exempt the following: -

- Tax on electricity required for operation and maintenance of the metro system.
- Municipal Taxes.

14.8.2 As per the present policy 50% of the Central Taxes may be paid by GOI as subordinate Debt and balance 50% will be paid by the concerned State Government. Rajasthan State Government may pursue the Central government to extend the same benefit to Jaipur Metro.

14.9 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.

Chapter 15

Conclusions And Recommendations

CHAPTER 15

CONCLUSIONS AND RECOMMENDATIONS

15.1 Jaipur has witnessed enormous growth during the last 10 years. Jaipur is the second fastest growing city in India. The growth of Jaipur in 1981, 1991, 2001 and 2011 census has been faster than as envisaged in the earlier master plan which is mainly the result of immigration as the city provided better employment opportunities & is very peaceful. Jaipur is the principal administrative, commercial and distribution center of the State. Jaipur has come up as a major tourist destination with domestic as well as foreign tourist traffic increasing every year which has resulted in growth in hospitality, entertainment, recreation, trade industry. With setting up of 60 engineering colleges, 40 business management institutes, 15 pharmacy, 9 medical & dental colleges and 4 hotel management institutes, Jaipur is fast developing as educational hub of Rajasthan. Rapid urbanization in the recent past has put the city's travel infrastructure to stress. With 19544 small scale units and 48 large and medium scale units in 19 industrial areas, traffic in the city is expected to shoot up. Being thickly populated area, Jaipur's traffic needs cannot be met by only road-based system.

The existing urban transport system of Jaipur City, which is road-based, has already come under stress leading to longer travel time, increased air pollution and rise in number of road accidents. Share of public transport (motorized) has fallen from 26% to 19% with Fatality Index of 15. 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 Medium Metro with carrying capacity of about 25,000 to 50,000 phpdt will be adequate to meet not only the traffic needs for the present but for the future 30 to 40 years also. A Medium Metro System consisting of two Corridors namely (i) Sitapura to Ambabari Corridor (23.099 Km)and Mansarovar to Badi Chaupar Corridor (12.067 Km)at an estimated completion cost of Rs. 9732Crores (with Central taxes & duties) to be made operational has accordingly been recommended. However, this DPR is prepared separately and this DPR is only for Phase I (Mansarovar- Badi Chaupar Corridor) as desired by JMRC from Mansarovar to Chandpole of 12.067 km.

15.2 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.

15.3 After examining the various options for execution of Jaipur Metro Project, GoR has decided to execute Phase I i.e. Mansarovar to Badi Chauper (East- West corridor) on Chennai, Bnagalore and DMRC model.

15.4 The fare structure has been prepared based on prevailing fare structure in different PT/IPT modes as indicated in finance chapter. Subsequently, for the purpose of assessing returns from the project, the fares have been revised every second year with an escalation of 10 % every two years.

15.5 As in the case of Delhi Metro, the GoR has exempted the Rajasthan Value Added Tax (VAT) and Entry Tax to Jaipur Metro. It should also exempt the following: -

- Tax on electricity required for operation and maintenance of the metro system.
- Municipal Taxes.

15.6 As per the present policy 50% of the Central Taxes may be paid by GOI as subordinate Debt and balance 50% will be paid by the concerned State Government. Rajasthan State Government may pursue the Central government to extend the same benefit to Jaipur Metro.

15.7 With the consideration that 12.5 Ha of Govt. land will be available for PD, the Financial Internal Rate of Return (FIRR) for the project has been assessed as 8.24% with central taxes and the Economic Internal Rate of Return (EIRR) works out 18.6%.

15.8 To avoid delays in processing the clearance for the Project, It is suggested that immediately on receipt of the revised DPR, the State Government should approve this DPR 'in principle' and forward the DPR to the Secretary, Ministry of Urban Development, Government of India, advising the GOI of the State Government's intention to take up the Project on DMRC pattern requesting for the GOI's "in principle" for funding the Project on DMRC/CMRL/BMRCL Pattern.

15.9 A PSU of the State Government, Jaipur Metro Rail Corporation Ltd. (JMRC) for Jaipur Metro, set up under the Companies Act, 1956 has been made functional with posting of Managing Director and Functional Directors.

15.10 Meanwhile the State Government should freeze all future developments along the proposed route of Jaipur Metro to avoid infructuous expenditure.

15.11 As it could take some time to make Jaipur Metro Rail Corporation fully functional and initially JMRC is lacking in expertise, JMRC has already taken decision to do the part of phase I through DMRC on deposit terms. To commission the entire Phase I corridor expeditiously, it is recommended that balance of phase I should also be got done through DMRC on the deposit terms or any other agency as EPC contract (with DMRC as GC) but with the same system and rolling stock as being planned by DMRC for Phase IA.

15.12 As the Rajasthan Government was very keen to start the financial functioning of Jaipur Metro Stage-1 by June 2013, for which Rajasthan Government has already registered Jaipur Metro Rail Corporation Ltd with provision for Government of India to join later on, Rajasthan Government has handed over the project Phase-I A i.e from Mansarovar to Chandpole on turn-key basis to DMRC since there is no experience and expertise with the State Government for handling such a complex project. This will help in quick decision making, keep down the cost of the project and can save about a year in implementation. Action as suggested in para 15.11 for the balance portion of Phase I may be taken expeditiously.