UPDATED FINAL DETAILED PROJECT REPORT

FOR

LUCKNOW METRO RAIL PROJECT (PHASE – I)

Client: Government of Uttar Pradesh

Prepared By:

दिल्ली मेट्रो रेल कॉरपोरेशन लिमिटेड

DELHI METRO RAIL CORPORATION LTD.

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LUCKNOW METRO PROJECT

I N D E X

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SALIENT FEATURES

1. Gauge (Nominal) 1435 mm

2. Route Length (between dead ends)

Corridors	Elevated (km)	Underground (km)	Total Length (km)
North – South Corridor (CCS Airport to Munshi Pulia)	**19.438**	**3.440**	**22.878**
East – West Corridor (Lucknow Rly. Station to Vasantkunj)	**4.548**	**6.550**	**11.098**
Total	**23.986**	**9.990**	**33.976**

3. Number of stations

Description	Underground	Elevated	Total
North – South Corridor (CCS Airport to Munshi Pulia)	**3**	**19**	**22**
East – West Corridor (Lucknow Rly. Station to Vasantkunj)	**7**	**5**	**12**
Total	**10**	**24**	**34**

4. Traffic Forecast

Year	Corridor Length (km)	PHPDT	Daily Passenger km	Daily Ridership	Average Trip Length (km)
North-South Corridor : CCS Airport to Munshi Pulia					
2015		13190	3227960	429250	7.52
2020		20976	4886515	644659	7.58
2025	22.878	25890	6132646	833240	7.36
2030		34955	7664688	1054290	7.27
2041		44408	9501868	1343970	7.07
East-West Corridor : Lucknow Rly Station to Vasant kunj					
2015		7639	619487	155650	3.98
2020	11.098	14157	1007262	243300	4.14
2025		21434	1477121	345930	4.27
2030		29171	1982341	459940	4.31

Year	Corridor Length (km)	PHPDT	Daily Passenger km	Daily Ridership	Average Trip Length (km)
2041		36196	2496832	600200	4.16

5. Train Operation

Capacity Provided for Corridor-I: North –South Corridor

Particulars	Year	Headway (min)	No. of Rakes	Rake Consist	No. of Coaches	Max. PHPDT Demand	PHPDT Capacity Available
CCS Airport to Alambagh Bus Stand	2015	14	13	6 car	78	6172	6746 (8580*)
Alambagh Bus Stand to Mahanagar		7				13190	13491 (17160)*
Mahanagar to Munshipulia		14				8451	6746 (8580*)
CCS Airport to Alambagh Bus Stand	2020	9	18	6 car	108	9658	10493 (13347*)
Alambagh Bus Stand to Mahanagar		4.5				20976	20987 (26693)*
Mahanagar to Munshipulia		9				13498	10493 (13347*)
CCS Airport to Alambagh Bus Stand	2025	7	23	6 car	138	13159	13491 (17160*)
Alambagh Bus Stand to Mahanagar		3.5				25890	26983 (34320)*
Mahanagar to Munshipulia		7				15644	13491 (17160*)
CCS Airport to Alambagh Bus Stand	2030	5	30	6 car	180	14995	18888 (24024*)
Alambagh Bus Stand to Mahanagar		2.5				34955	37776 (48048)*
Mahanagar to Munshipulia		5				21246	18888 (24024*)
CCS Airport to Alambagh Bus Stand	2041	4	38	6 car	228	19581	23610
Alambagh Bus Stand to Mahanagar		2				44408	47220 (60060*)
Mahanagar to Munshipulia		4				26894	23610 (30030*)

Capacity Provided for Corridor-I: East –West Corridor

Particulars	Year	Head way (min)	No. of Rakes	Rake Consist	No. of Coaches	Max. PHPDT Demand	PHPDT Capacity Available
Lucknow Railway Station to Thakurganj	2015	11	7	6 car	42	8104	8585 (10920*)
Thakurganj to Vasant kunj		22				1831	4293 (5460)*
Lucknow Railway Station to Thakurganj	2020	6.5	9	6 car	54	14157	14529 (18480*)
Thakurganj to Vasant kunj		13				3638	7265 (9240)*
Lucknow Railway Station to Thakurganj	2025	4.5	12	6 car	72	21434	20987 (26693*)
Thakurganj to Vasant kunj		9				5765	10493 (13347)*
Lucknow Railway Station to Thakurganj	2030	3	17	6 car	102	29171	31480 (40040*)
Thakurganj to Vasant kunj		6				7522	15740 (20020)*
Lucknow Railway Station to Thakurganj	2041	2.5	20	6 car	120	36196	37776 (48048*)
Thakurganj to Vasant kunj		5				9110	18888 (24024*)

* @ 8 persons per square meter of standee area

6. Speed

Designed Speed	80 kmph
Scheduled speed	34 kmph for N-S Corridor 32 kmph for E-W Corridor

7. Traction Power Supply

a) Voltage — 25 KV OHE

b) Power Demand (MVA)

Corridor		Year				
		2015	2020	2025	2030	2041
Corridor – 1 North – South Corridor (CCS Airport - Indira Nagar - Munshi Pulia, 22.88 km with 19 elevated and 3 U/G stations)	Traction	7.27	10.97	13.98	19.46	23.78
	Auxiliary	13.96	16.68	18.16	24.09	24.09
	Total	**21.23**	**27.64**	**32.14**	**43.55**	**47.86**
Corridor – 2 East – West Corridor (Lucknow Railway Station to Vasantkunj, 11.10 km with 5 elevated and 7 U/G stations)	Traction	3.26	5.08	6.92	10.11	11.69
	Auxiliary	20.38	23.47	24.15	27.79	27.79
	Total	**23.64**	**28.55**	**31.07**	**37.90**	**39.48**

c) Sub Stations

Corridor	Grid sub-station (with Input voltage)	Location of RSS of Metro Authority	Approx. length of cables
Corridor – 1 North – South Corridor (CCS Airport to Munshi Pulia)	Near Kanpur Road / Transport Nagar Sub Station at 220 kV	Amausi 220/33/25 kV RSS	2 to 3 km. 220kV cabling Double circuit
	Power Grid (PGCIL) 220 kV Sub Station at Kursi Road	Munshi Pulia 220/33/25 kV RSS	6 to 7 km. 220kV cabling Double circuit
Corridor – 2 East – West Corridor (Lucknow Railway Station to Vasantkunj)	220 kV Sub Station at Hardoi Road	132/33/25 kV RSS near Vasant Kunj	2 km. 132kV cabling Double circuit
	TRT / Hardoi Road Sub Station,132 kV	132/33/25 KV RSS Near lucknow railway station/ near Nawajganj	2 km. 132kV cabling Single circuit

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 6 coach unit - 1574 Passengers
e) Class of accommodation - One

9. Maintenance Facilities

Maintenance Depot for Corridor-1 - Transport Nagar
Maintenance Depot for Corridor-2 - Vasant Kunj 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 cost (at May 2013 prices) without taxes & duties

Corridor I	Rs. 4992 Crores
Corridor II	Rs. 3723 Crores
Total	**Rs. 8715 Crores**

14. Total estimated completion cost(including escalation and Central taxes only)

North – South Corridor (Completion March 2018)	Rs. 6880 Crores
East – West Corridor (Completion March 2019)	Rs.5494 Crores
Total	**Rs.12374Crores**

15. Financial Indices

a) FIRR

Description	FIRR
With property development	**8.12%**
Without property development	**4.43%**

b) EIRR

The EIRR (without taxes) in economic terms work out to be **19.43 %** for the project.

Executive Summary

EXECUTIVE SUMMARY

0.1 INTRODUCTION

0.1.1 Background

Economic growth and spatial development are quite often governed by the quality and quantity of infrastructure provided. While an inadequate transport facilities causes congestion, delays and hazards result in significant socio – economic costs to the society. An oversupply, apart from being uneconomical, often acts as counter to the long term spatial development strategies of settlements and regions. Supplying and maintaining an optimal level of infrastructure is the key to planned development. India is passing a stage where urbanization is taking place at an increasing rate. With rapid urbanization, there has been a widening gap between demand and supply of urban infrastructure of which transportation is an essential component.

Lucknow is popularly known for its cultural and intellectual traditions as well as, its current status as a nucleus of service industry, education & research. Lucknow is the capital of Uttar Pradesh & administrative headquarters of Lucknow district & division. With its 2.2 (COI, 2001 Estimates) million inhabitants Lucknow Urban Agglomeration has currently over 3 million population. The master plan has projected a population of about 3.2 million and 4.0 million by years 2011 & 2021 respectively. Being an important cultural and trading centre Lucknow continues to grow and attract large number of people to the city. The rapid growth of the city and the associated urban sprawl has accentuated the demand supply mismatch amidst the constrained transport infrastructure resulting in economic and social externalities. Lucknow must keep pace with the demographic and economic growth. The inadequate commuter transportation system in Lucknow is overwhelmed by upsurge of private automobiles. Private vehicles (motorised 2-wheelers and cars) constitute 90 percent of total vehicles registered in Lucknow City. The supply of city buses being only 6 per lakh population is inadequate for a city's size like Lucknow. The benchmark is between 70 to 80 buses per lakh residents in an urban area in India.

One of the key issues to be tackled is to improvise on a reliable public transport system; above all, lay emphasis on a mass transportation system which is environmental friendly to cater to city's growing travelling needs to sustain in the growing economic activities. India being in the process of economic reforms and that such mass transport systems will involve heavy investments.

Against this backdrop of increasing number of vehicles on road and concomitant congestion and air pollution, the Lucknow Development Authority commissioned DMRC to prepare Detailed Project Report for a Mass Rapid Transit System (MRTS) for Lucknow City to serve forecast travel up to the horizon year 2030.

0.1.2 Study Area

The geographic area within the jurisdiction of Lucknow Development Authority (LDA) will be the Study Area (Figure 1.1) for the current Study.

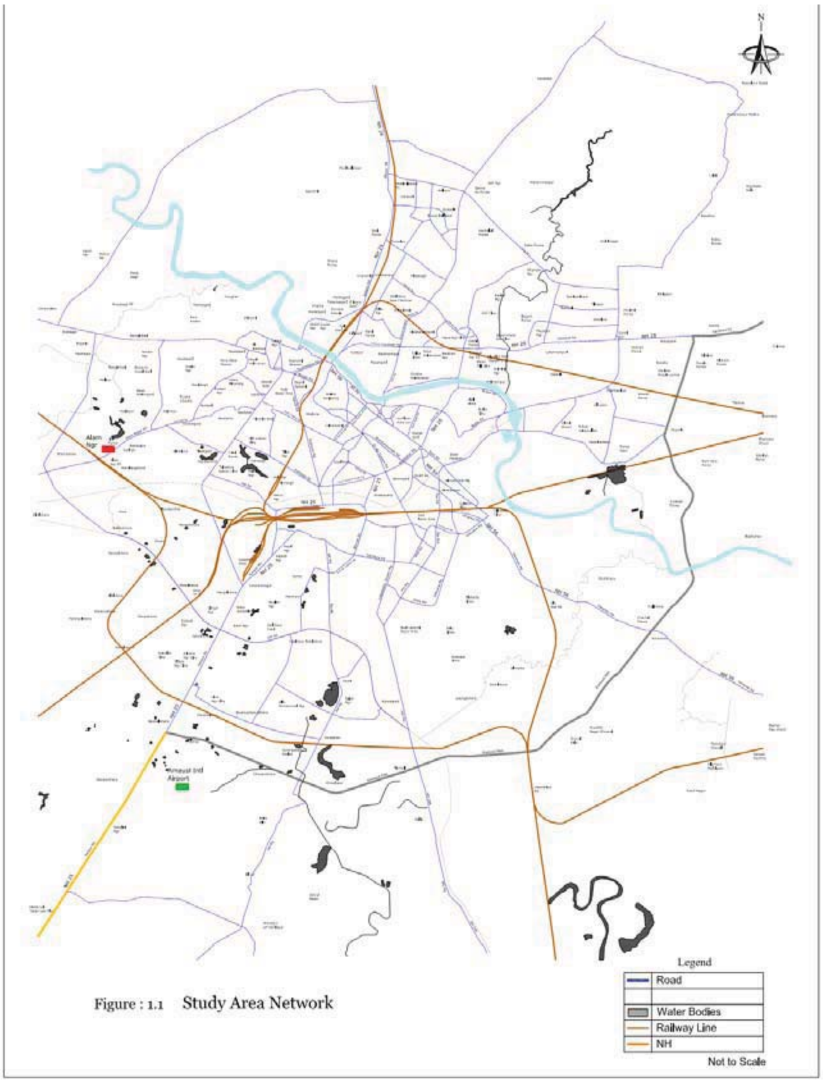


Fig. 0.1 - Study Area

0.2 TRAFFIC DEMAND

Large number of alternate routes for Metro for Lucknow was taken in the traffic analysis and the Peak Hour and Peak direction traffic (PHPDT) on such routes determined. Based on PHPDT, two routes; one connecting North to South and East to West were identified. North – South corridor starts at Amusai airport and ends at Munshipulia via Hazaratganj, Sachivalaya, IT Chouraha etc with a total length of 22.878 km. East- West corridor with its Length of 11.098kms, starts at Charbagh Railway station and ends at Vasant kunj passing through City railway station, Balaganj, Musabagh etc.

0.2.1 Section Loading

The traffic assignment was carried out with the proposed alignments in place. The loading on the proposed metro alignments is presented in Table below:-

Table 0.1 - summary of transport demand projections

Year	Corridor Length (km)	PHPDT	Daily Passenger Km	Daily Ridership	Average Trip Length (km)
North-South Corridor : CCS Airport to Munshi Pulia					
2015	22.878	13190	3176450	429250	7.52
2020		20976	4963877	644659	7.58
2025		25890	6499272	833240	7.36
2030		34955	8223462	1054290	7.27
2041		44408	10482966	1343970	7.07
East-West Corridor : Lucknow Rly Station to Vasant kunj					
2015	11.098	7639	762685	155650	3.8
2020		14157	1240830	243300	4.14
2025		21434	1764243	345930	4.27
2030		29171	2345694	459940	4.31
2041		36196	3061020	600200	4.16

The total ridership in the proposed North- South corridor in the year 2015 and 2041 will be 4.29 and 13.44 lakhs passengers per day respectively. The daily ridership on the East- West corridor will be 1.55 lakhs in 2015 and 6.00 lakhs passengers per day in 2041.

The maximum range of PHPDT on the North-South alignment in 2015 will be 13190 and by 2041 the maximum range of PHPDT is projected to be in the order of 41969. The maximum range of PHPDT on the East-West alignment in 2015 will be 7639 and by 2041 the maximum range of PHPDT is projected to be in the order of 44408. Station wise boarding, alighting and sectional load for different horizon years are presented in Annexure 2.2.

0.2.2 Station Loading (Daily And Peak)

The daily station loading (two way boarding's) for both the alignments are presented in **Tables below:-**

Table 0.2 - Daily Station Loading for North-South corridor

Station	Station Name	2015	2020	2025	2030	2041
1	CCS Airport	1170	1260	1340	1400	1520
2	Amausi	4700	5020	5370	5610	6070
3	Transport Nagar	2530	6690	9280	12330	18460
4	Krishnagar	10340	24050	29780	56570	74850
5	Singar Nagar	5780	10780	16240	19370	26990
6	Alambagh	13180	18840	21000	26250	35040
7	Alambagh Bus Stn	12340	20990	28410	37580	63020
8	Mawaiya	50990	61889	63180	72600	87180
9	Durgapuri	25980	35910	56450	59330	88130
10	Lucknow Rly. Stn	77650	143030	186620	241260	332350
11	Hussain Ganj	36760	44940	60180	78300	88620
12	Sachivalaya	11370	14800	17510	23410	26710
13	Hazarat Ganj	17380	21440	25170	31600	37070
14	KDSinghBabuStadium	4550	6720	10060	16450	14280
15	Vishwavidyalaya	5540	10580	14340	20810	18710
16	IT College Junction	10210	17500	24830	30870	27480
17	Mahanagar	50420	68100	88720	103210	118720
18	Badshah Nagar	13480	26270	36640	44000	61990
19	Lekhraj Market	21220	32100	41980	56330	71860
20	Ram Sagar Mishra Nagar	10410	16470	21360	27930	37240
21	Indira Nagar	15930	21310	29050	38030	53270
22	Munshipulia	27320	35970	45730	51050	54410
	Total	**4,29,250**	**6,44,659**	**8,33,240**	**10,54,290**	**13,43,970**

(Note: Numbers are daily Boarding's on both directions (Up and Down)

Table 0.3 - Daily Station Loading for East-West Corridor

STATION NO.	STATION NAME	2015	2020	2025	2030	2041
1	Lucknow Rly. Stn	39620	44980	48040	50430	65960
2	Gautam Buddha Marg	64000	11330	17280	22630	47820
3	Aminabad	22460	31100	38770	47340	62550
4	Pandey Ganj	24810	34280	44250	62760	71910
5	City Rly. Stn	8450	13190	18800	24900	34710
6	Medical Chauraha	9950	17120	26350	38570	50830
7	Nawajganj	16950	35000	63260	89770	104090
8	Thakurganj	8000	17680	36670	44670	63840
9	Balaganj	6150	19190	28510	51400	59430
10	Sarfarazganj	3970	6970	8430	9720	16140
11	Musabagh	7170	8180	9590	11420	13150
12	Vasant kunj	1720	4280	5980	7140	9270
	Total	**2,13,250**	**2,43,300**	**3,45,930**	**4,60,750**	**5,99,700**

(Note: Numbers are Daily Boarding's on both directions (Up and Down)

Table 0.4 - Overall Average Trip Length in the Network

Year	Av. Trip length(km)
2015	6.58
2020	6.64
2025	6.45
2030	6.37
2041	6.17

0.3 PLANNING & DESIGN PARAMETERS

0.3.1 Route Alignment & Geometric Design Parameters

The geometric design norms presented have been worked out based on a detailed evaluation of passenger comfort, safety, experience and internationally accepted practices used currently operating rapid transit and rail systems. Various alternatives were considered for most of these parameters but the best-suited ones have been adopted for the system as a whole.

0.3.2 Alignment Considerations

- Minimum tangent lengths between curves are recommended to ensure sufficient time for passengers to recover from one curve before entering another.
- Super elevation on curves is applied to counter the effect of lateral force felt by passengers and to prevent passengers from feeling as if they are sliding across the seat.
- Minimum vertical curve radii are designed with passenger comfort in mind.

0.3.3 General Criteria

General criteria used for the design purpose is given below:

Table 0.5 - Design Criteria

SN	Criteria	Dimension
1	Gauge (14mm below top of rail crown)	1435 mm
2	Design Speed	80 kmph
3	Maximum axle load	16T
4	Electric power collection	25 v ac (OHE)

0.3.4 Curved Sections

0.3.4.1 Circular Curves

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

The minimum length of a circular curve shall be either V/2 in metres, where V is the design speed in km/h or 25 m whichever is higher in order to accommodate the full length of a car/coach.

For dual tracks on curves, the smaller of the two radii shall govern the selection of clearance requirement and minimum spacing of track centres. The curve parameters are as below:

Table 0.6

CURVE RADIUS IN MID SECTION	
(i) Underground sections	
Minimum	**300 m**
Absolute Minimum	**200 m**
(ii) Elevated Section	
Minimum	**200 m**
Absolute minimum	**120 m**
Minimum curve radius at stations	1000 m
Maximum permissible cant (Ca)	120 mm
Maximum cant deficiency (Cd)	100

0.3.4.2 Vertical Curves

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

Vertical curves in main lines shall wherever possible be positioned such that coincidence with both transition curves and canted portions is avoided. Where such coincidence is unavoidable the largest practicable vertical curve radius shall be employed and the cant gradient shall be the minimum. In all such cases the resultant geometry shall be verified as being compatible with safe passage at the design speeds by the proposed rolling stock.

Minimum radius and length of vertical curves shall be:

Table 0.7

RADIUS OF VERTICAL CURVES	
On main line	
desirable	**2500 m**
Absolute minimum	**1500 m**
Other Locations	**1500 m**
Minimum length of vertical curve	20

0.3.5 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.

0.3.5.1 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.

0.3.5.2 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.

0.4 CIVIL ENGINEERING

During the traffic studies carried out for Lucknow City, number of corridors were examined based on the Peak hour Peak Direction traffic (PHPDT) and the importance of locality to be served, two corridors have finally been frozen i.e.Corridor-1 from North to South and Corridor-2 from East to West. Of the two corridors the North-South corridor from Chaudhari Charan Singh Airport to Munshi Pulia has been recommended for execution in the Phase-I.

Two corridors, i.e. North-South and East-West Corridors have been proposed for Lucknow Metro is shown as Figure 4.1. Both the North –South Corridor and the East-West Corridors are partly underground and elevated. The elevated alignment is mostly located on the median of the roads. In the central area near Lucknow Railway Station, Aminabad, Hazratganj the N-S and E-W corridor will run underground with switch-over ramps for transitions from elevated to underground on NH-25 (Kanpur Road) and underground to elevated on the Mahatma Gandhi Road at the end of Hazratganj Market for the N-S corridor, for E-W corridor the ramp has been proposed at the Hardoi road to transit from underground to elevated. The depots for the East – West corridor has been proposed in Open Land behind Fish Mandi on the Hardoi Road and for North-South Corridor in open / Agricultural land near Amausi Airport. The break-up of length of the two corridors (in kilometers) is given below in **Table below:-**

Table 0.8 - Proposed MRTS Corriodrs

Corridors	Total	Elevated	Ramp	Underground	At Grade
North – South (CCS Airport to Munshi Pulia)	22.878 km	19.051 km	0.774 km	3.053 km	-
East – West (Lko rly. Station to Vasantkunj)	11.098 km	4.295 km	0.505 km	6.298 km	-

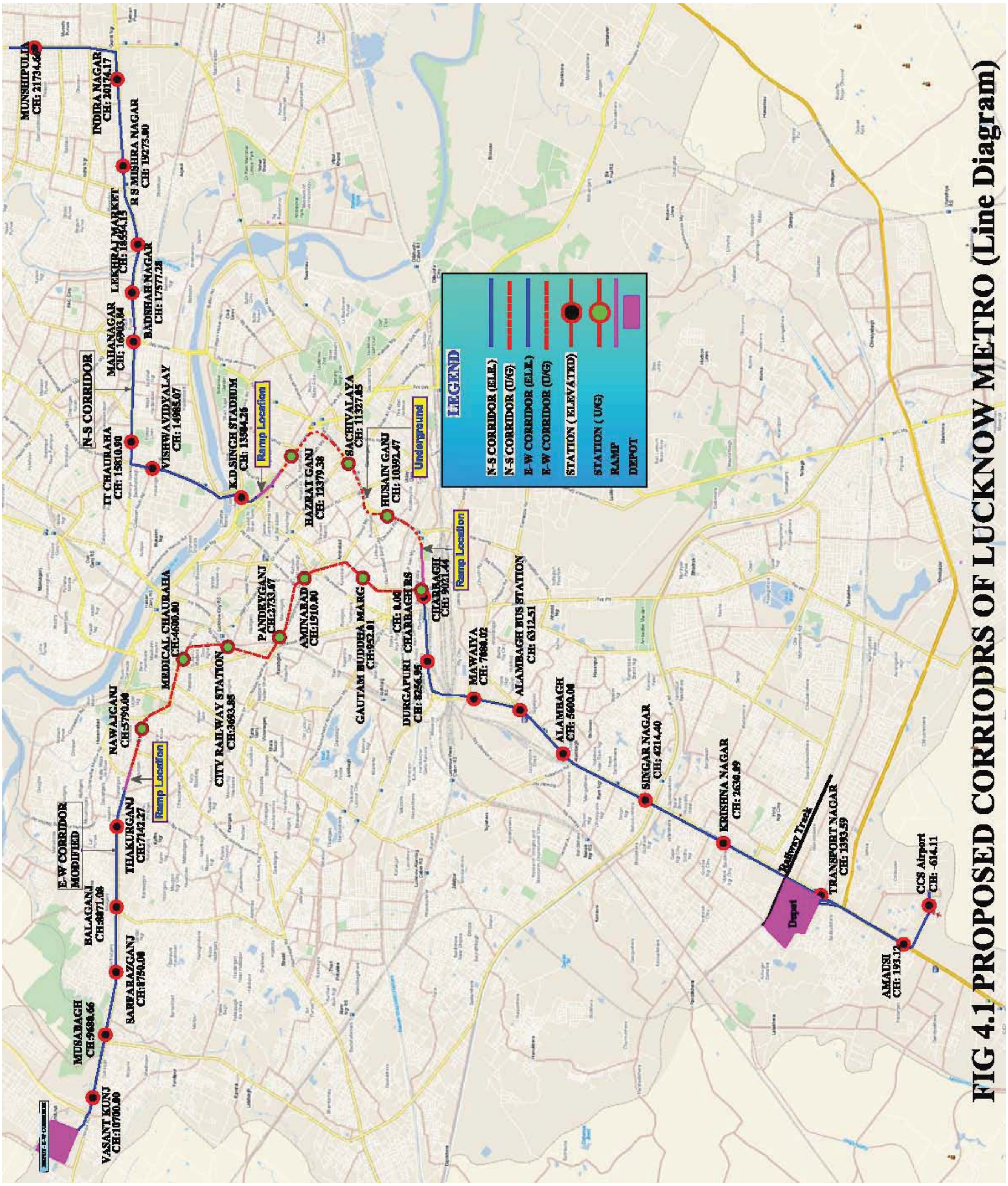


FIG 4.1 PROPOSED CORRIODRS OF LUCKNOW METRO (Line Diagram)

0.4.1 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 before and after Switch Over Ramp (SOR) and at the start of the alignment at Lucknow Station. 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.

0.4.2 Underground Stations

All the seven 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.

0.4.3 Cut And Cover Method Of Construction Of Underground Stations

Cut and Cover mainly consists of following steps:

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

0.4.4 Utility Diversion

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

0.4.5 Curvature

The proposed East- west corridor has 55% of the alignment underground and also the topology of Lucknow is not very undulating, yet to place the stations at proper locations number of horizontal curves have been proposed. The radius of curves at few locations is kept as low as 300 m in the underground section to fit the underground stations in such a way that the property acquisition can be minimised. 22.93 % of the length of the alignment is on curves. The details of curves on East- West Corridor are given in Table below:-

Table 0.9 - Details Of Horizontal Curves – Proposed East West Corridor

TS / PC (TP1)	SC (TP2)	CS (TP3)	ST / PT (TP4)	Radius (m)	Transition Length (m)	Length of Curve (m)	Straight between two curves (m)
Start of Alignment			-113.00				304.494
191.49	216.49	248.80	273.80	1010.000	25	32.305	315.44
589.24	644.24	789.20	844.20	300.000	55	144.958	360.201
1204.40	1259.40	1621.54	1676.54	307.525	55	362.147	417.87
2094.41	2149.41	2358.16	2413.16	305.000	55	208.743	30.321
2443.48	2498.48	2595.59	2650.59	305.000	55	97.108	356.356
3006.94	3061.94	3533.40	3588.40	305.000	55	471.454	308.15
3896.55	3951.55	4446.92	4501.92	310.000	55	495.374	622.869
5124.79	5179.79	5349.33	5404.33	500.000	55	169.542	46.021
5450.35	5505.35	5637.33	5692.33	305.000	55	131.974	323.839
6016.16	6036.16	6041.61	6061.61	3000.000	20	5.445	171.313

TS / PC (TP1)	SC (TP2)	CS (TP3)	ST / PT (TP4)	Radius (m)	Transition Length (m)	Length of Curve (m)	Straight between two curves (m)
6232.92	6242.92	6294.42	6304.42	2300.000	10	51.503	30.795
6335.22	6345.22	6428.85	6438.85	3000.000	10	83.635	425.884
6864.74	6919.74	7034.91	7089.91	500.000	55	115.177	257.855
7347.77	-	-	7379.13	8000.000	0	31.359	298.636
7677.76	7687.76	7748.47	7758.46	3000.000	10	60.702	122.853
7881.32	7896.32	7924.50	7939.50	2000.000	15	28.181	151.429
8090.93	8110.93	8184.21	8204.21	1500.000	20	73.285	58.554
8262.77	8282.77	8342.64	8362.64	1400.000	20	59.871	63.665
8426.30	8436.30	8478.29	8488.28	3000.000	10	41.986	381.468
8869.75	8889.75	8985.08	9005.09	1400.000	20	95.332	176.656
9181.74	9211.74	9352.13	9382.13	1200.000	30	140.389	709.336
10091.47	-	-	10139.12	10000.000	0	47.656	846.003
10985.13	**End of Alignment**						

0.4.6 Break Up Of Alignment Length For East-West Corridor

The alignment is proposed to be underground at the start from Lucknow Railway station and will switchover to be elevated after Nawajganj station. The first elevated station will be Thakurganj. Normally the underground stations are constructed by Cut and Cover method, in which the road and properties above the proposed station location are acquired temporarily for the construction period and again developed after the construction is over. Sometimes, it is not possible to construct the underground running section by tunnelling method and cut & cover method is used in such locations. Locations of Crossovers and Scissors are constructed by cut and cover. The minimum horizontal distance between two Tunnels i.e track centres to lower the Tunnel Boring Machines should be 12.0 m, so in case the distance between two tunnels i.e. track centres is less than 12.0 m the section will have to be constructed by the Cut and cover method. Along the alignment different stretches will adopt different methodology of construction. Break-up lengths of E-W Corridor is given in **Table below:-**

Table 0.10 - Sections & Methods Of Construction

	Chainage (Km)		Length (Km)	Method of Construction	Remarks / Reasons
	From	To			
Underground Section					
	(-) 0.113	0.257	0.370	Cut and Cover	Distance between track centre are 4.5 m at start along with station and scissor is to placed after the station. After the scissor crossover the tracks w diverge to avoid the minor bridge.
	0.257	5.718	5.461	Tunnel boring Machine	After the track centres are 12. m apart, TBM can start.
	5.948	6.185	0.237	Cut and Cover	From Nawajganj station till start of ramp.
	6.185	6.676	0.490	Ramp	Switchover ramp from underground to elevated
Elevated Section					
	6.676	10.985	4.309	Elevated Box girder Viaduct	
Total Length (km)			**11.098**		

0.4.7 Station Planning

The proposed metro for lucknow consists of two corridors namely:

1. North-South Corridor: CCS Airport – Munshi Pulia

2. East West Corridor: Charbagh/Lucknow Railway Station – Vasant Kunj

The length of the proposed N-S corridor is 22.878 km and E-W corridor is 11.098 km. Along the North-South corridor 22 stations have been planned, 12 stations have been planned along the East-West corridor. The locations of the stations have been identified taking into consideration the constraints in land acquisition, congestion issues and integration. Therefore, stations are proposed in such a way so as to attract maximum demand from the traffic nodal points.

0.4.7.1 Planning And Design Criteria For Stations

Salient features of a typical station are as follows:

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.

The platform level has adequate assembly space for passengers for both normal operating conditions and a recognized abnormal scenario.

The platform level at elevated stations is determined by a critical clearance of 5.50-m under the concourse above the road intersection, allowing 3.00-m for the concourse height, about 1-m for concourse floor and 2.00-m for structure of tracks above the concourse. Further, the platforms are 1.09-m above the tracks. This would make the platforms in an elevated situation at least 13.60m above ground.

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.

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.

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

Station entrances are located with particular reference to passenger catchment points and physical site constraints within the right-of-way allocated to the MRTS. Office accommodation, operational areas and plant room space is required in the non-public areas at each station.

- Tunnel Ventilation fans and ASS in underground stations are provided at platform level/ concourse level depending on availability of land for locating vent shafts.
- The DG set, bore well pump houses and ground tank would be located generally in one area on ground.
- 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.
- 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.
- 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.
- 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.

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

A list of accommodation required in the non-public area at each station is given below:

Table 0.11

Non Public Area – Station Accommodation	
Station Control Room	Cash & Ticket Room
Platform Supervisor's Booth	Fire Tank & Pump room
Station Master's Office	Staff Area
Traction Substation	UPS and Battery Room
Information & Enquiries	Cleaner's Room
Signaling Room	Security Room
Ticket Office	Staff Toilets
Communication Room	Refuse Store
Ticket Hall Supervisor & Excess Fare Collection (Passenger Office)	Miscellaneous Operations Room
Station Substation	First Aid Room

0.4.8 Geo-Technical Investigations

General Geology & Characteristics - Location

Two corridors and a 3.5 km link line i.e. North-South and East-West have been identified as potential MRTS in Lucknow in Phase I. The details of the N-S and E-W corridor identified have already been discussed in the previous sections. Geotechnical investigations have been carried out along the proposed alignments to determine the strata, depth of foundation and safe bearing capacity of foundations required for the above proposed Metro corridors.

Physiography & Climate

Lucknow city is situate in the Gangetic plain and is located in the **Seismic Zone III**. The city has a warm humid subtropical climate with maximum temperature rising to 40-45 degree Celsius and minimum temperature lowering down to around 3 degree Celsius. The city gets an average rainfall of 1010mm mostly from the South-west Monsoon winds.

Field Work

Subsurface explorations were carried out along the length of the proposed corridors. Bore holes were done at every 500m at the proposed NS and EW corridors. The summary of field work conducted is given in **Table below:-**

Table 0.12 - Summary Of Field Investigation

NORTH SOUTH CORRIDOR			
BOREHOLE NO.	DEPTH OF BOREHOLE (m)	DEPTH OF WATER TABLE BELOW GROUND LEVEL (m)	SOIL/ROCK
BH-01	30.0	18.60	Only Soil
BH-02	30.0	19.00	Only Soil
BH-03	30.0	20.00	Only Soil
BH-04	30.0	18.00	Only Soil
BH-05	30.0	21.50	Only Soil
BH-06	30.0	25.50	Only Soil
BH-07	30.0	27.00	Only Soil
BH-08	30.0	Not Met	Only Soil
BH-09	30.0	Not Met	Only Soil
BH-10	30.0	Not Met	Only Soil
BH-11	30.0	Not Met	Only Soil
BH-12	30.0	Not Met	Only Soil
BH-13	30.0	Not Met	Only Soil
BH-14	30.0	Not Met	Only Soil
BH-15	30.0	Not Met	Only Soil
BH-16	30.0	Not Met	Only Soil

NORTH SOUTH CORRIDOR			
BOREHOLE NO.	**DEPTH OF BOREHOLE (m)**	**DEPTH OF WATER TABLE BELOW GROUND LEVEL (m)**	**SOIL/ROCK**
BH-17	30.0	Not Met	Only Soil
BH-18	30.0	Not Met	Only Soil
BH-19	30.0	Not Met	Only Soil
BH-20	30.0	Not Met	Only Soil
BH-21	30.0	Not Met	Only Soil
BH-22	30.0	Not Met	Only Soil
BH-23	30.0	Not Met	Only Soil
BH-24	30.0	Not Met	Only Soil
BH-25	30.0	Not Met	Only Soil
BH-26	30.0	Not Met	Only Soil
BH-27	30.0	Not Met	Only Soil
BH-28	30.0	Not Met	Only Soil
BH-29	30.0	Not Met	Only Soil
BH-30	30.0	Not Met	Only Soil
BH-31	30.0	Not Met	Only Soil
BH-32	30.0	Not Met	Only Soil
BH-33	30.0	Not Met	Only Soil
BH-34	30.0	Not Met	Only Soil
BH-35	30.0	Not Met	Only Soil
BH-36	30.0	Not Met	Only Soil
BH-37	30.0	Not Met	Only Soil
BH-38	30.0	Not Met	Only Soil
BH-39	30.0	Not Met	Only Soil
BH-40	30.0	Not Met	Only Soil
BH-41	30.0	Not Met	Only Soil
BH-42	30.0	Not Met	Only Soil
BH-43	30.0	Not Met	Only Soil
BH-44	30.0	Not Met	Only Soil

NORTH SOUTH CORRIDOR			
BOREHOLE NO.	DEPTH OF BOREHOLE (m)	DEPTH OF WATER TABLE BELOW GROUND LEVEL (m)	SOIL/ROCK
BH-45	30.0	Not Met	Only Soil
BH-46	30.0	Not Met	Only Soil

Table 0.13

EAST WEST CORRIDOR			
BOREHOLE NO.	DEPTH OF BOREHOLE (m)	DEPTH OF WATER TABLE BELOW GROUND LEVEL (m)	SOIL/ROCK
BH-01	30.0	23.00	Only Soil
BH-02	30.0	22.00	Only Soil
BH-03	30.0	27.00	Only Soil
BH-04	30.0	26.00	Only Soil
BH-05	30.0	24.00	Only Soil
BH-06	30.0	28.00	Only Soil
BH-07	30.0	29.00	Only Soil
BH-08	30.0	30.00	Only Soil
BH-09	30.0	NIL	Only Soil
BH-10	30.0	NIL	Only Soil
BH-11	30.0	NIL	Only Soil
BH-12	30.0	NIL	Only Soil
BH-13	30.0	26.00	Only Soil
BH-14	30.0	26.00	Only Soil
BH-15	30.0	20.00	Only Soil
BH-16	30.0	20.00	Only Soil
BH-17	30.0	22.00	Only Soil
BH-18	30.0	13.50	Only Soil
BH-19	30.0	13.00	Only Soil

EAST WEST CORRIDOR			
BOREHOLE NO.	**DEPTH OF BOREHOLE (m)**	**DEPTH OF WATER TABLE BELOW GROUND LEVEL (m)**	**SOIL/ROCK**
BH-20	30.0	19.00	Only Soil
BH-21	30.0	20.00	Only Soil
BH-22	30.0	27.10	Only Soil
BH-23	30.0	22.00	Only Soil
BH-24	30.0	26.50	Only Soil
BH-25	30.0	26.40	Only Soil
BH-26	30.0	26.50	Only Soil
BH-27	30.0	28.10	Only Soil
BH-28	30.0	13.30	Only Soil
BH-29	30.0	12.40	Only Soil
BH-30	30.0	13.05	Only Soil
BH-31	30.0	17.10	Only Soil
BH-32	30.0	16.50	Only Soil

0.4.9 Land

Land Requirement for following Major Components

Availability of land is one of the major prerequisites for a project in cities like Lucknow. 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 land acquisition is required is minimum. 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. Etc
-

Table 0.14 - Summary of Permanent Land Requirement (Ha)

Sr. No.	Description	Corridor 1 (N-S Corridor)		Corridor 2 (E-W Corridor)	
		Govt.	Private	Govt.	Private
1	Stations	1.83	2.02	0.81	1.87
2	Running Section	1.05	3.68	0.00	0.75
3	RSS/TSS	1.6	0.00	1.6	0.00
4	Depots	37.8	0.00	12.33	0.00
Total		**42.30**	**5.70**	**14.74**	**2.62**

Total Land required permanently for both corridors: 57.04 Ha (Govt.) + 8.32 Ha (Pvt.) = 65.36 Ha.

Table 0.15 - Summary of Temporary Land Requirement (Ha)

Sr. No.	Description	Corridor 1 (N-S Corridor)		Corridor 2 (E-W Corridor)	
		Govt.	Private	Govt.	Private
1	Stations	2.94	1.73	2.48	2.84
2	Running Section	0.00	0.00	0.00	0.00
3	Construction Depots	0.73	0.25	0.23	0
Total		**3.67**	**1.98**	**2.71**	**2.84**

Total Land required for temporarily for construction for both corridors: 6.38 Ha (Govt.) + 4.82Ha (Pvt.) = 11.20 Ha.

0.5 TRAIN OPERATION PLAN

0.5.1 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.
- Multi-tasking of train operation and maintenance staff.

0.5.2 Salient Features

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

A) North- South Corridor:

a) CCS Airport to Munshipulia: 34 kmph

b) Alambagh Bus Stand to Mahanagar: 33 kmph

B) East-West Corridor:

a) Lucknow Railway Station to Vasant Kunj: 32 kmph

b) Lucknow Railway Station to Thakurganj: 33 kmph

0.5.3 Train Formation

To meet the above projected traffic demand, the possibility of running trains with composition of 6 Car trains with different headway has been examined.

The basic unit of 6-car train comprising of DMC + TC + MC + MC + TC + DMC configuration is selected for the Lucknow Metro Corridors for the year 2015, 2020, 2025, 2030 & 2041.

Composition

DMC : Driving Trailer Car

MC : Motor Car

TC : Trailer Car

6 Car Train Compositions: DMC + TC +MC + MC + TC + DMC

Capacity

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

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

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

0.5.4 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:

Requirements of coaches is calculated based on following assumptions-

Assumptions –

I) Train Composition planned as under

6 car Train Composition : DMC + TC + MC + MC + TC+ DMC

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:

i) North- South Corridor:

a) CCS Airport to Munshipulia: 34 kmph

b) Alambagh Bus Stand to Mahanagar: 33 kmph

ii) East-West Corridor:

a) Lucknow Railway Station to Vasant Kunj: 32 kmph

b) Lucknow Railway Station to Thakurganj: 33 kmphh

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

0.6 ROLLING STOCK

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

0.6.1 Optimization Of Coach Size

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

Table 0.16 - Size of the coach

Description	Length*	Width	Height
Driving Motor Car (DMC)	21.64 m	2.9 m	3.9 m
Trailer car (TC)/Motor Car (MC)	21.34 m	2.9 m	3.9 m

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

0.6.2 Passenger Carrying Capacity

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

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

Following train composition is recommended:

6-car Train: DMC + TC +MC + MC + MTC + DMC

Table below shows the carrying capacity of Medium Rail Vehicles.

Table 0.17 - Carrying Capacity of Medium Rail Vehicles

	Driving Motor car		Trailer car / Motor car		6 Car Train	
	Normal	**Crush**	**Normal**	**Crush**	**Normal**	**Crush**
Seated	43	43	50	50	286	286
Standing	102	204	110	220	644	1288
Total	145	247	160	270	930	1574

NORMAL-3 Person/sqm of standee area

CRUSH -6 Person/sqm of standee area

0.7 POWER SUPPLY ARRANGEMENTS

0.7.1 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 – 75KWh/1000 GTKM

(ii) Regeneration by rolling stock – 30%

(iii) Elevated station load – initially 200KW, which will increase to 500 KW in the year 2041.

(iv) Underground Station load – initially 2000 kW, which will increase to 2500 kW in the year 2041.

(v) Depot auxiliary load - initially 1500KW, which will increase to 2500 KW in the year 2041.

Keeping in view of the train operation plan and demand of auxiliary and traction power, power requirement projected for the year 2015, 2020, 2025, 2030 and 2041 respectively are summarized in **Table below:-**

Table 0.18 - Power Demand Estimation (MVA)

Corridor		Year 2015	2020	2025	2030	2041
Corridor – 1 North – South Corridor (CCS Airport - Indira Nagar - Munshi Pulia, 22.88 km with 19 elevated and 3 U/G stations)	Traction	7.27	10.97	13.98	19.46	23.78
	Auxiliary	13.96	16.68	18.16	24.09	24.09
	Total	**21.23**	**27.64**	**32.14**	**43.55**	**47.86**
Corridor – 2 East – West Corridor (Lucknow Railway Station to Vasantkunj, 11.10 km with 5 elevated and 7 U/G stations)	Traction	3.26	5.08	6.92	10.11	11.69
	Auxiliary	20.38	23.47	24.15	27.79	27.79
	Total	**23.64**	**28.55**	**31.07**	**37.90**	**39.48**

0.8 VENTILATION AND AIR-CONDITIONING SYSTEM (for lucknow metro underground corridor)

The Ventilation and Air-conditioning (VAC) system requirement for the underground sections of the proposed Lucknow Metro alignment includes the following:

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

0.8.1 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.

0.9 SIGNALLING

The signalling 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 an efficient train services on the network.

0.9.1 Standards

The following standards will be adopted with regard to the Signalling system.

Table 0.19

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.

Description	Standards
▪ 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.

0.10 TELECOMMUNICATIONS AND AUTOMATIC FARE COLLECTION SYSTEM

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.

0.10.1 Technology

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

Table 0.20

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.

System	Standards
• 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.

0.10.2 Automatic Fare Collection

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

0.10.3 Automatic fare collection systems have the following advantages:

1. Less number of staff required.
2. Less possibility of leakage of revenue due to automatic ticket check by control gates.
3. Recycling of ticket fraudulently by staff avoided.
4. Efficient and easy to operate, faster evacuation both in normal and emergency.
5. System is amenable for quick fare changes.

6. Management information reports generation easy.
7. System has multi-operator capabilities. Same Smart Card can be used for other applications also, including in other lines of the Metro.
8. AFC systems are the worldwide accepted systems for LRT/Metro environment.

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

0.10.4 Technology

The technology proposed for AFC systems are given in **Table below:-**

Table 0.21

Standards	Description
• Fare media	a) Contactless smart card – for multiple journeys. b) Smart Contactless Token – for Single Journeys.
• Gates	Computer controlled retractable flap type 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.

Standards	Description
• Ticket Reader (TR) 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 utilized

0.11 MAINTENANCE DEPOT

0.11.1 It is proposed to establish one depot- cum- workshop near Transport Nagar for North South Corridor and one depot- cum- workshop near Vasant kunj for East West Corridor with following functions:

a) Depot- cum- workshop near Transport Nagar for North South Corridor

(i) Major overhauls of all the trains of N-S corridor.

(ii) All minor schedules and repairs of N-S corridor.

(iii) Lifting for replacement of heavy equipment and testing thereafter of N-S corridor.

(iv) Repair of heavy equipments of N-S corridor.

b) Depot- cum- workshop near Vasant Kunj for East West Corridor

(i) Major overhauls of all the trains of East- West Corridor.

(ii) All minor schedules and repairs of East- West Corridor.

(iii) Lifting for replacement of heavy equipment and testing thereafter of East- West Corridor.

(iv) Repair of heavy equipments of East- West Corridor.

The Depot planning near Transport Nagar for North South Corridor and near Vasant Kunj for East West Corridor is based on following assumptions:

(i) Enough space should be available near Transport Nagar for North South Corridor and near vasant kunj for East West Corridor for establishment of a Depot- Cum- workshop

(ii) All inspection, workshop lines and stabling lines are designed to accommodate one trainset of 6- car.

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

(iv) Provision of transfer line from one corridor to another corridor.

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

- Layout of Stabling-shed, Inspection-shed, minor repairs and heavy repair overhauling workshop and cleaning of Rolling Stock.
- Operational and functional safety requirements.
- Ancillary buildings for other maintenance facilities.
- Electrical & Mechanical Services, power supply and distribution system.
- Water Supplies, Drainage & Sewerage.

0.12 ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

0.12.1 Environmental Impacts

Lucknow is the capital city of Uttar Pradesh, the most populous state of India. Lucknow had a population of 22.45 lakh in 2001 and 29.08 lakh in 2011. The Lucknow Metro is being proposed to strengthen public transport system in the city.

Any environment has a limited carrying capacity and it can only sustain negative impact up to a level without further degradation. But sensitive systems are not so resilient to cope up with changes in physical and natural environment, thus leading to negative impact and socio-economic losses. The railway development projects, like any other projects, have certain adverse, as well as, beneficial impacts on biophysical and social environment. Though railway projects do not come under the preview of environmental clearance from Ministry of Environment and Forest, Government of India, the Environmental Impact Assessment provides tools for decision-making, as well as, it also help in ensuring the sustainable development with least environmental damage by providing proper Environmental Management Plan.

0.12.2 Methodology

The EIA study comprises of the following stages.

Table 0.22

Stage 'A'	Determination of baseline conditions.
Stage 'B'	Assessing the impacts on the environment due to the construction and operation of the project and recommendations on preventive measures to be taken to minimize the impact on the environment to acceptable levels
Stage 'C'	Preparation of EIA document containing Environment Management Plan

0.13 COST ESTIMATES

0.13.1 North-South Corridor

The overall capital cost for Chaudhary Charan Singh Airport – Munshipulia Corridor at May 2013 price level, works out to Rs. 4992Crores excluding taxes and duties, but including general charges & design charges @ 7% on all items except land and 3% contingencies on all items. Estimated total taxes & duties are Rs. 729 Crore.

0.13.2 Charbagh Railway Station – Vasantkunj

The overall capital cost for Charbagh Railway Station – Vasantkunj Corridor at May 2013 price level, works out to Rs. 3723Crores excluding taxes and duties but including general charges & design charges @ 7% on all items except land and 3% contingencies on all items. Estimated total taxes & duties are Rs. 572Crore.

0.14 FINANCING OPTIONS, FARE STRUCTURE AND FINANCIAL VIABILITY

The Lucknow Metro Project is proposed to be constructed with an estimated cost of Rs 9786.00 Crore with central taxes and land cost. The length of the metro system and estimated cost at May-2013 price level without central taxes and with central taxes is placed in **Table below:**

Table 0.23 - Cost Details

Sr. No.	Name of Corridor	Distance (KMs)	Estimated cost without taxes (Rs/Crore)	Estimated cost with Central taxes & land cost (Rs/Crore)
1	N-S Corridor (CCS Airport-Munshi Pulia)	22.878	4,992.00	5,590.00
2	E-W Corridor (Charbagh-Vasant Kunj)	11.098	3,723.00	4,196.00

The estimated cost at May-2013 price level includes an amount of Rs.10.83 Crore as one-time charges of security personal towards cost of weapons, barricades, and hand held and door detector machine etc. However, the recurring cost towards salary and allowances of security personal have not taken in to account in FIRR calculation.

0.14.1 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 @7.5% PA. It has been assumed that UP State Government will exempt the local taxes or reimburse the same and provide the land worth Rs. 545.00 crore (without considering escalation) free of cost or it shall provide Interest Free SD.

It is assumed that the construction work will start on 01.01.2014 and 01.09.2014 respectively for N-S corridor & E-W corridor and is expected to be completed on 31.03.2018 and 31.03.2019 with Revenue Opening Date (ROD) as 01.04.2018 & 01.04.2019 respectively for the both the corridors. The total completion costs duly escalated and shown in the table 11.2 have been taken as the initial investment. The cash flow of investments separately is placed in **Table below:**

Table 0.24 - Year –wise Investment (Completion Cost)

Figures in Rs. Crore

Financial Year	Cost at May 2013 Price Level			Completion Cost		
	Corridor-I	Corridor-II	Total	Corridor-I	Corridor-II	Total
2013-14	179.00	0.00	179.00	179.00	0.00	179.00
2014-15	908.00	257.00	1165.00	967.00	272.00	1239.00
2015-16	1169.00	660.00	1829.00	1331.00	754.00	2085.00
2016-17	1563.00	860.00	2423.00	1942.00	1055.00	2997.00
2017-18	1042.00	1210.00	2252.00	1392.00	1616.00	3008.00
2018-19	521.00	806.00	1327.00	748.00	1157.00	1905.00
2019-20	208.00	242.00	450.00	321.00	373.00	694.00
2020-21	0.00	161.00	161.00	0.00	267.00	267.00
Total	**5590.00**	**4196.00**	**9786.00**	**6880.00**	**5494.00**	**12374.00**

0.14.2 Financial Internal Rate of Return (FIRR)

The Financial Internal Rate of Return (FIRR) obtained costs for 30 years business model including construction period is followings:-

Description	FIRR
With Property Development	8.12%
Without Property Development	4.43%

The various sensitivities with regard to increase/decrease in capital costs, O&M costs and revenues are placed in **Table below:**

Table 0.25 –FIRR (Combined) Sensitivity

Capital Cost with Central Taxes but without land cost			
10% increase in capital cost	**20% increase in capital cost**	**10% decrease in capital cost**	**20% decrease in capital cost**
7.25%	6.49%	9.15%	10.39%
REVENUE			
20% decrease in Fare Box revenue	**10% decrease in Fare Box revenue**	**10% increase in Fare Box revenue**	**20% increase in Fare Box revenue**
5.52%	6.91%	9.22%	10.21%

Capital Cost with Central Taxes but without land cost	
O&M COSTS	
10% increase in O&M cost	10% decrease in O&M cost
7.74%	8.50%

0.14.3 Financing Options

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

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

Rail based mass transit systems are characterised by heavy capital investments coupled with long gestation period leading to low financial rates of return although the economic benefits to the society are immense. Such systems generate externalities, which do not get captured in monetary terms and, therefore, do not flow back to the system. However, experience all over the world reveals that both construction and operations of metro are highly subsidised. Government involvement in the funding of metro systems is a foregone conclusion. Singapore had a 100% capital contribution from the government, Hong Kong 78% for the first three lines and 66% for the later 2 lines. The Phase-I, Phase-II as well as Phase-III of Delhi MRTS project, Chennai and Bengaluru metros are also funded with a mixture of equity and debt (ODA) by GOI & concerned state governments.

0.14.4 Alternative Models of Financing

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

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

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

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

Table 0.26 - Funding pattern under SPV model (with central taxes)

Particulars	With Taxes & Duties			
	Corridor-I	Corridor-II	Total	% of contribution
Equity By GOI	1003.00	786.50	1789.50	14.46%
Equity By GUP	1003.00	786.50	1789.50	14.46%
SD for CT by GUP (50%)	373.00	312.50	685.50	5.54%
SD for CT by GOI (50%)	373.00	312.50	685.50	5.54%
SD for Land by GUP (100%)	381.00	164.00	545.00	4.40%
Contribution of Local Bodies under 'Innovative Financing'	245.00	105.00	350.00	2.83%
1.40% JICA Loan /12% Market Borrowings	3502.00	3027.00	6529.00	52.77%
Total	**6880.00**	**5494.00**	**12374.00**	**100.00%**

In addition to the above, State Taxes of Rs.333.00 crore on completion cost basis has to be either reimbursed or exempted by state government.

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

The funding pattern assumed under this model excluding the cost of land is placed in Table below:

Table 0.27(a) Funding pattern under BOT –Combined (16% EIRR) (With central taxes, without land cost and without PD)

Particulars	With Taxes & Duties	
	Amount (Rs/Crore)	% Of contribution
VGF by GOI	2365.80	20.00%
VGF by GUP	5994.20	50.67%
Equity by Concessionaire	1156.00	9.77%
Concessionaire's debt @12% PA	2313.00	19.56%
Total	**11829.00**	**100.00**
Land Free by GUP	545.00	
IDC	126.00	
Total	**12500.00**	**100.00%**

Table 0.27(b) Funding pattern under BOT –Combined (16% EIRR) (With central taxes, without land cost and with PD)

Particulars	With Taxes & Duties	
	Amount (Rs/Crore)	% Of contribution
VGF by GOI	2365.80	20.00%
VGF by GUP	1634.20	13.82%
Equity by Concessionaire	2610.00	22.06%
Concessionaire's debt @12% PA	5219.00	44.12%
Total	**11829.00**	**100.00**
Land Free by GUP	545.00	
IDC	477.00	
Total	**12851.00**	**100.00%**

In addition to the above, State Taxes of Rs.333.00 crore on completion cost basis has to be either reimbursed or exempted by state government.

Recommendations:

The FIRR of Lucknow Metro Rail Project with property development is **8.12%** including central taxes. Therefore the corridors are recommended for implementation.

The total fund contribution of GOI & GOUP under various alternatives is given in **Table below:**

Table 0.28

Rs. in crore

Particulars	SPV Model	BOT Model without PD	BOT Model with PD
GOI	2475.00	2365.80	2365.80
GOUP	3020.00	6539.20	2179.20
Total	**5495.00**	**8905.00**	**4545.00**

In addition to the above, State Taxes of Rs.333.00 crore on completion cost basis has to be either reimbursed or exempted by state government.

The funding pattern assumed under SPV model and BOT model with PD is depicted in the pie chart i.e., Figure 0.3 and 0.4 as under: -

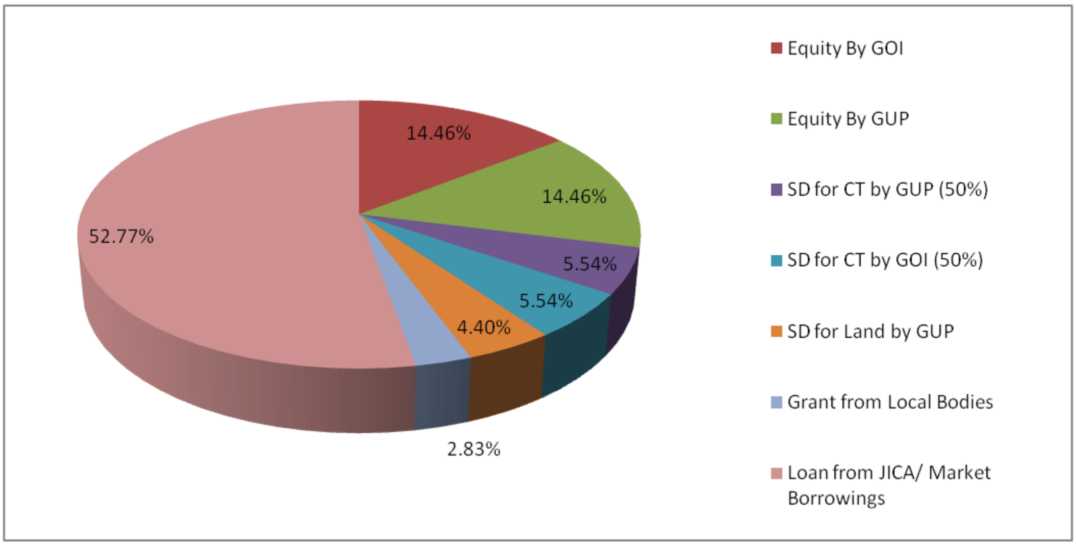


Figure 0.3 - Funding pattern under SPV Model

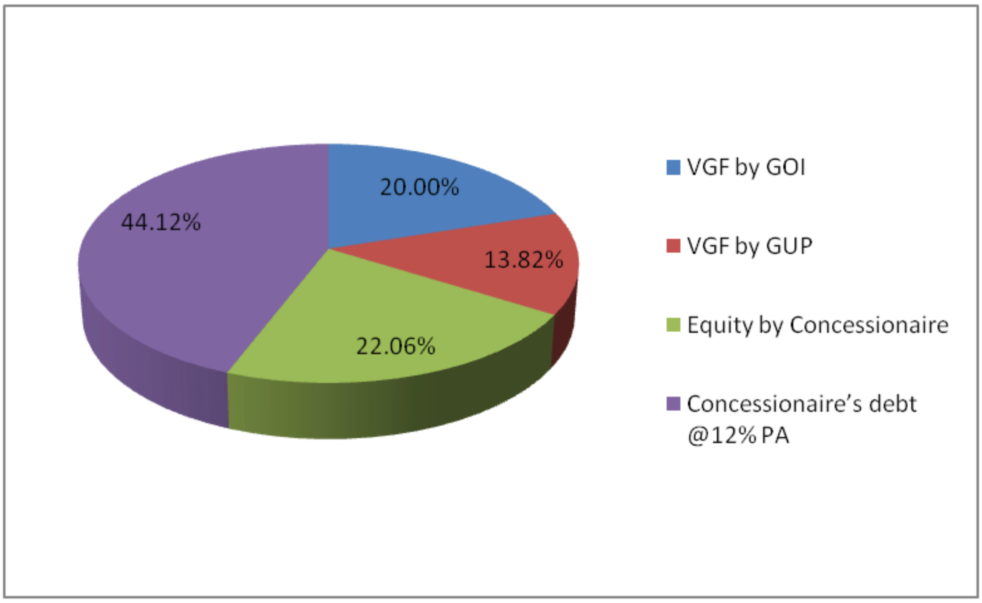


Figure 0.4Funding pattern under BOT Model with PD

0.15 ECONOMIC ANALYSIS

The sources from where economic savings occur are identified first. Although there are many kinds of primary, secondary and tertiary benefits, only the quantifiable components can be taken to measure the benefits. These components are quantified by linking with the number of passengers shifted and the passenger km saved by the trips which are shifted from road/rail based modes to metro. It may be observed that first four benefit components given in **Table 0.29** are direct benefits due to shifting of trips to metro, but other benefit components are due to decongestion effect on the road. Benefit components were first estimated applying market values then were converted into respective Economic values by using separate economic factors which are also given in table 0.29. Depending upon methodology of estimation, economic factors are assumed. Overall economic value of benefit components is 90% of the market value. Similarly economic value of the cost components are 80% of the market cost.

Table 0.29 - Benefit Components due to Metro

S. No.	Benefit Components	Economic Factors
1	Construction Cost	80%
2	Maintenance Cost	80%
3	Annual Time Cost Saved by Metro Passengers	100%

4	Annual Fuel Cost Saved by Metro Passengers	80%
5	Annual Vehicle Operating Cost Saved saved by Metro Passengers	80%
6	Emission Saving Cost	100%
7	Accident Cost	100%
8	Annual Time Cost Saved by Road Passengers	100%

0.16 IMPLEMENTATION PLAN

On receipt of the Detailed Project Report, following action will be required for implementing the Lucknow Metro:

- Approval to the Detailed Project Report to be taken from Uttar Pradesh State Government (Cabinet approval).
- The DPR to be forwarded to the Ministry of Urban Development(GOI), Planning Commission and Finance Ministry with the request for approving the Metro project and for financial participation through equity contribution in the SPV.
- Signing of an MOU between Uttar Pradesh 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.
- Lucknow Metro Rail Corporation Ltd, the Special Purpose Vehicle (SPV) set up for implementing the project and for its subsequent Operation & Maintenance should be made functional early.
- The Metro Railways (Amendment) Act-2009 can readily be made use of for implementation of Lucknow Metro by declaring Lucknow City as Metropolitan Area in terms of clause c of section 243 P of Constitution.
- Request to GOI for a notification for making the Metro Railways (Amendment)) Act 2009 applicable to Lucknow Metro.

- The State Government should formulate the funding plan for executing this project and get the same approved by the Government of India. The loan portion of the funding will have to be tied up by State Government in consultation with the Government of India.

- The Government should freeze all developments along the corridors suggested. For any constructions within 50 m. of the proposed alignment a system of No Objection Certificate should be introduced so that infructuous expenditure at a later stage is avoided.

- The Metro Railways (Amendment) Act-2009 can readily be made use of for implementation of Lucknow Metro by declaring Lucknow City as Metropolitan Area.

0.16.1 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. Uttar pradesh government has to register lucknow metro rail corporation ltd (lmrc) for lucknow metro under the companies act, 1956. This spv shall be 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 lmrc 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 lmrc 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. The managing director should be a technocrat of proven record and impeccable integrity. A railway background would be an added advantage. A metro background would be most desirable.

0.16.2 IMPLEMENTATION ON DELHI METRO MODEL

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

Government of Uttar Pradesh in its decision on taken on 14/06/2013 intends to implement Phase – 1 of the Lucknow Metro Rail Project in two stages; North South Corridor in first stage (Phase 1 A) and East West Corridor in second stage (Phase 1 B). A suggested project implementation schedule is given below.

The proposed date of commissioning of the both corridor with suggested dates of important milestones is given in **Tables below:**

Table 0.30 - Implementation Schedule through DMRC model

Phase 1A – North south Corridor

S. No.	Item of Work	Completion Date
1	Submission of Final DPR to State Govt.	25.07.2013
2	Approval of DPR by State Government	31.07.2013
3	Submission of DPR for Approval of Ministry of Urban Development (MoUD).	15.08.2013
4	Appoint interim Consultant for preliminary works	15.09.2013
5	Approval of Project by Empowered Committee	30.09.2013
6	Sanction of Project by EGOM.	01.10.2013
7	Appoint General Consultant	01.01.2014
8	Tendering, Execution of works and Procurement of equipments, coaches and installations	01.01.2014 - 31.12.2017
9	Testing and Commissioning	01.01.2018 – 31.03.2018
10	Revenue Operation	01.04.2018

Table 0.31 - Implementation Schedule through DMRC model

Phase 1B – East west Corridor

S. No.	Item of Work	Completion Date
1	Submission of Final DPR to State Govt.	25.07.2013
2	Approval of DPR by State Government	31.03.2014
3	Submission of DPR for Approval of Ministry of Urban Development (MoUD).	30.04.2014
4	Appoint interim Consultant for preliminary works	31.05.2014
5	Approval of Project by Empowered Committee	15.06.2014
6	Sanction of Project by EGOM.	15.07.2014

S. No.	Item of Work	Completion Date
7	Appoint General Consultant	31.08.2014
8	Tendering, Execution of works and Procurement of equipments, coaches and installations	01.09.2014 - 31.12.2018
9	Testing and Commissioning	01.01.2019 – 31.03.2019
10	Revenue Operation	01.04.2019

Both corridors can be divided into sections for the purpose of commercial opening in stages.

0.17 CONCLUSIONS AND RECOMMENDATIONS

0.17.1 Lucknow has witnessed enormous growth during the last 10 years. The growth is mainly the result of immigration as the city provided better employment opportunities. Lucknow is the principal administrative, commercial and distribution center of the State. Lucknow is fast developing as educational hub of Uttar Pradesh. Rapid urbanization in the recent past has put the city's travel infrastructure to stress. Being thickly populated area, Lucknow's traffic needs cannot be met by only road-based system.

0.17.2 The existing urban transport system of Lucknow 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. 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.

0.17.3 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) Amausi to Munshi Pulia Corridor (22.878 km) and (ii) Lucknow Railway Station to Vasant Kunj Corridor on Hardoi Road (11.098 km) at an estimated completion cost of **Rs. 6880.00Crores** and **Rs.5494.00Crores** respectively(with Central taxes & duties) to be made operational as recommended in implementation chapter.

0.17.4 After examining the various options for execution of Lucknow Metro Project, it has been recommended that the project should be got executed through a SPV on DMRC funding pattern.

0.17.5 A PSU of the State Government, Lucknow Metro Rail Corporation Ltd. (LMRC) for Lucknow Metro, to be set up under the Companies Act, 1956 should be made functional by posting Managing Director and Functional Directors.

0.17.6 Delhi Metro Rail Corporation can also be considered straightaway for being appointed as General Consultant to LMRC which will reduce the construction time by 4 to 6 months.

Chapter 1

Introduction

CHAPTER - 1

INTRODUCTION

1.1. BACKGROUND

Economic growth and spatial development are quite often governed by the quality and quantity of infrastructure provided. While an inadequate transport facilities causes congestion, delays and hazards result in significant socio – economic costs to the society. An oversupply, apart from being uneconomical, often acts as counter to the long term spatial development strategies of settlements and regions. Supplying and maintaining an optimal level of infrastructure is the key to planned development. India is passing a stage where urbanization is taking place at an increasing rate. With rapid urbanization, there has been a widening gap between demand and supply of urban infrastructure of which transportation is an essential component.

Lucknow is popularly known for its cultural and intellectual traditions as well as, its current status as a nucleus of service industry, education & research. Lucknow is the capital of Uttar Pradesh & administrative headquarters of Lucknow district & division. With its 2.2 (COI, 2001 Estimates) million inhabitants Lucknow Urban Agglomeration has currently over 3 million population. The master plan has projected a population of about 3.2 million and 4.0 million by years 2011 & 2021 respectively. Being an important cultural and trading centre Lucknow continues to grow and attract large number of people to the city. The rapid growth of the city and the associated urban sprawl has accentuated the demand supply mismatch amidst the constrained transport infrastructure resulting in economic and social externalities. Lucknow must keep pace with the demographic and economic growth. The inadequate commuter transportation system in Lucknow is overwhelmed by upsurge of private automobiles. Private vehicles (motorised 2-wheelers and cars) constitute 90 percent of total vehicles registered in Lucknow City. The supply of city buses being only 6 per lakh population is inadequate for a city's size like Lucknow. The benchmark is between 70 to 80 buses per lakh residents in an urban area in India.

One of the key issues to be tackled is to improvise on a reliable public transport system; above all, lay emphasis on a mass transportation system which is environmental friendly to cater to city's growing travelling needs to sustain in the growing economic activities. India being in the process of economic reforms and that such mass transport systems will involve heavy investments.

Against this backdrop of increasing number of vehicles on road and concomitant congestion and air pollution, the Lucknow Development Authority commissioned DMRC to prepare Detailed Project Report for a Mass Rapid Transit System (MRTS) for Lucknow City to serve forecast travel up to the horizon year 2030.

1.2. SCOPE & OBJECTIVE OF THE STUDY

Uttar Pradesh being the most populous state in India, demand for mobility in the state has been increasing very fast with the rapidly changing socio-economic environment. Lucknow, the capital city of the state of Uttar Pradesh, being the administrative centre has undergone considerable growth in various development related activities and functions. With the increasing number of industries located in and around the city, has led to considerable increase in transport demand. The city is experiencing heavy congestion, delay and vehicular pollution because of the inadequate transport infrastructure. The low share of modal split in favour of public transport emphasizes the urgent need for reviewing the existing public transport system and plan for a suitable system to meet the future demand. In order to increase the share of public transport the strategic plan should be to improve the public transport system and examine the feasibility of introducing mass transit system in a phased programme.

The Government of Uttar Pradesh is seized of the matter and desired to carry out a study of Mass Transport System for the city of Lucknow to enable smooth dispersal of intra-city traffic.

Government of Uttar Pradesh have commissioned Delhi Metro Rail Corporation (DMRC) for undertaking Detailed Project Report for MRT System in Lucknow.

The objective and scope of services are outlined below:

i) Traffic and Transportation surveys for estimation of transport demand and projection of sectional and station traffic loads for various horizon years

ii) Field surveys and preparation of topographical survey plans for route alignments and assessments of land requirements for facilities like station areas, electric sub-stations (TSS & RSS), maintenance and construction depots

iii) Field surveys for identification of major above ground utilities along the proposed metro corridors requiring diversion / relocation. Details of underground utilities shall be supplied by state government through the concerned utilities agencies

iv) Geometric design of the route alignments covering horizontal as well as vertical profiles

v) Location of stations and general layout plans for stations and integration area

vi) EIA study and preparation and preparation of EMP for negative impacts, if any

vii) Geotechnical investigations along the identified corridors

viii) Technology selection – broad details of traction and signalling system, rolling stock and track etc.

ix) Conceptual Plan for the rolling stock maintenance depots.

x) Implementation schedule

xi) Estimation of construction costs and operating costs and maintenance expenses

xii) Study on the fare structure

xiii) Financial and economic analysis

xiv) Evolving a Funding Plan and Institutional Arrangement for the Project

xv) Preparation and submission of DPR.

1.3. STUDY AREA

The geographic area within the jurisdiction of Lucknow Development Authority (LDA) will be the Study Area (**Figure 1.1**) for the current Study.

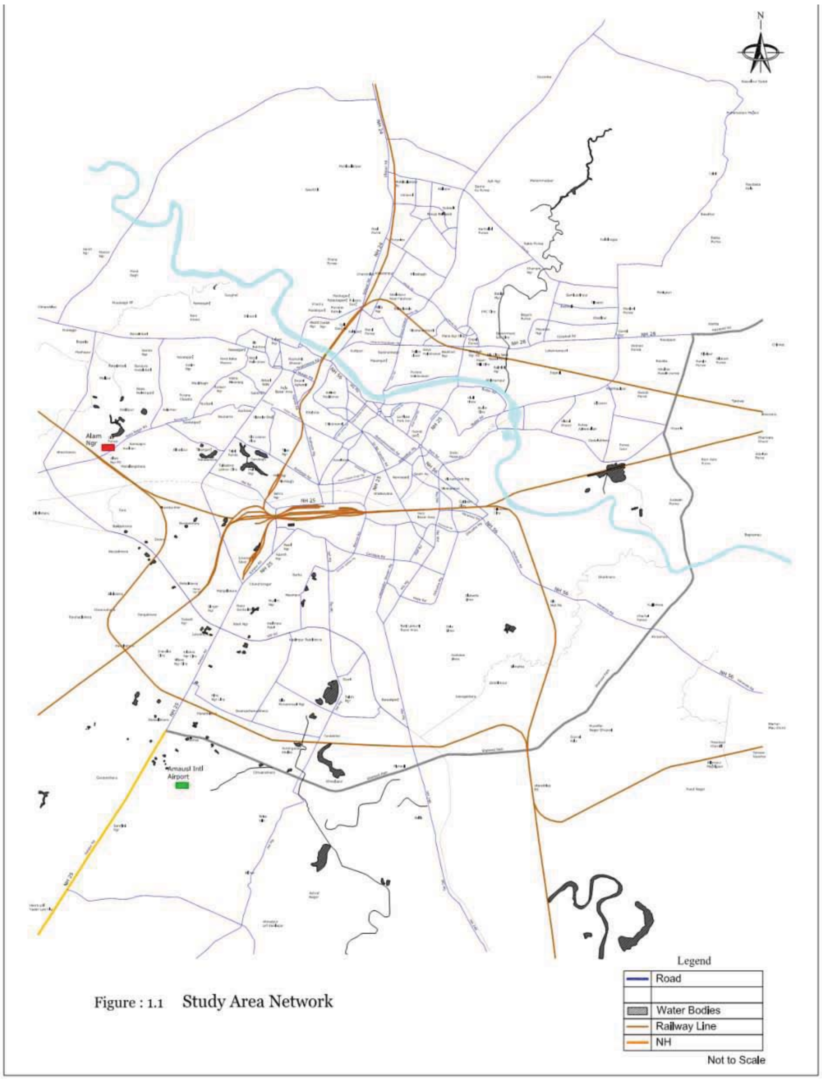


Figure : 1.1 Study Area Network

Fig. 1.1 Study Area

1.4. EARLIER STUDIES AND EFFORTS

Major traffic and transportation studies, conducted in the city of Lucknow have been reviewed and are summarised below.

1.4.1. Lucknow Area Transportation Studies

In 1988, the School of Planning and Architecture, New Delhi completed the report on Lucknow Transport System Plan-2001. In this study existing traffic and travel characteristics had been reviewed and land use-transport model was developed to evaluate alternate policies, strategies and plans for Lucknow city. An important recommendation of the study was a medium capacity Light Rail Transport System to cater to future mass transport needs of the city. The study recommended two corridors of LRT-North-South Corridor (9.6 km) and East West Corridor (13.6 km) with a total length of 23.2 km. The study also recommended that the possible extension of LRT network to cover other major travel demand corridors may be studied as a part of feasibility studies of LRT system. Considering the configurations of existing intercity railway lines, the study concluded their role in meeting intra-city travel demand is very limited in the next 10-15 years.

1.4.2. Comprehensive Traffic and Transportation Studies for Lucknow

The National Transportation Planning and Research Centre (NATPAC) was commissioned in 1994 for preparation CTTS. The broad objective of the study involved short term, medium term and long term solutions and policy guidelines for improving the overall transportation system. The study emphasized that the transport demand and the rate of growth of traffic would get reduced significantly on city roads when the new residential development takes place in the periphery of the city and work and commercial centres are decentralized. The study indicated that a balanced and integrated urban transport system can be achieved by increasing the share of mass transport modes i.e., targeting buses/LRT.

1.4.3. Transport Plan for Lucknow City

The Central Institute of Road Transport (CIRT) had done this study in the year 1994. The main objective of the study was to identify the problems of transport and circulation and to arrive at solutions which are within the economic research of the authorities. The study emphasized that Lucknow city is unable to cope with the rapid increase of population due to large scale immigration from its hinterland and the consequent demand on transport facilities. The road network presents an alarming deterioration caused by encroachments, on street parking and intermixing of slow and fast modes of transport.

This study recommended the development of roads, management of traffic and identification of traffic improvement schemes. The study focused on various modes of transportation, their contribution to mobility and their relative emphasis needed to make circulation faster and easier. No primary survey was done in this study and the study was totally based on secondary data.

1.4.4. Physical and Financial Plan for Lucknow Metropolis - 2015

The Physical and Financial plan for Lucknow-2015 was entrusted to RITES by Lucknow Development Authority. The study consolidated various proposals regarding traffic and transportation studies and suggested a transport sector plan which included road development, traffic management, parking measures, bus system, improvements in passenger and goods terminals. The study also stressed on the need of a Light Rail Transit System on the lines of the SPA study.

1.4.5. Conclusions

Review of the various studies conducted so far conducted in the city of Lucknow has established that there is a need for a mass transport system to cater to future transport demand and achieve sustainability for mobility of transport.

1.4.6. Benefits of Mass Transport System

The main benefits addressed by mass transport are the mobility and freedom. The sustainability of mass transport has greater potential and major benefits occur through immediate means of helping the environment and conserving energy. In developing countries, like India, benefit through mass transit systems extend to urban poor with affordable fare structure when compared with costs incurred by private transportation on fuels, parking, congestion etc. The supply of planned and integrated mass public transport is the only way to relieve traffic congestion and reduce hours of delay on major travel corridors in Lucknow. Moreover, supply MRTS in Lucknow will mean a lot in terms of sustainable means of transport that meets the mobility and accessibility needs of people – a need of the hour in the Country and Uttar Pradesh.

1.4.7. Metro System World wide

Metro system is used in metropolitan areas to transport large number of people at high frequency. Rapid transit evolved from railways during the late 19th Century. The first system opened was the Metropolitan Railway (London) which connected most of the main railway termini around the city. The technology swiftly spread to other cities in Europe and then to United States and other parts of the world. At present, more than 160 cities have built rapid transit systems, and about twenty five have new systems under construction. The system is seen as an alternative to an extensive road transport system with many motorways. The capital cost is high, with public financing normally required.

India is experiencing a rapid growth in both population and rate of urbanisation. Travel demand is increasing by 5% annually on average, leading to sharp increase in personal vehicles and overwhelming the limited transport infrastructure. A need was therefore felt to develop mass rapid transit systems in metro cities of India to reduce the burden on normal railways as well as road transport service providers. Major cities were facing a situation of rising population and increasing vehicles which had led to problems like congestion and pollution. To overcome these problems, Indian Railways took an initiative towards development of urban mass transit system by starting metro rail.

Metro rail systems are operational in Delhi & Kolkata and the projects are taken in various cities like Bangalore, Mumbai, Chennai, Hyderabad, Jaipur, Kolkata.

A summary of metro network developed worldwide is given below in **Table 1.1**.

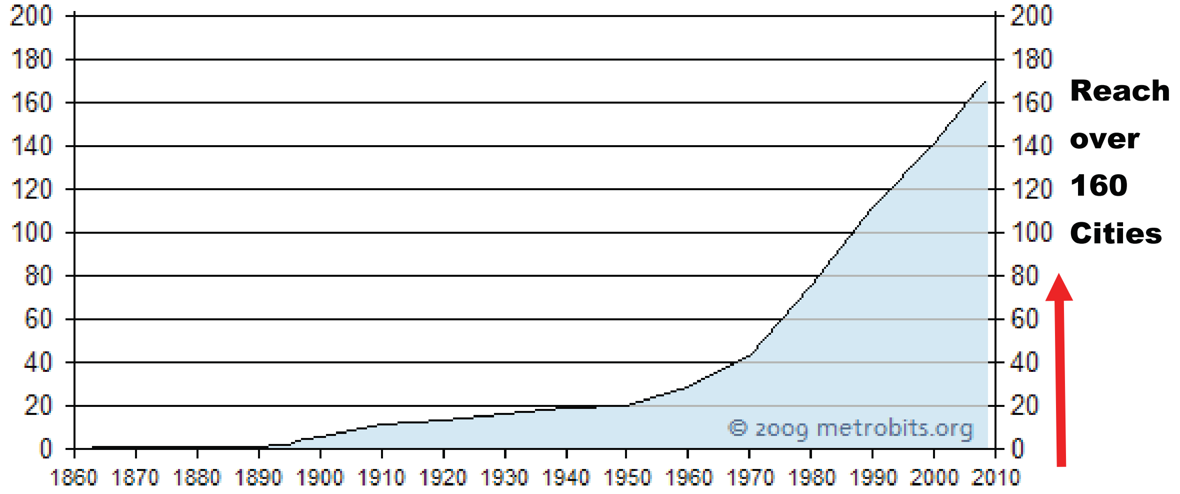
Table 1.1 SPREAD OF WORLD METRO RAIL SYSTEMS

City	Country	Continent	Commencement	Network Length (km)	Daily Ridership (million)
Adana	Turkey	Asia	18-Mar-09	13.5	
Amsterdam	Netherlands	Europe	16-Oct-77	32.7	0.233
Ankara	Turkey	Asia	30-Aug-96	23.1	0.31
Antwerp	Belgium	Europe	25-Mar-75	7.6	
Athens	Greece	Europe	1954	52.0	0.937
Atlanta	USA	America	30-Jun-79	79.2	0.0932
Baku	Azerbaijan	Asia	6-Nov-67	32.9	0.482
Baltimore	USA	America	21-Nov-83	24.5	0.0356
Bangkok	Thailand	Asia	5-Dec-99	74.9	0.564
Barcelona	Spain	Europe	30-Dec-24	119.4	1.1
Beijing	China	Asia	1-Oct-69	337.0	3.99
Belo Horizonte	Brazil	America	1-Aug-86	28.1	
Berlin	Germany	Europe	18-Feb-02	147.4	1.39
Bielefeld	Germany	Europe	21-Sep-71	5.2	
Bilbao	Spain	Europe	11-Nov-95	40.6	0.238
Bochum	Germany	Europe	26-May-79	21.5	
Bonn	Germany	Europe	22-Mar-75	9.0	
Boston	USA	America	1 Sep 1897	60.5	0.4
Brasilia	Brazil	America	31-Mar-01	42.0	0.0438
Brussels	Belgium	Europe	20-Sep-76	32.2	0.364
Bucharest	Romania	Europe	16-Nov-79	67.7	0.304
Budapest	Hungary	Europe	2 May 1896	33.0	0.814
Buenos Aires	Argentina	America	1-Dec-13	48.1	0.789
Buffalo	USA	America	18-May-85	8.4	
Bursa	Turkey	Asia	19-Aug-02	25.4	
Busan	South Korea	Asia	19-Jul-85	95.0	0.704
Cairo	Egypt	Africa	27-Sep-87	65.5	1.92
Caracas	Venezuela	America	27-Mar-83	60.5	1.25
Catania	Italy	Europe	27-Jun-99	3.8	
Changchun	China	Asia	Oct-02	17.0	
Charleroi	Belgium	Europe	21-Jun-76	17.5	
Chengdu	China	Asia	27-Sep-10	18.5	
Chennai	India	Asia	19-Oct-97	27.0	
Chiba	Japan	Asia	28-Mar-88	15.5	
Chicago	USA	America	6 Jun 1892	166.0	0.542
Chongqing	China	Asia	18-Jun-05	19.5	
Cleveland	USA	America	15-Mar-55	31.0	0.0137
Cologne	Germany	Europe	11-Oct-68	45.0	
Copenhagen	Denmark	Europe	19-Oct-02	21.0	0.126
Daegu	South Korea	Asia	26-Nov-97	53.9	0.301
Daejeon	South Korea	Asia	16-Mar-06	22.6	0.0795
Dalian	China	Asia	1-May-03	49.0	
Delhi	India	Asia	24-Dec-02	328.5	2.3
Detroit	USA	America	Jul-87	4.8	
Dnepropetrovsk	Ukraine	Europe	29-Dec-95	7.1	0.0384
Dortmund	Germany	Europe	17-May-76	29.5	

City	Country	Continent	Commencement	Network Length (km)	Daily Ridership (million)
Dubai	United Arab Emirates	Asia	9-Sep-09	52.1	
Duesseldorf	Germany	Europe	4-Oct-81	9.6	
Duisburg	Germany	Europe	11-Jul-92	14.3	
Edmonton	Canada	America	22-Apr-78	20.4	
Essen	Germany	Europe	5-Oct-67	20.2	
Frankfurt	Germany	Europe	4-Oct-68	20.5	
Fukuoka	Japan	Asia	26-Jul-81	29.8	0.34
Gelsenkirchen	Germany	Europe	1-Sep-84	5.5	
Genoa	Italy	Europe	13-Jun-90	5.2	
Glasgow	United Kingdom	Europe	14 Dec 1896	10.4	0.0411
Guadalajara	Mexico	America	1-Sep-89	24.0	
Guangzhou	China	Asia	28-Jun-99	231.9	1.85
Gwangju	South Korea	Asia	28-Apr-04	20.1	0.0466
Haifa	Israel	Asia	1959	1.8	
Hamburg	Germany	Europe	1-Mar-12	100.7	0.518
Hanover	Germany	Europe	28-Sep-75	18.6	
Helsinki	Finland	Europe	3-Aug-82	21.0	0.156
Hiroshima	Japan	Asia	20-Aug-94	18.4	0.0493
Hong Kong	China	Asia	1-Oct-79	188.1	3.62
Incheon	South Korea	Asia	6-Oct-99	29.5	0.2
Istanbul	Turkey	Europe	16-Sep-00	16.9	0.186
Izmir	Turkey	Asia	22-May-00	11.5	0.0822
Jacksonville	USA	America	30-May-89	6.9	
Kamakura	Japan	Asia	3-Mar-70	6.6	
Kaohsiung	Taiwan	Asia	9-Mar-08	42.7	0.0822
Kazan	Russia	Europe	27-Aug-05	10.9	0.0192
Kharkov	Ukraine	Europe	23-Aug-75	37.4	0.762
Kiev	Ukraine	Europe	22-Oct-60	63.7	1.76
Kitakyushu	Japan	Asia	9-Jan-85	8.8	
Kobe	Japan	Asia	13-Mar-77	30.6	0.332
Kolkata	India	Asia	24-Oct-84	22.6	0.474
Kryvyi Rih	Ukraine	Europe	26-Dec-86	18.0	
Kuala Lumpur	Malaysia	Asia	16-Dec-96	64.0	0.299
Kyoto	Japan	Asia	1-Apr-81	31.3	0.345
Las Vegas	USA	America	15-Jul-04	6.2	
Lausanne	Switzerland	Europe	24-May-91	13.7	
Lille	France	Europe	25-Apr-83	45.5	0.203
Lima	Peru	America	13-Jan-03	10.0	
Lisbon	Portugal	Europe	29-Dec-59	41.0	0.488
London	United Kingdom	Europe	10 Jan 1863	408.0	2.99
Los Angeles	USA	America	30-Jan-93	59.3	0.129
Ludwigshafen	Germany	Europe	29-May-69	4.0	
Lyon	France	Europe	28-Apr-78	30.7	0.499
Madrid	Spain	Europe	17-Oct-19	286.3	1.78
Manila	Philippines	Asia	1-Dec-84	51.5	0.948
Maracaibo	Venezuela	America	8-Jun-09	6.5	
Marseille	France	Europe	26-Nov-77	21.8	0.159
Mecca	Saudi Arabia	Asia	13-Nov-10	18.1	
Medellin	Colombia	America	30-Nov-95	28.8	0.425
Mexico City	Mexico	America	5-Sep-69	201.7	3.88
Miami	USA	America	21-May-84	36.0	0.0493
Milan	Italy	Europe	1-Nov-64	79.4	0.899

City	Country	Continent	Commencement	Network Length (km)	Daily Ridership (million)
Minsk	Belarus	Europe	26-Jun-84	30.3	0.718
Monterrey	Mexico	America	25-Apr-91	31.5	
Montreal	Canada	America	14-Oct-66	69.2	0.6
Moscow	Russia	Europe	15-May-35	302.0	6.55
Mulheim	Germany	Europe	3-Nov-79	9.0	
Mumbai	India	Asia		171.0	
Munich	Germany	Europe	19-Oct-71	94.2	0.962
Nagoya	Japan	Asia	15-Nov-57	89.0	1.17
Naha	Japan	Asia	10-Aug-03	12.8	
Nanjing	China	Asia	27-Aug-05	84.7	0.4
Naples	Italy	Europe	28-Mar-93	31.8	0.0795
New York	USA	America	27-Oct-04	368.0	4.33
Newark	USA	America	26-May-35	2.2	
Newcastle	United Kingdom	Europe	7-Aug-80	76.5	0.104
Nizhny Novgorod	Russia	Europe	20-Nov-85	15.5	0.0904
Novosibirsk	Russia	Asia	7-Jan-86	16.4	0.192
Nuremberg	Germany	Europe	1-Mar-72	34.6	0.315
Oporto	Portugal	Europe	7-Dec-02	21.7	
Osaka	Japan	Asia	20-May-33	137.8	2.36
Oslo	Norway	Europe	22-May-66	62.0	0.214
Palma de Mallorca	Spain	Europe	25-Apr-07	8.3	
Paris	France	Europe	19-Jul-00	213.0	4.05
Perugia	Italy	Europe	29-Jan-08	3.0	
Philadelphia	USA	America	4-Mar-07	62.0	0.192
Pittsburgh	USA	America	3-Jul-85	2.9	
Porto Alegre	Brazil	America	2-Mar-85	33.8	
Poznan	Poland	Europe	1-Mar-97	6.1	
Prague	Czech Republic	Europe	9-May-74	59.1	1.6
Pyongyang	North Korea	Asia	6-Sep-73	22.5	0.0959
Recife	Brazil	America	11-Mar-85	39.7	
Rennes	France	Europe	16-Mar-02	9.0	0.063
Rio de Janeiro	Brazil	America	5-Mar-79	42.0	0.37
Rome	Italy	Europe	10-Feb-55	39.0	0.907
Rotterdam	Netherlands	Europe	10-Feb-68	47.0	0.238
Rouen	France	Europe	17-Dec-94	2.2	
Saint Louis	USA	America	31-Jul-93	73.4	
Saint Petersburg	Russia	Europe	15-Nov-55	110.2	2.25
Samara	Russia	Europe	26-Dec-87	10.2	0.0329
San Francisco	USA	America	11-Sep-72	166.9	0.293
San Juan	Puerto Rico	America	6-Jun-05	17.2	0.0247
Santiago	Chile	America	15-Sep-75	102.4	1.67
Santo Domingo	Dominican Republic	America	30-Jan-09	14.5	0.2
Sao Paulo	Brazil	America	14-Sep-74	69.7	1.93
Sapporo	Japan	Asia	16-Dec-71	48.0	0.573
Seattle	USA	America	18-Jul-09	22.2	
Sendai	Japan	Asia	15-Jul-87	14.8	0.159
Seoul	South Korea	Asia	15-Aug-74	286.9	5.61
Seville	Spain	Europe	2-Apr-09	18.0	
Shanghai	China	Asia	10-Apr-95	423.0	3.56
Shenyang	China	Asia	27-Sep-10	27.8	
Shenzhen	China	Asia	28-Dec-04	69.1	0.362

City	Country	Continent	Commencement	Network Length (km)	Daily Ridership (million)
Singapore	Singapore	Asia	7-Nov-87	129.7	1.81
Sofia	Bulgaria	Europe	28-Jan-98	18.0	0.0795
Stockholm	Sweden	Europe	1-Oct-50	105.7	0.841
Stuttgart	Germany	Europe	10-Jun-66	24.0	
Sydney	Australia	Oceania	1926	22.1	
Taipei	Taiwan	Asia	28-Mar-96	100.8	1.27
Tama	Japan	Asia	27-Nov-98	16.0	
Tashkent	Uzbekistan	Asia	6-Nov-77	36.2	0.195
Tbilisi	Georgia	Asia	11-Jan-66	26.3	0.252
Tehran	Iran	Asia	21-Feb-00	66.0	1.26
The Hague	Netherlands	Europe	16-Oct-04	27.9	
Tianjin	China	Asia	28-Mar-04	72.0	0.0411
Tokyo	Japan	Asia	30-Dec-27	304.5	8.7
Toronto	Canada	America	30-Apr-54	71.3	0.762
Toulouse	France	Europe	26-Jun-93	27.5	0.115
Turin	Italy	Europe	4-Feb-06	9.6	
Valencia	Venezuela	America	18-Oct-06	6.2	0.0493
Valencia	Spain	Europe	3-Oct-88	31.8	
Valparaiso	Chile	America	23-Nov-05	43.0	
Vancouver	Canada	America	3-Jan-86	69.5	0.203
Vienna	Austria	Europe	25-Feb-78	74.6	1.4
Volgograd	Russia	Europe	5-Nov-84	3.3	
Warsaw	Poland	Europe	7-Apr-95	22.6	0.345
Washington	USA	America	27-Mar-76	171.2	0.611
Wuhan	China	Asia	28-Sep-04	28.0	0.0356
Wuppertal	Germany	Europe	1-Mar-01	13.3	
Yekaterinburg	Russia	Asia	26-Apr-91	8.5	0.126
Yerevan	Armenia	Asia	7-Mar-81	12.1	0.0466



WORLD METRO GRAPH

Famous Metro Systems

London

Meddellin

Taipei

Paris

Delhi

Kolkata

1.5. STUDY AREA PROFILE

1.5.1. Introduction

Lucknow is the capital of Uttar Pradesh and is situated about 500km southeast of New Delhi. The city lies at an average altitude of 110 meters above mean sea level and generally slopes to the east. The most densely populated areas of the city are on the southern bank of river Gomti and several planned residential colonies are developed to the northern side of the river.

1.5.2. Demographic and Social Profile

Lucknow Urban Agglomeration (LUA) became a million plus city in 1981. As per 2001 census the population of Lucknow Urban Agglomeration is 22.46 lakh. The population of Lucknow grew more than the other cities mainly due to the extension of the jurisdiction of Lucknow Municipal Corporation from 14,594 hectares in 1981 to 33,750 hectares in 1991. Projecting the past trends, Lucknow Urban Agglomeration is expected to have population of about 32, 26,000 in 2011 and 45, 00,000 in 2021.The growth has been projected based on Master Plan 2021 land use in peripheral areas. The growth of population Lucknow city is shown in **Figure 1.2.**

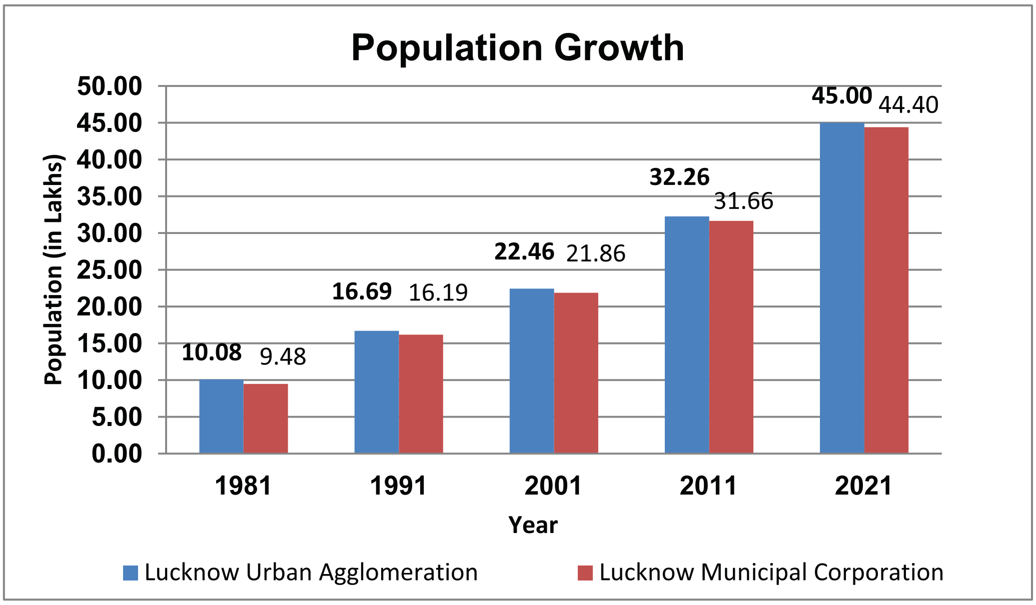


Figure 1.2 POPULATION GROWTH IN LUCKNOW CITY

1.5.3. Economic Profile

The major industries in and around Lucknow includes aeronautics, machine tools, distillery chemicals, furniture and chikan embroidery. It is also a major centre for research & development and an education centre. The city is a prominent administrative and commercial centre of the State. The workers population in the city is around 28%. The tertiary sector has seen a rise in terms of share of workforce i.e. it accounted for about 80% of workforce in 2001 as compared to 77% in 1981. In recent years there has been a noticeable rise in retail trade and health services. The Master Plan 2021 envisages that the proportion of tertiary workers in Urban Agglomeration Area will not change significantly in 2011 & 2021, there will be a decrease in the proportion of primary workers and a relative rise in secondary workers.

1.5.4. Traffic & Transportation Scenario

Lucknow over the last few years has been growing with a spread of around 25 km radius. The major traffic attracting zones i.e. offices and commercial complexes are located in the central part of the city thereby congesting the central area. The growth of city in recent years has resulted in increased transport demand and motorized vehicles. However transport infrastructure in the city has not grown correspondingly and is inadequate to accommodate the traffic. The registered vehicles have grown at a rate of 40,000 vehicles per year in the past decade. The roads and parking spaces in the city have become extremely congested, especially during peak hours. The share of personalized modes has been increasing continuously due to inadequate supply of Public Transport along with its inadequate level of service.

At present the public bus transportation in the city operates with a fleet of 104 buses. The available multiple modes of public transport in the city are taxis, city buses, cycle rickshaws, auto rickshaws. As per 2021 Master Plan it is estimated that around 13.5 lakh residents will need public transport daily. Given the number of buses and the constraints of road network, it seems that it will not be possible to meet the travel demand through the current fleet of public buses or private taxis and three wheelers.

The major traffic generating areas in Lucknow are Railway Station, Charbagh Bus Stand, Vidhan Sabha, Secretariat and the commercial areas in the central part of the city. Also with the absence of proper public transport system, many personalized modes have emerged in the city. Hence it was decided to plan for suitable mass transportation system to cater the future demand.

1.5.5. Key Issues of Urban Transport in Lucknow

- Heavily congested narrow roads with mixed traffic conditions and frequent traffic jams at intersections.
- Very high parking demand due to propagation of personalized vehicles
- Rapid development of the peripheral areas has increased demand for new connections to central part of the city.
- Public transport system in the city is confined to a small portion of the city and has poor frequency due to limited availability of fleet size. City also lacks institutional support for planning, management and operationalisation of safe and reliable pubic transport
- The condition & width of roads requires attention in terms of widening, remove the encroachments and construct subways, flyovers and parking places.

1.6. NEED FOR MRTS SYSTEM IN LUCKNOW

The exponential growth in the city's population coupled with faster growth in the number of motorized vehicles in the city, poses a formidable problem to the city's planner for providing a transport system for providing quicker, safer, more economical and pollution free transport system. Thus implementation of robust mass urban public transport system explore has become essential to cope up with the increasing demand. This has led to the possibility of the Rail based MRTS for Lucknow city. The rail based MRT system shall also be in line with Lucknow' image of being a modern city with rich heritage.

Against this background, Government of Uttar Pradesh has commissioned Delhi Metro Rail Corporation (DMRC) for undertaking Detailed Project Report for MRT system in Lucknow. Numbers of metro alignments were chosen and traffic was estimated. DMRC has finally identified 2 corridors based on the existing & projected travel demand, demographic features, existing and proposed land use pattern in the city. The corridor identified includes influence areas like Hazaratganj, Alamnagar, Charbagh, Vijaynagar, Airport etc. The Corridors are:

Corridor 1: North South Corridor (Approx. Length – 23kms)

Amausi – Transport Nagar – Krishna Nagar – Singar Nagar – Alambagh – Alambagh Bus Station – Mawaiya – Charbagh Railway Station – Lucknow Railway Station – KKC – Husian Ganj – Sachivalaya – Hazrat ganj – K.D. Singh Stadium – Vishwavidyalaya – IT Chauraha Badshahbagh – Mahanagar – Badshah Nagar – Lekhraj Market – Ramsagar Mishra Nagar – Indira Nagar – Munshipulia

Corridor 2: East West Corridor (Rajajipuram to Patrakarpuram, Gomti Nagar)

Rajaipuram Road - Rajajipuram West – Tikiatganj - Motijheel area – Aishbagh - Tilak Nagar - Subhash Marg – Aminabad - Kaisarbagh – Hazratganj - Subash Marg - Butler Road – Dr. Ram Manohar Lohia Park (Vishal Khand) - Vipul Khand - Patrakarpuram in Gomti Nagar.

1.6.1. Network Evaluation (Engineering)

A detailed technical feasibility of these proposed metro corridors was done through a traffic study and engineering alignment option study and was discussed with LDA several times. A group of second order corridors were also considered for evaluation as potential mass transit routes. The criteria of selection for most desirable option was ridership, accessibility & integration, ROW of major roads, type of metro (elevated and underground requirements), cost elements, acquisition of build up property, O&M depot locations and minimum disturbance / avoidance of heritage structures prevalent in these sections. The heritage structures are present on almost all the selected options and final decision on selection of final set of corridors was a challenging task to DMRC and the associated consultants'.

The following corridors (**Figure 1.3**) were considered before arriving on final Corridors:

i. NS: Amausi to Munshi Pulia via Kanpur Road and Faizabad Road (23 km)

ii. EW: Rajaji Puram to Gomtinagar crossing CBD and Hazazrat Ganj (18 km)

iii. Modified NS Corridor from Krishan Nagar to Muhibullahpur along Kanpur Road, Hazrat Ganj, MG Road, Hasan Ganj RS, crossing Gomti River near Bara Imambara along Sitapur NH-24 till Muhibullahpur / IET (20.5 km)

iv. Modified EW Corridor from Rajaipuram to Munshi Pulia via CBD, via Hazrat Ganj, Stadium, Parivartan Chk, IT Charaha along Faizabad Road till Munshi Pulia (18.6 km)

v. Modified EW Corridor from Lucknow Railway Station along Gautam Budha Marg via Aminabad, Pandey Ganj, City RS, Medical Crossing, Nawajganj and thereafter; along Hardoi Road up to Vasant Kunj (11.1 km)

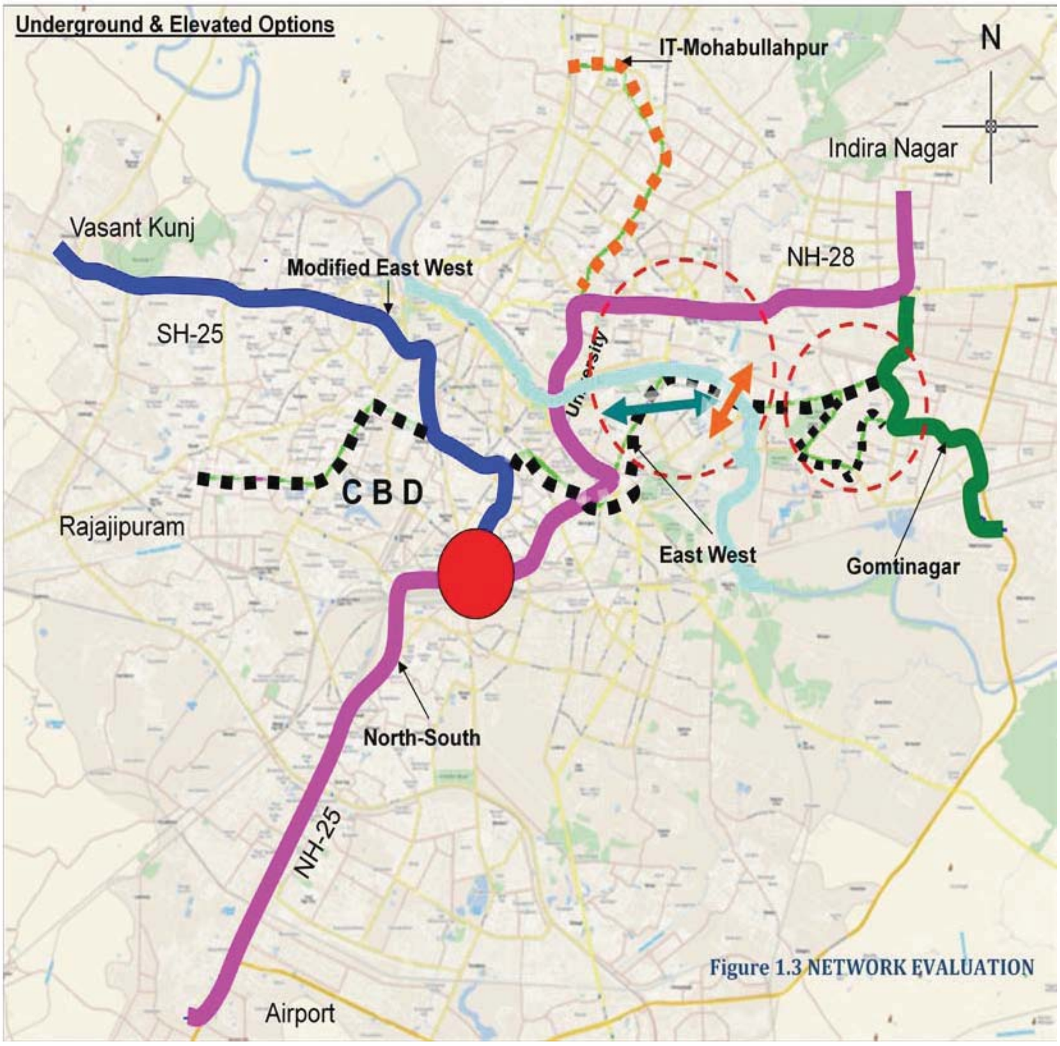


Fig 1.3

The feasibility of these alternatives is discussed hereunder:

(a) NS: AMAUSI TO MUNSHI PULIA VIA KANPUR ROAD AND FAIZABAD ROAD

The NS corridor (i) above was selected and considerable feasible and connecting Amausi with Munshi Pulia. Following issues were studied in detail before finalising / freezing this corridor.

- The alignment was considered underground initially for a length of 5.1 km between Charbagh and KD Singh Babu Stadium. The location and positioning of ramp to cross river Gomti elevated was a major issue to be encountered. The road widths near Hazratganj market is barely 17m and the width of ramp to be provided was 10 m which would block the carriageway and sufficient width was not available for road traffic. As an alternative the ramp positioning near / opposite KD Singh Babu Stadium was also dropped in view of heritage structure at the Victoria Memorial site housed in the Begam Hazrat Mahal Park.
- Crossing of alignment across River Gomti underground was also dropped in view of complex geometry and availability of insufficient lengths for switch over between elevated to underground.
- To streamline these issues an elevated option was considered keeping in view the cost implications and complexity of construction of underground metro stations. There were no major obstacles for the alignment between Amausi and Mawaiya and the alignment was placed central along the Kanpur Road, which has sizeable ROW.
- The challenges posed by the elevated option were more near the existing BG Railway Line near Mawaiya Junction. In case the alignment has to cross the rail-lines elevated, the minimum metro rail level shall be 12 m above the broad gauge rail lines. To encounter this, extra dose bridge was envisaged to cross the railway lines elevated with span of about 80m.
- The issue of ramp positioning near KD Singh Babu Stadium could be avoided with the elevated option.
- The other constraints were on Faziabad Road between Mahangar and Lekhraj Market. The alignment has to surpass Indra Flyover before Mahanagar Junction and proposed ROB / Flyover planned across NH-28 crossing the rail lines near Kukrail Nala. The alignment has been planned double elevated at these locations.
- Finally, alignment has to turn at the Polytechnic Junction to terminate at Munshi Pulia. At this location the alignment has been planned to negotiate existing flyover at a safe distance.

(b) EW: RAJAJI PURAM TO GOMTINAGAR CROSSING CBD AND HAZAZRAT GANJ

Proposed EW corridor (ii above) was envisaged to connect Gomti Nagar with Rajajipuram via central area, posed feasibility and ridership issues considering the following:

- The alignment was proposed to connect the Eastern part of Lucknow i.e. Gomti Nagar developing rapidly in terms of infrastructure facilities, education, medical facilities and Rajajipuram, the old established residential settlement in the west.

- The alignment was proposed to commence elevated from the Rajajipuram West near Auto stand. The alignment was to cross congested area of the Central Lucknow and was envisaged underground immediately after the proposed Rajajipuram West station.
- Crossing Aishbag Road the proposed connection with Hazratganj was aligned via crossing Subasha Marg, Aminabad, Kaiserbagh Junction reaching Vidhan-Sabha Marg. The alignment was then planned along the major banks road and approaching the Hazratganj Junction beneath Sarojni Nagar Road.
- From Hazratganj Junction, it followed underground via Ashoka Marg reaching Shakti Bhawan
- The alignment was to cross Gomti River elevated. The switch over ramp had been proposed in the campus of the Botanical garden along the boundary wall. The alignment was planned to cross the Gomti River before the Cremation area, Baikunth Dham. Thereafter, alignment followed the road towards Fun Mall to reach Ram Manohar Lohiya Park towards Gomti Nagar.
- To reach Gomti Nagar, 2 elevated options were considered. Initially, the alignment was planned along Lohia Park Road turning at City Montessari School to reach Patrakar Puram. This would involve large scale property acquisition to provide adequate geometry and avoid the heritage Mutiny Ground.
- In the other option after Patrakarpuram the alignment was planned to cross the under-construction Flyover at a double height and reaching the terminating station Haneyman Chowk via Jaipuria School of management, Jaipuria School and Viraat Khand Market. The total length of the corridor was proposed to be 18.8 km and the underground section shall be about 8.5 km long. A total of 11 metro stations were planned on this corridor of which 6 stations were underground.
- The 4 km section between Botanical Garden and Sangeet Academy along the Butler Road did not attract significant ridership owing proximity to Butler Road flanked adjacent to riverbanks and therefore, no major station were planned. The positioning of elevated bridge across river Gomti was possible only the upstream side and would pose construction hazards. No other location was possible due presence of 3 existing bridges at this location.
- Since the metro connection to Gomti Nagar is vital, therefore, it was decided that a proposal for connecting proposed Indranagar metro station near Polytechnic Junction will be planned with an additional platform to aid possible metro connection via Wave Mall, Pickup Bhawan, Mashadipur and Patrakarpuram. This can then expanded in the Gomti Nagar area depending upon the future growth and potential of public transport demand.
- Similarly, the connectivity to Rajajipuram can be enhanced by integrating City railway Station in the central area by a dedicated bus route.
- Therefore, this alignment was dropped.

(c) MODIFIED NS CORRIDOR FROM KRISHAN NAGAR TO MUHIBULLAHPUR ALONG KANPUR ROAD, HAZRAT GANJ, MG ROAD, HASAN GANJ RS, CROSSING GOMTI RIVER NEAR JUNCTION OF MG ROAD & NH-24 ALONG SITAPUR ROAD TILL MUHIBULLAHPUR / IET (25 KM).

This alignment was tested as an alternative and was not considered due to presence of BG railway from Hasan Ganj towards Sitapur. A suitable sub-urban railway network can be planned along this corridor to cater to potential public transport demand.

(d) MODIFIED EW CORRIDOR FROM RAJAJIPURAM TO MUNSHI PULIA VIA CENTRAL AREA CONNECTING HAZRAT GANJ, STADIUM, PARIVARTAN CHK, IT CHARAHA ALONG FAIZABAD ROAD TILL MUNSHI PULIA (17 KM)

This corridor did not attract significant traffic and there were many engineering constraints along this route and hence was not considered feasible.

(e) MODIFIED EAST WEST METRO CORRIDOR (LUCKNOW RS TO HARDOI ROAD) – 11 KM.

To cater to potential public mass transport demand in the central area a modified alignment (Lucknow Railway Station to Vasant Kunj on Hardoi Road) was tested as a viable alternative. The route between Lucknow RS via Gautam Budha Marg, Subash Marg to Hardoi Road via Chowk Chauraha is busy route and attracts considerable public transport trips throughout the day. The busy and commercial nature of Hardoi Road is poised for future growth and will need a mass transport facility in coming years. Many new residential and commercial establishments are proposed along this corridor till the Musabagh Forest. A six lane corridor gives access to newly planned residential settlement at Vasant Kunj. Hardoi Road has a planned ROW of over 30m and construction elevated metro is feasible.

The planning of alignment along this corridor was supplemented by connecting Lucknow RS with Gautam Budha Marg, Aminabad, Pandeyganj, Lucknow Cuty RS at Wazirganj, Medical College connecting Hardoi Road besides Chota and Bara Imambara (maintaining a safe distance). The placement of station has been planned carefully in view of built-up nature and possible integration of proposed metro with other modes of traffic. A major bus terminal is also under construction near the Fish Mandi adjacent to proposed O&M Metro Depot location near Vasant Kunj. This will also integrate the metro corridor with road based bus system and cater to traveling needs.

The proposed alignment between Lucknow RS and Chowk Chauraha is planned underground in view dense mix of commercial cum residential landuse and thereafter, the alignment is proposed elevated along Hardoi Road till Vasant Kunj.

1.6.2. Recommended MRTS Network for Phase I

The recommended network for Phase I of MRTS in Lucknow City was finalized based on the above evaluation. The 2 corridors were finalized in Consultation with LDA and the preparation of DPR was taken for these 2 corridors. The corridors are presented in **Table 1.2 & Figure 1.4**. The NS and EW corridors will have a direct passenger interchange facilities at Lucknow RS. Proposed depot locations have been planned at Amausi and Vasant Kunj on terminal ends on NS and EW corridors.

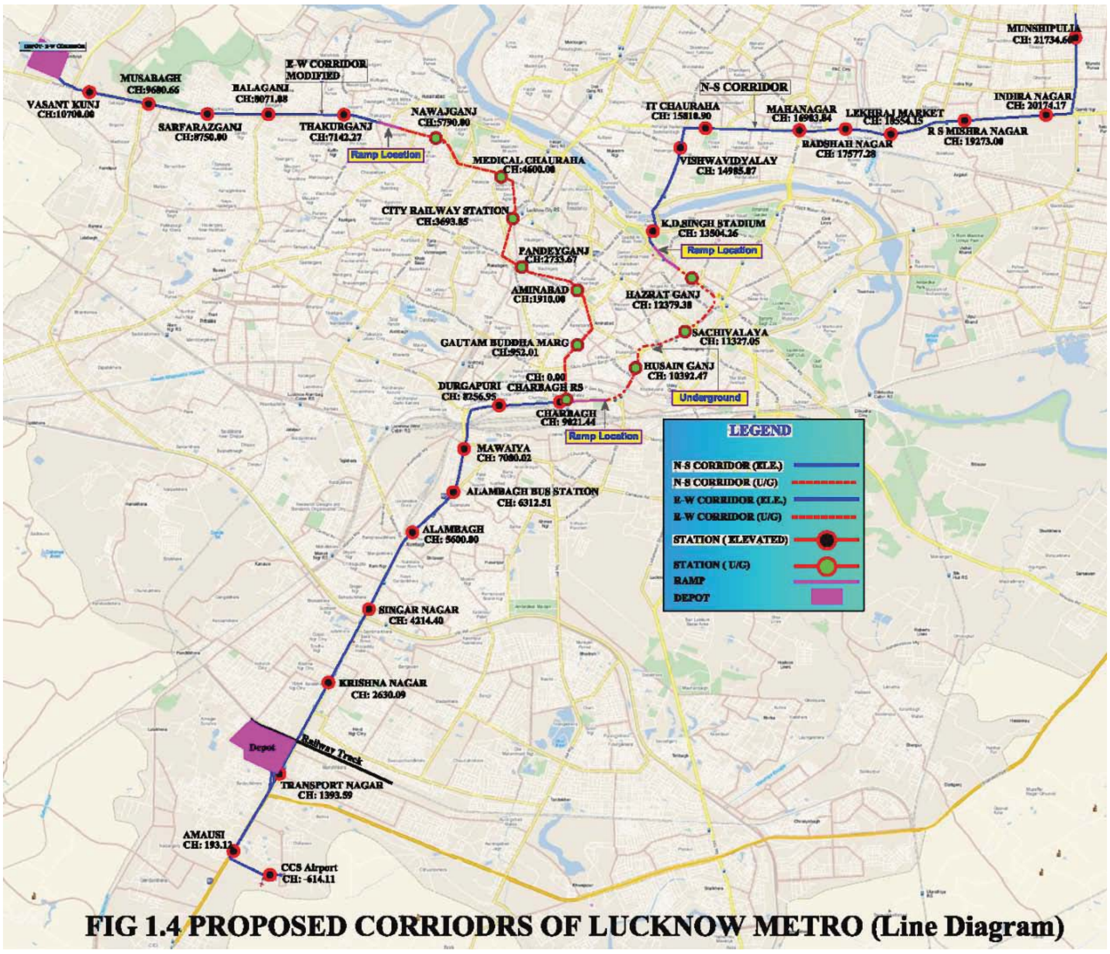


FIG 1.4 PROPOSED CORRIODRS OF LUCKNOW METRO (Line Diagram)

Fig 1.4 Proposed Corridors of Lucknow Metro Phase-I

Table 1.2 MRTS Lucknow – Phase I

SN	Corridor	Route	Major Destinations	Length (km)
1	North South (NS)	Kanpur Road, Vidhan Sabha Marg, Ambedkar Marg, part of MG Road, University Road, Faizabad Road & Himalaya Marg	Amausi, Krishna Nagar, Alambagh, Charbagh, Hussain Ganj, Hazratganj, Vishwavidyalay, IT Chauraha, Mahanagar, Indiranagar, Munshi Pulia	22.878
2	Modified East West (EW)	Gautam Budha Marg, parts of Ganga Prasad Marg, Mirtaki Marg & Hardoi Road	Lucknow RS (Charbagh), Aminabad, Pandeyganj, Medical College, Nawajganj, Thakurganj, Musabad & Vasant Kunj	11.098

1.7. STRUCTURING OF REPORT

This report has been compiled in 17 chapters. Chapter one presents a concise write-up on the background, need and objective of the assignment. The traffic demand analysis has been presented in the second chapter. In the chapter three, the geometric standards and norms have been summarised. Chapter four described the presents details for topographic, geo-tech investigations surveys conducted as part of the study as inputs to DPR preparation, the detailed alignment- horizontal and vertical geometric designs and station area planning including integration measures have been illustrated in detail.

Other chapters contain the details of systems, power supply, signalling system and operations. The twelfth chapter has focussed on environmental and social impact assessment as per the prevailing guidelines prescribed by MoEF and National Rehabilitation Policy. The SIA also includes the details of households/titleholders of the likely property acquisition necessary for the implementation of the project.

Chapter 2

Traffic Demand Analysis

CHAPTER 2

TRAFFIC DEMAND ANALYSIS

2.0 TRANSPORT DEMAND FORECAST

2.1 TRAVEL CHARACTERISTICS

2.1.1. GENERAL

Large number of alternate routes for Metro for Lucknow was taken in the traffic analysis and the Peak Hour and Peak direction traffic (PHPDT) on such routes determined. Based on PHPDT, two routes; one connecting North to South and East to West were identified. North – South corridor starts at Amusai airport and ends at Munshipulia via Hazaratganj, Sachivalaya, IT Chouraha etc with a total length of 22.878 km. East- West corridor with its Length of 11.098kms, starts at Charbagh Railway station and ends at Vasant kunj passing through City railway station, Balaganj, Musabagh etc.

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

2.1.2. TRANSPORT DEMAND MODELLING

Database

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

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 2.3**.

2.1.3 ZONING

The entire study area has been delineated into 127 zones as shown in **Figure 2.4.** Among them 119 are the internal zones and the remaining zones (8 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

Description	2001	2011	2021	2031*
Population(in lakhs)	22.45	29.08	44.41	54.61
Employment(in lakhs)	6.17	9.19	13.50	17.47

(Source: Lucknow Master Plan 2021, 2031*WSA Analysis)

These figures are based on the Census (2011) and projected for future in consultation with the city development authorities.

2.1.4 VEHICLE GROWTH

The number of registered vehicles in Lucknow was 1010226 till March 2009 with a growth rate of 7% in the year 2008-2009. The vehicle population for the past five years is presented in **Table 2.2**. Private vehicular transport constitutes a very sizeable proportion. Two wheelers account for more than three- fourths of the total registered vehicles, while cars constitute 14%.

Table 2.2 Vehicle Registration Data (2004-2008)

Year	Goods Vehicles			Passenger Vehicles						Total	Growth
	Heavy Goods Vehicles	Light Goods Vehicles	wheelers Goods Vehicles	Buses	Taxi	Tempo Taxi	Auto Rickshaw	Two wheelers	Four wheelers		
2004-05	5303	4780	2392	3553	4602	7381	1544	601745	97317	728617	-
2005-06	5541	5018	2782	3831	5080	7475	2228	660332	106874	799161	10%
2006-07	5893	5783	3197	3914	6283	8233	4762	720158	105447	863670	8%
2007-08	6066	6738	3576	3842	7083	8216	5008	771846	129316	941691	9%
2008-09	6242	7657	3776	3741	7399	8447	5015	825088	142861	1010226	7%

2.1.5 TRIP INFORMATION

The trip information obtained from the survey has been analyzed with respect to distribution of total trips by mode. The daily trips by various modes are presented in **Table 2.3 and Fig. 2.1.**

Table 2.3 Distribution of Motorized Trips

Sl. No	Mode	Internal Trips	External Trips	Total Trips
1	Two-wheeler	1342500	43913	1386413
2	Car	156225	60200	216425
3	Auto rickshaw	71525	15938	87463
4	Public Transit	316850	157000	473850
	Total	**1887100**	**221640**	**2164151**

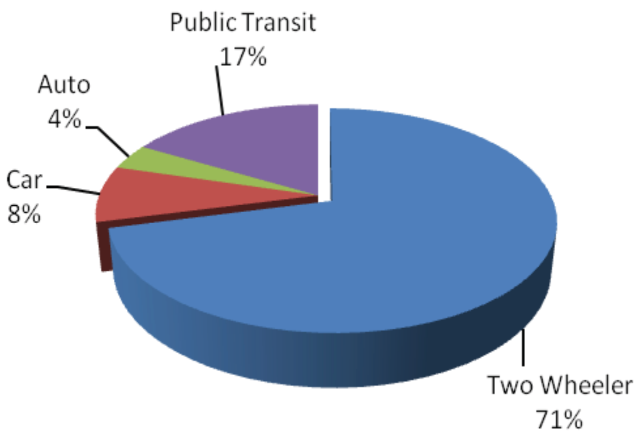


Figure 2.1. Mode Split – Motorized

Bus trips constitute about 17% of the total trips while Two-wheeler trips are 71 %, Auto trips 4% and Car trips constitutes 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 CAPACITY OF THE ROAD SYSTEM

The types of roads and their capacities are given in **Table 2.4.**

TABLE 2.4 TYPES OF ROADS AND THEIR CAPACITIES

Functional Characteristics	Directional capacity
4L-2W-UD	3800
4L-2W-D	4500
6L-2W-D	6700

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

2.2.3 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 BPR functions and fed into the model as input in the highway network. The form of the BPR function is

$TC = T0 * (1+\alpha * (v/c) \hat{}\beta)$

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 each category of road is given in **Table 2.5.**

Table 2.5: BPR Functions

Road way Class	Functional Characteristics	Directional Capacity	Free Flow Speed	ALPHA	BETA
1	1L-2W-UD	900	22	3.5	1.6
2	1.5L-2W-UD	1400	27	3.8	1.6
3	2L-2W-UD	1900	36	5.2	1.8
4	3L-2W-UD	2800	38	4.7	1.8
5	3L-2W-D	3400	31	5.0	1.8
6	4L-2W-D	4500	43	5.5	3.3
7	6L-2W-D	6700	49	6.8	3.8

2.2.4 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.

2.2.5 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 2.6**

Table 2.6 Generation for Total Trips

Description	Co-off.
Intercept	0.0343
X Variable	311.65

By using the above table the value of R^2 was found to be 0.55, T-value – 10.7, F-value-114.2 (**Assuming Population in zones as the variable**).

Table 2.7 Trip attraction for total trips

Description	Co-off.
Intercept	0.104
X Variable	393.92

By using above expression the value of R^2 was found to be 0.66, T-value-12.7, F Value-160.8 (**Assuming Employment in zone as variable).**

2.2.6 PER CAPITA TRIP RATE (PCTR)

Adopted Per Capita Trip Rate for base and horizon years i.e., 2011, 2015 and 2020 2025 and 2030 are as given in the **Table 2.8.**

Table 2.8 Adopted PCTR (Motorised) Value

Year	PCTR Value
2009	0.63
2015	0.77
2020	0.91
2025	0.96
2030	1.01

2.2.7 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 logic 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:

Tijm= ri Gi sj Aj Fijm

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

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

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 2.5**.

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.

2.2.8 DETERRENCE 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

Mode	Morning Peak		
	K	**ALPHA**	**BETA**
Two wheeler	3.4	-0.2	52.8
Car	4.2	0.8	12.0
Auto Rickshaw	9.1	1.0	26.8
Public Transport	4.0	0.2	59.4

2.2.9 TRIP ASSIGNMENT

2.2.9.1 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.

2.2.9.2 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 2.6**.

2.2.9.3 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	PCE Values
Private Vehicles& IPT	Two wheeler	0.54
	Auto rickshaw	0.43
	Car	0.38
Commercial Vehicles	**Modes**	**PCU Values**
	Truck	2.2
	MAV	4.0
	LCV	1.4

2.3 TRANSPORT DEMAND PROJECTIONS

2.3.1 Based on traffic projections, DMRC has identified the under mentioned corridors for Phase-I of Lucknow Metro :

a) North-South corridor starts at Chaudhary Charan Singh Airport and ends at Munshipulia via Sachivalaya, Hazaratganj, IT College Junction, Indira Nagar with a total length of 22.878 km having 22 stations (3 underground & 19 elevated).

b) East- West corridor (length = 11.098 km) starts at Lucknow Railway station and ends at Vasantkunj passing through Lucknow City Railway Station, Balaganj, Musabagh having 12 stations (7 underground & 5 elevated).

2.3.2 The proposed Phase-I Corridors of Lucknow Metro are shown in **Fig 2.2.** The proposed stations on the North-South corridor and East -West corridor Link and the distance between the stations are given in **Tables 2.11** and **Table 2.12**.

Table 2.11 – Inter- Station Distances on the North-South Corridor

S. No	Name of Stations	Inter – Station Distance (in m)
1	CCS Airport	-
2	Amausi	807.23
3	Transport Nagar	1200.47
4	Krishna Nagar	1236.50
5	Singar Nagar	1584.31
6	Alambagh	1385.60
7	Alambagh Bus Stand	712.51
8	Mawaiya	767.51
9	Durgapuri	1176.93
10	Charbagh / Lko Rly Station	764.49
11	HussainGunj	1371.03
12	Sachiwalaya	934.58
13	HazratGunj	1052.33
14	KD Singh Babu Stadium	1124.88
15	Vishwavidyalaya	1480.81
16	IT College Junction	825.83
17	Mahanagar	1092.94
18	Badshah Nagar	673.44
19	Lekhraj Market	976.87
20	Ram Sagar Mishra Nagar	718.85
21	Indra Nagar	901.17
22	Munshi Pulia	1560.49

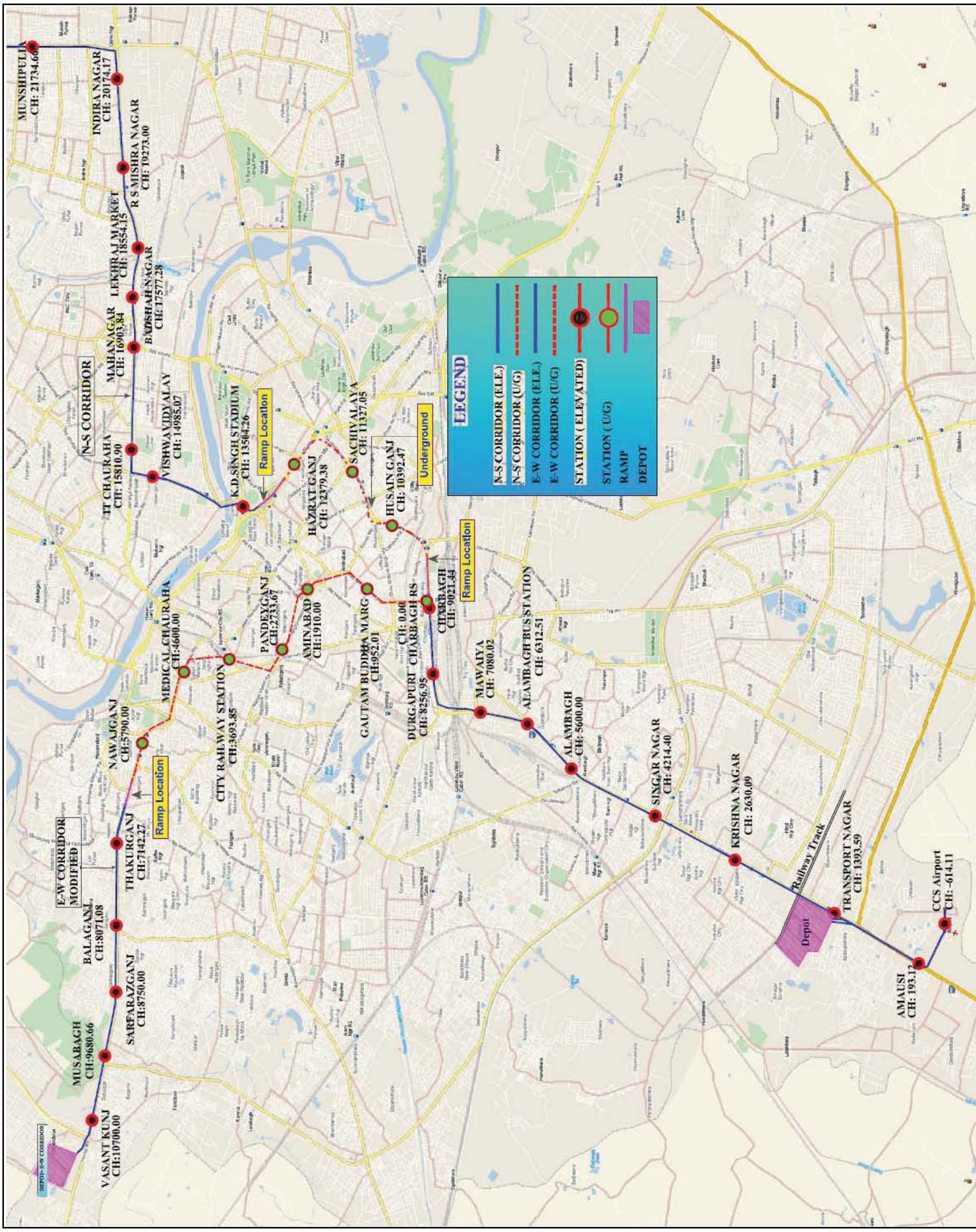


FIG 2.2 PROPOSED CORRIODRS OF LUCKNOW METRO

Table 2.12 – Inter -Station Distances on the East-West Corridor

S. No	Name of Stations	Inter – Station Distance (in m)
1	Charbagh/Lucknow Rly. Stn	(-)113.00
2	Gautam Buddha Marg	988.966
3	Aminabad	964.46
4	Pandey Gunj	823.67
5	Lucknow City Rly. Stn	916.98
6	Medical Chauraha	949.35
7	Nawajganj	1189.66
8	Thakurganj	1342.39
9	Balaganj	938.70
10	Sarfarazganj	679.91
11	Musabagh	929.67
12	Vasantkunj	853.19

2.3.3 SECTION LOADING

The traffic assignment was carried out with the proposed alignments in place. The loading on the proposed metro alignments is presented in **Table 2.13.**

Table 2.13 Summary of Transport Demand Projections

Year	Corridor Length (km)	PHPDT	Daily Passenger Km	Daily Ridership	Average Trip Length (km)
North-South Corridor : CCS Airport to Munshi Pulia					
2015	22.878	13190	3227960	429250	7.52
2020		20976	4886515	644659	7.58
2025		25890	6132646	833240	7.36
2030		34955	7664688	1054290	7.27
2041		44408	9501868	1343970	7.07
East-West Corridor : Lucknow Rly Station to Vasant kunj					
2015	11.098	7639	619487	155650	3.98
2020		14157	1007262	243300	4.14
2025		21434	1477121	345930	4.27
2030		29171	1982341	459940	4.31
2041		36196	2496832	600200	4.16

The total ridership in the proposed North- South corridor in the year 2015 and 2041 will be 4.29 and 13.44 lakhs passengers per day respectively. The daily ridership on the East- West corridor will be 1.55 lakhs in 2015 and 6.00 lakhs passengers per day in 2041.

The maximum range of PHPDT on the North-South alignment in 2015 will be 13190 and by 2041 the maximum range of PHPDT is projected to be in the order of 41969. The maximum range of PHPDT on the East-West alignment in 2015 will be 7639 and by 2041 the maximum range of PHPDT is projected to be in the order of 44408. Station wise boarding, alighting and sectional load for different horizon years are presented in **Annexure 2.2.**

2.3.4 STATION LOADING

The daily station loading (two way boarding's) for both the alignments are presented in **Table 2.14 to table 2.15**

Table 2.14 Daily Station Loading for North-South corridor

Station no	Station Name	2015	2020	2025	2030	2041
1	CCS Airport	1170	1260	1340	1400	1520
2	Amausi	4700	5020	5370	5610	6070
3	Transport Nagar	2530	6690	9280	12330	18460
4	Krishnagar	10340	24050	29780	56570	74850
5	Singar Nagar	5780	10780	16240	19370	26990
6	Alambagh	13180	18840	21000	26250	35040
7	Alambagh Bus Stn	12340	20990	28410	37580	63020
8	Mawaiya	50990	61889	63180	72600	87180
9	Durgapuri	25980	35910	56450	59330	88130
10	Lucknow Rly. Stn	77650	143030	186620	241260	332350
11	Hussain Ganj	36760	44940	60180	78300	88620
12	Sachivalaya	11370	14800	17510	23410	26710
13	Hazarat Ganj	17380	21440	25170	31600	37070
14	KDSinghBabuStadium	4550	6720	10060	16450	14280
15	Vishwavidyalaya	5540	10580	14340	20810	18710
16	IT College Junction	10210	17500	24830	30870	27480
17	Mahanagar	50420	68100	88720	103210	118720
18	Badshah Nagar	13480	26270	36640	44000	61990
19	Lekhraj Market	21220	32100	41980	56330	71860
20	Ram Sagar Mishra Nagar	10410	16470	21360	27930	37240
21	Indira Nagar	15930	21310	29050	38030	53270
22	Munshipulia	27320	35970	45730	51050	54410
	Total	**4,29,250**	**6,44,659**	**8,33,240**	**10,54,290**	**13,43,970**

(Note: Numbers are daily Boarding's on both directions (Up and Down)

Table 2.15 Daily Station Loading for East-West Corridor

STATION NO.	STATION NAME	2015	2020	2025	2030	2041
1	Lucknow Rly. Stn	39620	44980	48040	50430	65960
2	Gautam Buddha Marg	64000	11330	17280	22630	47820
3	Aminabad	22460	31100	38770	47340	62550
4	Pandey Ganj	24810	34280	44250	62760	71910
5	City Rly. Stn	8450	13190	18800	24900	34710
6	Medical Chauraha	9950	17120	26350	38570	50830
7	Nawajganj	16950	35000	63260	89770	104090
8	Thakurganj	8000	17680	36670	44670	63840
9	Balaganj	6150	19190	28510	51400	59430
10	Sarfarazganj	3970	6970	8430	9720	16140
11	Musabagh	7170	8180	9590	11420	13150
12	Vasant kunj	1720	4280	5980	7140	9270
	Total	**2,13,250**	**2,43,300**	**3,45,930**	**4,60,750**	**5,99,700**

(Note: Numbers are Daily Boarding's on both directions (Up and Down)

2.3.5 MODE SHIFT

The number of trips shifted to metro from personalize modes, IPT, shared auto and public transport in the peak hour are given in **Table 2.16.** During peak hour 0.64 lakh trips will be shifted to metro in 2015 and 1.51 lakh trips in 2030.

Table 2.16 Mode Shift

Year	Mode	TRIPS	%
2015	Two wheeler	12850	20%
	Car	4497.5	7%
	Auto	1285	2%
	Shared Auto	16062.5	25%
	Public Transport	29555	46%
	Total	**64250**	**100%**
2020	Two wheeler	28415	32%
	Car	7104	8%
	Auto	4440	5%
	Shared Auto	17759	20%
	Public Transport	31079	35%
	Total	**88796**	**100%**
2025	Two wheeler	34196	29%
	Car	22404	19%
	Auto	5896	5%
	Shared Auto	18867	16%

Year	Mode	TRIPS	%
	Public Transport	36554	31%
	Total	**117917**	**100%**
2030	Two wheeler	63631.68	42%
	Car	22725.6	15%
	Auto	4545.12	3%
	Shared Auto	22725.6	15%
	Public Transport	37876	25%
	Total	**151504**	**100%**

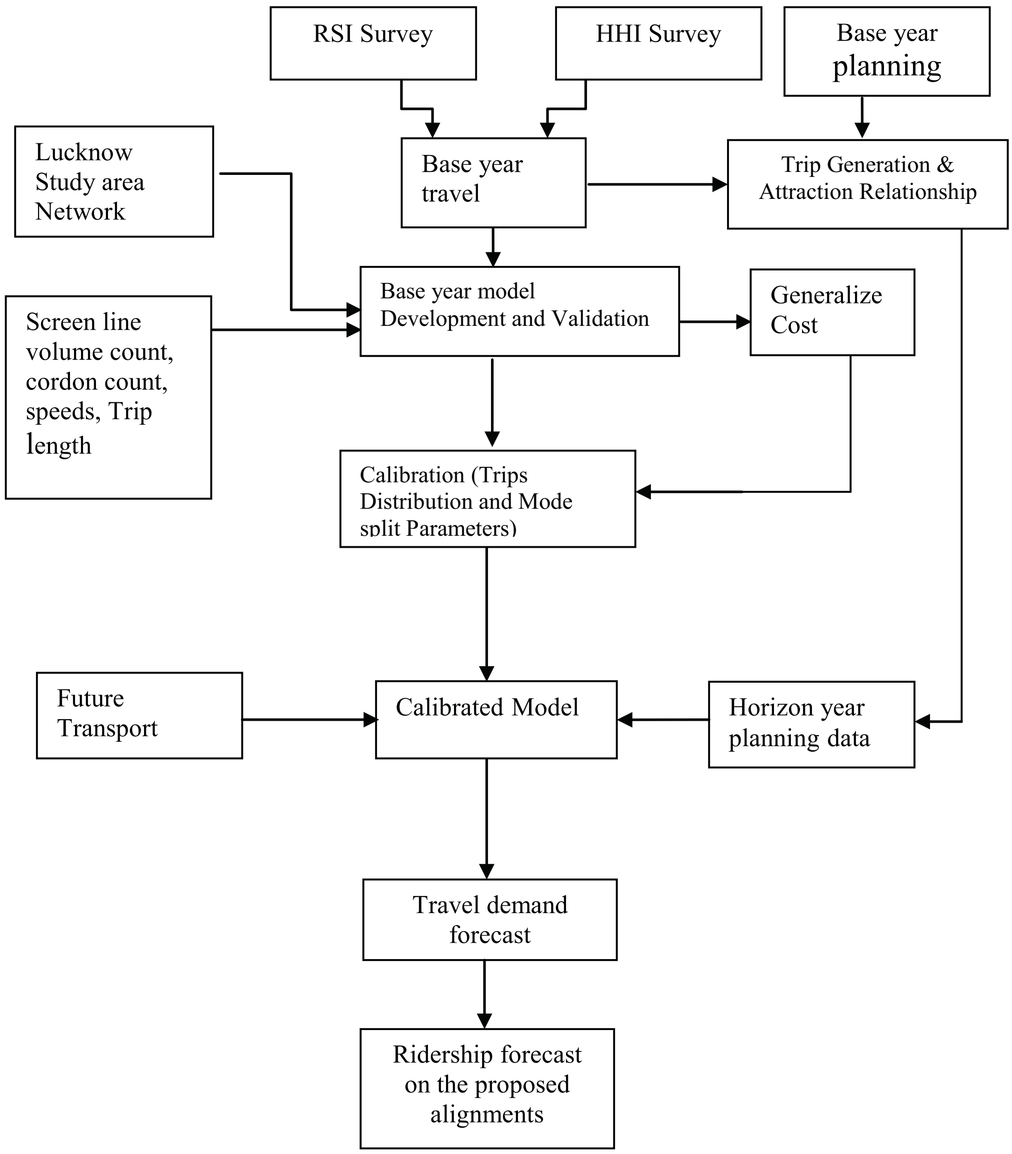


Figure 2.3: Modeling approach

2.3.6 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 2015 and 2041 for North-south corridor is 7.9 km and 8.2 km and for East west corridor the trip length is 4.9 km in 2015 and increasing to 5.1km in 2041.

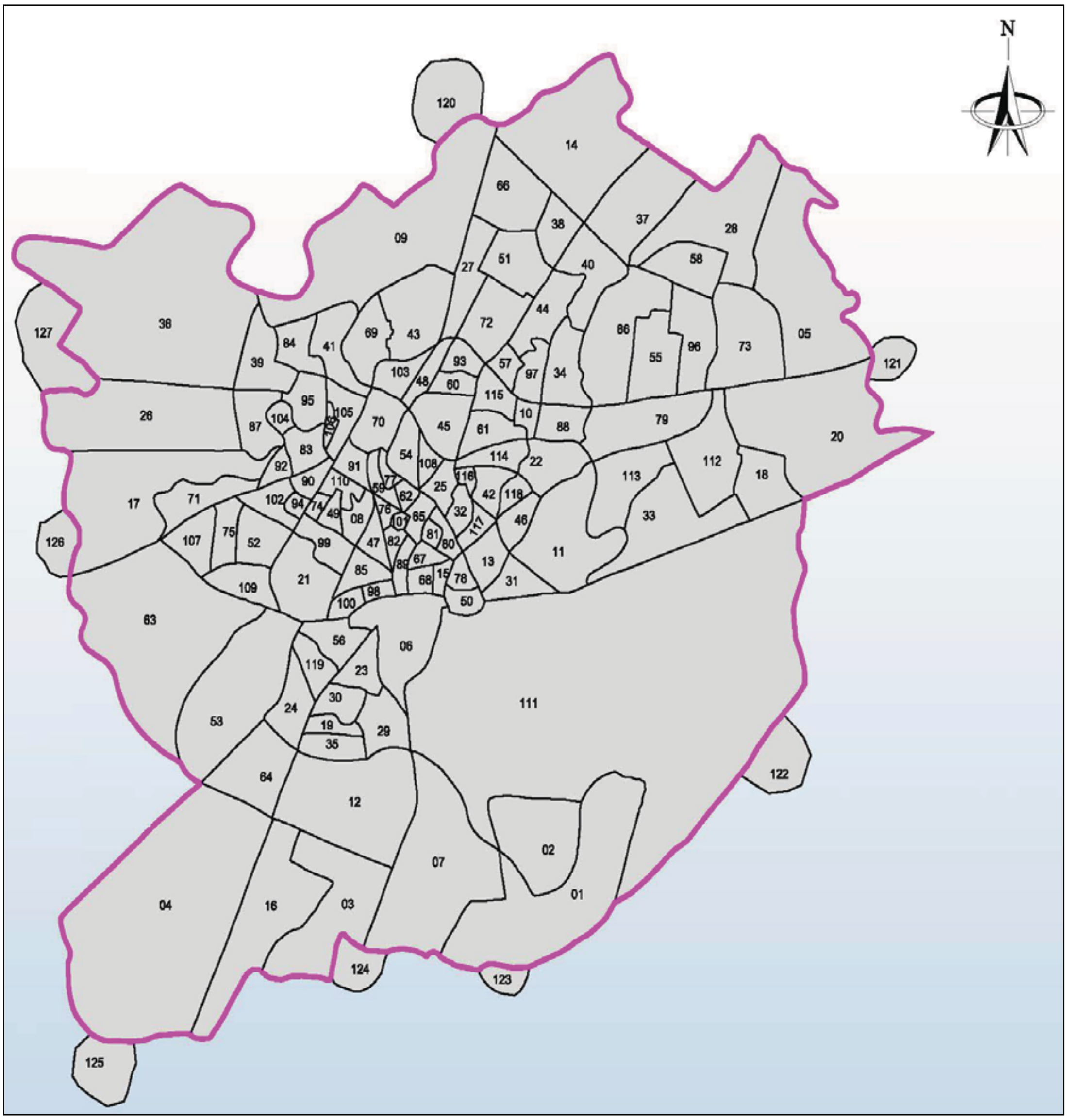


Figure 2.4: Zoning System

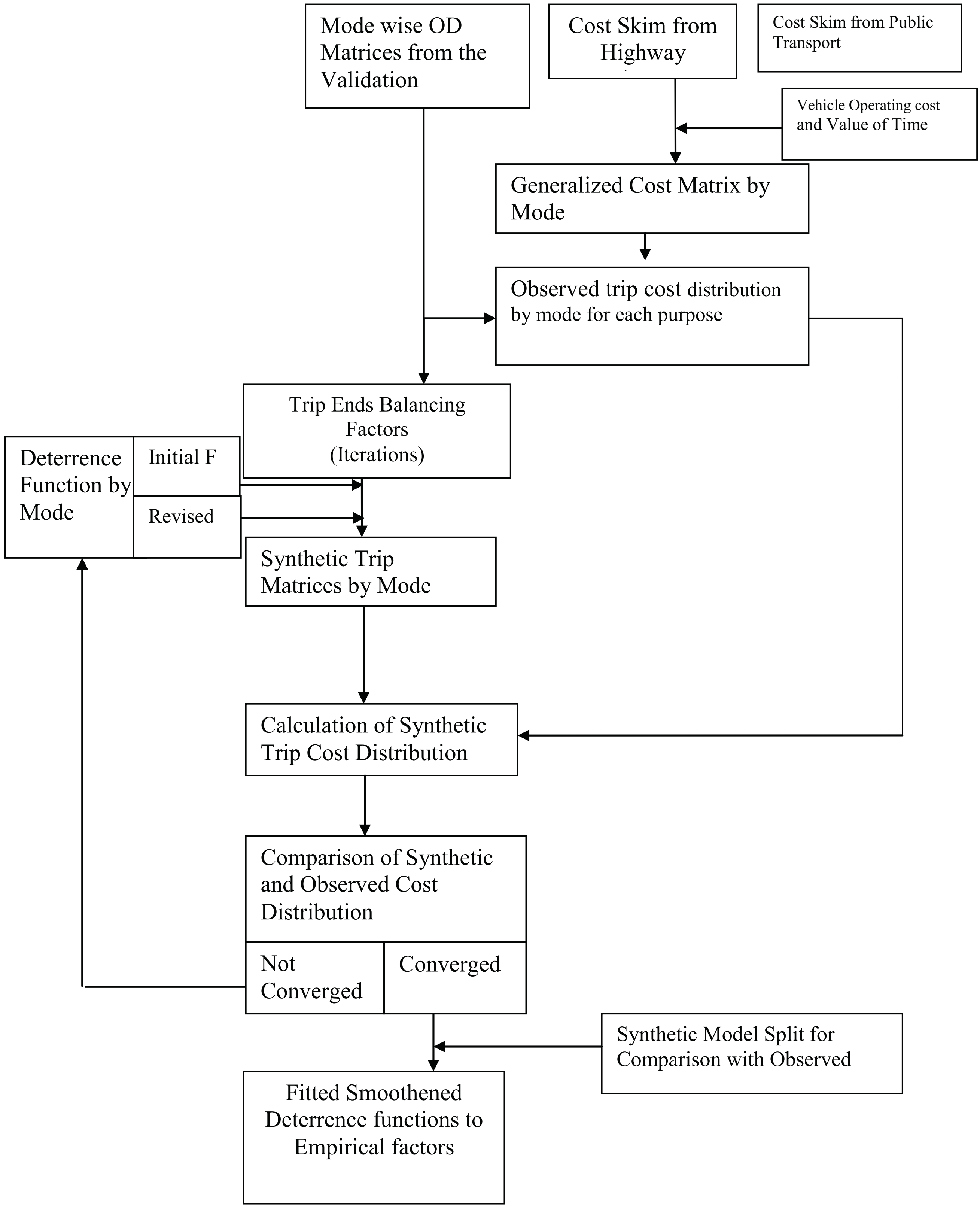


Figure 2.5: Calibration Process

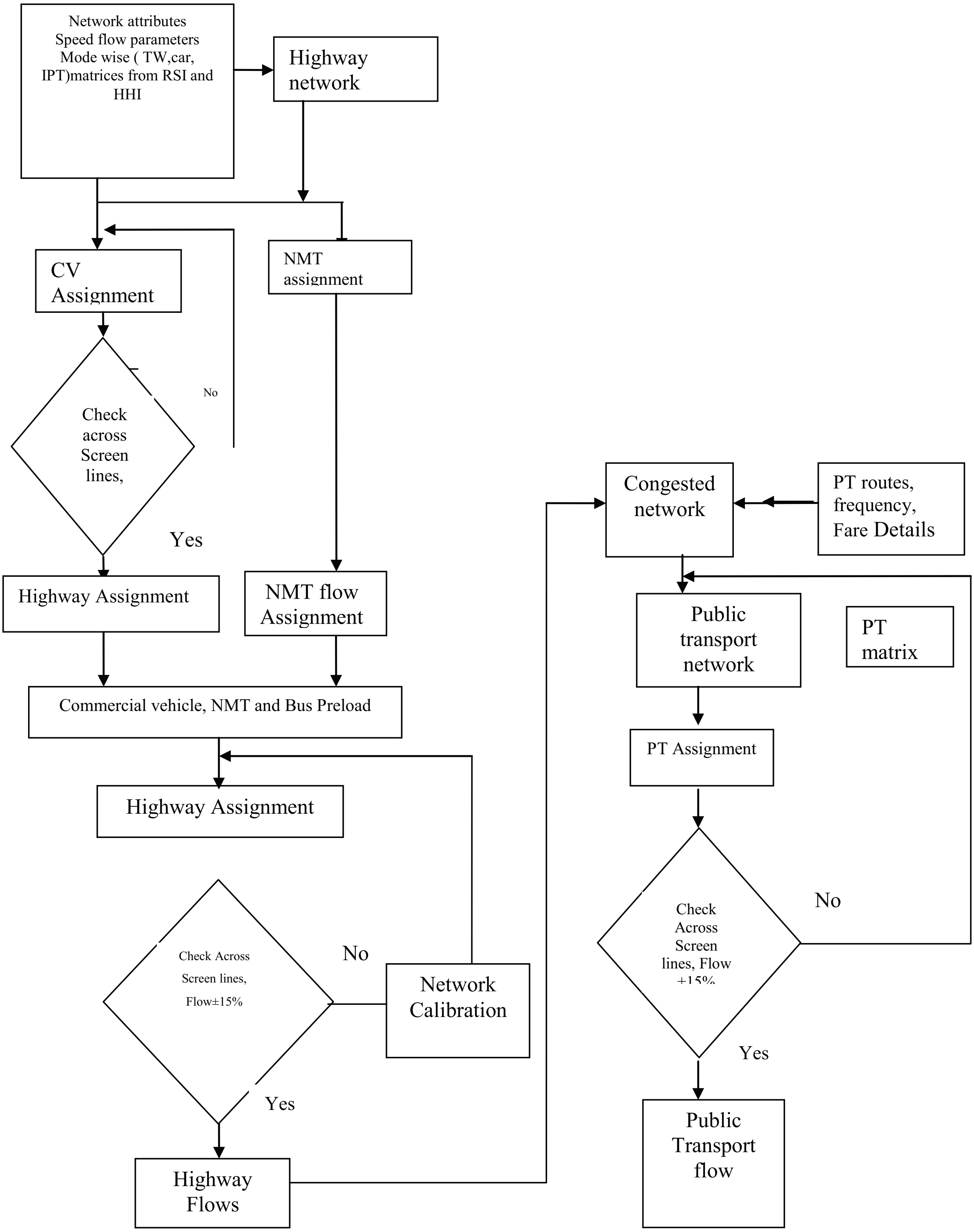


Figure 2.6. Trip Assignment

ANNEXURE -2.1

ZONE NUMBERS AND ZONE NAMES

Zone No	Zone name
1	Ibrahimpur ward
2	Kharik ward
3	Raj Vijli pasi ward
4	Sarojini nagar ward
5	Shaheed bagath singh ward
6	Gurugovind singhward
7	Sharda nagar ward
8	Tilak nagar ward
9	Fazulla ganj ward
10	Nishatganj ward
11	Vikramaditya ward
12	Viddya wati devi nagar ward
13	Murali nagar ward
14	Janakipuram ward
15	Lal kuwan ward
16	Hind nagar ward
17	Haider ganj ward
18	Rajeev gandi nagar ward
19	Jai prakash nagar ward
20	Churhat ward
21	Ambedkar nagar ward
22	Ram mohan rai ward
23	Babu kunj bihari ward
24	Ramji lal ward
25	Rani laxmi bai ward
26	Knahiya madhavpur ward
27	Kavi jai sankar prasad ward
28	Indra priyadarshini nagar
29	Geeta palli ward
30	OM nagar ward
31	Mahatma gandi ward
32	Jagdish chandrabosh ward
33	Rafi ahmed kidwai nagar
34	Maha nagar ward
35	Guru nanak nagar ward
36	Balak ganj ward
37	Shankar purwa ward
38	Lala lajapathi rai nagar ward
39	Mallahi tola ward

Zone No	Zone name
40	Lohiya nagar ward
41	Husainabad ward
42	Hazaratganj ward
43	Triveni nagar ward
44	Begam hazarat mahal ward
45	Mankameswar mandir ward
46	Ram tirath ward
47	Rajendra nagar ward
48	Daliganj ward
49	Jai sansthan ward
50	Banarsi das ward
51	Bajrangbali mandir ward
52	Labour colony ward
53	Keshari khera ward
54	Peer jalil ward
55	Mathli sharan gupta ward
56	Sardar patel nagar ward
57	Chandganj kalyan ward
58	Babu jagjeevan nagar ward
59	Mashakganj ward
60	Ashok azad ward
61	Kalvin college ward
62	Gola ganj ward
63	Alam nagar ward
64	Chitragupt nagar ward
65	Aminabad ward
66	Bharatendu Harish chand
67	Yadunath sainiyal ward
68	Gautam budh ward
69	Ayodya das ward
70	Nethajii subhash ward
71	Sahadatganj ward
72	Aliganj ward
73	Ismailganj ward
74	Aishbag ward
75	Hardeen rai nagar ward
76	Molvi ganj ward
77	Wazir ganj ward
78	Husainganj ward
79	Gomati nagar ward
80	Nazar bagh ward
81	Shivaji marg ward
82	Bashirat ganj ward

Zone No	Zone name
83	Moulana kalve avid ward
84	Daulatganj ward
85	Motilal nehru nagar ward
86	Lal bahudur shastri ward
87	Garhipeer khan ward
88	Paper mill colony ward
89	Ganesh ganj ward
90	Asafabad ward
91	Yahivaganj ward
92	Kashmiri mohalla ward
93	Nirala nagar ward
94	Bhawani ganj ward
95	Acharya narendra dev ward
96	Indra nagar ward
97	Viveknand pur ward
98	Chandra bhan gupta ward
99	Malviya nagar ward
100	Sewa gram stadium ward
101	Abdul hameed ward
102	Seetla devi ward
103	Kadam rasul ward
104	Amar ganj ward
105	Chauk ward
106	Bazar kali ji ward
107	Kuwar jyoti ward
108	Raza bazaar ward
109	Rajaji puram ward
110	Kundari kabab ganj ward
111	Cantonment
112	Rajeev gandi nagar ward
113	Rafi ahmed kidwai nagar
114	Ram mohan rai ward
115	Kalvin college ward
116	Hazaratganj ward
117	Jagdish chandrabosh ward
118	Hazaratganj ward
119	Sardar patel nagar ward

ANNEXURE - 2.2

Peak Hour Section Loadings - 2015 - North South Corridor

Station no	Station Name	Boarding	Alighting	Sectional loading	Station no	Station Name	Boarding	Alighting	Sectional loading
1	CCS Airport	117	0	117	22	Munshipulia	2732	0	2732
2	Amausi	470	0	587	21	Indira Nagar	1593	0	4325
3	Transport Nagar	253	0	840	20	Ram Sagar Mishra Nagar	883	191	5017
4	Krishnagar	946	52	1734	19	Lekhraj Market	1897	83	6831
5	Singar Nagar	551	44	2241	18	Badshah Nagar	1120	91	7860
6	Alambagh	1132	90	3283	17	Mahanagar	4304	288	11876
7	Alambagh Bus Stand	932	140	4075	16	IT College Junction	428	231	12073
8	MAWAIYA	4557	226	8406	15	Vishwavidyalaya	257	531	11799
9	Durgapuri	1748	276	9878	14	KDSinghBabuStadium	192	617	11374
10	Lucknow Rly. Stn	3820	2525	11173	13	Hazarat Ganj	1254	577	12051
11	Hussain Ganj	2472	455	13190	12	Sachivalaya	748	442	12357
12	Sachivalaya	389	513	13066	11	Hussain Ganj	1204	769	12792
13	Hazarat Ganj	484	1220	12330	10	Lucknow Rly. Stn	3945	4237	12500
14	KDSinghBabuStadium	263	640	11953	9	Durgapuri	850	1146	12204
15	Vishwavidyalaya	297	965	11285	8	MAWAIYA	542	3821	8925
16	IT College Junction	593	863	11015	7	Alambagh Bus Stn	302	3055	6172
17	Mahanagar	738	3302	8451	6	Alambagh	186	1874	4484
18	Badshah Nagar	228	1389	7290	5	Singar Nagar	27	861	3650
19	Lekhraj Market	225	969	6546	4	Krishnagar	88	1216	2522
20	Ram Sagar Mishra Nagar	158	2426	4278	3	Transport Nagar	0	1226	1296
21	Indira Nagar	0	503	3775	2	Amausi	0	1037	259
22	Munshipulia	0	3775	0	1	CCS Airport	0	259	0

Peak Hour Section Loadings - 2020 - North South Corridor

Station no	Station Name	Boarding	Alighting	Sectional loading	Station no	Station Name	Boarding	Alighting	Sectional loading
1	CCS Airport	126	0	126	22	Munshipulia	3597	0	3597
2	Amausi	502	0	628	21	Indira Nagar	2131	0	5728
3	Transport Nagar	669	0	1297	20	Ram Sagar Mishra Nagar	1481	328	6881
4	Krishnagar	2267	68	3496	19	Lekhraj Market	2921	134	9668
5	Singar Nagar	1014	53	4457	18	Badshah Nagar	2301	183	11786
6	Alambagh	1587	174	5870	17	Mahanagar	5943	559	17170
7	Alambagh Bus Stand	1578	309	7139	16	IT College Junction	901	398	17673
8	MAWAIYA	5457	393	12203	15	Vishwavidyalaya	512	1068	17117
9	Durgapuri	2408	530	14081	14	KDSinghBabuStadium	338	877	16578
10	Lucknow Rly. Stn	8059	3352	18788	13	Hazarat Ganj	1498	972	17104
11	Hussain Ganj	2890	702	20976	12	Sachivalaya	867	771	17200
12	Sachivalaya	613	912	20677	11	Hussain Ganj	1604	1288	17516
13	Hazarat Ganj	646	2259	19064	10	Lucknow Rly. Stn	6244	5562	18198
14	KDSinghBabuStadium	334	1030	18368	9	Durgapuri	1183	2338	17043
15	Vishwavidyalaya	546	1670	17244	8	MAWAIYA	732	3967	13808
16	IT College Junction	849	1240	16853	7	Alambagh Bus Stn	521	4671	9658
17	Mahanagar	867	4222	13498	6	Alambagh	297	2548	7407
18	Badshah Nagar	326	2177	11647	5	Singar Nagar	64	1275	6196
19	Lekhraj Market	289	1303	10633	4	Krishnagar	138	2509	3825
20	Ram Sagar Mishra Nagar	166	3934	6865	3	Transport Nagar	0	1746	2079
21	Indira Nagar	0	797	6068	2	Amausi	0	1664	415
22	Munshipulia	0	6068	0	1	CCS Airport	0	415	0

Peak Hour Section Loadings - 2025 - North South Corridor

Station no	Station Name	Boarding	Alighting	Sectional loading	Station no	Station Name	Boarding	Alighting	Sectional loading
1	CCS Airport	134	0	134	22	Munshipulia	4573	0	4573
2	Amausi	537	0	671	21	Indira Nagar	2905	0	7478
3	Transport Nagar	928	0	1599	20	Ram Sagar Mishra Nagar	1932	349	9061
4	Krishnagar	2799	92	4306	19	Lekhraj Market	3746	156	12651
5	Singar Nagar	1537	68	5775	18	Badshah Nagar	3143	271	15523
6	Alambagh	1771	381	7165	17	Mahanagar	7636	644	22515
7	Alambagh Bus Stand	2125	538	8752	16	IT College Junction	1434	577	23372
8	MAWAIYA	5506	518	13740	15	Vishwavidyalaya	787	1623	22536
9	Durgapuri	3960	653	17047	14	KDSinghBabuStadium	485	1227	21794
10	Lucknow Rly. Stn	9963	3903	23107	13	Hazarat Ganj	1749	1489	22054
11	Hussain Ganj	3626	843	25890	12	Sachivalaya	1103	1123	22034
12	Sachivalaya	648	1362	25176	11	Hussain Ganj	2392	1688	22738
13	Hazarat Ganj	768	3459	22485	10	Lucknow Rly. Stn	8699	7124	24313
14	KDSinghBabuStadium	521	1389	21617	9	Durgapuri	1685	3586	22412
15	Vishwavidyalaya	647	2247	20017	8	MAWAIYA	812	5189	18035
16	IT College Junction	1049	1524	19542	7	Alambagh Bus Stand	716	5592	13159
17	Mahanagar	1236	5134	15644	6	Alambagh	329	2967	10521
18	Badshah Nagar	521	2817	13348	5	Singar Nagar	87	1611	8997
19	Lekhraj Market	452	1465	12335	4	Krishnagar	179	3886	5290
20	Ram Sagar Mishra Nagar	204	5087	7452	3	Transport Nagar	0	2345	2945
21	Indira Nagar	0	998	6454	2	Amausi	0	2357	588
22	Munshipulia	0	6454	0	1	CCS	0	588	0

Peak Hour Section Loadings - 2030 - North South Corridor

Station no	Station Name	Boarding	Alighting	Sectional loading	Station no	Station Name	Boarding	Alighting	Sectional loading
1	CCS	140	0	140	22	Munshipulia	5105	0	5105
2	Amausi	561	0	701	21	Indira Nagar	3803	0	8908
3	Transport Nagar	1233	0	1934	20	Ram Sagar Mishra Nagar	2535	477	10966
4	Krishnagar	5413	123	7224	19	Lekhraj Market	5078	194	15850
5	Singar Nagar	1824	85	8963	18	Badshah Nagar	3671	443	19078
6	Alambagh	2200	642	10521	17	Mahanagar	8632	914	26796
7	Alambagh Bus Stand	2994	766	12749	16	IT College Junction	1998	938	27856
8	MAWAIYA	6357	682	18424	15	Vishwavidyalaya	1322	2513	26665
9	Durgapuri	4321	957	21788	14	KDSinghBabuStadium	969	1688	25946
10	Lucknow Rly. Stn	14116	4746	31158	13	Hazarat Ganj	2293	2844	25395
11	Hussain Ganj	4816	1019	34955	12	Sachivalaya	1547	1658	25284
12	Sachivalaya	794	1919	33830	11	Hussain Ganj	3014	2437	25861
13	Hazarat Ganj	867	4715	29982	10	Lucknow Rly. Stn	10010	8308	27563
14	KDSinghBabuStadium	676	1954	28704	9	Durgapuri	1612	3952	25223
15	Vishwavidyalaya	759	3055	26408	8	MAWAIYA	903	5564	20562
16	IT College Junction	1089	1959	25538	7	Alambagh Bus Stand	764	6331	14995
17	Mahanagar	1689	5981	21246	6	Alambagh	425	3537	11883
18	Badshah Nagar	729	3635	18340	5	Singar Nagar	113	1988	10008
19	Lekhraj Market	555	1724	17171	4	Krishnagar	244	4541	5711
20	Ram Sagar Mishra Nagar	258	6773	10656	3	Transport Nagar	0	2424	3287
21	Indira Nagar	0	2368	8288	2	Amausi	0	2630	657
22	Munshipulia	0	8288	0	1	CCS	0	657	0

Peak Hour Section Loadings - 2041 - North South Corridor

Station no	Station Name	Boarding	Alighting	Sectional loading	Station no	Station Name	Boarding	Alighting	Sectional loading
1	CCS	152	0	152	22	Munshipulia	5441	0	5441
2	Amausi	607	0	759	21	Indira Nagar	5327	0	10768
3	Transport Nagar	1846	0	2605	20	Ram Sagar Mishra Nagar	3347	609	13506
4	Krishnagar	7113	147	9571	19	Lekhraj Market	6459	446	19519
5	Singar Nagar	2348	91	11828	18	Badshah Nagar	5377	532	24364
6	Alambagh	2893	688	14033	17	Mahanagar	9566	1314	32616
7	Alambagh Bus Stand	5249	1075	18207	16	IT College Junction	1377	1480	32513
8	MAWAIYA	7503	1321	24389	15	Vishwavidyalaya	969	3052	30430
9	Durgapuri	6620	1330	29679	14	KDSinghBabuStadium	677	2668	28439
10	Lucknow Rly. Stn	17254	6242	40691	13	Hazarat Ganj	2643	3235	27847
11	Hussain Ganj	5179	1462	44408	12	Sachivalaya	1853	2038	27662
12	Sachivalaya	818	2733	42493	11	Hussain Ganj	3683	3128	28217
13	Hazarat Ganj	1064	5519	38038	10	Lucknow Rly. Stn	15981	9562	34636
14	KDSinghBabuStadium	751	2948	35841	9	Durgapuri	2193	4492	32337
15	Vishwavidyalaya	902	3793	32950	8	MAWAIYA	1215	7217	26335
16	IT College Junction	1371	2416	31905	7	Alambagh Bus Stand	1053	7807	19581
17	Mahanagar	2306	7317	26894	6	Alambagh	611	5053	15139
18	Badshah Nagar	822	4602	23114	5	Singar Nagar	351	2689	12801
19	Lekhraj Market	727	2204	21637	4	Krishnagar	372	4757	8416
20	Ram Sagar Mishra Nagar	377	7953	14061	3	Transport Nagar	0	3724	4692
21	Indira Nagar	0	3725	10336	2	Amausi	0	3684	1008
22	Munshipulia	0	10336	0	1	CCS	0	1008	0

Peak Hour Section Loadings – 2015– East-West Corridor

Station no	Station Name	Boarding	Alighting	Sectional loading		Station no	Station Name	Boarding	Alighting	Sectional loading
1	Lucknow Rly. Stn	3962	0	3962		12	Vasant kunj	172	0	180
2	Gautam Buddha Marg	206	176	3992		11	Musabagh	697	2	907
3	Aminabad	631	1629	2994		10	Sarfarazganj	376	10	1291
4	Pandey Ganj	305	683	2616		9	Balaganj	535	20	1831
5	City Rly. Stn	59	638	2037		8	Thakurganj	730	58	2537
6	Medical Chauraha	113	514	1636		7	Nawajganj	1596	223	3984
7	Nawajganj	99	721	1014		6	Medical Chauraha	882	166	4741
8	Thakurganj	70	273	811		5	City Rly. Stn	786	192	5372
9	Balaganj	80	377	514		4	Pandey Ganj	2176	446	7203
10	Sarfarazganj	21	329	206		3	Aminabad	1615	970	7923
11	Musabagh	20	156	70		2	Gautam Buddha Marg	434	273	8104
12	Vasant kunj	0	70	0		1	Lucknow Rly. Stn	0	7639	0

Peak Hour Section Loadings – 2020– East-West Corridor

Station no	Station Name	Boarding	Alighting	Sectional loading		Station no	Station Name	Boarding	Alighting	Sectional loading
1	Lucknow Rly. Stn	4498	0	4498		12	Vasant kunj	428	0	428
2	Gautam Buddha Marg	311	276	4533		11	Musabagh	796	3	1221
3	Aminabad	824	2167	3190		10	Sarfarazganj	672	12	1881
4	Pandey Ganj	489	808	2871		9	Balaganj	1800	43	3638
5	City Rly. Stn	96	661	2306		8	Thakurganj	1603	125	5116
6	Medical Chauraha	134	697	1743		7	Nawajganj	3330	312	8134
7	Nawajganj	170	786	1127		6	Medical Chauraha	1578	196	9516
8	Thakurganj	165	312	980		5	City Rly. Stn	1223	282	10457
9	Balaganj	119	391	708		4	Pandey Ganj	2939	573	12823
10	Sarfarazganj	25	411	322		3	Aminabad	2286	1295	13814
11	Musabagh	22	215	129		2	Gautam Buddha Marg	822	479	14157
12	Vasant kunj	0	129	0		1	Lucknow Rly. Stn	0	14157	0

Peak Hour Section Loadings – 2025– East-West Corridor

Station no	Station Name	Boarding	Alighting	Sectional loading		Station no	Station Name	Boarding	Alighting	Sectional loading
1	Lucknow Rly. Stn	4804	0	4804		12	Vasant kunj	598	0	598
2	Gautam Buddha Marg	387	335	4856		11	Musabagh	933	5	1526
3	Aminabad	890	2367	3379		10	Sarfarazganj	810	17	2319
4	Pandey Ganj	529	1029	2879		9	Balaganj	3504	58	5765
5	City Rly. Stn	163	735	2307		8	Thakurganj	2641	159	8247
6	Medical Chauraha	184	731	1760		7	Nawajganj	5978	585	13640
7	Nawajganj	348	806	1302		6	Medical Chauraha	2451	372	15719
8	Thakurganj	210	406	1106		5	City Rly. Stn	1717	324	17112
9	Balaganj	163	442	827		4	Pandey Ganj	3896	816	20192
10	Sarfarazganj	33	457	403		3	Aminabad	2987	2200	20979
11	Musabagh	26	280	149		2	Gautam Buddha Marg	1341	886	21434
12	Vasant kunj	0	149	0		1	Lucknow Rly. Stn	0	21434	0

Peak Hour Section Loadings – 2030– East-West Corridor

Station no	Station Name	Boarding	Alighting	Sectional loading		Station no	Station Name	Boarding	Alighting	Sectional loading
1	Lucknow Rly. Stn	5043	0	5043		12	Vasant kunj	714	0	714
2	Gautam Buddha Marg	421	387	5077		11	Musabagh	1113	8	1819
3	Aminabad	998	2446	3629		10	Sarfarazganj	935	23	2731
4	Pandey Ganj	664	1068	3225		9	Balaganj	4866	75	7522
5	City Rly. Stn	247	848	2624		8	Thakurganj	4169	234	11457
6	Medical Chauraha	280	846	2058		7	Nawajganj	8564	747	19274
7	Nawajganj	413	895	1576		6	Medical Chauraha	3577	516	22335
8	Thakurganj	298	482	1392		5	City Rly. Stn	2162	561	23936
9	Balaganj	274	509	1157		4	Pandey Ganj	5612	1256	28292
10	Sarfarazganj	37	669	525		3	Aminabad	3736	3135	28893
11	Musabagh	29	362	192		2	Gautam Buddha Marg	1842	1564	29171
12	Vasant kunj	0	192	0		1	Lucknow Rly. Stn	0	29171	0

Peak Hour Section Loadings – 2041– East-West Corridor

Station no	Station Name	Boarding	Alighting	Sectional loading		Station no	Station Name	Boarding	Alighting	Sectional loading
1	Lucknow Rly. Stn	6596	0	6596		12	Vasant kunj	927	0	927
2	Gautam Buddha Marg	618	451	6763		11	Musabagh	1269	34	2162
3	Aminabad	1023	2864	4922		10	Sarfarazganj	1545	107	3600
4	Pandey Ganj	720	1418	4224		9	Balaganj	5642	132	9110
5	City Rly. Stn	344	1096	3472		8	Thakurganj	6043	479	14674
6	Medical Chauraha	334	911	2895		7	Nawajganj	9943	919	23698
7	Nawajganj	466	1065	2296		6	Medical Chauraha	4749	780	27667
8	Thakurganj	341	614	2023		5	City Rly. Stn	3127	806	29988
9	Balaganj	351	592	1812		4	Pandey Ganj	6471	1503	34956
10	Sarfarazganj	69	691	1190		3	Aminabad	5232	4662	35526
11	Musabagh	46	571	665		2	Gautam Buddha Marg	4164	3494	36196
12	Vasant kunj	0	665	0		1	Lucknow Rly. Stn	0	36196	0

Annexure 2.3.

Trip Length Distribution for Metro Trips in Peak Hour

Trip Length Distribution-North South Corridor - 2015	
Trip Length (km)	**Trips**
0-3	7085
3-6	11572
6-9	12863
9-12	9718
12-15	4165
15-18	2039
>18	483
Trip Length Distribution - North South Corridor - 2020	
Trip Length (km)	**Trips**
0-3	8318
3-6	14039
6-9	15237
9-12	10406
12-15	4935
15-18	2561
>18	654
Trip Length Distribution - North South Corridor - 2025	
Trip Length (km)	**Trips**
0-3	12285
3-6	21554
6-9	23278
9-12	14469
12-15	7013
15-18	3718
>18	1007
Trip Length Distribution - North South Corridor - 2030	
Trip Length (km)	**Trips**
0-3	15757
3-6	27589
6-9	29137
9-12	17626
12-15	8728
15-18	5263
>18	1329

Trip Length Distribution - North South Corridor - 2041	
Trip Length (km)	**Trips**
0-3	21276
3-6	35343
6-9	36492
9-12	21897
12-15	10873
15-18	6705
>18	1811
Trip Length Distribution – East –West Corridor – 2015	
Trip Length (km)	**Trips**
0-3	8340
3-6	4560
6-9	1641
9-12	1023
Trip Length Distribution – East –West Corridor – 2020	
Trip Length (km)	**Trips**
0-3	11711
3-6	7550
6-9	3480
9-12	1588
Trip Length Distribution – East –West Corridor – 2025	
Trip Length (km)	**Trips**
0-3	15540
3-6	11467
6-9	5709
9-12	1877
Trip Length Distribution – East –West Corridor – 2030	
Trip Length (km)	**Trips**
0-3	20134
3-6	15628
6-9	7998
9-12	2184
Trip Length Distribution – East –West Corridor – 2041	
Trip Length (km)	**Trips**
0-3	25119
3-6	21421
6-9	10279
9-12	3202

Overall Average Trip Length in the Network	
Year	**Av. Trip length(km)**
2015	6.58
2020	6.64
2025	6.45
2030	6.37
2041	6.17

Chapter 3

Planning & Design Parameters

CHAPTER - 3

PLANNING & DESIGN PARAMETERS

3.0 ROUTE ALIGNMENT & GEOMETRIC DESIGN PARAMETERS

The geometric design norms presented in this chapter have been worked out based on a detailed evaluation of passenger comfort, safety, experience and internationally accepted practices used currently operating rapid transit and rail systems. Various alternatives were considered for most of these parameters but the best-suited ones have been adopted for the system as a whole.

3.1 ALIGNMENT CONSIDERATIONS

- Minimum tangent lengths between curves are recommended to ensure sufficient time for passengers to recover from one curve before entering another.
- Super elevation on curves is applied to counter the effect of lateral force felt by passengers and to prevent passengers from feeling as if they are sliding across the seat.
- Minimum vertical curve radii are designed with passenger comfort in mind.

3.2. GENERAL CRITERIA

General criteria used for the design purpose is given below:

TABLE 3.1 DESIGN CRITERIA

SN	CRITERIA	DIMENSION
1	Gauge (14mm below top of rail crown)	1435 mm
2	Design Speed	80 kmph
3	Maximum axle load	16T
4	Electric power collection	25 kv ac (OHE)

3.3 HORIZONTAL ALIGNMENT

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

The maximum operating speed for the mainline shall be 80 km/hr. Wherever, feasible, maximum speed will be maintained through the curved sections also by providing adequate cant. On consideration of maximum allowable cant of 110 mm and cant deficiency of 85 mm on metro tracks, the safe speed on curves of radii of 350 m or more is 80 km/h. On elevated section use of curves with desirable minimum radius of 200 m having speed of 60 km/h shall be adopted. There are however, exceptional situations where due to site constraints; use of sharper curves is unavoidable. On few locations adoption of curves of 122.1 m radius (safe speed of 40 km/h) has been necessary. However in underground section desirable minimum radius of curve shall be 300 m for the ease of working of the tunnel boring machine (TBM) with absolute minimum radius of 200 m in case the construction is done by New Austrian Tunnelling Method or by Cut & Cover.

3.3.1 TANGENT SECTIONS

The horizontal alignment shall be on tangent at all station platforms for the entire length of the platform. The platform length is based on a "full train set" length, which consists of 6 coaches /cars. To maintain constant distance between platform and vehicle, tangent section shall also extend beyond each end of platform. The minimum desirable tangent length beyond each end of a platform is usually based on length of one coach / car. Wherever straight is not possible at station platform, maximum curve radius of 1000 m is proposed.

3.3.2 CURVED SECTIONS

Circular Curves

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

The minimum length of a circular curve shall be either V/2 in metres, where V is the design speed in km/h or 25 m whichever is higher in order to accommodate the full length of a car/coach.

For dual tracks on curves, the smaller of the two radii shall govern the selection of clearance requirement and minimum spacing of track centres. The curve parameters are as below:

CURVE RADIUS IN MID SECTION	
(i) Underground sections	
Minimum	300 m
Absolute Minimum	200 m
(ii) Elevated Section	
Minimum	200 m
Absolute minimum	120 m
Minimum curve radius at stations	**1000 m**
Maximum permissible cant (Ca)	**120 mm**
Maximum cant deficiency (Cd)	**100 mm**

Compound Curves

Compound curves will not normally be required between two different radii of the circular curves where the change of radius of the larger curve does not exceed 15% of the radius of the smaller curve and provided cant deficiency and/or cant excess criteria are not exceeded for either circular curve. Where a compound circular curve is employed with a change of radius greater than 15% of the smaller radius, or where the cant deficiency or cant excess criteria necessitate a change in cant between the circular curves, a suitable transition curve shall be interposed between two parts of the curve. The length of such a transition curve shall be equal to the difference between the required transition lengths at each end of the curve.

Reverse Curves

The use of reverse curves is discouraged but where necessary, the two curves shall be separated by a length equal to the sum of the two spiral curve lengths. If restricted by physical constraints, the cant can vary continuously from one direction to the other.

Transition curves

As far as possible, the alignment follows the existing roads. The existing roads also have frequent curves and leads to introduction of many horizontal curves in the metro route alignment. Larger radii shall be used whenever possible to improve rider comfort. However, it is necessary to provide transition curves at both ends of the circular curves for smooth transition of the cars /coaches from straight section to canted / super elevated curves section.

The topology of Lucknow is not very undulating; the terrain type is almost plain. But there are number of grade separators in the city and bridges across the river Gomti. Thus, it is necessary to provide vertical curves along the alignment to maintain sufficient clearance from the existing structures. In case of ballast less track, it is desirable that the vertical curves and the transition curves of horizontal curves should not overlap. Minimum straight length between two transition curves shall be either 25m or nil and minimum curve length between two transition curves shall be 25m.

For safety and comfort of passengers, the transition curves have to be designed with 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	
No overlap is allowed between transition curves and vertical curves.		
Minimum straight between two Transition curves		either 25 m or NIL
Minimum curve length between two transition curves		25

3.4 VERTICAL ALIGNMENT

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

3.4.1 ELEVATED SECTIONS

Track supporting structures on Elevated sections are to permit a minimum vertical clearance of 5.5 m above road level. For meeting this requirement with the 'Box' shaped pre-stressed concrete girders, 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.

Similarly, the rail level for the stations on road locations (with concourse on sides on ground) shall be at least 10.5 m above the road level in the central portion and 9.5 m at ends.

The track centre on the elevated section is kept as 4.2 m uniform through out the corridor to standardize the superstructure, except at few locations wherever scissors crossings are planned; it is kept at 4.5m.

3.4.2 UNDERGROUND SECTIONS

Rail level at midsection in tunnelling portion shall be kept at least 12.0 m below the ground level. At stations, the desirable depth of rail below ground level shall be at least 13 m, so that station concourse can be accommodated above the platforms. This requirement has been kept in view while designing the vertical profile.

Track centre in underground sections are as follows.

Sections where stations are to be constructed by Cut & Cover and running section by TBM to accommodate 12m wide platform	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 are to be constructed by Cut and Cover	4.50 m

The Interchange station between the North-South and East-West corridor has been proposed at Lucknow Rly. Station. The Lucknow Station in the North-South corridor will be elevated and in the East-West corridor will be underground.

3.5 GRADIENTS

3.5.1 STATION TRACKS

Normally the stations shall be on level stretch. Change of grade within length of station platform plus one car beyond each end of the platform is not permitted. There preferred grade for station areas is 0.0% (although there must be adequate drainage).

3.5.2 INTER-STATION TRACKS

The grade on the sections between the stations shall not be steeper than 2.0%. However, there are a few situations, where steeper gradients are unavoidable, such as

a) Switch over ramp between underground and elevated sections where a grade of up to 4% is adopted to minimise the length of ramp.

b) Where the existing road gradient is more than 2% as the elevated section is kept parallel to the road surface to minimise the rail level (to reduce the pier height).

So the maximum desirable sustained grade shall be 4% or less. The minimum desirable length of constant profile grade shall be 100 metres. A flat (0.0%) grade is accepted, if adequate drainage can be provided. However, in practice alternating longitudinal grades of 0.5% with drains at the low point, being the most effective way of assuring proper drainage. Drainage provisions in tunnel sections shall require the profile to have a desirable minimum grade of 0.5% and an absolute minimum of 0.25%.

3.5.3 DEPOT TRACKS

In case of depots the desirable grade on stabling tracks is 0.0% but the maximum grade shall not exceed 0.3%. Adequate track drainage shall be designed to suit the actual grade. All shop tracks be at0.0% grade. Sidings shall be level or shall fall away from the main line connection at a gradient not exceeding 0.25%. Train berths shall be level or shall fall towards the end stops at a gradient not exceeding 0.25%.

3.6 VERTICAL CURVES

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

Vertical curves in main lines shall wherever possible be positioned such that coincidence with both transition curves and canted portions is avoided. Where such coincidence is unavoidable the largest practicable vertical curve radius shall be employed and the cant gradient shall be the minimum. In all such cases the resultant geometry shall be verified as being compatible with safe passage at the design speeds by the proposed rolling stock.

Minimum radius and length of vertical curves shall be:

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**

3.7 DESIGN SPEED

The maximum sectional speed will be 80 kmph. However, the applied cant and the length of the transition will be decided in relation to normal speeds at various locations as determined by simulation studies of the alignment. The objective is to minimise the wear on rails at curved portions. The parameters of cant, permitted speed and min transition lengths are summarised below:

CANTS, PERMITTED SPEED AND MINIMUM TRANSITION LENGTH FOR CURVES

RADIUS	ACTUAL CANT	PERMITTED SPEED
(m)	**(mm)**	**(kmph)**
120	110.00	40
150	110.00	45
200	110.00	55
300	110.00	70
400	110.00	80
500	80.00	80
600	65.00	80
700	55.00	80
800	50.00	80

900	45.00	80
1000	40.00	80
1500	25.00	80
2000	20.00	80
2500	15.00	80
3000	15.00	80
3500	10.00	80
4000	10.00	80

3.8 STATION LOCATIONS

Stations have been located so as to serve passenger requirements and enable convenient integration with other modes of transport. However effort has also been made to plan the station locations as uniform an inter station distance as feasible. The average spacing of stations is kept close to one km for better operational plans.

3.9 PERMANENT WAY

3.9.1 CHOICE OF GAUGE

Based on extensive survey of the travel pattern in Lucknow City and discussions with the officials of the State Government and Lucknow Development Authority, DMRC has finalized the following corridors as most eligible for introduction of a Metro System in Lucknow City. The brief details of the corridors are as under:

a) North-South corridor from Amausi to Minshipulia covering a length of 22.878 km with 22 stations out of which three underground and remaining elevated.

c) East-West corridor from Lucknow Railway Station to Vasantkunj covering a length of 10.985 km with 12 stations (7 underground & 5 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 commuter 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 cross-overs 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.

3.9.2 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.

3.9.3 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.

3.9.4 BALLAST-LESS TRACK ON VIADUCTS

On the viaducts, it is proposed to adopt plinth type ballast less track structure with RCC derailment guards integrated with the plinths (shown in **Fig.3.1**). Further, it is proposed to Fastenings System suitable system for both types of ballast less and ballasted track structure complying to performance as laid down by Railway Board vide their Circular No. 2009/Proj/MAS/9/2, dated 02.05.2010 with a base-plate to base-plate spacing of 65 cm. on viaducts. The toe load design for the clips is to be finalised at the detail design stage.

3.9.5 BALLAST LESS TRACK IN DEPOT

The ballast less 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.

3.9.6 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.3.2**).

  ii) On Depot lines, 1 in 7 type turnout with a lead radius of 140 metres and permissible speed on divergent track as 25 km/h (shown in **Fig.3.3**).

- 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.3.4**).

- 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 ballast less 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.

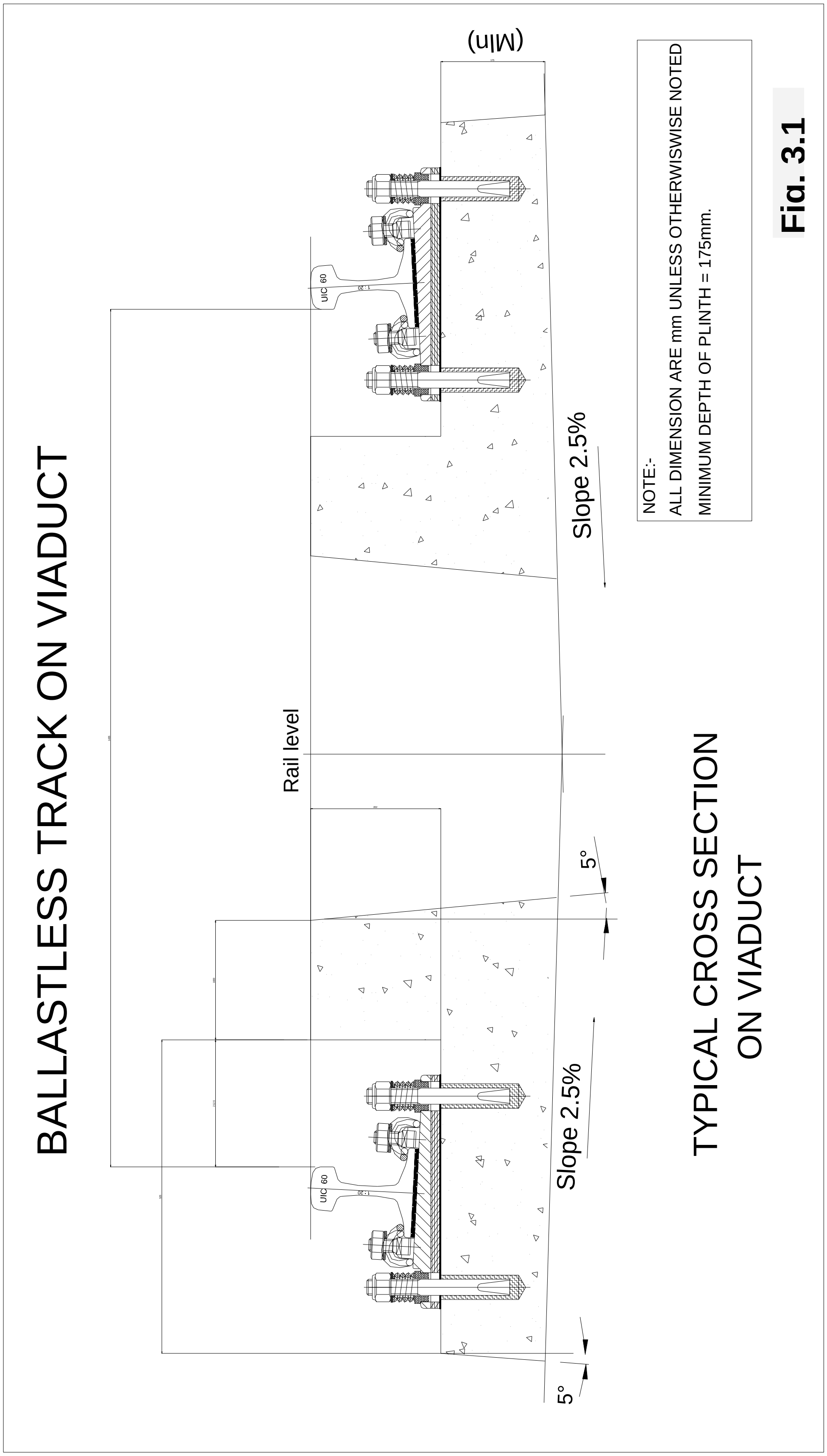
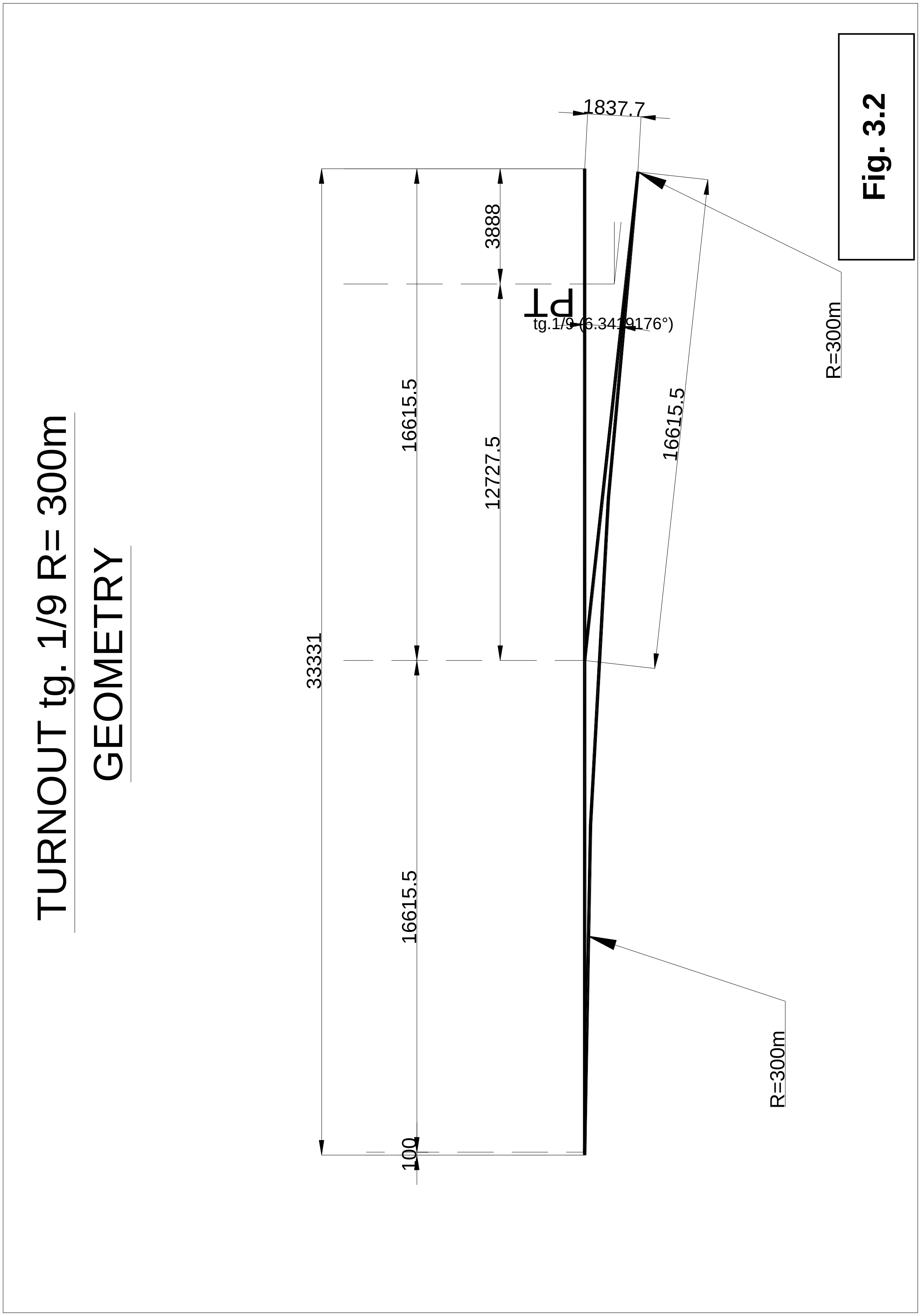

BALLASTLESS TRACK ON VIADUCT
Rail level
UIC 60
UIC 60
Slope 2.5%
Slope 2.5%
5°
5°
(Min)
TYPICAL CROSS SECTION ON VIADUCT
NOTE:-
ALL DIMENSION ARE mm UNLESS OTHERWISWISE NOTED
MINIMUM DEPTH OF PLINTH = 175mm.

Fig. 3.1



TURNOUT tg. 1/9 R= 300m
GEOMETRY
Fig. 3.2
1837.7
3888
PT
tg.1/9 (6.3419176°)
16615.5
12727.5
16615.5
33331
16615.5
100
R=300m
R=300m

TURNOUT tg. 1/7 R= 190 m

GEOMETRY

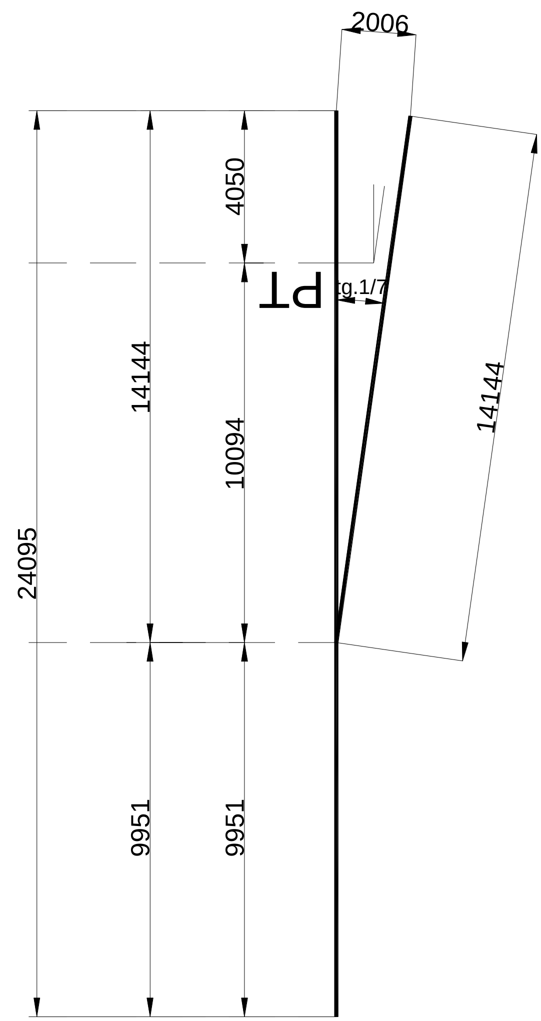


Fig No. 3.3

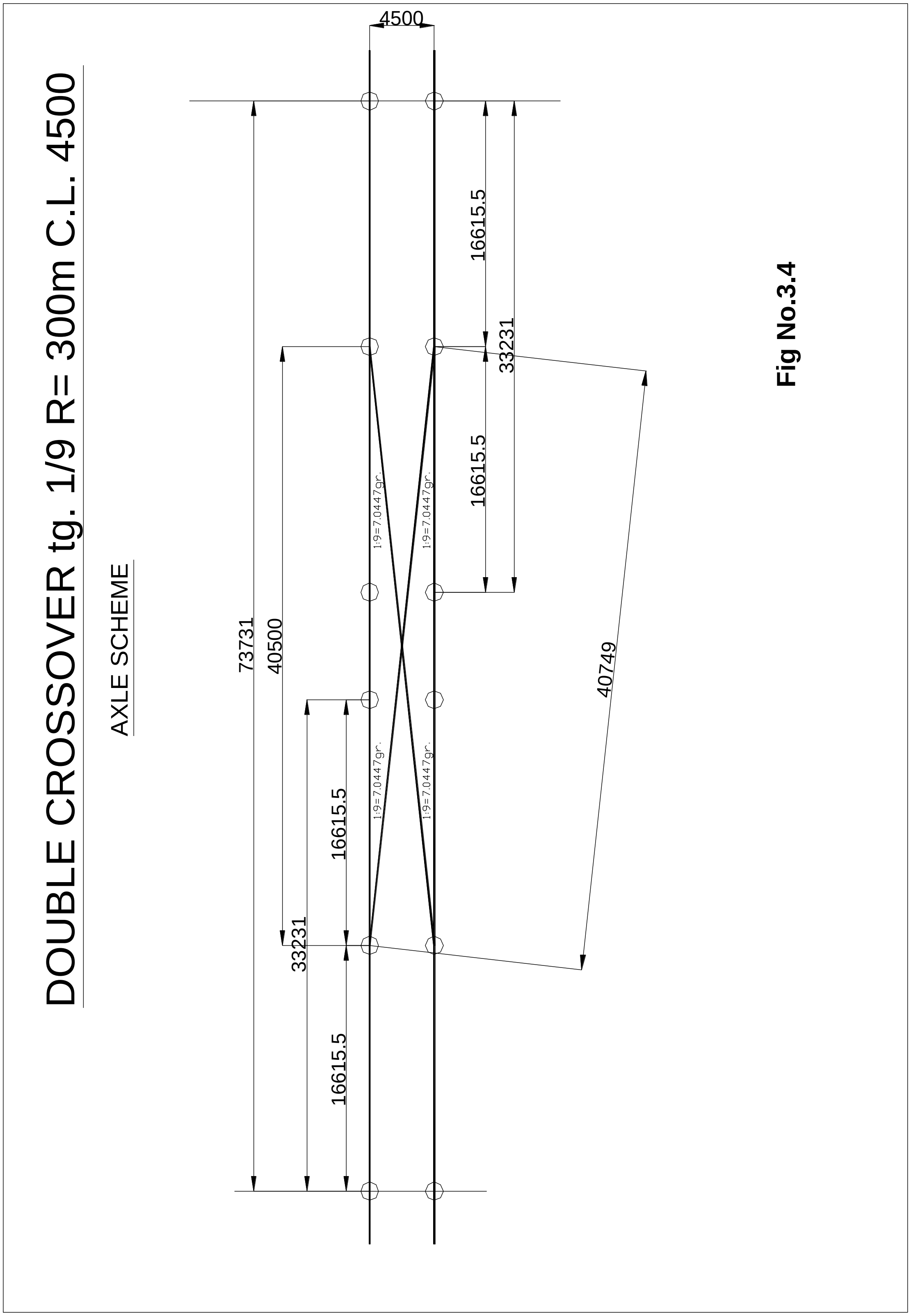

DOUBLE CROSSOVER tg. 1/9 R= 300m C.L. 4500
AXLE SCHEME
4500
73731
40500
16615.5
33231
16615.5
16615.5
33231
16615.5
40749
1:9=7.0447gr.
1:9=7.0447gr.
1:9=7.0447gr.
1:9=7.0447gr.

Fig No.3.4

Chapter 4

Civil Engineering

- 4.1 Route Alignment
- 4.2 Geotechnical Investigations
- 4.3 Station Planning
- 4.4 Construction Methodology
- 4.5 Utility Diversions
- 4.6 Land Requirement For Corridors

CHAPTER - 4

CIVIL ENGINEERING

4. CIVIL ENGINEERING

4.1 ROUTE ALIGNMENT

During the traffic studies carried out for Lucknow City, number of corridors were examined based on the Peak hour Peak Direction traffic (PHPDT) and the importance of locality to be served, two corridors have finally been frozen i.e.Corridor-1 from North to South and Corridor-2 from East to West. Of the two corridors the North-South corridor from Chaudhari Charan Singh Airport to Munshi Pulia has been recommended for execution in the Phase-I.

Two corridors, i.e. North-South and East-West Corridors have been proposed for Lucknow Metro is shown as **Figure 4.1**. Both the North –South Corridor and the East-West Corridors are partly underground and elevated. The elevated alignment is mostly located on the median of the roads. In the central area near Lucknow Railway Station, Aminabad, Hazratganj the N-S and E-W corridor will run underground with switch-over ramps for transitions from elevated to underground on NH-25 (Kanpur Road) and underground to elevated on the Mahatma Gandhi Road at the end of Hazratganj Market for the N-S corridor, for E-W corridor the ramp has been proposed at the Hardoi road to transit from underground to elevated. The depots for the East – West corridor has been proposed in Open Land behind Fish Mandi on the Hardoi Road and for North-South Corridor in open / Agricultural land near Amausi Airport. The break-up of length of the two corridors (in kilometers) is given below in **Table 4.1**.

Table 4.1 PROPOSED MRTS CORRIODRS

Corridors	Total	Elevated	Ramp	Underground	At Grade
North – South (CCS Airport to Munshi Pulia)	22.878 km	19.051 km	0.774 km	3.053 km	-
East – West (Lko rly. Station to Vasantkunj)	11.098 km	4.295 km	0.505 km	6.298 km	-

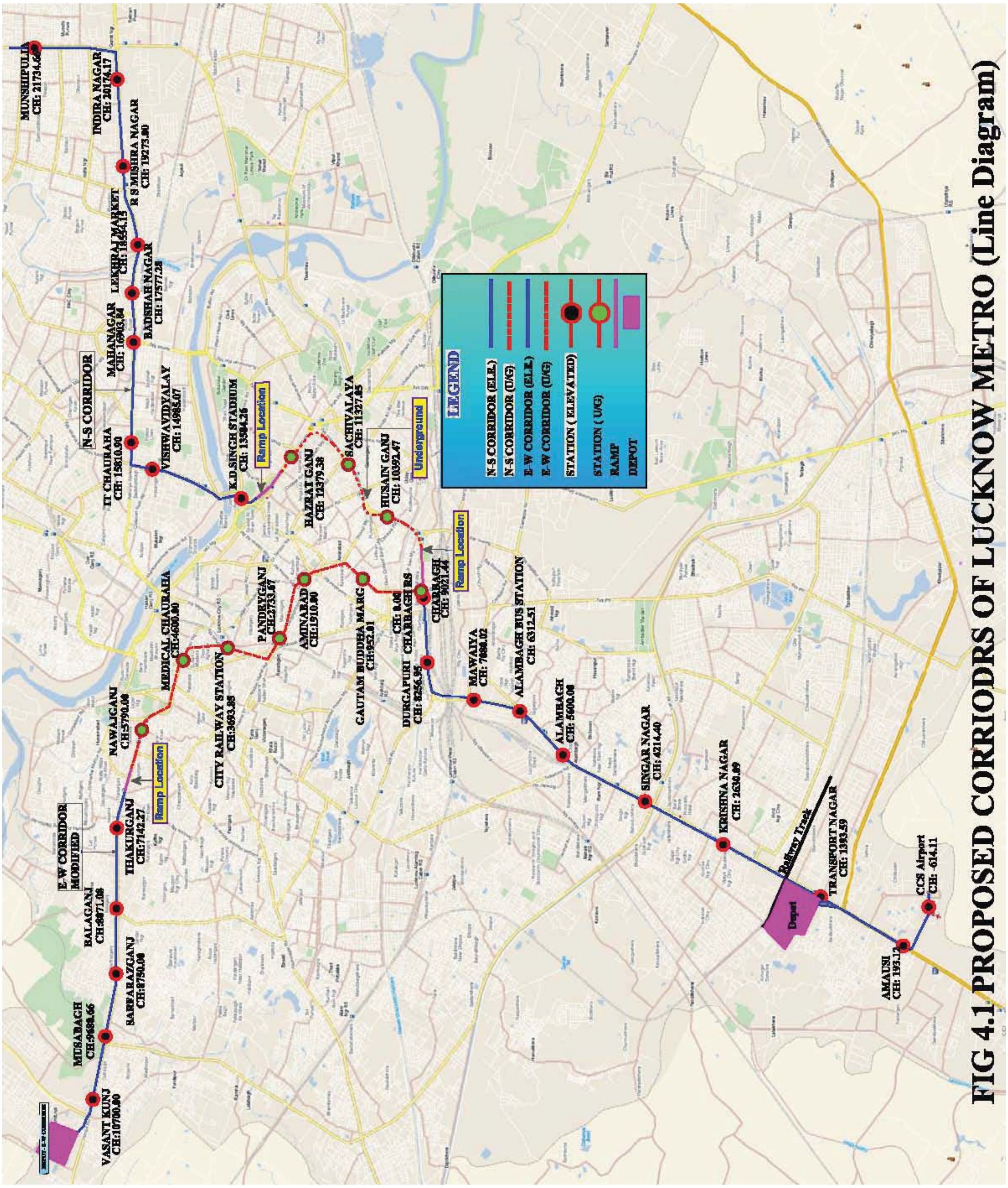


FIG 4.1 PROPOSED CORRIODRS OF LUCKNOW METRO (Line Diagram)

4.1.1 CORRIDOR 1: NORTH-SOUTH

4.1.1.1 General Description of the Route

The 22.878 km long alignment is planned partially underground in the central area of Lucknow and partially elevated. This corridor originates from the campus of the

Chaudhary Charan Singh International Airport, Amausi, with a terminal station namely Chaudhary Charan Singh (CCS) near the parking of the new terminal and will serve the old terminal also via skywalks. The alignment starts from chainage (-)735.00 and the centreline of the first station i.e CCS station is taken as (-) 614.11 for reckoning of chainage on Corridor-1, as compared to the previous plan. The chainage increases form CCS Airport, Amausi to MunshiPulia Station. The Line from Amausi towards Munshi Pulia is named as “Dn Line” and from Munshi Pulia to Amausi is named as “Up Line”. The alignment will terminate at the Chaudhary Charan Singh Airport Station with the trait reversed facility on the front via the proposed crossover towards Munshi Pulia. Only one platform will be used for operations.

The CCS station has been proposed and designed in coordination with the development master plan of the CCS airport’s new terminal. From the CCS Station the alignment runs towards west (towards NH-25) parallel to the road towards airport. Near the T-Junction the alignment takes sharp right turn with a radius of 122.1 m and turns toward north of the corridor along the NH-25. At km 193.12 of N.H-25, Amausi station has been proposed on the center of the road and the alignment runs towards the north direction along the National Highway-25 (Kanpur Road). The alignment runs along the central median of the NH-25 with three curves of large radii > 3500 m till the next station Transport Nagar at chainage 1393.59. This station will very well serve the RTO office, the literacy house and the police quarters. One important road 6 lane (from Ramabai Ambedkar Maidan) also joins the alignment at chainage 1025.49 in between the proposed Amausi and Transport Nagar Metro Station. The Depot has been proposed on the LHS of the road in the campus of PAC just before the Transport Nagar Station.

Further also the alignment also runs along NH-25 towards north on median of the road. There is a ROB (Rail Over Bridge) at chainage 1955.90 (Kanpur-Khaika). The Metro alignment will cross the ROB with rail level as 18.74 m from ground level and with a height difference of 11.41 m from the existing rail tracks. The alignment up to the next station Krishna Nagar, proposed at chainage 2630.09 is on the straight. After the Krishna Nagar station two large curves of radii 9000 m and 16000 m are provided to keep the alignment along the median of the road. Office of Home Guards and Lucknow Polytechnic is situate between chainage 2950.00 and chainage 3235.00 on RHS of the alignment and Krishna Nagar Police station at chainage 3218.00 on the LHS.

The next station on the alignment is Singar Nagar at Chainage 4214.40.The station has been proposed just after the major junction of VIP Road and the connection to Hardoi Road. The station is proposed at the busy market area and the alignment follows median of the road. Further, the alignment continues along the centreline of the road till Alambagh junction. Just before the Alambagh Junction the alignment goes off the road towards LHS (with a curve radius of 250 m) to avoid very sharp curve and the Alambagh Station (at chainage 5600.00) has been proposed immediately after crossing the junction, so that the entry/ exit points can be placed in the open area. The road on the LHS is the Talkatora Road and goes towards Rajajipuram. The boundary on the LHS of the road is of the Railway’s Locomotive Workshop, Alambagh.

From the Alambagh station the alignment continues to follow the centreline of the Kanpur Road (NH-25) in the Alambagh Market area and the next station is proposed as Alambagh Bus Stand metro station (at Chainage 6312.51).

After the Alambagh Bus stand, the alignment continues to follow the NH 25 and turns left with 300 m curve radius and the Mawaiya station (at Chainage 7080.02) has been proposed just before the TN Chowk (at chainage 7224.65). The two roads on TN road junction go to Cantonment area on RHS and towards Talkatora on LHS.

After the Mawaiya station the alignment crosses over railways area. Few railway quarters and the thermite wealding trainee's hostel at this area will have to be acquired. From chainage 7476.86 to 7554.08 there are existing railway tracks for the Charbagh Railway Station, Lucknow Railway Station and towards the yard. Total 12 number of running railway track lines will be crossed with a span length of 88.81 m. The rail level has been kept at 11 to 12 m above the running railway track levels. After crossing the railway llines, the alignment crosses over railway land and takes right with a curve radius of 140.0m to follow the centreline of NH-25 and fit the Durgapuri station at chainage 8256.95.

The alignment continues to follows the center of the road and the next station i.e. Lucknow/ Charbagh Railway Station proposed at chainage 9021.44.This station have been planned in integration with the Charbagh underground station on East-West corridor. As, the East-West corridor will be take up by the state government after a revised detailed feasibility study, the elevated station has been proposed and designed in a manner to integrate the Charbagh Bus stand, NE railway line station of Indian Railways, the Charbagh railway station. A common entry exit structure has been proposed for the elevated as well as the underground station. From chainage 8643.19 to chainage 8831.41, Charbagh Bus Depot exists on the LHS of the road. After Lucknow Railway Station the alignment has to corss through congested areas of Hussainganj and Hazratganj. Also, the alignment has to cross along the Vidhan Sabha. These locations being valued aesthetically, considered most congested roads during peak hours and with a view of security to the Vidhan sabha, the alignment has been proposed to be undergrounf in these locations. After the Charbagh Station the ramp has been proposed to switch from elevated to underground at a gradient of -3.98%. The ramp has been planned along the center of the road and strategically to avoid any infringement with the railways land. The rail level at the start of the ramp is + 8.0 m from ground at chainage 9320.49. The switch over point where the rail level is 0.0 is at chainage 9527.02. The ramp ends at chainage 9730.83 and the rail level at this chainage is -8.0 m i.e 8.0 m below ground level. The ramp ends at 32m before the KKC Junction. The track center to center distances have been increased to 32 m after the ramp to avoid any infringement with the foundations of the minor bridge over Hyder Canal. After the end of ramp at chainage 9730.83, the construction will done by cut and cover method till chainage 9838.6. At this chainage the rail level will be at 12 m below ground level and also the track centers will be more than 12.0 m, to facilitate the lowering of shaft for the Tunnel Boring Machine (TBM).

The first underground station Hussianganj has been proposed below the road at chaingae 10392.47. After the Hussainganj Station, the alignment takes sharp right turn to fit the next underground station “Sachiwalaya” in front of the Bapu Bhawan at chainage 11327.04. After the station the alignment takes sharp left turn at a curve radius of 300m and goes off the road so as to place the next station Hazratganj at chainage 12379.38 at the center of the road.

After the Hazrajganj station, the alignment has been proposed to be elevated and thus a switch over ramp has been proposed from the end of the Hazratganj Market till the parivartan Chowk along the road center and GPO at a gradient of 3.95%. The cut and cover construction methodology will be used from the Hazratganj Station. To keep the width of ramp at minimum, the the tracks has been proposed at center to center distance of 4.2m. From chainage 12256.38 to chainage 12783.38 the construction will be done by cut and cover alongwith the ramp. Two major structures i.e the Orietal building and a shopping mall will have to be acquired for construction. The rail level at the start of ramp at chainage 12783.38 is -8.0m and the rail level at the end of ramp is +8.0m at chainage 13147.42. Along the ramp, widening of roads upto 5.0 m on both sides has been proposed. The alignment at chainage 13250.65 achieves sufficient height from road for vertical clearance of 5.5 m above road at Parivartan Chowk. After the end of ramp, the alignment takes sharp right turn at curve radius of 120.0 m to fit in the K D Singh stadium station at chainage 13504.26, partially over road and partially in the campus of Hotel Clarks Awadh. This station will be accessible for the traffic from High court, M G Road etc. The alignment has been planned while maintaining a safe distance from the protected monuments like Sadat Ali’s Tomb, Murshid Jadi’s Tomb, Victoria Memorial etc. After the K D Singh stadium station, the alignment takes sharp right turn with a curve radius of 122.1 m preceded by a reverse curve of same radius. The alignment crosses the Gomti River and then follows the center of the University road till the Vishwavavidylaya station at chainage 14985.07. The cross-section drawing of the Gomti River has been received from the Irrigation Department of GoUP. The cross section drawing is attached herewith as **Figure 4.12**. This data has been obtained officially from Irrigation Department, Govt. of UP. To avoid any property acquisition at the IT Junction, the alignment takes sharp right turn with curve radius of 120.0 and follows the Faizabad road / NH-28. The IT college station has been proposed at chainage 15810.90 at the center of the road. The Isbela Thoburn College is located before this station on the LHS and Reserve Police Line area is on the RHS of the alignment. The alignment follows the centreline of the Faizabad Road NH-28 up to chainage 15964.80, 140.17 metres before the start of the Flyover (Indira Flyover Bridge) and shifts on LHS of the Flyover and crosses the railway lines at chainage 16278. The alignment maintains a safe distance from the flyover. Acquisition of properties will be needed along the proposed route in this section, which is comparatively lesser, if the alignment is planned on the RHS of the existing flyover. At the end of the flyover, near Mahanagar Junction there is an existing flyover across the proposed alignment. The next station Mahanagar (Chainage 16903.84) has been proposed after crossing the flyover at the Mahanagar junction and parallel to the other existing flyover turning towards the Paper Mill. The rail level at the station has been kept at 17.00m above the ground level for sufficient clearance from the flyover top. The station centreline is 16.36m from the edge of the flyover on the left hand side and land and property acquisitions are required in this location also. The alignment again meets the centreline of the NH-28 (Faizabad Road) at 106.47 m from the end of the flyover at chainage 17208.76 and continues to follow the curves along the road centreline and reaches the next proposed station at Badshahnagar (Chainage 17577.28). The alignment then goes off the road on the LHS to cross the Kukrail Nala at Chainage 17872.21 to chainage 17908.25. The span of the existing minor bridge over the Kukrail Nala is 70.0 m and to avoid such a large span, the alignment has been planned along the LHS and crosses the Nala' location off the road. The alignment maintains sufficient distance from the existing ROW. Property acquisitions are required along the route where the alignment goes off the road and also where the alignment will meet the road centre. UP Bridge Corporation has proposed a flyover across the existing Bridge. Therefore, proposed metro corridor will have to cross the proposed PWD flyover at a safe height with the rail level at 24-25 m above the ground level. As per the drawing provided by UPPWD, NH Division (attached as **Figure 4.13)** the finished level of the flyover at the proposed metro alignment location is 121.337m (as in drawing provided by UPPWD) and the rail level of metro alignment has been proposed at 131.786m (reference from SOI Bench mark). The alignment then takes right turn to again meet the NH-28 (Faizabad Road) at chainage 18161.09 and will continue to follow the existing road centreline. The next station Lekhraj Market (Chainage 18554.15) has been proposed at the centre of the road with the entry / exit points on the service roads of the market.

After the Lekhraj Market, the alignment continues to follow the road centreline and the next station is proposed at Ram Sagar Mishra Nagar (Chainage 19273.00). There are no major issues in the station location and sufficient road width, as well as, vacant land is available to construct the associated facilities with the station. After the station location HAL (Hindustan Aeronautics Ltd.) has its Accessories Manufacturing Division along the corridor on the RHS and on LHS is Gajipur police station and market. Further the alignment continues along the Faizabad Road and the Indira Nagar Station (Chainage 20174.17) has been proposed at a distance of 300.0 m from the HAL's main entrance. There are commercial buildings on both side of the station location. After the Indira Nagar station the alignment will take a sharp left turn of radius 150.0 m towards Munshi Pulia alongside the Polytechnic Flyover. At this station, junction arrangement is has been suggested for integration with proposed MRTS link to Gomti Nagar area. Two cross-overs one each in the front and rear are proposed at this station. In addition to this, 2 turnouts for the line coming from Gomti Nagar for connecting to mainline are also proposed.

After the alignment takes left turn towards Munshi Pulia, it will pass over few Pucca and few temporary Shops and Buildings and one under construction market complex and further will follow the left edge of the road along the boundary wall of ST Automotives, Gyan Mandir Kanya Inter College, Reliance auto work shop and over Shivam Palace. Then the alignment takes a right turn towards the road centreline at the end / start of the Polytechnic flyover. The alignment then continues along the centreline of the road and along Indira Nagar to reach the last station Munshi Pulia (Chainage 21734.26). The alignment has been extended 408.73 m from the centre line of the station to maintain a safe & proper reversal distance and will terminate at chainage 22143.26. Further the road heads towards Kukrail Reserve Forest and very congested built-up area of Indira Nagar and Munshi Pulia. At this 4-Leg Munshi Pulia Junction, road on the LHS is the Ring Road that crosses the Indira Nagar, Vikash Nagar, Tedhi Pulia etc and the road on the RHS goes towards the Indira Nagar Colony.

4.1.1.2 Terminal Stations

South Terminal

The Chaudhary Charan Singh Airport station will be the terminating station on the South end of the North-South Alignment. There is potential traffic along the NH-25 (Kanpur Road) towards Sarojni Nagar. At present there is no such proposal to extend the line towards these areas. Any extension proposed will be taken up in subsequent phases. The Terminal station has been proposed with following objectives:

- The master plan of AAI has been taken in consideration and the location of the proposed metro station has been proposed, accordingly.
- Being a National Highway, areas further ahead are well served with public transport that can integrate with the existing metro.
- There is enough land available for integration of various modes of transport. As the terminating station is proposed at the T-Junction towards Airport, it will cater to the passengers for various airlines along with the commuters coming form Kanpur and other places via Bus or any other mode.

North Terminal

The development is not very prominent beyond Munshi Pulia. Although roads are being constructed but the majority of buildings along the roads are shops and markets. Further along the route, there are built-up residential settlements and it is not feasible technically for further extension. Munshi Pulia Junction being a commercial centre and integration point for commuters serving the educational institutions and residential settlements. The station serves the ring road also.

4.1.1.3 Major Roads along the Route

The major roads along and across the alignment are given in the **Table 4.2**.

Table 4.2 MAJOR ROADS ALONG/ACROSS THE N-S CORRIDOR

Road	Chainage (m)	Direction (LHS / RHS)	Name of major roads across the alignment	Road Width
Kanpur road (NH-25)	590	RHS	International Air Cargo	09.17
Kanpur road (NH-25)	1025	RHS	Saheed Path	47.73
Kanpur road (NH-25)	1378	RHS	To RTO Office	14.00
Kanpur road (NH-25)	1479	RHS	To RTO Office	12.00
Kanpur road (NH-25)	1796	RHS	WBM Road	13.44
Kanpur road (NH-25)	2183	RHS	To Hind Nagar	10.69
Kanpur road (NH-25)	2475	RHS	To CMS College	09.18
Kanpur road (NH-25)	3330	RHS	To LDA office	09.74
Kanpur road (NH-25)	3657	RHS	To Aashiyana	11.84
Kanpur road (NH-25)	3883	RHS	To Aashiyana	13.19
Kanpur road (NH-25)	4018	RHS	To Canal Colony	22.79

Road	Chainage (m)	Direction (LHS / RHS)	Name of major roads across the alignment	Road Width
Kanpur road (NH-25)	4114	RHS	VIP Road	27.85
Kanpur road (NH-25)	4114	LHS	Towards Hardoi Road	26.15
Kanpur road (NH-25)	5430	LHS	To Rajaji Puram	09.25
Kanpur road (NH-25)	6500	RHS	Alambagh Marg	09.50
Kanpur road (NH-25)	7225	LHS	To Aishbagh Rly. Stn./ Talkatora (TN Chowk)	13.15
Kanpur road (NH-25)	7225	RHS	To Cantt. (TN Chowk)	6.49
Kanpur road (NH-25)	7756	LHS	Aishbag RS / Mill Road	14.5
Kanpur road (NH-25)	8470	LHS	G B Marg (To Aminabad)	18.48
Kanpur road (NH-25)	8870	LHS	Subhash Marg	18.5
Kanpur road (NH-25)	9150	LHS	To Naka Hindola	21.30
Kanpur road (NH-25)	9785	RHS	To SGPGI	8.08
Kanpur road (NH-25)	10655	LHS	Shivaji Marg & Guru Gobind Singh Marg	12.00
Kanpur road (NH-25)	10960	LHS	To Cantt	16.78
Kanpur road (NH-25)	10960	RHS	To Cantt	13.75
Kanpur road (NH-25)	11500	LHS	To Lalbagh (B.N Road)	14.60
Kanpur road (NH-25)	11500	RHS	To PGI	21.75
Kanpur road (NH-25)	11880	LHS	TN Road	15.50
MG Road	12400	RHS	Sahnajab Road	13.70
MG Road	12715	LHS	To SBI Local Head office	13.60
MG Road	12840	RHS	Maqbara Road	08.80
MG Road	13100	RHS	To K.D.Singh Stadium	13.86
MG Road	13250	RHS	Pariwartan Chowk	4 Legs
University Road	15172	-	IT Chauraha	4 Legs
Faizabad Road (NH-28)	16760	LHS	To Mahanagar (Flyover)	24.61
Faizabad Road (NH-28)	16760	RHS	To paper Mills(Flyover)	19.84
Faizabad Road (NH-28)	17150	LHS	To Badshah Nagar (Badshah Nagar Crossing)	13.31
Faizabad Road (NH-28)	17150	RHS	To Badshah Nagar rly Station (Badshah Nagar Crossing)	09.59
Faizabad Road (NH-28)	18430	LHS	To Indira Nagar	15.85
Faizabad Road (NH-28)	18788	LHS	Aditya Mishra Marg	15.15
Faizabad Road (NH-28)	19288	LHS	Bhooth Nath Marg	10.75
Faizabad Road (NH-28)	20244	LHS	To Indira Nagar (Arawali Marg)	16.50
Faizabad Road (NH-28)	20570	-	Polytechnic Chauraha	4-Leg
Himalaya Marg	20950	LHS	To Nishat Ganj	15.25
Himalaya Marg	21385	LHS	Kukrail Picnic Spot Road	15.25
Himalaya Marg	21900	LHS	To Sitapur	21.77
Himalaya Marg	21900	RHS	To Milayam Nagar	09.86

4.1.1.4 Alignment Route

The salient features of NS alignment is described distinctly and briefly with following sections.

(i) Elevated Section – Chainage (-) 735.00 to 9320.49

From chainage (-) 735.00 upto the start of ramp at chainage 9320.49, the alignment is elevated. Most of the elevated portion of the section follows the road geometry and centreline, except at the Alambagh Junction. The NH-25 is almost straight at most of the locations, yet to follow the road centreline 15 nos. of curves have been proposed in the 10055.49 m long stretch. The vertical alignment has been designed keeping in view the vertical clearance from the existing ground level is minimum 5.5 m and specially at rail line at chainage 1955.14 the rail level is 18.59 m above ground level. The topology is almost flat and thus not much steep gradients have been used in the alignment design. The gradient at all the station locations is flat.

(ii) Switch over Ramp - Chainage 9320.49 to 9730.83

As the alignment has to pass through very congested areas like Hussainganj and areas having very prominent structures like the Vidhan Sabha, Hazratganj etc., it has to be underground, so that the visual aesthetic value of the structures are retained and land acquisition can be avoided. To transit from elevated to underground the ramp has been proposed on the center of the NH-25 from chainage 9320.49 to 9730.83 after the Charbagh Railway Station.

The ramp has been planned at a gradient of 3.98% to minimise the length. A length of 410.34 m will be acquired permanently at the center of the road.

(iii) Underground Section – Chainage 9730.83 to 12783.38

Underground Section can further be divided in two sections

a) Underground section by Cut and Cover

b) Underground section by Tunneling Boring Machine (TBM) / New Austrian Tunneling Method (NATM)

(a) Underground section by Cut & Cover Method

At the end of the ramp the track centers are at a distance of 6.25m center to center. The shafts of Tunnel Boring Machines can not be lowered till the track centers are at a minimum distance of 12.0 m. So from chainage 9730.83 to 9838.61 the construction will be achieved by cut and cover. At chainage 9838.61 TBM shafts will be lowered. The cut and cover in this area needs few properties to be acquired.

Before the start of other switch-over-ramp from underground to elevated, The alignment after the Hazratganj station till start of ramp near the UP cooperative Bank at chainage 12783.38, the construction will be done by cut and cover.

(b) Underground section by Tunnel Boring Machine (TBM) / New Austrian Tunneling Method (NATM)

At chainage 9838.61 the tracks are 12.0 m apart and hence TBM shafts can be lowered.

The tunnelling will continue till chainage 12256.38 at the start of the Hazratganj Station. At this point the track centers are at 15.05 m. There are 3 underground stations proposed in this section. Most of the alignment is on curve to follow the road center to plan the stations under the road.

(vi) Switch Over Ramp km 12783.38 to km 13147.42

After crossing the prominent locations and congested market areas, the ramp has been proposed after the hazratganj station on MG Road. Wideing of roads have been proposed along both sides from UP post Master General office till start of K D Singh Babu stadium.A gradient of 3.95% has been proposed on the ramp to minimise the ramp length and to achieve the sufficient clearance from ground level before the Pariwartan chowk.

(vii) Elevated section km 13147.42 to km 22143.26

From Parivartan Chowk, the K D Singh Babu stadium has been proposed before the Gomti river. The alignment then follows the university road and takes a sharp right turn at IT Junction on to the NH-28, Faizabad Road and continues till the Polytechnic Chauraha and terminates at Munshipulia. The alignment follows the road center a most of the places except at the Indira flyover and Kokrail nala.The alignment has been proposed on the LHS of the Indra flyover flyover and also on LHS of the Kukrail Nala. Both these locations need some property acquisitions. The 8995.84 m alignment has 20 horizontal curves.

4.1.1.5 Vertical Profile

The topology of Lucknow is not very undulating and the terrain type in most of the length and sections along the proposed metro routes is plain. The level difference from lowest point on NH-28 (Faizabad Road) to highest point on NH-25 (Kanpur Road) is 16.0 m. None of the roads are very undulating and have smooth terrain except on University Road immediately after crossing the Gomti Bridge where the gradient is 2.5%. But the vertical profile of the proposed metro alignment will have vertical curves as there are ROB's, existing railway tracks and flyovers along the alignment and also at few locations the alignment had to be planned off the roads in view of geometric constraints. The gradients observed on this corridor are given in the **Table 4.3**.

Table 4.3 VERTICAL PROFILE – PROPOSED NORTH SOUTH METRO CORRIDOR

Type	Start Chainage	Start Elevation	Start Grade	End Chainage	End Elevation	End Grade	Length	Rise/ Fall
Linear	-0+735	133.22	0.00%	-0+119.155	133.225	0.00%	615.845	Level
Symmetrical Parabola	-0+119.155	133.225	0.00%	-0+62.779	133.382	0.56%	56.376	Rise
Linear	-0+62.779	133.382	0.56%	0+062.774	134.08	0.56%	125.553	Rise
Symmetrical Parabola	0+062.774	134.08	0.56%	0+114.558	134.225	0.00%	51.783	Rise
Linear	0+114.558	134.225	0.00%	0+271.894	134.225	0.00%	157.336	Level
Symmetrical Parabola	0+271.894	134.225	0.00%	0+320.838	133.764	-1.88%	48.944	Fall

Type	Start Chainage	Start Elevation	Start Grade	End Chainage	End Elevation	End Grade	Length	Rise/ Fall
Linear	0+320.838	133.764	-1.88%	0+402.153	132.233	-1.88%	81.315	Fall
Symmetrical Parabola	0+402.153	132.233	-1.88%	0+498.151	131.384	0.11%	95.998	Fall
Linear	0+498.151	131.384	0.11%	0+927.813	131.866	0.11%	429.661	Rise
Symmetrical Parabola	0+927.813	131.866	0.11%	0+995.484	132.17	0.79%	67.671	Rise
Linear	0+995.484	132.17	0.79%	1+253.608	134.199	0.79%	258.124	Rise
Symmetrical Parabola	1+253.608	134.199	0.79%	1+295.490	134.364	0.00%	41.882	Rise
Linear	1+295.490	134.364	0.00%	1+481.746	134.364	0.00%	186.256	Level
Symmetrical Parabola	1+481.746	134.364	0.00%	1+523.502	134.666	1.45%	41.756	Rise
Linear	1+523.502	134.666	1.45%	1+882.194	139.863	1.45%	358.693	Rise
Symmetrical Parabola	1+882.194	139.863	1.45%	2+059.945	139.993	-1.30%	177.751	Rise
Linear	2+059.945	139.993	-1.30%	2+463.256	134.741	-1.30%	403.311	Fall
Symmetrical Parabola	2+463.256	134.741	-1.30%	2+506.964	134.456	0.00%	43.708	Fall
Linear	2+506.964	134.456	0.00%	2+730.819	134.456	0.00%	223.855	Level
Symmetrical Parabola	2+730.819	134.456	0.00%	2+787.179	134.016	-1.56%	56.36	Fall
Linear	2+787.179	134.016	-1.56%	2+891.085	132.393	-1.56%	103.906	Fall
Symmetrical Parabola	2+891.085	132.393	-1.56%	2+946.282	131.981	0.07%	55.197	Fall
Linear	2+946.282	131.981	0.07%	3+910.516	132.631	0.07%	964.234	Rise
Symmetrical Parabola	3+910.516	132.631	0.07%	3+959.574	132.966	1.30%	49.058	Rise
Linear	3+959.574	132.966	1.30%	4+100.293	134.796	1.30%	140.72	Rise
Symmetrical Parabola	4+100.293	134.796	1.30%	4+136.704	135.033	0.00%	36.411	Rise
Linear	4+136.704	135.033	0.00%	4+326.263	135.033	0.00%	189.559	Level
Symmetrical Parabola	4+326.263	135.033	0.00%	4+374.625	134.683	-1.45%	48.362	Fall
Linear	4+374.625	134.683	-1.45%	4+577.467	131.746	-1.45%	202.842	Fall
Symmetrical Parabola	4+577.467	131.746	-1.45%	4+633.432	131.343	0.01%	55.965	Fall
Linear	4+633.432	131.343	0.01%	5+108.445	131.373	0.01%	475.013	Rise
Symmetrical Parabola	5+108.445	131.373	0.01%	5+164.612	131.752	1.35%	56.167	Rise
Linear	5+164.612	131.752	1.35%	5+322.220	133.871	1.35%	157.607	Rise
Symmetrical Parabola	5+322.220	133.871	1.35%	5+371.767	134.204	0.00%	49.548	Rise
Linear	5+371.767	134.204	0.00%	5+704.692	134.205	0.00%	332.925	Rise
Symmetrical Parabola	5+704.692	134.205	0.00%	5+749.558	133.794	-1.83%	44.866	Fall
Linear	5+749.558	133.794	-1.83%	5+863.447	131.706	-1.83%	113.889	Fall
Symmetrical Parabola	5+863.447	131.706	-1.83%	5+910.750	131.181	-0.39%	47.302	Fall
Linear	5+910.750	131.181	-0.39%	5+997.969	130.845	-0.39%	87.219	Fall
Symmetrical Parabola	5+997.969	130.845	-0.39%	6+044.980	130.96	0.88%	47.012	Rise
Linear	6+044.980	130.96	0.88%	6+172.503	132.075	0.88%	127.523	Rise
Symmetrical	6+172.503	132.075	0.88%	6+203.311	132.21	0.00%	30.808	Rise

Type	Start Chainage	Start Elevation	Start Grade	End Chainage	End Elevation	End Grade	Length	Rise/ Fall
Parabola								
Linear	6+203.311	132.21	0.00%	6+451.044	132.21	0.00%	247.732	Level
Symmetrical Parabola	6+451.044	132.21	0.00%	6+514.621	131.582	-1.98%	63.577	Fall
Linear	6+514.621	131.582	-1.98%	6+607.460	129.748	-1.98%	92.839	Fall
Symmetrical Parabola	6+607.460	129.748	-1.98%	6+644.958	129.359	-0.10%	37.498	Fall
Linear	6+644.958	129.359	-0.10%	6+799.882	129.203	-0.10%	154.923	Fall
Symmetrical Parabola	6+799.882	129.203	-0.10%	6+840.510	129.575	1.93%	40.628	Rise
Linear	6+840.510	129.575	1.93%	6+956.923	131.824	1.93%	116.413	Rise
Symmetrical Parabola	6+956.923	131.824	1.93%	6+995.546	132.197	0.00%	38.623	Rise
Linear	6+995.546	132.197	0.00%	7+393.474	132.197	0.00%	397.928	Level
Symmetrical Parabola	7+393.474	132.197	0.00%	7+490.548	131.385	-1.67%	97.074	Fall
Linear	7+490.548	131.385	-1.67%	7+728.800	127.397	-1.67%	238.253	Fall
Symmetrical Parabola	7+728.800	127.397	-1.67%	7+788.408	127.287	1.31%	59.608	Fall
Linear	7+788.408	127.287	1.31%	8+151.059	132.026	1.31%	362.651	Rise
Symmetrical Parabola	8+151.059	132.026	1.31%	8+177.189	132.197	0.00%	26.13	Rise
Linear	8+177.189	132.197	0.00%	8+336.006	132.197	0.00%	158.816	Level
Symmetrical Parabola	8+336.006	132.197	0.00%	8+377.146	131.837	-1.75%	41.141	Fall
Linear	8+377.146	131.837	-1.75%	8+498.917	129.702	-1.75%	121.77	Fall
Symmetrical Parabola	8+498.917	129.702	-1.75%	8+557.159	129.229	0.13%	58.242	Fall
Linear	8+557.159	129.229	0.13%	8+749.731	129.471	0.13%	192.573	Rise
Symmetrical Parabola	8+749.731	129.471	0.13%	8+810.511	130.111	1.98%	60.78	Rise
Linear	8+810.511	130.111	1.98%	8+907.515	132.033	1.98%	97.004	Rise
Symmetrical Parabola	8+907.515	132.033	1.98%	8+947.138	132.426	0.00%	39.623	Rise
Linear	8+947.138	132.426	0.00%	9+092.631	132.426	0.00%	145.493	Level
Symmetrical Parabola	9+092.631	132.426	0.00%	9+116.451	132.284	-1.19%	23.82	Fall
Linear	9+116.451	132.284	-1.19%	9+145.478	131.939	-1.19%	29.026	Fall
Symmetrical Parabola	9+145.478	131.939	-1.19%	9+168.242	131.538	-2.33%	22.764	Fall
Linear	9+168.242	131.538	-2.33%	9+250.510	129.621	-2.33%	82.268	Fall
Symmetrical Parabola	9+250.510	129.621	-2.33%	9+272.182	128.999	-3.42%	21.672	Fall
Linear	9+272.182	128.999	-3.42%	9+309.780	127.715	-3.42%	37.598	Fall
Symmetrical Parabola	9+309.780	127.715	-3.42%	9+329.780	126.975	-3.98%	20	Fall
Linear	9+329.780	126.975	-3.98%	10+041.186	98.634	-3.98%	711.406	Fall
Symmetrical Parabola	10+041.186	98.634	-3.98%	10+128.823	96.889	0.00%	87.636	Fall
Linear	10+128.823	96.889	0.00%	10+434.511	96.89	0.00%	305.688	Rise
Symmetrical Parabola	10+434.511	96.89	0.00%	10+471.986	96.637	-1.35%	37.476	Fall
Linear	10+471.986	96.637	-1.35%	10+612.072	94.748	-1.35%	140.086	Fall

Type	Start Chainage	Start Elevation	Start Grade	End Chainage	End Elevation	End Grade	Length	Rise/ Fall
Symmetrical Parabola	10+612.072	94.748	-1.35%	10+657.523	94.42	-0.10%	45.45	Fall
Linear	10+657.523	94.42	-0.10%	10+969.191	94.116	-0.10%	311.668	Fall
Symmetrical Parabola	10+969.191	94.116	-0.10%	10+990.191	94.021	-0.81%	21	Fall
Linear	10+990.191	94.021	-0.81%	11+114.682	93.016	-0.81%	124.491	Fall
Symmetrical Parabola	11+114.682	93.016	-0.81%	11+136.791	92.927	0.00%	22.109	Fall
Linear	11+136.791	92.927	0.00%	11+596.672	92.927	0.00%	459.881	Level
Symmetrical Parabola	11+596.672	92.927	0.00%	11+617.672	92.906	-0.20%	21	Fall
Linear	11+617.672	92.906	-0.20%	12+018.256	92.094	-0.20%	400.584	Fall
Symmetrical Parabola	12+018.256	92.094	-0.20%	12+083.440	92.49	1.42%	65.184	Rise
Linear	12+083.440	92.49	1.42%	12+190.193	94.004	1.42%	106.753	Rise
Symmetrical Parabola	12+190.193	94.004	1.42%	12+218.542	94.205	0.00%	28.35	Rise
Linear	12+218.542	94.205	0.00%	12+507.731	94.205	0.00%	289.189	Level
Symmetrical Parabola	12+507.731	94.205	0.00%	12+590.565	95.84	3.95%	82.834	Rise
Linear	12+590.565	95.84	3.95%	13+188.158	119.428	3.95%	597.593	Rise
Symmetrical Parabola	13+188.158	119.428	3.95%	13+229.056	120.643	2.00%	40.898	Rise
Linear	13+229.056	120.643	2.00%	13+328.110	122.621	2.00%	99.054	Rise
Symmetrical Parabola	13+328.110	122.621	2.00%	13+370.031	123.04	0.00%	41.921	Rise
Linear	13+370.031	123.04	0.00%	13+767.972	123.042	0.00%	397.941	Rise
Symmetrical Parabola	13+767.972	123.042	0.00%	13+813.237	122.642	-1.77%	45.265	Fall
Linear	13+813.237	122.642	-1.77%	14+039.395	118.642	-1.77%	226.159	Fall
Symmetrical Parabola	14+039.395	118.642	-1.77%	14+102.352	118.472	1.23%	62.956	Fall
Linear	14+102.352	118.472	1.23%	14+252.906	120.323	1.23%	150.555	Rise
Symmetrical Parabola	14+252.906	120.323	1.23%	14+272.978	120.474	0.27%	20.072	Rise
Linear	14+272.978	120.474	0.27%	14+659.112	121.53	0.27%	386.133	Rise
Symmetrical Parabola	14+659.112	121.53	0.27%	14+680.112	121.681	1.17%	21	Rise
Linear	14+680.112	121.681	1.17%	14+835.961	123.503	1.17%	155.849	Rise
Symmetrical Parabola	14+835.961	123.503	1.17%	14+867.125	123.685	0.00%	31.164	Rise
Linear	14+867.125	123.685	0.00%	15+116.922	123.686	0.00%	249.797	Rise
Symmetrical Parabola	15+116.922	123.686	0.00%	15+138.891	123.592	-0.85%	21.969	Fall
Linear	15+138.891	123.592	-0.85%	15+415.655	121.233	-0.85%	276.764	Fall
Symmetrical Parabola	15+415.655	121.233	-0.85%	15+465.460	121.3	1.12%	49.805	Rise
Linear	15+465.460	121.3	1.12%	15+665.528	123.548	1.12%	200.068	Rise
Symmetrical Parabola	15+665.528	123.548	1.12%	15+706.377	123.778	0.00%	40.848	Rise
Linear	15+706.377	123.778	0.00%	15+928.136	123.778	0.00%	221.759	Level
Symmetrical Parabola	15+928.136	123.778	0.00%	15+977.966	123.298	-1.93%	49.83	Fall

Type	Start Chainage	Start Elevation	Start Grade	End Chainage	End Elevation	End Grade	Length	Rise/ Fall
Linear	15+977.966	123.298	-1.93%	16+102.365	120.899	-1.93%	124.399	Fall
Symmetrical Parabola	16+102.365	120.899	-1.93%	16+158.187	120.419	0.21%	55.822	Fall
Linear	16+158.187	120.419	0.21%	16+473.156	121.078	0.21%	314.969	Rise
Symmetrical Parabola	16+473.156	121.078	0.21%	16+555.885	121.987	1.99%	82.729	Rise
Linear	16+555.885	121.987	1.99%	16+722.002	125.289	1.99%	166.117	Rise
Symmetrical Parabola	16+722.002	125.289	1.99%	16+791.505	125.98	0.00%	69.503	Rise
Linear	16+791.505	125.98	0.00%	17+050.502	125.98	0.00%	258.997	Level
Symmetrical Parabola	17+050.502	125.98	0.00%	17+089.469	125.917	-0.33%	38.967	Fall
Linear	17+089.469	125.917	-0.33%	17+432.519	124.791	-0.33%	343.049	Fall
Symmetrical Parabola	17+432.519	124.791	-0.33%	17+465.491	124.736	0.00%	32.973	Fall
Linear	17+465.491	124.736	0.00%	17+651.656	124.737	0.00%	186.164	Rise
Symmetrical Parabola	17+651.656	124.737	0.00%	17+706.254	125.447	2.60%	54.599	Rise
Linear	17+706.254	125.447	2.60%	17+950.309	131.794	2.60%	244.055	Rise
Symmetrical Parabola	17+950.309	131.794	2.60%	18+041.764	132.082	-1.97%	91.455	Rise
Linear	18+041.764	132.082	-1.97%	18+365.897	125.688	-1.97%	324.133	Fall
Symmetrical Parabola	18+365.897	125.688	-1.97%	18+425.592	125.099	0.00%	59.695	Fall
Linear	18+425.592	125.099	0.00%	18+688.599	125.099	0.00%	263.007	Level
Symmetrical Parabola	18+688.599	125.099	0.00%	18+753.212	124.666	-1.34%	64.613	Fall
Linear	18+753.212	124.666	-1.34%	18+838.164	123.526	-1.34%	84.952	Fall
Symmetrical Parabola	18+838.164	123.526	-1.34%	18+913.804	123.289	0.71%	75.639	Fall
Linear	18+913.804	123.289	0.71%	18+989.314	123.828	0.71%	75.511	Rise
Symmetrical Parabola	18+989.314	123.828	0.71%	19+025.563	124.319	2.00%	36.249	Rise
Linear	19+025.563	124.319	2.00%	19+131.019	126.423	2.00%	105.456	Rise
Symmetrical Parabola	19+131.019	126.423	2.00%	19+184.758	126.959	0.00%	53.739	Rise
Linear	19+184.758	126.959	0.00%	19+368.624	126.959	0.00%	183.866	Level
Symmetrical Parabola	19+368.624	126.959	0.00%	19+405.659	126.681	-1.50%	37.036	Fall
Linear	19+405.659	126.681	-1.50%	19+524.048	124.903	-1.50%	118.389	Fall
Symmetrical Parabola	19+524.048	124.903	-1.50%	19+560.954	124.686	0.32%	36.906	Fall
Linear	19+560.954	124.686	0.32%	19+792.279	125.434	0.32%	231.324	Rise
Symmetrical Parabola	19+792.279	125.434	0.32%	19+852.353	126.204	2.24%	60.074	Rise
Linear	19+852.353	126.204	2.24%	19+957.326	128.553	2.24%	104.973	Rise
Symmetrical Parabola	19+957.326	128.553	2.24%	20+002.077	129.054	0.00%	44.751	Rise
Linear	20+002.077	129.054	0.00%	20+342.530	129.055	0.00%	340.453	Rise
Symmetrical Parabola	20+342.530	129.055	0.00%	20+419.653	128.398	-1.70%	77.123	Fall
Linear	20+419.653	128.398	-1.70%	20+581.088	125.648	-1.70%	161.435	Fall
Symmetrical	20+581.088	125.648	-1.70%	20+615.792	125.358	0.03%	34.704	Fall

Type	Start Chainage	Start Elevation	Start Grade	End Chainage	End Elevation	End Grade	Length	Rise/ Fall
Parabola								
Linear	20+615.792	125.358	0.03%	21+380.420	125.601	0.03%	764.628	Rise
Symmetrical Parabola	21+380.420	125.601	0.03%	21+446.192	126.133	1.59%	65.772	Rise
Linear	21+446.192	126.133	1.59%	21+560.821	127.95	1.59%	114.629	Rise
Symmetrical Parabola	21+560.821	127.95	1.59%	21+629.188	128.492	0.00%	68.366	Rise
Linear	21+629.188	128.492	0.00%	21+893.580	128.492	0.00%	264.393	Level
Symmetrical Parabola	21+893.580	128.492	0.00%	21+937.230	128.144	-1.60%	43.649	Fall
Linear	21+937.230	128.144	-1.60%	22+143.260	124.857	-1.60%	206.031	Fall

4.1.1.6 Curvature

Although the topology of Lucknow is not very undulating and the terrain type is plain, yet the existing road has frequent horizontal curves to negotiate the densely built up areas. The proposed alignment also negotiates frequent horizontal curves to follow the existing road median. At some places there are sharp turns and curves along the road and this necessitates provision of sharp curves on metro alignment also. The radius of curves at intersections and at few locations has been planned as less as 122.1 m to reduce property acquisition. 22.74% of the length of the alignment is on curves. The details of curves planned on the proposed North-South Corridor are presented in Table **4.4**.

Table 4.4 DETAILS OF HORIZONTAL CURVES – PROPOSED NORTH SOUTH METRO

CHAINAGE				RADIUS (m)	TRANSITION LENGTH (m)	CURVE LENGTH (m)	STRAIGHT BETWEEN TWO CURVES (m)
P1	P2	P3	P4				
(TS/ PC)	(SC)	(CS)	(ST/PT)				
Start of Alignment			-735.00				282.14
-452.86	-397.46	-370.38	-314.98	157.25	55.40	27.08	133.72
-181.26	-125.78	5.92	61.39	122.10	55.48	131.70	448.53
509.93	-	-	729.22	20000.00	-	0.00	403.55
1132.76	1142.76	1297.00	1307.00	3500.00	10.00	154.24	1409.19
2716.19	-	-	2791.46	9000.00	-	0.00	653.00
3444.46	-	-	4100.09	16500.00	-	0.00	1272.28
5372.38	5427.38	5466.24	5521.24	250.00	55.00	38.86	411.09
5932.33	5952.33	6045.97	6065.98	1400.00	20.00	93.64	312.83
6378.80	6433.80	6537.08	6592.08	300.00	55.00	103.28	577.57
7169.65	7224.65	7269.11	7324.11	400.00	55.00	44.45	264.04
7588.15	7643.15	7790.15	7845.15	145.00	55.00	147.00	149.53
7994.68	8049.68	8070.49	8125.49	480.00	55.00	20.80	170.19
8295.68	8300.68	8403.15	8408.15	5000.00	5.00	102.47	708.43
9116.58	9144.58	9169.31	9197.31	1100.00	28.00	24.73	23.60
9220.91	9248.91	9273.64	9301.64	1100.00	28.00	24.73	382.63
9684.27	9739.96	9985.02	10040.70	307.53	55.69	245.06	111.85
10152.55	10208.23	10241.01	10296.70	307.53	55.69	32.78	241.63

CHAINAGE				RADIUS (m)	TRANSITION LENGTH (m)	CURVE LENGTH (m)	STRAIGHT BETWEEN TWO CURVES (m)
P1	P2	P3	P4				
(TS/ PC)	(SC)	(CS)	(ST/PT)				
10538.33	10594.01	10903.76	10959.44	307.53	55.69	309.74	63.78
11023.22	11078.90	11151.59	11207.27	307.53	55.69	72.68	226.39
11433.67	11489.18	11517.33	11572.84	407.53	55.52	28.14	129.67
11702.52	11758.20	12219.90	12275.58	307.53	55.69	461.70	367.05
12642.63	12692.63	12713.45	12763.45	660.00	50.00	20.82	94.35
12857.80	12912.80	12957.96	13012.96	300.00	55.00	45.16	237.69
13250.65	13306.13	13370.88	13426.36	122.10	55.48	64.75	150.14
13576.50	13631.98	13656.35	13711.83	122.10	55.48	24.37	0.02
13711.85	13767.33	13814.97	13870.45	122.10	55.48	47.64	89.60
13960.06	13980.06	14275.51	14295.51	1500.00	20.00	295.45	303.58
14599.09	14654.09	14684.31	14739.31	500.00	55.00	30.22	44.52
14783.83	14801.83	14867.75	14885.75	1800.00	18.00	65.92	181.94
15067.69	15123.17	15239.85	15295.33	122.10	55.48	116.68	600.64
15895.97	15925.97	15988.28	16018.28	1000.00	30.00	62.31	154.25
16172.53	16212.53	16241.42	16281.42	800.00	40.00	28.89	831.50
17112.92	17167.92	17198.20	17253.20	500.00	55.00	30.28	0.00
17253.20	17308.20	17353.57	17408.57	450.00	55.00	45.37	476.01
17884.58	17899.58	17935.13	17950.13	2000.00	15.00	35.55	91.81
18041.94	18096.94	18128.14	18183.14	300.00	55.00	31.20	87.86
18271.00	18311.00	18441.92	18481.92	760.00	40.00	130.92	140.51
18622.43	18677.43	18771.10	18826.10	450.00	55.00	93.66	1024.31
19850.41	-	-	20032.74	13000.00	-	-	395.00
20427.74	20482.74	20616.01	20671.01	150.00	55.00	133.27	68.84
20739.85	20779.85	20865.08	20905.08	800.00	40.00	85.23	101.26
21006.34	21036.34	21099.47	21129.47	1010.00	30.00	63.13	220.77
21350.24	**End of Alignment**						

4.1.1.7 Break up of Alignment Length for North-South Corridor

Break-up of alignment length for N-S Corridor is given in **Table 4.5**.

Table 4.5 BREAK-UP OF ALIGNMENT LENGTH

SN	Description Ele/UG/At grade	Chainage (Km)		Length (m)	Method of Construction / Structure Type
		From	To		
1.	Elevated	-735.00	9320.49	10055.49	Segmental Box Girder
2.	Ramp	9320.49	9730.83	410.34	Ramp
3.	Underground	9730.83	9838.61	107.78	Cut and Cover
4.	Underground	9838.61	12256.38	2417.77	TBM
5.	Underground	12256.38	12783.38	527.00	Cut and Cover
6.	Ramp	12783.38	13147.42	364.04	Ramp
7.	Elevated	13147.42	22143.26	8995.84	Segmental Box Girder
Total Length				**22878.26**	

4.1.2 CORRIDOR-2: EAST-WEST

4.1.2.1 General Description of the Route

The East-West corridor starts from Lucknow Railway station. The alignment for first 6.48 km from Lucknow Station is underground and thereafter elevated. The Lucknow RS is the first station on the corridor and the chainage at the centre of the station has been adopted as 0.000. The Line from Lucknow RS towards Vasantkunj has been named as "Down Line" and line from Vasantkunj towards Lucknow RS is named as "Up Line". The chainage at the dead end of proposed Lucknow Metro station is (–) 113.0m and the distance between both the track centres is 4.5 m for providing scissor crossovers in front of the station as front end reversal has been proposed. There is not enough land available after the station box to construct the crossovers thus reversal of trains has been proposed on front of the stations. Proposed Lucknow Metro Station will be the integrating station for the East-West and North-South corridor. The North-South corridor station is elevated. Both the stations will be integrated through common entry points and the concourse will be connected via escalators and staircases so that passengers can directly interchange from elevated to underground and vice-versa. The alignment follows the centreline of the Gautam Buddha Marg up to chainage 0.174 till the scissor crossover. After the scissor crossover the Upline and Downline tracks will move away from each other so as to avoid the bridge at chainage 309.2 to 348.2. The Downline track center is at a distance of 8.52 m from the abutment edge of the minor bridge and the Upline track center is at a distance of 8.42 m from the abutment edge. At chainage 252.26 m the track centres are at a distance of 12.0 m and the TBM (tunnel boring machine) will be lowered at this location. Till chainage 252.26 the alignment will be constructed by cut and cover. After crossing the canal underground at a depth of 17.6 m below the road level, alignment will achieve track center to center distance of 15.05 m following two consecutive curves of 250.0 m & 300.0 m for Up-Line and 350m & 300.0m for Down-Line. The next underground station Gautam Buddha Marg has been proposed at chainage 988.96. The station has been proposed slightly off the center of the road on LHS to avoid acquisition on both sides of the road, as the available ROW at the proposed station location on Gautam Buddha Marg is only 15.0m. The properties will be acquired temporarily for the construction period of three years and will be redeveloped on the same location after the construction is over. Only few properties will be acquired permanently for the entry/exit staircases and ancillary buildings.

Further the alignment continues below the road centre (Gautam Buddha Marg) and the next station is planned at Aminabad (Chainage 1953.45) proposed in the Jhandewala Park at the heart of the Aminabad Market Area. This station will serve the City's very congested central areas like Kaiserbagh, Lalbagh, Aminabad etc. and provide connectivity to the other parts of the city center. The station has been fitted diagonally in the park to accommodate the whole station length and to avoid acquisition of property. There is an underground car parking below the far end of the Jhandewala Park. The rail level at the stations has been kept at 15.5m below the ground level to accommodate the concourse area etc.

After the Aminabad station the alignment continues further under the built-up area and takes a left turn to fit the next station Pandeyganj (Chainage 2777.12) parallel to the Ganga Prasad Marg and has been located just before the junction of Nadan Mahal Road, Subhash Marg and Ganga Prasad Marg under the built-up area as the road width is not sufficient and congested to accommodate the station. At the junction of the above three roads there is a rail crossing under the road. The station has been proposed to be constructed by NATM (New Austrian Tunneling Method) with the alignment by TBM, so that the acquisition of properties can be minimised. The alignment further continues and takes a sharp right turn of radius 300.0 m to fit the Lucknow city metro station (Chainage 3694.10) in the open area just before the Lucknow City Railway Station. The length of the curve is 462.82m. After Lucknow City Station, the alignment further runs beneath built up area and it take a left turn before the next station Medical Chauraha (Chainage 4643.45). The proposed Medical Chauraha Station is beneath road adjacent to the campus of Madarsa Sultanul Madaris and extends beyond the junction. This station has been proposed near the Queens Mary Medical College and Chatrapati Sahuji Medical University.

The alignment further continues underground below the LDA Park and the Play Ground to reach the Hardoi Road. The next station Nawajganj (Chainage 5833.11) is proposed on Hardoi Road. The distance between centre of the Up-line and Down-line tracks has been kept as 15.05 m for the underground portion.

After Nawajganj station the switchover ramp has been proposed at the centre of the road. This will require some acquisition and widening of the road. The length of the ramp will be 504.55 m at a rising gradient of 3.50%. Before the start of ramp the down-line track takes a reverse curve of radius 1000.0m and 1200.00m and the Upline tracks takes reverse curve of 1100.00m and 1050.00m, so that the distance between the Up-line and down-line track centres is 4.2m before start of the ramp.

The alignment further follows the centre of the Hardoi Road and the next elevated station at Thakurganj is proposed at Ch. 7175.50 m. The alignment further continues and keeps following the centre of the Hardoi Road and reaches the next station Balaganj (Chainage 8114.19). The Balaganj station has been proposed at the Balaganj Junction. The four legged Junction is very busy during the peak hours. The road on the LHS is the Balaganj Compwell Road and on the RHS is the Jal Nigam Road. The next station proposed is Sarfarazganj with Ch. as 8794.11 m. It is located near Niyaz Duniya Complex and the NLG Marble Store.

The next station Musabagh (Chainage 9723.78m) has been proposed near the Musabgh Forest area and before the T-Junction of the 6-lane Road towards NH-25.

Further the alignment continues alongside forest area and follows the straight road to the next station Vasant Kunj (Chainage 10576.99). The station has been proposed before the T-Junction of under construction 6-lane road towards Sitapur. Along Sitapur Road, Lucknow Development Authority has proposed Vasant Kunj Township on the LHS of the road towards Sitapur. Awas Vikas Parishad has also proposed a Township Amrapali adjacent to the Vasantkunj Township. On the RHS of the Sitapur Road, Mandi Parishad has its open land that will be converted to Mandi in future and also has a portion reserved as graveyard. The alignment will finally terminate straight on the Hardoi Road at a distance of 407 m from the centre of the terminating station and will have the dead end at Chainage 10985 m.

The Depot for the corridor has been proposed at a barren land of length 500m and width 350m that belongs to LDA, behind the Fish Market Mandi.

4.1.2.2 Terminal Stations

East / Central Terminal

The Lucknow metro station will be the terminating station on the Eastern end of the East-West corridor. The existing Indian Railway Station of Lucknow and Charbagh will be integrated with the proposed metro corridor effectively. Being located at the central part of the Lucknow City, this corridor can also be referred as Central–West Corridor.

Following are few reasons for justification as the terminating station:

- The station has been proposed partially in the parking area of the Lucknow Junction to give access to commuter's directly using the sub-urban & long distant railway system.
- This station will integrate and serve central part and also the northern and southern part by integrating with N-S corridor direct interchange.

West terminal

The Vasant Kunj station will be the terminating station at the western end of the East-West corridor. A suitable site for the O&M Depot is also available near the station. This facility avoids the idle running of trains at the beginning/end of services during Morning and late night. Accordingly, the terminal station is proposed just at the depot area.

Justification as the terminating station:

- The potential mass transport route is up to Vasant Kunj an upcoming residential settlement and will attract sizeable demand along the Hardoi Road.
- The depot land is also available at a distance of 350.0 m from the centre of the terminating station.
- Beyond this point the famous Malihabad Mango Gardens are located which will restrict development. However, the extension of this Corridor on Sitapur Road may be possible in near future.
- Along the side road towards Sitapur, just after the Vasant Kunj station, Lucknow Development Authority has proposed its Vasantkunj township and Awas Vikas has proposed its Amrapali Township. Also adjacent to the depot land, low cost housing flats are being constructed under the Kanshi Ram Yojna. LDA's major City Bus Stand is under construction beside the Fish Mandi at a walking distance from the proposed terminating metro station. This will be an ideal integration point for the passengers commuting from Hardoi and other adjoining areas.

4.1.2.3 Major Roads along the Route

The major roads along and across the alignment are given in the **Table 4.6**.

Table 4.6 MAJOR ROADS ALONG/ACROSS THE E-W CORRIDOR

Road	Chainage (m)	Direction (LHS / RHS)	Name of Road across the alignment	Road Width
Underground Section				
Gautam Buddha Marg	0.00	Centre	Kanpur Road (NH-25)	22.42
Gautam Buddha Marg	190	RHS & LHS	AP Sen Road	07.00
Gautam Buddha Marg	333	LHS	Vijay Nagar Road	05.65
Gautam Buddha Marg	497	LHS	Gurudwara Road	20.00
Gautam Buddha Marg	502	RHS	Guru Gobind Singh Road	20.00
Gautam Buddha Marg	634	LHS	Shiv Puri Road	06.15
Gautam Buddha Marg	1272	RHS	Shivaji Marg	14.79
Gautam Buddha Marg	1572	Centre	Aminabad Road	09.30
Gautam Buddha Marg	1733	Centre	Aminabad Road	11.00
Gautam Buddha Marg	1777	LHS	GangaPrasad Marg	09.82
Hardoi Road	5576	RHS	Girdhari Lal Mathur Road	15.77
Hardoi Road	5721	LHS	Fly Over Bridge	14.24
Hardoi Road	6356	RHS	Imambara Road	07.32
Elevated Section				
Hardoi Road	6495	LHS	Napier Road	06.13
Hardoi Road	6712	RHS	Girdhari Lal Main Road	06.78
Hardoi Road	8158	RHS	Jal Nigam Road	08.51
Hardoi Road	8172	LHS	Balaganj Compwell Road	19.27
Hardoi Road	9893	LHS	Towards NH-25	19.13
Hardoi Road	10066	RHS	Pdionj Road	16.94

4.1.2.4 Alignment Route

The salient features of EW alignment properly are summarised below:

(i) Underground section km (-)0.113 to km 6.185

Underground section can be further divided into two sections

(a) Underground section by Cut & Cover Method

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

(ii) Underground section by Cut & Cover Method

The chainage at the dead end of the alignment is (–)113.0 and the distance between both the track centres is 4.5 m. As scissor crossovers construction can be achieved by cut and cover method only, it is not possible to place the scissors before the proposed Lucknow metro station at km 0.000 that is the integrating station of elevated N-S and underground E-W corridor, being closer to the dead end of the alignment. Thus, front end reversal has been proposed i.e. the scissor crossover will be provided on the front end of Lucknow station.

After the scissor corssover the tracks diverges from each other. From this station the alignment runs underground on the Gautam Buddha Marg till the next station Gautam Buddha Marg (chainage 988.86). At this location the average road width is only 15.0 m. From km -0.113 to km 0.257 the alignment shall be constructed by cut & cover till the tracks achieve horizontal distance of 12.0m. Again from km 5.948 to km 6.185 the alignment will be constructed by cut & cover for two tracks to come at a distance of 4.2 m c/c.

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

At km 0.257 the tracks are 12.0 m apart and hence TBM can be lowered at road to avoid the acquisition of properties. The next station is planned on the Gautam Buddha Marg named Gautam Buddha Marg Station (at chainage 988.96), where the track centres is at a distance of 15.05 m to accommodate 12.0m wide platform.

From chainage 0.257 onwards the tracks are > 12.0 m c/c and the construction will carried out by Tunnel Boring Machine (TBM) till chainage 5.717 m i.e. start point of the last underground station Nawajganj. There are very frequent sharp curves, but at none of the locations curve radius of less than 300.0 m has been designed.

(iv) Switch Over Ramp km 6.185 to km 6.676 and for alignment to Depot

After the Nawajganj station the switchover ramp has been proposed at the centre of the road. This will require some acquisition and widening of the road. The length of the ramp will be 490.31 m at a rising gradient of 3.5%. Before the start of ramp both the track takes reverse curves so that at the start of the ramp the track centres are 4.2m apart. This will minimise the acquisition. AT the end of the alignment is the depot on surface. The alignment is then planned and taken to depot.

(v) Elevated section km 6.676 to km 10.985

From km 6.676 at the end of the ramp till km 10.985 (terminating point), the alignment is elevated. Minimum vertical clearance of 5.5 m from underside of viaduct to the road / ground surface has been maintained through out the section. The alignment follows the centre of the Hardoi Road till the dead end near the Fish Mandi.

4.1.2.5 Vertical profile

The topology of Lucknow is not very undulating and the terrain is almost plain along the alignment route corridor. The maximum and minimum levels are 120.9 m and 114.6 m respectively along the roads. The level difference from lowest point on Kamal Road near Medical Chauraha to highest point on Subhash Marg is 6.3 m only. The alignment is following the existing road gradient in the underground and elevated sections and thus the vertical profile of the proposed metro alignment has a number of vertical curves. As the Up-line and Down-line tracks will move independently, so there is a difference in the vertical profile of both the tracks. The gradients in this stretch are given in the **Table 4.7**.

Table 4.7 VERTICAL PROFILE ON EAST-WEST CORRIDOR

Type	Start Chainage	Start Elevation	Start Grade	End Chainage	End Elevation	End Grade	Length	Rise/Fall
Linear	-113.00	102.00	0.00%	301.56	102.00	0.00%	414.56	LEVEL
Symmetrical Parabola	301.56	102.00	0.00%	345.59	102.12	0.56%	44.02	RISE
Linear	345.59	102.12	0.56%	465.53	102.78	0.56%	119.94	RISE
Symmetrical Parabola	465.53	102.78	0.56%	520.62	102.98	0.16%	55.09	RISE
Linear	520.62	102.98	0.16%	737.47	103.33	0.16%	216.85	RISE
Symmetrical Parabola	737.47	103.33	0.16%	786.92	103.37	0.00%	49.44	RISE
Linear	786.92	103.37	0.00%	1156.96	103.37	0.00%	370.04	LEVEL
Symmetrical Parabola	1156.96	103.37	0.00%	1183.22	103.13	-1.82%	26.26	FALL
Linear	1183.22	103.13	-1.82%	1320.33	100.64	-1.82%	137.11	FALL
Symmetrical Parabola	1320.33	100.64	-1.82%	1349.11	100.60	1.54%	28.78	FALL
Linear	1349.11	100.60	1.54%	1573.06	104.05	1.54%	223.95	RISE
Symmetrical Parabola	1573.06	104.05	1.54%	1599.06	104.22	-0.28%	26.00	RISE
Linear	1599.06	104.22	-0.28%	1786.71	103.69	-0.28%	187.65	FALL
Symmetrical Parabola	1786.71	103.69	-0.28%	1812.71	103.65	0.00%	26.00	FALL
Linear	1812.71	103.65	0.00%	2158.75	103.65	0.00%	346.04	LEVEL
Symmetrical Parabola	2158.75	103.65	0.00%	2184.75	103.45	-1.58%	26.00	FALL
Linear	2184.75	103.45	-1.58%	2555.71	97.60	-1.58%	370.96	FALL
Symmetrical Parabola	2555.71	97.60	-1.58%	2585.71	97.36	0.00%	30.00	FALL
Linear	2585.71	97.36	0.00%	2931.48	97.36	0.00%	345.78	LEVEL
Symmetrical Parabola	2931.48	97.36	0.00%	2958.48	97.48	0.92%	27.00	RISE
Linear	2958.48	97.48	0.92%	3265.77	100.31	0.92%	307.29	RISE
Symmetrical Parabola	3265.77	100.31	0.92%	3290.77	100.65	1.83%	25.00	RISE
Linear	3290.77	100.65	1.83%	3502.85	104.52	1.83%	212.08	RISE
Symmetrical Parabola	3502.85	104.52	1.83%	3528.85	104.76	0.00%	26.00	RISE
Linear	3528.85	104.76	0.00%	3843.64	104.76	0.00%	314.79	LEVEL
Symmetrical Parabola	3843.64	104.76	0.00%	3869.64	104.67	-0.72%	26.00	FALL
Linear	3869.64	104.67	-0.72%	4200.58	102.27	-0.72%	330.94	FALL
Symmetrical Parabola	4200.58	102.27	-0.72%	4228.58	102.38	1.52%	28.00	RISE
Linear	4228.58	102.38	1.52%	4399.87	104.99	1.52%	171.29	RISE
Symmetrical Parabola	4399.87	104.99	1.52%	4426.87	105.20	0.00%	27.00	RISE
Linear	4426.87	105.20	0.00%	4802.50	105.20	0.00%	375.63	LEVEL
Symmetrical Parabola	4802.50	105.20	0.00%	4859.24	104.67	-1.85%	56.74	FALL
Linear	4859.24	104.67	-1.85%	5035.37	101.41	-1.85%	176.14	FALL
Symmetrical Parabola	5035.37	101.41	-1.85%	5089.79	101.03	0.45%	54.41	FALL
Linear	5089.79	101.03	0.45%	5577.13	103.22	0.45%	487.34	RISE

Type	Start Chainage	Start Elevation	Start Grade	End Chainage	End Elevation	End Grade	Length	Rise/Fall
Symmetrical Parabola	5577.13	103.22	0.45%	5622.40	103.32	0.00%	45.28	RISE
Linear	5622.40	103.32	0.00%	5964.70	103.32	0.00%	342.30	LEVEL
Symmetrical Parabola	5964.70	103.32	0.00%	6009.17	103.81	2.19%	44.47	RISE
Linear	6009.17	103.81	2.19%	6171.68	107.37	2.19%	162.52	RISE
Symmetrical Parabola	6171.68	107.37	2.19%	6208.31	108.41	3.50%	36.63	RISE
Linear	6208.31	108.41	3.50%	6762.38	127.79	3.50%	554.07	RISE
Symmetrical Parabola	6762.38	127.79	3.50%	6847.99	129.31	0.07%	85.61	RISE
Linear	6847.99	129.31	0.07%	6998.67	129.42	0.07%	150.68	RISE
Symmetrical Parabola	6998.67	129.42	0.07%	7024.62	129.43	0.00%	25.95	RISE
Linear	7024.62	129.43	0.00%	7277.16	129.43	0.00%	252.54	LEVEL
Symmetrical Parabola	7277.16	129.43	0.00%	7322.44	129.03	-1.79%	45.28	FALL
Linear	7322.44	129.03	-1.79%	7383.84	127.93	-1.79%	61.40	FALL
Symmetrical Parabola	7383.84	127.93	-1.79%	7454.12	127.46	0.47%	70.28	FALL
Linear	7454.12	127.46	0.47%	7689.56	128.57	0.47%	235.45	RISE
Symmetrical Parabola	7689.56	128.57	0.47%	7714.56	128.77	1.05%	25.00	RISE
Linear	7714.56	128.77	1.05%	7985.43	131.61	1.05%	270.87	RISE
Symmetrical Parabola	7985.43	131.61	1.05%	8011.72	131.75	0.00%	26.29	RISE
Linear	8011.72	131.75	0.00%	8209.55	131.75	0.00%	197.83	LEVEL
Symmetrical Parabola	8209.55	131.75	0.00%	8254.72	131.45	-1.36%	45.17	FALL
Linear	8254.72	131.45	-1.36%	8370.24	129.87	-1.36%	115.53	FALL
Symmetrical Parabola	8370.24	129.87	-1.36%	8421.34	129.70	0.70%	51.10	FALL
Linear	8421.34	129.70	0.70%	8527.13	130.44	0.70%	105.78	RISE
Symmetrical Parabola	8527.13	130.44	0.70%	8553.13	130.76	1.80%	26.00	RISE
Linear	8553.13	130.76	1.80%	8659.45	132.67	1.80%	106.32	RISE
Symmetrical Parabola	8659.45	132.67	1.80%	8704.88	133.08	0.00%	45.43	RISE
Linear	8704.88	133.08	0.00%	8890.99	133.08	0.00%	186.11	LEVEL
Symmetrical Parabola	8890.99	133.08	0.00%	8933.15	132.73	-1.70%	42.16	FALL
Linear	8933.15	132.73	-1.70%	9035.53	130.99	-1.70%	102.38	FALL
Symmetrical Parabola	9035.53	130.99	-1.70%	9071.52	130.61	-0.43%	35.99	FALL
Linear	9071.52	130.61	-0.43%	9453.00	128.96	-0.43%	381.47	FALL
Symmetrical Parabola	9453.00	128.96	-0.43%	9498.87	129.16	1.29%	45.87	RISE
Linear	9498.87	129.16	1.29%	9601.78	130.49	1.29%	102.91	RISE
Symmetrical Parabola	9601.78	130.49	1.29%	9630.72	130.67	0.00%	28.94	RISE
Linear	9630.72	130.67	0.00%	9837.10	130.67	0.00%	206.39	LEVEL
Symmetrical Parabola	9837.10	130.67	0.00%	9882.91	130.39	-1.24%	45.81	FALL
Linear	9882.91	130.39	-1.24%	9973.62	129.27	-1.24%	90.71	FALL

Type	Start Chainage	Start Elevation	Start Grade	End Chainage	End Elevation	End Grade	Length	Rise/Fall
Symmetrical Parabola	9973.62	129.27	-1.24%	10037.58	129.02	0.46%	63.96	FALL
Linear	10037.58	129.02	0.46%	10294.51	130.20	0.46%	256.94	RISE
Symmetrical Parabola	10294.51	130.20	0.46%	10325.12	130.51	1.55%	30.60	RISE
Linear	10325.12	130.51	1.55%	10452.15	132.48	1.55%	127.03	RISE
Symmetrical Parabola	10452.15	132.48	1.55%	10488.50	132.76	0.00%	36.35	RISE
Linear	10488.50	132.76	0.00%	10717.36	132.76	0.00%	228.86	LEVEL
Symmetrical Parabola	10717.36	132.76	0.00%	10754.20	132.50	-1.45%	36.84	FALL
Linear	10754.20	132.50	-1.45%	10985.08	129.14	-1.45%	230.88	FALL

4.1.2.6 Curvature

The proposed East- west corridor has 55% of the alignment underground and also the topology of Lucknow is not very undulating, yet to place the stations at proper locations number of horizontal curves have been proposed. The radius of curves at few locations is kept as low as 300 m in the underground section to fit the underground stations in such a way that the property acquisition can be minimised. 22.93 % of the length of the alignment is on curves. The details of curves on East- West Corridor are given in **Table 4.8**.

Table 4.8 DETAILS OF HORIZONTAL CURVES – PROPOSED EAST WEST CORRIDOR

TS / PC (TP1)	SC (TP2)	CS (TP3)	ST / PT (TP4)	Radius (m)	Transition Length (m)	Length of Curve (m)	Straight between two curves (m)
Start of Alignment			-113.00				304.494
191.49	216.49	248.80	273.80	1010.000	25	32.305	315.44
589.24	644.24	789.20	844.20	300.000	55	144.958	360.201
1204.40	1259.40	1621.54	1676.54	307.525	55	362.147	417.87
2094.41	2149.41	2358.16	2413.16	305.000	55	208.743	30.321
2443.48	2498.48	2595.59	2650.59	305.000	55	97.108	356.356
3006.94	3061.94	3533.40	3588.40	305.000	55	471.454	308.15
3896.55	3951.55	4446.92	4501.92	310.000	55	495.374	622.869
5124.79	5179.79	5349.33	5404.33	500.000	55	169.542	46.021
5450.35	5505.35	5637.33	5692.33	305.000	55	131.974	323.839
6016.16	6036.16	6041.61	6061.61	3000.000	20	5.445	171.313
6232.92	6242.92	6294.42	6304.42	2300.000	10	51.503	30.795
6335.22	6345.22	6428.85	6438.85	3000.000	10	83.635	425.884
6864.74	6919.74	7034.91	7089.91	500.000	55	115.177	257.855
7347.77	-	-	7379.13	8000.000	0	31.359	298.636
7677.76	7687.76	7748.47	7758.46	3000.000	10	60.702	122.853
7881.32	7896.32	7924.50	7939.50	2000.000	15	28.181	151.429
8090.93	8110.93	8184.21	8204.21	1500.000	20	73.285	58.554
8262.77	8282.77	8342.64	8362.64	1400.000	20	59.871	63.665

TS / PC (TP1)	SC (TP2)	CS (TP3)	ST / PT (TP4)	Radius (m)	Transition Length (m)	Length of Curve (m)	Straight between two curves (m)
8426.30	8436.30	8478.29	8488.28	3000.000	10	41.986	381.468
8869.75	8889.75	8985.08	9005.09	1400.000	20	95.332	176.656
9181.74	9211.74	9352.13	9382.13	1200.000	30	140.389	709.336
10091.47	-	-	10139.12	10000.000	0	47.656	846.003
10985.13	**End of Alignment**						

4.1.2.7 Break up of Alignment Length for East-West Corridor

The alignment is proposed to be underground at the start from Lucknow Railway station and will switchover to be elevated after Nawajganj station. The first elevated station will be Thakurganj. Normally the underground stations are constructed by Cut and Cover method, in which the road and properties above the proposed station location are acquired temporarily for the construction period and again developed after the construction is over. Sometimes, it is not possible to construct the underground running section by tunnelling method and cut & cover method is used in such locations. Locations of Crossovers and Scissors are constructed by cut and cover. The minimum horizontal distance between two Tunnels i.e track centres to lower the Tunnel Boring Machines should be 12.0 m, so in case the distance between two tunnels i.e. track centres is less than 12.0 m the section will have to be constructed by the Cut and cover method. Along the alignment different stretches will adopt different methodology of construction. Break-up lengths of E-W Corridor is given in **Table 4.9.**

Table 4.9 SECTIONS & METHODS OF CONSTRUCTION

SN	Chainage (Km)		Length (Km)	Method of Construction	Remarks / Reasons
	From	To			
Underground Section					
1.	(-) 0.113	0.257	0.370	Cut and Cover	Distance between track centres are 4.5 m at start along with station and scissor is to placed after the station. After the scissor crossover the tracks will diverge to avoid the minor bridge.
2.	0.257	5.718	5.461	Tunnel boring Machine	After the track centres are 12.0 m apart, TBM can start.
3.	5.948	6.185	0.237	Cut and Cover	From Nawajganj station till start of ramp.
4.	6.185	6.676	0.490	Ramp	Switchover ramp from underground to elevated
Elevated Section					
5.	6.676	10.985	4.309	Elevated Box girder Viaduct	
Total Length (km)			**11.098**		

4.1.3 SWITCH OVER RAMPS

Switch over ramp is required for transitioning the alignment from Elevated corridor to Underground or vice versa. On North-South corridor one ramp has been proposed to take the alignment from elevated to At-Grade to enter into the Depot area. East-West corridor one such ramp has been proposed. The location of ramp is selected to avoid obstruction to the existing road connection branching from Mandi Road.

4.1.3.1 Ramp on N-S Corridor on Open Land near Amausi Airport (Depot Link)

The ramp has been proposed on the open land in front of the Amausi Airport on RHS of the Kanpur Road (NH-25) immediately after crossing the ITTUP Institute Tool Training Center. This land is vacant. Part of the land belongs to State Govt. and part of land in under the possession of Airport Authority of India. A gradient of 3.85% has been provided on the ramp, so that sufficient clearance from the AAI's Air Funnel zone can be achieved. The ramp will start at chainage 526.98 and achieve sufficient height of 7.5m rail level at chainage 722.15.The length of ramp 195.17 m.

4.1.3.2 Ramp on N-S Corridor on center of the Kanpur Road-NH-25.

After the Alambagh Bus stand station the alignment has to cross through some very important locations such as Lucknow Railway Station, Vidhan Sabha, Hazratganj Market etc. These locations are importance in view of heritage status, and prominent historical / public place. In order to maintain the visual aesthetics of buildings, avoid the over-ground acquisition, minimise inconvenience to the existing traffic it has been proposed to cross underground between the areas from Mawaiya Junction to Lucknow University. To transit from elevated to underground, a ramp of approx length of 430m has been proposed.

After the Alambagh bus stand the ramp will start at chainage 6616.32 with the rail level at +7.5 m and end at km 7046.01 where the rail level is at -8.0m. The ramp has been proposed on NH-25 on the road center between Amry Supply Depot and the Railway Quarters, in order to avoid any corss road/side roads. The width of the ramp shall be 10.0m. From the end of the ramp at chainage 7046.01 till the chainage 7400.00, construction will be done by cut and cover till the track centers are at a distance of 12.0 m center to center. At this point the TBM's will be lowered and the alignment will continue to be underground from the end of the ramp.

4.1.3.3 Ramp on N-S Corridor on University Road

After crossing the Gomti river underground at a level of (-) 20.1 m below the bed level of the river, the alignment has been proposed to be elevated on University Road and Faizabad Road (NH-28). To transit from such under ground depth to elevated sections a switchover ramp has been proposed on the University Road. Once the rail levels are at -8.0 m from the ground level, the ramp starts at chainage 14254.40. To reduce the length of ramp and to achieve a safe height for the Vishwavidyalaya station the gradient of the ramp and the alignment has been proposed at 3.61%. The width of the ramp shall be 10.0m. Land will be acquired on both sides of the road to fit the ramp at the center. At chainage 14734.66 the rail level is +7.5m from ground level and the ramp will end at this chainage.

4.1.3.4 Ramp on E-W Corridor on Hardoi Road

The ramp has been proposed on the Hardoi Road at the centre of the existing road (SH-25). A gradient of 3.5% has been provided on the ramp. The ramp will cover about 10.0 m of road width from chainage 6185.26 to 6689.84 where the ramp will end. In this stretch, there are no cross roads but have 6 T-connection roads at Chainage 6322.86 on LHS, chainage 6400.00m on RHS, chainage 6537.98m on LHS, chainage 6608.70m on LHS and at chainage 6651.79m on RHS. This ramp will not block the side roads but the commuters will have to take turns from the extreme ends of the ramp to access these side roads from the Hardoi Road.

4.1.4 TURNOUTS AND CROSSOVERS

Turnouts are used to divert the trains from one track to other. Turnouts are also used to provide disabled siding preferably on every 6th station. A turnout consists of a pair of switches and a crossing, connected by closure rails. Turnouts and crossovers shall not be placed along a curve, but instead on straight and levelled tracks. It should also not fall on vertical curves. Normally along the running sections 1:9 turnouts are used whereas 1:7 turnouts can be used in depot tracks. SRJ of turnouts is located at a distance of 15.0 m from the platform end.

4.2 GEOTECHNICAL INVESTIGATIONS

4.2.1 GENERAL GEOLOGY & CHARACTERISTICS

4.2.1.1 Location

Two corridors and a 3.5 km link line i.e. North-South, East-West and Gomti Nagar Link have been identified as potential MRTS in Lucknow in Phase I. The details of the N-S and E-W and Gomti Nagar Link Line corridor identified have already been discussed in the previous sections. Geotechnical investigations have been carried out along the proposed alignments to determine the strata, depth of foundation and safe bearing capacity of foundations required for the above proposed Metro corridors.

4.2.1.2 Physiography & Climate

Lucknow city is situate in the Gangetic plain and is located in the **Seismic Zone III**. The city has a warm humid subtropical climate with maximum temperature rising to 40-45 degree Celsius and minimum temperature lowering down to around 3 degree Celsius. The city gets an average rainfall of 1010mm mostly from the South-west Monsoon winds.

4.2.2 FIELD WORK

Subsurface explorations were carried out along the length of the proposed corridors. Bore holes were done at every 500m at the proposed NS and EW corridors. The summary of field work conducted is given in **Table 4.10**.

Table 4.10 SUMMARY OF FIELD INVESTIGATION

NORTH SOUTH CORRIDOR			
BOREHOLE NO.	DEPTH OF BOREHOLE (m)	DEPTH OF WATER TABLE BELOW GROUND LEVEL (m)	SOIL/ROCK
BH-01	30.0	18.60	Only Soil
BH-02	30.0	19.00	Only Soil
BH-03	30.0	20.00	Only Soil
BH-04	30.0	18.00	Only Soil
BH-05	30.0	21.50	Only Soil
BH-06	30.0	25.50	Only Soil
BH-07	30.0	27.00	Only Soil
BH-08	30.0	Not Met	Only Soil
BH-09	30.0	Not Met	Only Soil
BH-10	30.0	Not Met	Only Soil
BH-11	30.0	Not Met	Only Soil
BH-12	30.0	Not Met	Only Soil
BH-13	30.0	Not Met	Only Soil
BH-14	30.0	Not Met	Only Soil
BH-15	30.0	Not Met	Only Soil
BH-16	30.0	Not Met	Only Soil
BH-17	30.0	Not Met	Only Soil
BH-18	30.0	Not Met	Only Soil
BH-19	30.0	Not Met	Only Soil
BH-20	30.0	Not Met	Only Soil
BH-21	30.0	Not Met	Only Soil
BH-22	30.0	Not Met	Only Soil
BH-23	30.0	Not Met	Only Soil
BH-24	30.0	Not Met	Only Soil
BH-25	30.0	Not Met	Only Soil
BH-26	30.0	Not Met	Only Soil
BH-27	30.0	Not Met	Only Soil
BH-28	30.0	Not Met	Only Soil
BH-29	30.0	Not Met	Only Soil
BH-30	30.0	Not Met	Only Soil
BH-31	30.0	Not Met	Only Soil
BH-32	30.0	Not Met	Only Soil
BH-33	30.0	Not Met	Only Soil
BH-34	30.0	Not Met	Only Soil
BH-35	30.0	Not Met	Only Soil
BH-36	30.0	Not Met	Only Soil
BH-37	30.0	Not Met	Only Soil
BH-38	30.0	Not Met	Only Soil
BH-39	30.0	Not Met	Only Soil
BH-40	30.0	Not Met	Only Soil
BH-41	30.0	Not Met	Only Soil
BH-42	30.0	Not Met	Only Soil
BH-43	30.0	Not Met	Only Soil
BH-44	30.0	Not Met	Only Soil
BH-45	30.0	Not Met	Only Soil
BH-46	30.0	Not Met	Only Soil

EAST WEST CORRIDOR AND GOMTI NAGAR			
BH-01	30.0	23.00	Only Soil
BH-02	30.0	22.00	Only Soil
BH-03	30.0	27.00	Only Soil
BH-04	30.0	26.00	Only Soil
BH-05	30.0	24.00	Only Soil
BH-06	30.0	28.00	Only Soil
BH-07	30.0	29.00	Only Soil
BH-08	30.0	30.00	Only Soil
BH-09	30.0	NIL	Only Soil
BH-10	30.0	NIL	Only Soil
BH-11	30.0	NIL	Only Soil
BH-12	30.0	NIL	Only Soil
BH-13	30.0	26.00	Only Soil
BH-14	30.0	26.00	Only Soil
BH-15	30.0	20.00	Only Soil
BH-16	30.0	20.00	Only Soil
BH-17	30.0	22.00	Only Soil
BH-18	30.0	13.50	Only Soil
BH-19	30.0	13.00	Only Soil
BH-20	30.0	19.00	Only Soil
BH-21	30.0	20.00	Only Soil
BH-22	30.0	27.10	Only Soil
BH-23	30.0	22.00	Only Soil
BH-24	30.0	26.50	Only Soil
BH-25	30.0	26.40	Only Soil
BH-26	30.0	26.50	Only Soil
BH-27	30.0	28.10	Only Soil
BH-28	30.0	13.30	Only Soil
BH-29	30.0	12.40	Only Soil
BH-30	30.0	13.05	Only Soil
BH-31	30.0	17.10	Only Soil
BH-32	30.0	16.50	Only Soil

4.2.3 ENGINEERING DESIGN PARAMETERS

The details of the engineering investigations and analysis done thereafter are explained below in subsequent sections.

4.2.3.1 Proposed North-South Corridor

Chainage: -0.735 to 22.143

Type: Partially Elevated & Underground Rail Corridor

Borehole Nos.: BH-01 to BH-46

Proposed East-West Corridor

Chainage: -0.113 to 10.985

Type: Partly Elevated and Partly underground Rail Corridor

Borehole Nos.: BH-01 to BH-24

Gomti Nagar Link

Borehole Nos.: BH-25 to BH-27

Amausi Airport Depot

Borehole Nos.: BH-28 to BH-32

4.2.3.2 Design Parameters of Rail Corridor

The subsoil strata at proposed site on NS , EW and Gomti Nagar link corridor is generally homogeneous and comprises of mainly two types of layers details of which are as given below:

TYPE OF SOIL		
Engineering Parameter	**Layer Type I Silty Sand/Sandy Silt low plasticity**	**Layer Type II Clayey Silt of low to medium plasticity**
Classification as per IS 1498-1970	**SM/ML-CL**	**CI**

The engineering details (based on field test and laboratory test results) of the sub-soil strata are available separately in Geotechnical Investigation Report.

4.2.4 RECOMMENDATIONS

Depending on the field and laboratory observations of subsoil strata, test results and the type of structures proposed at site, the most feasible soil-foundation system is recommended as normal bored cast in situ R.C.C. piles foundations of 1.0m to 1.2m diameter for the NS, EW and Gomti Nagar link, at different depths with cut-off level at 2.0m depth below existing Ground level. The safe load carrying capacities of these piles are given in following **Table 4.11**.

Table 4.11 DESIGN PARAMETERS FOR FOUNDATION

Dia of piles (cm)	Cut-off level below EGL. (m)	Length of piles below cut-off (m)	Safe load carrying capacity of a pile (T)		
			In compression	In uplift	In lateral thrust
DESIGN PARAMETERS FOR FOUNDATIONS: NORTH-SOUTH CORRIDOR					
AT LOCATION BH-1					
120	2.0	18.0	373.4	100.0	40.2
		19.0	405.8	113.7	40.2
		19.0	439.7	128.2	40.2
AT LOCATION BH-2					
120	2.0	18.0	400.0	108.6	40.2
		19.0	430.0	121.1	40.2
		20.0	461.3	134.2	40.2
AT LOCATION BH-3					
120	2.0	18.0	406.7	114.1	40.2
		19.0	438.9	127.6	40.2
		20.0	472.5	141.8	40.2

Dia of piles (cm)	Cut-off level below EGL. (m)	Length of piles below cut-off (m)	Safe load carrying capacity of a pile (T)		
			In compression	In uplift	In lateral thrust
AT LOCATION BH-4					
120	2.0	20.0	223.8	78.1	40.2
		21.0	237.5	84.5	40.2
		22.0	251.6	91.2	40.2
AT LOCATION BH-5					
120	2.0	18.0	390.4	101.3	40.2
		19.0	422.1	114.5	40.2
		20.0	455.2	128.4	40.2
AT LOCATION BH-6					
120	2.0	20.0	256.9	89.9	40.2
		21.0	274.2	97.7	40.2
		22.0	292.5	106.0	40.2
AT LOCATION BH-7					
120	2.0	20.0	275.7	104.5	40.2
		21.0	291.8	111.8	40.2
		22.0	308.9	119.5	40.2
AT LOCATION BH-8					
120	2.0	20.0	240.1	84.6	40.2
		21.0	255.8	91.6	40.2
		22.0	272.5	99.1	40.2
AT LOCATION BH-9					
120	2.0	20.0	237.2	80.5	40.2
		21.0	253.4	87.7	40.2
		22.0	270.6	95.4	40.2
AT LOCATION BH-10					
120	2.0	18.0	424.8	109.2	40.2
		19.0	468.5	125.3	40.2
		20.0	515.2	143.0	40.2
AT LOCATION BH-11					
120	2.0	20.0	248.7	87.9	40.2
		21.0	264.7	95.0	40.2
		22.0	281.7	102.6	40.2
AT LOCATION BH-12					
120	2.0	20.0	335.4	136.8	40.2
		21.0	350.2	143.3	40.2
		22.0	365.9	150.3	40.2
AT LOCATION BH-13					
120	2.0	20.0	286.8	112.9	40.2
		21.0	303.5	120.4	40.2
		22.0	321.4	128.4	40.2

Dia of piles (cm)	Cut-off level below EGL. (m)	Length of piles below cut-off (m)	Safe load carrying capacity of a pile (T)		
			In compression	In uplift	In lateral thrust
AT LOCATION BH-14					
120	2.0	18.0	408.6	100.8	40.2
		19.0	448.9	115.1	40.2
		20.0	492.3	130.9	40.2
AT LOCATION BH-15					
120	2.0	18.0	230.0	83.9	40.2
		19.0	245.5	90.8	40.2
		20.0	262.1	98.3	40.2
AT LOCATION BH-16					
120	2.0	18.0	342.2	70.7	40.2
		19.0	367.5	77.6	40.2
		20.0	393.8	85.0	40.2
AT LOCATION BH-17					
120	2.0	18.0	418.0	108.1	40.2
		19.0	459.5	123.1	40.2
		20.0	504.1	139.7	40.2
AT LOCATION BH-18					
120	2.0	18.0	419.0	107.6	40.2
		19.0	461.1	122.8	40.2
		20.0	506.2	139.5	40.2
AT LOCATION BH-19					
120	2.0	20.0	248.1	84.9	40.2
		21.0	265.5	92.7	40.2
		22.0	284.0	101.1	40.2
AT LOCATION BH-20					
120	2.0	20.0	230.3	79.8	40.2
		21.0	245.9	86.8	40.2
		22.0	262.5	94.2	40.2
AT LOCATION BH-21					
120	2.0	21.0	260.7	97.1	40.2
		22.0	276.8	104.2	40.2
		23.0	293.9	111.9	40.2
AT LOCATION BH-22					
120	2.0	18.0	335.7	67.2	40.2
		19.0	373.5	80.2	40.2
		20.0	414.2	94.6	40.2
AT LOCATION BH-23					
120	2.0	18.0	345.5	70.0	40.2
		19.0	385.0	83.8	40.2
		20.0	427.7	99.2	40.2

Dia of piles (cm)	Cut-off level below EGL. (m)	Length of piles below cut-off (m)	Safe load carrying capacity of a pile (T)		
			In compression	In uplift	In lateral thrust
AT LOCATION BH-24					
120	2.0	21.0	236.1	85.8	40.2
		22.0	254.1	93.9	40.2
		23.0	273.2	102.6	40.2
AT LOCATION BH-25					
120	2.0	18.0	419.5	108.2	40.2
		19.0	462.4	124.0	40.2
		20.0	508.5	141.3	40.2
AT LOCATION BH-26					
120	2.0	20.0	265.0	103.2	40.2
		21.0	280.3	110.0	40.2
		22.0	296.6	117.3	40.2
AT LOCATION BH-27					
120	2.0	18.0	363.3	79.3	40.2
		19.0	403.8	93.6	40.2
		20.0	447.5	109.5	40.2
AT LOCATION BH-28					
120	2.0	18.0	348.1	72.4	40.2
		19.0	387.1	86.0	40.2
		20.0	429.2	101.2	40.2
AT LOCATION BH-29					
120	2.0	21.0	239.0	85.2	40.2
		22.0	255.2	92.5	40.2
		23.0	272.5	100.3	40.2
AT LOCATION BH-30					
120	2.0	18.0	346.4	72.1	40.2
		19.0	385.3	85.7	40.2
		20.0	427.2	100.8	40.2
AT LOCATION BH-31					
120	2.0	21.0	244.1	87.5	40.2
		22.0	260.5	94.9	40.2
		23.0	278.0	102.7	40.2
AT LOCATION BH-32					
120	2.0	18.0	429.1	114.1	40.2
		19.0	471.4	129.5	40.2
		20.0	516.9	146.6	40.2
AT LOCATION BH-33					
120	2.0	21.0	220.2	82.2	40.2
		22.0	235.9	89.2	40.2
		23.0	252.7	96.8	40.2

Dia of piles (cm)	Cut-off level below EGL. (m)	Length of piles below cut-off (m)	Safe load carrying capacity of a pile (T)		
			In compression	In uplift	In lateral thrust
AT LOCATION BH-34					
12 0	2.0	18.0	381.2	89.4	40.2
		19.0	421.3	103.6	40.2
		20.0	464.6	119.3	40.2
AT LOCATION BH-35					
120	2.0	21.0	279.2	109.6	40.2
		22.0	295.4	116.9	40.2
		23.0	312.7	124.7	40.2
AT LOCATION BH-36					
120	2.0	18.0	425.0	110.3	40.2
		19.0	465.2	124.6	40.2
		20.0	508.5	140.5	40.2
AT LOCATION BH-37					
120	2.0	21.0	287.5	112.6	40.2
		22.0	305.1	120.6	40.2
		23.0	324.0	129.2	40.2
AT LOCATION BH-38					
120	2.0	21.0	292.9	112.3	40.2
		22.0	310.1	120.1	40.2
		23.0	328.4	128.4	40.2
AT LOCATION BH-39					
120	2.0	21.0	255.2	96.3	40.2
		22.0	271.9	103.8	40.2
		23.0	289.7	111.9	40.2
AT LOCATION BH-40					
120	2.0	21.0	291.2	113.5	40.2
		22.0	308.0	121.0	40.2
		23.0	325.8	129.1	40.2
AT LOCATION BH-41					
120	2.0	21.0	282.7	110.4	40.2
		22.0	300.2	118.3	40.2
		23.0	318.9	126.8	40.2
AT LOCATION BH-42					
120	2.0	21.0	265.6	100.5	40.2
		22.0	283.6	108.6	40.2
		23.0	302.8	302.8	40.2
AT LOCATION BH-43					
120	2.0	20.0	358.6	148.0	40.2
		21.0	375.2	155.5	40.2
		22.0	393.0	163.6	40.2

Dia of piles (cm)	Cut-off level below EGL. (m)	Length of piles below cut-off (m)	Safe load carrying capacity of a pile (T)		
			In compression	In uplift	In lateral thrust
AT LOCATION BH-44					
120	2.0	21.0	357.8	145.8	40.2
		22.0	373.7	152.9	40.2
		23.0	390.6	160.5	40.2
AT LOCATION BH-45					
120	2.0	21.0	281.8	108.9	40.2
		22.0	298.5	116.4	40.2
		23.0	316.4	124.5	40.2
AT LOCATION BH-46					
120	2.0	21.0	280.6	109.1	40.2
		22.0	298.4	117.1	40.2
		23.0	317.3	125.7	40.2
DESIGN PARAMETERS FOR FOUNDATIONS: EAST-WEST CORRIDOR and GOMTI NAGAR					
AT LOCATION BH-1					
100	2.0	21	208.6	84.8	40.2
		22	224.1	92.3	40.2
		23	239.9	100.1	40.2
120	2.0	21	259.8	101.7	40.2
		22	278.5	110.8	40.2
		23	297.5	120.1	40.2
AT LOCATION BH-2					
100	2.0	21	253.9	107.5	40.2
		22	268.5	114.7	40.2
		23	283.3	121.9	40.2
120	2.0	21	314	129	40.2
		22	331.6	137.6	40.2
		23	349.5	146.3	40.2
AT LOCATION BH-3					
100	2.0	21	215.8	88.2	40.2
		22	231.2	95.5	40.2
		23	247	103.2	40.2
120	2.0	21	268.6	105.8	40.2
		22	287.1	114.6	40.2
		23	306.3	123.8	40.2
AT LOCATION BH-4					
100	2.0	21	229.9	92.1	40.2
		22	247.1	100.4	40.2
		23	265	109	40.2
120	2.0	21	287	110.5	40.2

Dia of piles (cm)	Cut-off level below EGL. (m)	Length of piles below cut-off (m)	Safe load carrying capacity of a pile (T)		
			In compression	In uplift	In lateral thrust
		22	307.9	120.4	40.2
		23	329.5	130.8	40.2
AT LOCATION BH-5					
100	2.0	21	213.1	86.9	40.2
		22	228.5	94.3	40.2
		23	244.4	101.9	40.2
120	2.0	21	265.3	104.3	40.2
		22	283.9	113.1	40.2
		23	303.1	122.3	40.2
AT LOCATION BH-6					
100	2.0	21	337.4	145.8	40.2
		22	354.7	154.1	40.2
		23	372.6	162.7	40.2
120	2.0	21	416	174.9	40.2
		22	436.9	184.9	40.2
		23	458.5	195.3	40.2
AT LOCATION BH-7					
100	2.0	21	312.2	136.2	40.2
		22	328.7	144	40.2
		23	345.8	152.3	40.2
120	2.0	21	384.4	163.4	40.2
		22	404.4	172.9	40.2
		23	425.1	182.7	40.2
AT LOCATION BH-8					
100	2.0	21	261.7	110.8	40.2
		22	278.2	118.7	40.2
		23	295.4	127	40.2
120	2.0	21	323.8	133	40.2
		22	343.8	142.5	40.2
		23	364.7	152.4	40.2
AT LOCATION BH-9					
100	2.0	21	294.1	125	40.2
		22	311.8	133.5	40.2
		23	330.2	142.3	40.2
120	2.0	21	363.6	150.1	40.2
		22	385	160.2	40.2
		23	407.3	170.8	40.2
AT LOCATION BH-10					
100	2.0	21	300.2	126.8	40.2
		22	317.9	135.3	40.2

Dia of piles (cm)	Cut-off level below EGL. (m)	Length of piles below cut-off (m)	Safe load carrying capacity of a pile (T)		
			In compression	In uplift	In lateral thrust
		23	336.3	144.1	40.2
120	2.0	21	371.6	152.1	40.2
		22	393.1	162.3	40.2
		23	415.3	173	40.2
AT LOCATION BH-11					
100	2.0	21	234.2	98.5	40.2
		22	249.5	105.8	40.2
		23	265.5	113.5	40.2
120	2.0	21	290.1	118.2	40.2
		22	308.7	127	40.2
		23	328	136.2	40.2
AT LOCATION BH-12					
100	2.0	21	266	114.6	40.2
		22	281.2	121.9	40.2
		23	297	129.4	40.2
120	2.0	21	328.2	137.5	40.2
		22	346.6	146.2	40.2
		23	365.7	155.3	40.2
AT LOCATION BH-13					
100	2.0	21	201.9	82.2	40.2
		22	217.4	89.6	40.2
		23	233.6	97.4	40.2
120	2.0	21	251.5	98.6	40.2
		22	270.3	107.5	40.2
		23	289.8	116.8	40.2
AT LOCATION BH-14					
100	2.0	21	266.3	114.1	40.2
		22	279.9	120.6	40.2
		23	294	127.4	40.2
120	2.0	21	328.8	136.9	40.2
		22	345.3	144.7	40.2
		23	362.3	152.9	40.2
AT LOCATION BH-15					
100	2.0	21	161.7	66.8	40.2
		22	171.8	71.7	40.2
		23	182.1	76.8	40.2
120	2.0	21	200.8	80.1	40.2
		22	213	86.1	40.2
		23	225.4	92.1	40.2
AT LOCATION BH-16					

Dia of piles (cm)	Cut-off level below EGL. (m)	Length of piles below cut-off (m)	Safe load carrying capacity of a pile (T)		
			In compression	In uplift	In lateral thrust
100	2.0	21	206.2	83.8	40.2
		22	220.1	90.5	40.2
		23	234.4	97.4	40.2
120	2.0	21	256.8	100.6	40.2
		22	273.6	108.6	40.2
		23	290.9	116.9	40.2
AT LOCATION BH-17					
100	2.0	21	180.9	72.6	40.2
		22	194	79	40.2
		23	207.3	85.6	40.2
120	2.0	21	225.7	87.2	40.2
		22	241.4	94.8	40.2
		23	257.5	102.7	40.2
AT LOCATION BH-18					
100	2.0	21	195.4	78.5	40.2
		22	208	84.7	40.2
		23	221	91.1	40.2
120	2.0	21	243.7	94.2	40.2
		22	259	101.7	40.2
		23	274.5	109.3	40.2
AT LOCATION BH-19					
100	2.0	21	309.5	137.2	40.2
		22	324.6	144.4	40.2
		23	340.2	152	40.2
120	2.0	21	379.9	164.7	40.2
		22	398.2	173.3	40.2
		23	417.2	182.3	40.2
AT LOCATION BH-20					
100	2.0	21	156.2	64.2	40.2
		22	166.1	69	40.2
		23	176.1	73.9	40.2
120	2.0	21	194.2	77.1	40.2
		22	206	82.8	40.2
		23	218.1	88.7	40.2
AT LOCATION BH-21					
100	2.0	21	180	71.1	40.2
		22	193	77.5	40.2
		23	206.3	84	40.2
120	2.0	21	225.1	85.3	40.2
		22	240.8	93.8	40.2

Dia of piles (cm)	Cut-off level below EGL. (m)	Length of piles below cut-off (m)	Safe load carrying capacity of a pile (T)		
			In compression	In uplift	In lateral thrust
		23	256.7	100.8	40.2
AT LOCATION BH-22					
100	2.0	21	184.5	75	40.2
		22	195.9	80.5	40.2
		23	207.6	86.1	40.2
120	2.0	21	229.7	90	40.2
		22	243.5	96.6	40.2
		23	257.6	103.4	40.2
AT LOCATION BH-23					
100	2.0	21	212.5	87.7	40.2
		22	227.3	94.9	40.2
		23	242.3	102.2	40.2
120	2.0	21	264.1	105.2	40.2
		22	281.8	113.9	40.2
		23	299.9	122.7	40.2
AT LOCATION BH-24					
100	2.0	21	225	94.9	40.2
		22	239.7	101.9	40.2
		23	255	109.3	40.2
120	2.0	21	278.6	113.8	40.2
		22	296.4	122.3	40.2
		23	315	131.1	40.2
AT LOCATION BH-25					
100	2.0	21	290.6	123.9	40.2
		22	307.8	132.1	40.2
		23	325.6	140.7	40.2
120	2.0	21	359.2	148.7	40.2
		22	380	158.5	40.2
		23	401.5	168.8	40.2
AT LOCATION BH-26					
100	2.0	21	464.6	108.1	40.2
		22	505	125.1	40.2
		23	547.1	142.9	40.2
120	2.0	21	619.2	129.7	40.2
		22	669.1	150.1	40.2
		23	721.2	171.5	40.2
AT LOCATION BH-27					
100	2.0	21	472.4	114.5	40.2
		22	511.9	131.2	40.2
		23	553.1	148.6	40.2

Dia of piles (cm)	Cut-off level below EGL. (m)	Length of piles below cut-off (m)	Safe load carrying capacity of a pile (T)		
			In compression	In uplift	In lateral thrust
120	2.0	21	627.3	137.4	40.2
		22	676.2	157.4	40.2
		23	727	178.4	40.2
AT LOCATION BH-28					
100	2.0	21	191.2	80.4	40.2
		22	203.2	86.2	40.2
		23	215.4	92.2	40.2
120	2.0	21	236.9	96.5	40.2
		22	251.3	103.5	40.2
		23	266	110.6	40.2
AT LOCATION BH-29					
100	2.0	21	325.5	91.1	40.2
		22	350.1	102.4	40.2
		23	375.4	113.9	40.2
120	2.0	21	425.6	109.3	40.2
		22	455.7	122.8	40.2
		23	486.5	136.7	40.2
AT LOCATION BH-30					
100	2.0	21	192.6	80.7	40.2
		22	204.9	86.7	40.2
		23	217.5	92.8	40.2
120	2.0	21	238.7	96.9	40.2
		22	253.5	104	40.2
		23	268.7	111.4	40.2
AT LOCATION BH-31					
100	2.0	21	431.6	95.9	40.2
		22	466.9	112.1	40.2
		23	502.9	128.7	40.2
120	2.0	21	576.3	115.1	40.2
		22	619.4	134.6	40.2
		23	663.4	154.5	40.2
AT LOCATION BH-32					
100	2.0	21	424.4	122.1	40.2
		22	453.5	135.6	40.2
		23	483.3	149.5	40.2
120	2.0	21	553.2	146.6	40.2
		22	588.7	162.8	40.2
		23	624.9	179.4	40.2

The ground water level was encountered at the depth varying from 18.0m to 27.0m below existing ground levels that too in only few boreholes. The measured ground water table may fluctuate due to variation in climatic conditions and rate of surface evaporation. However, for design and analyses purposes the ground water may be considered at the existing water table level.

4.3 STATION PLANNING

4.3.1 GENERAL

The proposed metro for Lucknow consists of two corridors namely:

1. North-South Corridor: CCS Airport – Munshi Pulia
2. East West Corridor: Charbagh/Lucknow Railway Station – Vasant Kunj

The length of the proposed N-S corridor is 22.878 km and E-W corridor is 11.098 km. Along the North-South corridor 22 stations have been planned, 12 stations have been planned along the East-West corridor. The locations of the stations have been identified taking into consideration the constraints in land acquisition, congestion issues and integration. Therefore, stations are proposed in such a way so as to attract maximum demand from the traffic nodal points.

4.3.2 TYPES OF PROPOSED METRO STATIONS

A total of 22 Stations have been planned along the proposed NS Corridor out of which 3 stations are underground and rest 19 are elevated. The N-S corridor is elevated for a length of 19.051 km, underground for a length of 3.053 km and two ramps are of total length 0.774 km.7 stations along the 11.098 km long EW corridor are Underground and remaining 5 are elevated. 6.298 km out of 11.098 km is underground and rest 4.295 km is elevated with one ramp of length 0.505 km.The two corridors meet at Charbagh / Lucknow Railway station which will be a major interchange station between NS and EW corridors. The sequence of stations with their respective chainages and location and platform characteristics for NS and EW metro corridors is presented in **Table 4.12**.

Table 4.12 STATION CHARACTERISTICS – PROPOSED NORTH SOUTH , Gomti Nagar Link & EAST WEST METRO CORRIDOR

Name of Station	Chainage (in m)	Distance from previous Station (in m)	Rail level (RL in m)	Height/Depth from Adjacent Ground	Platform Types and Nos	Alignment Description
A. North South Corridor						
Dead End	-735.00	NA				
CCS Airport	-614.11	120.89	133.225	12.503	Side Platform - 2	Elevated, straight
Amausi	193.12	807.23	134.225	12.516	Side Platform - 2	Elevated, straight
Transport Nagar	1393.59	1200.47	134.364	12.663	Side Platform - 2	Elevated, straight
Krishna Nagar	2630.09	1236.50	134.456	12.900	Side Platform - 2	Elevated, straight
Singar Nagar	4214.40	1584.31	135.033	13.490	Side Platform - 2	Elevated, straight
Alambagh	5600.00	1385.60	134.205	12.640	Side Platform - 2	Elevated, straight
Alambagh Bus Stand	6312.51	712.51	132.210	12.953	Side Platform - 2	Elevated, straight
Mawaiya	7080.02	767.51	132.197	12.703	Side Platform - 2	Elevated, straight
Durgapuri	8256.95	1176.93	132.197	14.33	Side Platform Station-4	Elevated, straight
Charbagh / Lko Rly Station	9021.44	764.49	132.426	12.533	Side Platform - 2	Elevated, straight
HussainGunj	10392.47	1371.03	96.890	(-) 20.903	Centre Island Platform -1	Underground, Straight
Sachiwalaya	11327.05	934.58	92.927	(-) 20.539	Centre Island Platform -1	Underground, Straight
HazratGunj	12379.38	1052.33	94.205	(-) 15.500	Centre Island Platform -1	Underground, Straight
KD Singh Babu Stadium	13504.26	1124.88	123.041	14.700	Side Platform - 2	Elevated, straight
Vishwavidyalaya	14985.07	1480.81	123.686	12.617	Side Platform - 2	Elevated, straight
IT College Junction	15810.90	825.83	123.778	12.933	Side Platform - 2	Elevated, straight

Table 4.12 STATION CHARACTERISTICS – PROPOSED NORTH SOUTH , Gomti Nagar Link & EAST WEST METRO CORRIDOR

Name of Station	Chainage (in m)	Distance from previous Station (in m)	Rail level (RL in m)	Height/Depth from Adjacent Ground	Platform Types and Nos	Alignment Description
Mahanagar	16903.84	1092.94	125.980	17.930	Side Platform - 2	Double Elevated, Straight, off the road
Badshah Nagar	17577.28	673.44	124.737	13.400	Side Platform - 2	Elevated, Straight
Lekhraj Market	18554.15	976.87	125.099	13.500	Side Platform - 2	Elevated, Straight
Ram Sagar Mishra Nagar	19273.00	718.85	126.959	12.703	Side Platform - 2	Elevated, Straight
Indra Nagar	20174.17	901.17	129.055	12.663	Side Platform - 2	Elevated, Straight
Munshi Pulia	21734.66	1560.49	128.492	12.843	Side Platform - 2	Elevated, Straight
Dead End	22143.26	408.60			-	-
B. East West Corridor						
Dead End	(-) 113.00	NA				
Charbagh/ Lucknow Railway Station	0.00	113.00	102.000	(-) 17.715	Side Platforms - 2	Underground, Straight
Gautam Buddha Marg	988.96	988.966	103.375	(-) 14.600	Central Island Platform -1	Underground, Straight
Aminabad	1953.42	964.46	103.657	(-) 15.691	Centre Island Platform -1	Underground, Straight
Pandeyganj	2777.09	823.67	97.364	(-) 19.414	Centre Island Platform -1	Underground, Straight
Lucknow City Railway Station	3694.07	916.98	104.767	(-) 14.160	Centre Island Platform -1	Underground, Straight
Medical Chauraha	4643.42	949.35	105.203	(-) 13.704	Centre Island Platform	Underground, Straight
Nawajganj	5833.08	1189.66	103.328	(-) 13.824	Centre Island Platform	Underground, Straight
Thakurganj	7175.47	1342.39	129.436	13.169	Side Platforms - 2	Elevated, Straight

Table 4.12 STATION CHARACTERISTICS – PROPOSED NORTH SOUTH , Gomti Nagar Link & EAST WEST METRO CORRIDOR

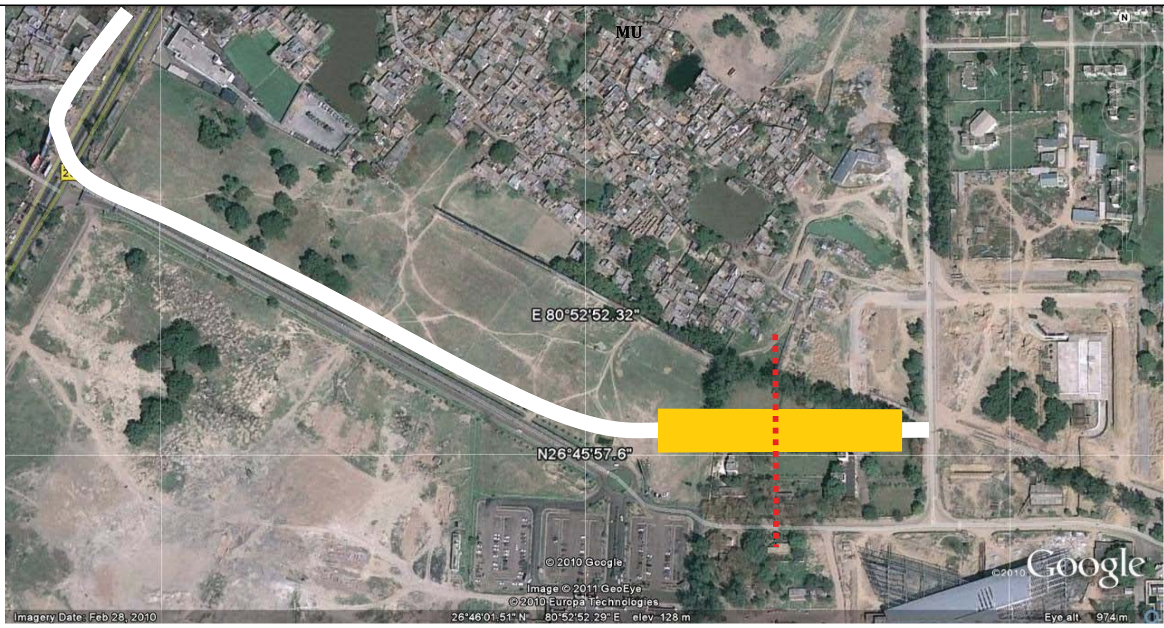
Name of Station	Chainage (in m)	Distance from previous Station (in m)	Rail level (RL in m)	Height/Depth from Adjacent Ground	Platform Types and Nos	Alignment Description
Balaganj	8114.17	938.70	131.757	12.807	Side Platforms - 2	Elevated, Curved
Sarfarazganj	8794.08	679.91	133.087	12.275	Side Platforms - 2	Elevated, Straight
Musabagh	9723.75	929.67	130.678	12.857	Side Platforms - 2	Elevated, Straight
Vasant Kunj	10576.94	853.19	132.767	12.522	Side Platforms - 2	Elevated, Straight
Dead End	10985.00	408.06	129.295	9.938	-	-

4.3.3 STATION LOCATIONS FOR NS

4.3.3.1 Chaudhary Charan Singh Airport Station

Chainage (m)	(-) 614.11
Interstation Distance (m)	NA
Rail Level (m)	133.225
Height from Ground (m)	12.503
Location	Located on the center of the road proposed for cirluation of airport traffic, Near the New Terminal. Integrated with the master plan of CCS Airport.
Entry exit stairs	Theee entry /exits have been proposed, one at the proposed parking lot and the other two connecting the old and new terminal by FOB.
Catchment area	Would mainly cater to Airport passengers, would also serve the airport employees and residential area of Chillawa.

Street Scape at Station Location



4.3.3.2 Amausi Station

Chainage (m)	193.12
Interstation Distance (m)	828.55
Rail Level (m)	134.225
Height from Ground (m)	12.516
Location	Located on the median of Kanpur road and centre line of the station is adjacent to Life Hospital on northern side.
Entry exit stairs	On northern side both stairs located on open land, one adjacent to Hardware shop & other to Sahu General Stores. On southern side located on vacant land adjacent to Sunny Toyota
Catchment area	Would mainly cater to Airport area, would also serve residential area of Vijaynagar, Sindhu Nagar, part of Indralok Colony and Hind Nagar



Street Scape at Station Location

4.3.3.3 Transport Nagar Station

Chainage (m)	1393.59
Inter-station Distance (m)	1200.46
Rail Level (m)	134.364
Height from Ground (m)	12.663
Location	Located on the median of Kanpur road and centre line of the station is adjacent to One Motors India Pvt. Ltd. on the southern side.
Entry exit stairs	On northern side both stairs located on open land, one adjacent to LUCAS India Service Ltd. & other to Police Quarters On southern side located on vacant land adjacent to Sunny Toyota and other in front of Motor India Pvt. Ltd.
Catchment area	Would mainly cater to Transport Nagar area, RTO office, areas along Kanpur Road, Hind Nagar, Subhash Nagar, Gopal Nagar, part of Sindhu Nagar and Indralok Colony

Street Scape at Station Location

4.3.3.4 Krishna Nagar Station

Chainage (m)	2630.09
Interstation Distance (m)	1236.50
Rail Level (m)	134.457
Height from Ground (m)	12.900
Location	Located on the median of Kanpur road and centre line of the station is adjacent to Madan Ply and Glass Centre on the northern side.
Entry exit stairs	On northern side both stairs located on open land, one adjacent to Indian Oil Petroleum and other to Tata Tiscon Showroom On southern side one stair is located adjacent to Rajat Enterprise & other to India Steel Corporation
Catchment area	Krishna Nagar, Bhehsa / Nahariya area, part of Vijay Nagar, Vishnulok Colony, Hind Nagar and Ashiana Colony

Street Scape at Station Location

4.3.3.5 Singaar Nagar Station

Chainage (m)	4214.40
Interstation Distance (m)	1584.31
Rail Level (m)	135.033
Height from Ground (m)	13.490
Location	Located on the median of Kanpur road and centre line of the station is adjacent to Bank of India on the northern side.
Entry exit stairs	On northern side one stair is located adjacent to Rajpal plaza & other to Onkar Maruti Suzuki On southern side one stair is located adjacent to Woodland shop & other to IDBI bank
Catchment area	Part of Alambagh and Krishna Nagar, Ram Nagar, Singaar Nagar, areas along Hardoi Road and Sarda Canal

Street Scape at Station Location

4.3.3.6 Alambagh Station

Chainage (m)	5600.00
Interstation Distance (m)	1385.60
Rail Level (m)	134.205
Height from Ground (m)	12.640
Location	Located on the median of Kanpur road and centre line of the station is adjacent to Mani Baha market on the northern side.
Entry exit stairs	On northern side stairs are located in park & open area On southern side stairs are located in open area
Catchment area	Alambagh, Chander Nagar, Gulab Vatika, Ram Prakash Khera Colony, Alambagh Gurudwara and could extend to Railway's RDSO/Manak Nagar and Rajajipuram area

Street Scape at Station Location

4.3.3.7 Alambagh Bus Station

Chainage (m)	6312.51
Interstation Distance (m)	712.51
Rail Level (m)	132.210
Height from Ground (m)	12.953
Location	Located on the median of Kanpur road and centre line of the station is adjacent to Kumar Hotel on the southern side.
Entry exit stairs	On northern side both stairs are located in an open area On southern side one stair is located adjacent to Meenu Ranu Auto Mobile *& other to Pushpa Bajaj Showroom
Catchment area	Lucknow Bus Station, part of Talkatora and nearby commercial areas along Kanpur Road

Street Scape at Station Location

4.3.3.8 Mawaiya Station

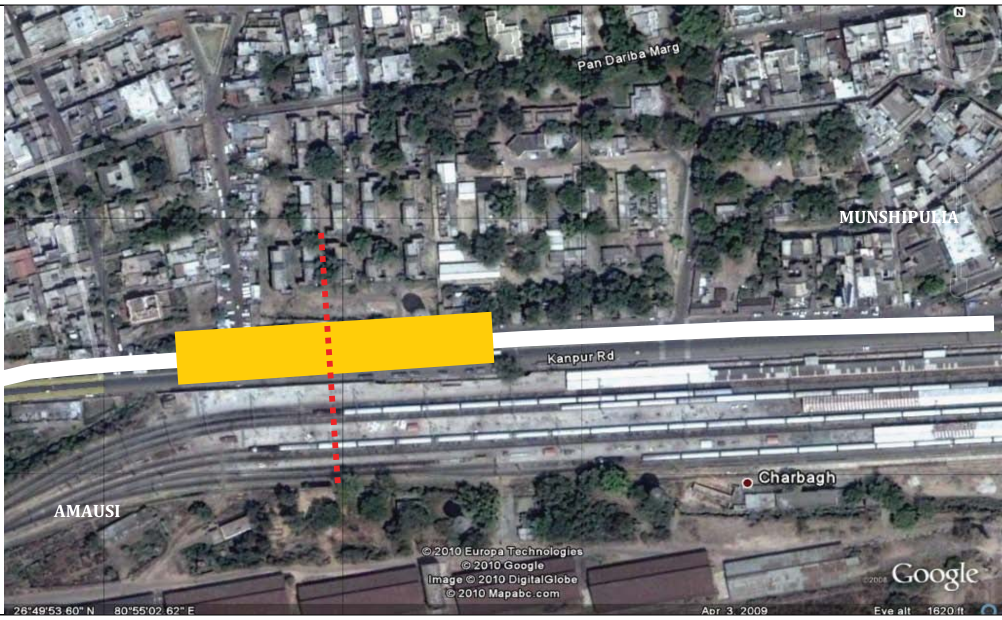
Chainage (m)	7080.02
Interstation Distance (m)	767.51
Rail Level (m)	132.197
Height from Ground (m)	12.703
Location	Located on the median of Kanpur road and centre line of the station is adjacent to the Army supply depot and T N CHowk.
Entry exit stairs	On northern side one stair is located in open land near Gandhi Inter College and on boundary of Army Supply Depot. On southern side stairs are located on open land and in front of the railway quarters.
Catchment area	Cantonment Area, Alambagh, Railway Colony, part of Mawaiya, Aishbagh, and could be extended to road towards Talkatora area.

Street Scape at Station Location

4.3.3.9 Durgapuri Station

Chainage (m)	8256.95
Interstation Distance (m)	1176.93
Rail Level (m)	132.197
Height from Ground (m)	14.330
Location	Located on the median of Kanpur road and centre line of the station is adjacent to Mechanical shed and platforms of the Indian Railway on northern side.
Entry exit stairs	On northern side one stair is located in temporary mechanical shed and open land near GRP Police line quarters On southern side stairs are located on open land adjacent to railway quarters and on open land at the end of platforms
Catchment area	Charbagh Area, Durgapuri, Chander Nagar, Railway Colony, part of Mawaiya, Pan Dariba, Moti Nagar, Aishbagh, and could be extended to eastern part of Talkatora area

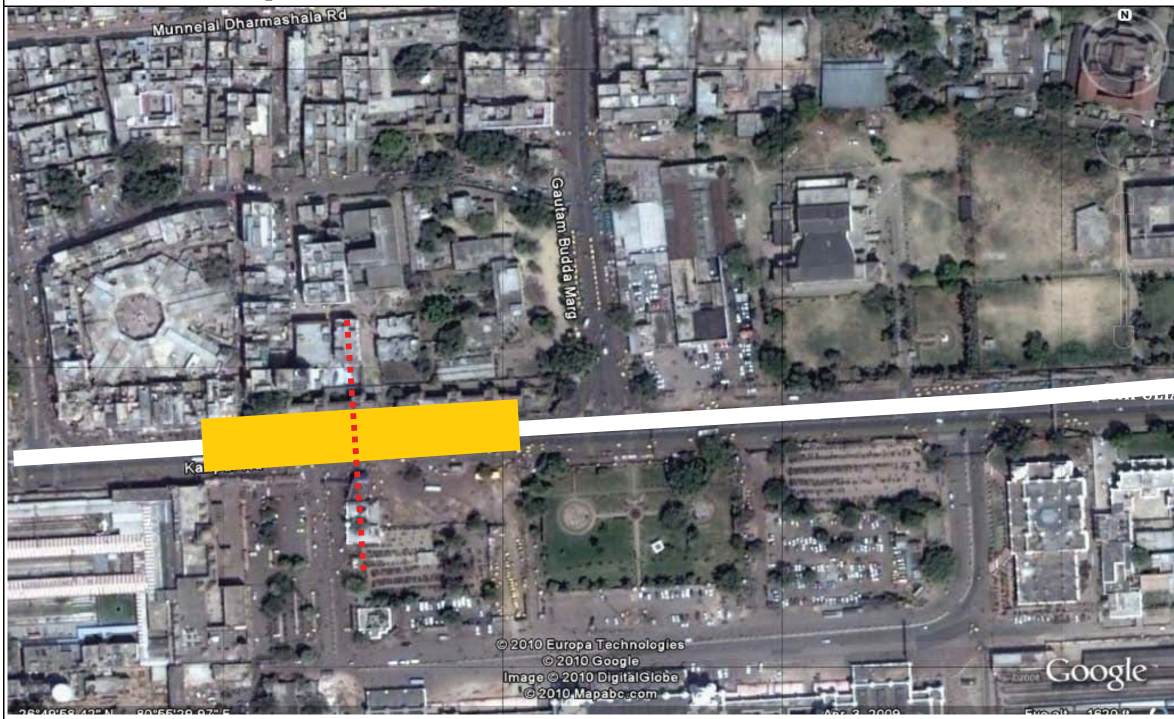

Street Scape at Station Location



4.3.3.10 Charbagh / Lucknow Station

Chainage (m)	9021.44
Interstation Distance (m)	764.49
Rail Level (m)	132.426
Depth from Ground (m)	12.533
Location	Located on the median of Station road and centre line of the station is adjacent to Kyjrati Hotel on the northern side.
Entry exit stairs	On northern side one stair is located adjacent to Railway Quarters & other to Kyjrati hotel On southern side both stairs are located in an open area
Catchment area	Charbagh Railway Station, Railway Stadium, part of Pan Dariba, Arya Nagar, part of Naka Hindola

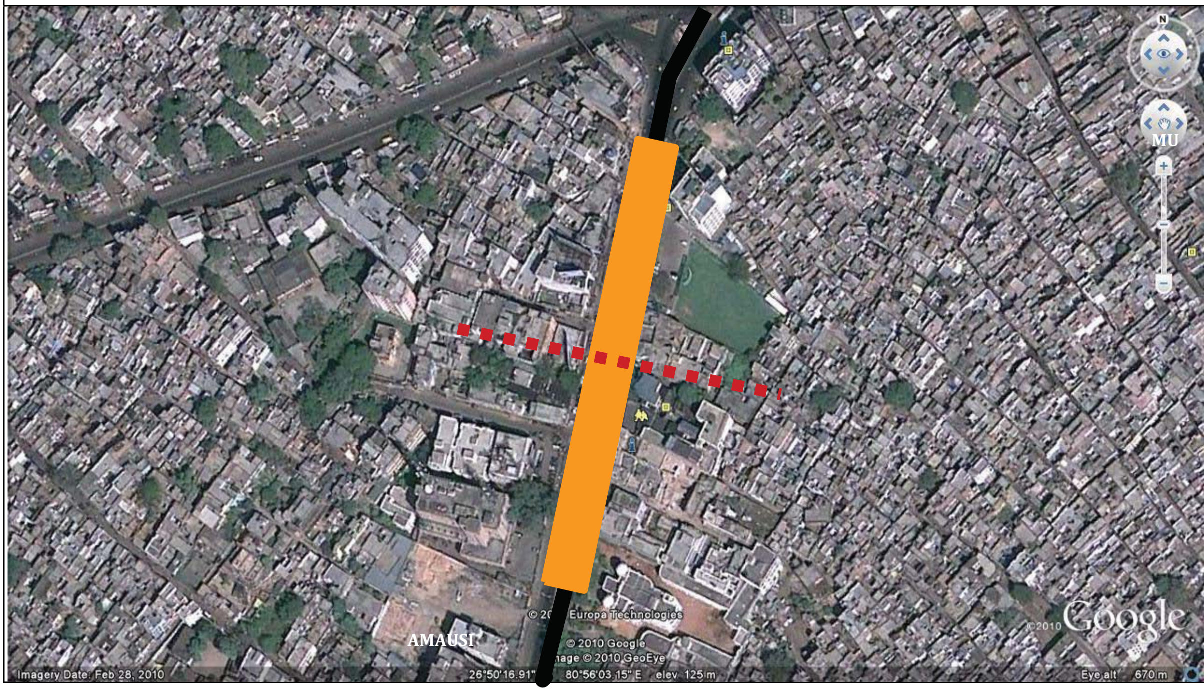
Street Scape at Station Location



4.3.3.11 Hussain Ganj Station

Chainage (m)	10392.47
Inter-station Distance (m)	1371.03
Rail Level (m)	96.890
Depth from Ground (m)	(-) 20.903
Location	Located on the median of Station road and centre line of the station is adjacent to Vidhan Mension on the northern side.
Entry exit stairs	On northern side one stair is located near Bombay sweet shop & other near Fubag bldg. On southern side stairs are located adjacent to Furniture shop & Hotel Raj
Catchment area	Dense mixed commercial & residential area on both sides of Shivaji Marg, Vidhan Sabha Marg, Guru Govind Singh Marg, Lalkuan, Ghasyari Mandi, part of Naka Hindola and Aminabad

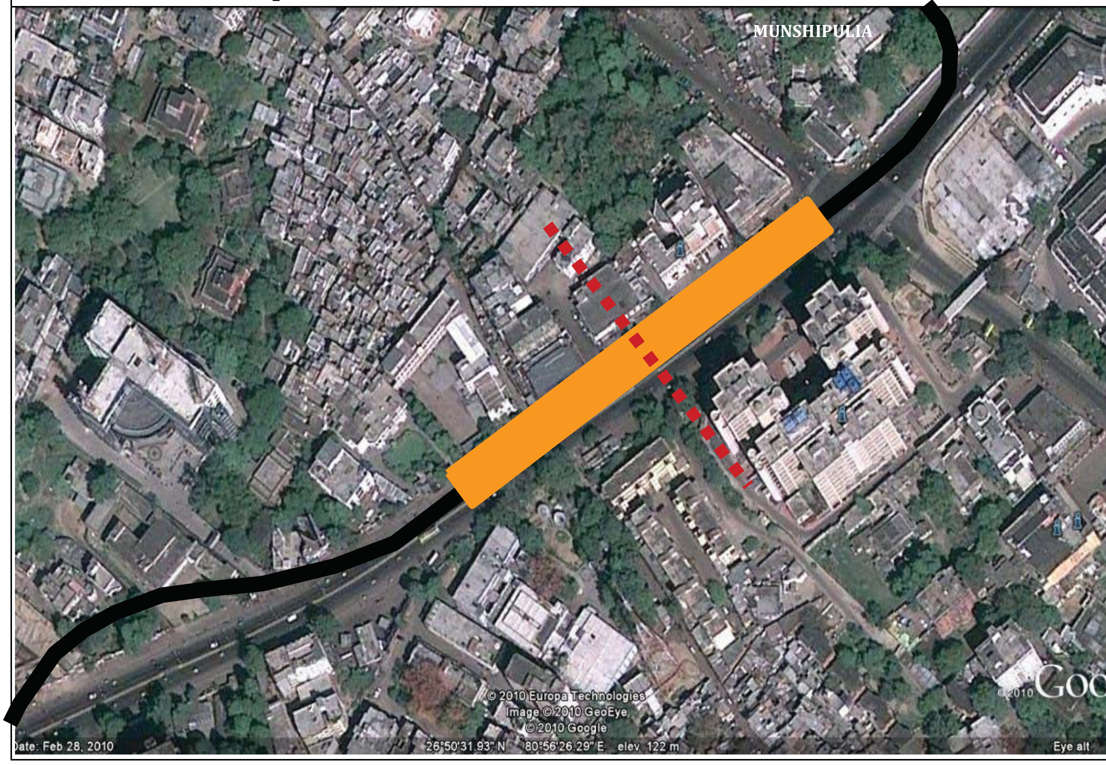
Street Scape at Station Location



4.3.3.12 Sachivalaya Station

Chainage (m)	11327.05
Interstation Distance (m)	934.58
Rail Level (m)	92.927
Depth from Ground (m)	(-) 20.539
Location	Located on the median of Vidhan Sabha Marg and centre line of the station is adjacent to Indian Community Party Office on the northern side.
Entry exit stairs	All the stairs are located in an open area
Catchment area	Part of Lalbagh, Darulshafa, Ganeshganj, and nearby offices like LDA, UP Sectariat, PWD, GPO etc

Street Scape at Station Location

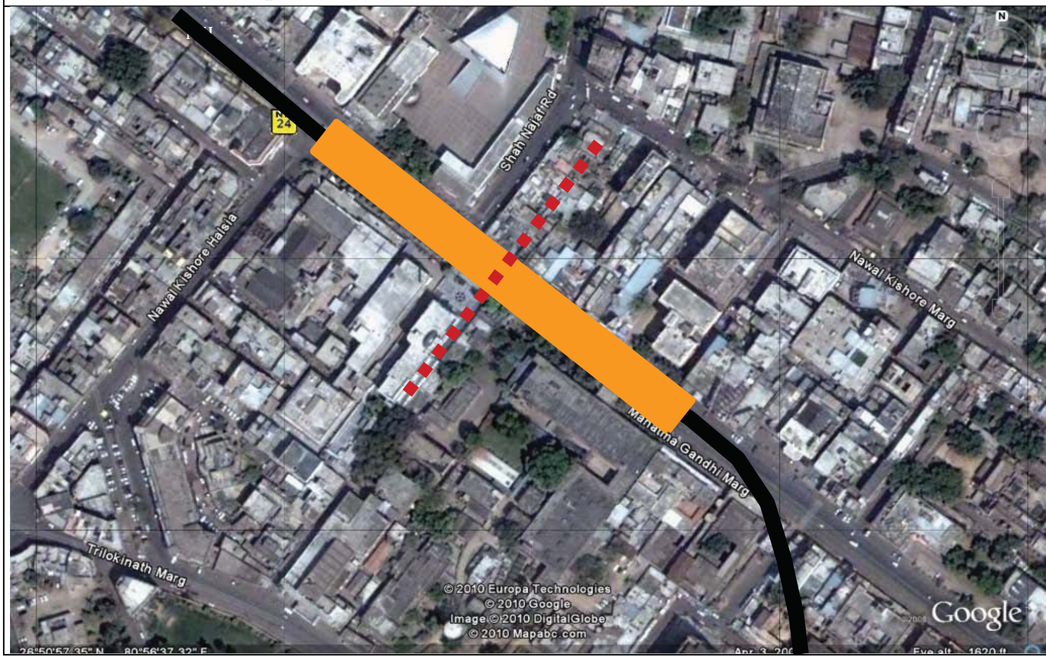


4.3.3.13 Hazrat Ganj Station

Chainage (m)	12379.38
Interstation Distance (m)	1052.33
Rail Level (m)	94.205
Depth from Ground (m)	(-) 15.5
Location	Located on the median of MG road and centre line of the station is adjacent to Rasool Manzil Complex on the northern side.
Entry exit stairs	On northern side one stair is located adjacent to Love lane bldg. & other near St. Joseph Cathedrad On southern side stairs are located on footpath

Catchment area	Mainly office cum commercial areas along both sides of Mahatma Gandhi Road like BSNL, DRM, Passport Office, Civil Hospital, Jawahar Bhawan, Indira Bhawan, Aaykar Bhawan, and part of Lalbagh Area

Street Scape Station Location

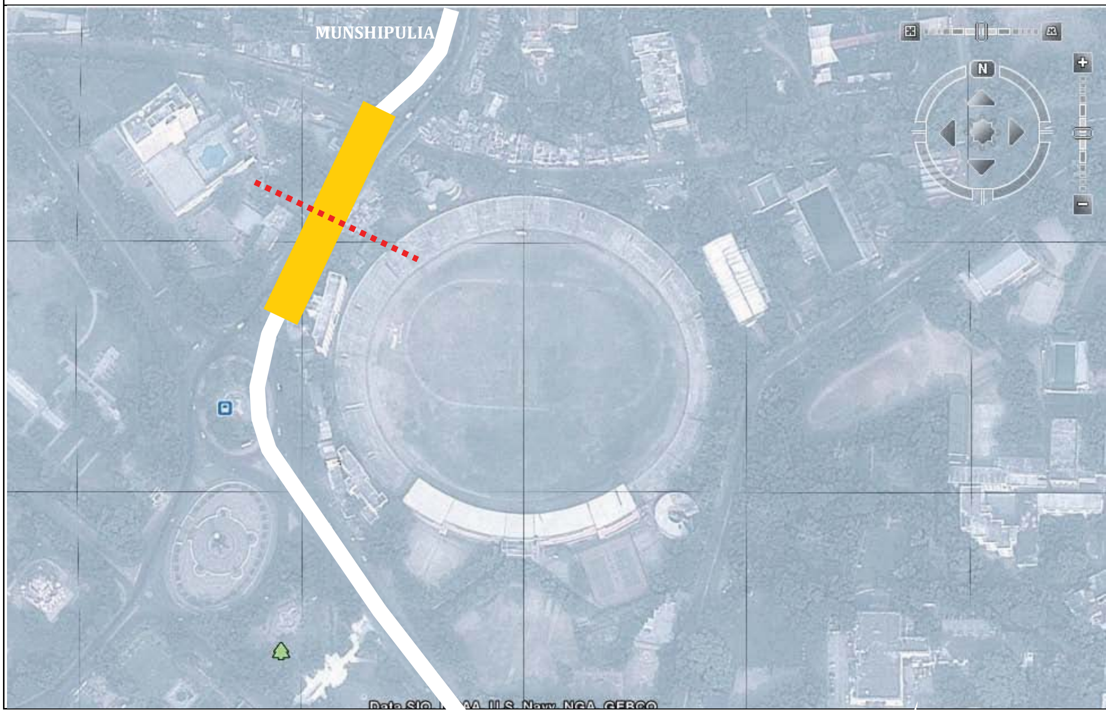


4.3.3.14 KD Singh Babu Stadium Station

Chainage (m)	13504.26
Interstation Distance (m)	1124.88
Rail Level (m)	123.041
Height from Ground (m)	14.7
Location	Located on the rear side campus of Hotel Clarks and part on road towards University at Pariwartan Chowk.
Entry exit stairs	On northern side stairs are located in footpath / open area at end of K D Singh stadium. On southern side one stair is located in park & other on park

	of hotel Clarks Awadh.
Catchment area	Areas like Begum Hazrat Mahal, Kaisarbagh, part of Hazratganj, Wazirganj, and Maulviganj. Also Highcourt bench, Balrampur Hospital, Bus Depot, Central Drug Research inst., Gymkhana Club

Street Scape at Station Location

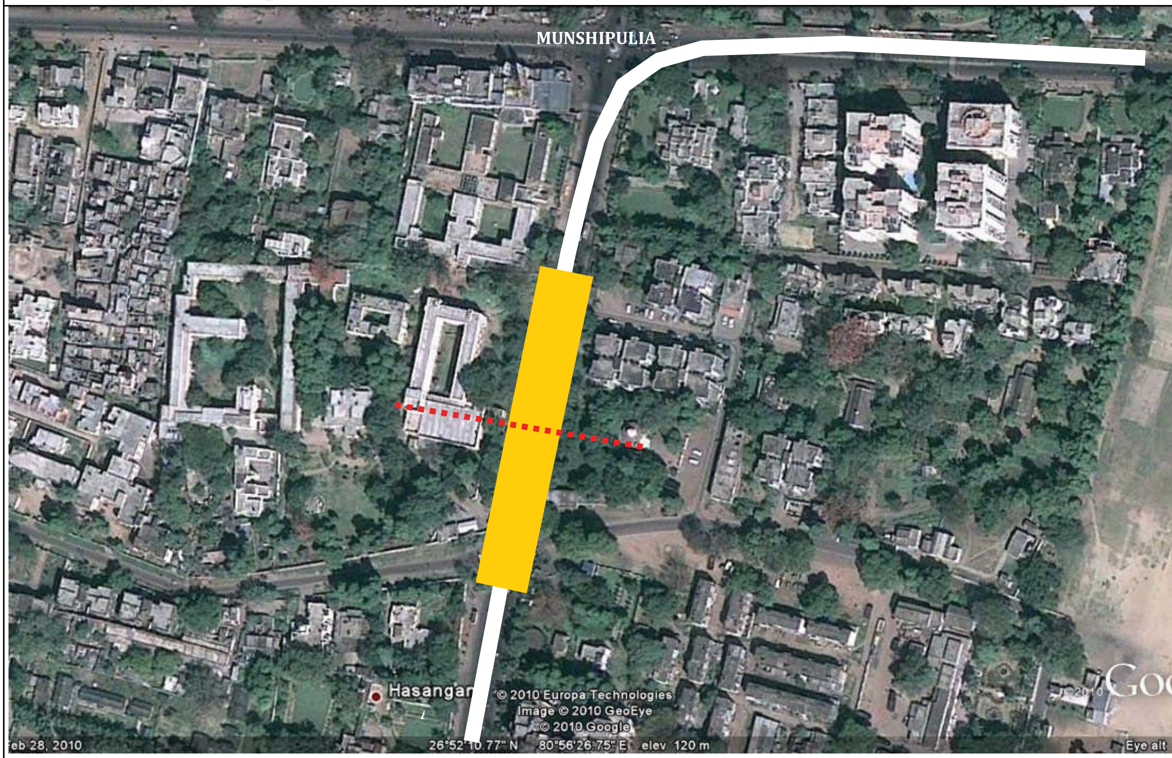


4.3.3.15 Vishvavidyalaya Station

Chainage (m)	14985.07
Interstation Distance (m)	1480.81
Rail Level (m)	123.686
Height from Ground (m)	12.617
Location	Located on the median of University road and centre line of the station is adjacent to Lucknow University on the northern side.
Entry exit stairs	All stairs are located in an open area
Catchment area	Hassanganj, Babuganj, Purana Haidarabad, Lucknow University

	area, part of Civil Lines and part of Mukarim Magar and Daliganj


Street Scape at Station Location



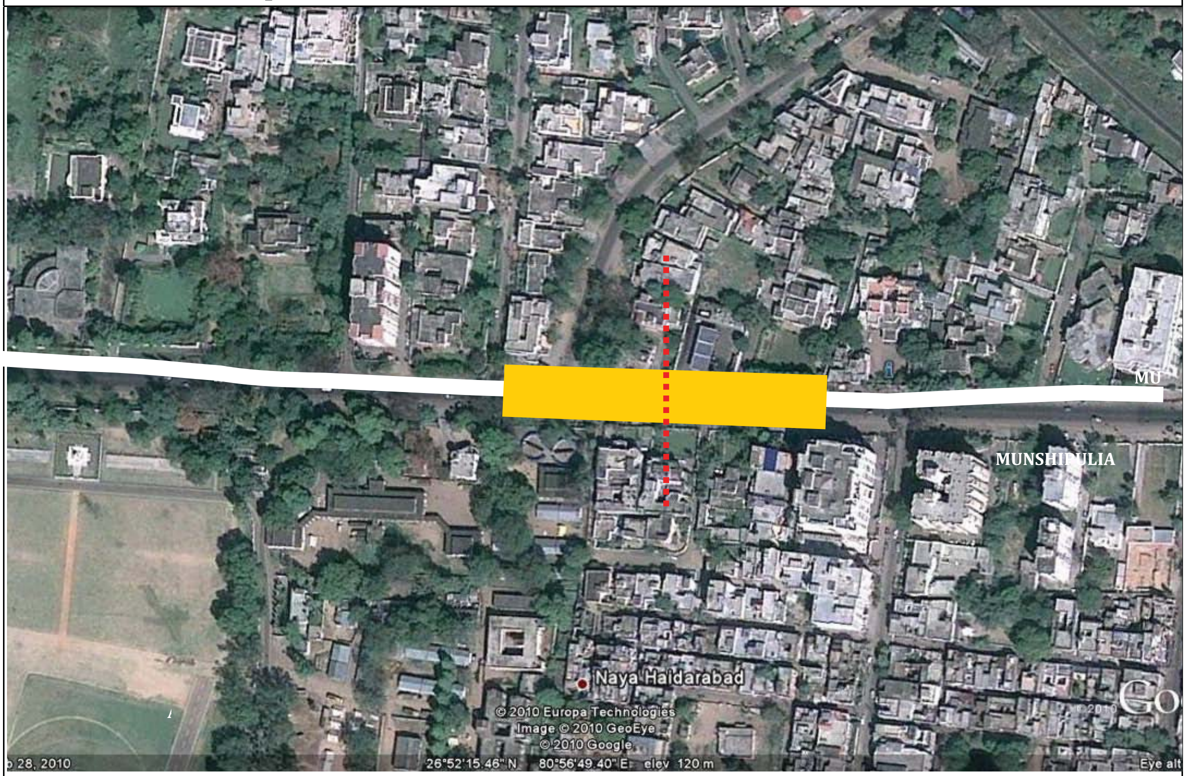
4.3.3.16 IT Chauraha Station

Chainage (m)	15810.90
Interstation Distance (m)	825.83
Rail Level (m)	123.778
Height from Ground (m)	12.933
Location	Located on the median of university road and centre line of the station is adjacent to IT Intermediate College on the northern side.

Entry exit stairs	All stairs are located in open area
Catchment area	Vivekanand Puri, Nirala Nagar, part of Naya Haidarabad, and Hassanganj etc.



Street Scape at Station Location

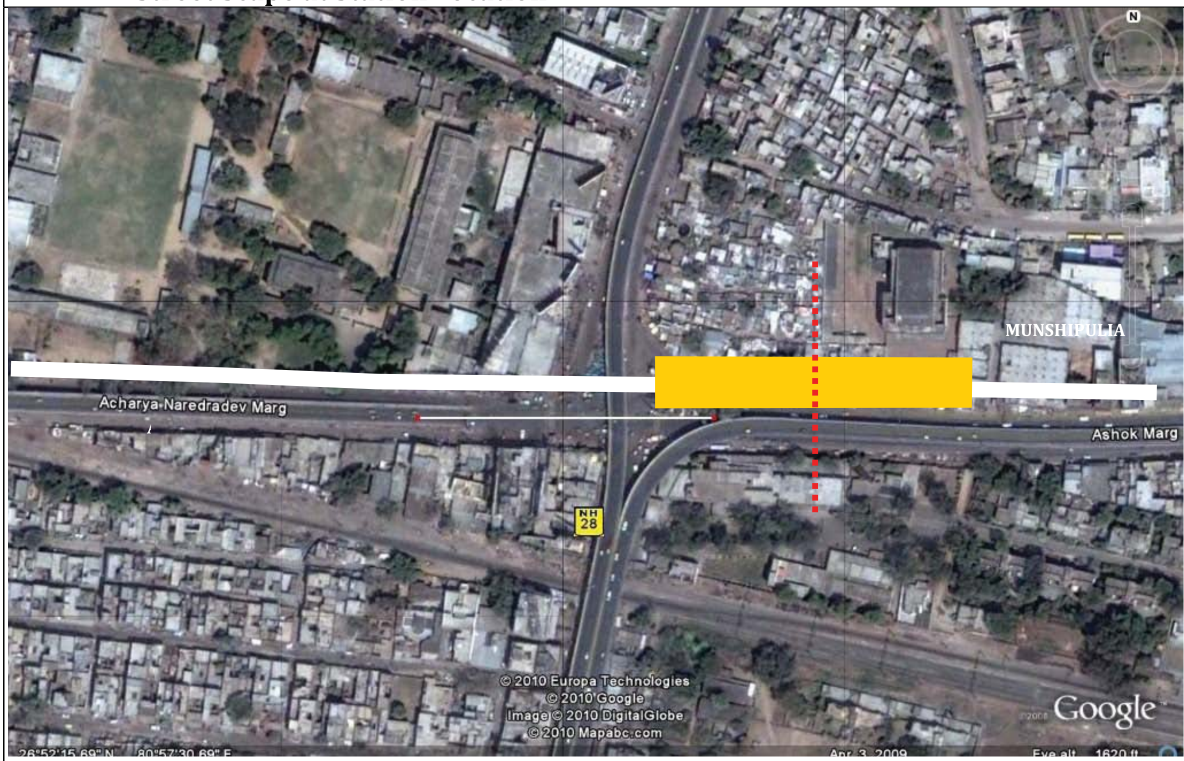


4.3.3.17 Mahanagar Station

Chainage (m)	16903.84
Interstation Distance (m)	1092.94
Rail Level (m)	125.980
Height from Ground (m)	17.930
Location	Located on the median of Faizabad road and centre line of the station is adjacent to Karamat Market on the northern side.
Entry exit stairs	On northern side stairs are located adjacent to shopping complex and temporary shops

	On southern side one stair is located near Railway hospital & other adjacent to Avadh agency
Catchment area	Naya Haidarabad, Nishatganj, Krishnanagar Colony, Mahanagar, part of Balmiki Nagar, and Fatima Hospital, Railway Hospital, Mahanagar Boys and Carmel Girls College

Street Scape at Station Location



4.3.3.18 Badshah Nagar Station

Chainage (m)	17577.28
Interstation Distance (m)	673.44
Rail Level (m)	124.737
Height from Ground (m)	13.400
Location	Located on the median of Faizabad road and centre line of the station is adjacent to Ran Basera complex on the northern side.

Entry/exit stairs	On northern side stairs are located in open area On southern side stairs are located near some temporary houses
Catchment area	Badshahnagar Colony, part of Balmiki Nagar, Karamat College, Sarvodaya Nagar and part of Khurram Nagar

Street Scape at Station Location

4.3.3.19 Lekhraj Market Station

Chainage (m)	18554.15
Interstation Distance (m)	976.90
Rail Level (m)	125.099
Height from Ground (m)	13.500
Location	Located on the median of Faizabad road and centre line of the station is adjacent to Lekhraj Market on the northern

	side.
Entry /exit stairs	On northern side both stairs are located in open area On southern side located in open area, one adjacent to Auto market shops
Catchment area	Murari Nagar, and commercial areas such as Lekhraj Market, Sahara Shopping Centre, Meena Market and surrounding residential areas

Street Scape at Station Location

4.3.3.20 Ramsagar Mishra Nagar Station

Chainage (m)	19273.00
Interstation Distance (m)	718.85
Rail Level (m)	126.959
Height from Ground (m)	12.703
Location	Located on the median of Faizabad road and centre line of the

	station is adjacent to Krishna Bazar Complex on the northern side.
Entry /exit stairs	On northern side stairs are located in open area On southern side stairs located in open area, one adjacent to Sharma Glass House
Catchment area	Mainly part of HAL Colony, Gomati Nagar, Indra Nagar, and commercial areas of Bhootnath Market, Amrapali Market, Azad Market

Street Scape at Station Location

4.3.3.21 Indira Nagar Station

Chainage (m)	20174.17
Interstation Distance (m)	901.10
Rail Level (m)	129.055
Height from Ground (m)	12.663

Location	Located on the median of Faizabad road and centre line of the station is adjacent to Deep on the southern side.
Entry/ exit stairs	On northern side one stair is located adjacent to Reliance Motor Care & other to Garg Traders On southern side stairs are located in open land of Deep Bhawan
Catchment area	Indira Nagar, HAL Colony, Gomati Nagar, part of Chinhat, Vishwas Khand, Vivek Khand II, III and IV and part of Vastu Khand. Would also serve the commercial areas like Sahara Trade Building, Westend Mall, Mandi Parishad, and Polytechnique

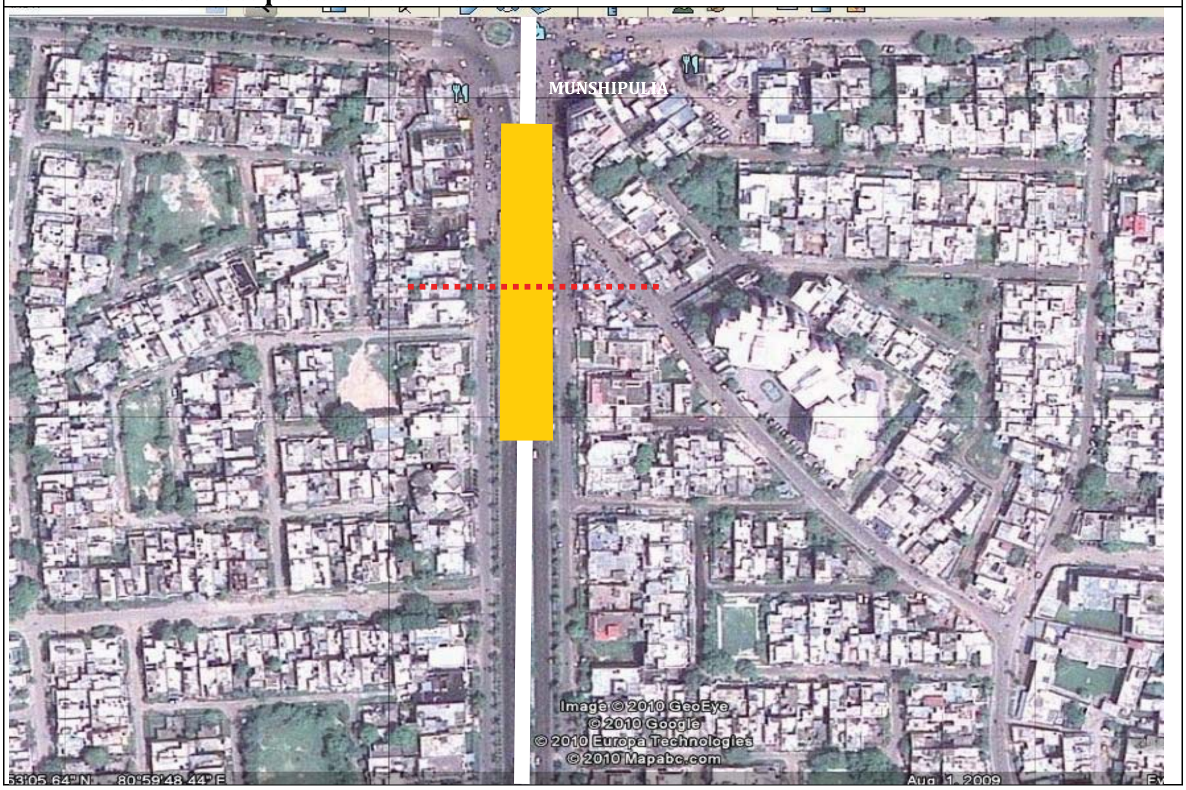
Street Scape at Station Location

4.3.3.22 Munshi Pulia Station

Chainage (m)	21734.66
Interstation Distance (m)	1560.56
Rail Level (m)	128.492

Height from Ground (m)	12.843
Location	Located on the median of Polytechnic road, center line of the station is adjacent to Brij Niwas building on northern side
Entry exit stairs	On northern side one stair is located adjacent to S.S Dewan bldg. & other near Patiksha bldg. On southern side stairs are located in an open area
Catchment area	Eastern part of Khurram Nagar, Munshipulia, Indira Nagar D Block, Hanuman Market, Ishwarpuri Colony,and part of Chinhat locality

Street Scape at Station Location



4.3.4 STATION LOCATIONS ON EW

4.3.4.1 Charbagh / Lucknow Station

Chainage (m)	0.00

Interstation Distance (m)	NA
Rail Level (m)	102.000
Depth from Ground (m)	17.715
Location	Centerline passes through adjacent to the Indian oil motor sales in the eastern side of the station
Entry exit stairs	At Charbagh Railway Station park on one side and space adjacent to indian Oil Motor Sales on the other side.
Catchment area	Would mainly cater to Charbagh Railway Station, would also serve part of Pan Dariba, Arya Nagar, part of Naka Hindola



Street Scape at Station Location

4.3.4.2 Gautam Buddha Marg Station

Chainage (m)	988.966

Interstation Distance (m)	988.966
Rail Level (m)	103.375
Depth from Ground (m)	14.600
Location	Centerline passes through adjacent to Bajaj Furniture on eastern side of station
Entry exit stairs	On acquired properties on western side and Ply House and shops adjacent to Bajaj Furniture on eastern side of station
Catchment area	Would mainly cater to dense commercial and residential area along both sides of Gautam Buddha Marg, Rani Ganj, Fatehganj, Kasai Bara, Husainganj, Naka Hindola, Lalkuan, part of Aishbagh and part of Arya Nagar

Street Scape at Station Location

4.3.4.3 Aminabad Station

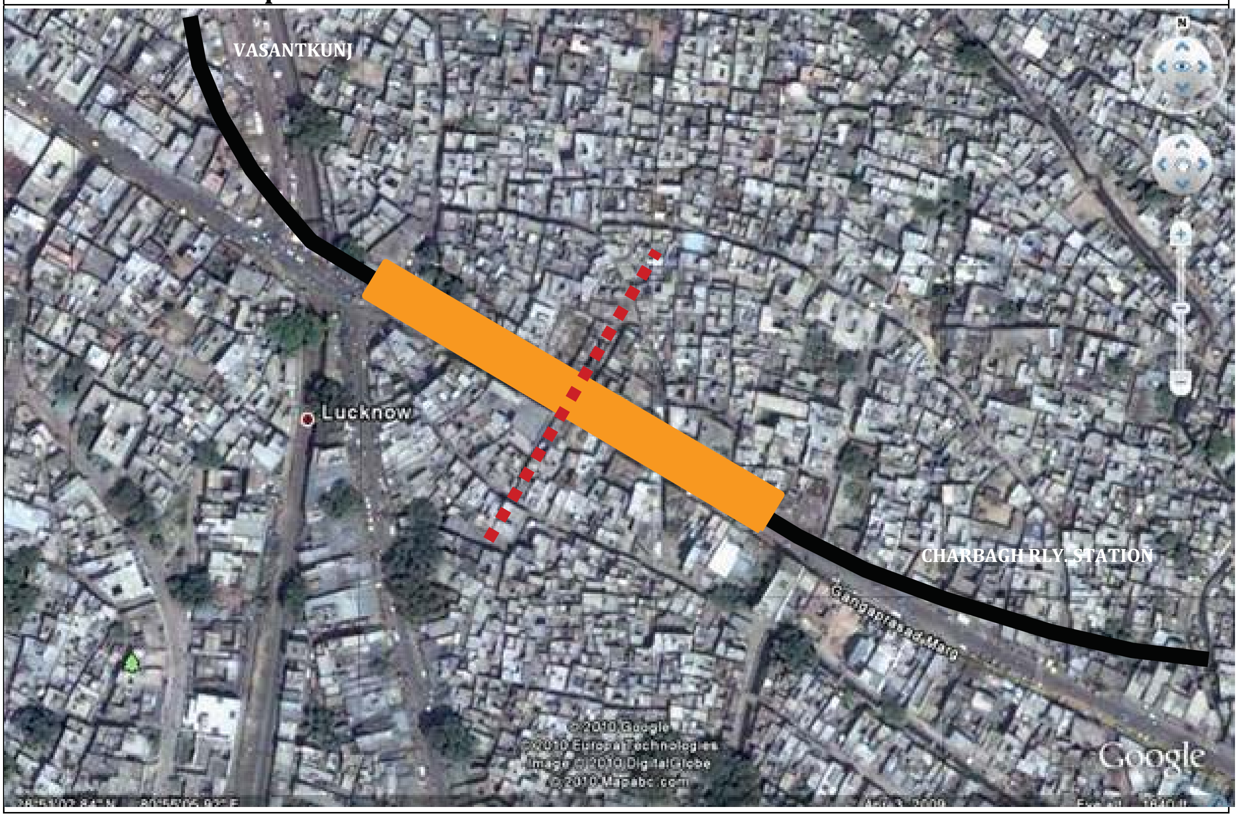
Chainage (m)	1953.42
Interstation Distance (m)	964.46
Rail Level (m)	103.657
Depth from Ground (m)	15.691
Location	Located beneath the Aminabad Park, centerline lies in front of Shobhit Complex in north eastern side of station block.
Entry exit stairs	Both entry/exit blocks would be situated at the Aminabad Park
Catchment area	Would cater to commercial hub of the city Aminabad, Jhandewalan Park, Kaisarbagh, part of Raniganj and Maulvigan

Street Scape at Station Location

4.3.4.4 Pandeyganj Station

Chainage (m)	2777.09
Interstation Distance (m)	823.67
Rail Level (m)	97.364
Depth from Ground (m)	19.414
Location	Off the road , underground station is placed in front of Shyam Kuti in north eastern side of station block
Entry exit stairs	Along the Gangaprasad Marg on acquired porperties
Catchment area	Pandeyganj, Wazirganj, Golaganj, Chikmandi, Maulviganj, Dubagwan and could extend upto Rakabganj and Rajendra Nagar

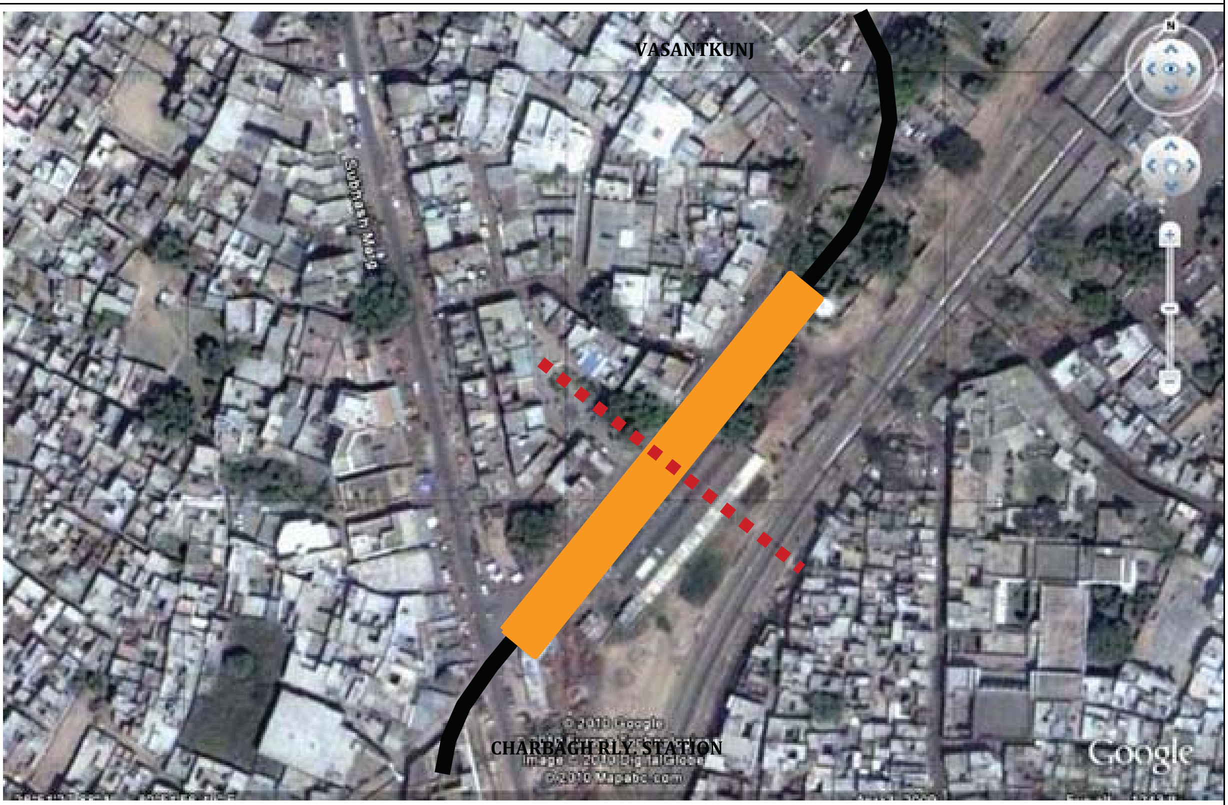
Street Scape at Station Location



4.3.4.5 City Railway Station

Chainage (m)	3694.07
Interstation Distance (m)	916.98
Rail Level (m)	104.767
Depth from Ground (m)	14.160
Location	Off the Subhash Marg, centre line of station lies in front of city railway station in south east side.
Entry exit stairs	Both the entry/exit blocks on available space along the railway tracks
Catchment area	Wazirganj, Yahiaganj, part of Rakabganj, Khajuwa area, Raja Bazar area and extend upto Shahganj and Chowk area

Street Scape at Station Location



4.3.4.6 Medical Chauraha Station

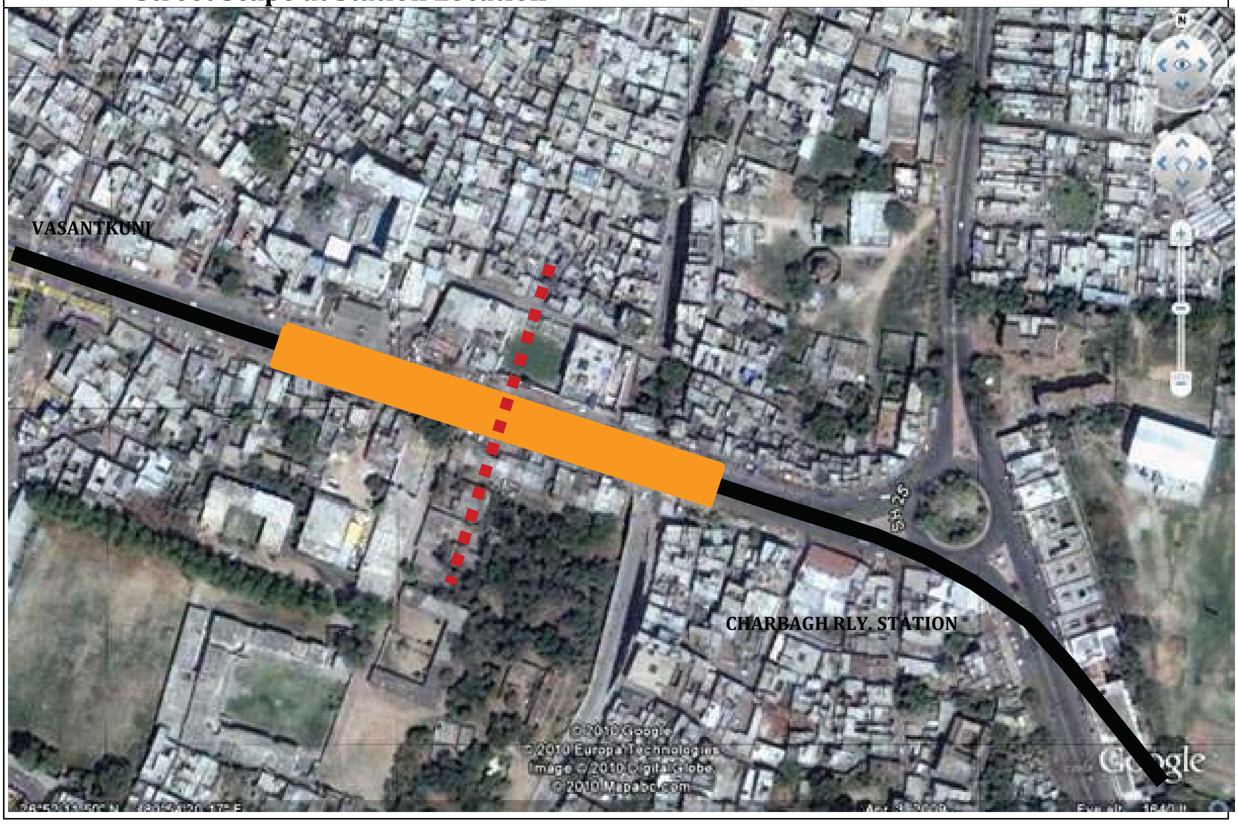
Chainage (m)	4643.42
Interstation Distance (m)	949.35
Rail Level (m)	105.203
Depth from Ground (m)	13.704
Location	Located beneath the medical chauraha, centerline lies in front of Madarsa Sultanul Mardaris building in south western side of station block.
Entry exit stairs	Southern Stair blocks on the available space on Queen Mary Hospital and northern stairs on vacant space
Catchment area	CSM Medical University and Hospital area, Patanala, Bara Imambara, Machchhi Bhawan, and Chowk area

Street Scape at Station Location

4.3.4.7 Nawajganj Station

Chainage (m)	5833.08
Interstation Distance (m)	1189.66
Rail Level (m)	103.328
Depth from Ground (m)	13.824
Location	Centerline of underground station passes through the Kapoor medical store in the south of the station
Entry exit stairs	Southern block at Kali inter college/Kapoor medical store and northern stairs at Lohiya lawns
Catchment area	Chaupatiyan, Part Of Chowk, Napier Park, Company Bagh, Husainabad, Sarai Male Khan, and Chota Imambara

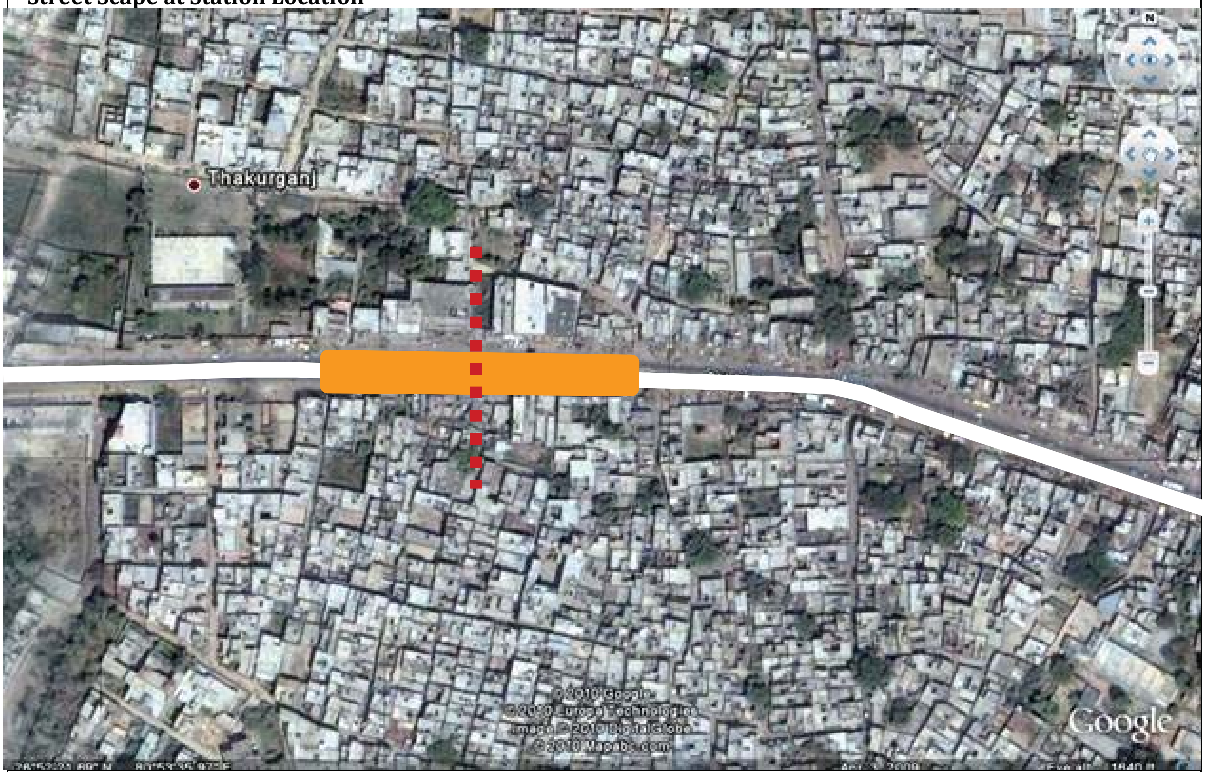
Street Scape at Station Location



4.3.4.8 Thakurganj Station

Chainage (m)	7175.47
Interstation Distance (m)	1342.39
Rail Level (m)	129.436
Height from Ground (m)	13.169
Location	Elevated station located on the median, Centerline passes through the shops adjacent to Mohit Market in the north of the station
Entry exit stairs	On northern side, Waterpump House premises & open space adjacent to Sri Ram Market and on southern side, open land besides Koti Bhawan & Surya Plaza along Pooja hostel lane
Catchment area	Thakurganj, Musahibganj, Daulatganj, Kaffim Nagar, Razabganj, Lat Purwa, and Ahmadganj

Street Scape at Station Location



4.3.4.9 Balaganj Station

Chainage (m)	8114.17
Interstation Distance (m)	938.70
Rail Level (m)	131.757
Height from Ground (m)	12.807
Location	Centerline passes through the police station in the south of the station
Entry exit stairs	open spaces on both sides of the station block are available for stair blocks
Catchment area	Balaganj, and areas like Rainnagan, Yasinganj, Mauzam Nagar, Niwati Tola,



Street Scape at Station Location

4.3.4.10 Sarfazganj Station

Chainage (m)	8794.08
Interstation Distance (m)	679.91
Rail Level (m)	133.087
Height from Ground (m)	12.275
Location	Centerline passes through the shops adjacent to Mass Auto Service in the north of the station
Entry exit stairs	open spaces in front of shops on both sides of the station block are available for stair blocks
Catchment area	Would cater mainly to Sarfazganj and also to Arihankhera, Banaura Husainbari, Sardar Nagar etc.

Street Scape at Station Location

4.3.4.11 Musabagh Station

Chainage (m)	9723.75
Interstation Distance (m)	929.67
Rail Level (m)	130.678
Height from Ground (m)	12.857
Location	Centerline passes adjacent to the culvert of nala in the north of the station
Entry exit stairs	open spaces on both sides of the station block is available for stair blocks
Catchment area	Would cater to Musabagh, Madhopur, Faridpur etc.

Street Scape at Station Location

4.3.4.12 Vasant Kunj Station

Chainage (m)	10576.94
Interstation Distance (m)	853.19
Rail Level (m)	132.767
Height from Ground (m)	12.522
Location	Centerline passes through the shops adjacent to Asha Trading Company in the north of the station
Entry exit stairs	open spaces on both sides of the station block along the State Highway 25 is available for stair blocks
Catchment area	Would cater to areas like Chhanduiya, Dubagga, and Begaria

Street Scape at Station Location

4.3.5 PLANNING AND DESIGN CRITERIA FOR STATIONS

Salient features of a typical station are as follows:

- 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.
- The platform level has adequate assembly space for passengers for both normal operating conditions and a recognized abnormal scenario.
- The platform level at elevated stations is determined by a critical clearance of 5.50-m under the concourse above the road intersection, allowing 3.00-m for the concourse height, about 1-m for concourse floor and 2.00-m for structure of tracks above the concourse. Further, the platforms are 1.09-m above the tracks. This would make the platforms in an elevated situation at least 13.60m above ground.
- 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.
- 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.
- Sufficient space for queuing and passenger flow has been allowed at the ticketing gates.
- Station entrances are located with particular reference to passenger catchment points and physical site constraints within the right-of-way allocated to the MRTS.
- Office accommodation, operational areas and plant room space is required in the non-public areas at each station.
- Tunnel Ventilation fans and ASS in underground stations are provided at platform level/ concourse level depending on availability of land for locating vent shafts.
- The DG set, bore well pump houses and ground tank would be located generally in one area on ground.
- 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.

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

A list of accommodation required in the non-public area at each station is given below:

Non Public Area – Station Accommodation	
Station Control Room	Cash & Ticket Room
Platform Supervisor's Booth	Fire Tank & Pump room
Station Master's Office	Staff Area
Traction Substation	UPS and Battery Room
Information & Enquiries	Cleaner's Room
Signaling Room	Security Room
Ticket Office	Staff Toilets
Communication Room	Refuse Store
Ticket Hall Supervisor & Excess Fare Collection (Passenger Office)	Miscellaneous Operations Room
Station Substation	First Aid Room

4.3.6 TYPICAL ELEVATED STATION

(applicable to the elevated stations on NS corridor (except *Durgapuri* Station- 4 platform, *Mahanagar Station*- double elevated- total 17 stations) and last 5 stations of EW corridor)

The station is generally located on the road median ~140 m long and is a three level structure. Passenger area on concourse is spread throughout the length of the station, with staircases leading from either side of the road. Passenger facilities like ticketing, information, etc as well as operational areas are provided at the concourse level. Typically, the concourse is divided into public and non-public zones. The non-public zone or the restricted zone contains station operational areas such as Station Control Room, Station Master's Office, Waiting Room, Meeting Room, UPS & Battery Room, Signalling Room, Train Crew Room & Supervisor's Office, Security Room, Station Store Room, Staff Toilets, etc. The public zone is further divided into paid and unpaid areas. Area left over in the unpaid zone, after accommodating the passenger movement and other station facilities is earmarked for commercial utilization.

Since the stations are planned generally in the middle of the road, minimum vertical clearance of 5.5-m has been provided under the concourse. Concourse floor level is about 6.5-m above the road. Consequently, platforms are at a level of about 13.6 m from the road. To reduce physical and visual impact of the elevated station, stations have been made transparent with minimum walls on the sides.

With respect to its spatial quality, an elevated MRT structure makes a great impact on the viewer as compared to an At-grade station. The positive dimension of this impact has been accentuated to enhance the acceptability of an elevated station and the above ground section of tracks. Structures that afford maximum transparency and are light looking have been envisaged. A slim and ultra-modern concrete form is proposed, as they would look both 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 aluminium cladding to achieve a light look. Platforms would be protected from the elements by providing an overhang of the roof and sidewalls would be avoided, thereby enhancing the transparent character of the station building. In order to allow unhindered traffic movement below the stations, portals across the road have been proposed.

A full length concourse affords excellent articulation with the street and allows flexibility in locating entrances. At the same time this concourse configuration also provides for unlimited options for connecting to the station in future, all along the face of the station as also from the ends, under the viaduct.

4.3.7 TYPICAL UNDERGROUND STATION A - APPLICABLE TO HAZRATGANJ ON NORTH –SOUTH CORRIDOR AND GAUTAM BUDHA MARG, AMINABAD, CITY RAILWAY STATION, MEDICAL CHAURAHA & NAWAZGANJ STATIONS ON EAST –WEST CORRIDOR

Aminabad, City Railway Station, Medical Chauraha and *Nawazganj* underground stations on the EW corridor follow a typical design, which is three level station with entrances and ventilation shafts at the ground level, a concourse with ticketing and AFCs at the mezzanine level and finally platforms at the lowest level. 140 m island platforms are proposed on the stations. Platforms are 12 m wide with 2 sets of staircase/ Esc banks planned leading to either end of the station. A lift is planned in the centre.

Two end concourses have been proposed, one at each end. The concourse is divided into paid and unpaid area by the AFC gates. Paid area is limited to access to the stair / esc bank and corridors connecting the two concourses, also lead to the lift which is centrally provided. A large cut out is proposed in the middle of paid concourse which provides visual connectivity between the concourse and platform.

Since the stations are in very busy areas, very limited space is available on the ground. All the over-ground structures are therefore, planned as and where space is available and are therefore, not necessarily grouped at ground level. Entrances are planned such as to provide at least two at each end of the station, one on either side of the vehicular road to provide pedestrian friendly access to station. Other over ground structures are ventilation shafts and independent access for firemen.

Layout of the station is such that provides a most direct and visually legible space. Consequently, the passenger flow is simple. Upon arrival at concourse level from street, ticket gates and AFC gates are clearly visible. As the passengers approach the AFC gates, entire platform is visible to them. From each end of concourse, only one bank of staircase/ esc is available, hence the passengers move without any confusion to the platform. Those looking fro elevator can see the same directly in front in the middle of the platform through the large double ht space connecting the two levels.

The USP of the station lies in the spatial quality created out of the structural form. The entire station passenger's area is designed as a column free, double height space which makes it possible for the passengers to be able to see the entire station concourse and platform from end to end just as approaching the AFC line. It is this spatial configuration from where the station will derive its aesthetics value. The sense of volume (12 m high, 20 m wide and approx 100m long space), visual legibility (little dependence on signage as the entire station is visible from entrance) and a sense of orientation are major components of the aesthetics of the entrances.

Regarding the entrances, it is proposed that the entrance structure is designed as a light weight providing the basic function of covering the entrance opening from the basement. Since the entire area is very heavily built up the light weight structures will be pleasing and welcome. ECS plant room is generally proposed at the concourse level, outside the station box, ASS at concourse level at the two ends and the TVF rooms in a track side configuration. Other back of the house areas are planned at both platform and concourse levels

4.3.8 TYPICAL UNDERGROUND STATION B - APPLICABLE TO HUSSAINGANJ, SACHIWALAYA ON NORTH SOUTH CORRIDOR

This station is same as the Typical Underground station A , except that this is a four level station. In this the entrances and ventilation shafts are at ground level and all other plant rooms which are genrally at grounfd level have been located in the -1 level. Space left over at -1 level is proposed to be utilised for developemnt of retail spaces. -2 level is concourse and -3 is paltform. There was acute shortage of land for locating plant rooms (chiller plants, pumprooms, DG set etc) . This led to a the evolution of this prototype station.

4.3.9 CHARBAGH / LUCKNOW STATION

Charbagh is an interchange terminal station. The EW underground corridor terminates here and the elevated NS corridor is connected with E-W Corridor. The underground and elevated stations of both the lines will have a common ticketing area and different platform levels with the ground level being also common.

The station is located at the T junction of Kanpur Road and *Gautam Budha Marg* directly in front of the main entrance of the Charbagh Railway station. Consequently, four entrances have been planned, one from each side of the T junction, to enter the station without having to cross vehicular traffic on these busy roads. Main entrance, which is also integrated entrance for both the lines, is at the ground level from the Charbagh Indian Railways station side. The entrance houses facilities for ticketing for corridors, lifts, stairs and escalators to reach the elevated, as well as, underground platforms. Passengers have to enter the common concourse and thereafter enter to paid area for both the stations for going to platforms.

Entrances to station have been located in a way that the passengers can enter to Underground concourse without crossing the roads.

4.3.10 PANDEY GANJ STATION - BUILT WITH NATM METHOD

The *Pandeyganj* underground station on the EW corridor is a tunneled station. The ground level has all the ticketing, electrical and equipment rooms. The passenger can take the elevator directly to the platforms three levels below from the paid area. The escalators stop at each intermediate level and the passenger has to walk around the escalator to go to the level below. The first level below the concourse / ground contains the ECS rooms and the second level contains the ASS and fan rooms (above the platforms in a standard configuration) for one of the lines. The final (-3) level is the platform level which contains the fan rooms in a tracks side configuration for the other line.

4.3.10.1 Passenger Amenities at Stations

Passenger amenities such as ticketing counters/automatic ticket vending machines, ticketing gate, etc. are provided in the concourse. Adequate facilities have been provided for system wide uniformity, although the requirements of the facilities actually vary from station to station. The same applies to provision of platform widths and staircase/escalators. Maximum capacity required at any station by the year 2030 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.*

4.3.11 CONCOURSE

Concourse forms the interface between street and platforms. This is where all the passenger amenities are provided. The concourse contains automatic fare collection system in a manner that divides the concourse into distinct *paid* and *unpaid* areas. The *'unpaid area'* is where passengers gain access to the system, obtain travel information and purchase tickets. On passing through the ticket gates, the passenger enters the *'paid area', which* includes access to the platforms. The concourse is planned in such a way that maximum surveillance can be achieved by the ticket hall supervisor over ticket machines, automatic fare collection (AFC) gates, stairs and escalators. Ticket machines and AFC gates are positioned to minimize cross flows of passengers and provide adequate circulation space. Sufficient space for queuing and passenger flow has been allowed in front of the ticketing gates.

4.3.12 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 2041 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.

4.3.13 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 card, etc. Accordingly, the requirement of ticket counters has been calculated and the same provided for in the plans.

4.3.14 PLATFORMS

A uniform platform width of 5.5-m wide including staircases and escalators in the central section is proposed for the elevated stations. This platform width has been checked for holding capacity of the platform for worst-case scenario (disruption period of 6 min) in the design year 2041. In the underground stations, 12 m wide island platforms are proposed in all locations except pandey ganja nd charbagh station on EW corridor.

4.3.15 STAIRS, ESCALATORS AND LIFTS FOR NORMAL AND EMERGENCY OPERATIONS

Provision has been made for escalators in the paid as well as entrance on both sides i.e. from ground to concourse and concourse to platforms. On each platform, two escalators have been proposed. In addition, two staircases with a combined width of 4.8 m are provided on each side platform connecting to the concourse. These stairs and escalator together provide an escape capacity adequate to evacuate passengers in emergency from platforms to concourse in 4.0 minutes in most stations. Wherever, this is inadequate, additional emergency exit staircases are proposed. (see table 4.13) While calculating the waiting passengers on the platform in emergency, provisions of NFPA 130, 2007 edition have been followed i.e. a service disruption of 6 min is assumed. Train loads also consider service disruption or full tarin load, which ever is lower. Lifts have been provided one each on either platform, to provide access for elderly and disabled. Since the rise from road to concourse is about 6.5-m, it is proposed to provide escalators and lifts in addition to stairs for vertical movement of passengers from street to concourse.

4.3.16 PASSENGER INFORMATION KIOSKS AND COMMERCIAL KIOSKS

Passenger Information Kiosks and Commercial Kiosks are provided in the unpaid and paid areas of the concourse respectively. Summary of passenger amenities required and proposed at stations based on projected traffic for the year 2041 is given in **Table 4.13**.

Table 4.13 PASSENGER TRAFFIC AND AMENITIES IN STATIONS (Year 2041)

Station	Peak Hour Boarding in 2041 (CCS airport to Munshi Pulia)	Peak Hour Boarding in 2041 (Munshi Pulia to CCS airport)	Ticketing Gates	Ticket Counters	Combined Width of Stairs from Platform to concourse in m	Additional emergency stairs in m	Lifts Proposed At Each Station		Escalators Proposed At Each Station	
							Ground to Conc	Conc to plat	Ground to Conc	Conc to plat
North South Corridor										
1. Chaudhary Charan Singh Airport	152	0	4	2	4.8	Nil	5	2	3	2
2. Amausi	607	0	4	2	4.8	Nil	4	2	4	2
3. Transport Nagar	1846	0	4	2	4.8	Nil	4	2	4	2
4. Krishnagar	7113	372	9	6	4.8	4.8	4	2	4	2
5. Singar Nagar	2348	351	4	3	4.8	2.4	4	2	4	2
6. Alambagh	2893	611	7	3	4.8	2.4	4	2	4	2
7. Alambagh Bus Stn	5249	1053	12	6	4.8	4.8	4	2	4	2
8. Mawaiya	7503	1215	12	7	4.8	6.0	4	2	4	2
9. Durgapuri	6620	2193	11	8	4.8	6.0	4	2	4	2
10. Charbagh / Lucknow Rly. Stn	17254	15981	17	14	9.6	12	5	2	3	10
11. Husain Ganj	5179	3683	9	7	4.8	4.8	4	2	4	2
12. Sachivalaya	818	1853	5	2	4.8	1.2	4	2	4	2
13. Hazarat Ganj	1064	2643	9	3	4.8	2.4	4	2	4	2
14. Stadium	751	677	5	2	4.8	1.2	4	2	4	2
15. Vishwavidyaly	902	969	6	2	4.8	1.2	4	2	4	2
16. IT Chauraha	1371	1377	5	3	4.8	1.2	4	2	4	2
17. Mahanagar	2306	9566	14	10	4.8	7.2	4	2	4	2
18. Badshah Nagar	822	5377	8	5	4.8	3.6	4	2	4	2
19. Lekhraj Market	727	6459	7	6	4.8	4.8	4	2	4	2
20. Ram Sagar Mishra Nagar	377	3347	7	3	4.8	2.4	4	2	4	2
21. Indira Nagar	0	5327	6	5	4.8	3.6	4	2	4	2
22. Munshipulia	0	5441	7	3	4.8	0.0	4	2	4	2

Station	Peak Hour Boarding in 2041 (Lucknow RS to Vasantkunj)	Peak Hour Boarding in 2041 (Vasantkunj to Lucknow RS)	Ticketing Gates	Ticket Counters	Combined Width of Stairs from Platform to concourse in m	Additional emergency stairs in m	Lifts Proposed At Each Station		Escalators Proposed At Each Station	
							Ground to Conc	Conc to plat	Ground to Conc	Conc to plat
East West Corridor										
1. Charbagh / Lucknow Rly. Stn	6596	0	24	9	4.8	4.8	6	2	3	8
2. Gautam Buddha Marg	618	4164	5	3	4.8	1.2	2	1	2	4
3. Aminabad	1023	5232	8	6	4.8	1.8	3	1	3	2
4. Pandey Ganj	720	6471	7	9	4.8	1.2	2		2	
5. City Rly. Stn	344	3127	4	4	4.8	1.2	3	1	2	2
6. Medical Chauraha	334	4749	4	6	4.8	1.2	5	1	5	2
7. Nawajganj	466	9943	9	13	4.8	1.2	4	1	4	2
8. Thakurganj	341	6043	5	7	4.8	Nil	4	2	4	2
9. Balaganj	351	5642	5	7	4.8	Nil	4	2	4	2
10. Sarfarazganj	69	1545	2	2	4.8	Nil	4	2	4	2
11. Musabagh	46	1269	2	2	4.8	Nil	4	2	4	2
12. Vasant kunj	0	927	2	1	4.8	Nil	4	2	4	2

4.3.17 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.

4.3.18 APPROACH ADOPTED IN PLANNING TRAFFIC INTEGRATION FACILITIES

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

4.3.19 OPERATIONAL INTEGRATION

Integration at operational level will be required to synchronize the timings of the MRTS services and the feeder service. For an efficient interchange, walking and waiting time at these stations will need to be minimized. Introduction of common ticketing and their availability at convenient locations will be necessary to ensure forecast patronage of the system. Last but not the least will be the need for an integrated passenger information system covering all the modes through the publication of common route guides, time tables and information boards at terminals and in the train coaches for providing updated information for users of the system.

4.4 CONSTRUCTION METHODOLOGY

4.4.1 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 before and after Switch Over Ramp (SOR) and at the start of the alignment at Lucknow Station. 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.

4.4.1.1 Underground Stations

All the seven 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. The typical dimension of box tunnel section is shown in **Fig. 4.2.**

4.4.1.2 Cut and Cover Method of Construction of Underground Stations

Cut and Cover mainly consists of following steps:

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

The typical section of Cut and Cover construction (Top-Down) method is shown in **Fig.4.3**.

4.4.1.3 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.

4.4.1.4 Support Walls

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

- It is rigid type of support system and therefore ensures the maximum safety against settlement to the adjacent structures.
- Can be used as part of the permanent structure and, therefore, considered economical.
- With diaphragm wall it is possible to construct an underground structure by top down method. In this method top slab is cast once the excavation is reached to the top slab level with rigid connections to the diaphragm wall which can be achieved by leaving couplers in the diaphragm wall reinforcement at appropriate level. This top slab then acts as strut between the two support walls and gives much more rigidity and safety to the construction. Excavation thereafter can be completed. This also helps in restoration of the surface faster without waiting for full structure to be completed.

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

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.

Retaining Casing Piles: This is suitable for situation where the cut and cover is to be done partly in soil and partly in rocky strata. 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 mm dia.

Soldier Piles and Lagging: Steel piles (H Section or I section) are driven into the ground at suitable interval (normally 1-1.5 mtr.) 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.

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 can not be used as part of permanent structure and permanent structure has to be constructed in- side of this temporary wall.

4.4.1.5 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.

4.4.2 CHOICE OF SUPERSTRUCTURE

The choice of superstructure has to be made keeping in view the ease of constructability and the maximum standardization of the form-work for a wide span ranges. Following type of superstructures has been considered:

4.4.2.1 Segmental Balanced Cantilever Method

- Cast-in-situ Segmental Balanced Cantilever Method.
- Precast Segmental box girder using external unbonded tendons.
- Precast segmental U-Channel superstructure with internal pre-stressing.

Cast-in-situ Segmental Balanced Cantilever Method

The formwork is supported from a movable form carrier. The form traveler moves forward on rails attached to the deck of the completed structure and is anchored to the deck at the rear. With the form traveler in place, a new segment is formed, cast and stressed to the previously constructed segment. A covering may be provided on the form carrier so that work may proceed during inclement weather.

Each segment is reinforced with conventional untensioned steel and sometimes by transverse or vertical prestressing or both, while the assembly of segments is achieved by longitudinal post-tensioning. One segment to the left of the pier is first constructed and then stressed against the crosshead, followed by the corresponding unit on the right, which will also be stressed against the crosshead. The sequence is then repeated. Additional prestressing shall be provided for continuity to the overall frame structure.

The operation sequence in cast in place balance cantilever construction is as follows:

- Setting up and adjusting carrier
- Setting up and aligning forms
- Placing reinforcement and tendon ducts
- Concreting
- Inserting prestress tendons in the segment and stressing
- Removing the formwork
- Moving the form carrier to the next position and starting a new cycle

The limitation of the method is that the strength of concrete is always on the critical path of construction and it also influences greatly the structure's deformability, particularly during construction.

Pre Cast Segmental Box Girder

This essentially consists of precast segmental construction with external prestressing and dries joints and is by far the most preferred technique in fast track projects. In such construction the prestressing is placed outside the structural concrete (but inside the box) 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 in association with external tendons. The schematic arrangement is shown at **Fig. 2.4**.

The main advantages of dry-jointed externally prestressed 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.

Pre Cast Segmental 'U' Girder

- The single U type of viaduct structure is also a precast segmental construction with internal prestressing and requires gluing and temporary prestressing 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:
- Built-in sound barrier.
- Built-in cable support and system function.
- Possibility to lower the longitudinal profile by approximately 1m compared to conventional design.
- Built-in structural elements capable of maintaining the trains on the bridge in case of derailment (a standard barrier design does not allow this)
- Built-in maintenance and evacuation path on either side of the track.

After studying all the feasible options, Pre-cast segmental box girder using external unbounded tendon had been adopted because of the advantages mentioned above. The schematic arrangement for this is shown in **Fig. 4.5.**

4.4.2.2 Span by Span Construction Method

Constructing the typical spans on an Advanced Launching Girder (ALG) with system formwork for span-by-span cast-in-situ construction:

Advanced Launching Girder with system formwork has been used in Singapore and it has demonstrated the effective use of this construction methodology in the viaduct construction to achieve quality finishes. The Advanced Launching Girder is a steel structure specially designed and fabricated for the cast-in-situ construction of the typical spans of the viaduct.

- Firstly, the piers and the cross heads are constructed in advance of the ALG. For the construction of every span, formwork units are adjusted, raised and suspended on the transverse trusses using Maccalloy bars (high tensile bars) in conjunction with the hollow ram jacks.

- After the formwork units are in place, fixing of reinforcement, placing of ducts and concreting will follow.
- When the structure achieves a concrete strength of 30 MPa, the stressing of the tendons will begin.
- Upon complete transfer of load to the starting elements and piers, the formwork units will be dismantled and placed on the working platform. The entire ALG will then be jacked to the next span. This cycle is then repeated.

The advantage of the span by span method of construction pertains to the pre-stressing steel requirement. Since the segments are supported by the form travellers, there are no cantilever stresses during construction, and pre-stress requirements are akin to those of conventional construction on false work.

The capital investment in the equipment for this type of construction is considerable. Taking into account total length of approximately 25.4 km of viaduct and the large number of equal spans, it may be economically justifiable for the equipment investment by the contractor.

4.4.2.3 Pre-Cast Construction

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 the 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 utilising 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.

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 areas, batching plant with storage facilities for aggregates and cement, site testing laboratories, reinforcement steel yard, fabrication yard, etc. An area of about 2.5

ha to 3 ha is required for each construction depot (one per contract).

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 launching scheme is shown in the **Figures 4.6 to 4.11**. Initially, the launching girder is erected on pier head at one end of the work. The segments are lifted in sequence as shown in the figures and 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.

4.4.2.4 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 prestressed 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.

4.4.2.5 Foundation Recommendation

Substratum consists of top 1 meter as filled up soil followed by sand, silty sand, silty sand mixed with gravel up to 30 meter depth. 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).

4.4.2.6 Construction of Stations

It is proposed to construct the elevated stations with elevated concourse over the road at most of the locations to minimize land acquisition. To keep the rail level low, it is proposed not to take viaduct through the stations. Thus a separate structural configuration is required (although this may necessitate the break in the launching operations at each station location). Sub-structure for the station portion will also be similar to that of viaduct and will be carried out in the same manner. However, there will be single viaduct column in the station area, which will be located on the median and supporting the concourse girders by a cantilever arm so as to eliminate the columns on right of way. Super-structure will consist of precast segmental box Girders for supporting the track structure and I Girder / Double T Girders for supporting the platform and concourse areas. A pre-cast or cast in situ prestressed cross girder will be required over the middle piers for supporting platform structure. Box shaped in situ prestressed cantilever cross girders are planned for supporting the concourse girders and escalators at mezzanine level. All the members will be pre-cast in a construction depot and launched at site through cranes.

4.4.2.7 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.

4.4.2.8 Reinforcement and pre-stressed Steel

It is proposed to use HYSD 415 or TMT steel as reinforcement bars.For pre-stressing work, low relaxation high tensile steel strands with the configuration 12 T 13 and or 19 K 15 is recommended (confirming to IS:14268).

4.4.2.9 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 sides 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:

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

4.5 UTILITY DIVERSIONS

4.5.1 INTRODUCTION

Besides the details of various aspects e.g. transport demand analysis, route alignment, station locations, system design, viaduct structure, geo-technical investigations etc. as brought out in previous 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.

4.5.2 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.

Organisations/Departments with concerned utility services in Lucknow are mentioned in **Table 4.14**.

Table 4.14 UTILITY RESPONSIBILITY DEPARTMENTS

SN	ORGANIZATION/ DEPARTMENT	UTILITY SERVICES
1.	Lucknow Nagar Nigam Lucknow Development Authority	Surface water drains, nallahs, Sewerage and drainage conduits, sewerage treatment plants, pumping stations,
3	Public Works Deptt. (PWD) and LDA Lucknow	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	Lucknow Traffic Police	Traffic signal posts, junction boxes and cable connections, etc.
6	Railway	Railway crossings, signals, railway bridges, etc.
7	UPPCL Lucknow	OH & Under Ground Electric cables and Electric poles
8	GAIL	Gas Pipelines

4.5.3 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.

4.5.4 DETAILS OF UTILITIES – ABOVE AND UNDER GROUND

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. Accordingly underground utilities will also needed to be shifted during construction of structures like piers, stations etc., since these will be interfering with the proposed alignment. Approximate numbers of utilities in North South & East West corridors are indicated in **Table 4.15 to 4.25**.

Table 4.15 DETAILS OF AFFECTED LIGHT AND SIGNAL POLES
North South Corridor

DETAILS OF AFFCETED LIGHT/SIGNAL POLES				
S.No.	Start Chainage in (Km)	End Chainage (in Km)	No. of light poles	No. of signal poles
1	-735.000	0.000	9	-
2	0.000	1.000	31	-
3	1.000	2.000	30	-
4	2.000	3.000	27	-
5	3.000	4.000	24	-
6	4.000	5.000	29	-
7	5.000	6.000	28	3
8	6.000	7.000	46	-
9	7.000	8.000	16	9
10	8.000	9.000	37	5
11	9.000	10.000	39	-
12	10.000	11.000	40	5
13	11.000	12.000	42	8
14	12.000	13.000	34	17
15	13.000	14.000	20	14
16	14.000	15.000	5	-
17	15.000	16.000	7	2
18	16.000	17.000	34	1
19	17.000	18.000	28	5
20	18.000	19.000	38	6
21	19.000	20.000	26	-
22	20.000	21.000	34	-
23	21.000	22.000	35	-
24	22.000	22.131	11	-

Table 4.16 DETAILS OF TELEPHONE POLES
North South Corridor

DETAILS OF AFFECTED TELEPHONE UTILITES				
S.No.	Start Chainage in (km)	End Chainage (in Km)	No. of Telephone poles	No. of telephone Junction box
1	-735.000	0.000	-	-
2	0.000	1.000	31	-
3	1.000	2.000	30	-
4	2.000	3.000	27	-
5	3.000	4.000	24	-

6	4.000	5.000	29	-
7	5.000	6.000	28	3
8	6.000	7.000	46	-
9	7.000	8.000	16	9
10	8.000	9.000	37	5
11	9.000	10.000	39	-
12	10.000	11.000	40	5
13	11.000	12.000	42	8
14	12.000	13.000	34	17
15	13.000	14.000	20	14
16	14.000	15.000	5	-
17	15.000	16.000	7	2
18	16.000	17.000	34	1
19	17.000	18.000	28	5
20	18.000	19.000	38	6
21	19.000	20.000	26	-
22	20.000	21.000	34	-
23	21.000	22.000	35	-
24	22.000	22.131	11	-

Table 4.17 DETAILS OF AFFECTED ELECTRICAL UTILITIES
North South Corridor

DETAILS OF AFFECTED ELECTRICAL UTILITES					
SN	Start Chainage in (Km)	End Chainage (in Km)	No. of Electric poles	No. of Electric Junction box	No. of Transformer
1	-735.000	0.000	2	-	-
2	0.000	1.000	14	-	2
3	1.000	2.000	14	1	4
4	2.000	3.000	50	2	2
5	3.000	4.000	71	7	4
6	4.000	5.000	62	8	7
7	5.000	6.000	37	-	8
8	6.000	7.000	15	1	2
9	7.000	8.000	15	1	10
10	8.000	9.000	27	-	3
11	9.000	10.000	18	1	1
12	10.000	11.000	53	6	4
13	11.000	12.000	24	20	6
14	12.000	13.000	3	33	7
15	13.000	14.000	12	-	1

16	14.000	15.000	55	1	2
17	15.000	16.000	37	4	3
18	16.000	17.000	29	4	4
19	17.000	18.000	48	1	1
20	18.000	19.000	45	10	16
21	19.000	20.000	39	7	6
22	20.000	21.000	31	6	2
23	21.000	22.000	26	-	2
24	22.000	22.131	15	2	1

Table 4.18 DETAILS OF AFFECTED OFC
North South Corridor

DETAILS OF AFFECTED OFC						
Location @ km	Affected Length (L.H.S.)	Affected Length (R.H.S.)	Descriptio n & Size	Depth (m)	Distance From C/L (L.H.S.)	Distance From C/L (R.H.S.)
TATA COMMUNICATIONS						
-0+735 – 0+000	-	-	OFC	1.5 -2.0	0	0
0+000 – 1+000	-	84.15	OFC	1.5 -2.0	0	0
1+000 – 2+000	-	486.05	OFC	1.5 -2.0	0	0
2+000 – 3+000	-	-	OFC	1.5 -2.0	0	0
3+000-4+000	337.65	-	OFC	1.5 -2.0	0	0
3+662.35	21.32				Crossing @ 3+662.35	
4+000-5+000	1000	-	OFC	1.5 -2.0	0	0
5+000-6+000	963.48	-	OFC	1.5 -2.0	0	0
5+355.54	21.56				Crossing @ 5+355.54	
5+392.06	22.41				Crossing @ 5+392.06	
6+000-7+000	1000	-	OFC	1.5 -2.0	0	0
7+000+8+000	100	-	OFC	1.5 -2.0	0	0
8+000-9+000	1000	-	OFC	1.5 -2.0	0	0
9+000-10+000	1000	487.78	OFC	1.5 -2.0		
9+512.22	20.56				Crossing @ 9+512.22	
10+000-11+000	997.65	1000	OFC	1.5 -2.0		
11+000-12+000	-	446.32	OFC	1.5 -2.0		
11+026.26	22.24				Crossing @ 11+026.26	
11+046.26	21.56				Crossing @ 11+046.26	
12+000-13+000	-	493.81	OFC	1.5 -2.0		
12090.94	20.56					

DETAILS OF AFFECTED OFC						
Location @ km	**Affected Length (L.H.S.)**	**Affected Length (R.H.S.)**	**Description & Size**	**Depth (m)**	**Distance From C/L (L.H.S.)**	**Distance From C/L (R.H.S.)**
13+000-14+000	80.65	-	OFC	1.5 -2.0		
14+000-15+000	-	-	OFC	1.5 -2.0		
15+000-16+000	273.74	-	OFC	1.5 -2.0		
16+627.25	20.10				Crossing @ 16+627.25	
16+647.25	20.55				Crossing @ 16+647.25	
16+000-17+000	-	-	OFC			
17+000-18+000	715.15	-	OFC	1.5 -2.0		
18+000-19+000	-	46.61	OFC	1.5 -2.0		
19+000-20+000	42.69	835.31	OFC			
19144.69	20.10				Crossing @ 19+144.69	
19164.69	20.55				Crossing @ 19+164.69	
20+000-21+000	609.45	-	OFC	1.5 -2.0		
21+000-22+000	-	-	OFC	1.5 -2.0		
22+000-22+300	-	-		1.5 -2.0		
VODAFONE						
9+000-10+000		70.78	OFC	1.5 - 2.5	-	8.45
9+829.18	20.0		OFC	1.5 - 2.5	-	-
9+835	20.0		OFC	1.5 - 2.5	-	-
9+871.74	20.0		OFC	1.5 - 2.5	-	-
9+883.83	20.0		OFC	1.5 - 2.5	Crossing @ 9+829.18	
10+000-11+000	684.33	882.45	OFC	1.5 -2.5	Crossing @ 9+835	8.13
10+046.96	20.0		OFC	1.5 -2.5	Crossing @ 10046.96	Crossing @ 9871.74
10+245.18	20.0		OFC	1.5 -2.5	Crossing @ 10245.18	Crossing @ 9883.83

DETAILS OF AFFECTED OFC						
Location @ km	**Affected Length (L.H.S.)**	**Affected Length (R.H.S.)**	**Description & Size**	**Depth (m)**	**Distance From C/L (L.H.S.)**	**Distance From C/L (R.H.S.)**
10+251.05	20.0		OFC	1.5 -2.5	Crossing @ 10251.05	
10+315.67	20.0		OFC	1.5 -2.5	Crossing @ 10315.67	
10+384.43	20.0		OFC	1.5 -2.5	Crossing @ 10384.43	
10+398.07	20.0		OFC	1.5 -2.5	Crossing @ 10398.07	
11+000-12+000	409.07	412.07	OFC	1.5 -2.5	8.0	8.0
12+000-13+000	107.54	0	OFC	1.5 -2.5	8.0	-
125010.1	20.0		OFC	1.5 -2.5	Crossing @ 125010.1	
13+000-14+000	44.79	350.74	OFC	1.5 -2.5	8.0	8.0
13196.45	20.0		OFC	1.5 -2.5	Crossing @ 13196.45	
14+000-15+000	-	919.54	OFC	1.5 -2.5	-	8.0
15+000-16+000	-	-	OFC	1.5 -2.5	-	-
16+000-17+000	-	947.05	OFC	1.5 -2.5	-	8.0
16852.44	24.32		OFC	1.5 -2.5	Crossing @ 16852.44	
17+000-18+000	697.5	263.25	OFC	1.5 -2.5	8.0	8.0
17270.24	23.34	-	OFC	1.5 -2.5	Crossing @ 10046.96	-
17+285.33	26.65		OFC	1.5 -2.5	Crossing @ 17285.33	
18+000-19+000	1000	-	OFC	1.5 -2.5	8.0	0
19+000-20+000	639.83	757.08	OFC	1.5 -2.5	8.0	8.0
19+644.16	23.56		OFC	1.5 -2.5	Crossing @ 19644.16	
19+647.83	24.12		OFC	1.5 -2.5	Crossing @ 19647.83	
19+998	22.54		OFC	1.5 -2.5	Crossing @ 19998	
20+000-21+000	830.20	762.12	OFC	1.5 -2.5	8.0	8.0
20+012.12	20.13		OFC	1.5 -2.5	Crossing @ 20012.12	
20+639.41	20.17		OFC	1.5 -2.5	Crossing @ 20639.41	
20+761.07	20.32		OFC	1.5 -2.5	Crossing @ 20761.07	
20+783.29	20.54		OFC	1.5 -2.5	Crossing @ 20783.29	
21+000-22+000	1000	-	OFC	1.5 -2.5	8.0	-
22+000-23+000	6.24	-	OFC	1.5 -2.5	8.0	-
AIRCEL						
9+000 – 10+000	126.43	110.58	OFC	2.0 – 3.0	7.28	8.11
10+000 – 11+000	998	1000	OFC	2.0 – 3.0	7.25	8.09
17+000 – 18+000	31.18		OFC	2.0 – 3.0	7.00	7.50
18+000 –	999.81		OFC	2.0 – 3.0	7.65	8.20

DETAILS OF AFFECTED OFC						
Location @ km	Affected Length (L.H.S.)	Affected Length (R.H.S.)	Description & Size	Depth (m)	Distance From C/L (L.H.S.)	Distance From C/L (R.H.S.)
19+000						
19+000 – 20+000	999.97	358.41	OFC	2.0 – 3.0	7.28	7.45
20+000 – 21+000	50.81	45.45	OFC	2.0 – 3.0	7.28	7.5
20+055	20.0		OFC	2.0 – 3.0	Crossing @20+055	

Table 4.19 DETAILS OF AFFECTED GAS PIPELINE – North South Corridor

DETAILS OF AFFECTED GAS PIPELINE						
Location @ Km.	Affected Length (L.H.S.)	Affected Length (R.H.S.)	Description & Size	Depth (m)	Distance From C/L (L.H.S.)	Distance From C/L (R.H.S.)
ADANI						
-0+735 – 0+000	844	-	8" Dia, High Pressure Gas Pipe Line	1.5 – 2.0	4.68	-
0+000 – 1+000	1000	-	8" Dia, High Pressure Gas Pipe Line	1.5 – 2.0	4.75	-
1+000 – 2+000	1001	-	8" Dia, High Pressure Gas Pipe Line	1.5 – 2.0	4.75	-
2+000 – 3+000	999	-	8" Dia, High Pressure Gas Pipe Line	1.5 – 2.0	4.75	-
3+000 – 4+000	1000	-	8" Dia, High Pressure Gas Pipe Line	1.5 – 2.0	4.75	-
4+000 – 5+000	1000	-	8" Dia, High Pressure Gas Pipe Line	1.5 – 2.0	4.75	-
5+000 – 6+000	993	-	8" Dia, High Pressure Gas Pipe Line	1.5 – 2.0	4.75	-
6+000 – 7+000	999	-	8" Dia, High Pressure Gas Pipe Line	1.5 – 2.0	4.75	-
7+000 – 8+000	669	-	8" Dia, High Pressure Gas Pipe Line	1.5 – 2.0	4.75	-

DETAILS OF AFFECTED GAS PIPELINE						
Location @ Km.	**Affected Length (L.H.S.)**	**Affected Length (R.H.S.)**	**Description & Size**	**Depth (m)**	**Distance From C/L (L.H.S.)**	**Distance From C/L (R.H.S.)**
8+000 – 9+000	642	-	8" Dia, High Pressure Gas Pipe Line	1.5 – 2.0	4.75	-
14+000 –15+000	-	594	8" Dia, High Pressure Gas Pipe Line	1.5 – 2.0	0	5.50
15+000 –16+000	574	-	8" Dia, High Pressure Gas Pipe Line	1.5 – 2.0	5.50	-
20+000 – 21+000	266	-	8" Dia, High Pressure Gas Pipe Line	1.5 – 2.0	3.75	-
21+000 – 22+000	61	-	8" Dia, High Pressure Gas Pipe Line	1.5 – 2.0	3.75	-
21+061	33	-	8" Dia, High Pressure Gas Pipe Line	1.5 – 2.0	Crossing @ 21+061	
22+000 – 23+000	-	-	8" Dia, High Pressure Gas Pipe Line		-	-
23+000 – 24+000	-	-	8" Dia, High Pressure Gas Pipe Line			
GREEN GAS LIMITED						
-0+735 – 0+000	-	500.22	12" Dia, High Pressure Gas Pipe Line	1.5 – 2.0	-	6.60
-0+492	23.34		12" Dia, High Pressure Gas Pipe Line	1.5 – 2.0		
0+000 – 1+000	-	1000.44	12" Dia, High Pressure Gas Pipe Line	1.5 – 2.0	-	7.40
1+000 – 2+000	-	998.84	12" Dia, High Pressure Gas Pipe Line	1.5 – 2.0	-	9.57
2+000 – 3+000	-	182.16	12" Dia, High Pressure Gas Pipe Line	1.5 – 2.0	-	9.15

Table 4.20 DETAILS OF AFFECTED LIGHT AND SIGNAL POLES – East West Corridor

DETAILS OF AFFECTED LIGHT/SIGNAL POLES				
SN	Start Chainage (in km)	End Chainage (in km)	No. of light poles	No. of signal poles
1	0.000	1.000	39	9
2	1.000	2.000	20	-
3	2.000	3.000	-	-
4	3.000	4.000	13	-
5	4.000	5.000	19	9
6	5.000	6.000	15	-
7	6.000	7.000	20	-
8	7.000	8.000	24	-
9	8.000	9.000	28	-
10	9.000	10.000	7	-
11	10.000	11.000	22	

Table 4.21 DETAILS OF AFFECTED TELEPHONE POLES– East West Corridor

DETAILS OF AFFECTED TELEPHONE POLES				
SN	Start Chainage (in Km)	End Chainage (in Km)	No. of Telephone poles	No. of telephone Junction box
1	0.000	1.000	26	1
2	1.000	2.000	32	6
3	2.000	3.000	5	-
4	3.000	4.000	2	-
5	4.000	5.000	10	-
6	5.000	6.000	11	2
7	6.000	7.000	12	3
8	7.000	8.000	3	-
9	8.000	9.000	2	1
10	9.000	10.000	1	-
11	10.000	11.000	4	1

Table 4.22 DETAILS OF AFFECTED ELECTRICAL UTILITIES – East West Corridor

DETAILS OF AFFECTED ELECTRICAL UTILITIES					
SN	**Start Chainage (in Km)**	**End Chainage (in Km)**	**No. of Electric poles**	**No. of Electric Junction box**	**No. of Transformer**
1	0.000	1.000	38	12	6
2	1.000	2.000	25	7	4
3	2.000	3.000	14	1	5
4	3.000	4.000	3	1	-
5	4.000	5.000	18	2	5
6	5.000	6.000	37	3	6
7	6.000	7.000	73	5	4
8	7.000	8.000	45	13	7
9	8.000	9.000	38	1	2
10	9.000	10.000	34	-	-
11	10.000	11.000	48	-	6

Table 4.23 DETAILS OF AFFECTED OFC – East West Corridor

DETAILS OF AFFECTED OFC						
Location@ km	**Affected Length (L.H.S.)**	**Affected Length (R.H.S.)**	**Description & Size**	**Depth (m)**	**Distance From C/L (L.H.S.)**	**Distance From C/L (R.H.S.)**
TATA COMMUNICATIONS						
-0+113 – 0+000	-	-	OFC	1.5 -2.0	-	-
0+000 – 1+000	-	-	OFC	1.5 -2.0	-	7.40
1+000 – 2+000	-	-	OFC	1.5 -2.0	9.57	9.57
2+000 – 3+000			OFC	1.5 -2.0	9.15	-
3+000-4+000	-	-	OFC	1.5 -2.0		
4+598.73	20.0		OFC	1.5 – 2.0	Crossing @ 4+598.73	
4+000-5+000	-	359.05	OFC	1.5 -2.0		
5+000-6+000	-	1000	OFC	1.5 -2.0		
6+000-7+000	-	1000	OFC	1.5 -2.0		
7+000-8+000	-	1000	OFC	1.5 -2.0		
8+000-9+000	-	1000	OFC	1.5 -2.0		
9+000-10+000	-	1000	OFC	1.5 -2.0		
10+000-11+000	-	25.65	OFC	1.5 -2.0		
VODAFONE						

DETAILS OF AFFECTED OFC						
Location@ km	Affected Length (L.H.S.)	Affected Length (R.H.S.)	Description & Size	Depth (m)	Distance From C/L (L.H.S.)	Distance From C/L (R.H.S.)
-0+735 – 0+000	-	-	OFC	2.0 -3.0	-	-
0+000 – 1+000	-	831.82	OFC	2.0 -3.0	-	7.40
1+256.45	20.0		OFC	2.0 -3.0	Crossing @ 1+256.45	
1+470.34	20.0		OFC	2.0 -3.0	Crossing @ 1+470.34	
1+535.73	20.0		OFC	2.0 -3.0	Crossing @ 1+535.73	
1+700.21	20.0		OFC	2.0 -3.0	Crossing @ 1+700.21	
1+735.51	20.0		OFC	2.0 -3.0	Crossing @ 1+735.51	
1+000 – 2+000	672.196	608.681	OFC	2.0 -3.0	9.57	9.57
2+000 – 3+000	987.58	-	OFC	2.0 -3.0	9.15	-

Table 4.24 DETAILS OF AFFECTED GAS PIPELINE – East West Corridor

DETAILS OF AFFECTED GAS PIPELINE						
Location@ Km.	Affected Length (L.H.S.)	Affected Length (R.H.S.)	Description & Size	Depth (m)	Distance From C/L (L.H.S.)	Distance From C/L (R.H.S.)
GREEN GAS LIMITED						
-0+113 – 0+000	-	113.00	12" Dia, High Pressure Gas Pipe Line	-	6.60	
0+000 – 1+000	-	1000.44	12" Dia, High Pressure Gas Pipe Line	-	7.40	
1+000 – 2+000	-	998.84	12" Dia, High Pressure Gas Pipe Line	-	9.57	
2+000 – 3+000	-	182.16	12" Dia, High Pressure Gas Pipe Line	-	9.15	
-0+492		34.19	12" Dia, High Pressure Gas Pipe Line			

Table 4.25 DETAILS OF AFFECTED TREES

DETAILS OF AFFECTED TRESS			
SN	**Corridor Name**	**Corridor Length (km)**	**No. of Trees**
1	North South	22.878	461
2	East- West	11.098	158

4.6 LAND REQUIREMENT FOR CORRIDORS

4.6.1 LAND REQUIREMENT FOR MAJOR COMPONENTS

Availability of land is one of the major prerequisites for a project in cities like Lucknow. 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 land acquisition is required is minimum. 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. etc

4.6.2 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 centre line) wherein no structures are to be located. In stretches, where the elevated alignment has to be located away from road, a strip of 20m width is proposed for acquisition, it ensures road access and working space all along the viaduct for working of emergency equipments and fire brigade.

4.6.3 LAND FOR UNDERGROUND STRETCHES

No land acquisition 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.

4.6.4 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 wide 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.

4.6.5 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 few Metro stations. The land requirement for placing the entry / exit staircases, ancillary building and other structures are as below.

Table 4.26 DETAILS OF LAND PLOTS TO BE ACQUIRED PERMANENTLY AT STATION LOCATIONS ON North South Corridor

SN	Plot No.	DETAILS	AREA (m2)		OWNERSHIP
			Govt	Private	
1	CCS1	Open land	1622.62		Government
2	CCS2	Open land	1408.56		Government
3	CCS3	Open land	639.56		Government
4	AMA1	Open land	226.50		Government
5	AMA2	International tranformer P(Ltd.)		122.65	Private
6	AMA3	Shanti sweet Shop		242.32	Private
7	AMA4	Open land	308.83		Government
8	AMA5	Open land	144.00		Government
9	TPN1	Open land		431.57	Private
10	TPN2	SHOPS		144.00	Private
11	TPN3	Open land		439.68	Private
12	TPN4	Open land		406.18	Private
13	TPN5	SHOPS		483.78	Private
14	KRN1	SHOPS		131.19	Private
15	KRN2	SHOPS		377.16	Private
16	KRN3	Open land		489.96	Private
17	KRN4	Open land		427.65	Private
18	SIN1	SHOPS		373.22	Private
19	SIN2	SHOPS		194.21	Private
20	SIN3	SHOPS		188.27	Private

SN	Plot No.	DETAILS	AREA (m2)		OWNERSHIP
			Govt	Private	
21	SIN4	SHOPS		144.00	Private
22	SIN5	SHOPS		331.47	Private
23	ALB1	Open land	459.10		Government
24	ALB2	SHOPS		417.71	Private
25	ALB3	Open land	600.17		Government
26	ALB4	Open land	661.98		Government
27	ALBSTA1	Open land		166.81	Private
28	ALBSTA2	SHOPS		262.09	Private
29	ALBSTA3	SHOPS		127.97	Private
30	ALBSTA4	Open land	390.76		Government
31	ALBSTA5	Open land	716.34		Government
32	Dug1	Open land	253.35		Government
33	Dug2	Small Worksop and Open Land		98.79	Private
34	Dug3	GRP quarters	284.66		Government
35	Dug4	Temporary Houses and Open Land		2232.36	Private
36	Dug5	Open Land	145.96		Government
37	LKN1	Railway Station Parking	178.15		Government
38	LKN2	Railway Quarters	375.17		Government
39	LKN3	Railway Quarters	377.04		Government
40	LKN4	Railway Station Parking	374.77		Government
41	LKN5	Railway Quarters	149.09		Government
42	HUS1	Open land	268.67		Government
43	HUS2	Open land		33.24	Private
44	HUS3	JITENDRA MISRA & ELYSIUM		236.75	Private
45	HUS4	Open land		33.24	Private
46	HUS5	NATIONAL PROGREESIVE SCHOOL		280.04	Government
47	HUS6	Open land	349.09		Government
48	SACH1	EYE HOSPITAL PVT		236.20	Private
49	SACH2	Paking Area of ALL INDIA RADIO	236.24		Government
50	SACH3	open Area in ALL INDIA RADIO Campus	33.24		Government
51	SACH4	SAHKANTA BHAWAN	33.24		Government
52	SACH5	Open Area inBapu Bhawan Campus	236.21		Government
53	SACH6	Paking Area inBapu Bhawan Campus	236.21		Government
54	HAZ1	Parking Area	405.36		Government
55	HAZ2	Open Area, Shops		654.89	Private
56	KD1	Open Park	367.05		Government
57	KD2	Park in Hotel Claark Campus	310.40		Government
58	KD3	Open Land	219.66		Government
59	KD4	Temporary Houses	393.56		Government
60	KD5	Open Land at Hotel Clarks		3179.87	Private

SN	Plot No.	DETAILS	AREA (m2) Govt	AREA (m2) Private	OWNERSHIP
		campus, Houses and Open land besides River Gomti			
61	VISH1	K ailash Hostel	438.04		Government
62	VISH2	Management Girls Hostel	342.63		Government
63	VISH3	Reserve Police Line	677.40		Government
64	VISH4	Reserve Police Line, Allahabad Bank ATM	446.73		Government
65	IT1	Open land	239.43		Government
66	IT2	Open land	407.69		Government
67	IT3	RESERVE POLICE LINE	226.58		Government
68	IT4	Fornt of BLOOMFOUNTAIN NIRMAN Appartment		221.52	Private
69	MAH1	SHED		357.92	Private
70	MAH2	STATE BANK OF INDIA,MUNNA TRADING COMPANY	239.65		Government
71	MAH3	DEEPAK COOL CORNER, SALOON SHOP, Temporary shop		244.04	Private
72	MAH4	TEMPORARY HOUSES,HOTEL,PUMP HOUSE & TANK	547.23		Government
73	BADS1	Open land		461.01	Private
74	BADS2	Open land		455.93	Private
75	BADS3	Open land	448.88		Government
76	BADS4	TEMPORARY HOUSE	565.58		Government
77	LEKH1	BUS SHEDS		499.46	Private
78	LEKH2	Open land		391.21	Private
79	LEKH3	Open land		908.05	Private
80	LEKH4	SHOPS		168.66	Private
81	RAM1	SHOPS		398.07	Private
82	RAM2	Open land	358.12		Government
83	RAM3	Open land	359.48		Government
84	RAM4	Open land		770.12	Private
85	IND1	GOPAL PLAZA		387.20	Private
86	IND2	Open land		331.77	Private
87	IND3	SUBHAM SWEETS SHOP		448.91	Private
88	IND4	DEEP BHAWAN	643.78		Government
89	MUN1	SHOPS		313.74	Private
90	MUN2	SHOPS		300.55	Private
91	MUN3	SHOPS		304.53	Private
92	MUN4	SHOPS		312.66	Private
		SUB TOTAL	**18346.72**	**20162.59**	
		TOTAL (Govt and Private)	**38509.31**		

Table 4.27 - DETAILS OF LAND PLOTS TO BE ACQUIRED TEMPORARILY DURING CONSTRUCTION AT STATION LOCATIONS – North South Corridor

SN	Plot No.	DETAILS	AREA (m^2) Govt	AREA (m^2) Pvt	OWNERSHIP
1	CCST1	Open land	3910.30		Government
2	CCST2	Open land	654.84		Government
3	AMAT1	Open land	855.78		Government
4	AMAT2	International tranformer P(Ltd.)	443.84		Government
5	AMAT3	Shanti sweet		196.35	Private
6	AMAT4	Open land		188.30	Private
7	TPNT1	Open land		228.23	Private
8	TPNT2	Open land		270.78	Private
9	TPNT3	Open land		222.29	Private
10	KRNT1	Open land		198.41	Private
11	KRNT2	Open land		419.10	Private
12	KRNT3	shops		96.47	Private
13	SINT1	shops		175.66	Private
14	ALBT1	Open land	213.83		Government
15	ALBT2	Mani Baha Market & Temple		205.35	Private
16	ALBT3	Open land		238.07	Private
17	ALBSTAT1	Public Toilet	195.23		Government
18	ALBSTAT2	Open land		186.65	Private
19	MAWT1	Army supply depot boundary	205.46		Government
20	MAWT2	Temporary Houses	142.77		Government
21	MAWT3	House and College Campus		192.50	Private
22	MAWT4	Army supply depot boundary	205.69		Government
23	DugT1	Open Land	303.16		Government
24	DugT2	Small Workshop		134.84	Private
25	DugT3	GRP Quarters	330.22		Government
26	DugT4	Temporary Houses and Shops		587.37	Private
27	LKNT1	Railway Station Parking	184.96		Government
28	LKNT2	Railway Quarters	222.34		Government
29	LKNT3	Railway Quarters	289.14		Government
30	LKNT4	Railway Station Parking	228.84		Government
31	HUST1	Vsha Fashion Design School, Aggarwal Building		9070.49	Private
32	SACHT1	Seventh Boy Adventis Sr Sec School, Eye Hospital Pvt ltd.	9170.97		Government
33	HAZT1	Jwala Sahortrivedi buildings, CATHEDRAL SR. SEC. SCHOOL	8892.47		Government
34	KDT1	Open Park	208.39		Government
35	KDT2	Park in Hotel Claark	337.12		Government

SN	Plot No.	DETAILS	AREA (m^2)		OWNERSHIP
			Govt	Pvt	
		Campus			
36	KDT3	Open Land	410.05		Government
37	KDT4	Temporary Houses	287.01		Government
38	KDT5	Open Land at Hotel Clarks campus, Houses and Open land besides River Gomti		805.24	Private
39	VISHT1	Management Girls Hostel	172.25		Government
40	VISHT2	Management Girls Hostel	85.88		Government
41	VISHT3	Reserve Police Line, ATM	158.56		Government
42	ITT1	Open Land	327.13		Government
43	ITT2	Reserve Police Line	197.58		Government
44	ITT3	Fornt Of Bloomfountain Nirman Appartment	170.11		Government
45	MAHT1	Shed		385.73	Private
46	MAHT2	State Bank Of India,Munna Trading Company		177.38	Private
47	MAHT3	Deepak Cool Corner, Saloon Shop, Temporary shop		170.96	Private
48	MAHT4	Temporary Houses,Hotel,Pump House&Tank		305.63	Private
49	MAHT5	Deepak Cool Corner,Saloon Shop		242.06	Private
50	BADST1	Open Land		204.19	
51	BADST2	SHOPS		335.18	Private
52	LEKHT1	Open Land		230.87	Private
53	LEKHT2	Open Land		179.15	Private
54	LEKHT3	Open Land		309.67	Private
55	LEKHT4	Shops		114.13	Private
56	RAMT1	Open Land		224.23	Private
57	RAMT2	Open Land		187.15	Private
58	RAMT3	Open Land		318.36	Private
59	INDT1	Mahindra Tower ,Gopal Plaza	206.04		Government
60	INDT2	Reliance Tower,Shivalik Complex &Auto Service Station	195.41		Government
61	INDT3	Deep Bhawan	230.71		Government
62	MUNT1	Open Land		113.96	Private
63	MUNT2	TATA BP.SOLAR INDIA LTD ,HOUSE PRAKASH PUNCHBATI BUILDING		126.85	Private
64	MUNT3	S.B Medical Shop &Shops		151.37	Private
65	MUNT4	Maa Vindhyawasini Traders		119.96	Private
		SUB TOTAL	**29436.08**	**17312.92**	
		TOTAL	**46749.00**		

Table 4.28 DETAILS OF LAND PLOTS TO BE ACQUIRED PERMANENTLY AT STATION LOCATIONS ON E-W CORRIDOR

SN	Plot No.	DETAILS	AREA (m^2)	OWNERSHIP
1	LKN1	EMPOLYMENT EXCHANGE	37.59	Government
2	LKN2	RAILWAY QUARTERS	417.19	Government
3	LKN3	Under constuction Fob	418.97	Government
4	LKN4	Lucknow Railway station park	1134.73	Government
5	LKN5	Lucknow Railway station	133.62	Government
6	LKN STAT6	Open	133.62	Government
7	GBM1	Shops, SAKET ELECTICALS	73.72	Private
8	GBM2	HARGOVIND DAYAL COMPLEX	246.64	Private
9	GBM3	HOUSE	33.88	Private
10	GBM4	HOUSE	628.52	Private
11	GBM5	HOUSE	33.87	Private
12	GBM6	HOUSE	246.76	Private
13	GBM7		37.08	Private
14	GBM8	KULBHASKER COMPLEX	288.55	Private
15	GBM9	SIMLAWALA PALACE,HOTEL MANDAKINI	247.22	Private
16	AMI1	Open	317.68	Government
17	AMI2	Open	263.28	Government
18	AMI3	Open	584.88	Government
19	AMI4	Open	487.98	Government
20	PAN1	Shops	2653.17	Private
21	PAN2	Shops	1866.11	Private
22	PAN3	Wine shop	27.95	Private
23	CRS1	Open	1319.30	Government
24	CRS2	Open	282.00	Government
25	CRS3	Open	201.93	Government
26	CRS4	Open	352.95	Government
27	MED1	Open	737.50	Government
28	MED2	Open	302.92	Government
29	MED3	Open	1859.58	Private
30	MED4	Open	405.74	Private
31	MED5	Open	755.57	Government
32	MED6	Open	226.41	Government
33	NAW1	Shops	243.08	Private
34	NAW2	Shops	95.24	Private
35	NAW3	Shops	263.75	Private
36	NAW4	Shops	693.46	Private
37	NAW5	Shops	79.05	Private
38	NAW6	Shops	308.83	Private

SN	Plot No.	DETAILS	AREA (m²)	OWNERSHIP
39	THA1	Shops	218.67	Private
40	THA2	Shops	168.44	Private
41	THA3	Shops	709.52	Private
42	THA4	Shops	394.73	Private
43	BAL1	Shops	587.73	Private
44	BAL2	Shops	623.19	Private
45	BAL3	Shops	207.79	Private
46	BAL4	Shops	253.64	Private
47	SAF1	Shops	638.95	Private
48	SAF2	Shops	311.70	Private
49	SAF3	Shops	296.22	Private
50	SAF4	Shops	372.80	Private
51	MUS1	Shops	536.81	Private
52	MUS2	Shops	449.74	Private
53	MUS3	Shops	545.40	Private
54	MUS4	Shops	427.41	Private
55	VAS1	Shops	390.25	Private
56	VAS2	Shops	390.74	Private
57	VAS3	Shops	323.04	Private
58	VAS4	Shops	471.81	Private
		TOTAL	**26758.9**	

Table 4.29 DETAILS OF LAND PLOTS TO BE ACQUIRED TEMPORARILY DURING CONSTRUCTION AT STATION LOCATIONS ON E-W CORRIDOR

Sr.No.	Plot No.	DETAILS	AREA (m²)	OWNERSHIP
1	LKNT1	Cut and Cover	7346.77	Government
2	GBMT1	Cut and Cover	8414.76	Private
3	AMINT1	Cut and Cover	9264.58	Government
4	CRST1	Cut and Cover	10936.29	Private
5	MEDT1	Cut and Cover	8219.29	Government
6	NAWT1	Cut and Cover	5102.79	Private
7	THAT1	Shops	230.07	Private
8	THAT2	Shops	249.71	Private
9	BALT1	Shops	230.74	Private
10	BALT2	Shops	268.20	Private
11	BALT3	Shops	125.04	Private
12	SAFT1	Shops	270.77	Private
13	SAFT2	Shops	255.83	Private
14	SAFT3	Shops	224.20	Private
15	SAFT4	Shops	248.59	Private
16	MUST1	Shops	215.77	Private
17	MUST2	Shops	214.89	Private
18	MUST3	Shops	267.98	Private
19	MUST4	Shops	213.98	Private
20	VAST1	Shops	218.37	Private
21	VAST2	Shops	244.71	Private
22	VAST3	Shops	169.44	Private
23	VAST4	Shops	255.65	Private
TOTAL			**53188.39**	

Table 4.30 SUMMARY OF LAND REQUIREMENT AT STATION LOCATIONS

Corridor	Acquisition Type	Land Area (m²)
Corridor 1 (North-South)	Permanent	38509.31
	Temporary	46749.00
Corridor 2 (East- West)	Permanent	26758.9
	Temporary	53188.39
Total Permanent		**65268.21**
Total Temporary		**99937.39**

4.6.6 LAND FOR DEPOT

As per the standards and requirements, a minimum of 20.0 Ha of land is required for construction of full fledge maintenance depot. The land proposed for construction of depot on the North South corridor is the PAC campus just opposite to the Transport Nagar besides NH-25. Total area of 37.8 Ha has been marked to be acquired. There are concrete structures as well as vacant land. The land has been identified and proposed by State Goverment.

22 Ha area abutting Hardoi road, behind the Fish Mandi have been identified for locating full fledged maintenance depot for E-W corridors . Earth filling is to be done to bring the existing ground level to designed level. The details of land requirement for depot are given in **Table 4.31**.

Table 4.31 LAND REQUIREMENT FOR DEPOTS

Plot No.	Location	Land Area (Ha)	Ownership
1	N-S Corridor, Opposite to Transport Nagar PAC Campus(Including staff quarters -0.55 Ha and PD area 0.93)	37.8	Government
2	E-W Corridor – Barren Land on Hardoi Road behind Fish Mandi	12.33	Government
	Total	**50.13**	

4.6.7 LAND FOR RECEIVING /TRACTION SUB STATION

The details of land requirement for RSS / TSS are given in **Table 4.32**.

Table 4.32 LAND REQUIREMENT FOR RSS/TSS

Corridor	Location	Land Area (Ha)	Ownership
Corridor 1 (North-South)	Transport nagar Depot	0.80	Government
	Near Mawaiya Junction	0.80	Government
Corridor 2 (East- West)	Polytechnic Chauraha	0.80	Government
	Hardoi Road Depot	0.80	Government
Total		**3.20**	

4.6.8 LAND REQUIREMENT FOR RUNNING SECTION

As indicated earlier, the ROW of the roads along which the alignment is planned is sufficiently wide except on few locations Mawaiya Junction, Hazratganj, along Indira flyover and Mahanagar Junction hence minimal land acquisition is required for except on the N-S corridor stretch as long as the alignment is straight and at the centre of the road. On the E-W corridor, the section on the start at the Lucknow railway station area and on the Gautam Buddha Marg, most of the part will be constructed by cut and cover, so temporary acquisition is required in these locations. Other than these areas, only underground station areas will be acquired temporarily, but the ramp location will be acquired and blocked permanently. However, at curved portions, the alignment could not be kept at the centre 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 4.33.**

Table 4.33 LAND REQUIREMENT ON RUNNING SECTION

SN	Plot No.	Between Stations		Details	Area (m^2)		Ownership
		from	to		Govt	Private	
Corridor 1- North South Corridor							
1.	1RS2	CCS Airport	Amausi	Open land near Amausi	1694.27		Government
2.	1RS3	Singaar Nagar	Alambagh	Ramratan Sarees, Radhika Medical, Sangeeta Sweet, SHOPS near Lalbagh Chowk		517.04	Private
3.	1RS4	Mawaiya	Durgapuri	Railway Training center / Quarters near Mawaiya	5003.78		Government
4.	1RS4A	Charbagh	Hussainganj	Kiran X Ray, Shivam Investment, Jain Hospital, Wine Shop, Workshop		1942.89	
5.	1RS5	Hazratganj	K D Singh Stadium	Oriental Building and Shopping Mall		2672.44	Government
6.	1RS6	Hazratganj	K D Singh Stadium	Park, GPO Land before Parivartan Chowk	3847.44		Government
7.	1RS8	Vishwavidyalaya	IT Collage	Neeraj Rastogi's House Campus at IT Chowraha		1129.88	Private
8.	1RS9	IT Collage	Mahanagar	Nirmal Niwas, Aggarwal Building, Women's tailor shop, Showcem paint shop, Temporary Shops, Harshita Complex		5484.76	Private
9.	1RS10	IT Collage	Mahanagar	Madanlal Arora		9245.15	Private

SN	Plot No.	Between Stations		Details	Area (m^2)		Ownership
		from	to		Govt	Private	
				General,English Wine Shop,Standrad Auto Motives,City Montessori Inter College			
10.	1RS10A	Mahanagar	Badshah Nagar	Shops at Mahanagar		2198.26	
11.	1RS11	Badshah nagar	Lekhraj Market	Bharat Motor Shop,Avadh Furniture,Chola Complex, Open land		5873.59	Private
12.	1RS12	Indira Nagar	Munshi Pulia	Amir tyre service, Amit motor service, R.N Traders, resturant, Saheed complex, Radha shop, Saheed Market(22 no. shops), UP battery service, ST automovie workshop, Realince workshop (vehicles), Shivam palace		7783.78	Private
				SUBTOTAL	10545.49	36847.79	
TOTAL AREA					47393.28		
Corridor 2 –East-West Corridor							
1	2RS1	Nawajganj	Thakurganj	Star Auto Mobiles, Meenar Marrige Hall, Rajdhani Cement Shop, Sr Complex, Masjid		2927.96	Private
2	2RS2	Nawajganj	Thakurganj	Avadh medical, krishna traders, manju sri apart. Sahu steels,krishna medicals		2737.78	Private
3	2RS3	Vasantkunj	Depot	Open Land, Temporay house Near Mosque		1850.79	Private
				Total Area	**7516.53**		

4.6.9 Land for Construction Depot

As no such land parcel is available close to corridors, separate land will be needed for the construction depot for both the corridors. The land parcels identified for locating Construction Depot have been listed below. The total area identified is about 2.25 Ha (2 Ha for N-S corridor and 0.25 Ha for E-W corridor), excluding the land area of maintenance depot, that will also be used as temporary construction depots. Thses land parcels will be acquired on temporary basis during construction period. The details of land requirement for depot are given in **Table 4.34**.

Table 4.34 LAND REQUIREMENT ON TEMPORARY BASIS FOR CONSTRUCTION DEPOT- North South Corridor

SN.	Plot No.	DETAILS	AREA (m²)		OWNERSHIP
			Govt	Pvt	
Corridor 1 – North South Corridor					
1	1RST1	Open Land on RHS of NH-25 opposite to Literacy House		2512.37	Private
2	1RST2	Open Land/ Sarojni Naidu Park	2742.80		Government
3	1RST3	Open Land / Police Line campus	2499.99		Government
4	1RST5	Open Land / Lucknow Polytechnic Campus	2015.65		Government
SUB TOTAL			7258.44	2512.37	
Total (Govt + Private)			9770.81		
Corridor 2 – East West Corridor					
5	2RST1	Open Land / ground in the Campus of Girls college behind Police station at Chowk Chauraha	2500.00	-	Government
Total (govt + private)			2500.00		

4.6.10 SUMMARY OF LAND REQUIREMENTS

Abstract of land requirements for Corridor 1 and Corridor 2 is given in **Table 4.35 and 4.36**.

Table 4.35 SUMMARY OF PERMANENT LAND REQUIREMENT (Ha)

Sr. No.	Description	Corridor 1 (N-S Corridor)		Corridor 2 (E-W Corridor)	
		Govt.	Private	Govt.	Private
1	Stations	1.83	2.02	0.81	1.87
2	Running Section	1.05	3.68	0.00	0.75
3	RSS/TSS	1.6	0.00	1.6	0.00
4	Depots	37.8	0.00	12.33	0.00
Total		**42.30**	**5.70**	**14.74**	**2.62**

Total Land required permanently for both corridors: 57.04 Ha (Govt.) + 8.32 Ha (Pvt.) = **65.36 Ha.**

Table 4.36 SUMMARY OF TEMPORARY LAND REQUIREMENT (Ha)

Sr. No.	Description	Corridor 1 (N-S Corridor)		Corridor 2 (E-W Corridor)	
		Govt.	Private	Govt.	Private
1	Stations	2.94	1.73	2.48	2.84
2	Running Section	0.00	0.00	0.00	0.00
3	Construction Depots	0.73	0.25	0.23	0
Total		**3.67**	**1.98**	**2.71**	**2.84**

Total Land required for temporarily for construction for both corridors: 6.38 Ha (Govt.) + 4.82Ha (Pvt.) **= 11.20 Ha.**

Figure 4.2 DIMENSIONS OF BOX TUNNEL SECTION

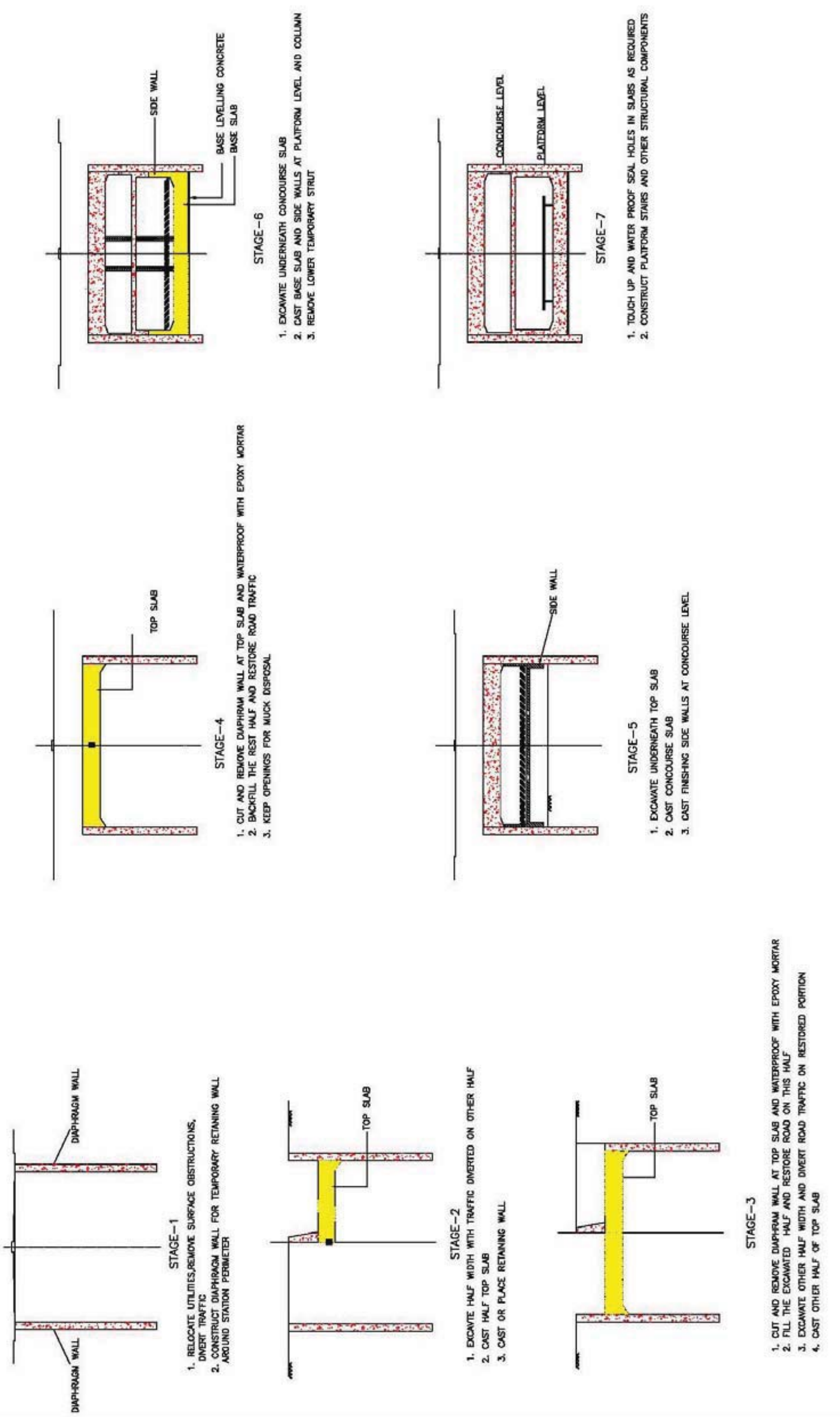


FIGURE 4.3 CUT & COVER STATION CONSTRUCTION SEQUENCE - TOP DOWN METHOD (TYPICAL SECTION)

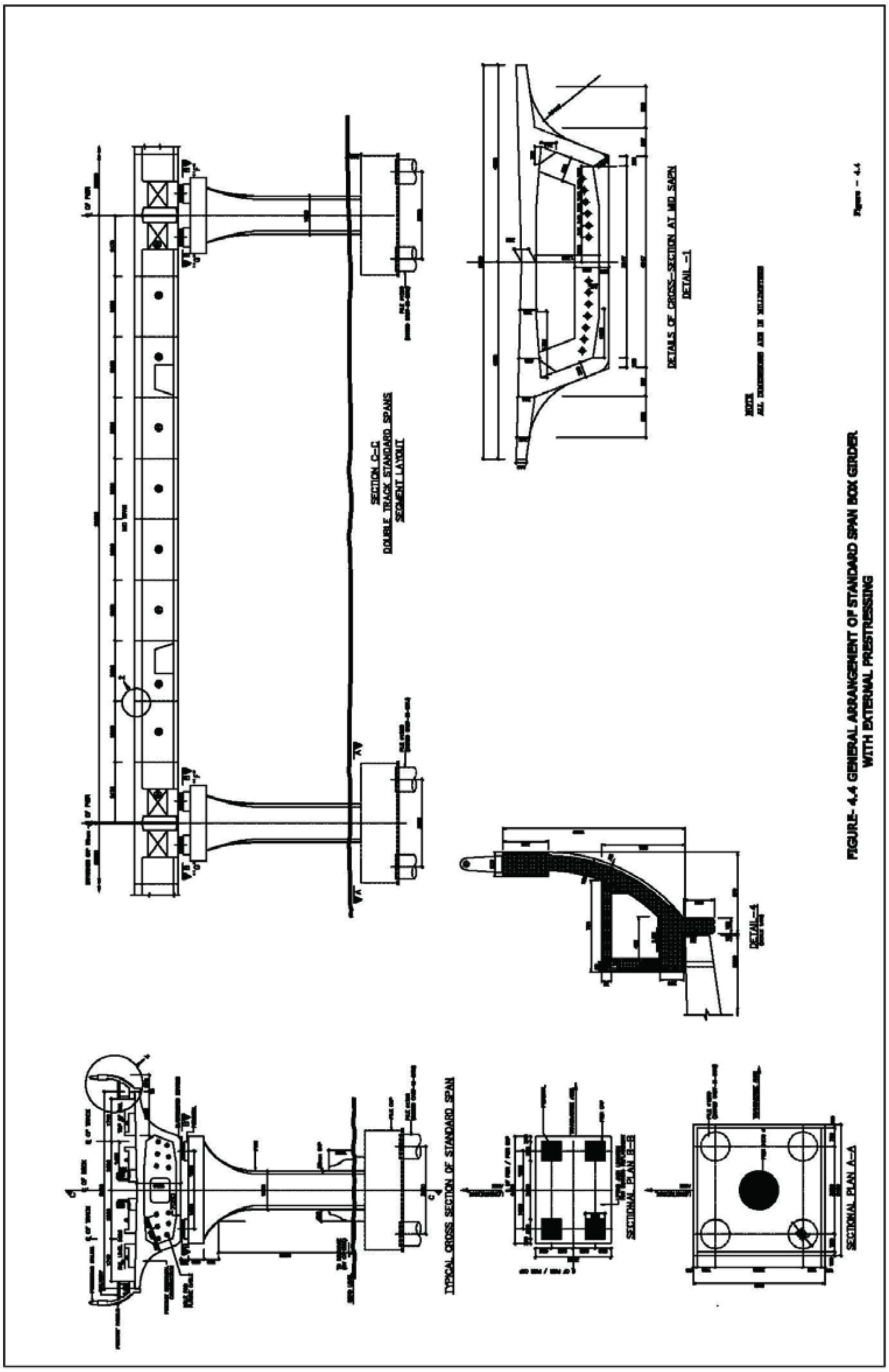


FIGURE-4.4 GENERAL ARRANGEMENT OF STANDARD SPAN BOX GIRDER WITH EXTERNAL PRESTRESSING

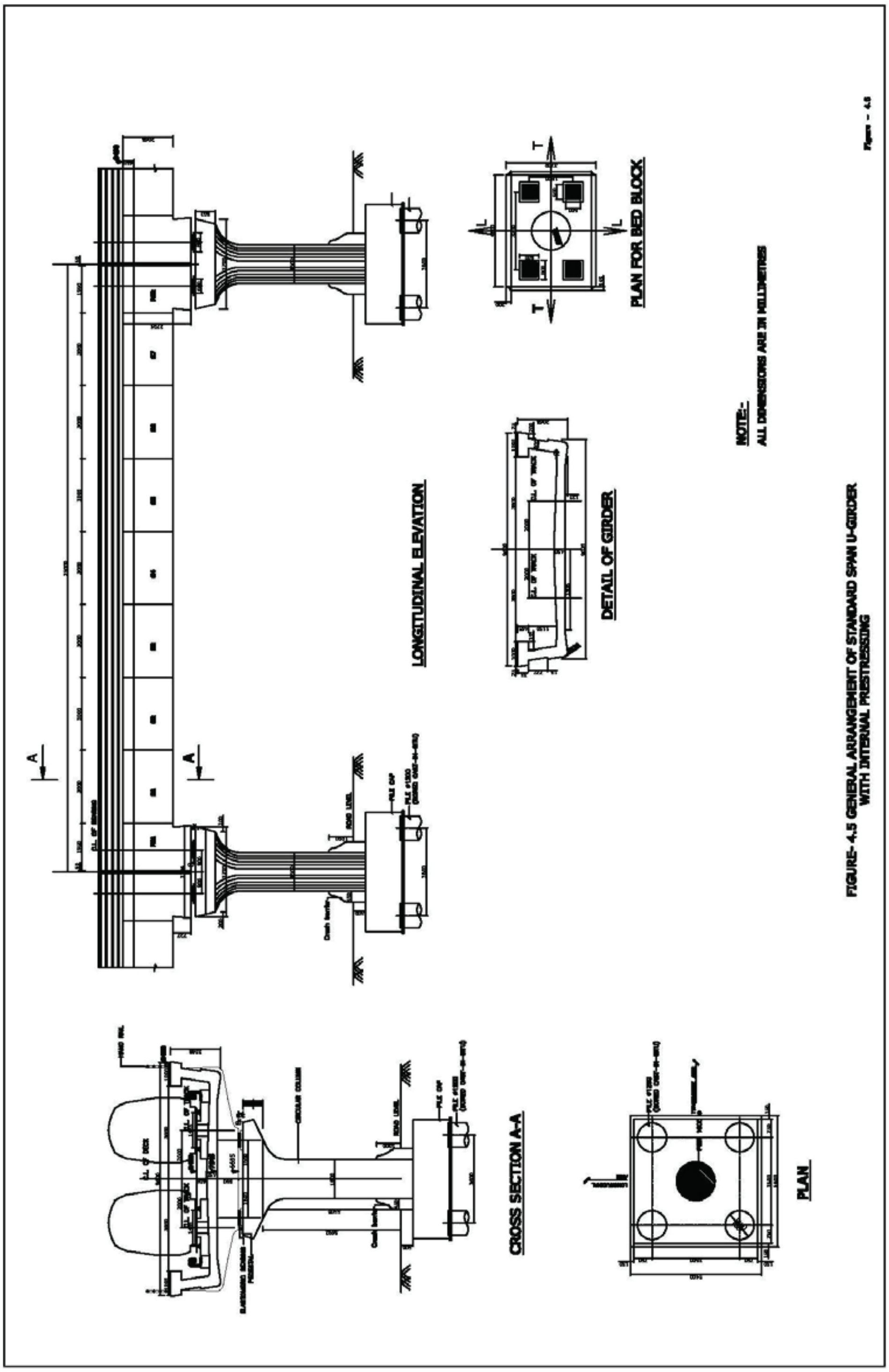


FIGURE- 4.5 GENERAL ARRANGEMENT OF STANDARD SPAN U-GIRDER WITH INTERNAL PRESTRESSING

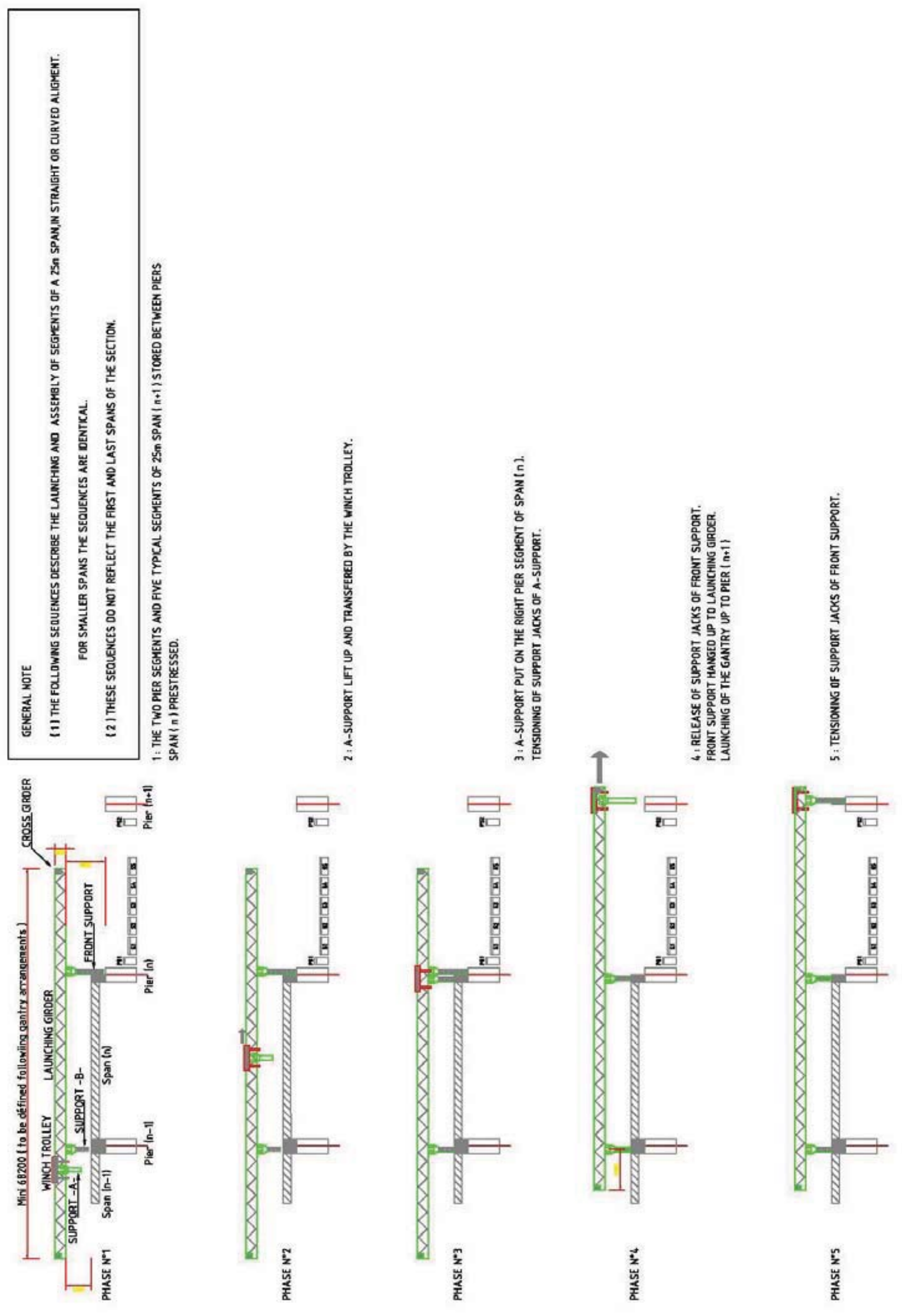


FIGURE 4.6 LAUNCHING SCHEME OF PRECAST SEGMENTAL CONSTRUCTION OF SUPERSTRUCTURE

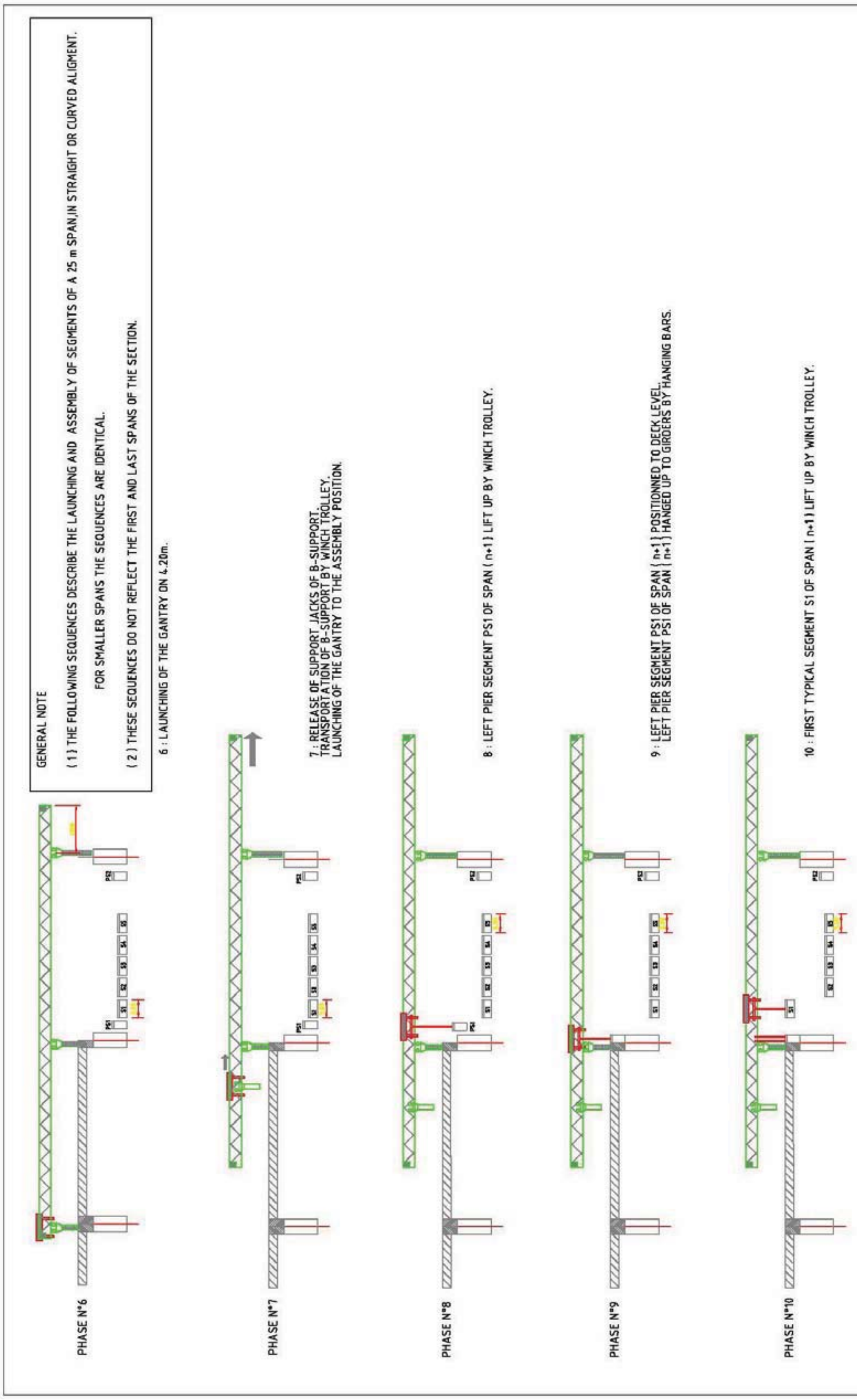


FIGURE 4.7 LAUNCHING SCHEME OF PRECAST SEGMENTAL CONSTRUCTION OF SUPERSTRUCTURE

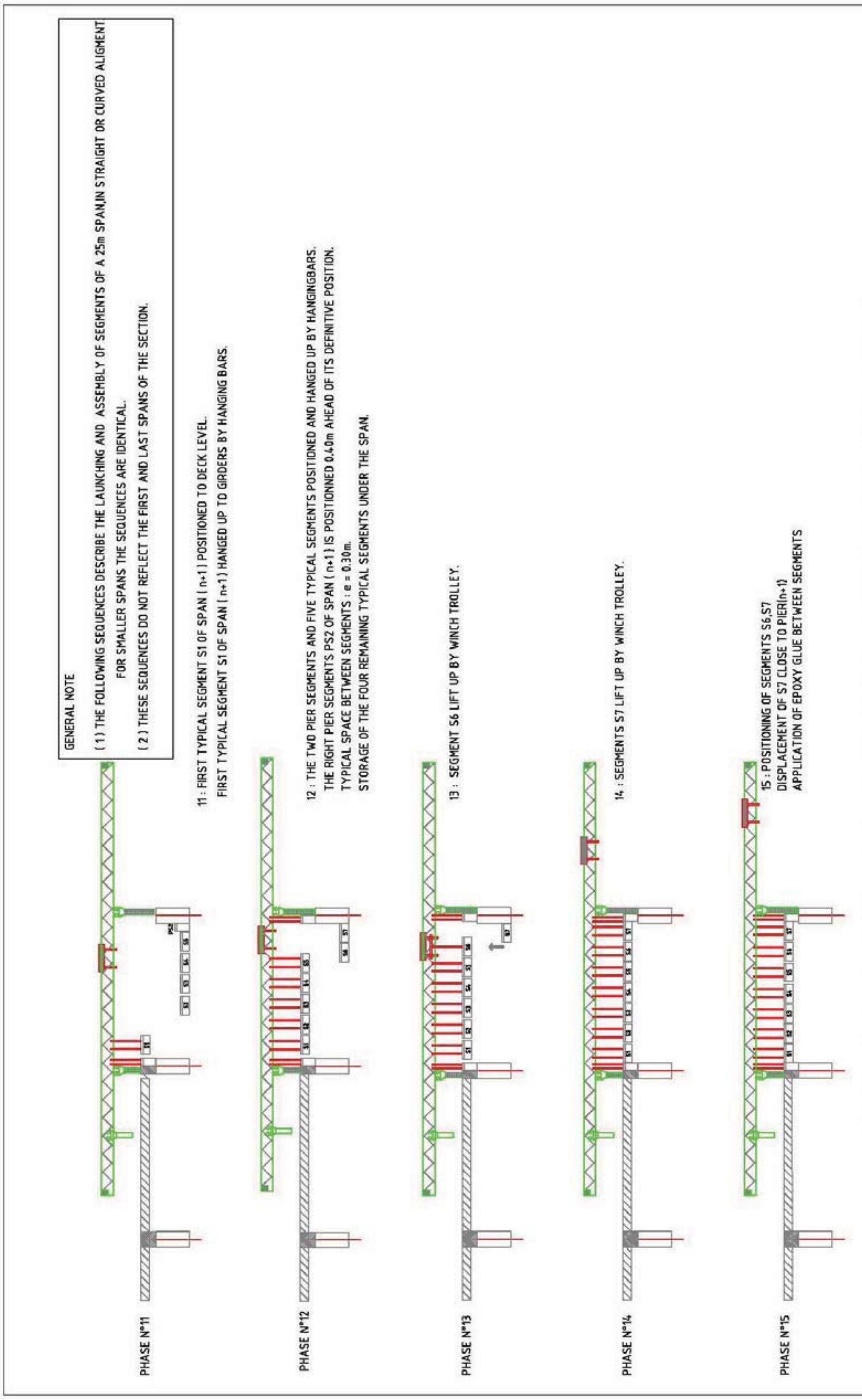


FIGURE 4.8 LAUNCHING SCHEME OF PRECAST SEGMENTAL CONSTRUCTION OF SUPERSTRUCTURE

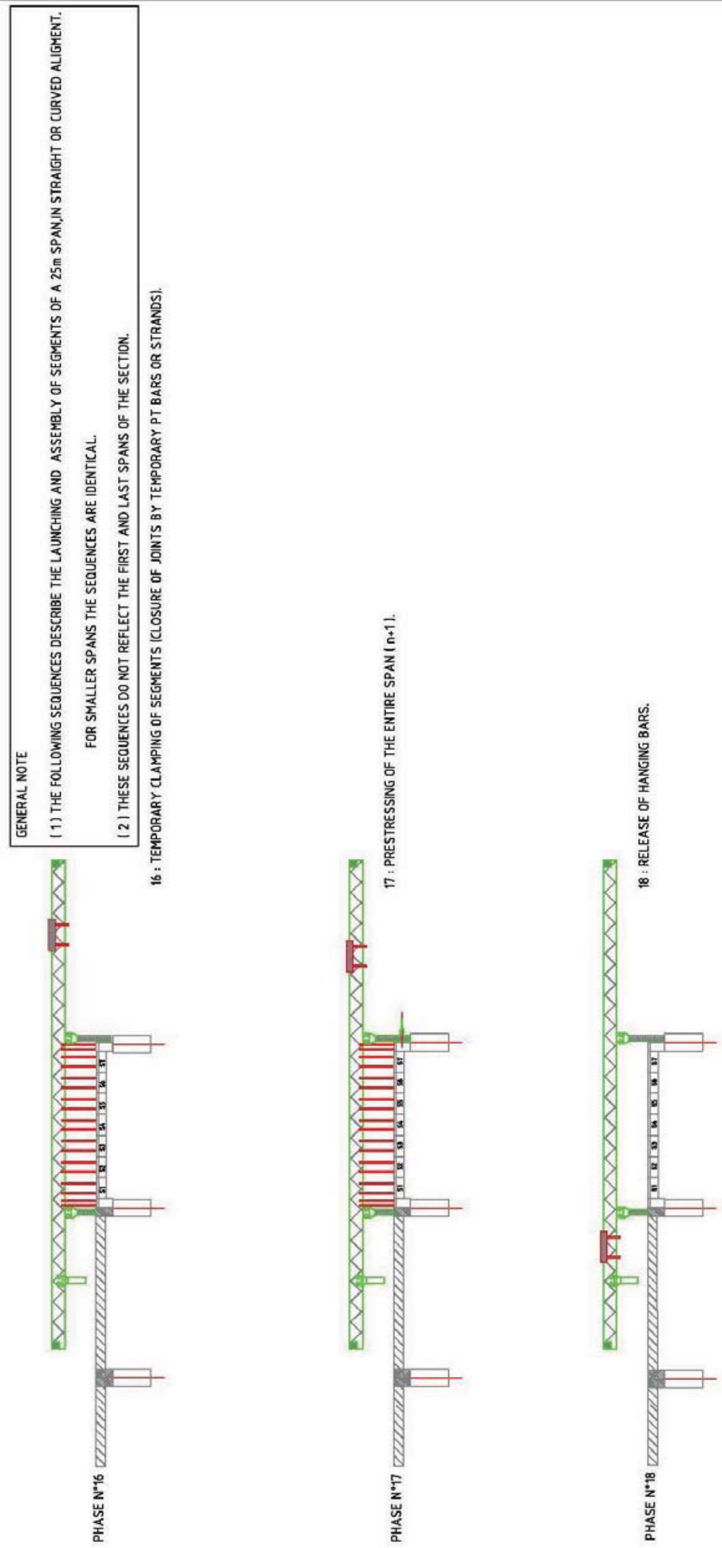


FIGURE 4.9 LAUNCHING SCHEME OF PRECAST SEGMENTAL CONSTRUCTION OF SUPERSTRUCTURE

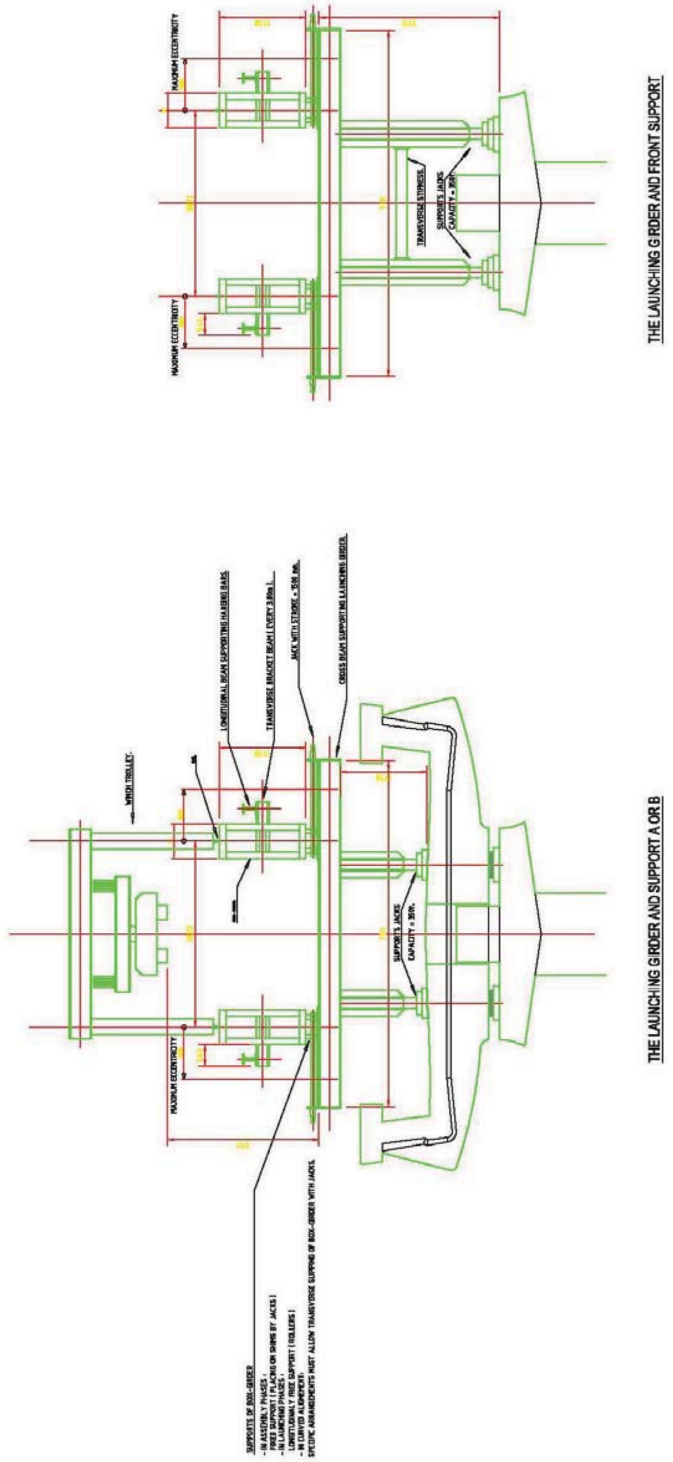


FIGURE 4.10 LAUNCHING SCHEME OF PRECAST SEGMENTAL CONSTRUCTION OF SUPERSTRUCTURE

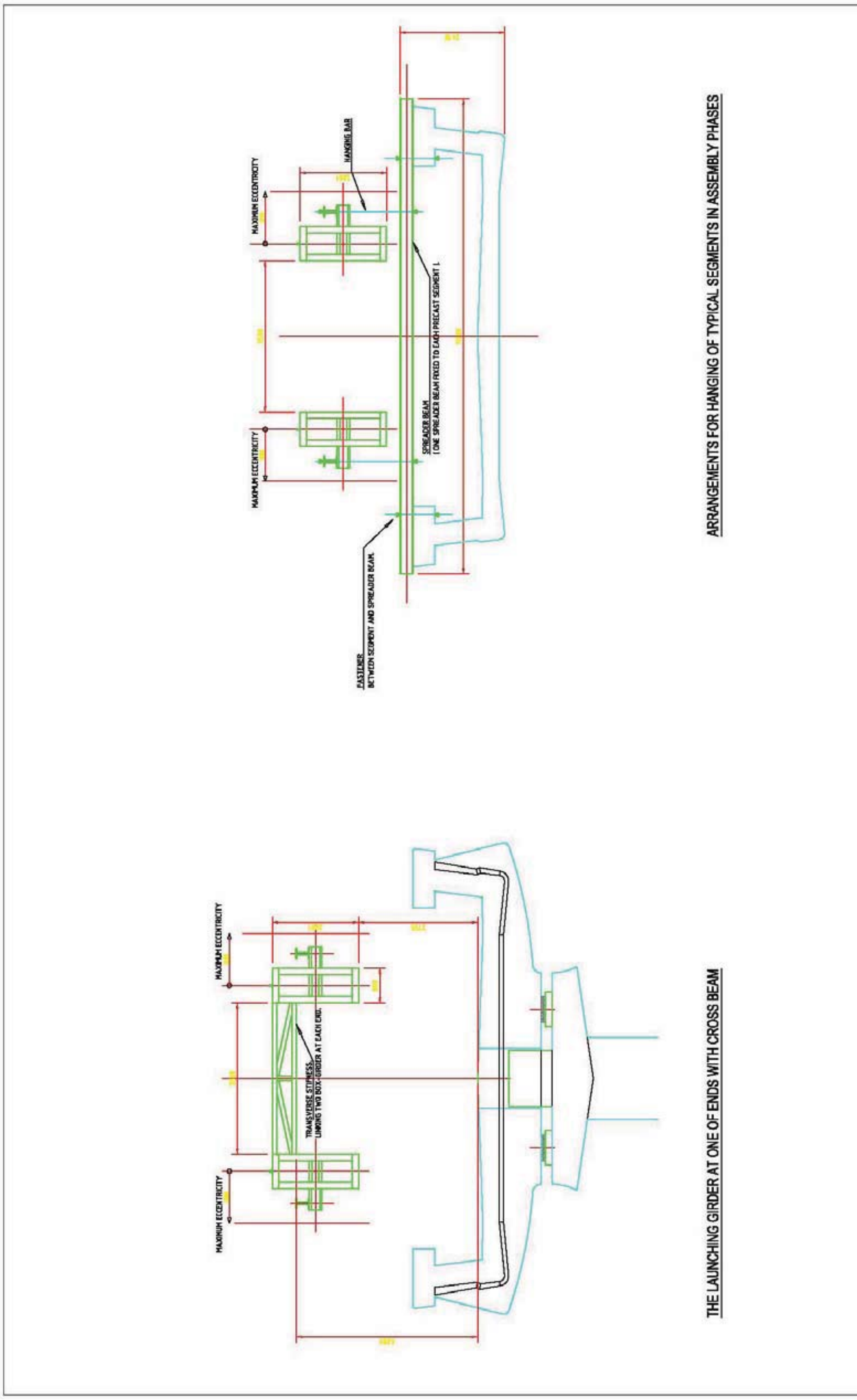


FIGURE 4.11 LAUNCHING SCHEME OF PRECAST SEGMENTAL CONSTRUCTION OF SUPERSTRUCTURE

Chapter 5

Train Operation Plan

CHAPTER 5

TRAIN OPERATION PLAN

5.1 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.
- Multi-tasking of train operation and maintenance staff.

5.2 STATIONS

List of stations for the Corridors of Lucknow Metro are given below:

NORTH-SOUTH CORRIDOR				
S. No	**Name of Stations**	**Change (in m)**	**Inter – Station Distance (in m)**	**Remarks**
	Dead End	-735.00	NA	
1	CCS Airport	-614.11	120.89	Elevated
2	Amausi	193.12	807.23	Elevated
3	Transport Nagar	1393.59	1200.47	Elevated
4	Krishna Nagar	2630.09	1236.50	Elevated
5	Singar Nagar	4214.40	1584.31	Elevated
6	Alambagh	5600.00	1385.60	Elevated
7	Alambagh Bus Stand	6312.51	712.51	Elevated
8	Mawaiya	7080.02	767.51	Elevated
9	Durgapuri	8256.95	1176.93	Elevated

NORTH-SOUTH CORRIDOR				
S. No	**Name of Stations**	**Change (in m)**	**Inter – Station Distance (in m)**	**Remarks**
10	Charbagh / Lko Rly Station	9021.44	764.49	Elevated
11	HussainGunj	10392.47	1371.03	Underground
12	Sachiwalaya	11327.05	934.58	Underground
13	HazratGunj	12379.38	1052.33	Underground
14	KD Singh Babu Stadium	13504.26	1124.88	Elevated
15	Vishwavidyalaya	14985.07	1480.81	Elevated
16	IT College Junction	15810.90	825.83	Elevated
17	Mahanagar	16903.84	1092.94	Elevated
18	Badshah Nagar	17577.28	673.44	Elevated
19	Lekhraj Market	18554.15	976.87	Elevated
20	Ram Sagar Mishra Nagar	19273.00	718.85	Elevated
21	Indra Nagar	20174.17	901.17	Elevated
22	Munshi Pulia	21734.66	1560.49	Elevated
	Dead End	22143.26	408.60	Elevated

EAST-WEST CORRIDOR				
S. No	**Name of Stations**	**Change (in m)**	**Inter – Station Distance (in m)**	**Remarks**
	Dead End	(-) 113.00	-	
1	Charbagh / Lucknow Railway Station	0	113	Underground
2	Gautam Buddha Marg	988.96	988.966	Underground
3	Aminabad	1953.42	964.46	Underground
4	Pandeyganj	2777.09	823.67	Underground
5	Lucknow City Railway Station	3694.07	916.98	Underground
6	Medical Chauraha	4643.42	949.35	Underground
7	Nawajganj	5833.08	1189.66	Underground

EAST-WEST CORRIDOR				
S. No	**Name of Stations**	**Change (in m)**	**Inter – Station Distance (in m)**	**Remarks**
8	Thakurganj	7175.47	1342.39	Elevated
9	Balaganj	8114.17	938.7	Elevated
10	Sarfarazganj	8794.08	679.91	Elevated
11	Musabagh	9723.75	929.67	Elevated
12	Vasant Kunj	10576.94	853.19	Elevated
	Dead End	10985	408.06	-

5.3 TRAIN OPERATION PLAN

5.3.1 Salient Features

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

  A) North- South Corridor:

  a) CCS Airport to Munshipulia: 34 kmph

  b) Alambagh Bus Stand to Mahanagar: 33 kmph

  B) East-West Corridor:

  a) Lucknow Railway Station to Vasant Kunj: 32 kmph

  b) Lucknow Railway Station to Thakurganj: 33 kmph

5.3.2 Traffic Demand

Peak hour peak direction traffic demands (PHPDT) for the Lucknow City 'North-South Corridor' & 'East- West Corridor' for the year 2015, 2020, 2025, 2030 and 2041 for the purpose of planning are indicated in Attachment I/A1, B1, C1, D1 & E1 and Attachment I/A2, B2, C2, D2 & E2 respectively.

5.3.3 Train formation

To meet the above projected traffic demand, the possibility of running trains with composition of 6 Car trains with different headway has been examined.

The basic unit of 6-car train comprising of DMC + TC + MC + MC + TC + DMC configuration is selected for the Lucknow Metro Corridors for the year 2015, 2020, 2025, 2030 & 2041.

Composition

DMC : Driving Trailer Car

MC : Motor Car

TC : Trailer Car

6 Car Train Compositions: DMC + TC +MC + MC + TC + DMC

Capacity

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

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

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

5.3.4 Train Operation Plan

Based on the projected PHPDT demand, train operation has been planned for Metro Corridors in Lucknow city for the year 2015, 2020, 2025, 2030 and 2041 as detailed below:

5.3.4.1 North- South Corridor:

Train Operation Plan for CCS Airport to Munshipulia has been planned in such a way that there are two loops of train operation. In one loop, trains run from CCS Airport to Munshipulia at a given headway and in other loop trains run from Alambagh Bus Stand to Mahanagar at the same headway, thus resulting in <u>half the headway</u> in Alambagh Bus Stand to Mahanagar as compared to CCS Airport to Alambagh Bus Stand & Mahanagar to Munshipulia.

<u>For this Train operation Plan, Reversal Facilities are required at Alambagh Bus Stand and Mahanagar.</u>

Train operation plan with train carrying **capacity @ 6 persons per square meter of standee area** on North- South Corridor are given below:

i) Year 2015:

a) CCS Airport to Alambagh Bus Stand Section (Refer Attachment I/A1)

- 14 min Headway with 6-car train.
- Available Peak Hour Peak Direction Capacity of 6746 @ 6 persons per square meter of standee area
- Available Peak Hour Peak Direction Capacity of 8580 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 6172 is in the Section between Alambagh to Alambagh Bus Stand and demand in the remaining sections is in the range of 259 to 4484 only. The planned capacity of 6746 (8580 under dense loading) is more than the PHPDT demand in six sections of CCS Airport to Alambagh Bus Stand section.

b) Alambagh Bus Stand to Mahanagar Section (Refer Attachment I/A1)

- 7 min Headway with 6-car train.
- Available Peak Hour Peak Direction Capacity of 13491 @ 6 persons per square meter of standee area
- Available Peak Hour Peak Direction Capacity of 17160 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 13190 is in the Section between Hussain Gunj and Sachiwalaya and demand in the remaining sections is in the range of 8925 to 13066 only. The planned capacity of 13491 (17160 under dense loading) is more than the PHPDT demand in ten sections of Alambagh Bus Stand to Mahanagar Section.

c) Mahanagar to Munshi Pulia Section (Refer Attachment I/A1)

- 14 min Headway with 6-car train.
- Available Peak Hour Peak Direction Capacity of 6746 @ 6 persons per square meter of standee area
- Available Peak Hour Peak Direction Capacity of 8580 @ 8 persons per square meter of standee area under dense loading conditions.

- The maximum PHPDT demand of 8451 is in the Section between Mahanagar and Badshah Nagar and demand in the remaining sections is in the range of 3775 to 6546 only. The planned capacity of 6746 (8580 under dense loading) is less than the PHPDT demand in one (zero, with dense loading capacity) sections out of three sections of Mahanagar to Munshi Pulia.

With this planned PHPDT capacity, optimum utilization of Rolling Stock will be achieved and empty running of trains will be considerably reduced. However, the Rolling Stock is designed for carrying higher density loading @ 8 standee passengers per square meter and in the sections in which PHPDT capacity exceeds the planned capacity, overloading during these periods will help in reducing the demand for increased deployment of Rolling Stock. Traffic demand and train capacity for this corridor in the year 2015 is tabulated and represented on a chart enclosed as Attachment I/A1.

ii) Year 2020:

a) CCS Airport to Alambagh Bus Stand Section (Refer Attachment I/B1)

- 9 min Headway with 6-car train.
- Available Peak Hour Peak Direction Capacity of 10493 @ 6 persons per square meter of standee area
- Available Peak Hour Peak Direction Capacity of 13347 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 9658 is in the Section between Alambagh to Alambagh Bus Stand and demand in the remaining sections is in the range of 415 to 7407 only. The planned capacity of 10493 (13347 under dense loading) is more than the PHPDT demand in six sections of CCS Airport to Alambagh Bus Stand section.

b) Alambagh Bus Stand to Mahanagar Section (Refer Attachment I/B1)

- 4.5 min Headway with 6-car train.
- Available Peak Hour Peak Direction Capacity of 20987 @ 6 persons per square meter of standee area
- Available Peak Hour Peak Direction Capacity of 26693 @ 8 persons per square meter of standee area under dense loading conditions.

- The maximum PHPDT demand of 20976 is in the Section between Hussain Gunj and Sachiwalaya and demand in the remaining sections is in the range of 13808 to 20677 only. The planned capacity of 20987 (26693 under dense loading) is more than the PHPDT demand in ten sections of Alambagh Bus Stand to Mahanagar Section.

c) Mahanagar to Munshi Pulia Section (Refer Attachment I/B1)

- 9 min Headway with 6-car train.
- Available Peak Hour Peak Direction Capacity of 10493 @ 6 persons per square meter of standee area
- Available Peak Hour Peak Direction Capacity of 13347 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 13498 is in the Section between Mahanagar and Badshah Nagar and demand in the remaining sections is in the range of 6068 to 10633 only. The planned capacity of 10493 (13347 under dense loading) is less than the PHPDT demand in one (one, with dense loading capacity) sections out of three sections of Mahanagar to Munshi Pulia.

With this planned PHPDT capacity, optimum utilization of Rolling Stock will be achieved and empty running of trains will be considerably reduced. However, the Rolling Stock is designed for carrying higher density loading @ 8 standee passengers per square meter and in the sections in which PHPDT capacity exceeds the planned capacity, overloading during these periods will help in reducing the demand for increased deployment of Rolling Stock. Traffic demand and train capacity for this corridor in the year 2020 is tabulated and represented on a chart enclosed as Attachment I/B1.

iii) Year 2025:

a) CCS Airport to Alambagh Bus Stand Section (Refer Attachment I/C1)

- 7 min Headway with 6-car train.
- Available Peak Hour Peak Direction Capacity of 13491 @ 6 persons per square meter of standee area
- Available Peak Hour Peak Direction Capacity of 17160 @ 8 persons per square meter of standee area under dense loading conditions.

- The maximum PHPDT demand of 13159 is in the Section between Alambagh to Alambagh Bus Stand and demand in the remaining sections is in the range of 588 to 10521 only. The planned capacity of 13491 (17160 under dense loading) is more than the PHPDT demand in six sections of CCS Airport to Alambagh Bus Stand section.

b) Alambagh Bus Stand to Mahanagar Section (Refer Attachment I/C1)

- 3.5 min Headway with 6-car train.
- Available Peak Hour Peak Direction Capacity of 26983 @ 6 persons per square meter of standee area
- Available Peak Hour Peak Direction Capacity of 34320 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 25890 is in the Section between Hussain Gunj and Sachiwalaya and demand in the remaining sections is in the range of 18035 to 25176 only. The planned capacity of 26983 (34320 under dense loading) is more than the PHPDT demand in ten sections of Alambagh Bus Stand to Mahanagar Section.

c) Mahanagar to Munshi Pulia Section (Refer Attachment I/C1)

- 3.5 min Headway with 6-car train.
- Available Peak Hour Peak Direction Capacity of 13491 @ 6 persons per square meter of standee area
- Available Peak Hour Peak Direction Capacity of 17160 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 15644 is in the Section between Mahanagar and Badshah Nagar and demand in the remaining sections is in the range of 6454 to 12335 only. The planned capacity of 13491 (17160 under dense loading) is less than the PHPDT demand in one (zero, with dense loading capacity) sections out of three sections of Mahanagar to Munshi Pulia.

With this planned PHPDT capacity, optimum utilization of Rolling Stock will be achieved and empty running of trains will be considerably reduced. However, the Rolling Stock is designed for carrying higher density loading @ 8 standee passengers per square meter and in the sections in which PHPDT capacity exceeds the planned capacity, overloading during these periods will help in reducing the demand for increased deployment of Rolling Stock. Traffic demand and train capacity for this corridor in the year 2025 is tabulated and represented on a chart enclosed as Attachment I/C1.

iv) Year 2030:

a) CCS Airport to Alambagh Bus Stand Section (Refer Attachment I/D1)

- 5 min Headway with 6-car train.
- Available Peak Hour Peak Direction Capacity of 18888 @ 6 persons per square meter of standee area
- Available Peak Hour Peak Direction Capacity of 24024 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 14995 is in the Section between Alambagh to Alambagh Bus Stand and demand in the remaining sections is in the range of 657 to 11883 only. The planned capacity of 18888 (24024 under dense loading) is more than the PHPDT demand in six sections of CCS Airport to Alambagh Bus Stand section.

b) Alambagh Bus Stand to Mahanagar Section (Refer Attachment I/D1)

- 2.5 min Headway with 6-car train.
- Available Peak Hour Peak Direction Capacity of 37776 @ 6 persons per square meter of standee area
- Available Peak Hour Peak Direction Capacity of 48048 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 34955 is in the Section between Hussain Gunj and Sachiwalaya and demand in the remaining sections is in the range of 20562 to 33830 only. The planned capacity of 37776 (48048 under dense loading) is more than the PHPDT demand in ten sections of Alambagh Bus Stand to Mahanagar Section.

c) Mahanagar to Munshi Pulia Section (Refer Attachment I/D1)

- 5 min Headway with 6-car train.
- Available Peak Hour Peak Direction Capacity of 18888 @ 6 persons per square meter of standee area

- Available Peak Hour Peak Direction Capacity of 24024 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 21246 is in the Section between Mahanagar and Badshah Nagar and demand in the remaining sections is in the range of 8288 to 17171 only. The planned capacity of 18888 (24024 under dense loading) is less than the PHPDT demand in one (zero, with dense loading capacity) sections out of three sections of Mahanagar to Munshi Pulia.

With this planned PHPDT capacity, optimum utilization of Rolling Stock will be achieved and empty running of trains will be considerably reduced. However, the Rolling Stock is designed for carrying higher density loading @ 8 standee passengers per square meter and in the sections in which PHPDT capacity exceeds the planned capacity, overloading during these periods will help in reducing the demand for increased deployment of Rolling Stock. Traffic demand and train capacity for this corridor in the year 2030 is tabulated and represented on a chart enclosed as Attachment I/D1.

v) Year 2041:

a) CCS Airport to Alambagh Bus Stand Section (Refer Attachment I/E1)

- 4 min Headway with 6-car train.
- Available Peak Hour Peak Direction Capacity of 23610 @ 6 persons per square meter of standee area
- Available Peak Hour Peak Direction Capacity of 30030 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 19581 is in the Section between Alambagh to Alambagh Bus Stand and demand in the remaining sections is in the range of 1008 to 15139 only. The planned capacity of 23610 (30030 under dense loading) is more than the PHPDT demand in six sections of CCS Airport to Alambagh Bus Stand section.

b) Alambagh Bus Stand to Mahanagar Section (Refer Attachment I/E1)

- 2 min Headway with 6-car train.
- Available Peak Hour Peak Direction Capacity of 47220 @ 6 persons per square meter of standee area

- Available Peak Hour Peak Direction Capacity of 60060 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 44408 is in the Section between Hussain Gunj and Sachiwalaya and demand in the remaining sections is in the range of 26335 to 42493 only. The planned capacity of 47220 (60060 under dense loading) is more than the PHPDT demand in ten sections of Alambagh Bus Stand to Mahanagar Section.

c) **Mahanagar to Munshi Pulia Section (Refer Attachment I/E1)**

- 4 min Headway with 6-car train.
- Available Peak Hour Peak Direction Capacity of 23610 @ 6 persons per square meter of standee area
- Available Peak Hour Peak Direction Capacity of 30030 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 26894 is in the Section between Mahanagar and Badshah Nagar and demand in the remaining sections is in the range of 10336 to 21637 only. The planned capacity of 23610 (30030 under dense loading) is less than the PHPDT demand in one (zero, with dense loading capacity) sections out of three sections of Mahanagar to Munshi Pulia.

With this planned PHPDT capacity, optimum utilization of Rolling Stock will be achieved and empty running of trains will be considerably reduced. However, the Rolling Stock is designed for carrying higher density loading @ 8 standee passengers per square meter and in the sections in which PHPDT capacity exceeds the planned capacity, overloading during these periods will help in reducing the demand for increased deployment of Rolling Stock. Traffic demand and train capacity for this corridor in the year 2041 is tabulated and represented on a chart enclosed as Attachment I/E1.

5.3.4.2 East- West Corridor:

Train Operation Plan for Lucknow Railway Station to Vasant Kunj has been planned in such a way that there are two loops of train operation. In one loop, trains run from Lucknow Railway Station to Vasant Kunj at a given headway and in other loop trains run from Lucknow Railway Station to Thakurganj at the same headway, thus resulting in half the headway in Lucknow Railway Station to Thakurganj as compared to Thakurganj to Vasant Kunj.

For this Train operation Plan, Reversal Facility is required at Thakurganj.

Train operation plan with train carrying **capacity @ 6 persons per square meter of standee area** on Corridor-II is given below:

i) Year 2015:

a) Lucknow Railway Station to Thakurganj Section (Refer Attachment I/A2)

- 11 min Headway with 6-car train.
- Available Peak Hour Peak Direction Capacity of 8585 @ 6 persons per square meter of standee area
- Available Peak Hour Peak Direction Capacity of 10920 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 8104 is in the Section between Lucknow Rly. Stn. and Gautam Buddha Marg and demand in the remaining sections is in the range of 2537 to 7923 only. The planned capacity of 8585 (10920 under dense loading) is more than the PHPDT demand in seven sections of Lucknow Railway Station to Thakurganj Section.

b) Thakurganj to Vasant kunj Section (Refer Attachment I/A2)

- 22 min Headway with 6-car train.
- Available Peak Hour Peak Direction Capacity of 4293 @ 6 persons per square meter of standee area
- Available Peak Hour Peak Direction Capacity of 5460 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 1813 is in the Section between Thakurganj and Balaganj and demand in the remaining sections is in the range of 180 to 1291 only. The planned capacity of 4293 (5460 under dense loading) is more than the PHPDT demand in four sections of Thakurganj to Vasant kunj Section.

With this planned PHPDT capacity, optimum utilization of Rolling Stock will be achieved and empty running of trains will be considerably reduced. However, the Rolling Stock is designed for carrying higher density loading @ 8 standee passengers per square meter and in the sections in which PHPDT capacity exceeds the planned capacity, overloading during these periods will help in reducing the demand for increased deployment of Rolling Stock. Traffic demand and train capacity for this corridor in the year 2015 is tabulated and represented on a chart enclosed as Attachment I/A2.

ii) Year 2020:

a) Lucknow Railway Station to Thakurganj Section (Refer Attachment I/B2)

- 6.5 min Headway with 6-car train.
- Available Peak Hour Peak Direction Capacity of 14529 @ 6 persons per square meter of standee area
- Available Peak Hour Peak Direction Capacity of 18480 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 14157 is in the Section between Lucknow Rly. Stn. and Gautam Buddha Marg and demand in the remaining sections is in the range of 5116 to 13814 only. The planned capacity of 14529 (18480 under dense loading) is more than the PHPDT demand in seven sections of Lucknow Railway Station to Thakurganj Section.

b) Thakurganj to Vasant kunj Section (Refer Attachment I/B2)

- 13 min Headway with 6-car train.
- Available Peak Hour Peak Direction Capacity of 7265 @ 6 persons per square meter of standee area
- Available Peak Hour Peak Direction Capacity of 9240 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 3638 is in the Section between Thakurganj and Balaganj and demand in the remaining sections is in the range of 428 to 1881 only. The planned capacity of 7265 (9240 under dense loading) is more than the PHPDT demand in four sections of Thakurganj to Vasant kunj Section.

With this planned PHPDT capacity, optimum utilization of Rolling Stock will be achieved and empty running of trains will be considerably reduced. However, the Rolling Stock is designed for carrying higher density loading @ 8 standee passengers per square meter and in the sections in which PHPDT capacity exceeds the planned capacity, overloading during these periods will help in reducing the demand for increased deployment of Rolling Stock. Traffic demand and train capacity for this corridor in the year 2020 is tabulated and represented on a chart enclosed as Attachment I/B2.

iii) Year 2025:

a) Lucknow Railway Station to Thakurganj Section (Refer Attachment I/C2)

- 4.5 min Headway with 6-car train.
- Available Peak Hour Peak Direction Capacity of 20987 @ 6 persons per square meter of standee area
- Available Peak Hour Peak Direction Capacity of 26693 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 21434 is in the Section between Lucknow Rly. Stn. and Gautam Buddha Marg and demand in the remaining sections is in the range of 8247 to 20979 only. The planned capacity of 20987 (26693 under dense loading) is more than the PHPDT demand in seven sections of Lucknow Railway Station to Thakurganj Section.

b) Thakurganj to Vasant kunj Section (Refer Attachment I/C2)

- 9 min Headway with 6-car train.
- Available Peak Hour Peak Direction Capacity of 10493 @ 6 persons per square meter of standee area
- Available Peak Hour Peak Direction Capacity of 13347 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 5765 is in the Section between Thakurganj and Balaganj and demand in the remaining sections is in the range of 598 to 2319 only. The planned capacity of 10493 (13347 under dense loading) is more than the PHPDT demand in four sections of Thakurganj to Vasant kunj Section.

With this planned PHPDT capacity, optimum utilization of Rolling Stock will be achieved and empty running of trains will be considerably reduced. However, the Rolling Stock is designed for carrying higher density loading @ 8 standee passengers per square meter and in the sections in which PHPDT capacity exceeds the planned capacity, overloading during these periods will help in reducing the demand for increased deployment of Rolling Stock. Traffic demand and train capacity for this corridor in the year 2025 is tabulated and represented on a chart enclosed as Attachment I/C2.

iv) Year 2030:

a) Lucknow Railway Station to Thakurganj Section (Refer Attachment I/D2)

- 3 min Headway with 6-car train.
- Available Peak Hour Peak Direction Capacity of 31480 @ 6 persons per square meter of standee area
- Available Peak Hour Peak Direction Capacity of 40040 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 29171 is in the Section between Lucknow Rly. Stn. and Gautam Buddha Marg and demand in the remaining sections is in the range of 11457 to 28893 only. The planned capacity of 31480 (40040 under dense loading) is more than the PHPDT demand in seven sections of Lucknow Railway Station to Thakurganj Section.

b) Thakurganj to Vasant kunj Section (Refer Attachment I/D2)

- 6 min Headway with 6-car train.
- Available Peak Hour Peak Direction Capacity of 15740 @ 6 persons per square meter of standee area
- Available Peak Hour Peak Direction Capacity of 20020 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 7522 is in the Section between Thakurganj and Balaganj and demand in the remaining sections is in the range of 714 to 2731 only. The planned capacity of 15740 (20020 under dense loading) is

more than the PHPDT demand in four sections of Thakurganj to Vasant kunj Section.

With this planned PHPDT capacity, optimum utilization of Rolling Stock will be achieved and empty running of trains will be considerably reduced. However, the Rolling Stock is designed for carrying higher density loading @ 8 standee passengers per square meter and in the sections in which PHPDT capacity exceeds the planned capacity, overloading during these periods will help in reducing the demand for increased deployment of Rolling Stock. Traffic demand and train capacity for this corridor in the year 2030 is tabulated and represented on a chart enclosed as Attachment I/D2.

v) Year 2041:

a) Lucknow Railway Station to Thakurganj Section (Refer Attachment I/E2)

- 2.5 min Headway with 6-car train.
- Available Peak Hour Peak Direction Capacity of 37776 @ 6 persons per square meter of standee area
- Available Peak Hour Peak Direction Capacity of 48048 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 36196 is in the Section between Lucknow Rly. Stn. and Gautam Buddha Marg and demand in the remaining sections is in the range of 14674 to 35526 only. The planned capacity of 37776 (48048 under dense loading) is more than the PHPDT demand in seven sections of Lucknow Railway Station to Thakurganj Section.

b) Thakurganj to Vasant kunj Section (Refer Attachment I/E2)

- 5 min Headway with 6-car train.
- Available Peak Hour Peak Direction Capacity of 18888 @ 6 persons per square meter of standee area
- Available Peak Hour Peak Direction Capacity of 24024 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 9110 is in the Section between Thakurganj and Balaganj and demand in the remaining sections is in the range of 927 to 3600 only. The planned capacity of 18888 (24024 under dense loading) is

more than the PHPDT demand in four sections of Thakurganj to Vasant kunj Section.

With this planned PHPDT capacity, optimum utilization of Rolling Stock will be achieved and empty running of trains will be considerably reduced. However, the Rolling Stock is designed for carrying higher density loading @ 8 standee passengers per square meter and in the sections in which PHPDT capacity exceeds the planned capacity, overloading during these periods will help in reducing the demand for increased deployment of Rolling Stock. Traffic demand and train capacity for this corridor in the year 2041 is tabulated and represented on a chart enclosed as Attachment I/E2.

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

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

A) Capacity Provided for North – South Corridor

North – South Corridor	Year	Headway (min)	No. of Rakes	Rake Consist	No. of Coaches	Max. PHPDT Demand	PHPDT Capacity Available
CCS Airport to Alambagh Bus Stand	2015	14	13	6 car	78	6172	6746 (8580*)
Alambagh Bus Stand to Mahanagar		7				13190	13491 (17160)*
Mahanagar to Munshipulia		14				8451	6746 (8580*)
CCS Airport to Alambagh Bus Stand	2020	9	18	6 car	108	9658	10493 (13347*)
Alambagh Bus Stand to Mahanagar		4.5				20976	20987 (26693)*
Mahanagar to Munshipulia		9				13498	10493 (13347*)
CCS Airport to Alambagh Bus Stand	2025	7	23	6 car	138	13159	13491 (17160*)
Alambagh Bus Stand to Mahanagar		3.5				25890	26983 (34320)*
Mahanagar to Munshipulia		7				15644	13491 (17160*)
CCS Airport to Alambagh Bus Stand	2030	5	30	6 car	180	14995	18888 (24024*)
Alambagh Bus Stand to Mahanagar		2.5				34955	37776 (48048)*
Mahanagar to Munshipulia		5				21246	18888 (24024*)
CCS Airport to Alambagh Bus Stand	2041	4	38	6 car	228	19581	23610 (30030*)
Alambagh Bus Stand to Mahanagar		2				44408	47220 (60060*)
Mahanagar to Munshipulia		4				26894	23610 (30030*)

* @ 8 persons per square meter of standee area

B) Capacity Provided for East-West corridor

East- West Corridor	Year	Headway (min)	No. of Rakes	Rake Consist	No. of Coaches	Max. PHPDT Demand	PHPDT Capacity Available
Lucknow Railway Station to Thakurganj	2015	11	7	6 car	42	8104	8585 (10920*)
Thakurganj to Vasant kunj		22				1831	4293 (5460)*
Lucknow Railway Station to Thakurganj	2020	6.5	9	6 car	54	14157	14529 (18480*)
Thakurganj to Vasant kunj		13				3638	7265 (9240)*
Lucknow Railway Station to Thakurganj	2025	4.5	12	6 car	72	21434	20987 (26693*)
Thakurganj to Vasant kunj		9				5765	10493 (13347)*
Lucknow Railway Station to Thakurganj	2030	3	17	6 car	102	29171	31480 (40040*)
Thakurganj to Vasant kunj		6				7522	15740 (20020)*
Lucknow Railway Station to Thakurganj	2041	2.5	20	6 car	120	36196	37776 (48048*)
Thakurganj to Vasant kunj		5				9110	18888 (24024*)

* @ 8 persons per square meter of standee area

5.3.5 Train Frequency:-

A) North- South Corridor:

North-South Corridor	2015		2020		2025		2030		2041	
	Peak Hour h/w	Lean Hour h/w	Peak Hour h/w	Lean Hour h/w	Peak Hour h/w	Lean Hour h/w	Peak Hour h/w	Lean Hour h/w	Peak Hour h/w	Lean Hour h/w
CCS Airport to Alambagh Bus Stand	14 min	20 to 60 min	9 min	12 to 40 min	7 min	10 to 30 min	5 min	8 to 20 min	4 min	6 to 20 min
Alambagh Bus Stand to Mahanagar	7 min	10 to 30 min	4.5 min	6 to 20 min	3.5 min	5 to 15 min	2.5 min	4 to 10 min	2 min	3 to 10min
Mahanagar to Munshipulia	14 min	20 to 60 min	9 min	12 to 40 min	7 min	10 to 30 min	5 min	8 to 20 min	4 min	6 to 20 min

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

B) East-West corridor

East-West Corridor	2015		2020		2025		2030		2041	
	Peak Hour h/w	Lean Hour h/w	Peak Hour h/w	Lean Hour h/w	Peak Hour h/w	Lean Hour h/w	Peak Hour h/w	Lean Hour h/w	Peak Hour h/w	Lean Hour h/w
Lucknow Railway Station to Thakurganj	11 min	16 to 40 min	6.5 min	10 to 30 min	4.5 min	6 to 20 min	3 min	5 to 15 min	2.5 min	4 to 10 min
Thakurganj to Vasant kunj	22 min	32 to 80 min	13 min	20 to 60 min	9 min	12 to 40 min	6 min	10 to 30 min	5 min	8 to 20min

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

5.3.6 Hourly Train Operation plan

A) North- South Corridor:

The hourly distribution of daily transport capacity is presented in **Table 1.1A, 1.1B, 1.1C, 1.2A,1.2B, 1.2C, 1.3A,1.3B, 1.3C, 1.4A, 1.4B, 1.4C, 1.5A, 1.5B & 1.5C** for years 2015, 2020, 2025, 2030 & 2041 for CCS Airport to Alambagh Bus Stand section, Alambagh Bus

Stand to Mahanagar section & Mahanagar to Munshipulia section respectively and enclosed as Attachment II. Number of train trips per direction per day for above corridors are worked out as 50,100 & 50 in the year 2015, 79, 158 & 79 in the year 2020, 100, 200 & 100 in the year 2025, 140, 280 & 140 in the year 2030 and 168, 336 & 168 in the year 2041 respectively. The directional splits for North-South Corridor are presented in **Table 2.1** enclosed as Attachment III.

B) East- West Corridor:

The hourly distribution of daily transport capacity is presented in **Table 2.1A, 2.1B, 2.2A, 2.2B, 2.3A, 2.3B, 2.4A, 2.4B, 2.5A & 2.5B** for years 2015, 2020, 2025, 2030 & 2041 for Lucknow Railway Station to Thakurganj section & Thakurganj to Vasant kunj section respectively and enclosed as Attachment II. Number of train trips per direction per day for above corridors are worked out as 64 & 32 in the year 2015, 106 & 53 in the year 2020, 158 & 79 in the year 2025, 216 & 108 in the year 2030 and 280 & 140 in the year 2041 respectively. The directional splits for East- West Corridor are presented in **Table 2.2** enclosed as Attachment III.

5.3.7 Vehicle Kilometer

Based on above planning, after considering maintenance period and assuming 340 days in service in a year, Vehicle Kilometers for North – South corridor and East- West Corridor is given in **Table 3.1 & 3.2** enclosed as Attachment IV.

5.4 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:

Requirements of coaches is calculated based on following assumptions-

Assumptions –

I) Train Composition planned as under

6 car Train Composition : DMC + TC + MC + MC + TC+ DMC

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:

i) North- South Corridor:

a) CCS Airport to Munshipulia: 34 kmph

b) Alambagh Bus Stand to Mahanagar: 33 kmph

ii) East-West Corridor:

a) Lucknow Railway Station to Vasant Kunj: 32 kmph

b) Lucknow Railway Station to Thakurganj: 33 kmphh

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

5.5 COST ESTIMATE

The estimated cost per coach at May 2010 Price level exclusive of taxes and duties may be assumed as Rs. 9.8 Crores per Coach. Total 78+42 = 120 coaches are required in year 2015 for the two Lines. Hence budget provision of Rs. 1200 Crores is to be kept in the Estimate for Rolling Stock.

Attachment - I/A1

PHPDT Demand and Capacity Chart

N-S Corridor :CCS Airport - Munshi Pulia

Year:	2015	
No. of Cars per Train:	6	
Passenger Capacity @ 6 persons/sqm of a 6-Car Train:	1574	
Passenger Capacity @ 8 persons/sqm of a 6-Car Train:	2002	
Headway (min)	7	*[Alambagh Bus Stand to Mahanagar]*
Headway (min)	14	*[CCS Airport to Alambagh Bus stand & Mahanagar to Munshi Pulia]*

S.N	FROM	TO	Traffic Demand in PHPDT	PHPDT Capacity @ 6p/sqm of standee area	PHPDT Capacity @ 8p/sqm of standee area
1	CCS Airport	Amausi	259	6746	8580
2	Amausi	Transport Nagar	1296	6746	8580
3	Transport Nagar	Krishna Nagar	2522	6746	8580
4	Krishna Nagar	Singar Nagar	3650	6746	8580
5	Singar Nagar	Alambagh	4484	6746	8580
6	Alambagh	Alambagh Bus Stand	6172	6746	8580
7	Alambagh Bus Stand	Mawaiya	8925	13491	17160
8	Mawaiya	Durgapuri	12204	13491	17160
9	Durgapuri	Charbagh / Lko Rly Station	12500	13491	17160
10	Charbagh / Lko Rly Station	HussainGunj	12792	13491	17160
11	HussainGunj	Sachiwalaya	13190	13491	17160
12	Sachiwalaya	HazratGunj	13066	13491	17160
13	HazratGunj	KD Singh Babu Stadium	12330	13491	17160
14	KD Singh Babu Stadium	Vishwavidyalaya	11953	13491	17160
15	Vishwavidyalaya	IT College Junction	12073	13491	17160
16	IT College Junction	Mahanagar	11876	13491	17160
17	Mahanagar	Badshah Nagar	8451	6746	8580
19	Lekhraj Market	Ram Sagar Mishra Nagar	6546	6746	8580
21	Indra Nagar	Munshi Pulia	3775	6746	8580

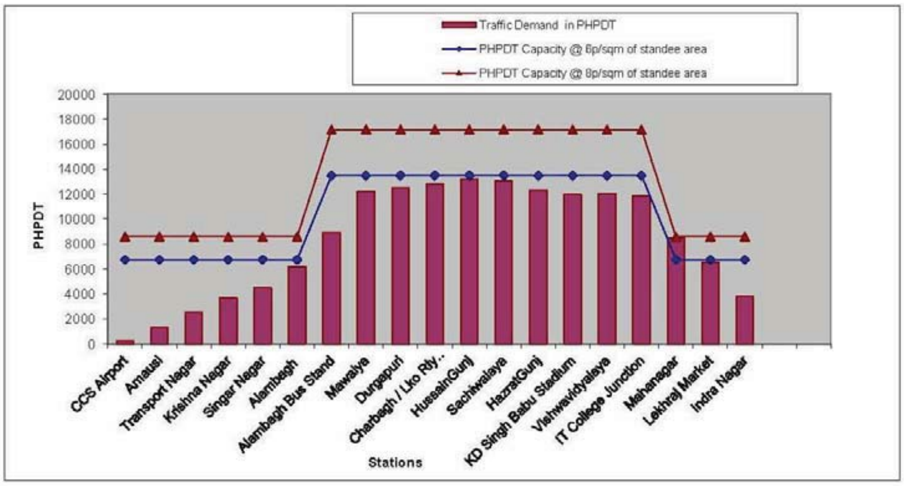


Fig 1.1

Attachment - I/B1

PHPDT Demand and Capacity Chart

N-S Corridor :CCS Airport - Munshi Pulia

Year:	2020	
No. of Cars per Train:	6	
Passenger Capacity @ 6 persons/sqm of a 6-Car Train:	1574	
Passenger Capacity @ 8 persons/sqm of a 6-Car Train:	2002	
Headway (min)	4.5	[Alambagh Bus Stand to Mahanagar]
Headway (min)	9	[CCS Airport to Alambagh Bus stand & Mahanagar to Munshi Pulia]

S.N	FROM	TO	Traffic Demand in PHPDT	PHPDT Capacity @ 6p/sqm of standee area	PHPDT Capacity @ 8p/sqm of standee area
1	CCS Airport	Amausi	415	10493	13347
2	Amausi	Transport Nagar	2079	10493	13347
3	Transport Nagar	Krishna Nagar	3825	10493	13347
4	Krishna Nagar	Singar Nagar	6196	10493	13347
5	Singar Nagar	Alambagh	7407	10493	13347
6	Alambagh	Alambagh Bus Stand	9658	10493	13347
7	Alambagh Bus Stand	Mawaiya	13808	20987	26693
8	Mawaiya	Durgapuri	17043	20987	26693
9	Durgapuri	Charbagh / Lko Rly Station	18198	20987	26693
10	Charbagh / Lko Rly Station	HussainGunj	18788	20987	26693
11	HussainGunj	Sachiwalaya	20976	20987	26693
12	Sachiwalaya	HazratGunj	20677	20987	26693
13	HazratGunj	KD Singh Babu Stadium	19064	20987	26693
14	KD Singh Babu Stadium	Vishwavidyalaya	18368	20987	26693
15	Vishwavidyalaya	IT College Junction	17673	20987	26693
16	IT College Junction	Mahanagar	17170	20987	26693
17	Mahanagar	Badshah Nagar	13498	10493	13347
19	Lekhraj Market	Ram Sagar Mishra Nagar	10633	10493	13347
21	Indra Nagar	Munshi Pulia	6068	10493	13347

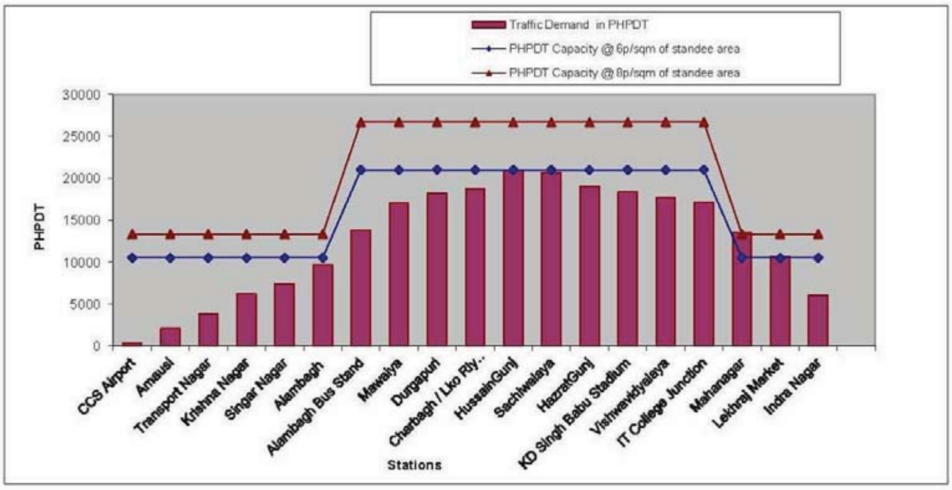


Fig 1.2

Attachment - I/C1

PHPDT Demand and Capacity Chart

N-S Corridor :CCS Airport - Munshi Pulia

Year:	2025	
No. of Cars per Train:	6	
Passenger Capacity @ 6 persons/sqm of a 6-Car Train:	1574	
Passenger Capacity @ 8 persons/sqm of a 6-Car Train:	2002	
Effective Headway (min)	3.5	*[Alambagh Bus Stand to Mahanagar]*
Effective Headway (min)	7	*[CCS Airport to Alambagh Bus stand & Mahanagar to Munshi Pulia]*

S.N	FROM	TO	Traffic Demand in PHPDT	PHPDT Capacity @ 6p/sqm of standee area	PHPDT Capacity @ 8p/sqm of standee area
1	CCS Airport	Amausi	588	13491	17160
2	Amausi	Transport Nagar	2945	13491	17160
3	Transport Nagar	Krishna Nagar	5290	13491	17160
4	Krishna Nagar	Singar Nagar	8997	13491	17160
5	Singar Nagar	Alambagh	10521	13491	17160
6	Alambagh	Alambagh Bus Stand	13159	13491	17160
7	Alambagh Bus Stand	Mawaiya	18035	26983	34320
8	Mawaiya	Durgapuri	22412	26983	34320
9	Durgapuri	Charbagh / Lko Rly Station	24313	26983	34320
10	Charbagh / Lko Rly Station	HussainGunj	23107	26983	34320
11	HussainGunj	Sachiwalaya	**25890**	26983	34320
12	Sachiwalaya	HazratGunj	25176	26983	34320
13	HazratGunj	KD Singh Babu Stadium	22485	26983	34320
14	KD Singh Babu Stadium	Vishwavidyalaya	22536	26983	34320
15	Vishwavidyalaya	IT College Junction	23372	26983	34320
16	IT College Junction	Mahanagar	22515	26983	34320
17	Mahanagar	Badshah Nagar	15644	13491	17160
19	Lekhraj Market	Ram Sagar Mishra Nagar	12335	13491	17160
21	Indra Nagar	Munshi Pulia	6454	13491	17160

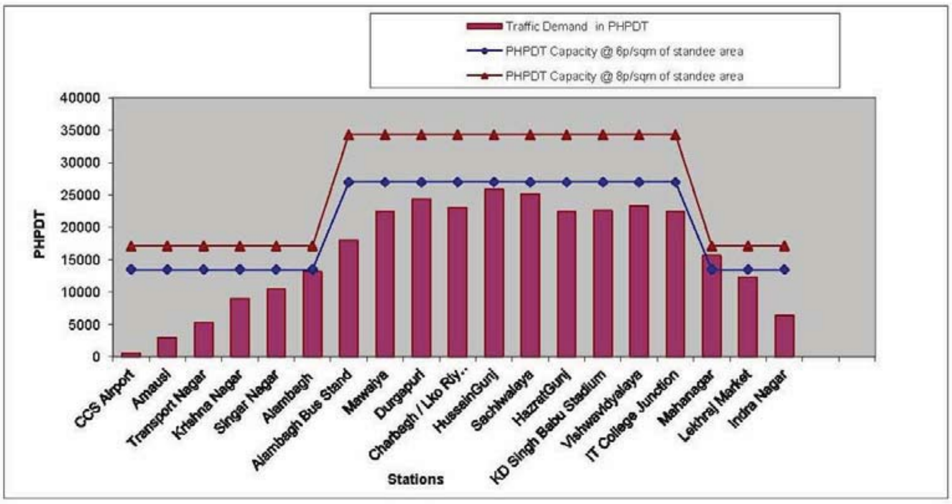


Fig 1.3

Attachment - I/D1

PHPDT Demand and Capacity Chart

N-S Corridor :CCS Airport - Munshi Pulia

Year:	2030	
No. of Cars per Train:	6	
Passenger Capacity @ 6 persons/sqm of a 6-Car Train:	1574	
Passenger Capacity @ 8 persons/sqm of a 6-Car Train:	2002	
Headway (min)	2.5	*[Alambagh Bus Stand to Mahanagar]*
Headway (min)	5	*[CCS Airport to Alambagh Bus stand & Mahanagar to Munshi Pulia]*

S.N	FROM	TO	Traffic Demand in PHPDT	PHPDT Capacity @ 6p/sqm of standee area	PHPDT Capacity @ 8p/sqm of standee area
1	CCS Airport	Amausi	657	18888	24024
2	Amausi	Transport Nagar	3287	18888	24024
3	Transport Nagar	Krishna Nagar	5711	18888	24024
4	Krishna Nagar	Singar Nagar	10008	18888	24024
5	Singar Nagar	Alambagh	11883	18888	24024
6	Alambagh	Alambagh Bus Stand	14995	18888	24024
7	Alambagh Bus Stand	Mawaiya	20562	37776	48048
8	Mawaiya	Durgapuri	25223	37776	48048
9	Durgapuri	Charbagh / Lko Rly Station	27563	37776	48048
10	Charbagh / Lko Rly Station	HussainGunj	31158	37776	48048
11	HussainGunj	Sachiwalaya	**34955**	37776	48048
12	Sachiwalaya	HazratGunj	33830	37776	48048
13	HazratGunj	KD Singh Babu Stadium	29982	37776	48048
14	KD Singh Babu Stadium	Vishwavidyalaya	28704	37776	48048
15	Vishwavidyalaya	IT College Junction	27856	37776	48048
16	IT College Junction	Mahanagar	26796	37776	48048
17	Mahanagar	Badshah Nagar	21246	18888	24024
19	Lekhraj Market	Ram Sagar Mishra Nagar	17171	18888	24024
21	Indra Nagar	Munshi Pulia	8288	18888	24024

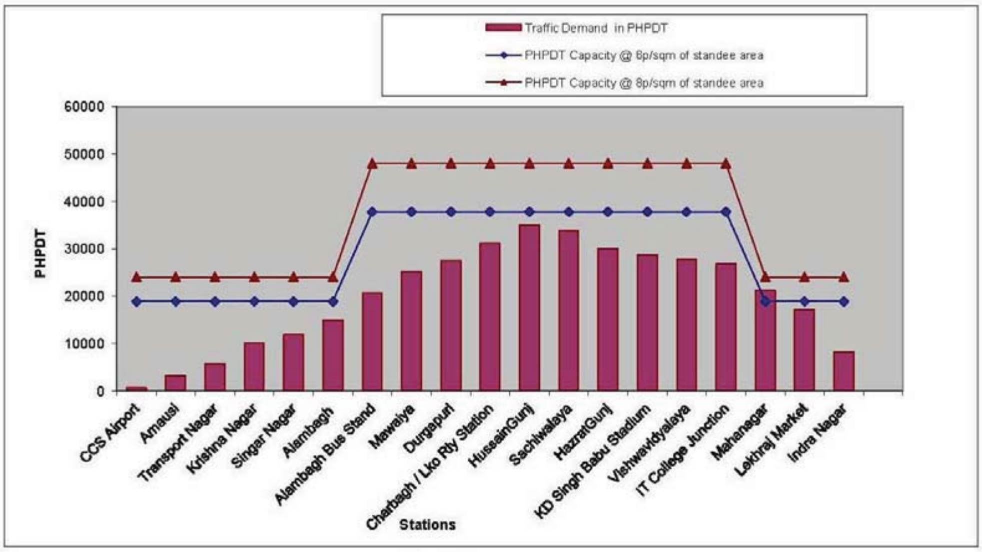


Fig 1.4

Attachment - I/E1

PHPDT Demand and Capacity Chart

N-S Corridor :CCS Airport - Munshi Pulia

Year:	2041	
No. of Cars per Train:	6	
Passenger Capacity @ 6 persons/sqm of a 6-Car Train:	1574	
Passenger Capacity @ 8 persons/sqm of a 6-Car Train:	2002	
Headway (min)	2	*[Alambagh Bus Stand to Mahanagar]*
Headway (min)	4	*[CCS Airport to Alambagh Bus stand & Mahanagar to Munshi Pulia]*

S.N	FROM	TO	Traffic Demand in PHPDT	PHPDT Capacity @ 6p/sqm of standee area	PHPDT Capacity @ 8p/sqm of standee area
1	CCS Airport	Amausi	1008	23610	30030
2	Amausi	Transport Nagar	4692	23610	30030
3	Transport Nagar	Krishna Nagar	8416	23610	30030
4	Krishna Nagar	Singar Nagar	12801	23610	30030
5	Singar Nagar	Alambagh	15139	23610	30030
6	Alambagh	Alambagh Bus Stand	19581	23610	30030
7	Alambagh Bus Stand	Mawaiya	26335	47220	60060
8	Mawaiya	Durgapuri	32337	47220	60060
9	Durgapuri	Charbagh / Lko Rly Station	34636	47220	60060
10	Charbagh / Lko Rly Station	HussainGunj	40691	47220	60060
11	HussainGunj	Sachiwalaya	**44408**	47220	60060
12	Sachiwalaya	HazratGunj	42493	47220	60060
13	HazratGunj	KD Singh Babu Stadium	38038	47220	60060
14	KD Singh Babu Stadium	Vishwavidyalaya	35841	47220	60060
15	Vishwavidyalaya	IT College Junction	32950	47220	60060
16	IT College Junction	Mahanagar	32616	47220	60060
17	Mahanagar	Badshah Nagar	26894	23610	30030
19	Lekhraj Market	Ram Sagar Mishra Nagar	21637	23610	30030
21	Indra Nagar	Munshi Pulia	10336	23610	30030

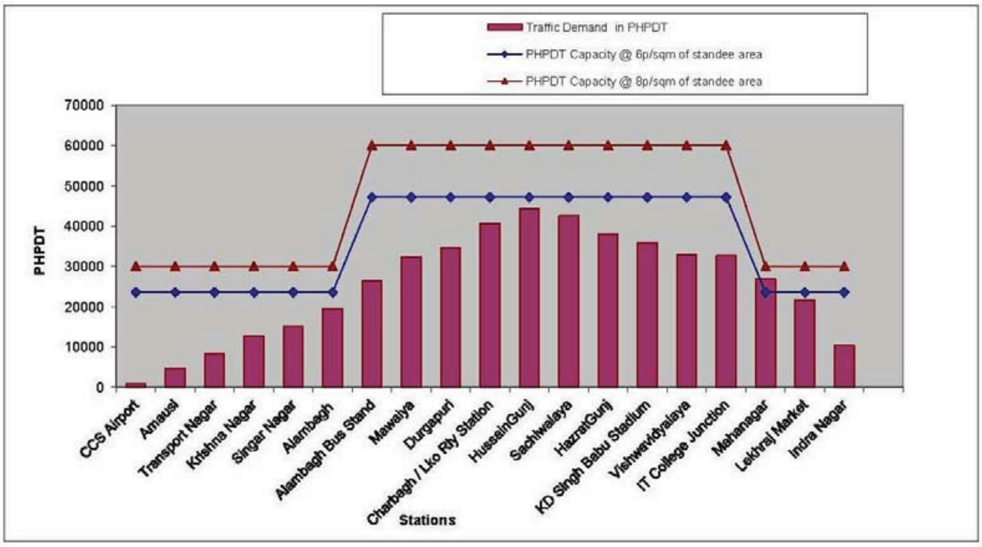


Fig 1.5

Attachment II

TABLE 1.1 A

Hourly Train Operation Plan for CCS Airport to Alambagh Bus Stand

Year: 2015

Configuration: 6 Car

Headway(min): 14

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	48	2	1
6 to 7	40	2	1
7 to 8	20	3	3
8 to 9	**14**	**4**	**5**
9 to 10	**14**	**4**	**4**
10 to 11	**14**	**4**	**5**
11 to12	20	3	3
12 to 13	40	1	2
13 to 14	48	1	1
14 to 15	48	1	1
15 to 16	40	2	1
16 to 17	20	3	3
17 to 18	**14**	**5**	**4**
18 to 19	**14**	**4**	**4**
19 to 20	**14**	**5**	**4**
20 to 21	20	3	3
21 to 22	40	1	2
22 to 23	48	1	2
23 to 24	60	1	1
Total No. of train trips per direction per day		**50**	**50**

Attachment II

TABLE 1.2 A
Hourly Train Operation Plan for CCS Airport to Alambagh Bus Stand

Year: 2020
Configuration: 6 Car
Headway(min): 9

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	32	2	1
6 to 7	24	3	2
7 to 8	12	5	5
8 to 9	**9**	**7**	**7**
9 to 10	**9**	**7**	**7**
10 to 11	**9**	**7**	**7**
11 to12	12	5	5
12 to 13	24	2	3
13 to 14	32	1	1
14 to 15	32	1	1
15 to 16	24	3	2
16 to 17	12	5	5
17 to 18	**9**	**7**	**7**
18 to 19	**9**	**7**	**7**
19 to 20	**9**	**7**	**7**
20 to 21	12	5	5
21 to 22	24	2	3
22 to 23	32	1	2
23 to 24	40	2	2
Total No. of train trips per direction per day		**79**	**79**

Attachment II

TABLE 1.3 A

Hourly Train Operation Plan for CCS Airport to Alambagh Bus Stand

Year: 2025

Configuration: 6 Car

Headway(min): 7

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	24	3	3
6 to 7	20	3	3
7 to 8	10	6	6
8 to 9	**7**	**8**	**9**
9 to 10	**7**	**9**	**8**
10 to 11	**7**	**8**	**9**
11 to12	10	6	6
12 to 13	20	3	3
13 to 14	24	3	2
14 to 15	24	2	3
15 to 16	20	3	3
16 to 17	10	6	6
17 to 18	**7**	**9**	**8**
18 to 19	**7**	**8**	**9**
19 to 20	**7**	**9**	**8**
20 to 21	10	6	6
21 to 22	20	3	3
22 to 23	24	3	3
23 to 24	30	2	2
Total No. of train trips per direction per day		**100**	**100**

Attachment II

TABLE 1.4 A

Hourly Train Operation Plan for CCS Airport to Alambagh Bus Stand

Year: 2030
Configuration: 6 Car
Headway(min): 5

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	16	4	4
6 to 7	12	5	5
7 to 8	8	8	7
8 to 9	**5**	**12**	**12**
9 to 10	**5**	**12**	**12**
10 to 11	**5**	**12**	**12**
11 to12	8	8	7
12 to 13	12	5	5
13 to 14	16	4	3
14 to 15	16	3	4
15 to 16	12	5	5
16 to 17	8	7	8
17 to 18	**5**	**12**	**12**
18 to 19	**5**	**12**	**12**
19 to 20	**5**	**12**	**12**
20 to 21	8	7	8
21 to 22	12	5	5
22 to 23	16	4	4
23 to 24	20	3	3
Total No. of train trips per direction per day		**140**	**140**

Attachment II

TABLE 1.5 A

Hourly Train Operation Plan for CCS Airport to Alambagh Bus Stand

Year: 2041

Configuration: 6 Car

Headway(min): 4

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	16	4	4
6 to 7	12	5	5
7 to 8	6	10	10
8 to 9	**4**	**15**	**15**
9 to 10	**4**	**15**	**15**
10 to 11	**4**	**15**	**15**
11 to12	6	10	10
12 to 13	12	5	5
13 to 14	16	4	3
14 to 15	16	3	4
15 to 16	12	5	5
16 to 17	6	10	10
17 to 18	**4**	**15**	**15**
18 to 19	**4**	**15**	**15**
19 to 20	**4**	**15**	**15**
20 to 21	6	10	10
21 to 22	12	5	5
22 to 23	16	4	4
23 to 24	20	3	3
Total No. of train trips per direction per day		**168**	**168**

Attachment II

TABLE 1.1B
Hourly Train Operation Plan for Alambagh Bus Stand to Mahanagar
Year: 2015
Configuration: 6 Car
Headway(min): 7

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	24	3	3
6 to 7	20	3	3
7 to 8	10	6	6
8 to 9	**7**	**8**	**9**
9 to 10	**7**	**9**	**8**
10 to 11	**7**	**8**	**9**
11 to12	10	6	6
12 to 13	20	3	3
13 to 14	24	3	2
14 to 15	24	2	3
15 to 16	20	3	3
16 to 17	10	6	6
17 to 18	**7**	**9**	**8**
18 to 19	**7**	**8**	**9**
19 to 20	**7**	**9**	**8**
20 to 21	10	6	6
21 to 22	20	3	3
22 to 23	24	3	3
23 to 24	30	2	2
Total No. of train trips per direction per day		**100**	**100**

Attachment II

TABLE 1.2B
Hourly Train Operation Plan for Alambagh Bus Stand to Mahanagar

Year: 2020
Configuration: 6 Car
Headway(min): 4.5

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	16	4	3
6 to 7	12	5	5
7 to 8	6	10	10
8 to 9	**4.5**	**13**	**14**
9 to 10	**4.5**	**14**	**13**
10 to 11	**4.5**	**13**	**14**
11 to12	6	10	10
12 to 13	12	5	5
13 to 14	16	3	4
14 to 15	16	4	3
15 to 16	12	5	5
16 to 17	6	10	10
17 to 18	**4.5**	**14**	**13**
18 to 19	**4.5**	**13**	**14**
19 to 20	**4.5**	**14**	**13**
20 to 21	6	10	10
21 to 22	12	5	5
22 to 23	16	3	4
23 to 24	20	3	3
Total No. of train trips per direction per day		**158**	**158**

Attachment II

TABLE 1.3B

Hourly Train Operation Plan for Alambagh Bus Stand to Mahanagar

Year: 2025

Configuration: 6 Car

Headway(min): 3.5

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	**3.5**	**17**	**18**
9 to 10	**3.5**	**17**	**17**
10 to 11	**3.5**	**17**	**18**
11 to12	5	12	12
12 to 13	10	6	6
13 to 14	12	5	5
14 to 15	12	5	5
15 to 16	10	6	6
16 to 17	5	12	12
17 to 18	**3.5**	**18**	**17**
18 to 19	**3.5**	**17**	**17**
19 to 20	**3.5**	**18**	**17**
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		**200**	**200**

Attachment II

TABLE 1.4B

Hourly Train Operation Plan for Alambagh Bus Stand to Mahanagar

Year: 2030

Configuration: 6 Car

Headway(min): 2.5

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	8	8	7
6 to 7	6	10	10
7 to 8	4	15	15
8 to 9	**2.5**	**24**	**24**
9 to 10	**2.5**	**24**	**24**
10 to 11	**2.5**	**24**	**24**
11 to12	4	15	15
12 to 13	6	10	10
13 to 14	8	8	7
14 to 15	8	7	8
15 to 16	6	10	10
16 to 17	4	15	15
17 to 18	**2.5**	**24**	**24**
18 to 19	**2.5**	**24**	**24**
19 to 20	**2.5**	**24**	**24**
20 to 21	4	15	15
21 to 22	6	10	10
22 to 23	8	7	8
23 to 24	10	6	6
Total No. of train trips per direction per day		**280**	**280**

Attachment II

TABLE 1.5B

Hourly Train Operation Plan for Alambagh Bus Stand to Mahanagar

Year: 2041

Configuration: 6 Car

Headway(min): 2

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	8	8	7
6 to 7	6	10	10
7 to 8	3	20	20
8 to 9	**2**	**30**	**30**
9 to 10	**2**	**30**	**30**
10 to 11	**2**	**30**	**30**
11 to12	3	20	20
12 to 13	6	10	10
13 to 14	8	8	7
14 to 15	8	7	8
15 to 16	6	10	10
16 to 17	3	20	20
17 to 18	**2**	**30**	**30**
18 to 19	**2**	**30**	**30**
19 to 20	**2**	**30**	**30**
20 to 21	3	20	20
21 to 22	6	10	10
22 to 23	8	7	8
23 to 24	10	6	6
Total No. of train trips per direction per day		**336**	**336**

Attachment II

TABLE 1.1 C
Hourly Train Operation Plan for Mahanagar to Munshi Pulia
Year: 2015
Configuration: 6 Car
Headway(min): 14

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	48	2	1
6 to 7	40	2	1
7 to 8	20	3	3
8 to 9	**14**	**4**	**5**
9 to 10	**14**	**4**	**4**
10 to 11	**14**	**4**	**5**
11 to12	20	3	3
12 to 13	40	1	2
13 to 14	48	1	1
14 to 15	48	1	1
15 to 16	40	2	1
16 to 17	20	3	3
17 to 18	**14**	**5**	**4**
18 to 19	**14**	**4**	**4**
19 to 20	**14**	**5**	**4**
20 to 21	20	3	3
21 to 22	40	1	2
22 to 23	48	1	2
23 to 24	60	1	1
Total No. of train trips per direction per day		**50**	**50**

Attachment II

TABLE 1.2 C
Hourly Train Operation Plan for Mahanagar to Munshi Pulia

Year: 2020
Configuration: 6 Car
Headway(min): 9

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	32	2	1
6 to 7	24	3	2
7 to 8	12	5	5
8 to 9	**9**	**7**	**7**
9 to 10	**9**	**7**	**7**
10 to 11	**9**	**7**	**7**
11 to12	12	5	5
12 to 13	24	2	3
13 to 14	32	1	1
14 to 15	32	1	1
15 to 16	24	3	2
16 to 17	12	5	5
17 to 18	**9**	**7**	**7**
18 to 19	**9**	**7**	**7**
19 to 20	**9**	**7**	**7**
20 to 21	12	5	5
21 to 22	24	2	3
22 to 23	32	1	2
23 to 24	40	2	2
Total No. of train trips per direction per day		**79**	**79**

Attachment II

TABLE 1.3 C

Hourly Train Operation Plan for Mahanagar to Munshi Pulia

Year: 2025

Configuration: 6 Car

Headway(min): 7

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	24	3	3
6 to 7	20	3	3
7 to 8	10	6	6
8 to 9	**7**	**8**	**9**
9 to 10	**7**	**9**	**8**
10 to 11	**7**	**8**	**9**
11 to12	10	6	6
12 to 13	20	3	3
13 to 14	24	3	2
14 to 15	24	2	3
15 to 16	20	3	3
16 to 17	10	6	6
17 to 18	**7**	**9**	**8**
18 to 19	**7**	**8**	**9**
19 to 20	**7**	**9**	**8**
20 to 21	10	6	6
21 to 22	20	3	3
22 to 23	24	3	3
23 to 24	30	2	2
Total No. of train trips per direction per day		**100**	**100**

Attachment II

TABLE 1.4 C

Hourly Train Operation Plan for Mahanagar to Munshi Pulia

Year: 2030
Configuration: 6 Car
Headway(min): 5

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	16	4	4
6 to 7	12	5	5
7 to 8	8	8	7
8 to 9	**5**	**12**	**12**
9 to 10	**5**	**12**	**12**
10 to 11	**5**	**12**	**12**
11 to12	8	8	7
12 to 13	12	5	5
13 to 14	16	4	3
14 to 15	16	3	4
15 to 16	12	5	5
16 to 17	8	7	8
17 to 18	**5**	**12**	**12**
18 to 19	**5**	**12**	**12**
19 to 20	**5**	**12**	**12**
20 to 21	8	7	8
21 to 22	12	5	5
22 to 23	16	4	4
23 to 24	20	3	3
Total No. of train trips per direction per day		**140**	**140**

Attachment II

TABLE 1.5 C

Hourly Train Operation Plan for Mahanagar to Munshi Pulia

Year: 2041

Configuration: 6 Car

Headway(min): 4

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	16	4	4
6 to 7	12	5	5
7 to 8	6	10	10
8 to 9	**4**	**15**	**15**
9 to 10	**4**	**15**	**15**
10 to 11	**4**	**15**	**15**
11 to12	6	10	10
12 to 13	12	5	5
13 to 14	16	4	3
14 to 15	16	3	4
15 to 16	12	5	5
16 to 17	6	10	10
17 to 18	**4**	**15**	**15**
18 to 19	**4**	**15**	**15**
19 to 20	**4**	**15**	**15**
20 to 21	6	10	10
21 to 22	12	5	5
22 to 23	16	4	4
23 to 24	20	3	3
Total No. of train trips per direction per day		**168**	**168**

Attachment III

TABLE 2.1
N-S Corridor :CCS Airport - Munshi Pulia
PHPDT for the Year 2015

S.No	From Station	To Station	Maximum PHPDT	Directional Split to Charbagh / Lko Rly Station	Directional Split to CCS Airport
1	CCS Airport	Amausi	259	50%	50%
2	Amausi	Transport Nagar	1296	50%	50%
3	Transport Nagar	Krishna Nagar	2522	50%	50%
4	Krishna Nagar	Singar Nagar	3650	50%	50%
5	Singar Nagar	Alambagh	4484	50%	50%
6	Alambagh	Alambagh Bus Stand	6172	50%	50%
7	Alambagh Bus Stand	Mawaiya	8925	50%	50%
8	Mawaiya	Durgapuri	12204	50%	50%
9	Durgapuri	Charbagh / Lko Rly Station	12500	50%	50%
10	Charbagh / Lko Rly Station	HussainGunj	12792	50%	50%
11	HussainGunj	Sachiwalaya	13190	50%	50%
12	Sachiwalaya	HazratGunj	13066	50%	50%
13	HazratGunj	KD Singh Babu Stadium	12330	50%	50%
14	KD Singh Babu Stadium	Vishwavidyalaya	11953	50%	50%
15	Vishwavidyalaya	IT College Junction	12073	50%	50%
16	IT College Junction	Mahanagar	11876	50%	50%
17	Mahanagar	Badshah Nagar	8451	50%	50%
18	Badshah Nagar	Lekhraj Market	7290	50%	50%
19	Lekhraj Market	Ram Sagar Mishra Nagar	6546	50%	50%
20	Ram Sagar Mishra Nagar	Indra Nagar	4325	50%	50%
21	Indra Nagar	Munshi Pulia	3775	50%	50%

Attachment IV

TABLE 3.1
Vehicle Kilometer
N-S Corridor :CCS Airport - Munshi Pulia

Year	2015			2020			2025			2030			2041		
Section	CCS Airport to Alambagh Bus Stand	Alambagh Bus Stand to Mahanagar	Mahanagar to Munshi Pulia	CCS Airport to Alambagh Bus Stand	Alambagh Bus Stand to Mahanagar	Mahanagar to Munshi Pulia	CCS Airport to Alambagh Bus Stand	Alambagh Bus Stand to Mahanagar	Mahanagar to Munshi Pulia	CCS Airport to Alambagh Bus Stand	Alambagh Bus Stand to Mahanagar	Mahanagar to Munshi Pulia	CCS Airport to Alambagh Bus Stand	Alambagh Bus Stand to Mahanagar	Mahanagar to Munshi Pulia
Section Length	6.21	11.30	4.83	6.21	11.30	4.83	6.21	11.30	4.83	6.21	11.30	4.83	6.21	11.30	4.83
No of cars per Train	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
No of working Days in a year	340	340	340	340	340	340	340	340	340	340	340	340	340	340	340
Number of Trains per day each Way	50	100	50	79	158	79	100	200	100	140	280	140	168	336	168
Daily Train -KM	621	2261	483	982	3572	763	1243	4522	966	1740	6330	1353	2088	7596	1623
Annual Train - KM (10^6)	2.11	7.69	1.64	3.34	12.14	2.60	4.23	15.37	3.29	5.92	21.52	4.60	7.10	25.83	5.52
Annual Vehicle - KM (10^5)	**12.68**	**46.12**	**9.86**	**20.03**	**72.87**	**15.57**	**25.35**	**92.24**	**19.71**	**35.49**	**129.13**	**27.59**	**42.59**	**154.96**	**33.11**

Attachment -V

Rake Requirement

N-S Corridor :CCS Airport - Munshi Pulia, Year : 2015

Section	Distance (kms)	Schedule Speed in kmph	Headway (min)	Rake Requirement					
				Bare	Traffic Reserve	R&M	Total No of Rakes	No. of Cars per rake	No. of Cars
CCS Airport to Munshi Pulia	22.35	34.00	14.00	7	1	1	9	6	54
Alambagh Bus stand to Mahanagar	10.59	33.00	14.00	4	0	0	4	6	24
				11	1	1	13	6	78

Above train Operation resulting in:

Section	Effective headway	No. of Rakes	No. of Car
Alambagh Bus stand to Mahanagar	7.00	*13 Rakes of 6 cars*	78
CCS Airport to Alambagh Bus stand & Mahanagar to Munshi Pulia	14.00		
Total turn around time(min)	6		

Note: For this Train operation Plan, Reversal Facilities are required at Alambagh Bus Stand and Mahanagar.

N-S Corridor :CCS Airport - Munshi Pulia, Year : 2020

Section	Distance (kms)	Schedule Speed in kmph	Headway (min)	Rake Requirement					
				Bare	Traffic Reserve	R&M	Total No of Rakes	No. of Cars per rake	No. of Cars
CCS Airport to Munshi Pulia	22.35	34.00	9.00	10	1	1	12	6	72
Alambagh Bus stand to Mahanagar	10.59	33.00	9.00	5	0	1	6	6	36
				15	1	2	18	6	108

Above train Operation resulting in:

Section	Effective headway	No. of Rakes	No. of Car
Alambagh Bus stand to Mahanagar	4.50	*18 Rakes of 6 cars*	108
CCS Airport to Alambagh Bus stand & Mahanagar to Munshi Pulia	9.00		
Total turn around time(min)	6		

Note: For this Train operation Plan, Reversal Facilities are required at Alambagh Bus Stand and Mahanagar.

N-S Corridor :CCS Airport - Munshi Pulia, Year : 2025

Section	Distance (kms)	Schedule Speed in kmph	Headway (min)	Rake Requirement					
				Bare	Traffic Reserve	R&M	Total No of Rakes	No. of Cars per rake	No. of Cars
CCS Airport to Munshi Pulia	22.35	34.00	7.00	13	1	1	15	6	90
Alambagh Bus stand to Mahanagar	10.59	33.00	7.00	7	0	1	8	6	48
				20	1	2	23	6	138

Above train Operation resulting in:

Section	Effective headway	No. of Rakes	No. of Car
Alambagh Bus stand to Mahanagar	3.50	*23 Rakes of 6 cars*	138
CCS Airport to Alambagh Bus stand & Mahanagar to Munshi Pulia	7.00		
Total turn around time(min)	6		

Note: For this Train operation Plan, Reversal Facilities are required at Alambagh Bus Stand and Mahanagar.

Attachment -V

Rake Requirement

N-S Corridor :CCS Airport - Munshi Pulia, Year : 2030

Section	Distance (kms)	Schedule Speed in kmph	Headway (min)	Rake Requirement					
				Bare	Traffic Reserve	R&M	Total No of Rakes	No. of Cars per rake	No. of Cars
CCS Airport to Munshi Pulia	22.35	34.00	5.00	17	1	2	20	6	120
Alambagh Bus stand to Mahanagar	10.59	33.00	5.00	9	0	1	10	6	60
				26	1	3	30	6	180

Above train Operation resulting in:

Section	Effective headway	No. of Rakes	No. of Car
Alambagh Bus stand to Mahanagar	2.50	*30 Rakes of 6 cars*	180
CCS Airport to Alambagh Bus stand & Mahanagar to Munshi Pulia	5.00		
Total turn around time(min)	6		

Note: For this Train operation Plan, Reversal Facilities are required at Alambagh Bus Stand and Mahanagar.

N-S Corridor :CCS Airport - Munshi Pulia, Year : 2041

Section	Distance (kms)	Schedule Speed in kmph	Headway (min)	Rake Requirement					
				Bare	Traffic Reserve	R&M	Total No of Rakes	No. of Cars per rake	No. of Cars
CCS Airport to Munshi Pulia	22.35	34.00	4.00	22	1	2	25	6	150
Alambagh Bus stand to Mahanagar	10.59	33.00	4.00	12	0	1	13	6	78
				34	1	3	38	6	228

Above train Operation resulting in:

Section	Effective headway	No. of Rakes	No. of Car
Alambagh Bus stand to Mahanagar	2.00	*38 Rakes of 6 cars*	228
CCS Airport to Alambagh Bus stand & Mahanagar to Munshi Pulia	4.00		
Total turn around time(min)			

Note: For this Train operation Plan, Reversal Facilities are required at Alambagh Bus Stand and Mahanagar.

Attachment - I/A2

PHPDT Demand and Capacity Chart

E- W Corridor: Lucknow Railway Satation - Vasant Kunj

Year:	2015	
No. of Cars per Train:	6	
Passenger Capacity @ 6 persons/sqm of a 6-Car Train:	1574	
Passenger Capacity @ 8 persons/sqm of a 6-Car Train:	2002	
Headway (min)	11	[Lucknow Rly. Stn. to Thakurganj]
Headway (min)	22	[Thakurganj to Vasant kunj]

S.N	FROM	TO	Traffic Demand in PHPDT	PHPDT Capacity @ 6p/sqm of standee area	PHPDT Capacity @ 8p/sqm of standee area
1	Lucknow Rly. Stn	Gautam Buddha Marg	8104	8585	10920
2	Gautam Buddha Marg	Aminabad	7923	8585	10920
3	Aminabad	Pandey Ganj	7203	8585	10920
4	Pandey Ganj	City Rly. Stn	5372	8585	10920
5	City Rly. Stn	Medical Chauraha	4741	8585	10920
6	Medical Chauraha	Nawajganj	3984	8585	10920
7	Nawajganj	Thakurganj	2537	8585	10920
8	Thakurganj	Balaganj	1831	4293	5460
9	Balaganj	Sarfarazganj	1291	4293	5460
10	Sarfarazganj	Musabagh	907	4293	5460
11	Musabagh	Vasant kunj	180	4293	5460

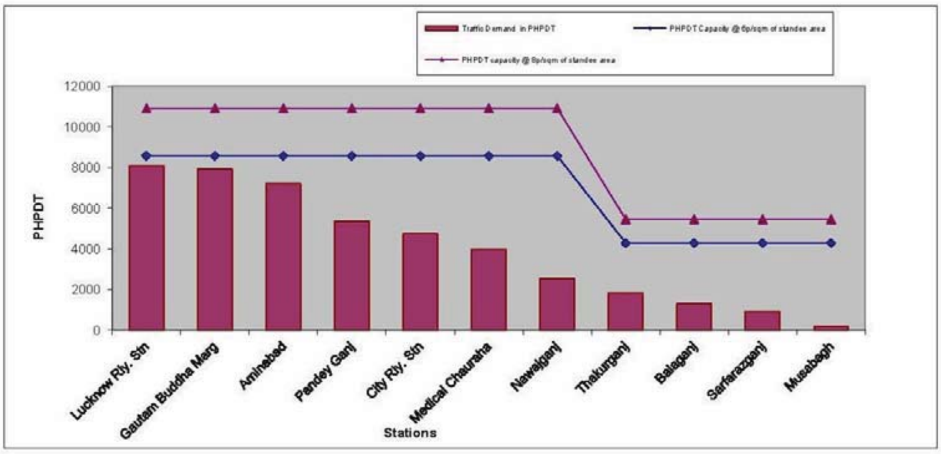


Fig 2.1

Attachment - I/B2

PHPDT Demand and Capacity Chart

E- W Corridor: Lucknow Railway Satation - Vasant Kunj

Year:	2020	
No. of Cars per Train:	6	
Passenger Capacity @ 6 persons/sqm of a 6-Car Train:	1574	
Passenger Capacity @ 8 persons/sqm of a 6-Car Train:	2002	
Headway (min)	6.5	*[Lucknow Rly. Stn. to Thakurganj]*
Headway (min)	13	*[Thakurganj to Vasant kunj]*

S.N	FROM	TO	Traffic Demand in PHPDT	PHPDT Capacity @ 6p/sqm of standee area	PHPDT Capacity @ 8p/sqm of standee area
1	Lucknow Rly. Stn	Gautam Buddha Marg	14157	14529	18480
2	Gautam Buddha Marg	Aminabad	13814	14529	18480
3	Aminabad	Pandey Ganj	12823	14529	18480
4	Pandey Ganj	City Rly. Stn	10457	14529	18480
5	City Rly. Stn	Medical Chauraha	9516	14529	18480
6	Medical Chauraha	Nawajganj	8134	14529	18480
7	Nawajganj	Thakurganj	5116	14529	18480
8	Thakurganj	Balaganj	3638	7265	9240
9	Balaganj	Sarfarazganj	1881	7265	9240
10	Sarfarazganj	Musabagh	1221	7265	9240
11	Musabagh	Vasant kunj	428	7265	9240

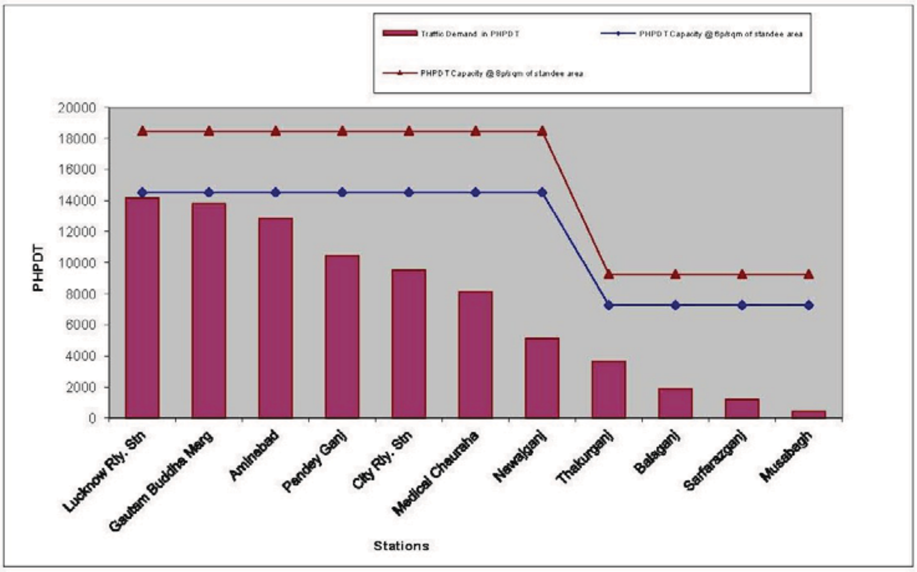


Fig 2.2

Attachment - I/C2

PHPDT Demand and Capacity Chart

E- W Corridor: Lucknow Railway Satation - Vasant Kunj

Year:	2025	
No. of Cars per Train:	6	
Passenger Capacity @ 6 persons/sqm of a 6-Car Train:	1574	
Passenger Capacity @ 8 persons/sqm of a 6-Car Train:	2002	
Headway (min)	4.5	[Lucknow Rly. Stn. to Thakurganj]
Headway (min)	9	[Thakurganj to Vasant kunj]

S.N	FROM	TO	Traffic Demand in PHPDT	PHPDT Capacity @ 6p/sqm of standee area	PHPDT Capacity @ 8p/sqm of standee area
1	Lucknow Rly. Stn	Gautam Buddha Marg	21434	20987	26693
2	Gautam Buddha Marg	Aminabad	20979	20987	26693
3	Aminabad	Pandey Ganj	20192	20987	26693
4	Pandey Ganj	City Rly. Stn	17112	20987	26693
5	City Rly. Stn	Medical Chauraha	15719	20987	26693
6	Medical Chauraha	Nawajganj	13640	20987	26693
7	Nawajganj	Thakurganj	8247	20987	26693
8	Thakurganj	Balaganj	5765	10493	13347
9	Balaganj	Sarfarazganj	2319	10493	13347
10	Sarfarazganj	Musabagh	1526	10493	13347
11	Musabagh	Vasant kunj	598	10493	13347

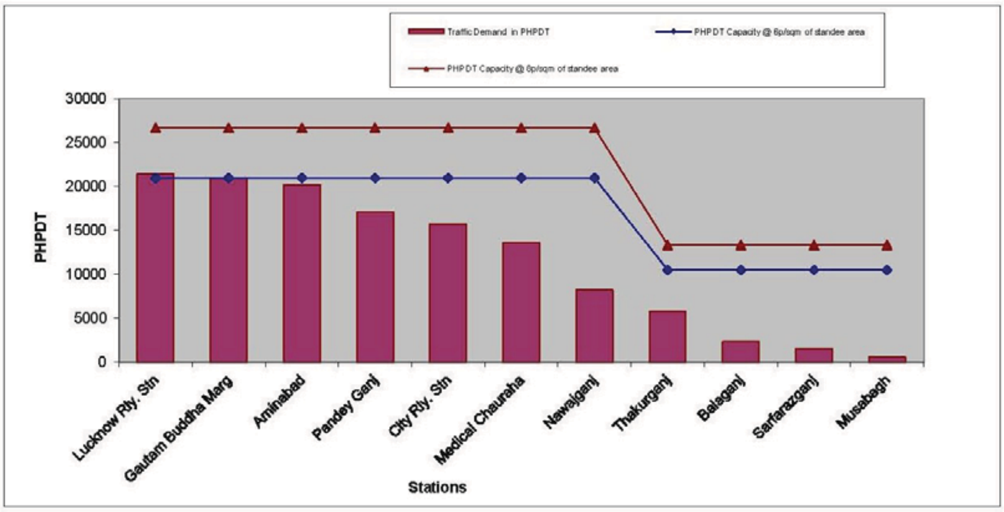


Fig 2.3

Attachment - I/D2

PHPDT Demand and Capacity Chart

E- W Corridor: Lucknow Railway Satation - Vasant Kunj

Year:	2030	
No. of Cars per Train:	6	
Passenger Capacity @ 6 persons/sqm of a 6-Car Train:	1574	
Passenger Capacity @ 8 persons/sqm of a 6-Car Train:	2002	
Headway (min)	3	*[Lucknow Rly. Stn. to Thakurganj]*
Headway (min)	6	*[Thakurganj to Vasant kunj]*

S.N	FROM	TO	Traffic Demand in PHPDT	PHPDT Capacity @ 6p/sqm of standee area	PHPDT Capacity @ 8p/sqm of standee area
1	Lucknow Rly. Stn	Gautam Buddha Marg	29171	31480	40040
2	Gautam Buddha Marg	Aminabad	28893	31480	40040
3	Aminabad	Pandey Ganj	28292	31480	40040
4	Pandey Ganj	City Rly. Stn	23936	31480	40040
5	City Rly. Stn	Medical Chauraha	22335	31480	40040
6	Medical Chauraha	Nawajganj	19274	31480	40040
7	Nawajganj	Thakurganj	11457	31480	40040
8	Thakurganj	Balaganj	7522	15740	20020
9	Balaganj	Sarfarazganj	2731	15740	20020
10	Sarfarazganj	Musabagh	1819	15740	20020
11	Musabagh	Vasant kunj	714	15740	20020

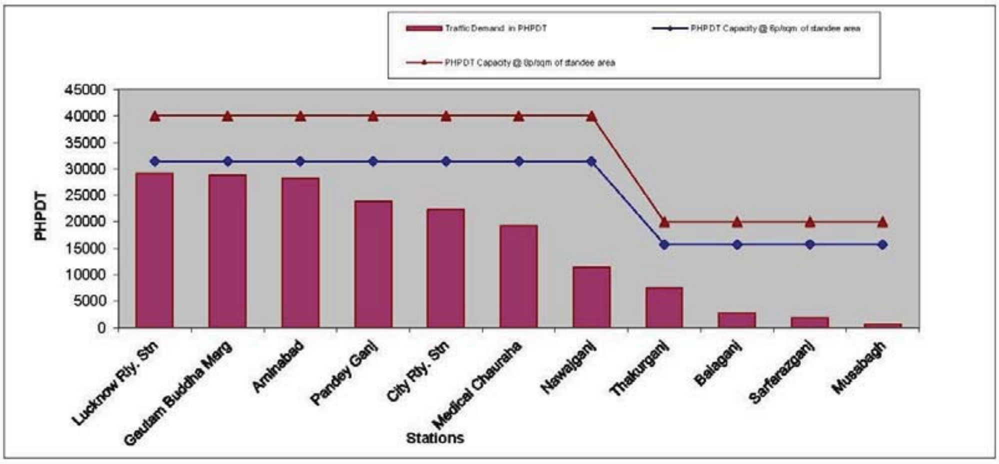


Fig 2.4

Attachment - I/E2

PHPDT Demand and Capacity Chart

E- W Corridor: Lucknow Railway Satation - Vasant Kunj

Year:	2041	
No. of Cars per Train:	6	
Passenger Capacity @ 6 persons/sqm of a 6-Car Train:	1574	
Passenger Capacity @ 8 persons/sqm of a 6-Car Train:	2002	
Headway (min)	2.5	*[Lucknow Rly. Stn. to Thakurganj]*
Headway (min)	5	*[Thakurganj to Vasant kunj]*

S.N	FROM	TO	Traffic Demand in PHPDT	PHPDT Capacity @ 6p/sqm of standee area	PHPDT Capacity @ 8p/sqm of standee area
1	Lucknow Rly. Stn	Gautam Buddha Marg	36196	37776	48048
2	Gautam Buddha Marg	Aminabad	35526	37776	48048
3	Aminabad	Pandey Ganj	34956	37776	48048
4	Pandey Ganj	City Rly. Stn	29988	37776	48048
5	City Rly. Stn	Medical Chauraha	27667	37776	48048
6	Medical Chauraha	Nawajganj	23698	37776	48048
7	Nawajganj	Thakurganj	14674	37776	48048
8	Thakurganj	Balaganj	9110	18888	24024
9	Balaganj	Sarfarazganj	3600	18888	24024
10	Sarfarazganj	Musabagh	2162	18888	24024
11	Musabagh	Vasant kunj	927	18888	24024

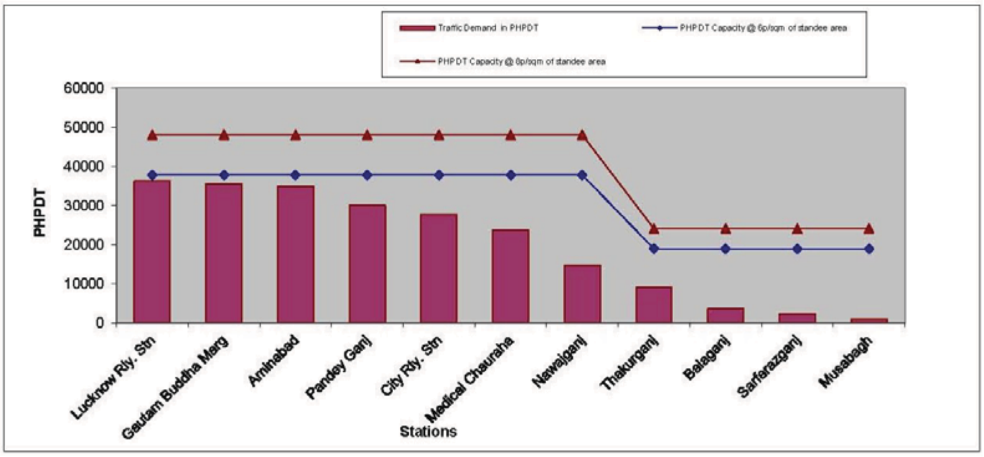


Fig 2.5

Attachment II

TABLE 2.1 A
Hourly Train Operation Plan for Lucknow Rly. Stn to Thakurganj
Year: 2015
Configuration: 6 Car
Headway(min): 11

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	32	2	1
6 to 7	24	3	2
7 to 8	16	4	3
8 to 9	**11**	**5**	**6**
9 to 10	**11**	**5**	**5**
10 to 11	**11**	**5**	**6**
11 to12	16	4	3
12 to 13	24	2	3
13 to 14	32	2	1
14 to 15	32	1	2
15 to 16	24	3	2
16 to 17	16	3	4
17 to 18	**11**	**6**	**5**
18 to 19	**11**	**5**	**5**
19 to 20	**11**	**6**	**5**
20 to 21	16	3	4
21 to 22	24	2	3
22 to 23	32	1	2
23 to 24	40	2	2
Total No. of train trips per direction per day		**64**	**64**

Attachment II

TABLE 2.2 A

Hourly Train Operation Plan for Lucknow Rly. Stn to Thakurganj

Year: 2020

Configuration: 6 Car

Headway(min): 6.5

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	24	3	2
6 to 7	20	3	3
7 to 8	10	6	6
8 to 9	**6.5**	**9**	**10**
9 to 10	**6.5**	**10**	**10**
10 to 11	**6.5**	**9**	**10**
11 to12	10	6	6
12 to 13	20	3	3
13 to 14	24	3	2
14 to 15	24	2	3
15 to 16	20	3	3
16 to 17	10	6	6
17 to 18	**6.5**	**10**	**9**
18 to 19	**6.5**	**10**	**10**
19 to 20	**6.5**	**10**	**9**
20 to 21	10	6	6
21 to 22	20	3	3
22 to 23	24	2	3
23 to 24	30	2	2
Total No. of train trips per direction per day		**106**	**106**

Attachment II

TABLE 2.3 A

Hourly Train Operation Plan for Lucknow Rly. Stn to Thakurganj

Year: 2025

Configuration: 6 Car

Headway(min): 4.5

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	16	4	3
6 to 7	12	5	5
7 to 8	6	10	10
8 to 9	**4.5**	**13**	**14**
9 to 10	**4.5**	**14**	**13**
10 to 11	**4.5**	**13**	**14**
11 to12	6	10	10
12 to 13	12	5	5
13 to 14	16	4	3
14 to 15	16	3	4
15 to 16	12	5	5
16 to 17	6	10	10
17 to 18	**4.5**	**14**	**13**
18 to 19	**4.5**	**13**	**14**
19 to 20	**4.5**	**14**	**13**
20 to 21	6	10	10
21 to 22	12	5	5
22 to 23	16	3	4
23 to 24	20	3	3
Total No. of train trips per direction per day		**158**	**158**

Attachment II

TABLE 2.4 A

Hourly Train Operation Plan for Lucknow Rly. Stn to Thakurganj

Year: 2030

Configuration: 6 Car

Headway(min): 3

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	12	5	5
6 to 7	10	6	6
7 to 8	5	12	12
8 to 9	**3**	**20**	**20**
9 to 10	**3**	**20**	**20**
10 to 11	**3**	**20**	**20**
11 to12	5	12	12
12 to 13	10	6	6
13 to 14	12	5	5
14 to 15	12	5	5
15 to 16	10	6	6
16 to 17	5	12	12
17 to 18	**3**	**20**	**20**
18 to 19	**3**	**20**	**20**
19 to 20	**3**	**20**	**20**
20 to 21	5	12	12
21 to 22	10	6	6
22 to 23	12	5	5
23 to 24	15	4	4
Total No. of train trips per direction per day		**216**	**216**

Attachment II

TABLE 2.5 A

Hourly Train Operation Plan for Lucknow Rly. Stn to Thakurganj

Year: 2041

Configuration: 6 Car

Headway(min): 2.5

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	8	8	7
6 to 7	6	10	10
7 to 8	4	15	15
8 to 9	**2.5**	**24**	**24**
9 to 10	**2.5**	**24**	**24**
10 to 11	**2.5**	**24**	**24**
11 to12	4	15	15
12 to 13	6	10	10
13 to 14	8	8	7
14 to 15	8	7	8
15 to 16	6	10	10
16 to 17	4	15	15
17 to 18	**2.5**	**24**	**24**
18 to 19	**2.5**	**24**	**24**
19 to 20	**2.5**	**24**	**24**
20 to 21	4	15	15
21 to 22	6	10	10
22 to 23	8	7	8
23 to 24	10	6	6
Total No. of train trips per direction per day		**280**	**280**

Attachment II

TABLE 2.1 B
Hourly Train Operation Plan for Thakurganj to Vasant kunj
Year: 2015
Configuration: 6 Car
Headway(min): 22

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	64	1	1
6 to 7	48	1	1
7 to 8	32	2	2
8 to 9	**22**	**3**	**2**
9 to 10	**22**	**2**	**3**
10 to 11	**22**	**3**	**2**
11 to12	32	2	2
12 to 13	48	1	1
13 to 14	64	1	1
14 to 15	64	1	1
15 to 16	48	1	1
16 to 17	32	2	2
17 to 18	**22**	**2**	**3**
18 to 19	**22**	**3**	**2**
19 to 20	**22**	**2**	**3**
20 to 21	32	2	2
21 to 22	48	1	1
22 to 23	64	1	1
23 to 24	80	1	1
Total No. of train trips per direction per day		**32**	**32**

Attachment II

TABLE 2.2 B

Hourly Train Operation Plan for Thakurganj to Vasant kunj

Year: 2020

Configuration: 6 Car

Headway(min): 13

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	48	1	1
6 to 7	40	2	1
7 to 8	20	3	3
8 to 9	**13**	**5**	**5**
9 to 10	**13**	**5**	**5**
10 to 11	**13**	**5**	**5**
11 to12	20	3	3
12 to 13	40	1	2
13 to 14	48	1	1
14 to 15	48	1	1
15 to 16	40	2	1
16 to 17	20	3	3
17 to 18	**13**	**5**	**5**
18 to 19	**13**	**5**	**5**
19 to 20	**13**	**5**	**5**
20 to 21	20	3	3
21 to 22	40	1	2
22 to 23	48	1	1
23 to 24	60	1	1
Total No. of train trips per direction per day		**53**	**53**

Attachment II

TABLE 2.3 B

Hourly Train Operation Plan for Thakurganj to Vasant kunj

Year: 2025

Configuration: 6 Car

Headway(min): 9

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	32	2	2
6 to 7	24	3	2
7 to 8	12	5	5
8 to 9	**9**	**6**	**7**
9 to 10	**9**	**7**	**6**
10 to 11	**9**	**6**	**7**
11 to12	12	5	5
12 to 13	24	2	3
13 to 14	32	2	2
14 to 15	32	2	2
15 to 16	24	3	2
16 to 17	12	5	5
17 to 18	**9**	**7**	**6**
18 to 19	**9**	**6**	**7**
19 to 20	**9**	**7**	**6**
20 to 21	12	5	5
21 to 22	24	2	3
22 to 23	32	2	2
23 to 24	40	2	2
Total No. of train trips per direction per day		**79**	**79**

Attachment II

TABLE 2.4 B

Hourly Train Operation Plan for Thakurganj to Vasant kunj

Year: 2030

Configuration: 6 Car

Headway(min): 6

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	24	2	3
6 to 7	20	3	3
7 to 8	10	6	6
8 to 9	**6**	**10**	**10**
9 to 10	**6**	**10**	**10**
10 to 11	**6**	**10**	**10**
11 to12	10	6	6
12 to 13	20	3	3
13 to 14	24	3	2
14 to 15	24	2	3
15 to 16	20	3	3
16 to 17	10	6	6
17 to 18	**6**	**10**	**10**
18 to 19	**6**	**10**	**10**
19 to 20	**6**	**10**	**10**
20 to 21	10	6	6
21 to 22	20	3	3
22 to 23	24	3	2
23 to 24	30	2	2
Total No. of train trips per direction per day		**108**	**108**

Attachment II

TABLE 2.5 B

Hourly Train Operation Plan for Thakurganj to Vasant kunj

Year: 2041

Configuration: 6 Car

Headway(min): 5

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	16	4	4
6 to 7	12	5	5
7 to 8	8	8	7
8 to 9	**5**	**12**	**12**
9 to 10	**5**	**12**	**12**
10 to 11	**5**	**12**	**12**
11 to12	8	8	7
12 to 13	12	5	5
13 to 14	16	4	3
14 to 15	16	3	4
15 to 16	12	5	5
16 to 17	8	7	8
17 to 18	**5**	**12**	**12**
18 to 19	**5**	**12**	**12**
19 to 20	**5**	**12**	**12**
20 to 21	8	7	8
21 to 22	12	5	5
22 to 23	16	4	4
23 to 24	20	3	3
Total No. of train trips per direction per day		**140**	**140**

Attachment III

TABLE 2.2
E- W Corridor: Lucknow Railway Satation - Vasant Kunj
PHPDT for the Year 2015

S.No	From Station	To Station	Maximum PHPDT	Directional Split to Vasant kunj	Directional Split to Lucknow Rly. Stn
1	Lucknow Rly. Stn	Gautam Buddha Marg	8104	50%	50%
2	Gautam Buddha Marg	Aminabad	7923	50%	50%
3	Aminabad	Pandey Ganj	7203	50%	50%
4	Pandey Ganj	City Rly. Stn	5372	50%	50%
5	City Rly. Stn	Medical Chauraha	4741	50%	50%
6	Medical Chauraha	Nawajganj	3984	50%	50%
7	Nawajganj	Thakurganj	2537	50%	50%
8	Thakurganj	Balaganj	1831	50%	50%
9	Balaganj	Sarfarazganj	1291	50%	50%
10	Sarfarazganj	Musabagh	907	50%	50%
11	Musabagh	Vasant kunj	180	50%	50%

Attachment IV

TABLE 3.2
Vehicle Kilometer
E- W Corridor: Lucknow Railway Satation - Vasant Kunj

Year	2015		2020		2025		2030		2041	
Section	*Lucknow Rly. Stn to Thakurganj*	*Thakurganj to Vasant kunj*	*Lucknow Rly. Stn to Thakurganj*	*Thakurganj to Vasant kunj*	*Lucknow Rly. Stn to Thakurganj*	*Thakurganj to Vasant kunj*	*Lucknow Rly. Stn to Thakurganj*	*Thakurganj to Vasant kunj*	*Lucknow Rly. Stn to Thakurganj*	*Thakurganj to Vasant kunj*
Section Length	10.58	7.18	10.58	7.18	10.58	7.18	10.58	7.18	10.58	7.18
No of cars per Train	6	6	6	6	6	6	6	6	6	6
No of working Days in a year	340	340	340	340	340	340	340	340	340	340
Number of Trains per day each Way	64	32	106	53	158	79	216	108	280	140
Daily Train -KM	1354	459	2242	761	3342	1134	4569	1550	5923	2009
Annual Train - KM (10^5)	4.60	1.56	7.62	2.59	11.36	3.85	15.54	5.27	20.14	6.83
Annual Vehicle - KM (10^5)	**27.62**	**9.37**	**45.74**	**15.52**	**68.18**	**23.13**	**93.21**	**31.62**	**120.83**	**40.99**

Attachment V

Rake Requirement

E- W Corridor: Lucknow Railway Satation - Vasant Kunj, Year : 2015

Section	Distance (kms)	Schedule Speed in kmph	Headway (min)	Rake Requirement					
				Bare	Traffic Reserve	R&M	Total No of Rakes	No. of Cars per rake	No. of Cars
Lucknow Rly. Stn to Vasant kunj	10.58	32.00	22.00	3	1	1	5	6	30
Lucknow Rly. Stn to Thakurganj	7.18	33.00	22.00	2	0	0	2	6	12
				5	1	1	7	6	42

Above train Operation resulting in:

Section	Effective headway (min)	No. of Rakes	No. of Car
Lucknow Rly. Stn to Thakurganj	11.00	*7 Rakes of 6 cars*	42
Thakurganj Vasant Kunj	22.00		
Total turn around time(min)	6		

Note: For this Train operation Plan, Reversal Facilitiy is required at Thakurganj.

E- W Corridor: Lucknow Railway Satation - Vasant Kunj, Year : 2020

Section	Distance (kms)	Schedule Speed in kmph	Headway (min)	Rake Requirement					
				Bare	Traffic Reserve	R&M	Total No of Rakes	No. of Cars per rake	No. of Cars
Lucknow Rly. Stn to Vasant kunj	10.58	32.00	13.00	4	1	1	6	6	36
Lucknow Rly. Stn to Thakurganj	7.18	33.00	13.00	3	0	0	3	6	18
				7	1	1	9	6	54

Above train Operation resulting in:

Section	Effective headway (min)	No. of Rakes	No. of Car
Lucknow Rly. Stn to Thakurganj	6.50	*9 Rakes of 6 cars*	54
Thakurganj Vasant Kunj	13.00		
Total turn around time(min)	6		

Note: For this Train operation Plan, Reversal Facilitiy is required at Thakurganj.

E- W Corridor: Lucknow Railway Satation - Vasant Kunj, Year : 2025

Section	Distance (kms)	Schedule Speed in kmph	Headway (min)	Rake Requirement					
				Bare	Traffic Reserve	R&M	Total No of Rakes	No. of Cars per rake	No. of Cars
Lucknow Rly. Stn to Vasant kunj	10.58	32.00	9.00	6	1	1	8	6	48
Lucknow Rly. Stn to Thakurganj	7.18	33.00	9.00	4	0	0	4	6	24
				10	1	1	12	6	72

Above train Operation resulting in:

Section	Effective headway (min)	No. of Rakes	No. of Car
Lucknow Rly. Stn to Thakurganj	4.50	*12 Rakes of 6 cars*	72
Thakurganj Vasant Kunj	9.00		
Total turn around time(min)	6		

Note: For this Train operation Plan, Reversal Facilitiy is required at Thakurganj.

E- W Corridor: Lucknow Railway Satation - Vasant Kunj, Year : 2030

Section	Distance (kms)	Schedule Speed in kmph	Headway (min)	Rake Requirement					
				Bare	Traffic Reserve	R&M	Total No of Rakes	No. of Cars per rake	No. of Cars
Lucknow Rly. Stn to Vasant kunj	10.58	32.00	6.00	8	1	1	10	6	60
Lucknow Rly. Stn to Thakurganj	7.18	33.00	6.00	6	0	1	7	6	42
				14	1	2	17	6	102

Above train Operation resulting in:

Section	Effective headway (min)	No. of Rakes	No. of Car
Lucknow Rly. Stn to Thakurganj	3.00	*17 Rakes of 6 cars*	102
Thakurganj Vasant Kunj	6.00		
Total turn around time(min)	6		

Note: For this Train operation Plan, Reversal Facilitiy is required at Thakurganj.

Attachment V

Rake Requirement

E- W Corridor: Lucknow Railway Satation - Vasant Kunj, Year : 2041

Section	Distance (kms)	Schedule Speed in kmph	Headway (min)	Rake Requirement					
				Bare	Traffic Reserve	R&M	Total No of Rakes	No. of Cars per rake	No. of Cars
Lucknow Rly. Stn to Vasant kunj	10.58	32.00	5.00	10	1	1	12	6	72
Lucknow Rly. Stn to Thakurganj	7.18	33.00	5.00	7	0	1	8	6	48
				17	1	2	20	6	120

Above train Operation resulting in:

Section	Effective headway (min)	No. of Rakes	No. of Car
Lucknow Rly. Stn to Thakurganj	2.50	*20 Rakes of 6 cars*	120
Thakurganj Vasant Kunj	5.00		
Total turn around time(min)	**6**		

Note: For this Train operation Plan, Reversal Facilitiy is required at Thakurganj.

SUMMARY SHEET AS ON: 18.07.13 LUCKNOW METRO

1. Corridors:

i) North-South Corridor: CCS Airport to Munshipulia

Train Operation Plan for CCS Airport to Munshipulia has been planned in such a way that there are two loops of train operation. In one loop, trains run from CCS Airport to Munshipulia at a given headway and in other loop trains run from Alambagh Bus Stand to Mahanagar at the same headway, thus resulting in half the headway in Alambagh Bus Stand to Mahanagar as compared to CCS Airport to Alambagh Bus Stand & Mahanagar to Munshipulia.

For this Train operation Plan, Reversal Facilities are required at Alambagh Bus Stand and Mahanagar.

ii) East-West Corridor: Lucknow Railway Station-Vasant Kunj

Train Operation Plan for Lucknow Railway Station to Vasant Kunj has been planned in such a way that there are two loops of train operation. In one loop, trains run from Lucknow Railway Station to Vasant Kunj at a given headway and in other loop trains run from Lucknow Railway Station to Thakurganj at the same headway, thus resulting in half the headway in Lucknow Railway Station to Thakurganj as compared to Thakurganj to Vasant Kunj.

For this Train operation Plan, Reversal Facility is required at Thakurganj.

2. Route Length (Centre to Centre):

i) North-South Corridor:

a) CCS Airport to Munshipulia : 22.349 KM

b) Alambagh Bus Stand to Mahanagar: 11.304 KM

ii) East- West Corridor:

a) Lucknow Railway Station to Vasant Kunj: 10.577 KM

b) Lucknow Railway Station to Thakurganj: 7.176 KM

3. Number of Stations:

i) North-South Corridor:

a) CCS Airport to Munshipulia : 22

b) Alambagh Bus Stand to Mahanagar: 12

ii) East- West Corridor:

a) Lucknow Railway Station to Vasant Kunj: 12

b) Lucknow Railway Station to Thakurganj: 8

4. Average Inter-station Distance:

i) North-South Corridor:

a) CCS Airport to Munshipulia : 1.064 KM

b) Alambagh Bus Stand to Mahanagar: 1.028 KM

ii) East- West Corridor:

a) Lucknow Railway Station to Vasant Kunj: 0.962 KM

b) Lucknow Railway Station to Thakurganj: 1.025 KM

5. Gauge: 1435 mm

6. Traction Power Supply

i) Voltage: 25 KV AC

ii) Current Collection: Overhead Current Collection system

7. Rolling Stock:

i) Coach Size:

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

**** Maximum length of Coach over coupler/buffers = 22.6 m***

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

PARTICULAR	*SEATED*	*STANDING*	*TOTAL*
DMC	43	204	247
TC/MC	50	220	270
6-CAR	286	1288	1574

Seating: Longitudinal

iii) Weight:

PARTICULAR	*TARE*	*PASSENGER*	*GROSS*
DMC	40	16.055	56.055
TC	40	17.55	57.55
MC	40	17.55	57.55
6-CAR	240	102.31	342.31

iv) Axle Load: To be designed for 16T

v) Max Acceleration: 1.0 m/s^2 to 1.1 $m/s^2 \pm 5\%$

vi) Max Deceleration: 1.1 m/s^2 (Normal Brake)

>1.3m/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):

A) North-South Corridor:

a) CCS Airport to Munshipulia : 34 kmph

b) Alambagh Bus Stand to Mahanagar: 33 kmph

B) East- West Corridor:

a) Lucknow Railway Station to Vasant Kunj: 32 kmph

b) Lucknow Railway Station to Thakurganj: 33 kmph

x) Composition: 6-car = DMC+TC+MC+MC+TC+DMC

xi) Cost per car: Rs.10 Crores exclusive of taxes and duties at May 2010 Price Level.

xii) Capacity Provided & Rake Requirement:

A) Capacity Provided for North – South Corridor

North – South Corridor	Year	Headway (min)	No. of Rakes	Rake Consist	No. of Coaches	Max. PHPDT Demand	PHPDT Capacity Available
CCS Airport to Alambagh Bus Stand	2015	14	13	6 car	78	6172	6746 (8580*)
Alambagh Bus Stand to Mahanagar		7				13190	13491 (17160)*
Mahanagar to Munshipulia		14				8451	6746 (8580*)
CCS Airport to Alambagh Bus Stand	2020	9	18	6 car	108	9658	10493 (13347*)
Alambagh Bus Stand to Mahanagar		4.5				20976	20987 (26693)*
Mahanagar to Munshipulia		9				13498	10493 (13347*)
CCS Airport to Alambagh Bus Stand	2025	7	23	6 car	138	13159	13491 (17160*)
Alambagh Bus Stand to Mahanagar		3.5				25890	26983 (34320)*
Mahanagar to Munshipulia		7				15644	13491 (17160*)
CCS Airport to Alambagh Bus Stand	2030	5	30	6 car	180	14995	18888 (24024*)
Alambagh Bus Stand to Mahanagar		2.5				34955	37776 (48048)*
Mahanagar to Munshipulia		5				21246	18888 (24024*)
CCS Airport to Alambagh Bus Stand	2041	4	38	6 car	228	19581	23610 (30030*)
Alambagh Bus Stand to Mahanagar		2				44408	47220 (60060*)
Mahanagar to Munshipulia		4				26894	23610 (30030*)

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

B) Capacity Provided for East-West corridor

East-West Corridor	Year	Headway (min)	No. of Rakes	Rake Consist	No. of Coaches	Max. PHPDT Demand	PHPDT Capacity Available
Lucknow Railway Station to Thakurganj	2015	11	7	6 car	42	8104	8585 (10920*)
Thakurganj to Vasant kunj		22				1831	4293 (5460)*
Lucknow Railway Station to Thakurganj	2020	6.5	9	6 car	54	14157	14529 (18480*)
Thakurganj to Vasant kunj		13				3638	7265 (9240)*
Lucknow Railway Station to Thakurganj	2025	4.5	12	6 car	72	21434	20987 (26693*)
Thakurganj to Vasant kunj		9				5765	10493 (13347)*
Lucknow Railway Station to Thakurganj	2030	3	17	6 car	102	29171	31480 (40040*)
Thakurganj to Vasant kunj		6				7522	15740 (20020)*
Lucknow Railway Station to Thakurganj	2041	2.5	20	6 car	120	36196	37776 (48048*)
Thakurganj to Vasant kunj		5				9110	18888 (24024*)

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

Chapter 6

Rolling Stock

CHAPTER - 6

ROLLING STOCK

6.1 INTRODUCTION

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

6.2 OPTIMIZATION OF COACH SIZE

The following optimum size of the coach has been chosen for this corridor as mentioned in Table 1.

Table 6.1 - Size of the coach

Description	Length*	Width	Height
Driving Motor Car (DMC)	**21.64 m**	**2.9 m**	**3.9 m**
Trailer car (TC)/Motor Car (MC)	**21.34 m**	**2.9 m**	**3.9 m**

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

6.2.1 PASSENGER CARRYING CAPACITY

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

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

Following train composition is recommended:
6-car Train: DMC + TC +MC + MC + MTC + DMC

Table 2 shows the carrying capacity of Medium Rail Vehicles.

Table 6.2 - Carrying Capacity of Medium Rail Vehicles

	Driving Motor car		Trailer car / Motor car		6 Car Train	
	Normal	**Crush**	**Normal**	**Crush**	**Normal**	**Crush**
Seated	43	43	50	50	286	286
Standing	102	204	110	220	644	1288
Total	145	247	160	270	930	1574

NORMAL-3 Person/sqm of standee area

CRUSH -6 Person/sqm of standee area

6.3 WEIGHT

The weights of motorcar and trailer cars have been estimated as in Table 3, referring to the experiences in Delhi Metro. The average passenger weight has been taken as 65 kg.

Table 6.3 - Weight of Light Rail Vehicles (TONNES)

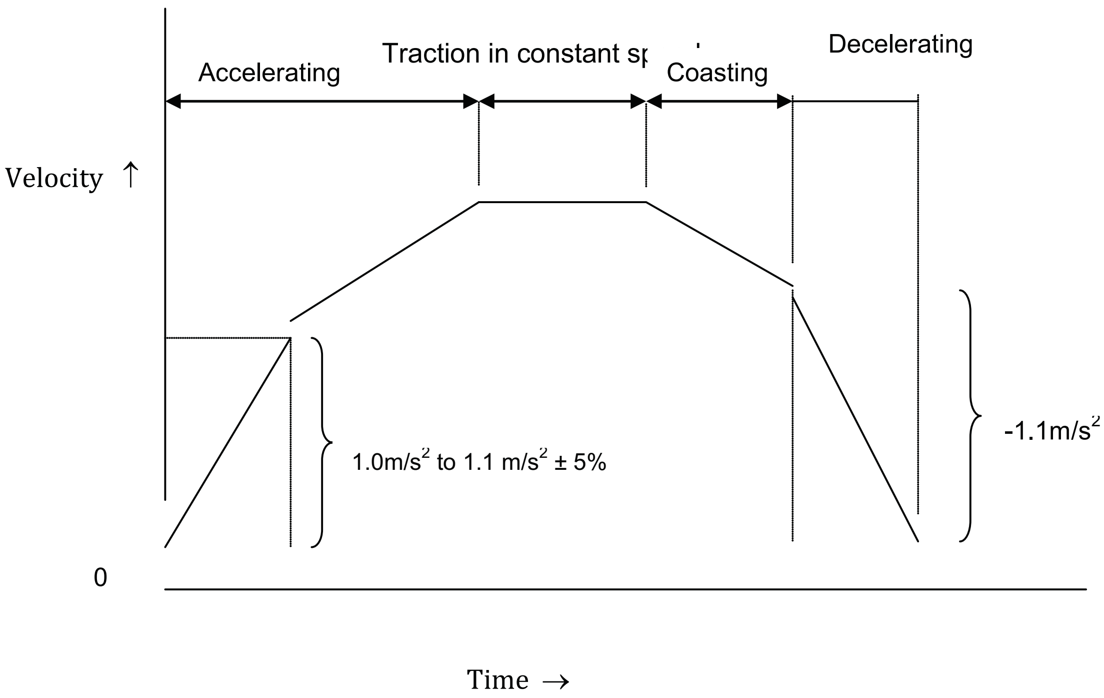
Description	DMC	TC	MC	6 Car train
TARE (maximum)	40	40	40	240
Passenger				
(Normal)	9.425	10.4	10.4	60.45
(Crush @6p/sqm)	16.055	17.55	17.55	102.31
(Crush @8p/sqm)	20.475	22.295	22.295	130.22
Gross				
(Normal)	49.425	50.4	50.4	300.45
(Crush @6p/sqm)	56.055	57.55	57.55	342.31
(Crush @8p/sqm)	60.475	62.295	62.295	370.22
Axle Load @6 person/sqm	14.014	14.388	14.388	
Axle Load @8 person/sqm	15.119	15.577	15.574	

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

6.4 PERFORMANCE PARAMETERS

The recommended performance parameters are:

Maximum Design Speed: 95 kmph
Maximum Operating Speed: 85 kmph
Max. Acceleration: 1.0 m/s^2 to 1.1 m/s^2 $\pm$ 5%
Max. Deceleration 1.1 m/s^2 (Normal brake)
More than 1.3 m/s^2 (Emergency brake)



6.5 COACH DESIGN AND BASIC PARAMETERS

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

(i) Proven equipment with high reliability
(ii) Passenger safety feature

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

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

6.6 SELECTION OF TECHNOLOGY

6.6.1 Low life cycle cost

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

6.6.2 CAR BODY

In the past carbon high tensile steel was invariably used for car bodies. In-fact almost all the coaches built by Indian Railways are of this type. These steel bodied coaches need frequent painting and corrosion repairs, which may have to be carried out up to 4-5 times during the service life of these coaches. It is now a standard practice to adopt stainless steel or aluminum for carbody.

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

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

6.6.3 BOGIES

Bolster less lightweight fabricated bogies with rubber springs are now universally adopted in metro cars. These bogies require less maintenance and overhaul interval is also of the order of 4,20,000km. Use of air spring at secondary stage is considered with a view to keep the floor level of the cars constant irrespective of passenger loading unlike those with coil spring. Perturbation from the track are also dampened inside the car body on account of the secondary air spring along with suitable Vertical Hydraulic Damper .The primary suspension system improve the curve running performance by reducing lateral forces through application of conical rubber spring. A smooth curving performance with better ride index is being ensured by provision of above type of bogies.

6.6.4 BRAKING SYSTEM

The brake system shall consist of –

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

The regenerative braking will be the main brake power of the train and will regain the maximum possible energy and pump it back to the system and thus fully utilize the advantage of 3 phase technology .The regenerative braking should have air supplement control to bear the load of trailer car. In addition, speed sensors mounted on each axle, control the braking force of the axles with anti skid valves, prompting re-adhesion in case of a skid .The brake actuator shall operate either a tread brake or a wheel disc brake, preferably a wheel disc brake.

6.6.5 PROPULSION SYSTEM TECHNOLOGY

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

The brush less 3 phase induction motors has now replaced the D.C. Series motors in traction applications. The induction motor, for the same power output, is smaller and lighter in weight and ideally suited for rail based Mass Rapid Transit applications. The motor tractive effort and speed is regulated by 'Variable Voltage and Variable frequency' control and can be programmed to suit the track profile and operating requirements. Another advantage of 3 phase a.c. drive and

VVVF control is that regenerative braking can be introduced by lowering the frequency and the voltage to reverse the power flow and to allow braking to very low speed.

For this corridor, three phase a.c. traction drive that are self-ventilated, highly reliable, robust construction and back up by slip/slid control have been recommended for adoption.

The AC catenary voltage is stepped down through a transformer and converted to DC voltage through converter and supply voltage to DC link, which feeds Inverter operated with Pulse Width Modulation (PWM) control technology and using Insulated Gate Bipolar Transistors (IGBT). Thus three-phase variable voltage variable frequency output drives the traction motors for propulsion.

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

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

6.6.6 INTERIOR AND GANGWAYS

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

Interior View

6.6.7 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 within least possible time without conflicting movement .As the alignment passes through elevated section above ground, automatic door closing mechanism is envisaged from consideration of passenger safety. Passenger doors are controlled electrically by a switch in Driver cab. Electrically controlled door operating mechanism has been preferred over pneumatically operated door to avoid cases of air leakage and sluggish operation of doors.

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

Passenger Doors

6.6.8 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 cooling, heating and dehumidifying and thus automatically controlling interior temperature throughout the passenger area at 25°C with 65% RH all the times under varying ambient conditions up to full load. For emergency situations such as power failure or both AC failures etc, ventilation provision supplied from battery will be made. Provision shall be made to shut off the fresh air intake and re-circulate the internal air of the coach, during an emergency condition, such as fire outside the train causing excessive heat and smoke to be drawn in to the coach.

6.6.9 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.

Driving Cab

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

6.6.10 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.

6.6.11 NOISE AND VIBRATION

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

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

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

6.6.12 PASSENGER SAFETY FEATURES

(i) ATP

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

(II) FIRE

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

(iii) EMERGENCY DOOR

The rolling stock is provided with emergency doors at both ends of the cab to ensure well directed evacuation of passengers in case of any emergency including fire in the train,

(iv) CRASH WORTHINESS FEATURES

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

(v) GANGWAYS

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

Gangways

The salient features of the proposed Rolling Stock are enclosed as

Attachment-I

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 (6 Car)**	DMC+TC+MC+MC+TC+DMC
4	**Coach Body**	Stainless Steel
5	**Coach Dimensions**	
5.1	Height	3.9 m
5.2	Width	2.9 m
5.3	Length over body (approx)	
	- Driving Motor Car (DMC)	21.64 m
	- Trailer Car (TC)	21.34 m
	- 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	
	DMC	247 (seating - 43 ; standing - 204)
	TC	270 (seating - 50 ; standing - 220)
	MC	270 (seating - 50 ; standing - 220)
7.2	Train Carrying capacity	
	6 car train	1574 (seating - 286 ; standing - 1288)
8	**Weight (Tonnes)**	
8.1	Tare weight (maximum)	
	DMC	40
	TC	40
	MC	40
8.2	Passenger Weight in tons	@ 0.065 T per passenger
	DMC	16.055
	TC	17.55
	MC	17.55
8.3	Gross weight in tons	

S. No.	Parameter	Details
	DMC	56.055
	TC	57.55
	MC	57.55
9	**Axle load(T)(@ 8 persons per sqm of standee area)**	**15.57**
		System should be designed for 16T axleload
10	**Maximum Train Length (6 car)-Approximate**	136. m
11	**Speed**	
10.1	Maximum Design Speed	95 Kmph
10.2	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 track**	1 m/sec^2 to 1.1 m/sec^2 ± 5%
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 3-car Unit (except DMC cab front side)	Automatic coupler with mechanical, electrical & pneumatic coupling

S. No.	Parameter	Details
	Front cab end of DMC car	Automatic coupler with mechanical & pneumatic coupling but without electrical coupling head
	Between cars of same Unit	Semi-permanent couplers
21	**Detrainment Door**	Front
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 6-car train shall be capable of pushing a fully loaded defective 6-car train without parking brakes applied on all sections including section of 3% gradient up to next station. Thereafter, after pasenger detrainment, the heathy train shall push the defective train till terminal station. - A 6-car fully loaded train shall be capable of clearing the section with the traction motors of one 3-car unit cut out.
35	**Gradient (max)**	3%
36	**Insulated Mat on roof**	Required
37	**Average Cost per car exclusive of taxes and duties at Oct 2008 Price level in Rs. Crores**	9.8
38	**Maximum Available PHPDT capacity**	37,776 @ 2.5 min headway

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 – 75KWh/1000 GTKM

(ii) Regeneration by rolling stock – 30%

(iii) Elevated station load – initially 200KW, which will increase to 500 KW in the year 2041.

(iv) Underground Station load – initially 2000 kW, which will increase to 2500 kW in the year 2041.

(v) Depot auxiliary load - initially 1500KW, which will increase to 2500 KW in the year 2041.

Keeping in view of the train operation plan and demand of auxiliary and traction power, power requirement projected for the year 2015, 2020, 2025, 2030 and 2041 respectively are summarized in table 7.1 below:-

Table 7.1 - Power Demand Estimation (MVA)

Corridor		**Year**				
		2015	**2020**	**2025**	**2030**	**2041**
Corridor – 1 North – South Corridor (CCS Airport - Indira Nagar - Munshi Pulia, 22.88 km with 19 elevated and 3 U/G stations)	Traction	7.27	10.97	13.98	19.46	23.78
	Auxiliary	13.96	16.68	18.16	24.09	24.09
	Total	**21.23**	**27.64**	**32.14**	**43.55**	**47.86**
Corridor – 2 East – West Corridor	Traction	3.26	5.08	6.92	10.11	11.69

Corridor		Year				
		2015	**2020**	**2025**	**2030**	**2041**
(Lucknow Railway Station to Vasantkunj, 11.10 km with 5 elevated and 7 U/G stations)	Auxiliary	20.38	23.47	24.15	27.79	27.79
	Total	**23.64**	**28.55**	**31.07**	**37.90**	**39.48**

Detailed calculations of power demand estimation are attached at **Annexure –7.1 & 7.2**

7.2 NEED FOR HIGH RELIABILITY OF POWER SUPPLY

The proposed Section of the Lucknow metro system is being designed to cater to about 60,000 passengers per direction during peak hours when trains are expected to run at 2.0 minutes intervals in 2041. 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 themselves.

7.3 SOURCES OF POWER SUPPLY

The high voltage power supply network of Lucknow city has 220kV and 132kV network to cater to various types of demand in vicinity of the proposed corridor. These sub stations are located along the alignment of Corridors. Keeping in view the reliability requirements, two independent sources 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 two corridors will meet at Lucknow Railway Station (Underground station of Corridor – 2). Therefore, to achieve the desired reliability, two Receiving Sub Stations (132 / 33 / 25 kV) are proposed to be set up for Corridor – 1 & Corridor – 2 each. Based on the discussions with Madhyanchal Vidyut Vitran Nigam Ltd., it is proposed to avail power supply for traction as well as auxiliary services from the following grid sub-stations at 132kV and 220 kV voltage through cable feeders.

Electric Power requirement for Corridor – 1 and Corridor – 2 is likely to be 22 MVA and 24 MVA approximately in year 2015 respectively and which is likely to increase to 48 MVA and 40 MVA respectively by the year 2041. Under normal conditions, this power will be equally shared between the two RSS feeding each corridor, while in case of failure of power supply from any one of the RSS; other RSS will feed the entire power requirement of the corridor.

Table 7.2 - Sources of Power Supply

Corridor	Grid sub-station (with Input voltage)	Location of RSS of Metro Authority	Approx. length of cables
Corridor – 1 North – South Corridor (CCS Airport to Munshi Pulia)	Near Kanpur Road / Transport Nagar Sub Station at 220 kV	Amausi 220/33/25 kV RSS	2 to 3 km. 220kV cabling Double circuit
	Power Grid (PGCIL) 220 kV Sub Station at Kursi Road	Munshi Pulia 220/33/25 kV RSS	6 to 7 km. 220kV cabling Double circuit
Corridor – 2 East – West Corridor (Lucknow Railway Station to Vasantkunj)	220 kV Sub Station at Hardoi Road	132/33/25 kV RSS near Vasant Kunj	2 km. 132kV cabling Double circuit
	TRT / Hardoi Road Sub Station,132 kV	132/33/25 KV RSS Near lucknow railway station/ near Nawajganj	2 km. 132kV cabling Single circuit

MVVNL have confirmed availability of requisite power at their above sub-stations vide letter No./75MD/MVVNL/camp, dated:- 01.04.2010 (**Annexure – 7.2**).Ideally the second source for elevated portion of corridor-2 should get supply near Nawaj Ganj. MVVNL has indicated their inability to provide power at Aminabad-Nawaj Ganj, therefore either to feed the section through second source available at that point of time or alternatively power can be available from TRT.A final decision can be taken in detailed design stage depending upon the phasing of these corridors.

Table 7.3 - Power Demand Projection for various sources

Corridor	Input Source / Receiving Sub Station (RSS)	Peak Demand – Normal (MVA)		Peak Demand – Emergency (MVA)	
		2015	2041	2015	2041
Corridor – 1 North – South Corridor (Amausi to Munshi Pulia)	Amausi 220/33/25 kV RSS				
	Traction	4.27	12.78	7.27	23.78
	Auxiliary	7.46	12.29	13.96	24.09
	Sub – Total (A)	11.73	25.07	21.23	47.87
	Munshi Pulia 220/33/25 kV RSS				
	Traction	3.0	11.0	7.27	23.78
	Auxiliary	6.5	11.8	13.96	24.09
	Sub – Total (B)	9.5	22.8	21.23	47.87
	TOTAL (A + B)	**21.23**	**47.87**		
Corridor – 2 East – West Corridor (Lucknow Railway Station to Vasantkunj)	132/33/25 kV RSS near Vasant Kunj				
	Traction	2.13	6.69	3.26	11.69
	Auxiliary	10.94	15.15	20.38	27.79
	Total	13.07	21.84	23.64	39.48
	132/33/25 KV RSS Near Lucknow railway station/ near Nawajganj				
	Traction	1.13	5.0	3.26	11.69
	Auxiliary	9.44	12.64	20.38	27.79
	Total	10.57	17.64	23.64	39.48
	TOTAL (A + B)	**23.64**	**39.48**		

The 220/132 kV power supply will be stepped down to 25kV single phase for traction purpose at the RSS of Lucknow Metro and fed to the OHE at viaduct through cable feeders. For feeding the auxiliary loads, the 220/132 kV power supply received will be stepped down to 33 kV and will be distributed along the alignment through 33kV Ring main cable network. These cables will be laid in dedicated ducts along the viaduct / on 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.

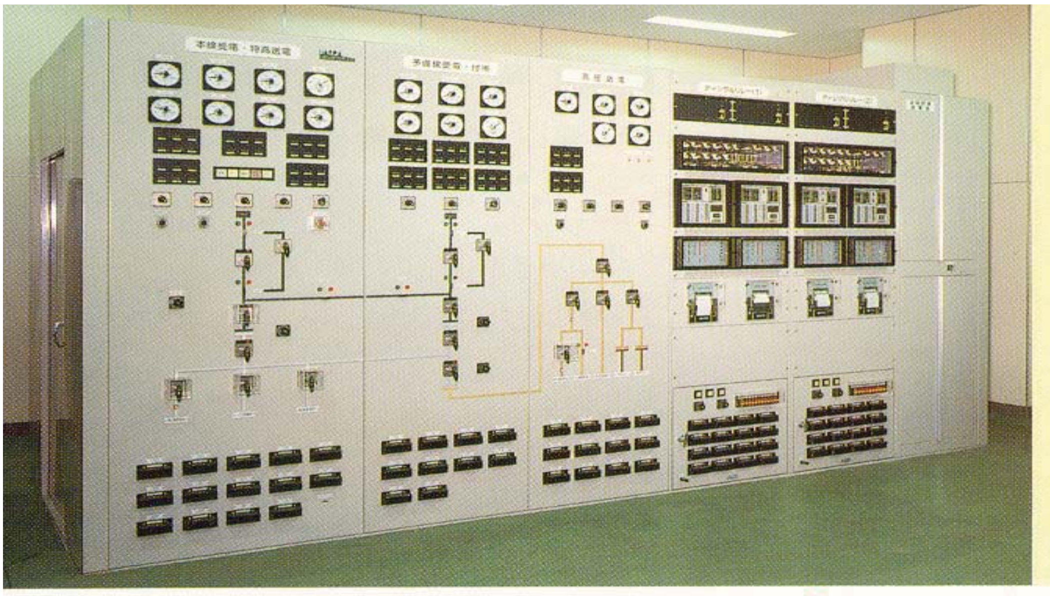
Typical High Voltage Receiving Sub-station

The 220/132kV cables will be laid through public pathways from MVVNL Grid Sub-stations to RSS of Metro Authority. For corridor – 1, RSS at Amausi and Munshi Pulia shall be provided with 2nos. (one as standby) 220/25 kV, 25 MVA single-phase traction Transformers for feeding Traction and 220/33 KV, 30/45 MVA three phase Transformers for feeding auxiliary loads. For corridor – 2, RSS at Vasantkunj and RSS Lucknow Railway Station 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 with a provision for enhancing the capacity to 45 MVA (if required) in future. 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 220/132 kV Switchgear is proposed for RSS's to be located in approx. 100 X 80 m (8000 sq. mtr.) land plot in depot area at Amausi, Munshi Pulia & Vasant Vihar, as the availability of Land in this area may not be a constraint. The RSS near Lucknow Railway 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 substation works will increase by nearly Rs.15- 20 Crore for each RSS.

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 500 KW in the year 2041 and 2000 kW for Underground Station which is likely to increase up to 2500 KW in the year 2041. In order to meet the requirement of auxiliary power, two (one transformer as standby) dry type cast resin transformers (33/0.415kV) of 500 kVA capacity are proposed to be installed at the elevated stations 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.

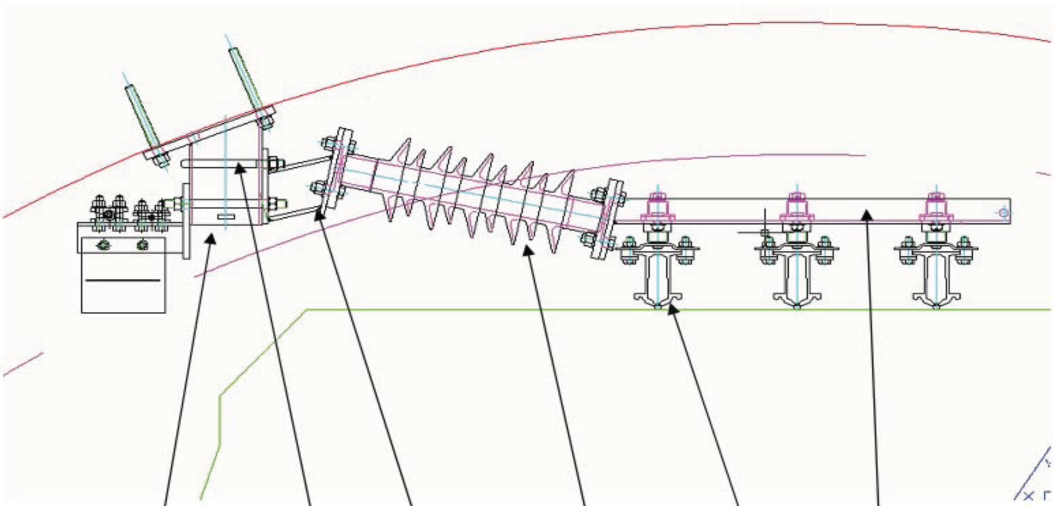
7.6 25 kV RIGID OHE SYSTEM. Detailed specification of equipment e.g. power cables, transformer, switchgear, E&M equipment etc shall be framed to reduce conducted or radiated emissions as per appropriate international standards. The Metro system as a whole (trains, signaling & telecom, traction power 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.

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) Minimum Contact wire height……………………………………………..4330mm

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)



25 KV ROCS Support

Aluminum Conductor (AAC) of 233 mm^2 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 25kV Flexible Overhead Equipment (OHE) system.

25kV ac flexible OHE system shall comprise 107 sq.mm 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.

7.7 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, 2 nos. 220/25kV traction transformers of 25MVA capacity and 2 nos 30/35 MVA capacity Auxiliary transformers shall be provided at each RSS in Corridor –I. and 2 nos. 132/25kV traction transformers of 15 MVA capacity and 2 nos. 30MVA capacity Auxiliary transformers shall be provided at each RSS in Corridor –II with a provision for enhancing the capacity to 45 MVA (if required) in future, being standard design (one to be in service and second one to serve as standby). The 220/132kV incoming cable shall be 3-phase single core XLPE insulated with adequate size of Aluminum conductor to meet the normal & emergency loading requirements and fault level of the 220/132 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 conductors 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.

7.8 STANDBY DIESEL GENERATOR (DG) SETS

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

7.9 SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA) SYSTEM

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

Digital Protection Control System (DPCS) is proposed for providing data acquisition, data processing, overall protection control, interlocking, inter-tripping and monitoring of the entire power supply system consisting of 33kV ac switchgear, transformers, 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.

7.10 ENERGY SAVING MEASURES

Energy charges of any metro system constitute a substantial portion of its operation & maintenance (O & M) costs. Therefore, it is imperative to incorporate energy saving measures in the system design itself. The auxiliary power consumption of metros is generally more than the traction energy consumed by train movement during initial years of operation. Subsequently, traction power consumption increases with increase in train frequency/composition in order to cater more traffic. The proposed system of Lucknow 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) has been incorporated in the system design.

(vii) Efficient energy management is possible with proposed modern SCADA system by way of maximum demand (MD) and power factor control.

7.11 ELECTRIC POWER TARIFF

The cost of electricity is a significant part of Operation & Maintenance (O&M) charges of the Metro System, which constitutes about 25 – 35% of total annual working cost. Therefore, it is the key element for the financial viability of the project. The annual energy consumption is assessed to be about 58.38 million units in initial years (2015), which will increase to

139.55 Million Units by year 2041 for Corridor – 1 and about 58 million units in initial years (2015), which will increase to 105.5 Million Units by year 2041 for Corridor – 2. 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 220/132 kV voltage level) plus nominal administrative charges i.e. on a no profit no loss basis. This is expected to be in the range of Rs. 3.00 per unit. It is proposed that Government of Uttar Pradesh take necessary steps to fix power tariff for Lucknow 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:- 7.2

(82)

Partha Sarthi Sen Sharma
I.A.S.
Managing Director

Madhyanchal Vidyut Vitran Nigam Limited
(U.P. Government Undertaking)
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Phone office 0522-2208737 & 2207065
Fax No 0522-2208769
e-mail : md.mvvnl2010@gmail.com

No: 175 MD/MVVNL/Camp

Dated: 01/4/2010

Subject: **Lucknow Metro Rail Project - regarding power supply requirement & sources.**

Executive Director (Electrical)]
Delhi Metro Rail Corporation Ltd.,
Metro Bhawan, Fire Brigade Lane,
Barakhamba Road,
New Delhi-110 001.

Please refer to your letter No. DMRC/Elect./Plg/Lucknow dated 01.4.2010 on the above mentioned subject. In principal below mentioned power supply sources may be indicated in the Detail Project Report to be submitted to Government of U.P.

S.No.	Corridor	Source-I	Source-2
1.	**Amausi to Munshi Pulia**	2 bays at 220 KV from proposed Transport Nagar sub station.	2 bays at 220 KV from 400 KV Power Grid (PGCIL) Sub Station at Kursi Road
2.	**Vasant Kunj to Rly Station**	2 bays at 132 KV from 220 KV Sub Station at Hardoi Road	One bay at 132 KV from TRT/Hardoi Road Sub Station

01/04/10

(Partha Sarthi Sen Sharma)
Managing Director

ANNEXURE-7.1

1 of 2

POWER REQUIREMENT NORTH SOUTH CORRIDOR LUCKNOW METRO

CCS Airport to Alambagh Bus Stand

	Year 2015		Year 2020		Year 2025		Year 2030		Year 2041	
Traction power requirements										
No of cars	6	(2MC+2DM(+2TC)	6	(2MC+2DM(+2TC)	6	(2MC+2DM(+2TC)	6	(2MC+2DM (+2TC)	6	(2MC+2DM (+2TC)
Passenger weight	130.13	T	130.13	T	130.13	T	130.13	T	130.13	T
Train Tare weight	240.0	T	240.0	T	240.0	T	240	T	240	T
Total train weight	370.13	T	370.13	T	370.13	T	370.13	T	370.13	T
Section length	7.05	KM	7.05	KM	7.05	KM	7.05	KM	7.05	KM
Headway	14	mts	9	mts	7	mts	5	mts	4	mts
Specific Energy consumption	75	KWhr/1000 GTKM	75	KWhr/1000 GTKM	75	KWhr/1000 GTKM	75	KWhr/1000G TKM	75	KWhr/1000G TKM
No. of trains/hr in both directions	9		13		17		24		30	
Peak traction power requirement	1.7	MW	2.6	MW	3.4	MW	4.7	MW	5.9	MW
Less Regeneration @ 30%	0.5	MW	0.8	MW	1.0	MW	1.4	MW	1.8	MW
Depot power requirements	1.0	MW	1.3	MW	1.5	MW	2.0	MW	2.0	MW
Net traction power requirement	2.2	MW	3.1	MW	3.8	MW	5.3	MW	6.1	MW
Total traction power requirement (MVA) assuming 5% energy losses and .95 pf	2.4	MVA	3.4	MVA	4.3	MVA	5.8	MVA	6.8	MVA
Station aux power requirements										
Elevated/at-grade station--power consumption	0.20	MW	0.25	MW	0.30	MW	0.50	MW	0.50	MW
Underground station--power consumption	2.00	MW	2.25	MW	2.25	MW	2.50	MW	2.50	MW
No. of elevated/at-grade stations	7		7		7		7		7	
No. of Underground stations	0		0		0		0		0	
Total Station Aux Power requirement	1.4	MW	1.8	MW	2.1	MW	3.5	MW	3.5	MW
Depot Aux power requirement	1.5	MW	2.0	MW	2.3	MW	2.5	MW	2.5	MW
Total Aux Power requirement	2.9	MW	3.8	MW	4.4	MW	6.0	MW	6.0	MW
Total aux power requirement (MVA) assuming 5% energy losses and .85 pf for aux loads	3.6	MVA	4.6	MVA	5.4	MVA	7.4	MVA	7.4	MVA
Total traction & aux power requirement (MVA)	6.0	MVA	8.0	MVA	9.6	MVA	13.3	MVA	14.2	MVA

Alambagh Bus Stand to Mahanagar

	Year 2015		Year 2020		Year 2025		Year 2030		Year 2041	
Traction power requirements										
No of cars	6	(2MC+2DM(+2TC)	6	(2MC+2DM(+2TC)	6	(2MC+2DM(+2TC)	6	(2MC+2DM(+2TC)	6	(2MC+2DM(+2TC)
Passenger weight	130.13	T	130.13	T	130.13	T	130.13	T	130.13	T
Train Tare weight	240.0	T	240.0	T	240.0	T	240.0	T	240.0	T
Total train weight	370.13	T	370.13	T	370.13	T	370.13	T	370.13	T
Section length	10.59	KM	10.59	KM	10.59	KM	10.59	KM	10.59	KM
Headway	7	mts	4.5	mts	3.5	mts	2.5	mts	2	mts
Specific Energy consumption	75	KWhr/1000 GTKM	75	KWhr/1000 GTKM	75	KWhr/1000 GTKM	75	KWhr/1000 GTKM	75	KWhr/1000 GTKM
No. of trains/hr in both directions	17		27		34		48		60	
Peak traction power requirement	5.0	MW	7.8	MW	10.1	MW	14.1	MW	17.6	MW
Less Regeneration @ 30%	1.5	MW	2.4	MW	3.0	MW	4.2	MW	5.3	MW
Depot power requirements										
Net traction power requirement	3.5	MW	5.5	MW	7.1	MW	9.9	MW	12.3	MW
Total traction power requirement (MVA) assuming 5% energy losses and .95 pf	3.9	MVA	6.1	MVA	7.8	MVA	10.9	MVA	13.6	MVA
Station aux power requirements										
Elevated/at-grade station--power consumption	0.20	MW	0.25	MW	0.30	MW	0.50	MW	0.50	MW
Underground station--power consumption	2.00	MW	2.25	MW	2.25	MW	2.50	MW	2.50	MW
No. of elevated/at-grade stations	7		7		7		7		7	
No. of Underground stations	3		3		3		3		3	
Total Station Aux Power requirement	7.4	MW	8.5	MW	8.9	MW	11.0	MW	11.0	MW
Depot Aux power requirement										
Total Aux Power requirement	7.4	MW	8.5	MW	8.9	MW	11.0	MW	11.0	MW
Total aux power requirement (MVA) assuming 5% energy losses and .85 pf for aux loads	9.1	MVA	10.5	MVA	10.9	MVA	13.6	MVA	13.6	MVA
Total traction & aux power requirement (MVA)	13.0	MVA	16.6	MVA	18.7	MVA	24.5	MVA	27.2	MVA

Mahanagar to Munshi Pulia

	Year 2015		Year 2020		Year 2025		Year 2030		Year 2041	
Traction power requirements										
No of cars	6	(2MC+2DM(+2TC)	6	(2MC+2DM(+2TC)	6	(2MC+2DM(+2TC)	6	(2MC+2DM(+2TC)	6	(2MC+2DM(+2TC)
Passenger weight	130.13	T	130.13	T	130.13	T	130.13	T	130.13	T
Train Tare weight	240.0	T	240.0	T	240.0	T	240.0	T	240.0	T
Total train weight	370.13	T	370.13	T	370.13	T	370.13	T	370.13	T
Section length	5.24	KM	5.24	KM	5.24	KM	5.24	KM	5.24	KM
Headway	14	mts	9	mts	7	mts	5	mts	4	mts
Specific Energy consumption	75	KWhr/1000 GTKM	75	KWhr/1000 GTKM	75	KWhr/1000 GTKM	75	KWhr/1000 GTKM	75	KWhr/1000 GTKM
No. of trains/hr in both directions	9		13		17		24		30	
Peak traction power requirement	1.2	MW	1.9	MW	2.5	MW	3.5	MW	4.4	MW
Less Regeneration @ 30%	0.4	MW	0.6	MW	0.7	MW	1.0	MW	1.3	MW
Depot power requirements										
Net traction power requirement	0.9	MW	1.4	MW	1.7	MW	2.4	MW	3.1	MW
Total traction power requirement (MVA) assuming 5% energy losses and .95 pf	1.0	MVA	1.5	MVA	1.9	MVA	2.7	MVA	3.4	MVA
Station aux power requirements										
Elevated/at-grade station--power consumption	0.20	MW	0.25	MW	0.30	MW	0.50	MW	0.50	MW
Underground station--power consumption	2.00	MW	2.25	MW	2.25	MW	2.50	MW	2.50	MW
No. of elevated/at-grade stations	5		5		5		5		5	
No. of Underground stations	0		0		0		0		0	
Total Station Aux Power requirement	1.0	MW	1.3	MW	1.5	MW	2.5	MW	2.5	MW
Depot Aux power requirement										
Total Aux Power requirement	1.0	MW	1.3	MW	1.5	MW	2.5	MW	2.5	MW
Total aux power requirement (MVA) assuming 5% energy losses and .85 pf for aux loads	1.2	MVA	1.5	MVA	1.9	MVA	3.1	MVA	3.1	MVA
Total traction & aux power requirement (MVA)	2.2	MVA	3.0	MVA	3.8	MVA	5.8	MVA	6.5	MVA

CCS Airport to Munshi Pulia

	Year 2015		Year 2020		Year 2025		Year 2030		Year 2041	
Traction power requirements										
No of cars										
Passenger weight										
Train Tare weight										
Total train weight										
Section length	22.88	KM	22.88	KM	22.88	KM	22.88	KM	22.88	KM
Headway										
Specific Energy consumption										
No. of trains/hr in both directions										
Peak traction power requirement										
Less Regeneration @ 30%										
Depot power requirements										
Net traction power requirement										
Total traction power requirement (MVA) assuming 5% energy losses and .95 pf	7.27	MVA	10.97	MVA	13.98	MVA	19.46	MVA	23.78	MVA
Station aux power requirements										
Elevated/at-grade station--power consumption										
Underground station--power consumption										
No. of elevated/at-grade stations										
No. of Underground stations										
Total Station Aux Power requirement										
Depot Aux power requirement										
Total Aux Power requirement										
Total aux power requirement (MVA) assuming 5% energy losses and .85 pf for aux loads	13.96	MVA	16.68	MVA	18.16	MVA	24.09	MVA	24.09	MVA
Total traction & aux power requirement (MVA)	21.23	MVA	27.64	MVA	32.14	MVA	43.55	MVA	47.86	MVA

ANNEXURE-2
2 of 2

ENERGY REQUIREMENT NORTH SOUTH CORRIDOR LUCKNOW METRO

CCS Airport to Alambagh Bus Stand										
Year	Year 2015		Year 2020		Year 2025		Year 2030		Year 2041	
Section length	7.05	KM	7.05	KM	7.05	KM	7.05	KM	7.05	KM
No. of trains per direction in a day*	50		79		100		140		168	
WEIGHT OF TRAIN & PASSENGER	370.1	T	370.1	T	370.1	T	370.1	T	370.1	T
SFC (NET) with 30% regen	53	KWH/1000GTKM	53	KWH/1000GTKM	53	KWH/1000GTKM	53	KWH/1000GTKM	53	KWH/1000GTKM
Yearly Traction Energy consumption with 365 days working with 30% regen	5.00	million units	7.90	million units	10.00	million units	14.00	million units	16.80	million units
Station aux power requirement										
Elevated/at-grade station	0.20	MW	0.25	MW	0.30	MW	0.50	MW	0.50	MW
U/G station	2.00	MW	2.25	MW	2.25	MW	2.50	MW	2.50	MW
No. of elevated/at-grade stations	7		7		7		7		7	
No. of Underground stations	0		0		0		0		0	
Total Station Aux Power requirement	1.4	MW	1.8	MW	2.1	MW	3.5	MW	3.5	MW
Depot Aux power requirement	1.5	MW	2.0	MW	2.3	MW	2.5	MW	2.5	MW
Total Aux Power requirement	2.9	MW	3.8	MW	4.4	MW	6.0	MW	6.0	MW
Total Aux power requirement (MVA) assuming 5% energy losses and .85 pf for aux loads	3.6	MVA	4.6	MVA	5.4	MVA	7.4	MVA	7.4	MVA
Diversity factor of aux loads	0.4		0.4		0.4		0.4		0.4	
Yearly Aux Energy consumption 20 hrs/day and 365 days working (million units)	8.89	million units	11.50	million units	13.49	million units	18.40	million units	18.40	million units
Net Annual Energy Consumption (Traction & Aux)	13.9	million units	19.4	million units	23.5	million units	32.4	million units	35.2	million units

Alambagh Bus Stand to Mahanagar										
Year	Year 2015		Year 2020		Year 2025		Year 2030		Year 2041	
Section length	10.59	KM	10.59	KM	10.59	KM	10.59	KM	10.59	KM
No. of trains per direction in a day*	100		158		200		280		336	
WEIGHT OF TRAIN & PASSENGER	370.1	T	370.1	T	370.1	T	370.1	T	370.1	T
SFC (NET) with 30% regen	53	KWH/1000GTKM	53	KWH/1000GTKM	53	KWH/1000GTKM	53	KWH/1000GTKM	53	KWH/1000GTKM
Yearly Traction Energy consumption with 365 days working with 30% regen	15.02	million units	23.74	million units	30.05	million units	42.07	million units	50.48	million units
Station aux power requirement										
Elevated/at-grade station	0.20	MW	0.25	MW	0.30	MW	0.50	MW	0.50	MW
U/G station	2.00	MW	2.25	MW	2.25	MW	2.50	MW	2.50	MW
No. of elevated/at-grade stations	7		7		7		7		7	
No. of Underground stations	3		3		3		3		3	
Total Station Aux Power requirement	7.4	MW	8.5	MW	8.9	MW	11.0	MW	11.0	MW
Depot Aux power requirement										
Total Aux Power requirement	7.4	MW	8.5	MW	8.9	MW	11.0	MW	11.0	MW
Total Aux power requirement (MVA) assuming 5% energy losses and .85 pf for aux loads	9.1	MVA	###	MVA	###	MVA	###	MVA	###	MVA
Diversity factor of aux loads	0.4		0.4		0.4		0.4		0.4	
Yearly Aux Energy consumption 20 hrs/day and 365 days working (million units)	22.69	million units	26.06	million units	27.13	million units	33.73	million units	33.73	million units
Net Annual Energy Consumption (Traction & Aux)	37.7	million units	49.8	million units	57.2	million units	75.8	million units	84.2	million units

Mahanagar to Munshi Pulia										
Year	Year 2015		Year 2020		Year 2025		Year 2030		Year 2041	
Section length	5.24	KM	5.24	KM	5.24	KM	5.24	KM	5.24	KM
No. of trains per direction in a day*	50		79		100		140		168	
WEIGHT OF TRAIN & PASSENGER	370.1	T	370.1	T	370.1	T	370.1	T	370.1	T
SFC (NET) with 30% regen	53	KWH/1000GTKM	53	KWH/1000GTKM	53	KWH/1000GTKM	53	KWH/1000GTKM	53	KWH/1000GTKM
Yearly Traction Energy consumption with 365 days working with 30% regen	3.72	million units	5.87	million units	7.43	million units	10.41	million units	12.49	million units
Station aux power requirement										
Elevated/at-grade station	0.20	MW	0.25	MW	0.30	MW	0.50	MW	0.50	MW
U/G station	2.00	MW	2.25	MW	2.25	MW	2.50	MW	2.50	MW
No. of elevated/at-grade stations	5		5		5		5		5	
No. of Underground stations	0		0		0		0		0	
Total Station Aux Power requirement	1.0	MW	1.3	MW	1.5	MW	2.5	MW	2.5	MW
Depot Aux power requirement										
Total Aux Power requirement	1.0	MW	1.3	MW	1.5	MW	2.5	MW	2.5	MW
Total Aux power requirement (MVA) assuming 5% energy losses and .85 pf for aux loads	1.2	MVA	1.5	MVA	1.9	MVA	3.1	MVA	3.1	MVA
Diversity factor of aux loads	0.4		0.4		0.4		0.4		0.4	
Yearly Aux Energy consumption 20 hrs/day and 365 days working (million units)	3.07	million units	3.83	million units	4.60	million units	7.67	million units	7.67	million units
Net Annual Energy Consumption (Traction & Aux)	6.8	million units	9.7	million units	12.0	million units	18.1	million units	20.2	million units

CCS Airport to Munshi Pulia										
Year	Year 2015		Year 2020		Year 2025		Year 2030		Year 2041	
Section length	22.88	KM	22.88	KM	22.88	KM	22.88	KM	22.88	KM
No. of trains per direction in a day*										
WEIGHT OF TRAIN & PASSENGER										
SFC (NET) with 30% regen										
Yearly Traction Energy consumption with 365 days working with 30% regen	23.74	million units	37.51	million units	47.48	million units	6647	million units	79.76	million units
Station aux power requirement										
Elevated/at-grade station										
U/G station										
No. of elevated/at-grade stations										
No. of Underground stations										
Total Station Aux Power requirement										
Depot Aux power requirement										
Total Aux Power requirement										
Total Aux power requirement (MVA) assuming 5% energy losses and .85 pf for aux loads										
Diversity factor of aux loads										
Yearly Aux Energy consumption 20 hrs/day and 365 days working (million units)	34.65	million units	41.39	million units	45.22	million units	59.79	million units	59.79	million units
Net Annual Energy Consumption (Traction & Aux)	58.38	million units	78.90	million units	92.70	million units	126.26	million units	139.55	million units

ANNEXURE 7.2
1 of 2

POWER REQUIREMENT EAST-WESTCORRIDOR LUCKNOW METRO

Description	Lucknow Rly. Station to Thakurganj									
	Year 2015		Year 2020		Year 2025		Year 2030		Year 2041	
Traction power requirements										
No of cars	6	(2MC+2DMC+2TC)	6	(2MC+2DMC+2TC)	6	(2MC+2DMC+2TC)	6	(2MC+2DMC+2TC)	6	(2MC+2DMC+2TC)
Passenger weight	130.13	T	130.1	T	130.1	T	130.1	T	130.1	T
Train Tare weight	240.0	T	240.0	T	240.0	T	240	T	240	T
Total train weight	370.13	T	370.13	T	370.13	T	370.13	T	370.13	T
Section length	7.29	KM	7.29	KM	7.29	KM	7.29	KM	7.29	KM
Headway	**11**	mts	**6.5**	mts	**4.5**	mts	**3**	mts	**2.5**	mts
Specific Energy consumption	75	KWhr/1000 GTKM	75	KWhr/1000 GTKM	75	KWhr/1000 GTKM	75	KWhr/1000GT KM	75	KWhr/1000GT KM
No. of trains/hr in both directions	11		18		27		40		48	
Peak traction power requirement	2.2	MW	3.7	MW	5.4	MW	8.1	MW	9.7	MW
Less Regeneration @ 30%	0.7	MW	1.1	MW	1.6	MW	2.4	MW	2.9	MW
Depot power requirements										
Net traction power requirement	1.5	MW	2.6	MW	3.8	MW	5.7	MW	6.8	MW
Total traction power requirement (MVA) assuming 5% energy losses and .95 pf	**1.7**	MVA	**2.9**	MVA	**4.2**	MVA	**6.3**	MVA	**7.5**	MVA
Station aux power requirements										
Elevated/at-grade station-power consumption	0.20	MW	0.25	MW	0.30	MW	0.50	MW	0.50	MW
Underground station-power consumption	2.00	MW	2.25	MW	2.25	MW	2.50	MW	2.50	MW
No. of elevated/at-grade stations	1		1		1		1		1	
No. of Underground stations	7		7		7		7		7	
Total Station Aux Power requirement	14.2	MW	16.0	MW	16.1	MW	18.0	MW	18.0	MW
Depot Aux power requirement										
Total Aux Power requirement	14.2	MW	16.0	MW	16.1	MW	18.0	MW	18.0	MW
Total aux power requirement (MVA) assuming 5% energy losses and .85 pf for aux loads	**17.5**	MVA	**19.8**	MVA	**19.8**	MVA	**22.2**	MVA	**22.2**	MVA
Total traction & aux power requirement (MVA)	**19.2**	MVA	**22.7**	MVA	**24.0**	MVA	**28.5**	MVA	**29.7**	MVA

Description	Thakurganj to Vasant Kunj									
	Year 2015		Year 2020		Year 2025		Year 2030		Year 2041	
Traction power requirements										
No of cars	6	(2MC+2DMC+2TC)	6	(2MC+2DMC+2TC)	6	(2MC+2DMC+2TC)	6	(2MC+2DMC+2TC)	6	(2MC+2DMC+2TC)
Passenger weight	130.1	T	130.1	T	130.1	T	130.1	T	130.1	T
Train Tare weight	240.0	T	240.0	T	240.0	T	240.0	T	240.0	T
Total train weight	370.13	T	370.13	T	370.13	T	370.13	T	370.13	T
Section length	3.81	KM	3.81	KM	3.81	KM	3.81	KM	3.81	KM
Headway	**22**	mts	**13**	mts	**9**	mts	**6**	mts	**5**	mts
Specific Energy consumption	75	KWhr/1000 GTKM	75	KWhr/1000 GTKM	75	KWhr/1000 GTKM	75	KWhr/1000 GTKM	75	KWhr/1000 GTKM
No. of trains/hr in both directions	5		9		13		20		24	
Peak traction power requirement	0.6	MW	1.0	MW	1.4	MW	2.1	MW	2.5	MW
Less Regeneration @ 30%	0.2	MW	0.3	MW	0.4	MW	0.6	MW	0.8	MW
Depot power requirements	1.0	MW	1.3	MW	1.5	MW	2.0	MW	2.0	MW
Net traction power requirement	1.4	MW	2.0	MW	2.5	MW	3.5	MW	3.8	MW
Total traction power requirement (MVA) assuming 5% energy losses and .95 pf	**1.6**	MVA	**2.2**	MVA	**2.7**	MVA	**3.8**	MVA	**4.2**	MVA
Station aux power requirements										
Elevated/at-grade station-power consumption	0.20	MW	0.25	MW	0.30	MW	0.50	MW	0.50	MW
Underground station-power consumption	2.00	MW	2.25	MW	2.25	MW	2.50	MW	2.50	MW
No. of elevated/at-grade stations	4		4		4		4		4	
No. of Underground stations	0		0		0		0		0	
Total Station Aux Power requirement	0.8	MW	1.0	MW	1.2	MW	2.0	MW	2.0	MW
Depot Aux power requirement	1.5	MW	2.0	MW	2.3	MW	2.5	MW	2.5	MW
Total Aux Power requirement	2.3	MW	3.0	MW	3.5	MW	4.5	MW	4.5	MW
Total aux power requirement (MVA) assuming 5% energy losses and .85 pf for aux loads	**2.8**	MVA	**3.7**	MVA	**4.3**	MVA	**5.6**	MVA	**5.6**	MVA
Total traction & aux power requirement (MVA)	**4.4**	MVA	**5.9**	MVA	**7.1**	MVA	**9.4**	MVA	**9.7**	MVA

Description	Lucknow Rly. Station to Vasant Kunj									
	Year 2015		Year 2020		Year 2025		Year 2030		Year 2041	
Traction power requirements										
No of cars										
Passenger weight										
Train Tare weight										
Total train weight										
Section length	**11.10**	**KM**	**11.10**	**KM**	**11.10**	**KM**	**11.10**	**KM**	**11.10**	**KM**
Headway										
Specific Energy consumption										
No. of trains/hr in both directions										
Peak traction power requirement										
Less Regeneration @ 30%										
Depot power requirements										
Net traction power requirement										
Total traction power requirement (MVA) assuming 5% energy losses and .95 pf	**3.26**	**MVA**	**5.08**	**MVA**	**6.92**	**MVA**	**10.11**	**MVA**	**11.69**	**MVA**
Station aux power requirements										
Elevated/at-grade station-power consumption										
Underground station-power consumption										
No. of elevated/at-grade stations										
No. of Underground stations										
Total Station Aux Power requirement										
Depot Aux power requirement										
Total Aux Power requirement										
Total aux power requirement (MVA) assuming 5% energy losses and .85 pf for aux loads	**20.38**	**MVA**	**23.47**	**MVA**	**24.15**	**MVA**	**27.79**	**MVA**	**27.79**	**MVA**
Total traction & aux power requirement (MVA)	**23.64**	**MVA**	**28.55**	**MVA**	**31.07**	**MVA**	**37.90**	**MVA**	**39.48**	**MVA**

ANNEXURE- 7.2
2 of 2

ENERGY REQUIREMENT EAST-WEST CORRIDOR LUCKNOW METRO

	Lucknow Rly. Station to Thakurganj									
Year	**Year 2015**		**Year 2020**		**Year 2025**		**Year 2030**		**Year 2041**	
Section length	7.29	KM	7.29	KM	7.29	KM	7.29	KM	7.29	KM
No. of trains per direction in a day*	64		106		158		216		280	
WEIGHT OF TRAIN & PASSENGER	370.1	T	370.1	T	370.1	T	370.1	T	370.1	T
SFC (NET) with 30% regen	53	KWH/1000GTKM	53	KWH/1000 GTKM	53	KWH/1000 GTKM	53	KWH/1000 GTKM	53	KWH/1000 GTKM
Yearly Traction Energy consumption with 365 days working with 30% regen	6.62	million units	10.96	million units	16.34	million units	22.33	million units	28.95	million units
Station aux power requirement										
Elevated/at-grade station	0.20	MW	0.25	MW	0.30	MW	0.50	MW	0.50	MW
U/G station	2.00	MW	2.25	MW	2.25	MW	2.50	MW	2.50	MW
No. of elevated/at-grade stations	1		1		1		1		1	
No. of Underground stations	7		7		7		7		7	
Total Station Aux Power requirement	14.2	MW	16.0	MW	16.1	MW	18.0	MW	18.0	MW
Depot Aux power requirement										
Total Aux Power requirement	14.2	MW	16.0	MW	16.1	MW	18.0	MW	18.0	MW
Total Aux power requirement (MVA) assuming 5% energy losses and .85 pf for aux loads	**17.5**	MVA	**19.8**	MVA	**19.8**	MVA	**22.2**	MVA	**22.2**	MVA
Diversity factor of aux loads	0.4		0.4		0.4		0.4		0.4	
Yearly Aux Energy consumption 20 hrs/day and 365 days working (million units)	43.54	million units	49.06	million units	49.21	million units	55.19	million units	55.19	million units
Net Annual Energy Consumption (Traction & Aux)	**50.2**	**million units**	**60.0**	**million units**	**65.5**	**million units**	**77.5**	**million units**	**84.1**	**million units**

	Thakurganj to Vasant Kunj									
Year	**Year 2015**		**Year 2020**		**Year 2025**		**Year 2030**		**Year 2041**	
Section length	3.81	KM	3.81	KM	3.81	KM	3.81	KM	3.81	KM
No. of trains per direction in a day*	32		53		79		108		140	
WEIGHT OF TRAIN & PASSENGER	370.1	T	370.1	T	370.1	T	370.1	T	370.1	T
SFC (NET) with 30% regen	53	KWH/1000 GTKM	53	KWH/1000 GTKM	53	KWH/1000 GTKM	53	KWH/1000 GTKM	53	KWH/1000 GTKM
Yearly Traction Energy consumption with 365 days working with 30% regen	1.73	million units	2.86	million units	4.27	million units	5.84	million units	7.57	million units
Station aux power requirement										
Elevated/at-grade station	0.20	MW	0.25	MW	0.30	MW	0.50	MW	0.50	MW
U/G station	2.00	MW	2.25	MW	2.25	MW	2.50	MW	2.50	MW
No. of elevated/at-grade stations	4		4		4		4		4	
No. of Underground stations	0		0		0		0		0	
Total Station Aux Power requirement	0.8	MW	1.0	MW	1.2	MW	2.0	MW	2.0	MW
Depot Aux power requirement	1.5	MW	2.0	MW	2.3	MW	2.5	MW	2.5	MW
Total Aux Power requirement	2.3	MW	3.0	MW	3.5	MW	4.5	MW	4.5	MW
Total Aux power requirement (MVA) assuming 5% energy losses and .85 pf for aux loads	**2.8**	MVA	**3.7**	MVA	**4.3**	MVA	**5.6**	MVA	**5.6**	MVA
Diversity factor of aux loads	0.4		0.4		0.4		0.4		0.4	
Yearly Aux Energy consumption 20 hrs/day and 365 days working (million units)	7.05	million units	9.20	million units	10.73	million units	13.80	million units	13.80	million units
Net Annual Energy Consumption (Traction & Aux)	**8.8**	**million units**	**12.1**	**million units**	**15.0**	**million units**	**19.6**	**million units**	**21.4**	**million units**

	Lucknow Rly. Station to Vasant Kunj									
Year	**Year 2015**		**Year 2020**		**Year 2025**		**Year 2030**		**Year 2041**	
Section length	11.10	KM	11.10	KM	11.10	KM	11.10	KM	11.10	KM
No. of trains per direction in a day*										
WEIGHT OF TRAIN & PASSENGER										
SFC (NET) with 30% regen										
Yearly Traction Energy consumption with 365 days working with 30% regen	8.35	million units	13.82	million units	20.60	million units	28.17	million units	36.51	million units
Station aux power requirement										
Elevated/at-grade station										
U/G station										
No. of elevated/at-grade stations										
No. of Underground stations										
Total Station Aux Power requirement										
Depot Aux power requirement										
Total Aux Power requirement										
Total Aux power requirement (MVA) assuming 5% energy losses and .85 pf for aux loads										
Diversity factor of aux loads										
Yearly Aux Energy consumption 20 hrs/day and 365 days working (million units)	50.59	million units	58.25	million units	59.94	million units	68.99	million units	68.99	million units
Net Annual Energy Consumption (Traction & Aux)	**58.94**	**million units**	**72.08**	**million units**	**80.54**	**million units**	**97.15**	**million units**	**105.50**	**million units**

Chapter 8

Ventilation and Air-conditioning System

CHAPTER – 8

VENTILATION AND AIR-CONDITIONING SYSTEM

8.1 INTRODUCTION

This chapter covers the Ventilation and Air-conditioning (VAC) system requirements for the underground sections of the proposed Lucknow 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 proposed alignment has two corridor of underground section i.e. Corridor -1 is having three underground stations with 3.44km length of underground running section and Corridor-2 is having seven underground stations with 5.9 km length of underground running section .

The MRTS alignment passes through the heart of the city. The underground section of **North-south** corridor starts from HussainGunj and passes through Sachiwalaya and HazaratGunj and **East-West** corridor starts from Lucknow Railway Station/ Charbagh and passes through Gautam Buddha Marg, Aminabad, Pandeyganj, Lucknow City Railway Station, Medical Chauraha and Nawajganj Metro Stations. The inter-station distances vary from 823 meters to 1371 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 Lucknow suggests that the summer and Monsoon season is generally between March to September. During the October to 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 Lucknow is to be obtained/ measured.

8.6 INTERNAL DESIGN CONDITIONS IN UNDERGROUND STATIONS

With hot and humid ambient conditions of Lucknow 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 : 40.80 DB, 23.1 WB

Monsoon: 28.80 DB, 33.1 WB

For Lucknow 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 Lucknow 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 requirement 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 TRACK WAY 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 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 track way exhaust system and either returned to the AHU'S or exhausted as required.

UVC Emitters can also be installed in the AHUs for the reduction of mould and fungus growth on the coil and keeps the surface clean, eliminating need for coil cleaning programme and improve the overall coil efficiency.

Following are the advantages of UVC emitter :

(a) UVC emitter kills or inactive surface and air borne microorganism that contribute to poor indoor air quality or spread of infectious diseases.

(b) UVC emitter doesn't allow bio film to form on cooling coil surface and lowers HVAC costs by resorting heat transfer and net cooling capacity.

(c) Increase in air flow resulted better air conditioning in the public area hence reduced requirement of additional cooling through AC plant.

Water-cooled chiller units with screw/centrifugal compressors are recommended to be provided at each station. 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 approximate area for air handling equipment room would be 800 sq. m at each end of the station .The station air conditioning equipment plant rooms are normally located at each end of the concourse for the two level stations. . 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 control 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.

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

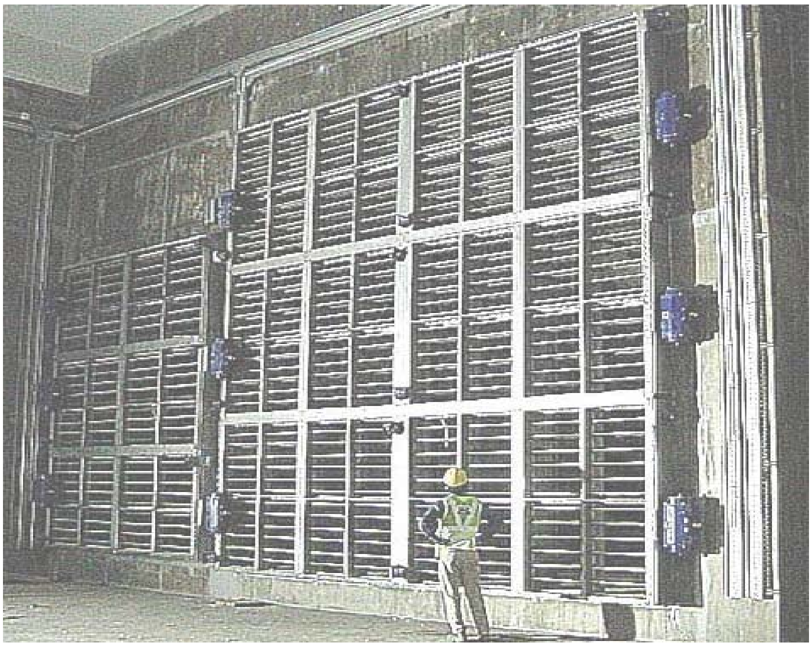
8.15 DESIGN CONCEPTS FOR TVS SYSTEM

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.

8.16.4 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) <u>Portal Entry and Exit Pressure Transients</u> – 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 is two portal location in North –south corridor between Charbagh/LKO Rly Station to HussainGunj and HazratGunj to KD Singh Babu Stadium and one portal location in East-West corridor between Nawajganj to Thakurganj.

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.

8.17 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.

8.17.1 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 Lucknow Metro.

Chapter 9

Signalling System

CHAPTER 9

SIGNALLING SYSTEM

9.1 INTRODUCTION

The signalling 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 an efficient train services on the network.

9.2 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 '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.
- 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 Signalling and telecommunication equipments by monitoring system status of trackside and train born equipments and enabling preventive maintenance.

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

9.3 SYSTEM DESCRIPTION AND SPECIFICATIONS

The Signalling 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

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

(ii) Automatic Train Operation (ATO)

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

(iii) Automatic Train Supervision (ATS)

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

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

- Automatic Route setting
- Automatic Train Regulation
- Continuous Tracking of train position
- Display Panel & Workstation interface
- 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.

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 proved 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-Trailable 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.

d. Signaling Scheme Plan

Conceptual Signaling Plans for Amausi – Munshi Pulia of North-South corridor and Lucknow Railway Station – Vasant Kunj of East-West corridor of Lucknow Metro are placed at **Annexure 9.1**.

9.4 STANDARDS

The following standards will be adopted with regard to the Signalling system.

Description	Standards
▪ Interlocking	Computer based Interlocking adopted for station having switches and crossing. All related equipment as far as possible will be centralised in the equipment room at the station. The depot shall be interlocked except for lines mainly used for 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	Air-conditioners for all equipment rooms.

Description	Standards
Conditions	
▪ 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.

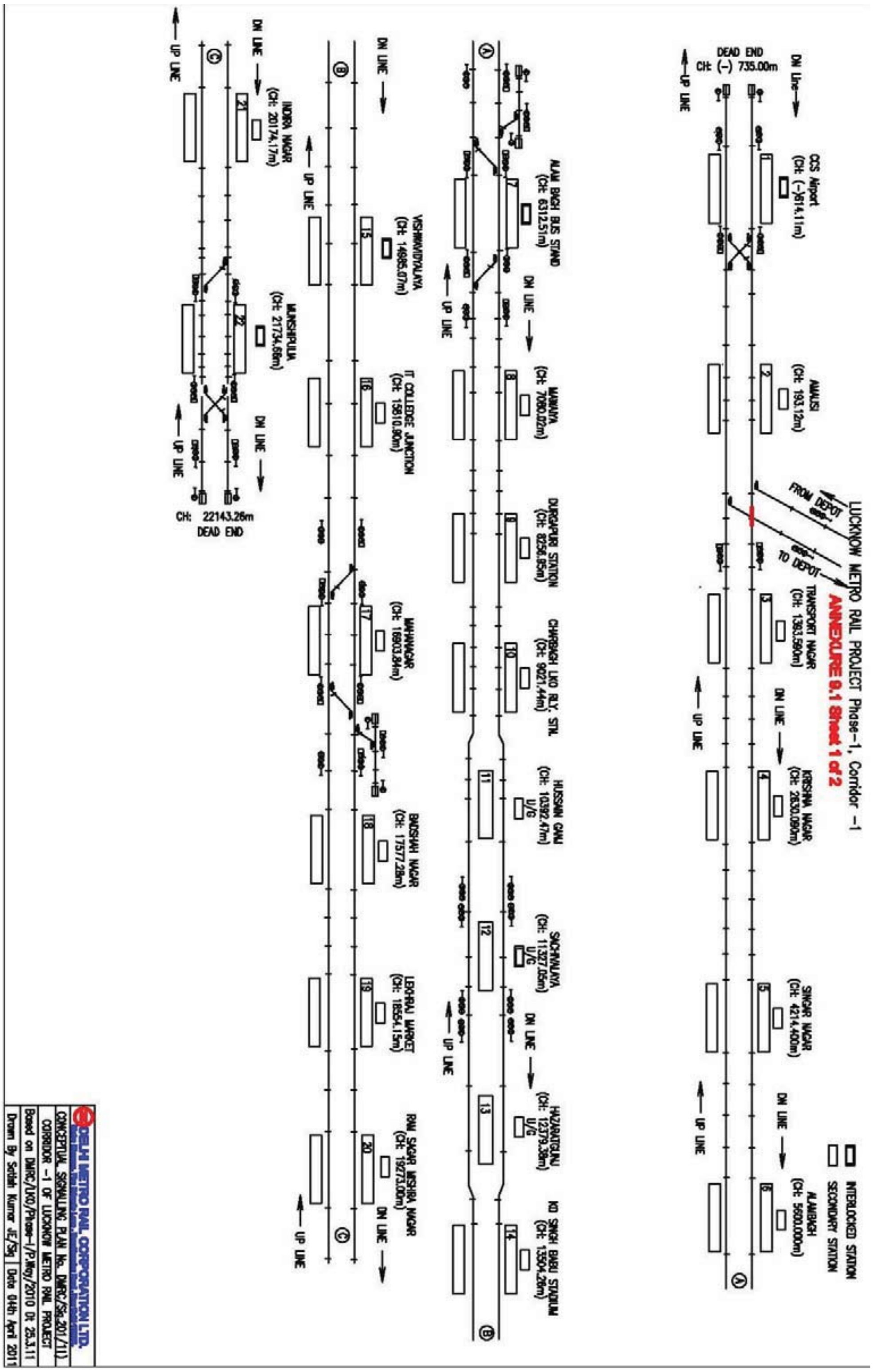
9.5 SPACE REQUIREMENT FOR SIGNALLING INSTALLATIONS

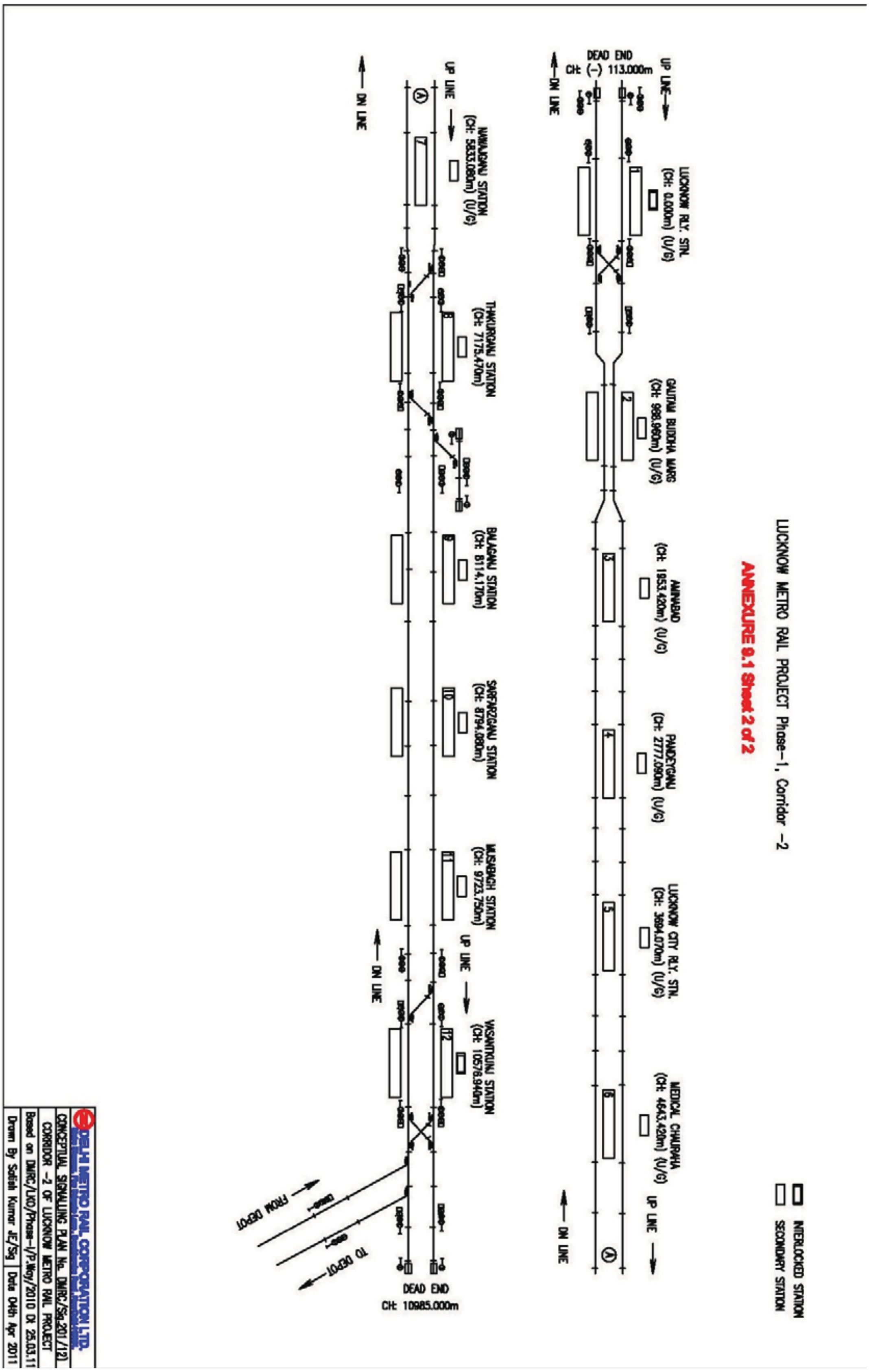
Adequate space for proper installations of all Signalling equipment at each of the stations has to be provided keeping in view the case of maintenance and use of instrumentation set up for regular testing and line up of the equipment/system. The areas required at each of the stations for Signalling equipment shall be generally 60 sq.m for UPS Room (common for signalling and telecom) and for Signalling Equipment Room 50 sq.m at interlocked station with points & 20 sq.m at other stations. 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.

9.6 MAINTENANCE PHILOSOPHY FOR SIGNALLING SYSTEMS

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

The defective card/ module / sub-system taken out from the section shall be sent for diagnostic and repair to a centralized S&T repair lab suitably located 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.


LUCKNOW METRO RAIL PROJECT Phase-1, Corridor -1
ANNEXURE 9.1 Sheet 1 of 2
INTERLOCKED STATION
SECONDARY STATION
DEAD END
CH: (-) 735.00m
CCS Airport
(CH: (-)614.11m)
AMAUSI
(CH: 193.12m)
FROM DEPOT
TO DEPOT
TRANSPORT NAGAR
(CH: 1363.560m)
KRISHNA NAGAR
(CH: 2830.090m)
SINGAR NAGAR
(CH: 4214.400m)
ALAMBAGH
(CH: 5600.000m)
ALAM BAGH BUS STAND
(CH: 6312.51m)
MAWAIYA
(CH: 7080.02m)
DURGAPURI STATION
(CH: 8256.05m)
CHARBAGH LKO RLY. STN.
(CH: 9021.44m)
HUSSAIN GANJ
(CH: 10392.47m)
U/G
SACHIVALAYA
(CH: 11327.05m)
HAZARATGUNJ
(CH: 12379.38m)
KD SINGH BABU STADIUM
(CH: 13504.26m)
VISHWAVIDYALAYA
(CH: 14885.07m)
IT COLLEDGE JUNCTION
(CH: 15810.90m)
MAHANAGAR
(CH: 16803.84m)
BADSHAH NAGAR
(CH: 17577.28m)
LEKHRAJ MARKET
(CH: 18554.15m)
RAM SAGAR MISHRA NAGAR
(CH: 19273.00m)
INDIRA NAGAR
(CH: 20174.17m)
MUNSHIPULIA
(CH: 21734.68m)
CH: 22143.26m
DEAD END
UP LINE
DN LINE
DELHI METRO RAIL CORPORATION LTD.
CONCEPTUAL SIGNALLING PLAN No. DMRC/S&.201/(11)
CORRIDOR -1 OF LUCKNOW METRO RAIL PROJECT
Based on DMRC/LKO/Phase-I/P.Way/2010 Dt 25.3.11
Drawn By Satish Kumar JE/S&T | Date 04th April 2011



LUCKNOW METRO RAIL PROJECT Phase-1, Corridor -2
ANNEXURE 9.1 Sheet 2 of 2
INTERLOCKED STATION
SECONDARY STATION
DEAD END
CH: (-) 113.000m
UP LINE
DN LINE
LUCKNOW RLY. STN. (CH: 0.000m) (U/G)
GAUTAM BUDDHA MARG (CH: 988.960m) (U/G)
AMINABAD (CH: 1853.420m) (U/G)
PANDEYGANJ (CH: 2777.090m) (U/G)
LUCKNOW CITY RLY. STN. (CH: 3694.070m) (U/G)
MEDICAL CHAURAHA (CH: 4643.420m) (U/G)
NAWAJGANJ STATION (CH: 5833.080m) (U/G)
THAKURGANJ STATION (CH: 7175.470m)
BALAGANJ STATION (CH: 8114.170m)
SARFARAZGANJ STATION (CH: 8794.080m)
MUSABAGH STATION (CH: 9723.750m)
VASANTKUNJ STATION (CH: 10576.940m)
FROM DEPOT
TO DEPOT
DEAD END
CH: 10985.000m
DELHI METRO RAIL CORPORATION LTD.
CONCEPTUAL SIGNALLING PLAN No. DMRC/Sig.201/12
CORRIDOR -2 OF LUCKNOW METRO RAIL PROJECT
Based on DMRC/LKO/Phase-I/P.Way/2010 Dt 25.03.11
Drawn By Satish Kumar JE/Sig
Date 04th Apr 2011

Chapter 10

Telecommunications and Automatic Fare Collection System

CHAPTER - 10

TELECOMMUNICATIONS AND AUTOMATIC FARE COLLECTION SYSTEM

10.1 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.

10.2 OVERVIEW

The telecommunication facilities proposed are helpful in meeting the requirements for

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

The proposed telecom system will cater to the following requirements:

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

10.3 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-4) 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, MPLS Ethernet Network 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 OCC/Depot shall be of larger sizes as per the actual number of users. The Exchanges will serve the subscribers at all the stations and OCC. 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 instant mobile radio communication between the motorman of the moving cars from any place and the Central Control .The motorman can also contact any station in the network through the central control, besides intimating the approaching trains about any emergency like accident, fire, line blocked etc., thus improving safety performance.

To provide adequate coverage, based on the RF site survey to be carried out during detailed Design stage, base stations for the system will be located at sites conveniently selected after detailed survey. Tentatively minimum 1 site every third station with 35 meter tower with Base Station shall be required along the route, on the N-S Corridor.

For the Elevated part of East – West Corridor, atleast 2 BTS stations will be required, with 35 m towers each. For the Underground Section, atleast one Base Station each shall be required at Gautam Budh Nagar, Lucknow City Railway Station and Nawajgang feeding through Bi-directional Amplifiers and Leaky Coaxial Cables, the adjacent stations/tunnels/ramp.

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 and Fire, 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) Centralised Clock System

This will ensure an accurate display of time through a synchronization system of slave clocks driven from a Master Clock fed from a GPS equipment 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.

ix) Technology

The Technologies proposed to be adopted for telecommunication systems are shown in Table 10.1:

TABLE 10.1

System	Standards
• Transmission Media	Optical Fibre system as the main bearer for bulk of the telecommunication network

System	Standards
• 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.

x) 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 25 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.

xi) Maintenance Philosophy for Telecom systems

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

The defective card/ module / sub-system taken out from the section shall be sent for diagnostic and repair to 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.

10.4 AUTOMATIC FARE COLLECTION

10.4.1 INTRODUCTION

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

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

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.

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

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

C) Choice of Control Gates

Retractable Flap Type/Paddle Type Control Gates are proposed which offer high throughput, require less maintenance and are latest in modern metros internationally. Tripod turnstile type gates offer less throughput and require more maintenance.

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.

10.4.2 Technology

The technology proposed for AFC systems are given in Table 10.2.

TABLE 10.2

Standards	Description
• Fare media	a) Contactless smart card – for multiple journeys. b) Smart Contactless Token – for Single Journeys.
• Gates	Computer controlled retractable flap type 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 (TR) 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 utilized.

Entry/Exit Gates

The numbers of various Telecom facilities needed is given in Annexure 10.1

Annexure 10.1

AFC Equipments Estimate for Metro systems in Lucknow (based on Traffic Projection for 2015)

S.No.	Station	Hourly Boarding	Peak Min. Boarding	Hourly Alighting	Peak min alighting	Gate Entry	Gate Exit	Disabled Gate	TOM	EFO	TR	TVM
	North-south corridor											
1	CCS Airport	117	2	259	5	2	2	1	2	2	4	2
2	Amausi	470	9	1037	21	2	2	1	2	2	4	2
3	Transport Nagar	253	5	1226	25	2	2	1	2	2	4	2
4	Krishnagar	946	19	1216	24	2	2	1	2	2	4	2
5	Singar Nagar	551	11	861	17	2	2	1	2	2	4	2
6	Alambagh	1132	23	1874	37	2	2	1	2	2	4	2
7	Alambagh Bus Stand	932	19	3055	61	2	2	1	1	2	4	2
8	MAWAIYA	4557	91	3821	76	3	3	1	5	2	4	2
9	Durgapuri	1748	35	1146	23	1	1	1	2	2	4	2
10	Lucknow Rly. Stn	3820	76	4237	85	3	2	1	4	2	4	2
11	Hussain Ganj	2472	49	769	15	2	2	1	2	2	4	2
12	Sachivalaya	389	8	442	9	2	2	1	2	2	4	2
13	Hazarat Ganj	484	10	577	12	2	2	1	2	2	4	2
14	KDSinghBabuStadium	263	5	617	12	2	2	1	2	2	4	2
15	Vishwavidyalaya	297	6	531	11	2	2	1	2	2	4	2
16	IT College Junction	593	12	231	5	0	0	1	1	2	4	2
17	Mahanagar	738	15	288	6	2	2	1	2	2	4	2
18	Badshah Nagar	228	5	91	2	2	2	1	0	2	4	2
19	Lekhraj Market	225	5	83	2	2	2	1	2	2	4	2
20	Ram Sagar Mishra Nagar	158	3	191	4	2	2	1	0	2	4	2
21	Indira Nagar	0	0	0	0	2	2	1	2	2	4	2
22	Munshipulia	0		0	0	2	2	1	2	2	4	2
	Total					**43**	**42**	**22**	**42**	**44**	**88**	**44**
	East-west Corridor											
1	Lucknow Railway station	3962	79	7639	153	3	5	1	4	2	4	2
2	Gautam Budha Marg	434	9	273	5	2	2	1	2	2	4	2
3	Aminabad	1615	32	1629	33	2	2	1	2	2	4	2
4	Pandeyaganj	2176	44	683	14	2	2	1	2	2	4	2
5	Lucknow City Railway station	786	16	638	13	2	2	1	2	2	4	2
6	Medical Chauraha	882	18	514	10	2	2	1	2	2	4	2
7	Nawabganj	1596	32	721	14	2	2	1	2	2	4	2
8	Thakurganj	730	15	273	5	2	2	1	2	2	4	2
9	Balaganj	535	11	377	8	2	2	1	2	2	4	2
10	Safaraganj	376	8	329	7	2	2	1	2	2	4	2
11	Musabagh	697	14	156	3	2	2	1	2	2	4	2
12	Vasantkunj	172	3	70	1	2	2	1	2	2	4	2
	Total					**25**	**27**	**12**	**25**	**24**	**48**	**24**

Assumptions:

1. 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.
2. One Disabled gate at each station.
3. Throughput of gate 30 passengers per minute, TOM 10 transactions per minutes.
4. Peak Minute traffic = 2% of peak hour traffic.
5. For Calclulation purpose, It is assumed that 50 % passenger will use Smart Card.

Chapter 11

Train Maintenance Depot

CHAPTER 11

DEPOT

11.1 LUCKNOW METRO SYSTEM COMPRISES OF FOLLOWING CORRIDORS:

S.N.	Name of Corridor	Gauge(mm)	Route Length(km)
1.	**North-South Corridor** CCS Airport -Munshi Pulia	1435	22.349
2.	**East-West Corridor** Lucknow Railway Station–Vasant Kunj	1435	11.304

11.2 Depot- cum- Workshop

It is proposed to establish one depot- cum- workshop near Transport Nagar for North South Corridor and one depot- cum- workshop near Vasant kunj for East West Corridor with following functions:

a) Depot- cum- workshop near Transport Nagar for North South Corridor

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

b) Depot- cum- workshop near Vasant Kunj for East West Corridor

(i) Major overhauls of all the trains of East- West Corridor except wheel pressing/ boring etc
(ii) All minor schedules and repairs of East- West Corridor.
(iii) Lifting for replacement of heavy equipment and testing thereafter of East- West Corridor.
(iv) Repair of heavy equipments of East- West Corridor.

The Depot planning near Transport Nagar for North South Corridor and near Vasant Kunj for East West Corridor is based on following assumptions:

(i) Enough space should be available near Transport Nagar for North South Corridor and near vasant kunj for East West Corridor for establishment of a Depot- Cum- workshop
(ii) All inspection, workshop lines and stabling lines are designed to accommodate one trainset of 6- car.
(iii) All stabling lines are planned in the proposed depot-cum-workshop assuming adequate space availability. In case of space constraint, if any, stabling facilities may need to be created at terminal stations or elsewhere to cater to the required stability facilities.

Provision of transfer line from one corridor to another corridor (which has not been planned at this stage), may be kept for future.

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

- Layout of Stabling-shed, Inspection-shed, minor repairs and heavy repair overhauling workshop and cleaning of Rolling Stock.
- Operational and functional safety requirements.
- Ancillary buildings for other maintenance facilities.
- Electrical & Mechanical Services, power supply and distribution system.
- Water Supplies, Drainage & Sewerage.

11.3 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.

11.4 ROLLING STOCK MAINTENANCE NEEDS

11.4.1 Maintenance Schedule

The following maintenance schedule has been envisaged for conceptual design of depots assuming average 300 kms earning for both corridors per train per day, taking in consideration the passenger load of 2015, 2020, 2025, 2030 & 2041 respectively.

Type of Schedule	Interval	Work Content	Locations
Daily	Daily	Check on the train condition and function at every daily service completion. Interval cleaning/mopping of floor and walls with vacuum cleaner.	Stabling Lines
"A" Service Check	5,000 Km (approx. 15 days)	Detailed inspection and testing of sub - systems, under frame, replacement/topping up of oils & lubricants.	Inspection Bays
"B" Service Check	15,000 Km (approx. 45 days)	Detailed Inspection of 'A' type tasks plus items at multiples of 15,000 Km ('B' type tasks)	Inspection Bays
Intermediate Overhaul (IOH)	420,000 Km, (3 and half Years approx.)	Check and testing of all sub-assemblies (Electrical + Mechanical). Overhaul of pneumatic valves, Compressor. Condition based maintenance of sub-systems to bring them to original condition. Replacement of parts and rectification, trial run.	Workshop
Periodical Overhaul (POH)	840,000 Km, (7 Years approx.)	Dismantling of all sub-assemblies, bogies suspension system, traction motor, gear, control equipment, air-conditioning units etc. Overhauling to bring them to original condition. Checking repair and replacement as necessary. Inspection and trial.	Workshop
Heavy Repairs	-	Changing of heavy item such as bogies, traction motor, axles, gear cases & axle boxes etc.	Workshop & Repair shop

The above Schedule may need slight revision based on the actual earned kilometers per train and the specific maintenance requirements of Rolling Stock finally procured.

11.4.2 Washing Needs of Rolling Stock

Cleanliness of the trains is essential. Following schedules are recommended for Indian environment:

S.N.	Kind Inspection	Maint. Cycle	Time	Maintenance Place
1.	Outside cleaning (wet washing on automatic washing plant)	3 Days	10 mins.	Single Pass through Automatic washing plant of Depot
2.	Outside heavy Cleaning (wet washing on automatic washing plant and Front Face, Vestibule/Buffer area. Floor, walls inside/outside of cars and roof. Manually)	30 days	2 – 3 hrs.	(Automatic washing plant & cleaning & washing shed)

Year-wise planning of maintenance facility setup at depot-cum-workshop based on planned Rolling Stock requirement in TOP is tabulated below:

(i) Planned rakes as per TOP:

a) Planned rakes as TOP for N- S Corridor:

Year	No. of Rakes	No. of coaches
2015	13	78
2020	18	108
2025	23	138
2030	30	180
2041	38	228

b) Planned rakes as TOP for E- W Corridor:

Year	No. of Rakes	No. of coaches
2015	7	42
2020	9	54
2025	12	72
2030	17	102
2041	20	120

(ii) Average earning/day/rake based on TOP:

a) Average earning/day/rake for N- S Corridor:

Year	Average earning/day/rake (KM)
2015	259
2020	295
2025	293
2030	314
2041	298

b) Average earning/day/rake for E- W Corridor:

Year	Average earning/day/rake (KM)
2015	259
2020	334
2025	373
2030	360
2041	397

(iii) Requirement of Stabling Lines (SBL), Inspection Lines (IBL) and Workshop Lines (WSL) in the Depot -cum –Workshop:

a) Requirement of Stabling Lines (SBL), Inspection Lines (IBL) and Workshop Lines (WSL) in the Depot -cum –Workshop at Transport Nagar for North South Corridor.

Year	No. of Trains	SBLs	IBLs	WSLs
2015	13	11 lines x one train of 6-car	One bay of three IBL for present with further provision to add one IBL. Each line will have capacity to accommodate 6 car trains.	One bay of 2 lines each with one train of 6-cars on each line and space earmarked for future extension of one bay of two lines
2020	18	16 lines x one train of 6-car	-do-	-do-
2025	23	21 lines x one train of 6-car	-do-	-do-
2030	30	28 lines x one train of 6-car	One bay of 4 lines each with one train of 6-cars	Two bay of 2 lines each with one train of 6-cars
2041	38	36 lines x one train of 6-car	-do-	-do-

All lines shall be suitable for placement of one train of 6-car trains on each line.

b) Requirement of Stabling Lines (SBL), Inspection Lines (IBL) and Workshop Lines (WSL) in the Depot -cum –Workshop at Vasant Kunj for East- West Corridor.

Year	No. of Trains	SBLs	IBLs	WSLs
2015	7	6 lines x one train of 6-car	One bay of two IBL for present with further provision to add one IBL. Each line will have capacity to accommodate 6 car trains.	One bay of 2 lines each with one train of 6-cars on each line
2020	9	7 lines x one train of 6-car	-do-	-do-
2025	12	10 lines x one train of 6-car	-do-	-do-
2030	17	15 lines x one train of 6-car	-do-	-do-
2041	20	18 lines x one train of 6-car	One bay of 3 lines each with one train of 6-cars	-do-

All lines shall be suitable for placement of one train of 6-car trains on each line.

11.5 REQUIREMENT OF MAINTENANCE / INSPECTION LINES FOR DEPOT-CUM-WORKSHOP

(a) Requirement of maintenance / Inspection lines in the depot-cum-workshop for N-S Corridor at Transport Nagar:

Schedule	Maintenance Requirement (No. of Cars)	Lines Needed
i) Year 2015 - Maximum no. of rake holding is 13 TS (13 X 6 Cars = 78 Cars)		
'A' Checks (5000 km) 15 days	13 X 6 Cars = 78 Cars	1 Line x one train of 6 cars (with Sunken Floor)
'B' Checks (15000 km) 45 days	13 X 6 Cars = 78 Cars	1 Line x one train of 6 cars (with Sunken Floor)
Unscheduled line & adjustment lines	For minor repairs, testing and after IOH/POH adjustments	1 Line x one train of 6 cars (with Sunken Floor)
Requirement		One bay of three IBL for present with

Schedule	Maintenance Requirement (No. of Cars)	Lines Needed
		further provision to add one IBL. Each line will have capacity to accommodate 6 car trains.
ii) Year 2020 - Maximum no. of rake holding is 18 TS (18 X 6 Cars = 108 Cars)		
'A' Checks (5000 km) 15 days	18 X 6 Cars = 108 Cars	1 Line x one train of 6 cars (with Sunken Floor)
'B' Checks (15000 km) 45 days	18 X 6 Cars = 108 Cars	1 Line x one train of 6 cars (with Sunken Floor)
Unscheduled line & adjustment lines	For minor repairs, testing and after IOH/POH adjustments	1 Line x one train of 6 cars (with Sunken Floor)
Requirement		One bay of three IBL for present with further provision to add one IBL. Each line will have capacity to accommodate 6 car trains.
iii) Year 2025 - Maximum no. of rake holding is 23 TS (23 X 6 Cars = 138 Cars)		
'A' Checks (5000 km) 15 days	23 X 6 Cars = 138	1 Line x one train of 6 cars (with Sunken Floor)
'B' Checks (15000 km) 45 days	23 X 6 Cars = 138	1 Line x one train of 6 cars (with Sunken Floor)
Unscheduled line & adjustment lines	For minor repairs, testing and after IOH/POH adjustments	1 Line x one train of 6 cars (with Sunken Floor)
Requirement		One bay of three IBL for present with further provision to add one IBL. Each line will have capacity to accommodate 6 car trains.
iv) Year 2030 - Maximum no. of rake holding is 30 TS (30 X 6 Cars = 180 Cars)		
'A' Checks (5000 km) 15 days	30 X 6 Cars = 180 Cars	2 Line x one train of 6 cars (with Sunken Floor)
'B' Checks (15000 km) 45 days	30 X 6 Cars = 180 Cars	1 Line x one train of 6 cars (with Sunken Floor)
Unscheduled line & adjustment lines	For minor repairs, testing and after IOH/POH adjustments	1 Line x one train of 6 cars (with Sunken Floor)
Requirement		One bay of 4 lines each with one train of 6-cars
v) Year 2041 - Maximum no. of rake holding is 38 TS (38 X 6 Cars = 228 Cars)		
'A' Checks (5000 km) 15 days	38 X 6 Cars = 228 Cars	2 Line x one train of 6 cars (with Sunken Floor)

Schedule	Maintenance Requirement (No. of Cars)	Lines Needed
'B' Checks (15000 km) 45 days	38 X 6 Cars = 228 Cars	1 Line x one train of 6 cars (with Sunken Floor)
Unscheduled line & adjustment lines	For minor repairs, testing and after IOH/POH adjustments	1 Line x one train of 6 cars (with Sunken Floor)
Requirement		One bay of 4 lines each with one train of 6-cars

All lines shall be suitable for placement of one train of 6-car trains on each line.

(b) Requirement of maintenance / Inspection lines in the Depot-cum-workshop for E-W Corridor at Vasant Kunj:

Schedule	Maintenance Requirement (No. of Cars)	Lines Needed
i) Year 2015 - Maximum no. of rake holding is 7 TS (7 X 6 Cars = 42 Cars)		
'A' Checks (5000 km) 15 days	7 X 6 Cars = 42 Cars	1 Line x one train of 6 cars (with Sunken Floor)
'B' Checks (15000 km) 45 days and Unscheduled line & adjustment lines	7 X 6 Cars = 42 Cars, and for minor repairs, testing and after IOH/POH adjustments	1 Line x one train of 6 cars (with Sunken Floor)
Requirement		One bay of two IBL for present with further provision to add one IBL. Each line will have capacity to accommodate 6 car trains.
ii) Year 2020- Maximum no. of rake holding is 9 TS (9 X 6 Cars = 54 Cars)		
'A' Checks (5000 km) 15 days	9 X 6 Cars = 54 Cars	1 Line x one train of 6 cars (with Sunken Floor)
'B' Checks (15000 km) 45 days and Unscheduled line & adjustment lines	79X 6 Cars = 54 Cars, and for minor repairs, testing and after IOH/POH adjustments	1 Line x one train of 6 cars (with Sunken Floor)
Requirement		One bay of two IBL for present with further provision to add one IBL. Each line will have capacity to accommodate 6 car trains.

iii) Year 2025 - Maximum no. of rake holding is 12 TS (12 X 6 Cars = 72 Cars)		
'A' Checks (5000 km) 15 days	12X 6 Cars = 72 Cars	1 Line x one train of 6 cars (with Sunken Floor)
'B' Checks (15000 km) 45 days and Unscheduled line & adjustment lines	12X 6 Cars = 72 Cars, and for minor repairs, testing and after IOH/POH adjustments	1 Line x one train of 6 cars (with Sunken Floor)
Requirement		One bay of two IBL for present with further provision to add one IBL. Each line will have capacity to accommodate 6 car trains.
iv) Year 2030 - Maximum no. of rake holding is 17 TS (17 X 6 Cars =102 Cars)		
'A' Checks (5000 km) 15 days	17 X 6 Cars = 102 Cars	1 Line x one train of 6 cars (with Sunken Floor)
'B' Checks (15000 km) 45 days and Unscheduled line & adjustment lines	17 X 6 Cars=102 Cars, and for minor repairs, testing and after IOH/POH adjustments	1 Line x one train of 6 cars (with Sunken Floor)
Requirement		One bay of two IBL for present with further provision to add one IBL. Each line will have capacity to accommodate 6 car trains.
v) Year 2041 - Maximum no. of rake holding is 20 TS (20X 6 Cars = 120 Cars)		
'A' Checks (5000 km) 15 days	20X 6 Cars = 120 Cars	1 Line x one train of 6 cars (with Sunken Floor)
'B' Checks (15000 km) 45 days	20X 6 Cars = 120 Cars	1 Line x one train of 6 cars (with Sunken Floor)
Unscheduled line & adjustment lines	For Minor repairs, testing and after IOH/POH adjustments	1 Line x one train of 6 cars (with Sunken Floor)
Requirement		One bay of 3 lines each with one train of 6-cars

All lines shall be suitable for placement of one train of 6-car trains on each line.

11.6 INSPECTION REQUIREMENTS AT DEPOTS FOR NORTH SOUTH CORRIDOR AND FOR EAST WEST CORRIDOR:

Facilities for carrying out inspection activitities shall be provided in the inspection bay for following Systems / Equipments of a train:

- Electronics; PA/PIS
- Mechanical components, couplers etc
- Batteries
- Air conditioner
- Brake modules
- Bogie
- Traction Motor
- Vehicle doors, windows and internal fittings
- Power system including converter, circuit breaker etc.

These activities shall be grouped into “A” checks and “B” checks. The minor scheduled inspections (“A” checks) shall be carried out during the day off peak and night. Since “B” checks take longer time, these cannot be completed in the off peak times. Certain inspection lines will be nominated for “A” checks. For “B” checks, separate line will be nominated where the rakes may be kept for long time.

One dedicated line in the shed will be used for minor repairs and for adjustment and testing after the IOH and POH. There shall be a spare line in inspection bay for this purpose.

11.7 DESIGN OF STABLING, INSPECTION AND WORKSHOP LINES

As per advised dimensions of the Rolling Stock, the length of 6-Car train would be Approx. 135.6 mts. (say 136 mts). For the design of the inspection/stabling/workshop lines in the depots and at terminal stations, the following lengths have been taken in consideration:

11.7.1 Stabling lines at depot near Transport Nagar for North South Corridor and near vasant kunj for East West Corridor:

For the design of the stabling lines in the depot and terminal stations or elsewhere (as may be required), following approximates lengths have been taken in consideration:

(i) Length of one 6- car train= 136 m

(ii) Free length at outer ends of one train of 6- cars (for cross pathway, Signal and Friction buffers)= 10m each side

(iii) Total length of Stabling lines = (i)+(ii)+(i)= 10+ 136 + 10 = 156

Looking to the car width of 2900mm on SG, 5m "Track Centre" is proposed for all the stabling lines. Thus, space between stabling shall be sufficient to include 1 mt. wide pathway to be constructed between tracks to provide access for internal train cleaning and undercarriage inspection with provision of following facilities:

a) Each Stabling line to have water connection facility so that local cleaning, if required, is facilitated.

b) Platforms at suitable points at each end of stabling lines to enable train operators to board or de- board conveniently.

11.7.2 Inspection Bay at depot-cum-workshop at Transport Nagar for N- S Corridor and depot-cum- workshop at vasant kunj for East- west corridor:

A) Inspection Bay at depot-cum-workshop at Transport Nagar for N- S Corridor:

The length of Inspection shed is computed as below:

(i) Length of a 6-car train= 136 m.

(ii) Cross- path at each end= 10 m

(iii) Length of Inspection line= (i)+(ii)+ (i) = 10+ 136 + 10= 156 m

The width of the Inspection bay in computed as below:

(i) Centre – to- centre spacing between the three lines= 7.5 m

(ii) Centre line of outer lines to column of Shed= 3.25 m

(iii) Width of a 4 line Inspection Bay= (ii)+(i)+(i)+(i)+(ii)= 3.25+ 7.5+ 7.5+ 7.5+3.25= 29 m

a) There shall be one inspection bay of 156 m X 29 m size with provision of accommodating four inspection lines (three IBL for present with further provision to add one IBL) each having sunken floor and overhead roof inspection platforms at each of the depot. The floor will be sunken by 1100mm. The track spacing between the adjacent IBLs shall be 7.5 m.

b) Roof Inspection platforms and walkways for roof inspection supported on the columns shall be provided. There would be lighting below the rail level to facilitate the under frame inspection. Ramps of 1:8 slopes, 3 meter wide should be provided with sunken floor system for movement of material for the cars. Further, 10m cross pathways are left at each end for movement of material by fork lifter/Leister/Hand trolley. 415V 3 phase 50 Hz, 230V 1 phase 50 Hz AC supply and Pneumatic supply shall also be made available on each inspection shed columns. Air-circulators shall be provided on each column. The inspection bay shall be provided with EOT crane of 1.5 T to facilitate lifting of equipment.

Roof and walls shall be of such design that optimum natural air ventilation occurs all the time and sufficient natural light is also available. Each Inspection bay will also have arrangement close by for cleaning of HVAC filter under high pressure water jet.

B) Inspection Bay at depot-cum-workshop at vasant kunj for E- W Corridor:

The length of Inspection shed is computed as below:

(i) Length of a 6-car train= 136 m.

(ii) Cross- path at each end= 10 m

(iii) Length of Inspection line= (i)+(ii)+ (i) = 10+ 136 + 10= 156 m

The width of the Inspection bay in computed as below:

(i) Centre – to- centre spacing between the three lines= 7.5 m

(ii) Centre line of outer lines to column of Shed= 3 m

(iii) Width of a three line Inspection Bay= (ii)+(i)+(i)+(ii)= 3+7.5+7.5+ 3= 21 m

a) There shall be one inspection bay of 156 m X 21 m size with provision of accommodating three inspection lines (two IBL for present with further provision to add one IBL) each having sunken floor and overhead roof inspection platforms at each of the depot. The floor will be sunken by 1100mm. The track spacing between the adjacent IBLs shall be 7.5 m.

b) Roof Inspection platforms and walkways for roof inspection supported on the columns shall be provided. There would be lighting below the rail level to facilitate the under frame inspection. Ramps of 1:8 slopes, 3 meter wide should be provided with sunken floor system for movement of material for the cars. Further, 10m cross pathways are left at each end for movement of material by fork lifter/Leister/Hand trolley. 415V 3 phase 50 Hz, 230V 1 phase 50 Hz AC supply and Pneumatic supply shall also be made available on each inspection shed columns. Air-circulators shall be provided on each column. The inspection bay shall be provided with EOT crane of 1.5 T to facilitate lifting of equipment.

   Roof and walls shall be of such design that optimum natural air ventilation occurs all the time and sufficient natural light is also available. Each Inspection bay will also have arrangement close by for cleaning of HVAC filter under high pressure water jet.

11.7.3 Workshop shed depots near Transport Nagar for North South Corridor and near vasant kunj for East West Corridor :

(a) There shall be one bay comprising of two lines each with capacity to accommodate one train of 6-cars on each line and space earmarked for future extension of one bay of two lines for North- South Corridor in Transport Nagar depot- cum- workshop (as detailed in 11.5 (iii) (a) above) and one bay comprising of two lines for East-West Corridor in vasant kunj depot- cum- workshop (as detailed in 11.5 (iii) (b) above). Size of the workshop bay of two lines is proposed to be 156m x 21m. The unscheduled lifting and heavy repair line shall be fitted with jack system capable to lift the 6-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. Each workshop bay shall be equipped with two trains 15T and 3T overhead cranes, each spanning the entire length of the workshop bay.

(b) There shall be provided space for repairs of HVAC, Door, and Traction motor etc. repairs. Distinct spaces shall be earmarked for dismantling/repairs/ assembling and testing of each of these equipments. Related machinery for Overhauling / Repairs & testing activities of every equipment are also to be housed in the space earmarked.

(c) There shall be washing and cleaning equipments on the workshop floor. Bogie test stand shall be provided in the workshop. Other heavy machinery shall also be suitably installed on the workshop floor. Air-circulators, lights, Powers supply points and compressed air supply line shall be provided on each workshop column.

(d) Workshop lines shall be inter-linked through turn tables, each suitable for movement of a train in AWo (unloaded) condition and shall also be capable to rotate with a fully loaded bogie on it. Repair of heavy equipments such as air conditioners shall be so located so that it does not affect the movement inside workshop.

(e) There shall be walkways on columns for roof inspections, along the workshop lines. These walkways shall not infringe with cars being lifted/ lowered by means of mobile jacks. Suitable space between the nearest exterior of a car and farthest edge of the walkway has to be ensured to avoid conflict in lifting and lowering of cars.

(f) The small component, bogie painting and battery maintenance cells will be located in the workshop with arrangement that fumes are extracted by suitable exhaust systems.

(g) Workshop will have service building with array of rooms along its length. Total size is proposed to be 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 trains opposite sides widthwise shall be open to facilitate natural air circulation and cross ventilation besides the egress & ingress for coaches. The sidewalls shall also have sufficient width of louvers for providing adequate ventilation.

(h) There shall be space for bogie/ axle repair shop with necessary infrastructure for disassembly, overhead, assembly and testing of mechanical components of bogies/ axle. The repair shop shall be easily approachable from with the workshop for transportation of components.

Following equipment repair/overhaul facilities are planned in the workshop and wheel repairs shop at the workshops depots near Transport Nagar for North South Corridor and near vasant kunj for East West Corridor:

1. Body furnishing
2. Bogie
3. Wheels
4. Traction Motors
5. Axle Box and Axle Bearing
6. Pantographs
7. Transformer, converter/inverter, circuit breaker
8. Battery
9. Air Compressor
10. Air-conditioner
11. Brake Equipment
12. Door actuators
13. Control and measuring equipments
14. Pneumatic equipment
15. Dampers and Springs
16. Couplers/Gangways
17. Coach Painting (Applicable only for Aluminum coaches, if any)

11.8 CAR DELIVERY AREA

There shall be rail connectivity between the Depot-cum- Workshop and mainline and all trains due for scheduled/ unscheduled works shall reach the depot-cum- Workshop by rail.

However in case of newly procured coaches, which are transported by road, these shall reach the Depot-cum Workshop by the road on trailers. To unload the coaches and bring them to the track, provision of space, along the side of shunting neck, has to be made for unloading of cars and other heavy materials. This area shall have an insulated track embedded in the floor facilitating the movement of road trawler, which brings in the cars. The length of the track embedded area shall be about 40m long. There should be enough space available for movement of heavy cranes for lifting of coaches. The unloading area should be easily accessible for heavy duty hydraulic trailers.

11.9 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.

11.10 INFRASTRUCTURE FACILITIES IN DEPOTS NEAR TRANSPORT NAGAR FOR NORTH SOUTH CORRIDOR AND NEAR VASANT KUNJ FOR EAST WEST CORRIDOR:

I. Inspection and Workshop facilities:

As indicated in 11.8.2 & 11.8.3 above.

II. Stabling Lines in Depot:

a) The requirement of lines shall be in accordance with the details indicated in para 11.8.1 above. A part of the stabling siding in the depot shall be covered with a roof in order to facilitate testing of air conditioning of trains and their pre-cooling under controlled condition of temperature.

b) Separate toilets adjustment to stabling lines shall be provided with small room for keeping cleaning aids and for utilization by the working staff.

III. Automatic Coach Washing Plant (AWP)

Provision to be made for Rolling Stock exterior surfaces to be washed using a fully automated Train Washing System, with a throughput capacity of approximately ten trains per hour. The AWP shall be situated at such a convenient point on the incoming route so that incoming trains can be washed before entry to the depot and undesirable movement/shunting over ingress and egress routes within the depot is avoided. Additional space for plant room for AWP system shall be earmarked alongside the washing apron as indicated at S. No. 6 of Para 11.12.1 (a) & 11.12.1 (b).

IV. Train Operators Booking Office

Suitable office facility adjacent to the stabling lines at each depot should be provided so that train operators reporting 'On' duty or going 'Off' duty can obtain updates regarding 'Special Notices', 'Safety Circulars' and other technical updates/information in vogue. These offices should have an attached a cycle/scooter/car stand facility for convenience of the train operating staff.

V. Test Track

A test track of 1000 mts. in length covered & fenced should be provided beside workshop in the depot. It shall be equipped with signaling equipments (ATP/ATO). It shall be used for the commissioning of the new trains, their trials and testing of the trains after the IOH and POH. Entry into the test track shall be planned for a 3-car train. In compliance to safety norms, the boundary of the track shall be completely fenced to prevent unauthorized trespassing across or along the track.

VI. Heavy Cleaning Shed

Monthly heavy cleaning of interior walls, floors, seats, windows glasses etc, outside heavy cleaning, Front/rear Face, Vestibule/ Buffer area, outside walls and roof shall be done manually in the interior cleaning plant designed for cleaning of one at a time. A line adjacent to inspection shed should be so provided that placement of rakes is possible from workshop or inspection lines & vice – versa conveniently and with ease.

VII. Power Supply

Auxiliary substations are planned for catering to the power supply requirement of the whole depot and workshop. Details of connected load feeder shall be worked out. Taking diversity factor of 0.5 the maximum demands shall be computed. Two trains Auxiliary substations are proposed, as the demand by machines in Workshop area would be very large. The standby power supply is proposed through DG set with AMF panel. The capacity of DG set will be adequate to supply all essential loads without over loading.

VIII. Compressed Air Supply

Silent type compressor units shall be suitably installed inside the depots at convenient location for the supply of compressed air to workshop and Inspection sheds. Thus, the pneumatic pipeline shall run within the workshop and inspection bays as to have compressed air supply line at all convenient points.

IX. Water Supply, Sewerage and Drainage Works

In house facilities shall be developed for the water supply of each depot. Sewerage, storm water drainage shall be given due care while designing the depots for efficient system functioning. Past records of Municipal Corporation shall be used to design the drainage system. Rainwater harvesting would be given due emphases to charge the 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 25 kV feed system.

XI. Watch Towers

There shall be provision of adequate number of watchtowers for the vigilance of depot boundary.

XII. Administrative Building

An administrative building close to the main entrance is planned. It can be suitably sized and architecturally designed at the detailed design stage. A time and security office is also provided close to main entrance. It shall be equipped with suitable Access control system for all the staff working in the complex.

XIII. Parking Facilities

a) Ample parking space shall be provided for the two trains wheelers and four wheelers at the following points.
   i) Close to the depot entry.
   ii) Close to the stabling lines.
   iii) Close to the Workshop/IBL.

b) Space for parking of road and re-railing equipments
   Enough space for parking of road vehicle/ trailers/ trucks etc. Enough space will also have to be earmarked adjacent to workshops. Similarly, provision of space for parking of re-railing equipments will have to be made close to the main exit gate of the Depot.

XIV. Shed and Buildings

The shed and buildings normally provided in the depot with their sizes and brief functions are indicated in Para 11.12.1 (a) & 11.12.1 (b). At the detailed design stage depending upon the land availability, the decision to locate these buildings can be taken. These can then be architecturally and functionally grouped.

XV. Plant and Machinery

a) A separate building is planned for housing pit wheel lathe (PWL), approachable from workshop, inspection bay and stabling lines through rail and road for placement of cars for re- profiling of wheels within the depot along with space for depot of scrap.

b) Requirement of buildings and major plants and machinery, is given in Para 11.12.1(a), 11.12.1 (b), Para 11.12.2 (a) & 11.12.2(b).

11.10.1 Following Safety features should be incorporated in the design of the Maintenance Depot-cum-Workshop near Transport Nagar for North South Corridor and near Vasant Kunj for East West Corridor:

a) 1.5 EOT cranes in the inspection bay should be interlocked with 25 kV ac OHE in such a way that, the cranes become operational only when the OHE is isolated and grounded.

b) Red flasher lights should be installed along the inspection lines at conspicuous location to indicate the OHE is 'Live'.

c) Multi level wheel and TM stacking arrangement should be an inbuilt feature at the end of Workshop Lines.

d) Pillars in the inspection bay & workshop should have provision for power sockets.

e) Placement of rakes from inspection/workshop lines on to washing lines for interior cleaning on their own power should be possible. Linking of OHE and its isolation at the cleaning area should be provided. Necessary requirements of safety should be kept in view.

f) The roof inspection platform should have open-able doors to facilitate staff to go up the roof for cleaning of roof. Suitable safety interlock should be provided to ensure maintenance staff are enabled to climb on the roof inspection platform only after the OHE is isolated.

g) Control Centre, PPIO & store depot must be close to Workshop.

h) Width of the doors of the sections wherein repairs of equipments are done should be at least 2 meters wide to allow free passage of equipment through them.

i) Provision of water hydrants should be done in workshops & stabling yards also.

j) Compressed air points along with water taps should be available in interior of buildings for cleaning.

k) Ventilation arrangement inside the inspection shed and workshop should be ensured. Arrangement for natural cross ventilation from one side to another of inspection & workshop bays to be incorporated along with optimum availability of natural light at floor level.

11.11 LIST OF BUILDINGS & LIST OF PLANTS & EQUIPMENTS AT DEPOT-CUM-WORKSHOP:

11.11.1 (a) List of Buildings at Depot- Cum- Workshop near Transport Nagar for North South Corridor :

S.No	Name of Building	Size	Remarks
1.	Inspection Shed	156m x 29m	Servicing of Cars for 15 days & 45 days inspection. [One bay of three IBL for present with further provision to add one IBL. Each line will have capacity to accommodate 6 car trains.]
	Workshop Shed	156m x 21m [One bay of two line each]	Major repair & overhaul of rolling stocks, diesel shunters, electric tractors, tower wagons. All heavy lifting jobs. [One bay of 2 lines each with one train of 6-cars on each line and space earmarked for future extension of one bay of two lines. Each line will have capacity to accommodate 6 car trains.]
	Associated Sections	156m x 8m	Rooms for carrying out the inspection & workshop activity.
	Stabling line shed	156m x 185m (for 38 trains)	Provisional for total area as per requirement of stabling of 38 rakes during year 2041 is to be made (with initial provision for 13 rakes only).
2.	Stores Depot & Offices including Goods Platform with Ramp	45m x 45m	i. Stocking of spares for regular & emergency requirement including consumable items. ii. This store caters for the requirement of depot for rolling stock & other disciplines. iii. To be provided with computerized inventory control. iv. Loading/Unloading of material received by road.
3.	Elect. Substation & DG set room	20m x 15m	To cater for normal and emergency power supply for depot, workshop, service and all other ancillary buildings, essential power supply for essential loads and security light.
4.	Traction repair depot and E &M repair shop	80m x 30m (partly double storey)	Stabling and routine maintenance of shunting engine etc. & Traction maintenance depot. For maintenance of lifts/escalators and other

S.No	Name of Building	Size	Remarks
			General service works.
5.	Cycle / Scooter / Car Parking	100m x 6m 60m x 6m	i. Close to the depot entry. ii. Close to the stabling lines.
6.	Auto coach washing plant	40m x 10m	For automatic washing of coaches. Provision of Washing apron for collection of dripping water and its proper drainage to be ensured.
7.	Washing apron for Interior Cleaning	166m x 6.5m	Heavy wet washing of rakes from inside, under frame, roof at 30 days interval.
8.	P-way office, store & Workshop including Welding plant	80m x 20m	i. For track maintenance of section and depot. ii. To weld rails for construction period only. iii. To stable track Tamping machine.
9.	Security office & Time Office Garages (4 Nos.)	15m x 8m	For security personnel. For time punching For parking vehicle jeep, truck etc.
10.	Check Post (2 Nos.)	5m x 3m	For security check of incoming/outgoing staff material and coaches.
11.	Watch Tower (4 Nos.)	3.6m x2.5 m	For security of the depot especially during night time.
12.	Depot control centre & Crew booking centre	25mx20m (double storey)	To control movement of trains in and out of the depot and for crew booking.
13.	O.H raw water Tank	1,00,000 Ltrs. Capacity	For Storage of water.
14.	Pump house Bore well	7.3mx5.4m (200 mm bore)	Submersible type pump planned with 200 mm diameter bore well.
15.	Dangerous goods Store	15m x 10m	For Storage of paints, inflammables & Lubricants
16.	a)Traction 25/33kV/66kV sub	a)120m x 80m	Traction Power Supply

S.No	Name of Building	Size	Remarks
	station b) Feeding Post	b) 15m x30m	
17.	Waste Collection Bin	10m x 10m	Garbage dumping
18.	Repair shops for S & T	40m x 20m	For the AFC gates, Signaling and telecom equipment.
19.	Work shop Manager Office	30m x 20m	Office of Depot in charge
20.	ATP & ATO Room	10m x 8m	To keep equipments of ATP/ATO
21.	Waste Water Treatment Plant	12m x 6m	For treating the discharge waters of the depot and remove the oil, acids etc. before discharging into the river, with U/G tank.
22.	Canteen	200 sqm.	To cater staff of depot and workshop. Should be in a separate building with modern kitchen ware and facilities. Obligatory as per statutory requirements.
23.	Toilets -Gents -Ladies	10m x 7m 10m x 7m	These toilets shall be approachable both from workshop as well as from inspection bay and ladies toilets shall be completely insulated from gent's toilet.

11.12.1 (b) List of Buildings at Depot- Cum- Workshop near vasant kunj for East West Corridor:

S.No	Name of Building	Size	Remarks
1.	Inspection Shed	156m x 21m	Servicing of Cars for 15 days & 45 days inspection. [One bay of two IBL for present with further provision to add one IBL. Each line will have capacity to accommodate 6 car trains.]
	Workshop Shed	156m x 21m	Major repair & overhaul of rolling stocks, diesel shunters, electric tractors, tower wagons. All heavy lifting jobs. [One bay of two line each with capacity to accommodate one

S.No	Name of Building	Size	Remarks
			train of 6 cars on each line]
	Associated Sections	156m x 8m	Rooms for carrying out the inspection & workshop activity.
	Stabling line shed	156m x 95m (for 20 trains)	Provisional for total area as per requirement of stabling of 20 rakes during year 2041 is to be made (with initial provision for 7 rakes only).
2.	Stores Depot & Offices including Goods Platform with Ramp	45m x 45m	i. Stocking of spares for regular & emergency requirement including consumable items. ii. This store caters for the requirement of depot for rolling stock & other disciplines. iii. To be provided with computerized inventory control. iv. Loading/Unloading of material received by road.
3.	Elect. Substation & DG set room	20m x 15m	To cater for normal and emergency power supply for depot, workshop, service and all other ancillary buildings, essential power supply for essential loads and security light.
4.	Traction repair depot and E &M repair shop	80m x 30m (partly double storey)	Stabling and routine maintenance of shunting engine etc. & Traction maintenance depot. For maintenance of lifts/escalators and other General service works.
5.	Cycle / Scooter / Car Parking	100m x 6m 60m x 6m	iii. Close to the depot entry. iv. Close to the stabling lines.
6.	Auto coach washing plant	40m x 10m	For automatic washing of coaches. Provision of Washing apron for collection of dripping water and its proper drainage to be ensured.
7.	Washing apron for	166m x 6.5m	Heavy wet washing of rakes from inside,

S.No	Name of Building	Size	Remarks
	Interior Cleaning		under frame, roof at 30 days interval.
8.	P-way office, store & Workshop including Welding plant	80m x 20m	iv. For track maintenance of section and depot. v. To weld rails for construction period only. vi. To stable track Tamping machine.
9.	Security office & Time Office Garages (4 Nos.)	15m x 8m	For security personnel. For time punching For parking vehicle jeep, truck etc.
10.	Check Post (2 Nos.)	5m x 3m	For security check of incoming/outgoing staff material and coaches.
11.	Watch Tower (4 Nos.)	3.6m x2.5 m	For security of the depot especially during night time.
12.	Depot control centre & Crew booking centre	25mx20m (double storey)	To control movement of trains in and out of the depot and for crew booking.
13.	O.H raw water Tank	1,00,000 Ltrs. Capacity	For Storage of water.
14.	Pump house Bore well	7.3mx5.4m (200 mm bore)	Submersible type pump planned with 200 mm diameter bore well.
15.	Dangerous goods Store	15m x 10m	For Storage of paints, inflammables & Lubricants
16.	a)Traction 25/33kV/66kV sub station b) Feeding Post	a)120m x 80m b) 15m x30m	Traction Power Supply
17.	Waste Collection Bin	10m x 10m	Garbage dumping
18.	Repair shops for S & T	40m x 20m	For the AFC gates, Signaling and telecom equipment.
19.	Work shop Manager	30m x 20m	Office of Depot in charge

S.No	Name of Building	Size	Remarks
	Office		
20.	ATP & ATO Room	10m x 8m	To keep equipments of ATP/ATO
21.	Waste Water Treatment Plant	12m x 6m	For treating the discharge waters of the depot and remove the oil, acids etc. before discharging into the river, with U/G tank.
22.	Canteen	200 sqm.	To cater staff of depot and workshop. Should be in a separate building with modern kitchen ware and facilities. Obligatory as per statutory requirements.
23.	Toilets -Gents -Ladies	 10m x 7m 10m x 7m	These toilets shall be approachable both from workshop as well as from inspection bay and ladies toilets shall be completely insulated from gent's toilet.

11.12.2 (a)List of Plants & Equipments at Depot-cum-Workshop near Transport Nagar for North South Corridor:

S. No.	Equipment	Qty.	Unit
1.	Under floor Pit wheel lathe, Chip crusher and conveyor for lathe on pit, Electric tractor for movement over under floor wheel lathe	1	No.
2.	Under floor lifting systems for 3-car unit for replacement of bogie	1	Set
3.	Mobile jacks 15T for lifting cars (set of 12 jacks)	1	No.
4.	Rerailing equipment consisting of rail cum road vehicle and associated jack system etc.	1	Set
5.	Run through type Automatic Washing plant for Metro cars.	1	No.
6.	Rail fed Bogie wash plant	1	No.
7.	Bogie test stand	1	No.
8.	Work lift platform	4	No.

S. No.	Equipment	Qty.	Unit
9.	Electric bogie tractor for pulling cars and bogies inside workshop	1	No.
10.	Chemical cleaning tanks, ultrasonic cleaning tanks, etc	1	Set
11.	Compressor for Inspection shed & shop air supply	2	No.
12.	(i) Travelling O/H crane Workshop 15T/3 T (ii) 1.5T Capacity (IBL):- 2 Nos.	2 2	No. No.
13.	Mobile jib crane	2	No.
14.	Mobile lifting table	4	No.
15.	Carbody stands	24	No.
16.	Bogie turn tables	2	No.
17.	Underframe & Bogie blowing plant & small parts/equipment	2	No.
18.	AC filter cleaning machine	1	No.
19.	Portable cleaning plant for rolling stock	1	No.
20.	High-pressure washing pump for front and rear end cleaning of car	2	No.
21.	Industrial furniture (Work Test Benches)	1	L.s.
22.	Minor diagnostic equipment and collective tools		Set
23.	Induction heater	1	No.
24.	Oven for the motors	1	No.
25.	EMU battery charger	2	No.
26.	Welding equipments (Mobile welding, oxyacetylene, fixed arc welding)	2	Set
27.	Electric and pneumatic tools		Set
28.	Measuring and testing equipment		Set
29.	Tool Kits		Set

S. No.	Equipment	Qty.	Unit
30.	Mobile safety steps	12	No.
31.	Fork lift tractor	2	No.
32.	Pallet trucks	6	No.
33.	RRV	1	
34.	Road vehicles (pickup van/ truck)	1	Set
35.	Miscellaneous office equipments		Set
36.	Vertical Boring Mainline for wheel discs	1	No.
37.	Press for removal and pressing of the wheel on axles	1	No.
38.	Axle journal turning and burnishing lathe	1	No.
39.	Special jigs and fixtures and test benches for Rolling Stock	1	set
40.	Stackers (1T for DCOS)	2	No.
41.	Storage Racks (W/shop & DCOS stores)	1	Set
42.	Test benches	1	Set
43.	Auto panto strip thickness meter		
44.	Vehicle mounted crane		
45.	Impulse Tester for TMs		
46.	Bearing puller		

11.12.2 (b)List of Plants & Equipments at Depot-cum-Workshop near vasant kunj for East West Corridor*:*

S. No.	Equipment	Qty.	Unit
1.	Under floor Pit wheel lathe, Chip crusher and conveyor for lathe on pit, Electric tractor for movement over under floor wheel lathe	1	No.

S. No.	Equipment	Qty.	Unit
2.	Under floor lifting systems for 3-car unit for replacement of bogie	1	Set
3.	Mobile jacks 15T for lifting cars (set of 12 jacks)	1	No.
4.	Rerailing equipment consisting of rail cum road vehicle and associated jack system etc.	1	Set
5.	Run through type Automatic Washing plant for Metro cars.	1	No.
6.	Rail fed Bogie wash plant	1	No.
7.	Bogie test stand	1	No.
8.	Work lift platform	4	No.
9.	Electric bogie tractor for pulling cars and bogies inside workshop	1	No.
10.	Chemical cleaning tanks, ultrasonic cleaning tanks, etc	1	Set
11.	Compressor for Inspection shed & shop air supply	2	No.
12.	(i) Travelling O/H crane Workshop 15T/3 T (ii) 1.5T Capacity (IBL):- 2 Nos.	2 2	No. No.
13.	Mobile jib crane	2	No.
14.	Mobile lifting table	4	No.
15.	Carbody stands	24	No.
16.	Bogie turn tables	2	No.
17.	Underframe & Bogie blowing plant & small parts/equipment	2	No.
18.	AC filter cleaning machine	1	No.
19.	Portable cleaning plant for rolling stock	1	No.
20.	High-pressure washing pump for front and rear end cleaning of car	2	No.
21.	Industrial furniture (Work Test Benches)	1	L.s.
22.	Minor diagnostic equipment and collective tools		Set

S. No.	Equipment	Qty.	Unit
23.	Induction heater	1	No.
24.	Oven for the motors	1	No.
25.	EMU battery charger	2	No.
26.	Welding equipments (Mobile welding, oxyacetylene, fixed arc welding)	2	Set
27.	Electric and pneumatic tools		Set
28.	Measuring and testing equipment		Set
29.	Tool Kits		Set
30.	Mobile safety steps	12	No.
31.	Fork lift tractor	2	No.
32.	Pallet trucks	6	No.
33.	RRV	1	
34.	Road vehicles (pickup van/ truck)	1	Set
35.	Miscellaneous office equipments		Set
36.	Axle journal turning and burnishing lathe	1	No.
37.	Special jigs and fixtures and test benches for Rolling Stock	1	set
38.	Stackers (1T for DCOS)	2	No.
39.	Storage Racks (W/shop & DCOS stores)	1	Set
40.	Test benches	1	Set
41.	Auto panto strip thickness meter		
42.	Vehicle mounted crane		
43.	Impulse Tester for TMs		
44.	Bearing puller		

Chapter 12

Environmental Impact Assessment

CHAPTER – 12

ENVIRONMENTAL IMPACT ASSESSMENT

12.1 BACKGROUND

Lucknow is the capital city of Uttar Pradesh, the most populous state of India. Lucknow had a population of 22.45 lakh in 2001 and 29.08 lakh in 2011. The Lucknow Metro is being proposed to strengthen public transport system in the city.

Any environment has a limited carrying capacity and it can only sustain negative impact up to a level without further degradation. But sensitive systems are not so resilient to cope up with changes in physical and natural environment, thus leading to negative impact and socio-economic losses. The railway development projects, like any other projects, have certain adverse, as well as, beneficial impacts on biophysical and social environment. Though railway projects do not come under the preview of environmental clearance from Ministry of Environment and Forest, Government of India, the Environmental Impact Assessment provides tools for decision-making, as well as, it also help in ensuring the sustainable development with least environmental damage by providing proper Environmental Management Plan.

12.2 OBJECTIVE

The objective of EIA study is to assess the following components.

i. To determine the baseline quality of various environmental components along the proposed corridor.

ii. To establish the general nature and categorization of potential impacts due to the project activities.

iii. To identify suitable Mitigation measures for all the potential impacts envisaged due to the proposed project

iv. To formulate an effective Environmental Management Plan for ensuring successful implementation of all the measures suggested during various stages of the project to avoid, mitigate or minimize the adverse impact due to the project.

v. To ensure that all the statutory requirements are met with.

vi. To prepare an Environmental Impact Assessment Report containing the above points

12.2.1 METHODOLOGY

The EIA study comprises of the following stages.

Stage 'A'	Determination of baseline conditions.
Stage 'B'	Assessing the impacts on the environment due to the construction and operation of the project and recommendations on preventive measures to be taken to minimize the impact on the environment to acceptable levels
Stage 'C'	Preparation of EIA document containing Environment Management Plan

12.3 BASELINE DATA

The baseline environmental conditions are reviewed through literature survey and field studies/monitoring. Information on the location of city's national parks, wildlife sanctuaries and ecologically sensitive areas like tropical forests, important lakes, biosphere reserves, ecological resources around the site have been collected. Following are the major components of field study:

12.3.1 STRIP MAP DATA COLLECTION

Field surveys have been conducted both by windshield surveys and by foot along the proposed corridor. The existing conditions were assessed by a team comprising the environmental specialists to identify the requirement of construction measures with minimum impact on environment.

12.3.2 PHYSICAL ENVIRONMENT

Physical presence of environmental components such as land use pattern, water resources, drainage condition, historical and archaeological sites, polluting industries, sensitive areas, plantations, etc were marked. Strip map database is prepared by precisely locating the details along the corridor of impact to characterise the environmental sensitivity of the feature for the EIA.

12.3.3 NATURAL ENVIRONMENT

Trees on the corridor which may be affected due to proposed cut were counted. Trees above the 30 cm girth were considered for the survey purpose. Other details such as type of trees and girth size have been collected. Any impacts on movement of animals, breeding grounds are also noted.

12.3.4 MEASUREMENT OF ENVIRONMENTAL QUALITY

Field monitoring has been carried out for studying existing ambient air quality, surface and ground water quality, ambient noise level and soil characteristics at various locations along the existing alignment.

12.3.5 AMBIENT AIR QUALITY

The Ambient Air Quality in terms of Suspended Particulated Matter (SPM), Respirable Particulated Matter (PM10), PM2.5, Oxides of Sulphur (SOx), Oxides of Nitrogen (NOx), Carbon Monoxide (CO) has been monitored at 4 locations for each Project corridor following the guidelines of CPCB and the requirement of MoEF. Samples have been collected twice a week for each site.

12.3.6 WATER QUALITY

Water Quality for both surface and ground water has been measured at 2 locations for each project corridor. The selection of the sampling site was made after site study following the standard sampling methods as prescribed by the Central Pollution Control Board.

The Ground water quality was measured at 2 locations along each project corridor. Ground water quality was monitored following standard methods and for the parameters given in IS:10500 for drinking water standard.

12.3.7 SOIL CHARACTERISTICS

The physio-chemical characteristics of soil along the proposed alignment were measured by collection of composite samples from each sampling site following the prescribed sampling and testing methodology.

12.3.8 AMBIENT NOISE LEVEL

Noise levels were measured at 5 locations 30-50 m away from the central line of the corridor at different hours of day and night by using noise meter (Taiwan made model no. SL-4001). Site selection for noise measurements was made based on the location of stations i.e. near sensitive sites such as educational institutions, religious places and hospitals.

12.3.9 SECONDARY DATA COLLECTION

The secondary data on various environmental aspects has been taken mainly from the published government literatures collected from different sources for providing general environmental profile within the project area and to identify the critical environmental concern within the study area.

12.3.10 ASSESSING THE IMPACT

12.3.10.1 Analysis of Data

The collected data was then analysed comparing with different statutory norms. The impact of the project on environment was assessed in relation to this existing environmental quality.

12.3.10.2 Impact Identification

Impact during construction and operation phase due to different project activities was identified and expressed through matrix methods.

12.3.10.3 Mitigation Measures and EMP

The project document was reviewed from environmental perspective both for construction phase and operation phase. Mitigation measure for environmental control was studies and then further activities have been suggested as appropriate for the case. An Environmental Management Plan has been developed based on the above studies and mitigation measures. EMP defines the responsibilities for different project groups and present documentation details.

12.3.11 LEGISLATION, POLICIES AND LEGAL FRAME WORK

The Government of India has enacted nearly 30 ‘Environment Conservation Laws and Acts’. Some of these are: Wildlife (Protection) Act 1972; Forest (Conservation) Act 1980; Water (Prevention and Control of Pollution) Act 1974, Air (Prevention and Control of Pollution) Act 1981; 1988 Amendment of Motor Vehicle Act (M.V.) Act, 1939 and Environment (Protection) Act (EPA) 1986.

Environment (Protection) Act, 1986 is widely regarded as a comprehensive / umbrella legislation for environment in its entity and it provides measures for protection of environment and aims at loopholes in the other related Acts. The other Acts and Rules related to environment in India, such as Air and Water Acts were brought under this umbrella legislation.

12.4 STUDY AREA CHARACTERISTICS

12.4.1 PRESENT TRANSPORT SCENARIO OF LUCKNOW

The number of registered vehicles in Lucknow was about 10 lakh till March 2009 with a growth rate of 7% in the year 2008-2009 (**Table 12.1**). Private vehicular transport constitutes a very sizeable proportion. Two wheelers account for more than three-fourths of the total registered vehicles, while cars constitute 14%.

TABLE 12.1 - VEHICLE SCENARIOS – LUCKNOW CITY

Geographical Position	26° 52' N Latitude, 80° 56' E Longitude 128 m Above Sea Level
Total Vehicle Population in Lucknow city as on March 2009	10 lakh
Growth of Vehicle over 2008-09	7 %
Share of cars and two-wheeler	80 %

At present the available multiple modes of public transport in the city are taxis, city buses, cycle rickshaws and auto rickshaws and CNG buses. CNG has been introduced recently as an auto fuel to keep the air pollution in control. The city bus service is run by *Lucknow Mahanagar Parivahan Sewa*, a Division of Uttar Pradesh State Road Transport Corporation (UPSRTC).

Uttar Pradesh State Road Transport Corporation (UPSRTC), introduced bus services under the banner "Lucknow Mahanagar Parivahan Sewa" on different routes of Lucknow city. The details of public transport as on 31-03-2007 are given in **Table 12.2**.

TABLE 12.2 - AVAILABILITY OF PUBLIC TRANSPORT

SN	Type of vehicles	Number
1	**Nagar Bus**	**110**
	CNG Bus	**43**
2	**Tempo Taxi**	**1776**
	Diesel	578
	CNG	1153
	Battery	45
3	**Auto Rickshaw**	**2129**
	Diesel	26
	CNG	2103

Source: RTO, Lucknow

12.4.2 TRANSPORT DEMAND ON PROPOSED METRO

The expected daily ridership on metro corridors (NS & EW) will 6.12 lakh by 2015, which expected to increase 15 lakh by 2030 (**Table 12.3**) when the full system is operational.

TABLE 12.3 - EXPECTED RIDERSHIP ON METRO (TRIPS /DAY – LAKH)

Year	NS Corridor	EW Corridor	Total Daily Ridership
2015	4.29	1.56	5.85
2020	6.45	2.43	8.88
2025	8.33	3.46	11.79
2030	10.54	4.60	15.14
2041	13.44	6.0	19.44

12.4.3 PROPOSED PROJECT

The proposed Lucknow Metro track will comprise of two corridors

North-South corridor from CCS airport to Munshipulia

East-West corridor from Lucknow Railway Station to Vasant Kunj

12.4.4 CONSTRUCTION METHODS

The foundation shall consist of a set of four piles and pile cap over it. The superstructure will be constructed by pre-caste segmental box girder.

The locations where the track centres are at a distance of less than 12.0 m, the construction shall be done by cut and cover. In the process the structures above the location are dismantled and after the construction work is over, those dismantled structures are again rebuilt. The locations where the track centres are at a distance of more than 12.0 m, the construction is done by Tunnel Boring Machine. The locations where scissors crossovers and turnouts are proposed shall be constructed by cut and cover.

All underground stations have been proposed to be constructed by cut and cover along the road section. The station locations where it is densely built-up, the Stations will be constructed by New Austrian Tunnelling Method (NATM). Construction material shall be stored at temporary construction depots (approx. area 2500 m^2) proposed at each every approx. 5 km section along the corridor and shall be transported to site through trucks / dumpers.

Water shall be required for Flushing of piles during excavation, concreting, curing etc. Quantity of water required equals about 3.5 Million m^3. The source for water supply shall be ground water or from Gomti River whichever is nearer. No storage of water has been planned.

Servicing centres for equipments shall be constructed at the construction depots. The residence of the construction workers shall be constructed in the temporary construction depots, metro depots and at site where-ever space is available. No. of workers will be approximately 5,324.

12.5 BACKGROUND ENVIRONMENT

12.5.1. SITE

The project site is located in the urban area of the Lucknow city. The two corridors proposed cross the city east-west and north-south along. The proposed metro railway track will be mostly elevated over the median of the roads and about 41 percent of it will remain underground. The river Gomti passes through the city west to east and then turns to south forming eastern boundary of the city. The city is mostly plain land at an average altitude of 128 m.

12.5.2 SEISMICITY

The earthquake zoning map of India divides India into 4 seismic zones (Zone 2, 3, 4 and 5). According to the present zoning map, Zone 5 expects the highest level of seismicity whereas Zone 2 is associated with the lowest level of seismicity. The city of Lucknow falls in Zone 3 (Figure 12.1). This zone is classified as Moderate Damage Risk Zone which is liable to MSK VII. The IS code assigns zone factor of 0.16 for Zone 3. MSK scale describes the impact as 'Felt by most indoors and by many outdoors. A few persons lose their balance. Many people are frightened and run outdoors. Small objects may fall and furniture may be shifted. Dishes and glassware may break. Farm animals may be frightened. Visible damage to masonry structures -cracks in plaster. Isolated cracks on the ground'. Comparing with Modified Mercalli intensity scale, Zone 3 can have earthquake of 5 to 5.9 Richter magnitudes near the epicentre of the earthquake.

12.5.3 CLIMATE

Lucknow has a warm humid subtropical climate with cool, dry winters from December to February and dry, hot summers from April to June. The rainy season is from mid-June to mid-September, when Lucknow gets an average rainfall of 1010 mm mostly from the south-west monsoon winds. In winter the maximum temperature is around 21 degrees Celsius and the minimum is in the 3 to 4 degrees Celsius range. Fog is quite common from late December to late January. Summers can be quite hot with temperatures rising to the 40 to 45 degree Celsius range, the average highs being in the high 30's.

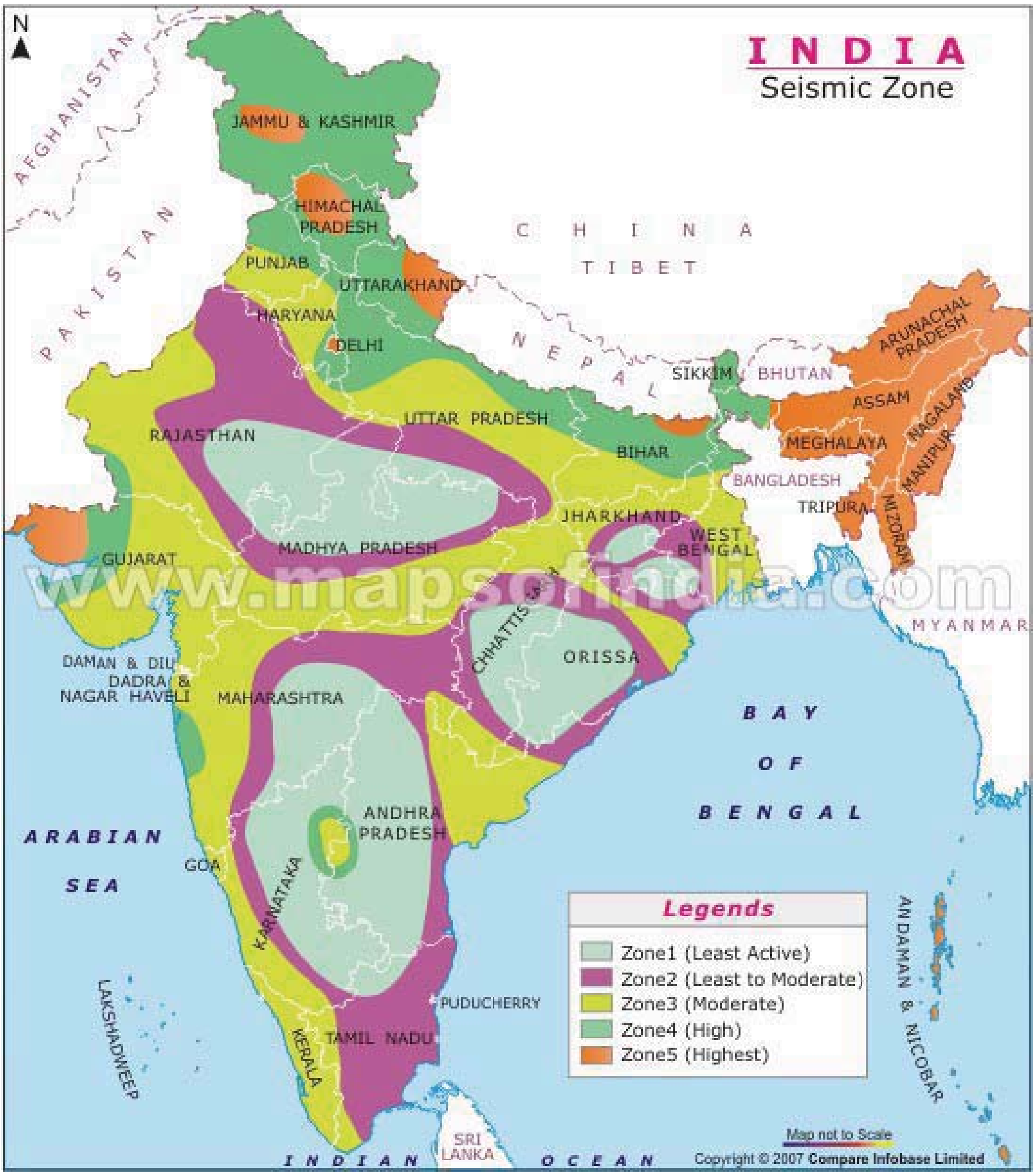


Figure 12.1 SEISMIC ZONE MAP OF INDIA

12.5.4 AIR QUALITY

Ambient air quality of Lucknow city for this project was monitored at total eight (8) sites along the East-West and North-South corridor (**Table 12.4, Figure 12.2)**. Monitoring was carried out for two (2) weeks, twice a week at each site in the month of May 2010. Main air pollutants monitored were

- Particulate matter of 10 micron and below
- Particulate matter of 2.5 micron and below
- Sulphur dioxide
- Nitrogen dioxide
- Carbon monoxide

The results show that desirable limits for particulate matters (10.5 micron and 2.5 micron) were crossed at number of places but the average values nearly all remained within limits. Sulphur dioxide levels remained very low, highest value being 8.7 μg/m^3 only. Nitrogen oxide levels were optimum near the 50% level of the permissible limit. The National Ambient Air Quality Standards are compiled in **Table 12.5**.

Figure 12.2 Ambient Air Quality Monitoring in progress

TABLE 12.4 - AMBIENT AIR QUALITY MONITORING ON MRTS CORRIODRS– MAY 2010

Parameter (Location)	MAX	MIN	AVG
PM 10 (µg/m³) micro gram per cubic metre			
NS-1	78	44	62.1
NS-2	147	70	116.0
NS-3	113	65	95.0
NS-4	84	41	61.0
EW-1	131	58	106.7
EW-2	118	93	106.5
EW-3	98	51	77.4
EW-4	131	58	106.7
PM 2.5 (µg/m³)			
NS-1	38	25	31.8
NS-2	67	38	55.0
NS-3	48	33	41.0
NS-4	37	24	30.0
EW-1	88	34	56.3
EW-2	53	37	46.3
EW-3	83	28	39.8
EW-4	63	36	51.0
SO_2 (µg/m³)			
NS-1	6.1	4.7	5.5
NS-2	8.7	7.4	7.9
NS-3	7.6	6.3	6.9
NS-4	7.2	5.8	6.3
EW-1	6.9	5.4	6.4
EW-2	6.3	5.4	5.7
EW-3	5.8	4.7	5.2
EW-4	6.9	5.4	6.4
NO_2 (µg/m³)			
NS-1	46.4	36.4	41.6
NS-2	52.7	49.4	51.2
NS-3	52.4	42.0	46.8
NS-4	43.9	36.6	40.1
EW-1	46.2	37.1	41.9
EW-2	41.2	36.4	39.2
EW-3	40.6	35.8	37.7
EW-4	46.2	37.1	41.9

NS – North-South Corridor;   EW – East-West Corridor

Locations Codes

NS-1= Krishna Nagar,
NS-2= Vidhan Bhawan Road, Hussaingunj,
NS-3= Police Line, Near Lucknow University,
NS-4 = Block-B, Indira Nagar,
EW-1= Near Charbag Railway Station,
EW-2= Medical Collage Chowraha,
EW-3=, Haribazar Balaganj
EW-4= Near Sabjimandi, Dubaga

TABLE 12.5 - AMBIENT AIR QUALITY STANDARDS

Pollutants	Time-weighted average	Residential, Rural & other Areas	Ecologically Sensitive Areas Notified by GOI
SulphurDioxide (SO_2)	24 hours	80 µg/m³	80 µg/m³
Oxides of Nitrogen as (NOx)	24 hours	80 µg/m³	80 µg/m³
Respirable Particulate Matter (RPM) (size less than 10 microns)	24 hours	100 µg/m³	100 µg/m³
PM 2.5 microns	24 hours**	60 µg/m³	60 µg/m³

12.5.5 WATER RESOURCES AND QUALITY

The two primary sources of water in Lucknow are from the river Gomti and ground water. Underground water is tapped from aquifers. The sediment in the central part of the city is fine grained and the thickness of sand layer is less between 30 cm and 135 m. Excess withdrawal of groundwater has formed a cone of depression in Lucknow city (Simlai 2006). Boreholes have been dug at certain locations along the corridor to study the water table for this project. The (46) borehole reports of North-South corridor shows that only 7 boreholes at the southern end of the N-S Corridor had water table within 30 meters and rest of the boreholes did not yield water within 30 m.

Gomti river water quality was monitored where it enters the city and at the middle of the city in May 2010, during the peak summer. The water quality from four (4) borewells along the project corridors was also monitored. The results are given below in **Table 12.6** and **Table 12.7.** The water quality standards for surface water and drinking water are also provided for comparison in **Table 12.8** and **Table 12.9**.

The results show that Gomti River water can be used as source for water supply after disinfection treatment. It can be also used for bathing though dissolved oxygen was slightly lower than prescribed standard. Dissolved solid contents are low and all the parameters are well within drinking water limit.

The quality of borewell water from different points shows that the water is safe for drinking. The construction work for Metro will require water from these sources.

TABLE 12.6 - GOMTI WATER QUALITY (MAY 2010)

Parameter	Unit	Gomti river middle point	Gomti river Entrance point
pH Value (at $28^{o}C$)		8.28	7.55
Temperature	^{0}C	32	32
Oil & Grease	mg/1	<1.4	<1.4
Total dissolve solid	mg/1	305	294
Total Suspended Solid	mg/l	17.2	31.4
Iron as Fe	mg/1	0.56	0.80
Chlorides as Cl	mg/1	25.5	29.7
Nitrate as NO_3	mg/1	14.52	14.0
Phosphate as PO_4	mg/1	0.53	0.60
Lead as Pb	mg/1	<0.005	<0.005
Chromium as Cr^{+6}	mg/1	<0.1	<0.1
Chemical Oxygen Demand	mg/1	11.04	7.36
Biochemical Oxygen Demand, 3 days at 27°C	mg/1	3.4	<2.0
D.O. At 29 ^{o}C	mg/1	4.1	4.08
Total Coliform	MPN/100 ml	1600	1600

TABLE 12.7 - WATER QUALITY AT BOREWELLS

Parameter	Unit	Indira Nagar N-S Corridor	Charbagh E-W Corridor	Dubgga E-W Corridor	Krishna Nagar N-S Corridor	Drinking Water Standard	
						Desirable	Permissible
pH Value		7.47	7.64	7.84	7.64	6.5	8.5
Total Hardness as $CaCO_3$	mg/1	399.36	245.76	280.32	276.48	300	600
Total dissolve solid	mg/1	460	495	518	434	500	2000
Alkalinity as $CaCO_3$	mg/1	253.44	330.24	291.84	372.48	200	600
Iron as Fe	mg/1	0.25	1.06	0.30	0.19	0.3	1.0
Chlorides as Cl	mg/1	103.66	45.89	40.78	30.59	250	-
Nitrate as NO_3	mg/1	18.8	22.6	13.1	4.0	45	-
Phosphate as PO_4	mg/1	0.15	0.12	0.25	0.20	-	-
Arsenic as As	mg/1	<0.01	<0.01	<0.01	<0.01	0.05	-
Lead as Pb	mg/1	<0.005	<0.005	<0.005	<0.005	0.05	-
Chromium as Cr^{+6}	mg/1	<0.1	<0.1	<0.1	<0.1	0.05	-

TABLE 12.8 - PRIMARY WATER QUALITY CRITERIA AS LAID DOWN BY THE CENTRAL POLLUTION CONTROL BOARD

SN	Water quality characteristics	Water Quality Class*				
		A	B	C	D	E
1	Dissolved oxygen (DO) mg/1 Min	6	5	4	4	-
2	Biochemical oxygen demand (BOD) mg/1 Max	2	3	3	-	-
3	Total coliforms organism**MPN/100ml,Max	50	500	5,000	-	-
3	PH value	6.5-8.5	6.5-8.5	6.9	6.5-8.5	6.5-8.5
4	Free ammonia (as N)mg/1,Max	-	-	-	1.2	-
5	Electrical conductivity, micromhos/cm Max	-	-	-	-	2,250
6	Sodium adsorption ratio (SAR) Max	-	-	-	-	26
7	Boron, mg/1 max	-	-	-	-	2

Class A *Drinking Water Source without Conventional Treatment but after Disinfection*
Class B *Outdoor Bathing*
Class C *Drinking Water Source with Conventional Treatment Followed by Disinfection*
Class D *Fish Culture and Wild Life Propagation*
Class E *Irrigation, Industrial Cooling or Controlled Waste Disposal*
Ref: *Central Pollution Control Board (Ministry of Environment & Forest, Govt. of India) Environmental Standards (water quality criteria)*

TABLE 12.9 - PRIMARILY WATER QUALITY CRITERIA FOR BATHING WATER UNDER ENVIRONMENT (PROTECTION) AMENDMENT RULES, 2001

SN	Parameters	Criteria
1	Dissolved oxygen (DO) mg/1, min	5
2	Biochemical oxygen demand (BOD) mg/1 Max	3 or less
3	Fecal Coliform MPN/100ml	500 (desirable), 2500 (Maximum permissible)
4	Fecal Streptococci MPN/100ml	100 (desirable), 500 (Maximum permissible)
5	pH	6.5 – 8.5

Ref: *Central Pollution Control Board (Ministry of Environment & Forest, Govt. of India) Environmental Standards (water quality criteria)*

12.5.6 NOISE

Ambient Noise level was monitored at four (4) places on each corridor for one full day during May 2010 (**Table 12.10**). Locations were selected to represent commercial, residential and silence zones. Noise levels have been presented as day time and night time averages and also as different percentile results to provide an overall noise scenario. The results are compiled and presented in **Table 12.11**. The results show the city is like any typical Indian urban scenario, noise levels crossing the desirable limits & the ambient noise standards are given in **Table12.12.**

TABLE 12.10 - NOISE MONITORING RESULTS ON EAST-WEST CORRIDOR

SN	Type of Area	Location	Leq dB(A) Day	Leq dB(A) Night	Lmax	Lmin	L90	L10
1	Commercial	Near Charbag Railway Station	71.4	50.4	77.0	46.9	73.5	47.5
2	Silence Zone	Near Medical College Chowraha	62.4	44.4	67.2	42.3	65.3	43.1
3	Residential	Near Haribazar Balaganj	58.2	43.6	65.7	39.1	59.3	40.1
4	Commercial	Near Sabjimandi Dubaga	64.6	46.6	70.6	39.8	66.9	44.3

TABLE 12.11 - NOISE MONITORING RESULTS ON NORTH-SOUTH CORRIDOR

SN	Type of Area	Location	Leq dB(A) Day	Leq dB(A) Night	Lmax	Lmin	L90	L10
1	Residential	NearKrishna Nagar	64.3	47.7	72.6	40.3	64.7	46.3
2	Commercial	Near Vidhan Bhawan Road Hussaingunj	68.6	53.9	72.4	41.3	71.5	47.8
3	Silence Zone	Near Police Line, Lucknow University	64.5	48.3	69.2	42.4	67.3	45.6
4	Residential	Near Block-B, Indira Nagar	57.8	48.2	65.6	40.5	58.6	42.0

TABLE 12.12 - NATIONAL AMBIENT NOISE STANDARDS

Area Code	Category of Zones	Limits of Leq in dB(A)	
		Day*	Night*
A	Industrial	75	70
B	Commercial	65	55
C	Residential and rural	55	45
D	Silence Zone **	50	40

Day time- 6 am to 10 pm, night time - 10 pm to 6 am

***Ref:** Central Pollution Control Board (Ministry of Environment & Forest, Govt. of India) Environmental Standards Rule 3(1) and 4(1) published in Gazette of India, vide S.O 123(E) dated 14.02.2000 and latest amendment on 11.10.2002 vide S.0.1088 (E), under environmental protection act.*

12.5.7 SOIL

Soil samples at 30 cm depth were collected from four locations (**Table 12.13**) and were analysed for texture and fertilizing properties. The results conclude that top soil is silt clay and favourable for agriculture.

TABLE 12.13 - SOIL QUALITY

Serial No.	Parameter	Sabjimandi (Dubagga) East-West Corridor	Indira Nagar North-South Corridor	Krishna Nagar North-South Corridor	Charbag, East -West Corridor
1	pH (1:5) at 30^{0}C	8.10	7.82	8.12	7.78
2	Texture	Silty Clay	Silty Clay	Silty Clay	Silty Clay
3	Nitrogen as N in mg/kg	51.08	61.82	102.14	59.14
4	Phosphorus as P in mg/kg	2.40	1.84	1.22	1.65
5	Potassium as K in mg/kg	203.84	123.80	170.06	231.34

12.5.8 ECOLOGY

The forest area is negligible in Lucknow district. Shisham, Dhak, Mahua, Babul, Neem, Peepal, Ashok, Khajur, Mango and Gular trees are grown here. In fact different varieties of mangoes specially Dashari are grown in Malihabad block of the district and exported to other countries too. The main crops are wheat, paddy, sugarcane, mustard, potatoes, and vegetables such as cauliflower, cabbage, tomato, brinjals are grown here. Similarly sunflowers, roses, and marigold are cultivated on quite a large area of the land. Apart from this, many medicinal and herbal plants are also grown here.

In the project area the trees planted along the project corridor will be directly impacted. A survey was conducted to find the quantum of impact on the trees along the corridors.

The major finding of the survey (**Table 12.14, 12.15 & 12.16)**) is that 158 trees will be impacted in E-W corridor out of which 77 trees can be called big trees. In the N-S corridor number of trees that may be impacted is 461 out of which 189 are big trees. In the Gomti Nagar Link number of trees that may be impacted is 437, out of which 47 are big trees. Major species to be impacted are Eucalyptus, Chilbil, Simul, Sisam etc.

TABLE 12.14 - TREES WITHIN 10 M ON EITHER SIDE OF CENTRE LINE OF E-W CORRIDOR

Tree Local Name	Girth Upto 1.3 (m)	Girth above 1.3 (m)	Total
Gular	0	1	1
Gulmohar	1	0	1
Rubber	1	0	1
Sajina	1	0	1
Pakur	3	0	3
Simul	3	1	4
Unknown	4	0	4
Debdar	0	5	5
Jamun	3	4	7
Sagwan	5	3	8
Neem	3	8	11
Khejur	12	0	12

Tree Local Name	Girth Upto 1.3 (m)	Girth above 1.3 (m)	Total
Pipal	0	15	15
Sisem	13	2	15
Eucalyptus	9	20	29
Chilbil	23	18	41
Total	**81**	**77**	**158**

TABLE 12.15 - TREES WITHIN 10 M ON EITHER SIDE OF CENTRE LINE OF N-S CORRIDOR

Tree Local Name	Girth Upto 1.3 (m)	Girth above above 1.3 (m)	Total
Jamrul	0	1	1
Mango	0	1	1
Sagun	0	1	1
Babul	1	1	2
Kadam	1	1	2
Khejur	4	0	4
Singri	3	1	4
Gular	2	3	5
Chatim	5	1	6
Unidentified	2	4	6
Sajina	4	3	7
Bat	5	3	8
Sagwan	5	3	8
Aam	5	4	9
Balamkhira	9	1	10
Chilbil	8	3	11
Imli	1	11	12
Pakur	7	7	14
Gulmohar	17	0	17
Pinni	4	15	19
Debdar	11	12	23
Dhaicha	23	0	23
Neem	10	13	23
Sisam	30	3	33
Simul	20	22	42
Eucalyptus	95	75	170
Total	**272**	**189**	**461**

TABLE 12.16 - TREES WITHIN 20 M OF CENTRE LINE OF GOMTI NAGAR LINK

Tree Local name	Girth upto 1.3 (m)	Girth above 1.3 (m)	Total
All Type Mixed	390	47	437

12.5.9 ARCHAEOLOGICAL SITES

Lucknow claims its historical root to mythological character Laxman of the epic Ramayana. In recent history Lucknow became capital of Oudh state under Mughal Empire in middle of the 18th Century and a number of magnificent royal buildings, mausoleums, mosques were built by the Muslim rulers of Lucknow. A number of such buildings have been declared 'Protected Site' by Archaeological Department.
Ancient Monuments and Archaeological Site and Remains Act 1958 (amended 2010) defines ancient monument, archaeological site and remains which are not less than one hundred years old and has historical, archaeological and artistic interest. Under this act a number of such monuments and sites of national importance have been declared as 'protected'. The limits of prohibited area and regulated area around the monuments and archaeological sites and remains have been specified under the Act as 100 m and 200 m respectively. No permission for construction of any public projects or any other nature shall be granted in the prohibited area of 100 m. Construction can be done within the regulated area (in between 100 m and 200 m) after approval from National Monument Authority.

8 nos of archaeological sites on N-S corridor and 1 no. on E-W corridor need to be considered for this purpose (Table 12.17 & 12.18). Two monuments on N-S corridor – (i) Alambagh Gate which is under the State Archaeology and (ii) the old gate and boundary of Amzad Ali Shah's Mausoleum fall within the prohibited area of 100 m from the centre line of the project corridor. The actual monument building is 160 m away from the proposed alignment. Total Nine (7) sites fall within regulated zone.

TABLE 12.17-PROTECTED AND REGULATED ARCHAEOLOGICAL SITES ON N-S CORRIDOR

SN	Name of Protected monument /Site	Location	Dist. from Centreline (m)	Chainage (km)
1	Alambagh Gate	N 26°48'50.01 E 80°54'11.06	32	5.620
2	Alambagh Cemetry	N 26°48'82.5 E80° 54'30.3	202	5.620
3	Amzad Ali Shah's Mausoleum	N26° 50'95.3 E80° 56'38.4	15m (from exterior old gate), 160m from main structure	12.523
4	Sapper's Tomb	NA	within 200	13.180
5	Tomb of Mushir Zadi	N26° 51'24.8 E80° 56'07.4	115	13.193
6	Tomb of Saadat Ali Khan	N26° 51'26.8 E80° 56'02.7	115	13.193
7	Victoria Memorial	N26° 51'38.1 E80° 56'03.6	102	13.428
8	Cementry on Faizabad Road	NA	Bet. 100-200	19.240

Ref: Field Survey with ASI officials

TABLE 12.18 - PROTECTED AND REGULATED ARCHAEOLOGICAL SITES ON E-W CORRIDOR

SN	Name of Site	Location	Distance from CL (m)	Chainage (km)
1	Jama Masjid	N26° 52'36'6 E80° 54'03'6	150	6.370

Ref: Field Survey with ASI officials

12.5.10 OTHER SENSITIVE LOCATIONS

Religious places, educational and medical institutions close to the project corridor have been considered as sensitive locations for construction and operational activities. The result of reconnaissance of the sensitive locations on the 2 corridors is presented in **Tables 12.19 to 12.22**.

On the N-S corridor 61 religious structures and 39 educational and medical institutions exist within 30 m from the centreline of the project corridor. On the E-W corridor 28 religious structures and 17 educational and medical institutions exist within 30 m from the centreline of the project corridor.

TABLE 12.19 - SENSITIVE LOCATIONS ON N-S CORRIDOR

Chainage (km)	Name	Approx. dist from CL (m)	Direction from CL (R/L)
0.000 Km	Life Hospital	27	L
1.450 Km	Hospital	31	R
1.750 Km	Nursery School (Ringing Bell)	10	L
2.050 Km	State Govt. Hospital	21	L
2.900 Km	Bhatnagar Nursing Home	16	R
3.040 Km	Lucknow Polytechnique College	28	R
4.275 Km	Lal Hospital	19	L
4.300 Km	Mehra hospital	21	R
4.725 Km	Suraj Singh Hospital	31	R
4.120 Km	Awadh Hospital	17	L
5.575 Km	Govt. Primary School	20	R
5.775 Km	Ajanta Hospital	22	R
6.000 Km	City Hospital & Trauma Centre	22	L
7.100 Km	Gandhi Inter College	18	L
9.750 Km	Dindayal Memorial Park	16	R
9.880 Km	KKC College	25	R
10.360 Km	National Progressive School	16	L
10.380 Km	City Montessori School	15	R
11.546 Km	Vidhan Sabha	16	R
12.770 Km	Sarojini Naidu Park	17	R
13.020 Km	KD Babu Singh Stadium	18	R
12.875 Km	Shyama Prasad Mukherjee Park	15	R
14.000 Km	Lucknow University	16	L
14.225 Km	Colvin Taluqdar's College	13	R
15.186 Km	IT College	25	L

Chainage (km)	Name	Approx. dist from CL (m)	Direction from CL (R/L)
15.590 Km	Vikram Mehta Hospital	25	L
16.300 Km	Fatima Hospital	21	L
16.440 Km	Karamant Girls' Muslim College	25	L
17.020 Km	City Montessori Inter College	18	L
17.200 Km	Mahanagar Girls' College	18	L
17.950 Km	Indira Nagar Public College	17	R
19.640 Km	Beniprasad Memorial Park	15	L
20.000 Km	Red Hill School	16	L
20.600 Km	Lucknow Polytechnica	65	R
20.720 Km	Gyan Mandir Kanya Intermediate College	3	L
21.200 Km	S.B. Inter College	16	R

Ref: Field Survey

TABLE 12.20 - RELIGIOUS LOCATIONS ON N-S CORRIDOR

Chainage (Km)	Type of Structure	Approx dist. From CL (m)	Distance from CL (R/L)
0.300 Km	Mosque	15	L
0.385 Km	Temple	16	L
0.600 Km	Temple	14	L
0.900 Km	Temple	19	L
0.9875 Km	Temple	19	L
1.300 Km	Mosque	13	R
2.000 Km	Temple	13	L
2.300 Km	Temple	15	R
2.650 Km	Temple	16	R
2.800 Km	Temple	15	R
4.450 Km	Temple	17	L
4.550 Km	Temple	18	L
4.625 Km	Temple	17	L
4.625 Km	Temple	17	R
4.900 Km	Bodh Vihar	15	R
5.250 Km	Satsang Bhawan	25	L
5.325 Km	Gurudwara	55	L
5.525 Km	Mosque	15	R
5.825 Km	Temple	20	L
6.225 Km	Temple	19	R
6.225 Km	Temple	19	R
6.225 Km	Temple	20	L
6.475 Km	Temple	18	L
7.000 Km	Mosque	20	L
7.911 Km	Mosque	15	L
8.061 Km	Temple	13	R
9.061 Km	Temple	25	R
9.361 Km	Temple	23	R
9.561 Km	Temple	25	L
10.604 Km	Temple	16	R
10.677 Km	Mosque	30	R
10.734 Km	Temple	25	L

Chainage (Km)	Type of Structure	Approx dist. From CL (m)	Distance from CL (R/L)
10.765Km	Mosque	30	R
10.900 Km	Temple	18	L
10.900 Km	Temple	20	R
11.421 Km	Mosque	16	R
11.496 Km	Temple	15	R
12.733Km	Temple	14	R
14.222 Km	Temple	15	L
14.347Km	Temple	16	L
14.675 Km	Temple	18	L
14.750 Km	Temple	20	R
16.550 Km	Mosque	18	L
17.550 Km	Temple	17	R
17.550 Km	Temple	12	R
17.925 Km	Temple	30	L
18.050 Km	Mosque	30	L
18.375 Km	Temple	14	L
18.475 Km	Temple	13	L
18.525 Km	Temple	13	L
18.700 Km	Temple	16	R
18.800 Km	Temple	15	R
18.875 Km	Temple	16	R
20.900 Km	Temple	15	L
20.925 Km	Mosque	25	R

Ref: Field Survey

TABLE 12.21 - SENSITIVE LOCATIONS ON E-W CORRIDOR

Chainage (Km)	Name	Approx. Distance From CL (m)	Direction from CL(R/L)
0.400 Km	Gurunanak Girl's College	18	L
0.950 Km	Kamaladevi Hospital	15	L
1.425 Km	Vidyant Hindu College	14	R
2.775 Km	Amar Convent School	20	L
4.700 Km	Sahuji Maharaja Medical University	35	R
4.700 Km	Queen Mary Hospital	30	R
5.775 Km	Kalicharan Inter College	25	L
5.850 Km	CMS School	17	R
5.875 Km	MG Montessori School	17	L
6.050 Km	Kamakhya College	16	R
6.125 Km	Saraswati Sishu Vidya mandir	17	R
6.225 Km	Brajraj Hospital	17	R
7.350 Km	Mother & Child Care Centre	20	R
7.400 Km	St. Joseph Inter College	18	R
7.750 Km	New Ideals Montessori School	13	L
8.125 Km	Glorious Public School	23	L
10.125 Km	Ramsa Hospital	30	L

TABLE 12.22 RELIGIOUS LOCATIONS ON E-W CORRIDOR

Chainage (Km)	Type	Approx. Distance From CL (m)	Direction from CL(R/L)
0.075 Km	Temple	20	L
0.325 Km	Temple	20	R
1.325 Km	Temple	19	R
1.400 Km	Temple	14	L
2.050 Km	Mosque	35	L
2.100 Km	Mosque	30	R
2.900 Km	Temple	6	R
2.950 Km	Temple	5	L
4.800 Km	Mosque	0	M
5.600 Km	Temple	4	L
5.850 Km	Mosque	17	L
6.600 Km	Mosque	18	R
6.600 Km	Mosque	25	L
6.650 Km	Temple	17	R
6.750 Km	Temple	18	R
6.800 Km	Temple	25	L
6.900 Km	Temple	15	L
7.850 Km	Temple	13	L
7.925 Km	Temple	16	R
8.150 Km	Temple	9	L
8.525 Km	Mosque	12	L
8.700 Km	Temple	20	L
8.750 Km	Temple	17	R
9.200 Km	Mosque	7	L
9.350 Km	Temple	30	L
9.625 Km	2 Temples	16	L
9.950 Km	Temple	16	R
10.250 Km	Temple	23	L

Ref: Field Survey

12.6 ENVIRONMENTAL IMPACT

12.6.1 INTRODUCTION

This section identifies and assesses the probable impacts on different environmental parameters due to planning, construction and the operation of the proposed development. After studying the existing baseline environmental scenario, initial field surveys, reviewing the process and related statutory norms, the major impacts have been identified and assessed during the design, construction and the operation phases. Metro construction related impacts occur at three stages of the project:

- Planning and Design
- Construction
- Operation

Planning and Design includes planning of the metro railway corridor alignment, underground and elevated sections, construction details, materials of construction etc. which ultimately decides the impact during later phases. Most of the impacts are during construction and operation phase. While some of the construction phase impacts are temporary, some also are permanent. Operation phase impacts are continuous in nature. To identify these impacts broadly on physical, ecological and social environment Impact Identification Matrix are developed.
Other important criteria for identification of impact are identification of the impact zone. For present screening studies, a Corridor of Impact (COI) of 30 m width from the central alignment has been considered.
Environmental parameters are broadly classified into three groups.

- Physical Environment
- Biological Environment
- Human Environment

Physical environment includes:

- Water Resources, Water Quality, Air Quality, Noise and Land environment
- Biological Environment includes:
- Flora, Terrestrial fauna, Avifauna, Aquatic flora & fauna, Plantation
- Social Environment includes:
- Rehabilitation, Employment, Agriculture, Housing, Culture etc.

An Impact Identification Matrix for all the phases of the project is presented in **Table 12.23**.

TABLE 12.23 - IMPACT MATRIX

Project Activity / Env. Component	Realignment of Utility Lines	Earth moving	Removing trees & vegetation	Construction work	Sanitation & disposal of water from tunnel	Vehicle & machine operation & maintenance	Vehicle operation
Air Noise		Dust Pollution	Reduced buffering of air and noise pollution	Noise, dust, air pollution	Odour	Air pollution	Noise, air pollution and dust
Water Resources & water quality	Contamination of water line, disturbance in sewerage and drainage line	Impact due to Soil Erosion		Impact on Water use, Contamination by fuel & lubricants,	Contamination of local water sources	Contamination of local water sources	
Land		Dumping of earth		Solid Waste	Contamination from wastes		
Trees	Impact on trees		Loss of trees & vegetation				
Cultural & Religious facility		Damage to structure	Loss of sacred trees	Disturbance to religious functions			
Sensitive Places		Noise, dust, air pollution		Noise, dust, air pollution			

12.6.2 IMPACT DUE TO DESIGN PHASE

The major impact associated with Design or Pre-construction phase deals with loss of land, properties and livelihood due to acquisition of properties. The design phase also decides the temporary acquiring of land for construction, shifting of different utilities. These issues were studied by environmental and social specialists to minimize the impact. Besides the impact on environment and social factors, there should also be consideration for legal issues so that the project can be operated with ease.

The utilities to be impacted have been identified. The land to be acquired permanently has been identified and its impact is covered under social impact. The permanently acquired land does not include any forest land or environmentally sensitive area.

The temporarily acquired lands for construction purpose and near stations have been identified. These land areas include school and college grounds and city parks. These locations would need special protection during construction phase as mentioned below in table 12.24.

TABLE 12.24 - LAND TO BE ACQUIRED FOR TEMPORARY / PERMANENT CONSTRUCTION DEPOT(S)

SN	Plot No.	Details	Area (m^2)	Ownership
N-S CORRIDOR				
1	Depot	PAC Campus Land opposite Transport Nagar	378000.00	Government
2	1RST1	Open Land on RHS of NH-25 opposite to Literacy House	2512.37	Private
3	1RST2	At Sarojini naidu Park beside K.D.Singh Babu stadium on RHS of the MG Road	2742.80	Government
4	1RST3	Open Ground in the campus of Reserve Police Line	2499.99	Government
6	1RST5	Open Land on RHS of Himalaya Marg beside the Polytechnic Flyover and adjacent to the Polytechnic Campus.	2015.65	Government
E-W CORRIDOR				
1	2RST1	Playground of Girls college	2500.00	Government
2	Depot	Open Land Behind Fish mandi	123300.00	Government

Ref: Field Survey and proposed design

12.6.3 IMPACT DURING CONSTRUCTION PHASE

The construction phase, in general, has adverse influence on all the components of environment. Most of these impacts are primarily due to negligent practices but are short lived and reversible in nature. A proper care is essential to minimize the adverse impacts to the possible extent to facilitate the restoration of the environment.

The standard construction works involves site clearance, excavation, filling of earth materials and sub grade materials, construction of pillars and laying of railway tracks, construction of bridges over the river, dumping of unusable debris materials, transportation of materials from production site to construction site, and other constructional activities and associated works like mobilization of constructional equipments, setting up of different construction plants, setting up of workforce camps, quarrying, transportation of materials, material storage etc. These activities have certain impacts of various magnitudes on different components of environment. The anticipated impacts due to all these activities have been described below.

12.6.3.1 Air Quality

Air quality is one of the most important parameters to be impacted during construction phase. Impacts on air quality during construction are due to generation of dust due to earth moving activities on road side, generation of dust due to excavation and handling of construction materials, emission of gaseous pollutants like sulphur dioxide, nitrogen oxides, hydrocarbon, particulates, carbon monoxide etc. from heavy vehicles and generation of dust due to movement of these vehicles. Transportation of earth and establishment of the material will involve use of heavy machinery like compactors, rollers, water tankers, and dumpers. This activity is machinery intensive resulting in dust generation.

As the construction will be carried out inside the city and mostly along the busy road sections, a large number of people will be exposed to the pollution. So mitigation of air pollution should be given priority.

12.6.3.2 Soil Erosion

The construction activities require excavation of soil. Soil erosion also takes place from the runoff from excavated areas, and underground tunnel faces. Especially construction works during monsoon season can cause such erosions more. The prevention measures require proper guarding of excavated areas, timing of activities and proper drainage arrangements. Dumping of construction materials without planning also cause much soil erosion, choking in local drainage and pollution of water bodies. Land is also impacted from oil residues, lead and other components from running of vehicles and construction machineries.

About 2.1 million cubic meter of earth will be excavated for the project work. The excavated earth shall be used for landfills and can be dumped in open grounds. The disposal location will be identified later.

12.6.3.3 Water Resources

Water is required for Flushing of piles during excavation, concreting, curing etc. Quantity of water required equals about 4,13,252.25 m^3. The source for water supply is mainly ground water or from Gomti River, whichever is nearer. However, proper permission from the relevant statutory authority needs to be obtained to avoid any unwanted impact on the water resource and subsequent impact on other users.

Water will also be required for human uses including drinking for the workers at workers’ camp and at construction sites. This water has to be acquired from the municipal supply or from boring well to have ground water. This also will require permission from the relevant statutory authority

The geological studies of the project area show water table 30 m below the surface at the most part of the corridor. As the depth of the ground water table is very high no adverse impact is anticipated on ground water during construction. Laying of pavement within the formation width may lead to reduction in the ground water recharge capacity. But as the area involved in the construction is very less, the chances of this influence will be non-significant

12.6.3.4 Water Quality

No permanent impact is anticipated on water quality due to the project. Construction activity may temporarily deteriorate surface water quality near the proposed alignment through increase in turbidity as well as in oil and grease. These impacts are temporary in nature and can be handled through the proposed mitigation measures.

Water may have to be pumped out during excavation work to facilitate underground work. The pumped water may contain high amount of suspended solids which can pollute outside water body. This needs special care so that pumped water is settled before discharge or some filtration applied.

One bridge on the Kukrail Nala has been proposed. The construction activities e.g. well foundation and sinking, foundation of piers etc can impact water quality due to spillage of construction materials, debris, oil from machines etc. This should be taken care during construction.

The improper sanitation at work camps, depots and waste disposal can also pollute local water body

12.6.3.5 Noise

Major noise pollution will be generated during construction phase from operation of heavy machineries; movement of heavy vehicles will also generate some noise. The construction equipment will have high noise levels, and can affect the personnel operating the machines. A lot of this problem can be reduced by proper mitigation measures. Also construction phase noise is a very much temporary affair. Each type of activity can generate different type and level of noise but that continue for a short period during the construction phase.

The acceptable limits (for 8 hour duration) of the equivalent noise level exposure during one shift is 90 dB(A). Hence, noise generated due to various activities in the construction camps may affect health of the workers. For reasons of occupational safety, exposure to impulses or impact noise should not exceed 140 dB (A) (peak acoustic pressure). Exposure to 10,000 impulses of 120 dB (A) is permissible in one day. A typical Noise generation due to different activities has been given in the **Table 12.25**.

TABLE 12.25 TYPICAL NOISE LEVELS OF PRINCIPAL CONSTRUCTION EQUIPMENT DURING MAJOR CONSTRUCTION ACTIVITY (NOISE LEVEL IN DB(A) AT 15 M)

CLEARING	
Bulldozer	80
Front end loader	72 - 84
Dump truck	83 - 94
Jack hammer	81 - 98
Crane with ball	75 - 87
EXCAVATION AND EARTH MOVING	
Bulldozer	80
Backhoe	72 - 93
Front end loader	72 - 84
Dump truck	83 - 94
Jack hammer	81 - 98
Scraper	80 - 93
STRUCTURE CONSTRUCTION	
Crane	75 - 77
Welding generator	71 - 82
Concrete mixer	74 - 88
Concrete pump	81 - 84
Concrete vibrator	76
Air compressor	74 - 87
Pneumatic tools	81 - 98
Bulldozer	80
Cement and dump trucks	83 - 94
Front end loader	72 - 84
Dump truck	83 - 94
Paver	86 - 88
GRAND AND COMPACTING	
Grader	80 -93
Roller	73 - 75
PAVING	
Paver	86 - 88
Truck	83 - 94
Tamper	74 - 77
LANDSCAPING AND CLEAN UP	
Bulldozer	80
Backhoe	72 - 93
Truck	83 - 94
Front end Loader	72 - 84
Dump Truck	83 - 94
Paver	86 - 88

From the above table it is evident that the operation of construction machinery e.g. hot-mixer, bulldozer, loader, backhoes, concrete mixer, etc will lead to rise in noise level to the range between 80-95 dB (A). Vehicles carrying construction materials will also act as the noise sources. The magnitude of impact from noise will depend upon types of equipment to be used, construction methods and also on work scheduling. However, the noise pollution generated due to different construction activities is a temporary affair. Each type of activity can generate different type and level of noise that continue for a short period during the operations of those activities.

The impact of noise depends on the location of the receptor and source. The noise level generated from a source decreases with distance as per the following empirical formula (inverse square law).

$SPL2 = SPL1 - 20Log_{10}(r_2/r_1)$

Where, SPL1 and SPL2 are the sound pressure levels at distance r_1 and r_2 respectively. Considering the stationary construction equipment as a point source generating 90 dB (A) at a reference distance of 2 m, computed distance require to meet the permissible limits during day time for different land use categories are given below in **Table 12.26**.

TABLE 12.26 - MINIMUM DISTANCE OF OPERATION FROM STATIONARY SOURCE REQUIRED FOR MEETING STANDARDS

Category	Permissible limits in day time (CPCB)	Distance required (m)
Silence zone	50 dB (A)	200
Residential	55 dB (A)	113
Commercial	65 dB (A)	36
Industrial	75 dB (A)	11

Ref: Central Pollution Control Board (Ministry of Environment and Forests) Guidelines

From the above table it may be noted that residence within 113 m from the road will be exposed to a noise higher than the permissible limit. The impacts will be significant on construction workers, working close to the machinery.

12.6.3.6 Utilities

Many types of utilities serving local and regional needs are falling under COI will need to be relocated from their present position due to the proposed widening alignment. These services are mainly lamp posts, electric poles, transformers, telephone poles, gas lines and optical fibre cables. The magnitudes of impact in each corridor on these services are presented below in **Table 12.27**. Such types of impacts are inevitable.

TABLE 12.27 AFFECTED UTILITIES

Item	NORTH-SOUTH	EAST-WEST
No. of Trees	690	362
Light Poles	661	207
Signal Poles	75	18
Telephone Poles	661	108
Telephone Junction box	75	14
Electric Poles	740	373
Electric Junction box	115	45
Transformer	98	45
Gas Pipeline – Affected Length – (m)	13478.65	2748.57

Ref: Field Survey and proposed design

12.6.3.7 Trees

The project corridors have trees and plantations on sides or in some stretches on the middle of the project corridor. Construction and maintenance activities can cause severe impact on these trees and plantations by removing them. This will cause also induced impact on local fauna and ecology. The loss of trees is also important for road users as these trees provide shade to the road users. The impact will depend on the number, density, and types of species of trees on each road.

The major finding of the survey is that 158 trees can be impacted in E-W corridor out of which 77 trees can be called big trees. In the N-S corridor number of trees that may be impacted is 461 out of which 189 are big trees. Major species to be impacted are Eucalyptus, Chilbil, Simul, Sisam etc.

Compensatory plantation near the project area needs to be carried out as detailed out in mitigation measures. With the proposed mitigation measures, there can be more trees planted as compared to existing one.

12.6.3.8 Archaeological Sites

There are Nine (9) archaeological sites near the project corridors falling within the prohibited or regulated zone. The construction works can have adverse impact on these sites because of vibration, air pollution and other pollutants. But necessary precautionary measures will be taken during the construction activities, so as to mitigate any adverse effect.

12.6.4 IMPACT DURING OPERATION PHASE

Operation phase is the period when the construction is complete and the rail services along the project corridors are started. Though this rapid transport system will have significant beneficial impact on people's mobility in the city, it also will have some impact on different environmental components.

12.6.4.1 Noise

The noise will impact the people outside on the elevated part of the corridor.

12.6.4.2 Air Quality

It is expected that air quality of the city will improve and people will depend on Metro service and there will be less increase in numbers of car and buses. As Metro operation will not locally emit any air pollution, ambient air quality will be better in future.

12.6.4.3 Refuse from Stations

The station will generate solid waste from different uses of the passengers. All wastes from stations need to be disposed properly to avoid any local pollution

12.6.4.4 Traffic problem near the Stations

There will be increased traffic near the stations. All stations also will not have parking spaces. If this traffic is not managed properly it can cause both noise and air pollution locally. This should be considered for long term planning.

12.7 ENVIRONMENTAL MITIGATION MEASURES

12.7.1 INTRODUCTION

Mitigation Plan is the key to ensure that the environmental qualities of the area will not deteriorate due to the construction and operation of the project. The probable impacts due to the construction activities and subsequent operation have been discussed in previous section. The Mitigation Plan covers all aspects of the construction and operation phases related to environment.

The mitigation plan needs to be implemented right from the conception stage and should continue till the end. The Plan has been divided into three phases –

(a) Design phase

(b) During construction phase and

(c) During operational phase.

12.7.2 DESIGN PHASE

Design of the project will also be based on social and environmental criteria. Important environmental components e.g. water supply, sewage disposal, drainage, trees, sensitive locations etc, and social components e,g, school, hospitals, places of worship, residential areas, commercial place etc. have been preliminarily identified on project corridors. While finalising alignments and deciding on corridor of impact, these data has been considered to minimize the impact on environment (**Table 12.28**).

Planning shall also be done for the realignment of the underground public utility lines e.g. water supply, sewage and storm water disposal, electricity, gas, telephone lines etc at planning stage. This will be done in consultation with the relevant authorities.

TABLE 12.28 - DESIGN PHASE MEASURES

Impacts	Mitigation Measures
Land Acquisition	Alignment design to minimize the land acquisition
Removal of Trees	Alignment design to reduce the number of trees to be cut. Compensatory plantation to be planned.
Impact on public utilities	Alignment design to consider. In case of removal alternate arrangement to be done before.
Impact on Archaeological and Cultural Sites	Alignment design to consider minimum impact
Access Restriction	Required alternatives, underpasses, proper signposts for people should be included in design
Environmental Specifications for Contractors	Environmental qualifications specification should be included in pre-qualification packages for the contractors

12.7.3 CONSTRUCTION PHASE

12.7.3.1 Air Quality and Noise

Construction activities at different phases can generate significant air quality problems. The project corridor has educational and medical institutions. There are also temples and mosques along the corridors. Some of the temporary acquired sites for construction includes spaces within educational institutions. So air quality and noise will be the major environmental issues. Mitigation measures suggested to reduce the impact as presented below in **Table 12.29**:

TABLE 12.29 - CONSTRUCTION PHASE MEASURES

Impacts	Mitigation Measures	
Dust	•	Water will be sprayed during construction phase if required, in earth handling sites and other excavation areas for suppression of dust. Dust emission from piles of excavated material should also be controlled by spraying water on the piles or should be kept covered by tarpaulin sheets. Special care should be taken when working near the educational and medical institutions.
Gaseous Pollution	•	Vehicles and machineries will be regularly maintained to conform to the emission standards stipulated under Environment (Protection), Rules 1986. The workers should be provided with masks in dusty condition and it will be responsibility of the supervising officers that the workers

Impacts		Mitigation Measures
		use the masks.
Noise	•	Noise levels of machineries used shall conform to relevant standards prescribed in Environment (Protection) Rules, 1986, Workers shall not be exposed to noise level more than permitted for industrial premises, i.e. 90 dBA (Leq) for 8 hours. Workers exposed to high noise level should use ear plugs Construction work generating noise pollution near the medical institution and residential areas should be stopped during night.

12.7.3.2 Water Resources and Water Quality

The project work may have some impact on water environment and also the requirement of water for construction activities may have some impact on local water resources. Mitigation measures to be taken to reduce the negative impact are presented below in **Table 12.30**:

TABLE 12.30 - IMPACT AND MITIGATION MEASURES FOR WATER RESOURCES

Impacts	Mitigation Measures
Realignment of underground water supply line and sewage line Closure or stoppage of access to public water taps on the roadside	• Realignment will be done in consultation with the authorities responsible for the maintenance of these utilities. The personnel from those organizations should be involved during this activity. If there is any requirement for closure or stoppage of access to public water taps on the roadside, alternative arrangements for the users will be made accordingly.
Flooding due to siltation of drainage channel	• Excavated earth and other construction materials should be stored away to prevent washing away.
Water use for construction	• Proper permission from relevant authorities to be obtained.
Contamination from wastes	• All practical measures will be taken to prevent any uncontrolled effluent discharge from construction workers camps and storages to water sources. The camp site will be provided with proper drainage connected with local drain.
Contamination from fuel and wastes	• Vehicle maintenance will be carried out in a confined area, away from water sources, and it will be ensured that used oil or lubricants are not disposed to watercourses.
Sanitation and Water use in Construction Camps	Construction camp will be organised in a planned manner. Workers shall be provided proper sanitation facilities including toilets. Solid wastes from camps will be disposed only in the waste bins provided by the Municipal corporation. Camps will have water supply facilities like tube wells or from separate municipal supply so that local water sources are not affected. Contractor and Supervising Engineer will be responsible for sanitation condition of the camp.

12.7.3.3 Draining of Water from Tunnel

The ground water table generally lies below 30 m. So problems of water flow associated with tunnelling should not be a major issue. In cut and cover type construction continuous pumping is an economical alternative. A suitable piezometer shall be installed to monitor the water table constantly and to see how much lowering has been effectively done. The dewatering should not be stopped unless it is ensured from design calculations that the load of the constructed box component has reached a stage where it will be able to counter act the hydrostatic pressure from below.

Water from the excavated site should be pumped out to a sump and then disposed after providing some settling time for particulates. To prevent loss of fines, inverted filter may have to be used.

The construction of diaphragm walls of concrete along the side of channels, before the commencement of excavation will be required. The concrete walls are taken down to rest on bed rock or impervious strata or, in their absence, deep enough below the bottom of excavation, to serve as an effective cut off for the inflow of ground water into the proposed excavation. The trenches are kept continuously filled with a thiotropic material like Bentonite slurry, which has the effect of stabilising the trench and preventing any subsidence.

During operation phase, seepage water has to be drained along the side of walls (retaining). The pumped water from sump will be put into storm water drain that is suitable for taking up this flow. These storm water drains finally join natural existing streams/nallah.

12.7.3.4 Excavated soil disposal

About 2.1 Million cubic meter of earth will be excavated for the project work. As the construction work will be done in a city, space for construction requirements will not be much available. Therefore an elaborate planning should be done to regularly dispose the excavated soil by trucks. The excavated earth at construction site should be stored and covered with tarpaulins to prevent erosion of soil and clogging of local drainage.

It should be seen that there is no spillage from the trucks and these trucks should be regularly washed and cleaned. All the usable excavated materials shall be re-used as fill materials. The movement of vehicles and equipments will be restricted to only designated route.

Designated storage site shall be used for fill materials and adequate stockpiling to prevent erosion and runoff related problem.

12.7.3.5 Utility Restoration

The utilities likely to be affected are mainly water supply and sewer pipe, storm water drains, telephone, cables, over head transmission lines, electric poles, traffic signals etc. These utilities have been identified at design phase. At the beginning of the construction work, it should be ensured that temporary or permanent substitutions for these utilities have been arranged. The related government departments and private agencies should be consulted otherwise the project schedule may hamper significantly and people will have to face much adverse impact.

12.7.3.6 Trees

Some trees have to be removed during construction activities. Field survey has found about 619 trees may be cut for the project. Mitigation measures to reduce the impact and trees suggested for plantation are suggested below in **Table 12.31** and **Table 12.32** respectively:

TABLE 12.31 - IMPACT AND MITIGATION MEASURES FOR TREES

Impacts	Mitigation Measures
Loss of trees	• Tree felling will be restricted to requirement of construction activities and reduction of accident possibilities. Five times the number of trees cut will be planted. So about 3100 trees are to be planted. Besides there will be more plantation on road sides. Plantation will be done as near as the old site, most preferably just beyond the existing position within Right of Way (ROW). To compensate the felling of trees and improve environmental quality trees may be planted in nearby areas beyond the project site. If space is not available, forest department will be approached to plant in degraded forest land. The species will be selected depending on site, plantation design and in consultation with local community.
Loss of Sacred Trees	• **In case of any sacred tree associated with community tradition, it will be preserved.**

TABLE 12.32 - SUGGESTED TREES FOR PLANTATION

Site	Desirable Species Characteristics	Recommended Plants
Parks and Gardens, Open Space and Housing Complexes	Evergreen ornamental tall trees with spreading crown along the periphery, planting medium height trees in groves, ornamental climbers and creepers on topiaries, provision for small lawn for green ambience	Trees; Samanea saman, Pterospermum acerifolium, Swietenia spp, Delonix regia, Jacaranda ovalifolia, Millingtonia hortensis, Fiscus spp, Schleichera oleosa
Roads – Wide to moderately wide roads with overhead interference	Evergreen and ornamental trees- height not exceeding 3m to 4m	Bahuinia spp., Lagerstroemia thorelli, Cassia bicaspsularis, Cassia fistula, Caesalpinia pulcherrima, Cordia sebestina, Nyctanthes arbortristis
Roads – Wide to moderately wide roads without overhead interference	Evergreen and ornamental trees with spreading crowns	Putranjiva roxburghii, Delonix regia,Peltophorum petrocarpum, Samanea saman, , Swietenia spp, Fiscus spp, Azardhica indica, Michelia champaca, Alstonia scholaris, Jacaranda ovalifolia

12.7.3.7 Archaeological Sites

The project corridor passes through the protected and regulated archaeological sites. In case of N-S corridor One (1) locations e.g. Alambagh Gate falls within the prohibited area of 100 m from the centre line of the project corridor where no construction work is permitted under law. The Alambagh gate is under the State Archaeology. Special legal permission will be therefore required and construction work has to be done with very special arrangements. The legal issue should be settled before the construction work.

In case of other sites, permission should be taken from National Monument Authority. Construction work near archaeological sites should be done in consultation with State Archaeological Department & Regional office of Archaeological Survey of India and measures suggested by them should be followed.

12.7.3.8 Traffic Diversion

As construction of some underground stations will be done by cut & cover method, the traffic that will be disrupted during construction period needs to be diverted onto some other route. Also to smoothen the traffic flow in some key market areas that will be interrupted during construction period, a traffic diversion plan has been proposed as given below:

Diversion Plan

- Traffic from southern area i.e. from Amausi till Alambagh area moving towards east direction i.e. Nawazganj & beyond till Vasant shall be diverted onto Tulsidas Marg from Alambagh
- Through movement on Kanpur road will be disrupted as Lucknow Rly. Station is proposed to be constructed by cut & cover method. Traffic from Alambagh, Mawaiyya shall be diverted onto Gregson road (road running parallel to Kanpur road on backside of railway station) that joins Moti lal Nehru Marg further.
- For smooth traffic flow between Hussain Ganj till Hazrat Ganj traffic shall be diverted onto following routes: From Hussain Ganj will diverted to Dr. RK Tandon Rd. and join University road further; From sachivalaya traffic shall be diverted onto Ashok Marg to avoid Hazratganj stretch.
- Traffic movement between Lucknow Rly. Station till Gautam Buddha marg will be blocked due to constrained ROW cut & cover construction of stations. The traffic from Charbagh shall be diverted onto Aminabad Road & Subhash marg. Aminabad road further joins University road and will carry the traffic moving towards Vishwavidhyalaya & beyond.
- Traffic movement between Medical Chauraha till Nawazganj will be blocked due to cut & cover construction method. Traffic shall be diverted onto Nabiullah road and joins Thakurganj further.

12.7.3.9 Environmental Enhancement

Environmental enhancement means providing some extra measures related to construction for people and community which improves the social environment.

12.7.3.10 Provision of Access

Construction engineering team will provide temporary access required for business, residences, schools and other properties including access at intersections.

12.7.3.11 Pedestrian access

Pedestrian access will be provided around construction zones and those will be notified by proper signboards.

12.7.3.12 Awareness and Safety

People should be informed about the construction activities and safety steps well visible from proper locations. There will be proper signs for safety and temporary accesses will be provided safety railings and other required support

12.7.3.13 Aesthetics

The construction sites to be surrounded by temporary walls made of tin, wood etc for separating the working area from public. The outside wall of these enclosures should be kept always clean. The outside wall should be brightly painted. At work sites in important city locations, the walls may be covered with paintings done by local school children. This will also have good local acceptance of the project. In some walls, the pictures of Lucknow's famous land marks can be pasted or painted. All these will change the dirty construction work into an aesthetic work.

12.7.3.14 Worker's Welfare

Workers' Camp

Workers' camp is normally a part of the construction process. However these camps are made in a much neglected manner and thus the camp becomes a source of environmental nuisance affecting the health of the workers also. As this work will be done on a city road, an exemplary camp can be a useful lesson to other contractors and public.

Risk from Operations

The Contractor is required to comply with all the precautions as required for the safety of the workmen as per the International Labour Organisation (ILO) Convention No. 62 as far as those are applicable to this contract. The contractor shall supply all necessary safety appliances such as safety goggles, helmets, masks, etc., to the workers and staff. The contractor has to comply with all regulation regarding safe scaffolding, ladders, working platforms, gangway, stairwells, excavations, trenches and safe means of entry and egress. Workers working on elevated platforms must be made to use safety belt as per recommendations

Risk from Electrical Equipment

Adequate precautions should be taken to prevent danger from electrical equipment. No material or any of the sites will be stacked or placed that will cause danger or inconvenience to any person or the public. All necessary fencing and lights will be provided to protect the public. All machines to be used in the construction will conform to the relevant Indian Standards (IS) codes, will be free from patent defect, will be kept in good working order, will be regularly inspected and properly maintained as per IS provisions and to the satisfaction of the Engineer.

Risk at Hazardous Activity

- All workers employed on mixing cement, lime mortars, concrete etc., will be provided with protective footwear and protective goggles. Workers, who are engaged in welding work's would be provided with welder's protective eye-shields. Stone-breakers will be provided with protective goggles and clothing and will be seated at sufficiently safe intervals.
- The use of any herbicide or other toxic chemical shall be strictly in accordance with the manufacturer's instructions. The Engineer shall be given proper notice of the proposed use of any herbicide or toxic chemical. A register of all herbicides and other toxic chemicals delivered to the site shall be kept and maintained up to date by the Contractor. The register shall include the trade name, physical properties and characteristics, chemical ingredients, health and safety hazard information, safe handling and storage procedures, and emergency and first aid procedures for the product.

Risk of Lead Pollution

No man below the age of 18 years and no woman shall be employed on the work of painting with products containing lead in any form. No paint containing lead or lead products will be used except in the form of paste or readymade paint. Face masks will be supplied for use by the workers when paint is applied in the form of spray or a surface having lead paint dry rubbed and scrapped.

Risk caused by Force Majure

All reasonable precaution will be taken to prevent danger of the workers and the public from fire, flood, drowning, etc. All necessary steps will be taken for prompt first aid treatment of all injuries likely to be sustained during the course of work.

Risk from Explosives

- Except as may be provided in the contract or ordered or authorized by the Engineer, the Contractor shall not use explosives. Where the use of explosives is so provided or ordered or authorised, the Contractor shall comply with the requirements of the the law of the land as applicable:
- The Contractor shall at all times take every possible precaution and shall comply with appropriate laws and regulations relating to the importation, handling, transportation, storage and use of explosives and shall, at all times when engaged in blasting operations, post sufficient warning flagmen, to the full satisfaction of the Engineer.
- The Contractor shall at all times make full liaison with and inform well in advance and obtain such permission as is required from all Government Authorities, public bodies and private parties whatsoever concerned or affected or likely to be concerned or affected by blasting operations.

First Aid

At every workplace, a readily available first aid unit including an adequate supply of sterilised dressing material and appliances will be provided as per the Factory Rules.

Potable Water

In every workplace at suitable and easily accessible places a sufficient supply of cold potable water (as per IS) will be provided and maintained. If the drinking water is obtained from an intermittent public water supply then, storage tanks will be provided.

Hygiene

- The Contractor during the progress of work will provide, erect and maintain necessary (temporary) living accommodation and ancillary facilities for labour to standards and scales approved by the resident engineer.
- There shall be provided within the precincts of every workplace, latrines and urinals in an accessible place, and the accommodation, separately for each for these, as per standards set by the Building and other Construction Workers (regulation of Employment and Conditions of Service) Act, 1996. If women are employed, separate latrines and urinals, screened from those for men and marked in the vernacular shall be provided. There shall be adequate supply of water, close to latrines and urinals.
- All temporary accommodation must be constructed and maintained in such a fashion that uncontaminated water is available for drinking, cooking and washing. The sewage system for the camp must be properly designed, built and operated so that no health hazard occurs and no pollution to the air, ground or adjacent watercourses takes place. Compliance with the relevant legislation must be strictly adhered to. Garbage bins must be provided in the camp and regularly emptied and the garbage disposed off in a hygienic manner. Construction camps are to be sited away from vulnerable people and adequate

health care is to be provided for the work force.

- On completion of the works, the whole of such temporary structures shall be cleared away, all rubbish burnt, excreta or other disposal pits or trenches filled in and effectively sealed off and the whole of the site left clean and tidy, at the Contractor's expense, to the entire satisfaction of the Engineer.

12.7.4 OPERATION PHASE

Environmental issues change during operation phase and its mitigation plan also has to be looked for a longer period of time.

12.7.4.1 Noise

The noise will impact the people outside on the elevated part of the corridor. Mostly upper stories of the buildings close to the corridor may face additional noise level. In case the elevated track goes too close to any sensitive building, noise barrier may be constructed there.

12.7.4.2 Refuse from Stations

The station will generate solid waste from different uses of the passengers. All wastes from stations need to be disposed properly to avoid any local pollution. The Metro authorities should have special group to work on this.

12.7.4.3 Traffic problem near the Stations

There will be increased traffic near the stations. All stations also will not have parking spaces. If this traffic is not managed properly it can cause both noise and air pollution locally. This should be considered for long term planning.

Proper traffic signs and special traffic lights may be required near the station area. This needs to be coordinated with city police and traffic authorities.

12.8 ENVIRONMENT MANAGEMENT PLAN

12.8.1 INTRODUCTION

Environmental Management Plan (EMP) is the key to ensure that the environmental quality of the zone under impact does not deteriorate beyond the expected level due to the construction and operation of the project. As discussed in the previous sections, the design, construction and operation activities can have various levels of environmental impacts. Though there have been always some attempts to mitigate the impact, yet those were always immediate response to some problems rather than an overall management of environmental issues. EMP ensures that the environmental mitigation measures and enhancement programme are properly implemented and the responsibility for implementation is clearly entrusted.

The main objective of the Environmental Management Plan is to ensure that:

- The EMP is integrated with various stages of the project planning and implementation (design, Construction and Operation Phase)
- The environmental safeguards are carried out correctly
- Site activities are well managed
- Adverse impacts on various environmental components are avoided or minimized
- All the relevant legislations are complied
- The project is monitored for the environmental impacts
- The Environmental Management Plan is integrated into the Contract Agreement.

Management plan consists of the following activities:

- Implementation of Environmental Mitigation Measures
- Monitoring
- Training
- Statutory requirements
- Documentation
- Plantation
-

12.8.2 IMPLEMENTATION OF ENVIRONMENTAL MITIGATION MEASURES

Implementation of Environmental Mitigation Measures is the most important task of EMP. An implementation task list is formed and all the mitigation measures are included. The responsible persons will have to monitor whether all the recommended measures are being implemented or not, if implemented then to what level. A monthly reporting chart may be prepared which will be filled up by the responsible official.

12.8.3 MONITORING

12.8.3.1 Air Quality

An air quality monitoring programme will be undertaken during construction. Monitoring will be undertaken at the points where baseline data has been collected during this study. These monitoring activities can result in designing more effective mitigation measures. Air quality should also be monitored during operation phase to compare the change in air quality due to implementation of the project. Major air quality monitoring parameters to be monitored are PM10, PM2.5, SO2 and NOX.

12.8.3.2 Water Quality

Water quality of local water supply that may be impacted by construction process and is used by local community shall be monitored. Monitoring parameters will be as per Drinking Water standard IS-10500 or surface water standard as relevant.

12.8.3.3 Plantation

Plantation of trees and their management will be an important environmental activity for the management group. The activities will include selection of plants, development of nurseries, protection of the plants, interaction with the roadside communities for plantation management, monitoring of the plantations etc. This will require interaction with Department of Forest, NGOs etc.

12.8.4 TRAINING

Training is of much importance in environmental management. Environmental science is a developing subject and the people implementing environmental strategies should remain update with the environmental control process. Environmental Management Plan will include suitable training courses for the working engineers and technicians. There should be workshop for the contractors to follow environmental norms.

12.8.5 STATUTORY REQUIREMENTS

Project Management and the contractors performing different activities will have to meet a number of requirements under different environmental acts e.g. Water (Prevention and Control of Pollution) Act, Air (Prevention and Control of Pollution) Act, Environment (Protection) Act, Hazardous Waste (Management and Handling) Rules, Manufacture, Storage and Import of Hazardous Chemicals Rules etc. Timely submission of the reports, attaining required standards under these rules, interaction with other government departments e.g. Department of Environment, Department of forest etc. will be the prime responsibility of the environmental management group.

12.8.6 DOCUMENTATION

Documentation of the environmental activities is one of the important steps in Environment Management Plan. All monitoring activities details, results, standards, statutory requirements documents, plantation details, equipment performance, other activities related to environment etc. will be documented in a proper manner so that the relevant information are quickly available as required. Documentation will include:

- Major technical information in construction and operation (similar to process information for a manufacturing unit)
- Organisational Charts

- Environmental Monitoring Standards
- Environmental and related legislation
- Operational Procedure
- Monitoring Records
- Quality Assurance Plan for Monitoring
- Emergency plans

12.8.7 ENVIRONMENT MANAGEMENT GROUP

A separate environmental management group will be established to implement the management plan. The group shall be headed by an Executive Engineer. The group shall ensure the suitability, adequacy and effectiveness of the Environment Management Programme. The management review process will ensure that the necessary information is collected to allow management to carry out its evaluation. This review will be documented.

Following is the standard agenda for Management Review Meeting (MRM)

- Review of previous meeting minutes
- Review of environmental policy
- Review of significant aspect
- Overall performance against objectives and targets and environmental management program
- Compliance of current legislation
- Changes in Corporate and site environmental strategy
- Changes in Corporate and site environmental requirements
- Views of interested parties, especially operational staff
- New and emerging environmental issues of relevance to the site
- Any incidents / accidents relating to emergency preparedness and response
- Suitability of designated responsibilities and organizational arrangements
- Any difficulty with the verification activities and corrective action, and internal audit programs
- Required changes to the environmental management system
- Resources to implement EMS
- Any other points with the permission of chair
- A management review will be conducted:
- At least every three months
- When important new environmental regulations or issues arise
- When new significant aspects are identified

12.9 SOCIAL IMPACT ASSESSMENT

Report on Social Impact Assessment is submitted separately with this DPR. Although the type of land in terms of govt. and private has been shown in chapter 4 along with the quantity of land required in Hectares. The major components of the SIA report will be description of the project, Methodology for Impact Assessment, Socio-economic information/ profile, scope of land acquisition & resettlement, stakeholders consultation & participation, Legal Framework, Relocation & Rehabilitation strategy, Resettlement budget and finally the grievance redress mechanisms.

Chapter 13

Cost Estimates

CHAPTER - 13

COST ESTIMATES

13.1 INTRODUCTION

Detailed cost estimates for North-South Corridor (Chaudhary Charan Singh Airport - Munshipulia), Gomti Nagar Link and East-West Corridor (Charbagh/Lucknow Railway Station – Vasantkunj) have been prepared covering civil, electrical, signalling and telecommunications works, rolling stock, environmental protection, rehabilitation, etc. considering 25 kV ac Overhead Traction System at May 2013 price level.

While preparing the capital cost estimates, various items have generally been grouped under three major heads on the basis of (i) route km length of alignment, (ii) number of units of that item, and (iii) item being an independent entity. All items related with alignment, 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 recently awarded rates of Phase III Delhi Metro Project and a suitable escalation factor has been applied to bring these costs to May 2013 price level. Land rates have not been changed and are same as these were in April 2011 DPR. The details of taxes and duties are worked out separately.

13.2 CAPITAL COST ESTIMATE – NORTH-SOUTH CORRIDOR

The overall capital cost for Chaudhary Charan Singh Airport – Munshipulia Corridor at May 2013 price level, works out to **Rs. 4992Crores** excluding taxes and duties, but including general charges & design charges @ 7% on all items except land and 3% contingencies on all items. The abstract capital cost estimates are shown at Table 13.1.

Table 13.1 - CAPITALS COST ESTIMATE
North South Corridor (Chaudhary Charan Singh Airport - Munshi Pulia)
Total length = 22.878 km

Total UG (Including C&C and half Ramp length) = 3.44 km
(UG by TBM: 2.418, UG by C&C: 1.022 including half ramp length)
Elv (including half ramp length) = 19.438 km
(Total Station = 22 nos, UG = 3, Elv = 19)

May 2013 level

S. No.	Item	Unit	Rate	Qty.	Amount (Rs. in Cr.)
				Without taxes	
1.0	**Land**				
1.1	Permanent				
a	Government	ha	**5.000**	42.300	211.50
b	Private	ha	**25.000**	5.700	142.50
1.2	Temporary				
a	Government	ha	**1.200**	3.670	4.40
b	Private	ha	**6.000**	1.980	11.88
	Subtotal (1)				**370.28**
2.0	**Alignment and Formation**				
2.1	Underground section by T.B.M excluding station length (240m each)	R. Km.	105.710	1.698	179.50
2.2	Underground section by Cut & Cover excluding station length (240m each)	R. Km.	97.970	1.022	100.13
2.3	Elevated section including station length	R. Km.	29.057	19.438	564.81
2.4	Entry to depot	R. Km.	29.057	1.000	29.06
	Subtotal (2)				**873.49**
3.0	**Station Buildings**				
3.1	Underground Station(240 m length) incl. EM works, lifts, escalators, VAC etc.	Each			
a	Underground Station- Civil works	Each	109.143	3	327.43
b	Underground Station- EM works etc.	Each	57.370	3	172.11
3.2	Elevated stations(including finishes)	Each			
a	Type (A) way side- civil works	Each	22.894	12	274.73
b	Type (A) way side- EM works etc	Each	6.500	12	78.00
c	Type (B) Way side with signalling-civil works	Each	24.655	5	123.28
d	Type (B) Way side with signalling-EM works etc	Each	6.500	5	32.50
e	Type (C), Terminal station -civil	Each	25.540	2	51.08

S. No.	Item	Unit	Rate	Qty.	Amount (Rs. in Cr.)
				Without taxes	
	works				
f	Type (c), Terminal station -EM works	Each	6.500	2	13.00
3.3	OCC bldg.	LS			
a	OCC bldg.-civil works	LS			40.00
b	OCC bldg.-EM works etc	LS			10.00
	Subtotal (3)				**1122.12**
4.0	**Depot**	LS			
a	Civil works	LS			70.00
b	EM works etc **(Without workshop)**	LS			105.00
	Subtotal (4)				**175.00**
5.0	**P-Way**				
5.1	Ballastless track for elevated & underground Section (22.878+1.000)	R. Km.	7.260	23.878	173.35
5.2	Ballasted track for at grade alignment (in depot)	R. Km.	7.260	5.000	36.30
	Subtotal (5)				**209.65**
6.0	**Traction & power supply incl. OHE, ASS etc. Excl. lifts & Escalators**				
6.1	UG Section	R.Km.	14.230	3.440	48.95
6.1	Elevated & at grade section (19.438+1.000)	R.Km.	9.560	20.438	195.39
	Subtotal (6)				**244.34**
7.0	**Signalling and Telecom.**				
7.1	Sig. & Telecom.	R. Km.	14.540	23.878	347.19
7.2	Automatic fare collection	Stn.			
	a) Underground stations	Each	5.000	3	15.00
	b) Elevated stations	Each	5.000	19	95.00
	Subtotal (7)				**457.19**
8.0	**R & R incl. Hutments etc.**	R. Km.	3.120	22.878	71.38
	Subtotal (8)				**71.38**
9.0	**Misc. Utilities, roadworks, other civil works such as median stn. signages Environmental protection**	R. Km.			
	Civil works **(3.53 cr/km)** + EM works (2.93 cr/km)	R. Km.	6.460	22.878	147.79
	Subtotal (9)				**147.79**
10.0	**Rolling Stock**	Each	9.800	78	764.40

S. No.	Item	Unit	Rate	Qty.	Amount (Rs. in Cr.)
				Without taxes	
	Subtotal (10)				**764.40**
11.0	**Capital expenditure on security**	LS			
a	Civil works	R.Km.	0.235	22.878	5.38
b	EM works etc	R.Km.	0.056	22.878	1.28
	Subtotal (11)				6.66
12.0	**Staff quarter for O & M**				
a	Civil works	R.Km.	1.042	22.878	23.84
b	EM works etc	R.Km.	0.258	22.878	5.90
	Sub Total (12)				**29.73**
13.0	**Capital expenditure on Multi-Modal Traffic Integration @ 2% of total cost excluding land**				**82.04**
	Sub Total (13)				**82.04**
14.0	**Total of all items except Land**				**4183.79**
15.0	**General Charges incl. Design charges @ 7 % on all items except land**				**292.87**
16.0	**Total of all items including G. Charges except land**				**4476.66**
17.0	**Continegencies @ 3 %**				**134.30**
18.0	**Gross Total**				**4610.96**
	Cost without land			**=**	**4611**
	Cost with land			**=**	**4992**

13.3 CAPITAL COST ESTIMATE – CHARBAGH RAILWAY STATION – VASANTKUNJ

The overall capital cost for Charbagh Railway Station – Vasantkunj Corridor at May 2013 price level, works out to Rs. 3723Crores excluding taxes and duties but including general charges & design charges @ 7% on all items except land and 3% contingencies on all items. The abstract capital cost estimates are shown at Table 13.2.

Table 13.2 CAPITAL COST ESTIMATE
E-W Corridor (Lucknow Railway Station to Vasant Kunj)
Total length = 11.098 km

Total UG (including C&C and half Ramp length) = 6.550 km
(UG by TBM: 5.462, UG by C&C: 1.088 including half ramp length)
Elv (including half ramp length) = 4.548 km
Total Station = 12 nos, UG = 7, Elv = 5

May 2013 level

S. No.	Item	Unit	Rate	Qty.	Amount (Rs. in Cr.)
				Without taxes	
1.0	**Land**				
1.1	Permanent				
a	Government	ha	5.000	14.740	73.70
b	Private	ha	25.000	2.620	65.50
1.2	Temporary				
a	Government	ha	1.200	2.710	3.25
b	Private	ha	6.000	2.840	17.04
	Subtotal (1)				**159.49**
2.0	**Alignment and Formation**				
2.1	Underground section by T.B.M excluding station length (240m each)	R. Km.	105.710	4.022	425.17
2.2	Underground section by Cut & Cover excluding station length (240m each)	R. Km.	97.970	0.848	83.08
2.3	Elevated section including station length	R. Km.	29.057	4.548	132.15
2.4	Entry to depot	R. Km.	29.057	0.350	10.17
	Subtotal (2)				**650.57**
3.0	**Station Buildings**				
3.1	Underground Station(240 m length) incl. EM works, lifts, escalators, VAC etc.	Each			
a	Underground Station- Civil works	Each	109.143	7	764.00
b	Underground Station- EM works etc.	Each	57.370	7	401.59
3.2	Elevated stations(including finishes)	Each			
a	Type (A) way side- civil works	Each	22.894	2	45.79
b	Type (A) way side- EM works etc	Each	6.500	2	13.00
c	Type (B) Way side with signalling- civil works	Each	24.655	2	49.31
d	Type (B) Way side with signalling- EM works etc	Each	6.500	2	13.00
e	Type (C), Terminal station -civil	Each	25.540	1	25.54

S. No.	Item	Unit	Rate	Qty.	Amount (Rs. in Cr.)
	works				
f	Type (c), Terminal station -EM works	Each	6.500	1	6.50
	Subtotal (3)				**1318.73**
4.0	**Depot**	LS			
a	Civil works	LS			70.00
b	EM works etc (**Without workshop)**	LS			105.00
	Subtotal (4)				**175.00**
5.0	**P-Way**				
5.1	Ballastless track for elevated & underground Section (11.098+0.350)	R. Km.	7.260	11.448	83.11
5.2	Ballasted track for at grade alignment (in depot)	R. Km.	7.260	5.000	36.30
	Subtotal (5)				**119.41**
6.0	**Traction & power supply incl. OHE, ASS etc. Excl. lifts & Escalators**				
6.1	UG Section	R.Km.	14.230	6.550	93.21
6.1	Elevated & at grade section (4.548+0.350)	R.Km.	9.560	4.898	46.82
	Subtotal (6)				**140.03**
7.0	**Signaling and Telecom.**				
7.1	Sig. & Telecom.	R. Km.	14.540	11.448	166.45
7.2	Automatic fare collection	Stn.			
	a) Underground stations	Each	5.000	7	35.00
	b) Elevated stations	Each	5.000	5	25.00
	Subtotal (7)				**226.45**
8.0	**R & R incl. Hutments etc.**	R. Km.	3.120	11.098	34.63
	Subtotal (8)				**34.63**
9.0	**Misc. Utilities, roadworks, other civil works such as median stn. signages Environmental protection**	R. Km.			
	Civil works **(3.53 cr/km)** + EM works (2.93 cr/km)	R. Km.	6.460	11.098	71.69
	Subtotal (9)				**71.69**
10.0	**Rolling Stock**	Each	9.800	42	411.60
	Subtotal (10)				**411.60**
11.0	**Capital expenditure on security**				
a	Civil works	R. Km.	0.235	11.098	2.61
b	EM works etc	R. Km.	0.056	11.098	0.62
	Subtotal (11)				3.23
12.0	**Staff quarter for O & M**				
a	Civil works	R. Km.	1.042	11.098	11.56
b	EM works etc	R. Km.	0.258	11.098	2.86
	Sub Total (12)				**14.42**

S. No.	Item	Unit	Rate	Qty.	Amount (Rs. in Cr.)
13.0	Capital expenditure on Multi-Modal Traffic Integration @ 2% of total cost excluding land				63.32
	Sub Total (13)				63.32
14.0	Total of all items except Land				3229.08
15.0	General Charges incl. Design charges @ 7% on all items except land				226.04
16.0	Total of all items including G. Charges except land				3455.12
17.0	Contingencies @ 3 %				103.65
18.0	Gross Total				3558.77
	Cost without land			=	3559
	Cost with land			=	3723

13.4 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) Total land permanently required for the project is 65.36 Ha out of which only 8.32 Ha is private land and major part of it *i.e.* 57.04 Ha is government land which includes 49.13 Ha land for depots at Transport Nagar and at Fish Mandi on Hardoi road.

iii) In addition to the lands required permanently, 6.38 Ha of Government land and 4.82 Ha of private land is temporarily required for construction of depots, running sections and stations. Ground rent charges for 3 years @ 6% per year of the cost of land have been provided for, in the project cost estimates.

iv) Total land requirements permanently for North-South Corridor have been worked out to 48.00 Ha, out of which 42.30 Ha is Govt. land and 5.70Ha is private land.

v) Similarly, for East-West Corridor, total permanent land required is 17.36 Ha, out of which 14.74 Ha is government and 2.62 Ha is private land.

vi) 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

13.5 FORMATION / ALIGNMENT

i) **Underground section:** The basis of rate is recently awarded rates of Phase III Delhi Metro Project and a suitable escalation factor has been applied to bring these costs to May 2013 price level. Costs are worked considering underground alignment to be done by Tunnel Boring Machines and cut & cover method, except 240 m lengths for each station, which is proposed to be done along with station work. Only one station is proposed to be constructed by cut & cover method.

ii) **Elevated Section:** The basis of rate is recently awarded rates of Phase III Delhi Metro Project and a suitable escalation factor has been applied to bring these costs to May 2013 price level. Cost of viaduct length for station has been included in elevated section.

13.6 STATION BUILDINGS

i) **Underground Stations:** Rates for underground stations are based on recently awarded rates of Phase III Delhi Metro Project and a suitable escalation factor has been applied to bring these costs to May 2013 price 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:** The basis of rate is recently awarded rates of Phase III Delhi Metro Project and a suitable escalation factor has been applied to bring these costs to May 2013 price 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.

13.7 PERMANENT WAY

For elevated and underground sections, ballast-less track and for at-grade section and Depot ballasted track has been planned. The basis of rate is recently awarded rates of Phase III Delhi Metro Project and a suitable escalation factor has been applied to bring these costs to May 2013 price level.

13.8 DEPOT

Separate Car Maintenance Depot-cum-Workshop for North-South Corridor and East-West Corridor has been proposed at Transport Nagar and at Fish mandi on Hardoi road respectively. The two depots are planned at ground level. Costs have been worked out for various items of building, elevated structures, tracks, boundary wall & plants machinery etc.

13.9 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 Delhi Metro.

13.10 ENVIRONMENTAL IMPACT ASSESSMENT

Provision for environmental impacts of the proposed corridors of Lucknow Metro has been made to cover various protection works, additional compensatory measures, compensation for loss of trees, compensatory afforestation and fencing, monitoring of water quality, air/noise pollution during construction, establishment of Environmental Division.

13.11 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.

13.12 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 basis of rate is recently awarded rates of Phase III Delhi Metro Project and a suitable escalation factor has been applied to bring these costs to May 2013 price level.

13.13 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.

13.14 SIGNALLING & TELECOMMUNICATION WORKS

The basis of rate is recently awarded rates of Phase III Delhi Metro Project and a suitable escalation factor has been applied to bring these costs to May 2013 price level and TPWS works. These rates include escalation during manufacture & supply of equipment and their installation at site, but exclude CD and WT.

13.15 AUTOMATIC FARE COLLECTION

The basis of rate is recently awarded rates of Phase III Delhi Metro Project and a suitable escalation factor has been applied to bring these costs to May 2013 price level. These rates exclude CD & WT, but include escalation during the period of equipment manufacture and their supply, including installation.

13.16 ROLLING STOCK

The estimated cost per coach at May 2013 price level exclusive of taxes and duties has been taken as Rs. 9.80 crores per coach.

13.16 First and last mile connectivity

Alongwith planning for Metro Rail System in any city, there is a need for providing a transportation system which is seamlessly integrated across all modes and provides first mile as well as last mile connectivity. It is also necessary that various public transportation modes including Inter-mediate Public Transport(IPT) and feeder buses etc. work together in order to facilitate increase ridership to the Metro system and case of using the Metro system by the public at large.

To achieve this goal, Metro Rail Stations influenced zone need to be defined which can be taken as approximately 5 kms for the motorized traffic and 1.5 km. for pedestrian/cyclists. Detailed Study is required to be done in this influenced zone of a Metro station for following aspects mainly:

i) Availability and review of existing public and IPT facilities, in terms of motorized and non-motorised mode with main consideration of the streets/roads adjoining literally to the stations and also to examine adequacy of availability of pedestrians/cycle paths in the influenced zone.

ii) Analysis and identification of gaps between supply and demand in terms of feeder facilities and other requirements for better first and last mile connectivity.

iii) Proposal for introduction/enhancement of feeder buses and cycle/pedestrians tracks, bike sharing arrangement for each Metro station to be finalised.

iv) Proposal for better integration of Metro station with other mode of transport, such as relocation of existing bus stop, introduction of new bus stop, bus base etc.

v) Cost of the requirements namely road widening including roads for pedestrian/cycle paths, feeder buses based on the outcome of the study.

The detailed study and requirement for providing first mil as well as last mile connectivity to the Metro users will be carried out separately and the same should be in place before the commercial operation of the Metro services for the benefit of the users as well as for better ridership and the financial viability of the project.

Since, it is envisaged that detailed study for provision of feeder buses, public bike sharing and pedestrianisation in the influence zone of metro stations will be done and put in place by the time commercial operation of the Metro services, a lump-sum cost of 2% of project cost(excluding taxes and land cost) is considered sufficient and included in the project cost of proposed Metro Rail System. If at any stage more feeder services etc.will be required, same can be augmented by concerned City and other Authorities.

13.18 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. 729Crores and Rs. 572Crores for North-South Corridor and East-West Corridor respectively (Table 13.3 and 13.4).

Table 13.3 - North South Corridor (CCS Airport - Munshi Pulia)
Details of Taxes and Duties

Customs duty =	22.8531%	
Excise duty =	12.36 %	
Sale tax =	6.25 %	= 12.5%/2
Works tax =	6.25 %	=12.5%/2
VAT =	12.5%	

S. No.	Description	Total cost without Taxes & duties (Cr.)	Taxes and duties					Total taxes & duties (Cr.)
			custom duty (Cr.)	excise duty (Cr.)	sale tax (Cr.)	works tax (Cr.)	VAT(Cr.)	
1	**Alignment & Formation**							
	Underground	279.62	19.17	16.93	4.81	4.81	9.62	**45.73**
	Elevated, at grade & entry to Depot	593.87		51.38	14.60	14.60	29.19	**80.57**
2	**Station Buildings**							
	a) Underground station-civil works	327.43	22.45	19.83	5.63	5.63	11.27	**53.55**
	b) Underground station-EM works	172.11	19.67	9.04	2.57	2.57	5.14	**33.84**
	Elevated station - civil works	449.08		38.85	11.04	11.04	22.08	**60.93**
	Elevated station-EM works	123.50	5.64	10.38	2.95	2.95	5.90	**21.92**
	e) OCC bldg-civil works	40.00		3.46	0.98	0.98	1.97	**5.43**
	f) OCC bldg-EM works	10.00	0.46	0.84	0.24	0.24	0.48	**1.78**
3	**Depot**							
	Civil works	70.00	4.80	4.24	1.20	1.20	2.41	**11.45**
	EM works	105.00	4.80	8.83	2.51	2.51	5.01	**18.64**
4	**P-Way**	209.65	38.33	4.41	1.25	1.25	2.50	**45.24**
5	**Traction & power supply**							
	Traction and power supply	244.34	22.34	15.40	4.38	4.38	8.75	**46.49**
6	**S and T Works**							
	S & T	347.19	63.47	8.58	2.44	2.44	4.88	**76.93**
	AFC	110.00	18.85	3.40	0.97	0.97	1.93	**24.18**
7	**R & R hutments**	71.38				4.46	4.46	**4.46**
8	**Misc.**							
	Civil works	172.37		14.91	4.24	4.24	8.47	**23.39**
	EM works	57.46		6.04	1.71	1.71	3.43	**9.47**
9	**Rolling stock**	764.40	153.73	7.37	2.09	2.09	4.19	**165.28**
10	**Security**							
	Civil works	5.38		0.47	0.17	0.17	0.34	**0.80**
	EM works	1.28		0.16	0.06	0.06	0.12	**0.27**
11	**Staff quarter for O & M**							
	Civil works	23.84		2.06	0.08	0.08	0.16	**2.23**
	EM works	5.90		0.73	0.26	0.26	0.53	**1.26**
	Total	**4183.79**	**373.71**	**223.90**	**63.60**	**68.07**	**131.67**	**729.27**
	Total taxes & Duties					**SAY**		**729**

Table 13.4 - Chargbagh to Vasant Kunj Corridor
Details of Taxes and Duties

Customs duty = 22.8531 %
Excise duty = 12.36 %
Sale tax = 6.25 % = 12.5%/2
Works tax = 6.25 % = 12.5%/2
VAT = 12.5 %

S. No.	Description	Total cost without Taxes & duties (Cr.)	Taxes and duties					Total taxes & duties (Cr.)
			custom duty (Cr.)	excise duty (Cr.)	sale tax (Cr.)	works tax (Cr.)	VAT (Cr.)	
1	**Alignment & Formation**							
	Underground	508.24	34.84	30.78	8.74	8.74	17.49	**83.11**
	Elevated, at grade & entry to Depot	142.32		12.31	3.50	3.50	7.00	**19.31**
2	**Station Buildings**							
	a) Underground station-civil works	764.00	52.38	46.27	13.14	13.14	26.29	**124.94**
	b) Underground station-EM works	401.59	45.89	21.10	5.99	5.99	11.99	**78.97**
	Elevated station - civil works	120.64		10.44	2.97	2.97	5.93	**16.37**
	Elevated station-EM works	32.50	1.49	2.73	0.78	0.78	1.55	**5.77**
	e) OCC bldg-civil works	0.00		0.00	0.00	0.00	0.00	**0.00**
	f) OCC bldg-EM works	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
3	**Depot**							
	Civil works	70.00	4.80	4.24	1.20	1.20	2.41	**11.45**
	EM works	105.00	4.80	8.83	2.51	2.51	5.01	**18.64**
4	**P-Way**	119.41	21.83	2.51	0.71	0.71	1.43	**25.77**
5	**Traction & power supply**							
	Traction and power supply	140.03	12.80	8.83	2.51	2.51	5.02	**26.64**
6	**S and T Works**							
	S & T	166.45	30.43	4.11	1.17	1.17	2.34	**36.88**
	AFC	60.00	10.28	1.85	0.53	0.53	1.05	**13.19**
	PSD	0.00						
7	**R & R hutments**	34.63				2.16	2.16	**2.16**
8	**Misc.**							
	Civil works	101.26		8.76	2.49	2.49	4.98	**13.74**
	EM works	33.75		3.55	1.01	1.01	2.01	**5.56**
9	**Rolling stock**	411.60	82.78	3.97	1.13	1.13	2.25	**89.00**
10	**Security**							
	Civil works	2.61		0.23	0.08	0.08	0.16	**0.39**
	EM works	0.62		0.08	0.03	0.03	0.06	**0.13**
11	**Staff quarter for O & M**							
	Civil works	11.56		1.00	0.04	0.04	0.08	**1.08**
	EM works	2.86		0.35	0.13	0.13	0.26	**0.61**
	Total	**3229.08**	**302.32**	**170.27**	**48.37**	**50.54**	**98.91**	**571.50**
	Total taxes & Duties					**SAY**		**572**

Chapter 14

Financing Options, Fare Structure & Financial Viability

Chapter - 14

FINANCING OPTIONS, FARE STRUCTURE AND FINANCIAL VIABILITY

14.1 INTRODUCTION

The Lucknow Metro Project is proposed to be constructed with an estimated cost of Rs 9786.00 Crore with central taxes and land cost. The length of the metro system and estimated cost at May-2013 price level without central taxes and with central taxes is placed in table 14.1 as under:

Table 14.1 Cost Details

Sr. No.	Name of Corridor	Distance (KMs)	Estimated cost without taxes (Rs/Crore)	Estimated cost with Central taxes & land cost (Rs/Crore)
1	N-S Corridor (CCS Airport-Munshi Pulia)	22.878	4,992.00	5,590.00
2	E-W Corridor (Charbagh-Vasant Kunj)	11.098	3,723.00	4,196.00

The estimated cost at May-2013 price level includes an amount of Rs.10.83 Crore as one-time charges of security personal towards cost of weapons, barricades, and hand held and door detector machine etc. However, the recurring cost towards salary and allowances of security personal have not taken in to account in FIRR calculation. 2% of the project cost is taken for feeder bus services to provide last mile connectivity to the metro network

14.2 COSTS

14.2.1 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 @7.5% PA. It has been assumed that UP State Government will exempt the local taxes or reimburse the same and provide the land worth Rs. 545.00 crore (without considering escalation) free of cost or it shall provide Interest Free SD.

It is assumed that the construction work will start on 01.01.2014 and 01.09.2014 respectively for N-S corridor & E-W corridor and is expected to be completed on 31.03.2018 and 31.03.2019 with Revenue Opening Date (ROD) as 01.04.2018 & 01.04.2019 respectively for the both the corridors. The total completion costs duly escalated and shown in the table 14.2 have been taken as the initial investment. The cash flow of investments separately is placed in Table –14.2 as below.

Table 14.2 Year –wise Investment (Completion Cost)

Figures in Rs. Crore

Financial Year	Cost at May 2013 Price Level			Completion Cost		
	Corridor-I	Corridor-II	Total	Corridor-I	Corridor-II	Total
2013-14	179.00	0.00	179.00	179.00	0.00	179.00
2014-15	908.00	257.00	1165.00	967.00	272.00	1239.00
2015-16	1169.00	660.00	1829.00	1331.00	754.00	2085.00
2016-17	1563.00	860.00	2423.00	1942.00	1055.00	2997.00
2017-18	1042.00	1210.00	2252.00	1392.00	1616.00	3008.00
2018-19	521.00	806.00	1327.00	748.00	1157.00	1905.00
2019-20	208.00	242.00	450.00	321.00	373.00	694.00
2020-21	0.00	161.00	161.00	0.00	267.00	267.00
Total	**5590.00**	**4196.00**	**9786.00**	**6880.00**	**5494.00**	**12374.00**

Although the construction is expected to get over by 31st March 2019, the cash flow spill over up to March 2021 on account of payment normally required to be made to the various contractors up to that period necessitated by contractual clauses.

The cost of Land of Rs. 545.00 crore (without considering escalation) included in the above completion cost will be provided free of cost by the UP Government. However, Cost of 60 hectare land to be provided by UP government has not been included in above.

14.2.2 Additional Investment

Total investment provided in the FIRR calculation towards requirement of additional rolling stock duly escalated @5% PA is placed in table 14.5 as under: -

Table 14.3 Additional Investment towards Rolling Stock

(Rs/Crore)

Financial Year	No. of Cars		Amount	
	Corridor-I	Corridor-II	Corridor-I	Corridor-II
2020-21	30	12	528.00	211.00
2025-26	30	18	674.00	405.00
2030-31	42	30	1205.00	861.00
2041-42	48	18	2355.00	883.00

14.2.3 Operation & Maintenance (O&M) Costs

The Operation & Maintenance costs can be divided into three major parts: -

(i) Staff costs

(ii) Maintenance cost which include expenditure towards upkeep and maintenance of the system and consumables

(iii) Energy costs

The requirement of staff has been assumed @ 35 persons per kilometre. The escalation factor used for staff costs is 9% per annum to provide for both escalation and growth in salaries.

The cost of other expenses is based on the actual O & M unit cost for the Delhi Metro Phase-II project. The average rate of electricity being paid by Delhi Metro for its Phase-I and Phase-II operations in Delhi is Rs. 5.80 per unit whereas for UP operation the applicable rate is Rs. 5.00 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 7.50% per annum. The O&M costs have been tabulated in Table 14.4.1, 14.4.2 & Table 14.4.3 as below for the both corridors:

Table 14.4.1 Operation and Maintenance Costs (Corridor-I)

Rs. In Crore

YEAR			Staff	Maintenance Expenses	Energy	Total
2018	-	2019	43.84	33.32	37.60	114.75
2019	-	2020	47.79	35.81	40.42	124.02
2020	-	2021	52.09	38.50	58.72	149.31
2021	-	2022	56.77	41.39	63.12	161.29
2022	-	2023	61.88	44.49	67.86	174.23
2023	-	2024	67.45	47.83	72.95	188.23
2024	-	2025	73.52	51.42	78.42	203.36
2025	-	2026	80.14	55.27	99.04	234.46
2026	-	2027	87.35	59.42	106.47	253.24

YEAR			Staff	Maintenance Expenses	Energy	Total
2027	-	2028	95.22	63.87	114.46	273.55
2028	-	2029	103.79	68.66	123.04	295.49
2029	-	2030	113.13	73.81	132.27	319.21
2030	-	2031	123.31	79.35	193.67	396.32
2031	-	2032	134.40	85.30	208.19	427.90
2032	-	2033	146.50	91.70	223.81	462.01
2033	-	2034	159.69	98.58	240.59	498.85
2034	-	2035	174.06	105.97	258.63	538.66
2035	-	2036	189.72	113.92	278.03	581.67
2036	-	2037	206.80	122.46	298.88	628.15
2037	-	2038	225.41	131.65	321.30	678.36
2038	-	2039	245.70	141.52	345.40	732.62
2039	-	2040	267.81	152.13	371.30	791.25
2040	-	2041	291.91	163.54	441.17	896.62
2041	-	2042	318.19	175.81	474.25	968.25
2042	-	2043	346.82	189.00	509.82	1045.64

Table 14.4.2 - Operation and Maintenance Costs (Corridor-II)

Rs. In Crore

YEAR			Staff	Maintenance Expenses	Energy	Total
2019	-	2020	21.69	19.38	38.55	79.61
2020	-	2021	23.64	20.83	50.68	95.15
2021	-	2022	25.77	22.39	54.48	102.64
2022	-	2023	28.09	24.07	58.56	110.72
2023	-	2024	30.62	25.88	62.95	119.45
2024	-	2025	33.37	27.82	67.68	128.87
2025	-	2026	36.38	29.90	81.29	147.57
2026	-	2027	39.65	32.15	87.39	159.18
2027	-	2028	43.22	34.56	93.94	171.72
2028	-	2029	47.11	37.15	100.99	185.24
2029	-	2030	51.35	39.94	108.56	199.84
2030	-	2031	55.97	42.93	140.77	239.67
2031	-	2032	61.01	46.15	151.33	258.49
2032	-	2033	66.50	49.61	162.68	278.79
2033	-	2034	72.48	53.33	174.88	300.69
2034	-	2035	79.01	57.33	188.00	324.33
2035	-	2036	86.12	61.63	202.10	349.84
2036	-	2037	93.87	66.25	217.25	377.37
2037	-	2038	102.31	71.22	233.55	407.08
2038	-	2039	111.52	76.57	251.06	439.15
2039	-	2040	121.56	82.31	269.89	473.76
2040	-	2041	132.50	88.48	290.13	511.11
2041	-	2042	144.43	95.12	338.70	578.24
2042	-	2043	157.42	102.25	364.10	623.78

Table 14.4.3 - Operation and Maintenance Costs (Combined)

Rs. In Crore

YEAR			Staff	Maintenance Expenses	Energy	Total
2018	-	2019	43.84	33.32	37.60	114.75
2019	-	2020	69.48	55.19	78.96	203.63
2020	-	2021	75.73	59.33	109.39	244.45
2021	-	2022	82.54	63.78	117.60	263.92
2022	-	2023	89.97	68.56	126.42	284.96
2023	-	2024	98.07	73.71	135.90	307.68
2024	-	2025	106.90	79.23	146.09	332.22
2025	-	2026	116.52	85.18	180.33	382.03
2026	-	2027	127.00	91.56	193.86	412.43
2027	-	2028	138.43	98.43	208.40	445.26
2028	-	2029	150.89	105.81	224.03	480.74
2029	-	2030	164.47	113.75	240.83	519.05
2030	-	2031	179.28	122.28	334.44	635.99
2031	-	2032	195.41	131.45	359.52	686.38
2032	-	2033	213.00	141.31	386.48	740.79
2033	-	2034	232.17	151.91	415.47	799.55
2034	-	2035	253.06	163.30	446.63	863.00
2035	-	2036	275.84	175.55	480.13	931.52
2036	-	2037	300.66	188.72	516.14	1005.52
2037	-	2038	327.72	202.87	554.85	1085.44
2038	-	2039	357.22	218.09	596.46	1171.77
2039	-	2040	389.37	234.44	641.20	1265.01
2040	-	2041	424.41	252.02	731.30	1407.74
2041	-	2042	462.61	270.93	812.95	1546.49
2042	-	2043	504.25	291.25	873.93	1669.42

14.2.4 Depreciation

Although depreciation does not enter the FIRR calculation (not being a cash outflow) unless a specific depreciation reserve fund has been provided, in the present calculation, depreciation calculations are placed for purpose of record.

14.2.5 Replacement Cost

The replacement costs are provided for meeting the cost on account of replacement of equipment due to wear and tear. With the nature of equipment proposed to be provided, it is expected that only 50% of the Signalling and Telecom and 25% of electrical works would require replacement after 20 years.

14.3 Revenues

The Revenue of Lucknow Metro mainly consists of fare box collection and other incomes from property development, advertisement, parking etc.

14.3.1 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.

14.3.2 Traffic

The projected ridership figures years are as indicated in table 14.5 as below: -

Table 14.5 - Projected Ridership

Financial Year	Trips per day (lakhs)	
	Corridor-I	Corridor-II
2018-19	4.97	-
2019-20	5.22	1.80
2020-21	6.45	2.43
2025-26	8.33	3.46
2030-31	10.54	4.60
2041-42	13.55	6.00

The growth rate for traffic is assumed at 5% Per Annum upto 2029-30 and thereafter @ 2.40% per annum.

14.3.3 Trip Distribution

The trip distribution has been worked out by considering average lead of 6.44 KM and, which is placed in Table 11.6 below: -

Table 14.6 - Trip Distribution

Distance in km	Percent distribution
0-2	14.00%
2-4	20.00%
4-6	23.00%
6-9	21.00%
9-12	10.00%
12-15	5.00%
15-18	3.00%
18-21	2.00%
21-24	1.00%
>24	1.00%
Total	**100.00%**

The graphic presentation of the same is placed below in Figure-14.1.

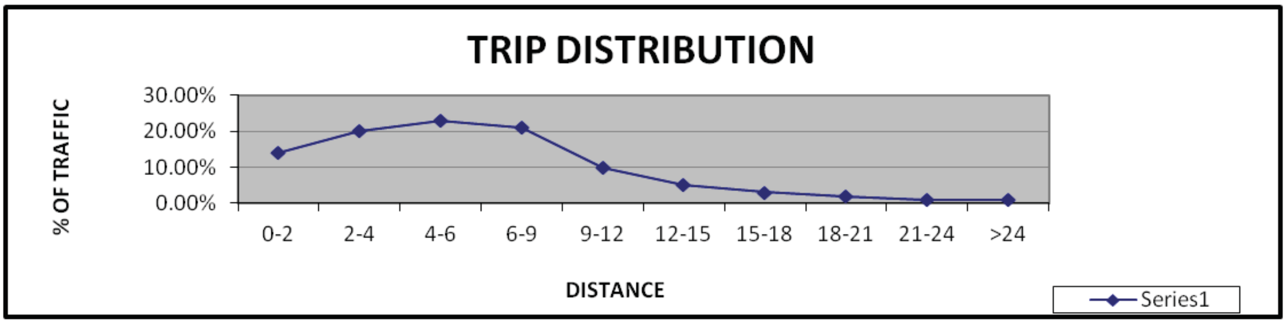


Figure 14.1 –Trip Distribution

14.3.4 Fare Structure

The Delhi Metro Fares structures as fixed by a fare fixation committee in 2009 have been assumed, which have been duly escalated @10.00% for every two years, which is placed in table 14.7.

Table 14.7 Fare Structure in 2018-19

Distance in kms.	Fare (Rs)
0-2	12
2-4	15
4-6	18
6-9	23
9-12	25
12-15	28
15-18	29
18-21	32
21-24	34
>24	35

14.3.5 Other sources of revenues

Other revenues from Property Development and advertisement have been estimated at 10% of the fare box revenues during operations. Apart from development of property on metro stations and depot it is possible to raise resources through leasing of parking rights at stations, advertisement on trains and tickets, advertisements within stations and parking lots, advertisements on viaducts, columns and other metro structures, co-branding rights to corporate, film shootings and special events on metro premises.

UP government vide letter no. 2624/Eight-1-13-09 L.D.A/13 dated 20.08.2013 has informed that 30% of total area available with FAR 5 for property development shall be used for commercial activity development and balance 70% shall be used for residential activity development. Accordingly calculation has been made.

SPV/BOT operator will engage a developer/Concessionaire for generating rental income. It is assumed that about 60.00 Hectare. i.e., 3,00,00,000 square feet area will be available for property development with a FAR of 5. The developer will bring equity to the extent of Rs.1660.00 crore and the balance amount towards construction shall be raised by SPV as 12% Market Debt. The estimated development cost will be Rs.6630.00 crore. It is assumed that the rental revenue will accrue to the developer from the FY 2018-19 which has been escalated @5% every year. Out of the estimated rental income, apart from meeting maintenance expenditure, the developer will repay the loan and interest. After meeting these obligations and retaining 14% return on his equity with an escalation @5% every year, the residual rental earnings will accrue to SPV, which has been taken into account in the FIRR calculations. The details of PD income accrue to SPV is tabulated as under:-

Table 14.8.1 - Estimated generation of Rental Income from PD

Rs. in Crore

Year	Construction cost	Up-front	Rental Income	Mainte-nance Expen-diture	Loan	IDC	Loan repay-ment	Bal Loan Amo-unt	Interest on Loan @12%	Return @14% to the developer	Resi-dual rental income to SPV
2013 - 2014	1200				868	52		920		-332	
2014 - 2015	1260				928	114		1962		-332	
2015 - 2016	1323				991	135		3088		-332	
2016 - 2017	1389				1057	153		4298		-332	
2017 - 2018	1458				1126	166		5590		-332	
2018 - 2019			5363	536			559	5031	671	232	3365
2019 - 2020			5399	540			559	4472	604	244	3452
2020 - 2021			208	21			559	3913	537	256	-1165
2021 - 2022			328	33			559	3354	470	269	-1003
2022 - 2023			689	69			559	2795	402	282	-623
2023 - 2024			724	72			559	2236	335	296	-538
2024 - 2025			760	76			559	1677	268	311	-454
2025 - 2026			798	80			559	1118	201	327	-369
2026 - 2027			838	84			559	559	134	343	-282
2027 - 2028			880	88			559	0	67	360	-194
2028 - 2029			924	92						378	454
2029 - 2030			970	97						397	476
2030 - 2031			1018	102						417	499
2031 - 2032			1069	107						438	524
2032 - 2033			1123	112						460	551
2033 - 2034			1179	118						483	578
2034 - 2035			1238	124						507	607
2035 - 2036			1300	130						532	638
2036 - 2037			1365	136						559	670
2037 - 2038			1433	143						587	703
2038 - 2039			1504	150						616	738
2039 - 2040			1580	158						647	775
2040 - 2041			1659	166						679	814
2041 - 2042			1742	174						713	855
2042 - 2043			1829	183						749	897
Total	**6630**	**0**	**35916**	**3591**	**4970**	**620**	**5590**		**3689**	**9422**	**11968**

14.4 Financial Internal Rate of Return (FIRR)

The Financial Internal Rate of Return (FIRR) obtained costs for 30 years business model works out to 8.12 % including construction period.

The FIRR with central taxes & duties is produced in Table 14.9.1, 14.9.2, 14.9.3 & 14.9.4

Table 14.9.1 –FIRR with Central Taxes (N-S Corridor)

Figs in cr. (Rs.)

Year			Outflow					Inflow			Cash Flow
			Completion Cost	Additional Cost	Running Expenses	Replacement costs	Total Costs	Fare Box Revenue	PD & ADVT	Total Revenue	IRR
2013	-	2014	179				179			0	-179
2014	-	2015	967				967			0	-967
2015	-	2016	1331				1331			0	-1331
2016	-	2017	1942				1942			0	-1942
2017	-	2018	1392				1392			0	-1392
2018	-	2019	748	0	115		863	333	33	366	-497
2019	-	2020	321	0	124		445	350	35	385	-60
2020	-	2021	0	528	149		677	480	48	528	-149
2021	-	2022	0	0	161		161	503	50	553	392
2022	-	2023	0	0	174		174	586	59	645	471
2023	-	2024	0	0	188		188	615	62	677	489
2024	-	2025	0	0	203		203	711	71	782	579
2025	-	2026	0	674	234		908	755	76	831	-77
2026	-	2027	0	0	253		253	868	87	955	702
2027	-	2028	0	0	274		274	911	91	1002	728
2028	-	2029	0	0	295		295	1052	105	1157	862
2029	-	2030	0	0	319		319	1104	110	1214	895
2030	-	2031	0	1205	396		1601	1272	127	1399	-202
2031	-	2032	0	0	428		428	1302	130	1432	1004
2032	-	2033	0	0	462		462	1468	147	1615	1153
2033	-	2034	0	0	499		499	1503	150	1653	1154
2034	-	2035	0	0	539		539	1703	170	1873	1334
2035	-	2036	0	0	582		582	1743	174	1917	1335
2036	-	2037	0	0	628		628	1963	196	2159	1531
2037	-	2038	0	0	678		678	2010	201	2211	1533
2038	-	2039	0	0	733	993	1726	2268	227	2495	769
2039	-	2040	0	0	791	774	1565	2323	232	2555	990
2040	-	2041	0	0	897	0	897	2618	262	2880	1983
2041	-	2042	0	2355	968	0	3323	2633	263	2896	-427
2042	-	2043	0	0	1046	0	1046	2969	297	3266	2220
Total			**6880**	**4762**	**11136**	**1767**	**24545**	**34043**	**3403**	**37446**	**6.69%**

Table 14.9.2 –FIRR with Central Taxes (E-W Corridor)

Figs in cr. (Rs.)

Year			Outflow					Inflow			Cash Flow
			Completion Cost	Additional Cost	Running Expenses	Replacement costs	Total Costs	Fare Box Revenue	PD & ADVT	Total Revenue	IRR
2014	-	2015	272				272			0	-272
2015	-	2016	754				754			0	-754
2016	-	2017	1055				1055			0	-1055
2017	-	2018	1616				1616			0	-1616
2018	-	2019	1157				1157			0	-1157
2019	-	2020	373	0	80		453	121	12	133	-320
2020	-	2021	267	211	95		573	181	18	199	-374
2021	-	2022	0	0	103		103	190	19	209	106
2022	-	2023	0	0	111		111	221	22	243	132
2023	-	2024	0	0	119		119	232	23	255	136
2024	-	2025	0	0	129		129	268	27	295	166
2025	-	2026	0	405	148		553	314	31	345	-208
2026	-	2027	0	0	159		159	360	36	396	237
2027	-	2028	0	0	172		172	378	38	416	244
2028	-	2029	0	0	185		185	437	44	481	296
2029	-	2030	0	0	200		200	458	46	504	304
2030	-	2031	0	861	240		1101	555	56	611	-490
2031	-	2032	0	0	258		258	568	57	625	367
2032	-	2033	0	0	279		279	640	64	704	425
2033	-	2034	0	0	301		301	656	66	722	421
2034	-	2035	0	0	324		324	742	74	816	492
2035	-	2036	0	0	350		350	760	76	836	486
2036	-	2037	0	0	377		377	856	86	942	565
2037	-	2038	0	0	407		407	877	88	965	558
2038	-	2039	0	0	439		439	989	99	1088	649
2039	-	2040	0	0	474	516	990	1013	101	1114	124
2040	-	2041	0	0	511	818	1329	1142	114	1256	-73
2041	-	2042	0	883	578	0	1461	1176	118	1294	-167
2042	-	2043	0	0	624	0	624	1326	133	1459	835
2043	-	2044	0	0	673	0	673	1357	136	1493	820
Total			**5494**	**2360**	**7336**	**1334**	**16524**	**15817**	**1584**	**17401**	**0.81%**

Table 14.9.3 –FIRR with Central Taxes (Combined without Property Development)

Figs in cr. (Rs.)

Year			Outflow					Inflow			Cash Flow
			Completion Cost	Additional Cost	Running Expenses	Replacement costs	Total Costs	Fare Box Revenue	PD & ADVT	Total Revenue	IRR
2013	-	2014	179				179			0	-179
2014	-	2015	1239				1239			0	-1239
2015	-	2016	2085				2085			0	-2085
2016	-	2017	2997				2997			0	-2997
2017	-	2018	3008				3008			0	-3008
2018	-	2019	1905	0	115		2020	333	33	366	-1654
2019	-	2020	694	0	204		898	471	47	518	-380
2020	-	2021	267	739	244		1250	660	66	726	-524
2021	-	2022	0	0	264		264	693	69	762	498
2022	-	2023	0	0	285		285	807	81	888	603
2023	-	2024	0	0	308		308	848	85	933	625
2024	-	2025	0	0	332		332	979	98	1077	745
2025	-	2026	0	1079	382		1461	1069	107	1176	-285
2026	-	2027	0	0	412		412	1229	123	1352	940
2027	-	2028	0	0	445		445	1290	129	1419	974
2028	-	2029	0	0	481		481	1489	149	1638	1157
2029	-	2030	0	0	519		519	1563	156	1719	1200
2030	-	2031	0	2066	636		2702	1827	183	2010	-692
2031	-	2032	0	0	686		686	1870	187	2057	1371
2032	-	2033	0	0	741		741	2108	211	2319	1578
2033	-	2034	0	0	800		800	2159	216	2375	1575
2034	-	2035	0	0	863		863	2445	245	2690	1827
2035	-	2036	0	0	932		932	2504	250	2754	1822
2036	-	2037	0	0	1006		1006	2819	282	3101	2095
2037	-	2038	0	0	1085		1085	2887	289	3176	2091
2038	-	2039	0	0	1172	993	2165	3258	326	3584	1419
2039	-	2040	0	0	1265	1290	2555	3337	334	3671	1116
2040	-	2041	0	0	1408	818	2226	3760	376	4136	1910
2041	-	2042	0	3238	1546	0	4784	3809	381	4190	-594
2042	-	2043	0	0	1669	0	1669	4294	429	4723	3054
Total			**12374**	**7122**	**17800**	**3101**	**40397**	**48508**	**4852**	**53360**	**4.43%**

Table 14.9.4 –FIRR with Central Taxes (Combined with Property Development)

Figs in cr. (Rs.)

Year			Outflow					Inflow				Cash Flow
			Completion Cost	Additional Cost	Running Expenses	Replacement costs	Total Costs	Fare Box Revenue	PD & ADVT	Additio-nal PD Income	Total Revenue	IRR
2013	-	2014	179				179				0	-179
2014	-	2015	1239				1239				0	-1239
2015	-	2016	2085				2085				0	-2085
2016	-	2017	2997				2997				0	-2997
2017	-	2018	3008				3008				0	-3008
2018	-	2019	1905		115		2020	333	33	3365	3731	1711
2019	-	2020	694		204		898	471	47	3452	3970	3072
2020	-	2021	267	739	244		1250	660	66	-1165	-439	-1689
2021	-	2022	0	0	264		264	693	69	-1003	-241	-505
2022	-	2023	0	0	285		285	807	81	-623	265	-20
2023	-	2024	0	0	308		308	848	85	-538	395	87
2024	-	2025	0	0	332		332	979	98	-454	623	291
2025	-	2026	0	1079	382		1461	1069	107	-369	807	-654
2026	-	2027	0	0	412		412	1229	123	-282	1070	658
2027	-	2028	0	0	445		445	1290	129	-194	1225	780
2028	-	2029	0	0	481		481	1489	149	454	2092	1611
2029	-	2030	0	0	519		519	1563	156	476	2195	1676
2030	-	2031	0	2066	636		2702	1827	183	499	2509	-193
2031	-	2032	0	0	686		686	1870	187	524	2581	1895
2032	-	2033	0	0	741		741	2108	211	551	2870	2129
2033	-	2034	0	0	800		800	2159	216	578	2953	2153
2034	-	2035	0	0	863		863	2445	245	607	3297	2434
2035	-	2036	0	0	932		932	2504	250	638	3392	2460
2036	-	2037	0	0	1006		1006	2819	282	670	3771	2765
2037	-	2038	0	0	1085		1085	2887	289	703	3879	2794
2038	-	2039	0	0	1172	993	2165	3258	326	738	4322	2157
2039	-	2040	0	0	1265	1290	2555	3337	334	775	4446	1891
2040	-	2041	0	0	1408	818	2226	3760	376	814	4950	2724
2041	-	2042	0	3238	1546	0	4784	3809	381	855	5045	261
2042	-	2043	0	0	1669	0	1669	4294	429	897	5620	3951
Total			**12374**	**7122**	**17800**	**3101**	**40397**	**48508**	**4852**	**11968**	**65328**	**8.12%**

The various sensitivities with regard to increase/decrease in capital costs, O&M costs and revenues are placed in Table 14.10 below : -

Table 14.10 –FIRR (Combined with PD) Sensitivity

Capital Cost with Central Taxes but without land cost			
10% increase in capital cost	**20% increase in capital cost**	**10% decrease in capital cost**	**20% decrease in capital cost**
7.25%	6.49%	9.15%	10.39%
REVENUE			
20% decrease in Fare Box revenue	**10% decrease in Fare Box revenue**	**10% increase in Fare Box revenue**	**20% increase in Fare Box revenue**
5.52%	6.91%	9.22%	10.21%
O&M COSTS			
10% increase in O&M cost		**10% decrease in O&M cost**	
7.74%		8.50%	

These sensitivities have been carried out independently for each factor.

14.5 FINANCING OPTIONS

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

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

Rail based mass transit systems are characterised by heavy capital investments coupled with long gestation period leading to low financial rates of return although the economic benefits to the society are immense. Such systems generate externalities, which do not get captured in monetary terms and, therefore, do not flow back to the system. However, experience all over the world reveals that both construction and operations of metro are highly subsidised. Government involvement in the funding of metro systems is a foregone conclusion. Singapore had a 100% capital contribution from the government, Hong Kong 78% for the first three lines and 66% for the later 2 lines. The Phase-I, Phase-II as well as Phase-III of Delhi MRTS project, Chennai and Bengaluru metros are also funded with a mixture of equity and debt (ODA) by GOI & concerned state governments.

14.5.1 Alternative Models Of Financing

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

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

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

SPV Model: The corridor is a standalone one and therefore forming a separate SPV may be in the name of Lucknow Metro Rail Corporation may be desirable. The funding pattern under this model (SPV) is placed in table 14.11 as under: -

Table 14.11 - Funding pattern under SPV model (with central taxes)

Particulars	With Taxes & Duties			
	Corridor-I	Corridor-II	Total	% of contribution
Equity By GOI	1003.00	786.50	1789.50	14.46%
Equity By GUP	1003.00	786.50	1789.50	14.46%
SD for CT by GUP (50%)	373.00	312.50	685.50	5.54%
SD for CT by GOI (50%)	373.00	312.50	685.50	5.54%
SD for Land by GUP (100%)	381.00	164.00	545.00	4.40%
Contribution of Local Bodies under 'Innovative Financing'	245.00	105.00	350.00	2.83%
1.40% JICA Loan /12% Market Borrowings	3502.00	3027.00	6529.00	52.77%
Total	**6880.00**	**5494.00**	**12374.00**	**100.00%**

In addition to the above, State Taxes of Rs.333.00 crore on completion cost basis has to be either reimbursed or exempted by state government.

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

The funding pattern assumed under this model excluding the cost of land is placed in table 14.12.1 & 14.12.2 tabulated as under: -

Table 14.12.1 Funding pattern under BOT –Combined (16% EIRR) - (With central taxes and without land cost and without Property Development)

Particulars	With Taxes & Duties	
	Amount (Rs/Crore)	% Of contribution
VGF by GOI	2365.80	20.00%
VGF by GUP	5994.20	50.67%
Equity by Concessionaire	1156.00	9.77%
Concessionaire's debt @12% PA	2313.00	19.56%
Total	**11829.00**	**100.00**
Land Free by GUP	545.00	
IDC	126.00	
Total	**12500.00**	**100.00%**

Table 14.12.2 Funding pattern under BOT –Combined (16% EIRR) (With central taxes and without land cost and with Property Development)

Particulars	With Taxes & Duties	
	Amount (Rs/Crore)	% Of contribution
VGF by GOI	2365.80	20.00%
VGF by GUP	1634.20	13.82%
Equity by Concessionaire	2610.00	22.06%
Concessionaire's debt @12% PA	5219.00	44.12%
Total	**11829.00**	**100.00**
Land Free by GUP	545.00	
IDC	477.00	
Total	**12851.00**	**100.00%**

In addition to the above, State Taxes of Rs.333.00 crore on completion cost basis has to be either reimbursed or exempted by state government.

14.6 RECOMMENDATIONS

The combined FIRR of subject metro with taxes is 8.12% with additional property development of 60 hectares. The pre-tax Equity IRR to the BOT operator is 16% with a total VGF of only Rs.4545 crore excluding the cost of 60 ha. Land required for PD if the additional PD income is considered. Since the UP government is providing huge land bank for PD, it is advisable to take up the job on DMRC model. Accordingly, the corridors are recommended for implementation.

The total fund contribution of GOI & GOUP under various alternatives is tabulated in **table 14.13.**

Table 14.13

Rs. In crore

Particulars	SPV Model	BOT Model without PD	BOT Model with PD
GOI	2475.00	2365.80	2365.80
GOUP	3020.00	6539.20	2179.20
Total	**5495.00**	**8905.00**	**4545.00**

In addition to the above, State Taxes of Rs.333.00 crore on completion cost basis has to be either reimbursed or exempted by state government.

Considering the difference, it is recommended to implement the project under SPV model as per the funding pattern given in Table 14.11.

The detailed cash flow statements under various alternatives are enclosed as per detail given below:-

Corridor	Option	Table No.
N-S Corridor	SPV Model with JICA Loan	14.14
	SPV Model with Market Borrowings	14.15
	BOT Model	14.16
E-W Corridor	SPV Model with JICA Loan	14.17
	SPV Model with Market Borrowings	14.18
	BOT Model	14.19
Combined	SPV Model with JICA Loan without PD	14.20
	SPV Model with Market Borrowings without PD	14.21
	BOT Model without PD	14.22
	SPV Model with JICA Loan with PD	14.23
	BOT Model with PD	14.24

The funding pattern assumed under SPV model & BOT model with PD is depicted in the pie chart i.e., Figure 14.2.1 & 14.2.2 as under: -

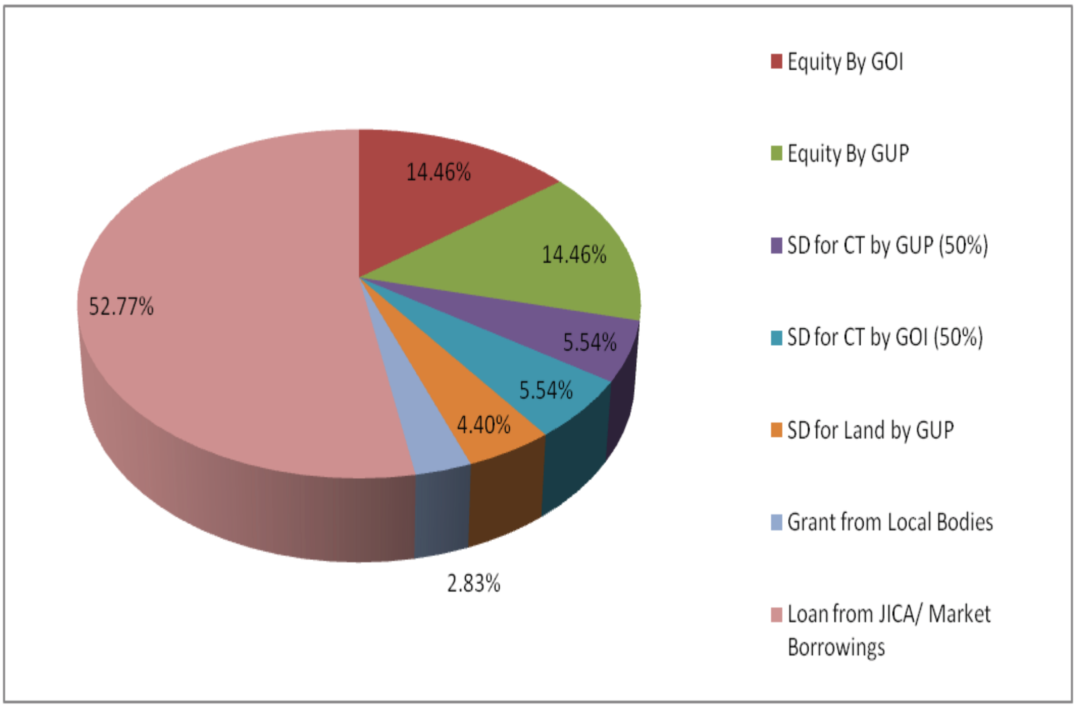


Figure 14.2.1 - Funding pattern under SPV Model

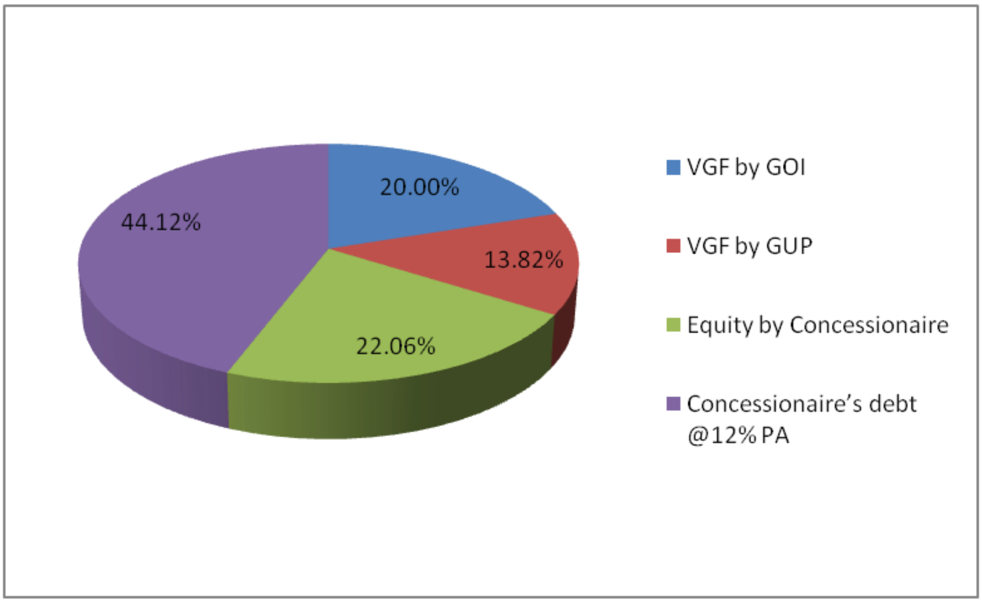


Figure 14.2.2- Funding pattern under BOT Model with PD

Lucknow Metro Project																						Table 14.14
CAPITAL COST-FIXED			5492																			
CAPITAL COST - CURRENT			6757													JICA Loan		1.40%				
DOMESTIC FUNDING - BASE CASE																						
Year	Completion Cost	Additional Capital	Running Expenses	Depreciation	Replacement Cost	Total Cost	Fare box Revenue	PD & Advertisement	Total Revenue	Net Cash Flow for IRR	Equity from GOI & GUP	Availability of cash	Cumulative cash	Cum. Loan	Loan	Repayment of Loan	IDC	Cumulative loan incl. IDC	Interest	Profit before Tax	Cash Balance	Cumulative Cash
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
2013 - 2014	178					178			0	-178	263	85	85	0	0	0	0	0				
2014 - 2015	952					952			0	-952	987	35	120	0	0	0	0	0				
2015 - 2016	1308					1308			0	-1308	987	-321	-201	201	201	0	1	202				
2016 - 2017	1904					1904			0	-1904	860	-1044	-1245	1245	1044	0	10	1256				
2017 - 2018	1365					1365			0	-1365	723	-642	-1887	1887	642	0	22	1920				
2018 - 2019	734	0	0	204		734	333	33	366	-368	0	-734	-2621	2621	734	0	0	2654	32	130	334	334
2019 - 2020	316	0	0	204		316	350	35	385	69		-316	-2937	2937	316	0		2970	39	142	346	680
2020 - 2021	0	528	0	220		528	480	48	528	0		0	0	0	0	0		2970	42	266	-42	638
2021 - 2022	0	0	0	220		0	503	50	553	553		0	0	0	0	0		2970	42	291	511	1149
2022 - 2023	0	0	0	220		0	586	59	645	645		0	0	0	0	0		2970	42	383	603	1753
2023 - 2024	0	0	0	220		0	615	62	677	677		0	0	0	0	149		2822	42	415	487	2240
2024 - 2025	0	0	0	220		0	711	71	782	782		0	0	0	0	149		2673	40	522	594	2834
2025 - 2026	0	674	0	240		674	755	76	831	157		0	0	0	0	149		2525	37	554	-29	2805
2026 - 2027	0	0	0	240		0	868	87	955	955		0	0	0	0	149		2376	35	680	771	3576
2027 - 2028	0	0	0	240		0	911	91	1002	1002		0	0	0	0	149		2228	33	729	820	4396
2028 - 2029	0	0	0	240		0	1052	105	1157	1157		0	0	0	0	149		2079	31	886	977	5374
2029 - 2030	0	0	0	240		0	1104	110	1214	1214		0	0	0	0	149		1931	29	945	1036	6410
2030 - 2031	0	1205	0	276		1205	1272	127	1399	194		0	0	0	0	149		1782	27	1096	18	6428
2031 - 2032	0	0	0	276		0	1302	130	1432	1432		0	0	0	0	149		1634	25	1131	1259	7687
2032 - 2033	0	0	0	276		0	1468	147	1615	1615		0	0	0	0	149		1485	23	1316	1444	9131
2033 - 2034	0	0	0	276		0	1503	150	1653	1653		0	0	0	0	149		1337	21	1356	1484	10614
2034 - 2035	0	0	0	276		0	1703	170	1873	1873		0	0	0	0	149		1188	19	1578	1706	12320
2035 - 2036	0	0	0	276		0	1743	174	1917	1917		0	0	0	0	149		1040	17	1624	1752	14072
2036 - 2037	0	0	0	276		0	1963	196	2159	2159		0	0	0	0	149		891	15	1868	1996	16068
2037 - 2038	0	0	0	276		0	2010	201	2211	2211		0	0	0	0	149		743	12	1923	2050	18118
2038 - 2039	0	0	0	306	993	993	2268	227	2495	1502		0	0	0	0	149		594	10	2179	1343	19461
2039 - 2040	0	0	0	329	774	774	2323	232	2555	1781		0	0	0	0	149		446	8	2218	1624	21085
2040 - 2041	0	0	0	329	0	0	2618	262	2880	2880		0	0	0	0	149		297	6	2545	2725	23811
2041 - 2042	0	2355	0	400	0	2355	2633	263	2896	541		0	0	0	0	149		149	4	2492	388	24199
2042 - 2043	0	0	0	400	0	0	2969	297	3266	3266		0	0	0	0	149		0	2	2864	3115	27314
	6757	4762	0	6680	1767	13286	34043	3403	37446	10.05%	3820				2937	2970	33		633	30133	27314	
										24160												

Table 14.15

Lucknow Metro Project

CAPITAL COST-FIXED			5492												Domestic Loan		12.00%					
CAPITAL COST - CURRENT			6757																			
DOMESTIC FUNDING - BASE CASE																						
Year	**Completion Cost**	**Additional Capital**	**Running Expenses**	**Depreciation**	**Replacement Cost**	**Total Cost**	**Fare box Revenue**	**PD & Advertisement**	**Total Revenue**	**Net Cash Flow for IRR**	**Equity from GOI & GUP**	**Availability of cash**	**Cumulative cash**	**Cum. Loan**	**Loan**	**Repayment of Loan**	**IDC**	**Cumulative loan incl. IDC**	**Interest**	**Profit before Tax**	**Cash Balance**	**Cumulative Cash**
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
2013 - 2014	178					178			0	-178	263	85	85	0	0	0	0	0				
2014 - 2015	952					952			0	-952	987	35	120	0	0	0	0	0				
2015 - 2016	1308					1308			0	-1308	987	-321	-201	201	201	0	12	213				
2016 - 2017	1904					1904			0	-1904	860	-1044	-1245	1245	1044	0	63	1320				
2017 - 2018	1365					1365			0	-1365	723	-642	-1887	1887	642	0	39	2001				
2018 - 2019	734	0	0	206		734	333	33	366	-368	0	-734	-2621	2621	734	0	0	2735	284	-124	82	82
2019 - 2020	316	0	0	206		316	350	35	385	69		-316	-2937	2937	316	0	0	3051	347	-168	38	120
2020 - 2021	0	528	0	222		528	480	48	528	0		0	0	0	0	306	0	2745	366	-60	-672	-552
2021 - 2022	0	0	0	222		0	503	50	553	553		0	0	0	0	306	0	2439	329	2	-82	-635
2022 - 2023	0	0	0	222		0	586	59	645	645		0	0	0	0	306	0	2133	293	130	46	-589
2023 - 2024	0	0	0	222		0	615	62	677	677		0	0	0	0	306	0	1827	256	199	115	-473
2024 - 2025	0	0	0	222		0	711	71	782	782		0	0	0	0	306	0	1521	219	341	257	-217
2025 - 2026	0	674	0	242		674	755	76	831	157		0	0	0	0	306	0	1215	183	406	-332	-548
2026 - 2027	0	0	0	242		0	868	87	955	955		0	0	0	0	306	0	909	146	567	503	-45
2027 - 2028	0	0	0	242		0	911	91	1002	1002		0	0	0	0	306	0	603	109	651	587	542
2028 - 2029	0	0	0	242		0	1052	105	1157	1157		0	0	0	0	306	0	297	72	843	779	1321
2029 - 2030	0	0	0	242		0	1104	110	1214	1214		0	0	0	0	297	0	0	36	936	881	2202
2030 - 2031	0	1205	0	278		1205	1272	127	1399	194		0	0	0	0	0	0	0	0	1121	194	2396
2031 - 2032	0	0	0	278		0	1302	130	1432	1432		0	0	0	0	0	0	0	0	1154	1432	3828
2032 - 2033	0	0	0	278		0	1468	147	1615	1615		0	0	0	0	0	0	0	0	1337	1615	5443
2033 - 2034	0	0	0	278		0	1503	150	1653	1653		0	0	0	0	0	0	0	0	1375	1653	7096
2034 - 2035	0	0	0	278		0	1703	170	1873	1873		0	0	0	0	0	0	0	0	1595	1873	8969
2035 - 2036	0	0	0	278		0	1743	174	1917	1917		0	0	0	0	0	0	0	0	1639	1917	10886
2036 - 2037	0	0	0	278		0	1963	196	2159	2159		0	0	0	0	0	0	0	0	1881	2159	13045
2037 - 2038	0	0	0	278		0	2010	201	2211	2211		0	0	0	0	0	0	0	0	1933	2211	15256
2038 - 2039	0	0	0	308	993	993	2268	227	2495	1502		0	0	0	0	0	0	0	0	2187	1502	16758
2039 - 2040	0	0	0	331	774	774	2323	232	2555	1781		0	0	0	0	0	0	0	0	2224	1781	18539
2040 - 2041	0	0	0	331	0	0	2618	262	2880	2880		0	0	0	0	0	0	0	0	2549	2880	21419
2041 - 2042	0	2355	0	402	0	2355	2633	263	2896	541		0	0	0	0	0	0	0	0	2494	541	21960
2042 - 2043	0	0	0	402	0	0	2969	297	3266	3266		0	0	0	0	0	0	0	0	2864	3266	25226
	6757	**4762**	**0**	**6730**	**1767**	**13286**	**34043**	**3403**	**37446**	**10.05%**	**3820**				**2937**	**3051**	**114**		**2640**	**28076**	**25226**	
										24160												

Table 14.16

Lucknow Metro Project																							
CAPITAL COST-FIXED			5492																				
CAPITAL COST - CURRENT			2536														12.00%						
DOMESTIC FUNDING - BASE CASE																							
Year	Completion Cost	Additional Capital	Running Expenses	Depreciation	Replacement Cost	Total Cost	Fare box Revenue	PD & Advertisement	Total Revenue	Net Cash Flow for IRR	Concessioner Equity	Availability of cash	Cumulative cash	Cum. Loan	Loan	Repayment of Loan	IDC	Cumulative loan incl. IDC	Interest	Profit before Tax	Cash Balance	Cumulative Cash	Return on Equity (EIRR) Pre-Tax
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
2013 - 2014	1					1			0	-1	169	168	168	0	0	0	0	0					-169
2014 - 2015	375					375			0	-375	169	-206	-38	38	38	0	2	40					-169
2015 - 2016	331					331			0	-331	169	-162	-200	200	162	0	14	216					-169
2016 - 2017	1054					1054			0	-1054	169	-885	-1085	1085	885	0	77	1178					-169
2017 - 2018	515					515			0	-515	169	-346	-1431	1431	346	0	151	1675					-169
2018 - 2019	84	0	0	83		84	333	33	366	282	0	-84	-1515	1515	84	0		1759	201	82	165	165	165
2019 - 2020	176	0	0	83		176	350	35	385	209		-176	-1691	1691	176	0		1935	211	91	174	339	174
2020 - 2021	0	528	0	99		528	480	48	528	0		0	0	0	0	0		1935	232	197	-232	107	-232
2021 - 2022	0	0	0	99		0	503	50	553	553		0	0	0	0	0		1935	232	222	321	428	321
2022 - 2023	0	0	0	99		0	586	59	645	645		0	0	0	0	0		1935	232	314	413	840	413
2023 - 2024	0	0	0	99		0	615	62	677	677		0	0	0	0	194		1742	232	346	251	1092	251
2024 - 2025	0	0	0	99		0	711	71	782	782		0	0	0	0	194		1548	209	474	380	1471	380
2025 - 2026	0	674	0	119		674	755	76	831	157		0	0	0	0	194		1355	186	526	-222	1249	-222
2026 - 2027	0	0	0	119		0	868	87	955	955		0	0	0	0	194		1161	163	673	599	1848	599
2027 - 2028	0	0	0	119		0	911	91	1002	1002		0	0	0	0	194		968	139	744	669	2517	669
2028 - 2029	0	0	0	119		0	1052	105	1157	1157		0	0	0	0	194		774	116	922	847	3364	847
2029 - 2030	0	0	0	119		0	1104	110	1214	1214		0	0	0	0	194		581	93	1002	928	4292	928
2030 - 2031	0	1205	0	155		1205	1272	127	1399	194		0	0	0	0	194		387	70	1174	-69	4223	-69
2031 - 2032	0	0	0	155		0	1302	130	1432	1432		0	0	0	0	194		194	46	1231	1192	5415	1192
2032 - 2033	0	0	0	155		0	1468	147	1615	1615		0	0	0	0	194		0	23	1437	1398	6813	1398
2033 - 2034	0	0	0	155		0	1503	150	1653	1653		0	0	0	0	0		0	0	1498	1653	8466	1653
2034 - 2035	0	0	0	155		0	1703	170	1873	1873		0	0	0	0	0		0	0	1718	1873	10339	1873
2035 - 2036	0	0	0	155		0	1743	174	1917	1917		0	0	0	0	0		0	0	1762	1917	12256	1917
2036 - 2037	0	0	0	155		0	1963	196	2159	2159		0	0	0	0	0		0	0	2004	2159	14415	2159
2037 - 2038	0	0	0	155		0	2010	201	2211	2211		0	0	0	0	0		0	0	2056	2211	16626	2211
2038 - 2039	0	0	0	185	993	993	2268	227	2495	1502		0	0	0	0	0		0	0	2310	1502	18128	1502
2039 - 2040	0	0	0	208	774	774	2323	232	2555	1781		0	0	0	0	0		0	0	2347	1781	19909	1781
2040 - 2041	0	0	0	208	0	0	2618	262	2880	2880		0	0	0	0	0		0	0	2672	2880	22789	2880
2041 - 2042	0	2355	0	279	0	2355	2633	263	2896	541		0	0	0	0	0		0	0	2617	541	23330	541
2042 - 2043	0	0	0	279	0	0	2969	297	3266	3266		0	0	0	0	0		0	0	2987	3266	26596	3266
	2536	**4762**	**0**	**3655**	**1767**	**9065**	**34043**	**3403**	**37446**	**19.52%**	**845**				**1691**	**1935**	**244**		**2386**	**31405**	**26596**		**22.90%**
										28381													

Table 14.17

Lucknow Metro Project

CAPITAL COST-FIXED	4120		
CAPITAL COST - CURRENT	5396	JICA Loan	1.40%
DOMESTIC FUNDING - BASE CASE			

Year	Completion Cost	Additional Capital	Running Expenses	Depreciation	Replacement Cost	Total Cost	Fare box Revenue	PD & Advertisement	Total Revenue	Net Cash Flow for IRR	Equity from GOI & GUP	Availability of cash	Cumulative cash	Cum. Loan	Loan	Repayment of Loan	IDC	Cumulative loan incl. IDC	Interest	Profit before Tax	Cash Balance	Cumulative Cash
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
2014 - 2015	268					268			0	-268	163	-105	-105	105	105	0	1	106				
2015 - 2016	740					740			0	-740	735	-5	-110	110	5	0	2	113				
2016 - 2017	1037					1037			0	-1037	734	-303	-413	413	303	0	4	420				
2017 - 2018	1585					1585			0	-1585	680	-905	-1318	1318	905	0	12	1337				
2018 - 2019	1136					1136			0	-1136	628	-508	-1826	1826	508	0	22	1867				
2019 - 2020	366	0	0	163		366	121	12	133	-233	0	-366	-2192	2192	366	0	0	2233	29	-59	104	104
2020 - 2021	264	211	0	169		475	181	18	199	-276		-264	-2456	2456	264	0		2497	33	-3	-45	59
2021 - 2022	0	0	0	169		0	190	19	209	209		0	0	0	0	0		2497	35	5	174	233
2022 - 2023	0	0	0	169		0	221	22	243	243		0	0	0	0	0		2497	35	39	208	441
2023 - 2024	0	0	0	169		0	232	23	255	255		0	0	0	0	0		2497	35	51	220	661
2024 - 2025	0	0	0	169		0	268	27	295	295		0	0	0	0	125		2372	35	91	135	797
2025 - 2026	0	405	0	181		405	314	31	345	-60		0	0	0	0	125		2247	33	131	-218	578
2026 - 2027	0	0	0	181		0	360	36	396	396		0	0	0	0	125		2122	31	184	240	818
2027 - 2028	0	0	0	181		0	378	38	416	416		0	0	0	0	125		1998	30	205	261	1080
2028 - 2029	0	0	0	181		0	437	44	481	481		0	0	0	0	125		1873	28	272	328	1408
2029 - 2030	0	0	0	181		0	458	46	504	504		0	0	0	0	125		1748	26	297	353	1761
2030 - 2031	0	861	0	207		861	555	56	611	-250		0	0	0	0	125		1623	24	380	-399	1361
2031 - 2032	0	0	0	207		0	568	57	625	625		0	0	0	0	125		1498	23	395	477	1839
2032 - 2033	0	0	0	207		0	640	64	704	704		0	0	0	0	125		1373	21	476	558	2397
2033 - 2034	0	0	0	207		0	656	66	722	722		0	0	0	0	125		1249	19	496	578	2975
2034 - 2035	0	0	0	207		0	742	74	816	816		0	0	0	0	125		1124	17	592	674	3649
2035 - 2036	0	0	0	207		0	760	76	836	836		0	0	0	0	125		999	16	613	695	4344
2036 - 2037	0	0	0	207		0	856	86	942	942		0	0	0	0	125		874	14	721	803	5147
2037 - 2038	0	0	0	207		0	877	88	965	965		0	0	0	0	125		749	12	746	828	5975
2038 - 2039	0	0	0	207		0	989	99	1088	1088		0	0	0	0	125		624	10	871	953	6928
2039 - 2040	0	0	0	222	516	516	1013	101	1114	598		0	0	0	0	125		499	9	883	464	7392
2040 - 2041	0	0	0	247	818	818	1142	114	1256	438		0	0	0	0	125		375	7	1002	306	7698
2041 - 2042	0	883	0	273	0	883	1176	118	1294	411		0	0	0	0	125		250	5	1016	281	7979
2042 - 2043	0	0	0	273	0	0	1326	133	1459	1459		0	0	0	0	125		125	3	1183	1331	9310
2043 - 2044	0	0	0	273	0	0	1357	136	1493	1493		0	0	0	0	125		0	2	1218	1366	10676
	5396	**2360**	**0**	**5064**	**1334**	**9090**	**15817**	**1584**	**17401**	**5.53%**	**2940**				**2456**	**2497**	**41**		**534**	**11803**	**10676**	
										8311												

Lucknow Metro Project | **Table 14.18**

CAPITAL COST-FIXED 4120
CAPITAL COST - CURRENT 5396
DOMESTIC FUNDING - BASE CASE

Domestic Loan 12.00%

Year	Completion Cost	Additional Capital	Running Expenses	Depreciation	Replacement Cost	Total Cost	Fare box Revenue	PD & Advertisement	Total Revenue	Net Cash Flow for IRR	Equity from GOI & GUP	Availability of cash	Cumulative cash	Cum. Loan	Loan	Repayment of Loan	IDC	Cumulative loan incl. IDC	Interest	Profit before Tax	Cash Balance	Cumulative Cash
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
2014 - 2015	268					268			0	-268	163	-105	-105	105	105	0	6	111				
2015 - 2016	740					740			0	-740	735	-5	-110	110	5	0	0	116				
2016 - 2017	1037					1037			0	-1037	734	-303	-413	413	303	0	18	437				
2017 - 2018	1585					1585			0	-1585	680	-905	-1318	1318	905	0	54	1396				
2018 - 2019	1136					1136			0	-1136	628	-508	-1826	1826	508	0	30	1934				
2019 - 2020	366	0	0	165		366	121	12	133	-233	0	-366	-2192	2192	366	0	0	2300	254	-286	-121	-121
2020 - 2021	264	211	0	171		475	181	18	199	-276		-264	-2456	2456	264	0	0	2564	292	-264	-304	-425
2021 - 2022	0	0	0	171		0	190	19	209	209		0	0	0	0	257	0	2307	308	-270	-356	-781
2022 - 2023	0	0	0	171		0	221	22	243	243		0	0	0	0	257	0	2050	277	-205	-291	-1071
2023 - 2024	0	0	0	171		0	232	23	255	255		0	0	0	0	257	0	1793	246	-162	-248	-1319
2024 - 2025	0	0	0	171		0	268	27	295	295		0	0	0	0	257	0	1536	215	-91	-177	-1497
2025 - 2026	0	405	0	183		405	314	31	345	-60		0	0	0	0	257	0	1279	184	-22	-501	-1998
2026 - 2027	0	0	0	183		0	360	36	396	396		0	0	0	0	257	0	1022	153	60	-14	-2012
2027 - 2028	0	0	0	183		0	378	38	416	416		0	0	0	0	257	0	765	123	110	36	-1976
2028 - 2029	0	0	0	183		0	437	44	481	481		0	0	0	0	257	0	508	92	206	132	-1844
2029 - 2030	0	0	0	183		0	458	46	504	504		0	0	0	0	257	0	251	61	260	186	-1658
2030 - 2031	0	861	0	209		861	555	56	611	-250		0	0	0	0	251	0	0	30	372	-531	-2189
2031 - 2032	0	0	0	209		0	568	57	625	625		0	0	0	0	0	0	0	0	416	625	-1564
2032 - 2033	0	0	0	209		0	640	64	704	704		0	0	0	0	0	0	0	0	495	704	-860
2033 - 2034	0	0	0	209		0	656	66	722	722		0	0	0	0	0	0	0	0	513	722	-138
2034 - 2035	0	0	0	209		0	742	74	816	816		0	0	0	0	0	0	0	0	607	816	678
2035 - 2036	0	0	0	209		0	760	76	836	836		0	0	0	0	0	0	0	0	627	836	1514
2036 - 2037	0	0	0	209		0	856	86	942	942		0	0	0	0	0	0	0	0	733	942	2456
2037 - 2038	0	0	0	209		0	877	88	965	965		0	0	0	0	0	0	0	0	756	965	3421
2038 - 2039	0	0	0	209		0	989	99	1088	1088		0	0	0	0	0	0	0	0	879	1088	4509
2039 - 2040	0	0	0	224	492	492	1013	101	1114	622		0	0	0	0	0	0	0	0	890	622	5131
2040 - 2041	0	0	0	247	779	779	1142	114	1256	477		0	0	0	0	0	0	0	0	1009	477	5608
2041 - 2042	0	883	0	273	0	883	1176	118	1294	411		0	0	0	0	0	0	0	0	1021	411	6019
2042 - 2043	0	0	0	273	0	0	1326	133	1459	1459		0	0	0	0	0	0	0	0	1186	1459	7478
2043 - 2044	0	0	0	273	0	0	1357	136	1493	1493		0	0	0	0	0	0	0	0	1220	1493	8971
	5396	**2360**	**0**	**5106**	**1271**	**9027**	**15817**	**1584**	**17401**	**5.56%**	**2940**				**2456**	**2564**	**108**		**2235**	**10060**	**8971**	
										8374												

Lucknow Metro Project — Table 14.19

CAPITAL COST-FIXED 4120 — 12.00%

CAPITAL COST - CURRENT 777

DOMESTIC FUNDING - BASE CASE

Year	Completion Cost	Additional Capital	Running Expenses	Depreciation	Replacement Cost	Total Cost	Fare box Revenue	PD & Advertisement	Total Revenue	Net Cash Flow for IRR	Concessioner Equity	Availability of cash	Cumulative cash	Cum. Loan	Loan	Repayment of Loan	IDC	Cumulative loan incl. IDC	Interest	Profit before Tax	Cash Balance	Cumulative Cash	Return on Equity (EIRR) Pre-Tax
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
2014 - 2015	13					13			0	-13	52	39	39	0	0	0	0	0					-52
2015 - 2016	35					35			0	-35	52	17	56	0	0	0	0	0					-52
2016 - 2017	133					133			0	-133	52	-81	-25	25	25	0	2	27					-52
2017 - 2018	135					135			0	-135	52	-83	-108	108	83	0	8	118					-52
2018 - 2019	86					86			0	-86	51	-35	-143	143	35	0	15	168					-51
2019 - 2020	111	0	0	24		111	121	12	133	22	0	-111	-254	254	111	0		279	20	89	113	113	113
2020 - 2021	264	211	0	30		475	181	18	199	-276		-264	-518	518	264	0		543	33	136	-45	67	-45
2021 - 2022	0	0	0	30		0	190	19	209	209		0	0	0	0	0		543	65	114	144	211	144
2022 - 2023	0	0	0	30		0	221	22	243	243		0	0	0	0	0		543	65	148	178	389	178
2023 - 2024	0	0	0	30		0	232	23	255	255		0	0	0	0	0		543	65	160	190	579	190
2024 - 2025	0	0	0	30		0	268	27	295	295		0	0	0	0	54		489	65	200	176	754	176
2025 - 2026	0	405	0	42		405	314	31	345	-60		0	0	0	0	54		434	59	244	-173	581	-173
2026 - 2027	0	0	0	42		0	360	36	396	396		0	0	0	0	54		380	52	302	290	871	290
2027 - 2028	0	0	0	42		0	378	38	416	416		0	0	0	0	54		326	46	328	316	1187	316
2028 - 2029	0	0	0	42		0	437	44	481	481		0	0	0	0	54		272	39	400	388	1575	388
2029 - 2030	0	0	0	42		0	458	46	504	504		0	0	0	0	54		217	33	429	417	1992	417
2030 - 2031	0	861	0	68		861	555	56	611	-250		0	0	0	0	54		163	26	517	-330	1661	-330
2031 - 2032	0	0	0	68		0	568	57	625	625		0	0	0	0	54		109	20	537	551	2213	551
2032 - 2033	0	0	0	68		0	640	64	704	704		0	0	0	0	54		54	13	623	637	2849	637
2033 - 2034	0	0	0	68		0	656	66	722	722		0	0	0	0	54		0	7	647	661	3511	661
2034 - 2035	0	0	0	68		0	742	74	816	816		0	0	0	0	0		0	0	748	816	4327	816
2035 - 2036	0	0	0	68		0	760	76	836	836		0	0	0	0	0		0	0	768	836	5163	836
2036 - 2037	0	0	0	68		0	856	86	942	942		0	0	0	0	0		0	0	874	942	6105	942
2037 - 2038	0	0	0	68		0	877	88	965	965		0	0	0	0	0		0	0	897	965	7070	965
2038 - 2039	0	0	0	68		0	989	99	1088	1088		0	0	0	0	0		0	0	1020	1088	8158	1088
2039 - 2040	0	0	0	83	492	492	1013	101	1114	622		0	0	0	0	0		0	0	1031	622	8780	622
2040 - 2041	0	0	0	106	779	779	1142	114	1256	477		0	0	0	0	0		0	0	1150	477	9257	477
2041 - 2042	0	883	0	132	0	883	1176	118	1294	411		0	0	0	0	0		0	0	1162	411	9668	411
2042 - 2043	0	0	0	132	0	0	1326	133	1459	1459		0	0	0	0	0		0	0	1327	1459	11127	1459
2043 - 2044	0	0	0	132	0	0	1357	136	1493	1493		0	0	0	0	0		0	0	1361	1493	12620	1493
	777	**2360**	**0**	**1581**	**1271**	**4408**	**15817**	**1584**	**17401**	**25.59%**	**259**				**518**	**543**	**25**		**608**	**15213**	**12620**		**29.45%**
										12993													

Table 14.20

Lucknow Metro Project																						
CAPITAL COST-FIXED		9612																				
CAPITAL COST - CURRENT		12153													JICA Loan		1.40%					
DOMESTIC FUNDING - BASE CASE																						
Year	Completion Cost	Additional Capital	Running Expenses	Depreciation	Replacement Cost	Total Cost	Fare box Revenue	PD & Advertisement	Total Revenue	Net Cash Flow for IRR	Equity from GOI & GUP	Availability of cash	Cumulative cash	Cum. Loan	Loan	Repayment of Loan	IDC	Cumulative loan incl. IDC	Interest	Profit before Tax	Cash Balance	Cumulative Cash
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
2013 - 2014	178					178			0	-178	426	248	248	0	0	0	0	0				
2014 - 2015	1220					1220			0	-1220	1722	502	750	0	0	0	0	0				
2015 - 2016	2048					2048			0	-2048	1721	-327	423	0	0	0	0	0				
2016 - 2017	2941					2941			0	-2941	1540	-1401	-978	978	978	0	7	985				
2017 - 2018	2950					2950			0	-2950	1351	-1599	-2577	2577	1599	0	25	2609				
2018 - 2019	1870	0	115	366		1985	333	33	366	-1619	0	-1870	-4447	4447	1870	0	0	4479	50	-165	201	201
2019 - 2020	682	0	204	366		886	471	47	518	-368	0	-682	-5129	5129	682	0		5161	67	-119	247	448
2020 - 2021	264	739	244	388		1247	660	66	726	-521		-264	-5393	5393	264	0		5425	74	20	-331	117
2021 - 2022	0	0	264	388		264	693	69	762	498		0	-5393	0	0	0		5425	76	34	422	539
2022 - 2023	0	0	285	388		285	807	81	888	603		0	-5393	0	0	0		5425	76	139	527	1066
2023 - 2024	0	0	308	388		308	848	85	933	625		0	-5393	0	0	271		5154	76	161	278	1344
2024 - 2025	0	0	332	388		332	979	98	1077	745		0	-5393	0	0	271		4883	72	285	402	1745
2025 - 2026	0	1079	382	420		1461	1069	107	1176	-285		0	-5393	0	0	271		4611	68	306	-625	1121
2026 - 2027	0	0	412	420		412	1229	123	1352	940		0	-5393	0	0	271		4340	65	455	604	1725
2027 - 2028	0	0	445	420		445	1290	129	1419	974		0	-5393	0	0	271		4069	61	493	642	2367
2028 - 2029	0	0	481	420		481	1489	149	1638	1157		0	-5393	0	0	271		3798	57	680	829	3196
2029 - 2030	0	0	519	420		519	1563	156	1719	1200		0	-5393	0	0	271		3526	53	727	876	4071
2030 - 2031	0	2066	636	482		2702	1827	183	2010	-692		0	-5393	0	0	271		3255	49	843	-1013	3059
2031 - 2032	0	0	686	482		686	1870	187	2057	1371		0	-5393	0	0	271		2984	46	843	1054	4113
2032 - 2033	0	0	741	482		741	2108	211	2319	1578		0	-5393	0	0	271		2713	42	1054	1265	5378
2033 - 2034	0	0	800	482		800	2159	216	2375	1575		0	-5393	0	0	271		2441	38	1055	1266	6644
2034 - 2035	0	0	863	482		863	2445	245	2690	1827		0	-5393	0	0	271		2170	34	1311	1522	8165
2035 - 2036	0	0	932	482		932	2504	250	2754	1822		0	-5393	0	0	271		1899	30	1310	1520	9686
2036 - 2037	0	0	1006	482		1006	2819	282	3101	2095		0	-5393	0	0	271		1628	27	1586	1797	11483
2037 - 2038	0	0	1085	482		1085	2887	289	3176	2091		0	-5393	0	0	271		1356	23	1586	1797	13280
2038 - 2039	0	0	1172	512	993	2165	3258	326	3584	1419		0	-5393	0	0	271		1085	19	1881	1129	14408
2039 - 2040	0	0	1265	551	1290	2555	3337	334	3671	1116		0	-5393	0	0	271		814	15	1840	830	15238
2040 - 2041	0	0	1408	576	818	2226	3760	376	4136	1910		0	-5393	0	0	271		543	11	2141	1627	16865
2041 - 2042	0	3238	1546	673	0	4784	3809	381	4190	-594		0	-5393	0	0	271		271	8	1963	-873	15992
2042 - 2043	0	0	1669	673	0	1669	4294	429	4723	3054		0	-5393	0	0	271		0	4	2377	2779	18771
	12153	**7122**	**17800**	**11613**	**3101**	**40176**	**48508**	**4852**	**53360**	**4.55%**	**6760**				**5393**	**5425**	**32**		**1141**	**22806**	**18771**	
										13184												

Lucknow Metro Project — Table 14.21

Lucknow Metro Project																						**Table 14.21**
CAPITAL COST-FIXED		9612																				
CAPITAL COST - CURRENT		12153													Market Borrowings		12.00%					
DOMESTIC FUNDING - BASE CASE																						
Year	**Completion Cost**	**Additional Capital**	**Running Expenses**	**Depreciation**	**Replacement Cost**	**Total Cost**	**Fare box Revenue**	**PD & Advertisement**	**Total Revenue**	**Net Cash Flow for IRR**	**Equity from GOI & GUP**	**Availability of cash**	**Cumulative cash**	**Cum. Loan**	**Loan**	**Repayment of Loan**	**IDC**	**Cumulative loan incl. IDC**	**Interest**	**Profit before Tax**	**Cash Balance**	**Cumulative Cash**
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
2013 - 2014	178					178			0	-178	426	248	248	0	0	0	0	0				
2014 - 2015	1220					1220			0	-1220	1722	502	750	0	0	0	0	0				
2015 - 2016	2048					2048			0	-2048	1721	-327	423	0	0	0	0	0				
2016 - 2017	2941					2941			0	-2941	1540	-1401	-978	978	978	0	59	1037				
2017 - 2018	2950					2950			0	-2950	1351	-1599	-2577	2577	1599	0	213	2849				
2018 - 2019	1870	0	115	373		1985	333	33	366	-1619	0	-1870	-4447	4447	1870	0		4719	454	-576	-203	-203
2019 - 2020	682	0	204	373		886	471	47	518	-368	0	-682	-5129	5129	682	0		5401	607	-666	-293	-496
2020 - 2021	264	739	244	395		1247	660	66	726	-521		-264	-5393	5393	264	0		5665	664	-577	-921	-1417
2021 - 2022	0	0	264	395		264	693	69	762	498		0	-5393	0	0	567		5098	680	-577	-749	-2166
2022 - 2023	0	0	285	395		285	807	81	888	603		0	-5393	0	0	567		4531	612	-404	-576	-2742
2023 - 2024	0	0	308	395		308	848	85	933	625		0	-5393	0	0	567		3964	544	-314	-486	-3228
2024 - 2025	0	0	332	395		332	979	98	1077	745		0	-5393	0	0	567		3397	476	-126	-298	-3525
2025 - 2026	0	1079	382	427		1461	1069	107	1176	-285		0	-5393	0	0	567		2830	408	-41	-1260	-4785
2026 - 2027	0	0	412	427		412	1229	123	1352	940		0	-5393	0	0	567		2263	340	173	33	-4751
2027 - 2028	0	0	445	427		445	1290	129	1419	974		0	-5393	0	0	567		1696	272	275	135	-4616
2028 - 2029	0	0	481	427		481	1489	149	1638	1157		0	-5393	0	0	567		1129	204	526	386	-4230
2029 - 2030	0	0	519	427		519	1563	156	1719	1200		0	-5393	0	0	567		562	135	638	498	-3732
2030 - 2031	0	2066	636	489		2702	1827	183	2010	-692		0	-5393	0	0	562		0	67	818	-1321	-5053
2031 - 2032	0	0	686	489		686	1870	187	2057	1371		0	-5393	0	0	0		0	0	882	1371	-3682
2032 - 2033	0	0	741	489		741	2108	211	2319	1578		0	-5393	0	0	0		0	0	1089	1578	-2104
2033 - 2034	0	0	800	489		800	2159	216	2375	1575		0	-5393	0	0	0		0	0	1086	1575	-529
2034 - 2035	0	0	863	489		863	2445	245	2690	1827		0	-5393	0	0	0		0	0	1338	1827	1298
2035 - 2036	0	0	932	489		932	2504	250	2754	1822		0	-5393	0	0	0		0	0	1333	1822	3120
2036 - 2037	0	0	1006	489		1006	2819	282	3101	2095		0	-5393	0	0	0		0	0	1606	2095	5215
2037 - 2038	0	0	1085	489		1085	2887	289	3176	2091		0	-5393	0	0	0		0	0	1602	2091	7306
2038 - 2039	0	0	1172	519	993	2165	3258	326	3584	1419		0	-5393	0	0	0		0	0	1893	1419	8725
2039 - 2040	0	0	1265	558	1290	2555	3337	334	3671	1116		0	-5393	0	0	0		0	0	1848	1116	9841
2040 - 2041	0	0	1408	583	818	2226	3760	376	4136	1910		0	-5393	0	0	0		0	0	2145	1910	11751
2041 - 2042	0	3238	1546	680	0	4784	3809	381	4190	-594		0	-5393	0	0	0		0	0	1964	-594	11157
2042 - 2043	0	0	1669	680	0	1669	4294	429	4723	3054		0	-5393	0	0	0		0	0	2374	3054	14211
	12153	**7122**	**17800**	**11788**	**3101**	**40176**	**48508**	**4852**	**53360**	**4.55%**	**6760**				**5393**	**5665**	**272**		**5461**	**18311**	**14211**	
										13184												

Lucknow Metro Project

Table 14.22

CAPITAL COST-FIXED 9612

CAPITAL COST - CURRENT 3518

DOMESTIC FUNDING - BASE CASE

IDC rate: 12.00%

Year	Completion Cost	Additional Capital	Running Expenses	Depreciation	Replacement Cost	Total Cost	Fare box Revenue	PD & Advertisement	Total Revenue	Net Cash Flow for IRR	Concessioner Equity	Availability of cash	Cumulative cash	Cum. Loan	Loan	Repayment of Loan	IDC	Cumulative loan incl. IDC	Interest	Profit before Tax	Cash Balance	Cumulative Cash	Return on Equity (EIRR) Pre-Tax
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
2013 - 2014	11					11			0	-11	235	224	224	0	0	0	0	0					-235
2014 - 2015	438					438			0	-438	235	-203	21	0	0	0	0	0					-235
2015 - 2016	416					416			0	-416	235	-181	-160	160	160	0	10	170					-235
2016 - 2017	387					387			0	-387	235	-152	-312	312	152	0	28	350					-235
2017 - 2018	500					500			0	-500	233	-267	-579	579	267	0	53	670					-233
2018 - 2019	820	0	115	106		935	333	33	366	-569	0	-820	-1399	1399	820	0		1490	80	65	171	171	171
2019 - 2020	682	0	204	106		886	471	47	518	-368		-682	-2081	2081	682	0		2172	179	29	135	306	135
2020 - 2021	264	739	244	128		1247	660	66	726	-521		-264	-2345	2345	264	0		2436	261	93	-518	-212	-518
2021 - 2022	0	0	264	128		264	693	69	762	498		0	0	0	0	0		2436	292	78	206	-6	206
2022 - 2023	0	0	285	128		285	807	81	888	603		0	0	0	0	0		2436	292	183	311	305	311
2023 - 2024	0	0	308	128		308	848	85	933	625		0	0	0	0	244		2192	292	205	89	394	89
2024 - 2025	0	0	332	128		332	979	98	1077	745		0	0	0	0	244		1949	263	354	238	632	238
2025 - 2026	0	1079	382	160		1461	1069	107	1176	-285		0	0	0	0	244		1705	234	400	-762	-131	-762
2026 - 2027	0	0	412	160		412	1229	123	1352	940		0	0	0	0	244		1462	205	575	492	361	492
2027 - 2028	0	0	445	160		445	1290	129	1419	974		0	0	0	0	244		1218	175	639	555	916	555
2028 - 2029	0	0	481	160		481	1489	149	1638	1157		0	0	0	0	244		974	146	851	767	1683	767
2029 - 2030	0	0	519	160		519	1563	156	1719	1200		0	0	0	0	244		731	117	923	839	2523	839
2030 - 2031	0	2066	636	222		2702	1827	183	2010	-692		0	0	0	0	244		487	88	1064	-1023	1500	-1023
2031 - 2032	0	0	686	222		686	1870	187	2057	1371		0	0	0	0	244		244	58	1091	1069	2569	1069
2032 - 2033	0	0	741	222		741	2108	211	2319	1578		0	0	0	0	244		0	29	1327	1305	3874	1305
2033 - 2034	0	0	800	222		800	2159	216	2375	1575		0	0	0	0	0		0	0	1353	1575	5449	1575
2034 - 2035	0	0	863	222		863	2445	245	2690	1827		0	0	0	0	0		0	0	1605	1827	7276	1827
2035 - 2036	0	0	932	222		932	2504	250	2754	1822		0	0	0	0	0		0	0	1600	1822	9098	1822
2036 - 2037	0	0	1006	222		1006	2819	282	3101	2095		0	0	0	0	0		0	0	1873	2095	11193	2095
2037 - 2038	0	0	1085	222		1085	2887	289	3176	2091		0	0	0	0	0		0	0	1869	2091	13284	2091
2038 - 2039	0	0	1172	252	993	2165	3258	326	3584	1419		0	0	0	0	0		0	0	2160	1419	14703	1419
2039 - 2040	0	0	1265	291	1290	2555	3337	334	3671	1116		0	0	0	0	0		0	0	2115	1116	15819	1116
2040 - 2041	0	0	1408	316	818	2226	3760	376	4136	1910		0	0	0	0	0		0	0	2412	1910	17729	1910
2041 - 2042	0	3238	1546	413	0	4784	3809	381	4190	-594		0	0	0	0	0		0	0	2231	-594	17135	-594
2042 - 2043	0	0	1669	413	0	1669	4294	429	4723	3054		0	0	0	0	0		0	0	2641	3054	20189	3054
	3518	**7122**	**17800**	**5113**	**3101**	**31541**	**48508**	**4852**	**53360**	**15.11%**	**1173**				**2345**	**2436**	**91**		**2712**	**27735**	**20189**		**16.01%**
										21819													

Lucknow Metro Project																							Table 14.23
CAPITAL COST-FIXED			9612														12.00%						
CAPITAL COST - CURRENT			7873																				
DOMESTIC FUNDING - BASE CASE																							
Year	Completion Cost	Additional Capital	Running Expenses	Depreciation	Replacement Cost	Total Cost	Fare box Revenue	PD & Advertisement	Total Revenue	Net Cash Flow for IRR	Concessioner Equity	Availability of cash	Cumulative cash	Cum. Loan	Loan	Repayment of Loan	IDC	Cumulative loan incl. IDC	Interest	Profit before Tax	Cash Balance	Cumulative Cash	Return on Equity (EIRR) Pre-Tax
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
2013 - 2014	11					11			0	-11	235	224	224	0	0	0	0	0					-235
2014 - 2015	288					288			0	-288	235	-53	171	0	0	0	0	0					-235
2015 - 2016	816					816			0	-816	235	-581	-410	410	410	0	25	435					-235
2016 - 2017	1837					1837			0	-1837	235	-1602	-2012	2012	1602	0	145	2182					-235
2017 - 2018	2200					2200			0	-2200	1684	-516	-2528	2528	516	0	272	2970					-1684
2018 - 2019	1775	0	115	236		1890	333	3398	3731	1841	0	-1775	-4303	4303	1775	0		4745	356	3024	3260	3260	3260
2019 - 2020	682	0	204	236		886	471	3499	3970	3084		-682	-4985	4985	682	0		5427	569	2961	3197	6456	3197
2020 - 2021	264	739	244	258		1247	660	-1099	-439	-1686		-264	-5249	5249	264	0		5691	651	-1592	-2073	4383	-2073
2021 - 2022	0	0	264	258		264	693	-934	-241	-505		0	0	0	0	0		5691	683	-1446	-1188	3195	-1188
2022 - 2023	0	0	285	258		285	807	-542	265	-20		0	0	0	0	0		5691	683	-961	-703	2492	-703
2023 - 2024	0	0	308	258		308	848	-453	395	87		0	0	0	0	569		5122	683	-854	-1165	1327	-1165
2024 - 2025	0	0	332	258		332	979	-356	623	291		0	0	0	0	569		4553	615	-582	-893	434	-893
2025 - 2026	0	1079	382	290		1461	1069	-262	807	-654		0	0	0	0	569		3984	546	-411	-1769	-1335	-1769
2026 - 2027	0	0	412	290		412	1229	-159	1070	658		0	0	0	0	569		3415	478	-110	-389	-1724	-389
2027 - 2028	0	0	445	290		445	1290	-65	1225	780		0	0	0	0	569		2846	410	80	-199	-1923	-199
2028 - 2029	0	0	481	290		481	1489	603	2092	1611		0	0	0	0	569		2276	341	980	700	-1223	700
2029 - 2030	0	0	519	290		519	1563	632	2195	1676		0	0	0	0	569		1707	273	1113	834	-389	834
2030 - 2031	0	2066	636	352		2702	1827	682	2509	-193		0	0	0	0	569		1138	205	1316	-967	-1356	-967
2031 - 2032	0	0	686	352		686	1870	711	2581	1895		0	0	0	0	569		569	137	1406	1189	-167	1189
2032 - 2033	0	0	741	352		741	2108	762	2870	2129		0	0	0	0	569		0	68	1709	1492	1325	1492
2033 - 2034	0	0	800	352		800	2159	794	2953	2153		0	0	0	0	0		0	0	1801	2153	3478	2153
2034 - 2035	0	0	863	352		863	2445	852	3297	2434		0	0	0	0	0		0	0	2082	2434	5912	2434
2035 - 2036	0	0	932	352		932	2504	888	3392	2460		0	0	0	0	0		0	0	2108	2460	8372	2460
2036 - 2037	0	0	1006	352		1006	2819	952	3771	2765		0	0	0	0	0		0	0	2413	2765	11137	2765
2037 - 2038	0	0	1085	352		1085	2887	992	3879	2794		0	0	0	0	0		0	0	2442	2794	13931	2794
2038 - 2039	0	0	1172	382	993	2165	3258	1064	4322	2157		0	0	0	0	0		0	0	2768	2157	16088	2157
2039 - 2040	0	0	1265	421	1290	2555	3337	1109	4446	1891		0	0	0	0	0		0	0	2760	1891	17979	1891
2040 - 2041	0	0	1408	446	818	2226	3760	1190	4950	2724		0	0	0	0	0		0	0	3096	2724	20703	2724
2041 - 2042	0	3238	1546	543	0	4784	3809	1236	5045	261		0	0	0	0	0		0	0	2956	261	20964	261
2042 - 2043	0	0	1669	543	0	1669	4294	1326	5620	3951		0	0	0	0	0		0	0	3408	3951	24915	3951
	7873	**7122**	**17800**	**8363**	**3101**	**35896**	**48508**	**16820**	**65328**	**14.20%**	**2624**				**5249**	**5691**	**442**		**6699**	**32466**	**24915**		**16.01%**
										29432													

Lucknow Metro Project																						Table 14.24
CAPITAL COST-FIXED			9612																			
CAPITAL COST - CURRENT			12153												JICA Loan		1.40%					
DOMESTIC FUNDING - BASE CASE																						
Year	Completion Cost	Additional Capital	Running Expenses	Depreciation	Replacement Cost	Total Cost	Fare box Revenue	PD & Advertisement	Total Revenue	Net Cash Flow for IRR	Equity from GOI & GUP	Availability of cash	Cumulative cash	Cum. Loan	Loan	Repayment of Loan	IDC	Cumulative loan incl. IDC	Interest	Profit before Tax	Cash Balance	Cumulative Cash
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
2013 - 2014	178					178			0	-178	426	248	248	0	0	0	0	0				
2014 - 2015	1220					1220			0	-1220	1722	502	750	0	0	0	0	0				
2015 - 2016	2048					2048			0	-2048	1721	-327	423	0	0	0	0	0				
2016 - 2017	2941					2941			0	-2941	1540	-1401	-978	978	978	0	7	985				
2017 - 2018	2950					2950			0	-2950	1351	-1599	-2577	2577	1599	0	25	2609				
2018 - 2019	1870	0	115	366		1985	333	3398	3731	1746	0	-1870	-4447	4447	1870	0	0	4479	50	3200	3566	3566
2019 - 2020	682	0	204	366		886	471	3499	3970	3084	0	-682	-5129	5129	682	0		5161	67	3333	3699	7265
2020 - 2021	264	739	244	388		1247	660	-1099	-439	-1686		-264	-5393	5393	264	0		5425	74	-1145	-1496	5769
2021 - 2022	0	0	264	388		264	693	-934	-241	-505		0	-5393	0	0	0		5425	76	-969	-581	5188
2022 - 2023	0	0	285	388		285	807	-542	265	-20		0	-5393	0	0	0		5425	76	-484	-96	5092
2023 - 2024	0	0	308	388		308	848	-453	395	87		0	-5393	0	0	271		5154	76	-377	-260	4832
2024 - 2025	0	0	332	388		332	979	-356	623	291		0	-5393	0	0	271		4883	72	-169	-52	4779
2025 - 2026	0	1079	382	420		1461	1069	-262	807	-654		0	-5393	0	0	271		4611	68	-63	-994	3786
2026 - 2027	0	0	412	420		412	1229	-159	1070	658		0	-5393	0	0	271		4340	65	173	322	4108
2027 - 2028	0	0	445	420		445	1290	-65	1225	780		0	-5393	0	0	271		4069	61	299	448	4556
2028 - 2029	0	0	481	420		481	1489	603	2092	1611		0	-5393	0	0	271		3798	57	1134	1283	5839
2029 - 2030	0	0	519	420		519	1563	632	2195	1676		0	-5393	0	0	271		3526	53	1203	1352	7190
2030 - 2031	0	2066	636	482		2702	1827	682	2509	-193		0	-5393	0	0	271		3255	49	1342	-514	6677
2031 - 2032	0	0	686	482		686	1870	711	2581	1895		0	-5393	0	0	271		2984	46	1367	1578	8255
2032 - 2033	0	0	741	482		741	2108	762	2870	2129		0	-5393	0	0	271		2713	42	1605	1816	10071
2033 - 2034	0	0	800	482		800	2159	794	2953	2153		0	-5393	0	0	271		2441	38	1633	1844	11915
2034 - 2035	0	0	863	482		863	2445	852	3297	2434		0	-5393	0	0	271		2170	34	1918	2129	14043
2035 - 2036	0	0	932	482		932	2504	888	3392	2460		0	-5393	0	0	271		1899	30	1948	2158	16202
2036 - 2037	0	0	1006	482		1006	2819	952	3771	2765		0	-5393	0	0	271		1628	27	2256	2467	18669
2037 - 2038	0	0	1085	482		1085	2887	992	3879	2794		0	-5393	0	0	271		1356	23	2289	2500	21169
2038 - 2039	0	0	1172	512	993	2165	3258	1064	4322	2157		0	-5393	0	0	271		1085	19	2619	1867	23035
2039 - 2040	0	0	1265	551	1290	2555	3337	1109	4446	1891		0	-5393	0	0	271		814	15	2615	1605	24640
2040 - 2041	0	0	1408	576	818	2226	3760	1190	4950	2724		0	-5393	0	0	271		543	11	2955	2441	27081
2041 - 2042	0	3238	1546	673	0	4784	3809	1236	5045	261		0	-5393	0	0	271		271	8	2818	-18	27063
2042 - 2043	0	0	1669	673	0	1669	4294	1326	5620	3951		0	-5393	0	0	271		0	4	3274	3676	30739
	12153	7122	17800	11613	3101	40176	48508	16820	65328	8.29%	6760				5393	5425	32		1141	34774	30739	
										25152												

Chapter 15

Economic Analysis

CHAPTER - 15

ECONOMIC APPRAISAL

15.1 INTRODUCTION

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

Economic appraisal of a project starts from quantification of measurable economic benefits in economic money values, which are basically the savings of resource cost due to introduction of the metro line. Economic savings are derived from the difference of the cost of the same benefit components under 'with' and 'without' metro line. Total net savings/or benefit is obtained by subtracting the economic cost of the project (incurred for construction (Capital) and maintenance (recurring) costs for the metro line) from the benefits out of the project in each year. The net benefit value which would be negative during initial years becomes positive as years pass. Internal rate of return and benefit cost ratio are derived from the stream.

The sources from where economic savings occur are identified first. Although there are many kinds of primary, secondary and tertiary benefits, only the quantifiable components can be taken to measure the benefits. These components are quantified by linking with the number of passengers shifted and the passenger km saved by the trips which are shifted from road/rail based modes to metro. It may be observed that first four benefit components given in **Table 15.1** are direct benefits due to shifting of trips to metro, but other benefit components are due to decongestion effect on the road. Benefit components were first estimated applying market values then were converted into respective Economic values by using separate economic factors which are also given in table 15.1. Depending upon methodology of estimation, economic factors are assumed. Overall economic value of benefit components is 90% of the market value. Similarly economic value of the cost components are 80% of the market cost.

Table 15.1 - Benefit Components due to Metro

S. No.	Benefit Components	Economic Factors
1	Construction Cost	80%
2	Maintenance Cost	80%
3	Annual Time Cost Saved by Metro Passengers	100%
4	Annual Fuel Cost Saved by Metro Passengers	80%
5	Annual Vehicle Operating Cost Saved saved by Metro Passengers	80%
6	Emission Saving Cost	100%
7	Accident Cost	100%
8	Annual Time Cost Saved by Road Passengers	100%

15.2 VALUES ADOPTED FOR SOME IMPORTANT VARIABLES

Benefit components are converted (by applying appropriate unit cost) to money values (Rs.). Derivation procedures of some of the values used for economic analysis are shown in **Table 15.2**.

Table 15.2 - Values adopted for some important variables

S. No.	Values	Important variables
1	Rs. 1.07/min (2012)	Time Cost derived from passenger's monthly income level.
2	Market Rate (2012)	Fuel Cost (value of Petrol, Diesel and CNG).
3	Table 15.3	Vehicle Operating Cost (Derived from Life Cycle Cost of different passenger vehicles per km)
4	Table 15.4 (CPCB)	Emission (gm/km as per CPCB and UK Norms) Emission Saving Cost (adopted for Indian conditions in Rs/ton).
5	Table 15.5 (Accident Rate & Cost)	Accident Rate (No of fatal and all accidents per one Cr.KM). Accident costs are derived from published papers at current rate.
6	51.68%	Passenger km – Vehicle km conversion factor and mode share percent values (derived from traffic volume count and modal split within study area as reported in chapter 2)
7	Road User Cost Study Model (CRRI-2010)	Fuel Consumption of vehicles at a given speed is derived
8	Rs. 0.5/vehicle km	Infra Structure Maintenance Cost is derived from published values on annual expenditure on roads and traffic and annual vehicle km

S. No.	Values	Important variables
9	11.12 min	Weighted Average of all mode travel time saved for average trip length km journey after Shifting (Derived)
10	20 kmph	Present Public Transport Journey Speed (Speed & Delay Study)

Table 15.3 - Vehicle Operating Cost in Rs.

Per Vehicle KM	Bus	4 Wh (Large)	4 Wh (Small)	2 Wh (MC)	2 Wh (SC)	3 Wh (Auto)	Mini Bus
Maintenance Cost	3.94	3.31	2.01	0.57	0.72	2.25	2.75
Capital Cost	2.40	2.67	1.20	0.18	0.16	0.72	1.72
Total VOC	6.98	6.58	3.54	0.82	0.96	3.27	4.92

Table 15.4 - Vehicle Emission 2011-2021(CPCB) and Cost in Rs.

VEHICLE	CO	HC	NOX	PM	CO	CO2
BUS	3.72	0.16	6.53	0.24	3.72	787.72
2W-2 STROKE	1.4	1.32	0.08	0.05	1.4	24.99
2W-4 STROKE	1.4	0.7	0.3	0.05	1.4	28.58
MINI BUS	2.48	0.83	8.26	0.58	2.48	358.98
4W-SMALL	1.39	0.15	0.12	0.02	1.39	139.51
4W-LARGE	0.58	0.05	0.45	0.05	0.58	156.55
TATA MAGIC	1.24	0.17	0.58	0.17	1.24	160
3W	2.45	0.75	0.12	0.08	2.45	77.89
Cost	RS. 100000 PER TON					500

Table 15.5 - Accident Rate$ and Cost in Rs

Type	Accident Rate per Cr. Vehicle KM	Accident Cost in Rs
Average of all types.	2.0	588911
Fatal Accident.	0.2	1692648

$ medium sized city accident rates are used

Traffic parameter values used for economic analysis are given in **Table 15.6.**

Table 15.6 - Traffic parameter values

TRAFFIC INPUT	2021	2026	2031	2036	2041
Trips/day Lucknow METRO	584900	887951	1179170	1514230	1729200
Line Length (km)	33.976	33.976	33.976	33.976	33.976
Average Trip length (km)	6.58	6.64	6.45	6.37	6.27
Passenger km	3849449	5896997	7609517	9652649	10846554
Passenger km/km	113299	173564	223967	284102	319242

15.3 ECONOMIC BENEFIT STREAM

Benefits in terms of money value are estimated directly from the projected passenger km saved for the horizon years (2020, 2025, 2030 and 2041) and values for other years are interpolated on the basis of projected traffic. Market values are used for calculating costs and then appropriate economic factors (see table 15.1) are applied. For each year values of each benefit components are obtained and thus benefit stream is estimated. Benefit Components Stream for **Lucknow Metro Rail** is shown in **Table 15.7**.

Table 15.7 - Year wise Economic Values of Benefit Components (Stream)

Year	Year	Annual Time Cost Saved by Metro Passengers in Cr. Rs.	Annual Fuel Cost Saved by Metro Passengers in Cr. Rs.	Annual Vehicle Operating Cost Saved by Metro Passengers in Cr. Rs.	Emission Saving Cost in Cr. Rs.	Accident Cost in Cr. Rs.	Annual Time Cost Saved by Road Passengers in Cr. Rs.	Annual Fuel Cost Saved by Road Passengers in Cr. Rs.	Annual Infra Structure Maintenance Cost in Cr. Rs.	Total Benefits without Discount in Cr. Rs.
2018	2019	121.17	46.81	26.63	13.48	3.51	19.63	0.85	10.58	242.65
2019	2020	461.85	171.77	103.64	44.51	13.68	76.54	3.19	38.87	914.06
2020	2021	528.13	189.16	121.00	42.70	16.00	89.56	3.60	42.83	1032.97
2021	2022	603.91	208.32	141.23	49.84	18.57	104.77	4.06	47.19	1177.90
2022	2023	672.34	223.46	160.53	56.65	20.99	119.35	4.45	50.63	1308.41
2023	2024	748.51	239.75	182.48	64.40	23.72	135.97	4.88	54.32	1454.03
2024	2025	833.32	257.29	207.42	73.20	26.81	154.90	5.34	58.29	1616.57
2025	2026	927.73	276.17	235.78	83.21	30.30	176.47	5.85	62.54	1798.05
2026	2027	1032.84	285.34	257.93	91.03	33.06	193.48	6.15	64.58	1964.42
2027	2028	1142.17	304.37	291.25	102.79	37.24	218.95	6.68	68.83	2172.29
2028	2029	1263.07	324.73	328.88	116.06	41.95	247.79	7.25	73.37	2403.10
2029	2030	1396.77	354.58	380.00	134.11	47.26	290.08	8.05	80.02	2690.85
2030	2031	1544.62	379.11	429.85	151.70	53.23	329.11	8.74	85.44	2981.80
2031	2032	1708.13	396.41	475.45	167.79	58.59	365.11	9.28	89.20	3269.96

Year	Year	Annual Time Cost Saved by Metro Passengers in Cr. Rs.	Annual Fuel Cost Saved by Metro Passengers in Cr. Rs.	Annual Vehicle Operating Cost Saved by Metro Passengers in Cr. Rs.	Emission Saving Cost in Cr. Rs.	Accident Cost in Cr. Rs.	Annual Time Cost Saved by Road Passengers in Cr. Rs.	Annual Fuel Cost Saved by Road Passengers in Cr. Rs.	Annual Infra Structure Maintenance Cost in Cr. Rs.	Total Benefits without Discount in Cr. Rs.
2032	2033	1914.61	427.34	542.92	187.30	66.63	418.20	10.21	96.15	3663.36
2033	2034	2146.06	460.67	619.97	209.08	75.76	479.01	11.24	103.64	4105.43
2034	2035	2405.48	496.61	707.96	233.38	86.15	548.67	12.37	111.71	4602.33
2035	2036	2696.26	535.35	808.43	260.52	97.97	628.45	13.62	120.41	5161.00
2036	2037	3022.20	577.11	923.15	290.81	111.40	719.83	14.99	129.79	5789.29
2037	2038	3387.53	622.13	1054.16	324.62	126.68	824.51	16.50	139.90	6496.03
2038	2039	3797.03	670.66	1203.77	362.36	144.06	944.40	18.16	150.80	7291.23
2039	2040	4256.02	722.97	1374.60	404.49	163.81	1081.73	19.99	162.54	8186.17
2040	2041	4770.51	779.37	1569.68	451.52	186.28	1239.03	22.00	175.20	9193.59
2041	2042	5347.18	840.17	1792.44	504.01	211.82	1419.21	24.22	188.84	10327.90
2042	2043	5993.57	905.71	2046.81	562.61	240.87	1625.58	26.66	203.55	11605.37

Table 15.8 - Accrued Benefit Values

Benefit Components	Accrued Benefit Values between 2018-2043 in Cr.Rs.	Percent
TIME COST-METRO	53357	48.40%
FUEL COST-METRO	13683	12.41%
VOC	20155	18.28%
EMISSION	5052	4.58%
ACCIDENT	1955	1.77%
TIME COST-ROAD	12552	11.39%
FUEL COST-ROAD	341	0.31%
INFRASTRUCTURE	3082	2.80%

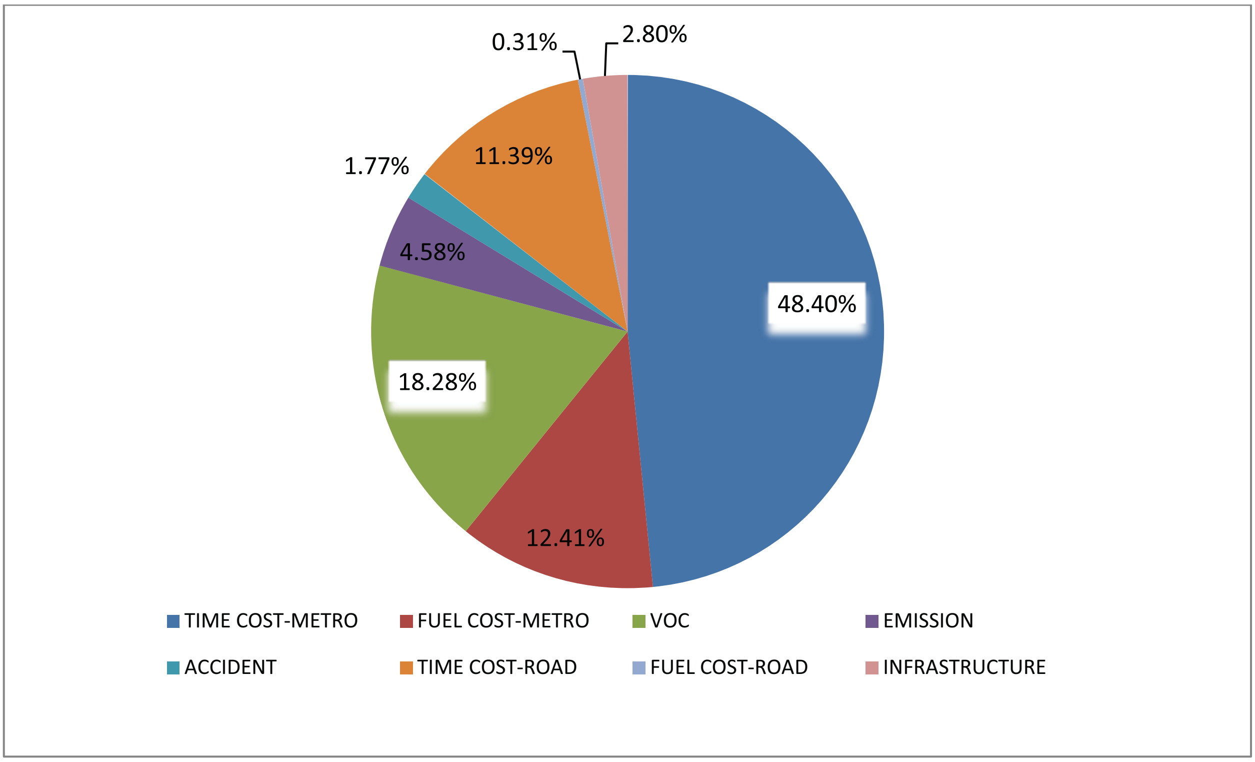


Figure 15.1 - Percent of Benefits

Components of Benefit (between the years 2018-2043) are shown in figure 15.1 which shows that benefits are mainly coming from saving of travel time (60%), VOC (18%) and fuel cost (13%) by shifted metro passengers and relieved road passengers. Environmental benefit from emission reduction, accident reduction and road maintenance cost (together) is 9%.

In this area, personalised modes (car, three and two wheelers) are dominant which have made vehicle by passenger ratio very high (51%). Average passenger wise modal split (with motorized vehicle class) obtained from the house hold survey shows that 77% trips are made by private modes and 8% are by IPT. Trips carried by Bus is about 15% as may be seen in table 15.8. Obviously presence of dependable mass transport system is not there.

Table 15.9 -Verage Modal Split In Study Area

Vehicles	% PASS	% Vehicle
BUS	14.53%	0.80%
MINI BUS	3.63%	0.42%
CAR	1.54%	1.02%
TAXI	0.17%	0.10%
2 WH	75.85%	94.09%
AUTO	4.27%	3.56%

15.4 METRO CONSTRUCTION COST

Total cost of metro construction (CAPITAL COST) is derived after considering cost of all major component such as Relocation and Rehabilitation(RR), Civil construction for underground and elevated portions, Stations and Depots, Track laying, Signalling and telecommunication, Power traction line, Rolling stock, Man power etc. RUCURRING COST includes energy cost, maintenance cost, and operation cost. Economic analysis period is taken from 2013-14 to 2042-43 out of which 5 years (2013-2018) are marked as construction period. Additional capital expenditure may be incurred in the years 2020-21 (Rs. 528 Cr.), 2025-26 (Rs.674 Cr.), 2030-31 (Rs. 1205 Cr.) & in 2041-42 (Rs. 2355 Cr.) for purchase of more rolling stock. Replacement cost was estimated as Rs. 1767 Cr. during 2038-2041. Operation is expected to start in 2018- 2019 (Year 6). This cost stream is generated with Central taxes. Detail is shown in **Table below:-**

Table 15.10 - Estimated Capital and Recurring Cost Including Central Tax

Year	Year	Capital Cost	Recurring Cost
Start	Ending	Cr. Rs.	Cr. Rs
2013	2014	178	0
2014	2015	952	0
2015	2016	1308	0
2016	2017	1904	0
2017	2018	1365	0
2018	2019	734	115
2019	2020	316	124
2020	2021	528	149
2021	2022	0	161
2022	2023	0	174
2023	2024	0	188
2024	2025	0	203
2025	2026	674	234
2026	2027	0	253
2027	2028	0	274
2028	2029	0	295
2029	2030	0	319
2030	2031	1205	396
2031	2032	0	428
2032	2033	0	462
2033	2034	0	499
2034	2035	0	539
2035	2036	0	582
2036	2037	0	628
2037	2038	0	678
2038	2039	993	733
2039	2040	774	791
2040	2041	0	897
2041	2042	2355	968
2042	2043	0	1046

15.5 ECONOMIC PERFORMANCE INDICATORS

After generating the cost and benefit stream tables, values of economic performance indicators are derived and are presented in **table 15.11**. Project period is 2013-2043, EIRR (with central tax) is found to be **19.43%** and B/C ratio as 5.19 and with 12 % discount, EIRR is 6.64% and B/C ratio is 1.92. NPV without discount is Rs 81911 Cr. and with 12% discount rate, NPV is Rs.4611 Cr. which shows that the project is economically viable.

Table 15.11 - Economic Indicator Values (with Central Tax)

Lucknow Metro Network	WITHOUT DISCOUNT	WITH DISCOUNT (12%)
Total cumulative cost	19538	5593
Total cumulative benefit	101449	10757
Benefit Cost Ratio	**5.19**	**1.92**
NPV	**81911**	**4611**

15.6 SENSITIVITY ANALYSIS

Sensitivity and B/C ratios both with and without discount was carried out and the output is given in the **table 15.12**. 2043-44 is taken for the year of comparison.

Table 15.12 - Sensitivity of EIRR

SENSITIVITY		WITHOUT DISCOUNT			WITH DISCOUNT		
TRAFFIC	COST	EIRR	B/C	COST	EIRR	B/C	COST
0%	0%	19.43%	5.19	19538	6.64%	1.92	5593
-10%	0%	18.78%	4.92	19538	6.06%	1.82	5593
-20%	0%	18.11%	4.65	19538	5.45%	1.72	5593
0%	10%	18.27%	4.72	21491	5.60%	1.75	6152
0%	20%	17.25%	4.33	23445	4.68%	1.60	6712
-10%	10%	17.64%	4.48	21491	5.04%	1.66	6152
-20%	20%	15.99%	3.88	23445	3.56%	1.44	6712

15.7 QUANTIFIED BENEFITS.

Benefits which are shown in previous tables are money value of the benefits. These benefits are estimated (in terms of quantity) first and then converted into money value. For brevity, only 5 year estimates are shown in table 15.13 (Reduction of Vehicle gas Emission).

Table 15.13 - Environmental Benefits Quantified

Tons/Year	2019	2020	2021	2022	2023
CO	1498.35	1634.55	1736.38	1844.60	1959.59
HC	1011.42	1103.36	1172.10	1245.14	1322.76
NOX	281.71	307.32	326.46	346.81	368.43
PM	56.37	61.49	65.33	69.40	73.72
SO2	3.75	4.10	4.35	4.62	4.91
CO2	38579	42085	44707	47493	50454
Total Emission Saved	41430	45196	48012	51004	54184

Quantified Travel Benefits are shown in Table 15.14, it may be seen that In 2020, Time saving will be 6.07 Crore (10 million) hours, fuel saving 37.17 thousand tons. Amount of travel in terms of road passenger km reduced due to shifting to Metro Rail is equivalent to reduction of 74357 vehicle (distributed as per modal split given in table 15.8) from the road. More than 22 fatal accidents and 180 other accidents may be avoided. Hence it is expected that there will be some improvement of the overall ambience of the city.

Table 15.14 - Travel Benefits Quantified

Quantified Benefits in Horizon Years	2019	2020	2021	2022	2023
Annual Time Saved by Metro Passengers in Cr. Hr.	5.57	6.07	6.43	6.82	7.23
Annual Fuel Saved by Metro Passengers in thousand Tons.	33.72	37.17	39.91	42.86	46.04
Daily vehicles reduced (off the road)	68161	74357	78990	83912	89144
CO2 reduced in thousand tons	38.58	42.09	44.71	47.49	50.45
Other gases reduced in thousand tons	2.85	3.11	3.30	3.51	3.73
Reduced No of Fatal Accidents in Year	20.73	22.48	23.75	25.08	26.49
Reduced No of Other Accidents in year	186.56	202.35	213.72	225.74	238.45
Annual Vehicle km Reduced in Thousand Km.	28.190	30.753	32.669	34.705	36.868

15.8 TRANSPORT ORIENTED DEVELOPMENT (TOD) & EIRR

In sensitivity analysis, effects of less traffic and more expenditure are shown. On the other hand, there may be generation (addition of extra trips) of ridership on Metro due to Transport Oriented Development. Introduction of Modern Mass Transit System (Metro) will have an impact on city's landuse in near future. Values of land which are closer to the metro line will increase very quickly, commercial activities near station areas will increase and people will not hesitate to live in remote areas of the city (but near to metro station). Due to presence of metro existing bus routes may change, some old routes may stop operation and some new routes may be introduced. A detail study will be needed to identify, quantify and to estimate economic impact of such likely changes. Detail discussion and evaluation is beyond the scope within this chapter. Nevertheless, it will be interesting to know, for 10% increase of ridership, EIRR value will be 20.06%, and for 20% increase EIRR will become 20.66%, keeping other traffic and cost inputs unchanged

Chapter 16

Implementation Plan

CHAPTER 16

IMPLEMENTATION PLAN

16.1 WAY FORWARD FOR IMPLEMENTING LUCKNOW METRO PROJECT

On receipt of the Detailed Project Report, following action will be required for implementing the Lucknow Metro:

- Approval to the Detailed Project Report to be taken from Uttar Pradesh State Government (Cabinet approval).
- The DPR to be forwarded to the Ministry of Urban Development(GOI), Planning Commission and Finance Ministry with the request for approving the Metro project and for financial participation through equity contribution in the SPV.
- Signing of an MOU between Uttar Pradesh 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.
- Lucknow Metro Rail Corporation Ltd, the Special Purpose Vehicle (SPV) set up for implementing the project and for its subsequent Operation & Maintenance should be made functional early.
- The Metro Railways (Amendment) Act-2009 can readily be made use of for implementation of Lucknow Metro by declaring Lucknow City as Metropolitan Area in terms of clause c of section 243 P of Constitution.
- Request to GOI for a notification for making the Metro Railways (Amendment)) Act 2009 applicable to Lucknow Metro.
- The State Government should formulate the funding plan for executing this project and get the same approved by the Government of India. The loan portion of the funding will have to be tied up by State Government in consultation with the Government of India.

- The Government should freeze all developments along the corridors suggested. For any constructions within 50 m. of the proposed alignment a system of No Objection Certificate should be introduced so that infructuous expenditure at a later stage is avoided.

- The Metro Railways (Amendment) Act-2009 can readily be made use of for implementation of Lucknow Metro by declaring Lucknow City as Metropolitan Area.

16.2 INSTITUTIONAL ARRANGEMENTS

To enable Lucknow 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:

16.2.1 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. Uttar Pradesh Government has to register Lucknow Metro Rail Corporation Ltd (LMRC) for Lucknow Metro under the Companies Act, 1956. This SPV shall be 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 LMRC 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 LMRC 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. The Managing Director should be a technocrat of proven record and impeccable integrity. A Railway background would be an added advantage. A metro background would be most desirable.

16.2.2 Implementation on Delhi Metro/Chennai Metro Model

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

Government of Uttar Pradesh in its decision on taken on 14/06/2013 intends to implement Phase – 1 of the Lucknow Metro Rail Project in two stages; North South Corridor in first stage (Phase 1 A) and East West Corridor in second stage (Phase 1 B). A suggested project implementation schedule is given below. The proposed date of commissioning of the both corridor with suggested dates of important milestones is given in Table 16.1 and 16.2 respectively.

Table 16.1 - Implementation Schedule through DMRC model
Phase 1A – North south Corridor

S. No.	Item of Work	Completion Date
1	Submission of Final DPR to State Govt.	25.07.2013
2	Approval of DPR by State Government	31.07.2013
3	Submission of DPR for Approval of Ministry of Urban Development (MoUD).	15.08.2013
4	Appoint interim Consultant for preliminary works	15.09.2013
5	Approval of Project by Empowered Committee	30.09.2013
6	Sanction of Project by EGOM.	01.10.2013
7	Appoint General Consultant	01.01.2014
8	Tendering, Execution of works and Procurement of equipments, coaches and installations	01.01.2014 - 31.12.2017
9	Testing and Commissioning	01.01.2018 – 31.03.2018
10	Revenue Operation	01.04.2018

Table 16.2 - Implementation Schedule through DMRC model
Phase 1B – East west Corridor

S. No.	Item of Work	Completion Date
1	Submission of Final DPR to State Govt.	25.07.2013
2	Approval of DPR by State Government	31.03.2014
3	Submission of DPR for Approval of Ministry of Urban Development (MoUD).	30.04.2014
4	Appoint interim Consultant for preliminary works	31.05.2014
5	Approval of Project by Empowered Committee	15.06.2014
6	Sanction of Project by EGOM.	15.07.2014

S. No.	Item of Work	Completion Date
7	Appoint General Consultant	31.08.2014
8	Tendering, Execution of works and Procurement of equipments, coaches and installations	01.09.2014 - 31.12.2018
9	Testing and Commissioning	01.01.2019 - 31.03.2019
10	Revenue Operation	01.04.2019

Both corridors can be divided into sections for the purpose of commercial opening in stages.

16.3 ORGANISATIONAL SET-UP OF LMRC

The LMRC Organization, as stated earlier, should be very lean but effective. It will consist of a non-executive Chairman, a Managing Director with full Executive Powers (in Schedule 'A') and three Functional Directors (in Schedule 'B') including Director (Finance). All the three Functional Directors will be full members of the Management Board. The Directors will be assisted by Heads of Departments in each of the major disciplines and they in turn will have Deputy Heads of Departments. The organization should be basically officer-oriented with only Personal Assistants and Technical Assistants attached to senior officers by eliminating unproductive layers of staff such as Peons, Clerks, etc. We strongly recommend that the total organizational strength is limited to 70 to 80 eliminating too many tiers to enable faster decision-making.

It is necessary for the LMRC officers to get exposed to the Metro technology and Metro culture through study tours of some of the selected foreign Metros and Delhi/Calcutta Metros.

Implementing a metro project in a congested metropolis is indeed a challenge. In sheer size, magnitude and technical complexity there are no parallels to metro projects. Further, these projects are to be carried out in difficult urban environment without dislocating city life, while at the same time preserving the environment. The project involves integration of a number of complex technical systems some of these technologies used in these systems are totally new to the country each one of which is a major project by itself. Interfacing various system contracts is a difficult and highly skilled exercise. Side by side, timely and adequate funds have to be assured for implementation and lands, without encumbrances, have to be taken possession of in time. Clearances from the local authorities have to be taken which includes permission to cut trees, diversion of utilities, management of road traffic, etc., all of which will call for an efficient and competent project implementing agency.

Metro projects cannot be executed the way Government agencies execute projects in this country. Timely completion is very important to safeguard the financial viability. Competent and skilled technical personal to man such an organization are difficult to mobilize. In fact such experienced persons are not readily available in the country. Being a rail based project, for most of the systems such as rolling stock, signaling, telecommunication, traction power supply, etc., persons with railway background would be necessary. As systems & construction technology used in metro are much more advanced and sophisticated than the one used in Railways as these have to suit dense urban areas, Metro experience will enable faster & smoother execution and thus is desirable & therefore should be preferred.

Since LMRC will not have the required expertise and experienced manpower to check and monitor the General Consultants it may be necessary to engage Prime Consultants from the very start of GC's assignment who will do this job on behalf of LMRC. Delhi Metro Rail Corporation can be considered for being appointed as Prime Consultant to LMRC.

Delhi Metro Rail Corporation can also be considered straightaway for being appointed as General Consultant to LMRC which will reduce the construction time by 4 to 6 months.

16.4 CONTRACTS

16.4.1 Civil Works

It is proposed to carry out the civil works through following construction contracts-

(a) *Viaduct Construction*-It is suggested that each contract can be limited to about 5 to 6 kms in length.

(b) *Station Contracts*- It is proposed that each station contract comprises of 3 to 6 stations.

Corridor wise number of contracts are expected to be as follows:

Table 16.2 - Construction Strategy (Elevated Portion)

Corridor	Length of Elevated Section (km)	Elevated Stations (Nos.)	Proposed Contracts	
			Viaduct	Station
Amausi- Munshi Pulia Corridor	19.438	19	3 Nos	4 Nos.
Lucknow Railway Station -Vasant Kunj Corridor	4.504	5	1 No.	1 No.

(c) Underground Section: Following contracts are suggested for underground section including stations:-

Table 16.3 - Construction Strategy (Underground Portion)

Corridor	Underground Section		Proposed Contracts
	Length (km)	Station (Nos.)	Underground section including stations
Amausi- Munshi Pulia Corridor	3.44	3	2 Nos
Lucknow Railway Station -Vasant Kunj Corridor	6.594	7	2 Nos

Architectural finishes, fire fighting arrangements and general electrification, will form part of civil contracts.

16.4.2 System Contracts

- Design, construct and installation for Traction and Power Supply.
- Design, construct and installation of Signal and Telecommunication works.
- Design, construct and installation of lifts.
- Design, construct and installation of escalators.
- Design, construct and commissioning of Automatic Fare Collection System.
- Design and supply of rolling stock.
- Installation of track in Depot and on main line.
- Design and installation of Signages.

16.4.3 Depot Contracts

The contracts are required for Civil and E&M works at Amausi Depot and Vasant Kunj Depot. Each depot will have one package for civil works.

The number of contracts for supply of Depot Equipment may be decided as and when the work is in progress.

16.5 HIGH POWER COMMITTEE

During the implementation of the project several problems with regard to acquisition of land, diversion of utilities, shifting of structures falling on the project alignment, rehabilitation of project affected persons, etc. are likely to arise. For expeditious resolution of these problems, an institutional mechanism needs to be set up at the State Government level. Towards this end, it is recommended that a High Power Committee under the chairmanship of Chief Secretary, Uttar Pradesh should be set up. Other members of this Committee should be Secretaries of the concerned Departments of the State Government and Heads of civic bodies who will be connected in one way or the other with the implementation of the project. Commissioner of Lucknow Development Authority and Chief Executive Officer of Lucknow Nagar Nigam should also be the member of this committee. This Committee should meet once a month and sort out all problems brought before it by LMRC and LDA. For Delhi Metro also such a High Power Committee was set up and it proved very useful in smooth implementation of the Delhi Metro rail project.

16.6 EMPOWERED COMMITTEE

At the Central Government level an Empowered Committee, under the chairmanship of Cabinet Secretary, is presently functioning for Delhi Metro project. Other members of this Committee are Secretaries of Planning Commission, Ministry of Home Affairs, Ministry of Urban Development, Ministry of Surface Transport, Ministry of Environment and Forests, Department of Expenditure, Chief Secretary of Delhi Government and a representative from the PMO. The Empowered Committee meets regularly and takes decisions on matters connected with inter-departmental coordination and overall planning, financing and implementation of the Delhi Metro project. It is suggested that the role of this Empowered Committee should be enlarged to include Lucknow Metro project also and the Chief Secretary, Uttar Pradesh should be inducted as a member of this Committee.

16.7 EMPOWERED GROUP OF MINISTERS (EGOM)

Union Cabinet had set up a Empowered Group of Ministers (EGoM) to take decisions on behalf of the Cabinet on policy matters concerning Delhi Metro project. The Group of Ministers is chaired by the Home Minister. Other members of the GOM are Minister of Urban Development and Poverty Alleviation, Minister of Railways, Minister of Finance and Company Affairs and Deputy Chairman Planning Commission. Chief Minister, Delhi and Lt. Governor, Delhi, are permanent invitees to all meetings of the GOM. The GOM meets whenever any problem requiring decision on behalf of the Union Cabinet is to be taken. It is suggested that the role of this GOM should be enlarged to include Lucknow Metro. The Chief Minister, Uttar Pradesh should be inducted as a member and should attend the meetings of GOM whenever any issue concerning Lucknow Metro is to be deliberated upon.

16.8 LEGAL COVER FOR LUCKNOW METRO

Construction of Lucknow Metro should commence soon. Thus there is immediate need to have a legislation to provide legal cover to the construction stage of Lucknow Metro.

Implementation of proposed Lucknow Metro can now be done under "The Metro Railways (Amendment) Act 2009". The copies of the Gazette notification and the amendment are put up enclosure to this chapter.

16.9 CONCESSIONS FROM GOVERNMENT

Metro rail projects need very heavy investment. Loans have invariably to be taken to fund a part of the capital cost of the projects. These projects yield low financial internal rate of return. With reasonable fare level, servicing of these loans often pose problems. To make the project financially viable, therefore, the fares need to be substantially increased to socially un-acceptable levels. This results in the ridership coming down significantly, as it is sensitive to increases in the fare level. Thus the very objective of constructing the metro rail system to provide an affordable mode of mass travel for public is defeated. It, therefore, becomes necessary to keep the initial capital cost of a metro project as low as possible so that the fare level of the metro system can be kept at reasonable level.

As in the case of Delhi Metro, the State Government should exempt/reimburse the Uttar Pradesh Value Added Tax (VAT) to Lucknow Metro. It should also exempt the following: -

- Tax on electricity required for operation and maintenance of the metro system.
- Municipal Taxes.

As per the present policy 50% of the Central Taxes will be paid by GOI as subordinate Debt and balance 50% will be paid by the concerned State Government. Uttar Pradesh State Government may pursue the Central government to extend the same benefit to Lucknow Metro.

16.10 POSTING OF OSD

Since sanction of Lucknow Metro and selection of full time Directors may take some time, it is recommended that Uttar Pradesh State Government should urgently post an Officer on Special Duty (OSD) with adequate powers to process and pursue sanction for this project and to take preliminary steps required for its implementation.

16.11 NEED FOR DEDICATED FUND FOR METRO PROJECTS

We also strongly recommend that the State Government start building up funds for the project through dedicated levies as has been done by other State Governments notably Karnataka.

To enable the State Governments to provide their share of equity in the Special Purpose Vehicles set up for such projects, it would be necessary to constitute a Special Metro Fund at the State Government level. The State Government should resort to imposition of dedicated levies for raising resources for these Funds. Areas where such dedicated levies are possible are given below:

- A 50% cess on the tax levies for registration of road vehicles.
- A Green Surcharge on fuel (petrol, diesel).

  The above two levies would also assist to discourage the use of personalized motorized vehicles and encourage the use of public transport, which would not only reduce the pollution level in the city but also reduce traffic congestion on the road.

- A onetime Green Tax (Rs. 5000 to Rs. 10000 for four wheelers and Rs. 2000 for two wheelers) on existing vehicles registered in the City.
- All receipts from traffic challans to be channeled to this Fund.
- A 1 % turnover Tax on all shops, restaurants and hotels on a monthly basis.
- A 20 % surcharge on Property Tax within the Corporation limits.
- Metro Tax @ 2% on pay rolls of all establishments having more than 100 employees. Such cess is in existence in a number of Western countries for raising resources for metro rail. The employers' benefit a good deal by good Metro System.
- Surcharge @ 10% on luxury tax on the earning of all Star Hotels. At present level, the luxury tax is 10%. The surcharge will raise the level to only 11%. Chinese cities have adopted this scheme.
- Densification ofCorridor by way of selling of Floor Area Ratio (FAR) along the proposed metro corridors.

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रजिस्ट्री सं॰ डी॰ एल॰-33004/99

REGD. NO. D. L.-33004/99

भारत का राजपत्र
The Gazette of India

असाधारण

EXTRAORDINARY

भाग II—खण्ड 3—उप-खण्ड (ii)

PART II—Section 3—Sub-section (ii)

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शहरी विकास मंत्रालय

(मैट्रो रेल प्रकोष्ठ)

अधिसूचना

नई दिल्ली, 7 सितम्बर, 2009

का.आ. 2279(अ).—केन्द्रीय सरकार, मैट्रो रेल (संशोधन) अधिनियम, 2009 (2009 का 34) की धारा 1 की उप-धारा (2) द्वारा प्रदत्त शक्तियों का प्रयोग करते हुए, 7 सितम्बर, 2009 को उस तारीख के रूप में नियत करती है, जिसको उक्त अधिनियम के उपबंध प्रवृत्त होंगे।

[फा.सं. के-14011/40/2003-एमआरटीएस/मैट्रो]

विमल कुजूर, अवर सचिव

MINISTRY OF URBAN DEVELOPMENT

(Metro Rail Cell)

NOTIFICATION

New Delhi, the 7th September, 2009

S.O. 2279(E).—In exercise of the powers conferred by sub-section (2) of Section 1 of the Metro Railways (Amendment) Act, 2009 (34 of 2009) the Central Government hereby appoints the Seventh September, 2009 as the date on which the provisions of the said Act, shall come into force.

[F. No.K-14011/40/2003-MRTS/Metro]

BIMAL KUJUR, Under Secy.

3269 GI/2009

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इस भाग में भिन्न पृष्ठ संख्या दी जाती है जिससे कि यह अलग संकलन के रूप में रखा जा सके।
Separate paging is given to this Part in order that it may be filed as a separate compilation.

MINISTRY OF LAW AND JUSTICE
(Legislative Department)

New Delhi, the 27th August, 2009/*Bhadra* 5, 1931 *(Saka)*

The following Act of Parliament received the assent of the President on the 26th August, 2009, and is hereby published for general information:—

THE METRO RAILWAYS (AMENDMENT) ACT, 2009

No. 34 OF 2009

[26*th August*, 2009.]

An Act further to amend the Metro Railways (Construction of Works) Act, 1978 and to amend the Delhi Metro Railway (Operation and Maintenance) Act, 2002.

BE it enacted by Parliament in the Sixtieth Year of the Republic of India as follows:—

CHAPTER I

PRELIMINARY

Short title and commencement

1. (*1*) This Act may be called the Metro Railways (Amendment) Act, 2009.

(*2*) It shall come into force on such date as the Central Government may, by notification in the Official Gazette, appoint.

CHAPTER II

AMENDMENT TO THE METRO RAILWAYS (CONSTRUCTION OF WORKS) ACT, 1978

Amendment of section 1.

2. In the Metro Railways (Construction of Works) Act, 1978 (hereafter in this Chapter referred to as the Metro Railways Act), in section 1, in sub-section (3), for the portion beginning with the words "such other metropolitan city" and ending with the words "to that city accordingly", the following shall be substituted, namely:— 33 of 1978.

"the National Capital Region, such other metropolitan city and metropolitan area, after consultation with the State Government, and with effect from such date as may be specified in that notification and thereupon the provisions of this Act shall apply to the National Capital Region, such metropolitan city or metropolitan area accordingly.".

Substitution of words "metropolitan city" by words "metropolitan city, metropolitan area and National Capital Region".

3. In the Metro Railways Act, for the words "metropolitan city" occurring in clause (*h*) of sub-section (*1*) of section 2, clause (*c*) of sub-section (*1*) of section 4 and clause (*a*) of sub-section (*1*) of section 32, the words "metropolitan city, metropolitan area and the National Capital Region" shall be substituted.

Amendment of section 2.

4. In section 2 of the Metro Railways Act, in sub-section (*1*),—

(*i*) after clause (*h*), the following clause shall be inserted, namely:—

'(*ha*) "metropolitan area" shall have the meaning assigned to it in clause (*c*) of article 243P of the Constitution;';

(*ii*) after clause (*o*), the following clause shall be inserted, namely:—

'(*oa*) "National Capital Region" means the National Capital Region as defined in clause (*f*) of section 2 of the National Capital Region Planning Board Act, 1985;'. 2 of 1985

CHAPTER III

AMENDMENT TO THE DELHI METRO RAILWAY (OPERATION AND MAINTENANCE) ACT, 2002

Substitution of references to "metropolitan city of Delhi" by references to "National Capital Region and any other metropolitan area".

5. Throughout the Delhi Metro Railway (Operation and Maintenance) Act, 2002 (hereafter in this Chapter referred to as the Delhi Metro Railway Act), for the words "metropolitan city of Delhi" wherever they occur, the words "the National Capital Region, metropolitan city and metropolitan area" shall be substituted. 60 of 2002.

Amendment of section 1.

6. In section 1 of the Delhi Metro Railway Act, for sub-sections (*1*) and (*2*), the following sub-sections shall be substituted, namely:—

"(*1*) This Act may be called the Metro Railways (Operation and Maintenance) Act, 2002.

(*2*) It extends in the first instance to the National Capital Region and the Central Government may, by notification, after consultation with the State Government, extend this Act to such other metropolitan area and metropolitan city, except the metropolitan city of Calcutta, and with effect from such date as may be specified in that notification and thereupon the provisions of this Act shall apply to that metropolitan area or metropolitan city accordingly.".

7. In section 2 of the Delhi Metro Railway Act, in sub-section (*1*),— Amendment of section 2.

(*i*) for clause (*a*), the following clauses shall be substituted, namely:—

'(*a*) "Central Government", in relation to technical planning and safety of metro railways, means the Ministry of the Government of India dealing with Railways;

(*aa*) "Claims Commissioner" means a Claims Commissioner appointed under section 48;';

(*ii*) for clause (*h*), the following clauses shall be substituted, namely:—

'(*h*) "metropolitan area" shall have the meaning assigned to it in clause (*c*) of article 243P of the Constitution;

(*ha*) "metropolitan city" means the metropolitan city of Bombay, Calcutta, Delhi or Madras;';

(*iii*) after clause (*k*), the following clause shall be inserted, namely:—

'(*ka*) "National Capital Region" means the National Capital Region as defined in clause (*f*) of section 2 of the National Capital Region Planning Board Act, 1985;'. 2 of 1985.

8. In section 6 of the Delhi Metro Railway Act, in sub-section (2), after clause (*b*), the following clauses shall be inserted, namely:— Amendment of section 6.

"(*ba*) develop any metro railway land for commercial use;

(*bb*) provide for carriage of passengers by integrated transport services or any other mode of transport;".

9. Section 7 of the Delhi Metro Railway Act shall be renumbered as sub-section (*1*) thereof and after sub-section (*1*) as so renumbered, the following sub-section shall be inserted, namely:— Amendment of section 7.

"(*2*) The Commissioner shall function under the administrative control of the Chief Commissioner of Railway Safety appointed under section 5 of the Railways Act, 1989.". 24 of 1989.

10. For section 12 of the Delhi Metro Railway Act, the following section shall be substituted, namely:— Substitution of new section for section 12.

"12. The Chief Commissioner of Railway Safety shall, for each financial year, prepare in such form, and within such time, as may be prescribed, an annual report giving a full account of the activities of the Commissioners during the financial year immediately preceding the financial year in which such report is prepared and forward copies thereof to the Central Government.". Annual report.

11. In section 13 of the Delhi Metro Railway Act, for the word "Commissioner", the words "Chief Commissioner of Railway Safety" shall be substituted. Amendment of section 13.

12. In section 23 of the Delhi Metro Railway Act, in sub-section (*1*), for the words "Hindi and English", the words "Hindi, English and official language of the State in which such station is located" shall be substituted. Amendment of section 23.

13. In section 26 of the Delhi Metro Railway Act, in sub-section (*1*), the words "a small" shall be omitted. Amendment of section 26.

14. In section 34 of the Delhi Metro Railway Act, for sub-section (*4*), the following sub-section shall be substituted, namely:— Amendment of section 34.

"(4) The Central Government and the State Government shall nominate one member each to the Fare Fixation Committee:

Provided that a person who is or has been an Additional Secretary to the Government of India or holds or has held an equivalent post in the Central Government or the State Government shall be qualified to be nominated as a member.".

Amendment of section 38.

15. In section 38 of the Delhi Metro Railway Act, in sub-section (2), for the words "Government of the National Capital Territory of Delhi", the words "State Government" shall be substituted.

Amendment of section 85.

16. In section 85 of the Delhi Metro Railway Act,—

(i) in sub-section (1), for the words "Government of the National Capital Territory of Delhi", the words "State Government" shall be substituted;

(ii) in sub-section (2), for the words "Government of the National Capital Territory of Delhi in the Delhi Gazette", the words "State Government" shall be substituted.

T.K. VISWANATHAN,
Secretary to the Govt. of India.

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Chapter 17

Conclusions and Recommendations

CHAPTER – 17

CONCLUSIONS AND RECOMMENDATIONS

17.1 Lucknow has witnessed enormous growth during the last 10 years. The growth is mainly the result of immigration as the city provided better employment opportunities. Lucknow is the principal administrative, commercial and distribution center of the State. Lucknow is fast developing as educational hub of Uttar Pradesh. Rapid urbanization in the recent past has put the city's travel infrastructure to stress. Being thickly populated area, Lucknow's traffic needs cannot be met by only road-based system.

The existing urban transport system of Lucknow 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. 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) Amausi to Munshi Pulia Corridor (22.878 km) and (ii) Lucknow Railway Station to Vasant Kunj Corridor on Hardoi Road (11.098 km) at an estimated completion cost of **Rs. 6880.00Crores and Rs.5494.00Crores** respectively(with Central taxes & duties) to be made operational as recommended in implementation chapter.

17.2 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.

17.3 After examining the various options for execution of Lucknow Metro Project**,** it has been recommended that the project should be got executed through a SPV on DMRC funding pattern

17.4 The fare structure has been estimated based on Delhi Metro fares decided by Fare Fixation Committee in 2009. Subsequently, for the purpose of assessing returns from the project, the fares have been revised every second year with an escalation of 10% every two years.

17.5 As in the case of Delhi Metro, the State Government should exempt/ reimburse the Uttar Pradesh Value Added Tax (VAT) to Lucknow Metro. It should also exempt the following:

- Tax on electricity required for operation and maintenance of the metro system.
- Municipal Taxes.

17.6 As per the present policy 50% of the Central Taxes will be paid by GOI as subordinate Debt and balance 50% will be paid by the concerned State Government. Uttar Pradesh State Government may pursue the Central Government to extend the same benefit to Lucknow Metro.

15.7 While the Financial Internal Rate of Return (FIRR) for the project has been assessed as **8.12%** with central taxes with property development and the Economic Internal Rate of Return (EIRR) works out **19.43%.**

17.8 To avoid delays in processing the clearance for the Project, Government of Uttar Pradesh should approve North South Corridor in first stage (Phase 1 A) immediately on receipt of the DPR and forward the DPR to the Secretary, Ministry of Urban Development, Government of India, advising the GOI of the State Government's intention to take up the Project on DMRC pattern requesting for the latter's "in principle" clearance to go ahead with the Project.

17.9 A PSU of the State Government, Lucknow Metro Rail Corporation Ltd. (LMRC) for Lucknow Metro, to be set up under the Companies Act, 1956 should be made functional by posting Managing Director and Functional Directors.

17.10 Since sanction of Lucknow Metro & making LMRC fully functional may take some time, it is recommended that the State Government should urgently post an Officer on Special Duty (OSD) with adequate powers to process and pursue sanction for this project and to initiate preliminary steps required for its implementation.

17.11 Meanwhile the State Government should freeze all future developments along the proposed route of Lucknow Metro to avoid in-fructuous expenditure.

17.12 As it may take some time to make Lucknow Metro Rail Corporation fully functional and initially LMRC may lack in expertise, it will be necessary to engage Interim Consultants who will do this job on behalf of LMRC in preparation of land plans, transferring the alignment from drawing to the ground, fixing the contracts for some of the selected elevated packages and depots and also to help LMRC in finalization of General Consultants.

17.13 To keep a check on the work of General Consultants and to ensure that the Metro is being constructed to meet the appropriate specifications and safety standards, LMRC will also need to engage the services of Prime Consultants from the very start of GC's assignment who will do this job on behalf of LMRC. Delhi Metro Rail Corporation can be considered for being appointment as prime consultant to LMRC of the project.

17.14 Delhi Metro Rail Corporation can also be considered straightaway for being appointed as General Consultant to LMRC which will reduce the construction time by 4 to 6 months.

Chapter -18

Disaster Management Measures

CHAPTER- 18

DISASTER MANAGEMENT MEASURES

18.1 INTRODUCTION

"Disaster is a crisis that results in massive damage to life and property, uproots the physical and psychological fabric of the affected communities and outstrips the capacity of the local community to cope with the situation." Disasters are those situations which cause acute distress to passengers, employees and outsiders and may even be caused by external factors. As per the disaster management act, 2005 *"disaster" means a catastrophe, mishap, calamity or grave occurrence in any area, arising from natural or manmade causes, or by accident or negligence which results in substantial loss of life or human suffering or damage to, and destruction of, property, or damage to, or degradation of, environment, and is of such a nature or magnitude as to be beyond the coping capacity of the community of the affected area".* As per world health organisation (who):

"Any occurrence that causes damage, economic disruption, loss of human life and deterioration of health and services on a scale sufficient to warrant an extra ordinary response from outside the affected community or area."

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

18.2 NEED FOR DISASTER MANAGEMENT MEASURES

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

18.3 OBJECTIVES:

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

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

18.4 LIST OF SERIOUS INCIDENTS REQUIRING USE OF PROVISIONS OF THE DISASTER MANAGEMENT MEASURES

Metro specific disasters can be classified into two broad categories e.g.: Man-made and Natural.

a. Man Made Disaster

1. Terrorist attack
2. Bomb threat/ Bomb blast
3. Hostage
4. Release of Chemical or biological gas in trains, stations or tunnels
5. Fire in metro buildings, underground/ elevated infrastructures, power stations, train depots etc.
6. Train accident and train collision/derailment of a passenger carrying train
7. Sabotage
8. Stampede

b. Natural Disaster

1. Earthquakes
2. Floods

18.5 PROVISIONS UNDER DISASTER MANAGEMENT ACT, 2005

A. The National Disaster Management Authority (NDMA)

Establishment of National Disaster Management Authority:-

(1) With effect from such date as the Central Government may, by notification in the Official Gazette appoint in this behalf, there shall be established for the purposes of this Act *(The Disaster Management Act, 2005),* an authority to be known as the National Disaster Management Authority.

(2) The National Authority shall consist of the Chairperson and such number of other members, not exceeding nine, as may be prescribed by the Central Government and, unless the rules otherwise provide, the National Authority shall consist of the following:-

(a) The Prime Minister of India, who shall be the Chairperson of the National Authority, ex officio;

(b) Other members, not exceeding nine, to be nominated by the Chairperson of the National Authority.

(3) The Chairperson of the National Authority may designate one of the members nominated under clause (b) of sub-section (2) to be the Vice- Chairperson of the National Authority.

(4) The term of office and conditions of service of members of the National Authority shall be such as may be prescribed.

B. State Disaster Management Authority:

Establishment of State Disaster Management Authority:-

(1) Every State Government shall, as soon as may be after the issue of the notification under sub-section (1) of section 3, by notification in the Official Gazette, establish a State Disaster Management Authority for the State with such name as may be specified in the notification of the State Government.

(2) A State Authority shall consist of the Chairperson and such number of other members, not exceeding nine, as may be prescribed by the State Government and, unless the rules otherwise provide, the State Authority shall consist of the following members, namely:-

(a) The Chief Minister of the State, who shall be Chairperson, ex officio;

(b) Other members, not exceeding eight, to be nominated by the Chairperson of the State Authority;

(c) The Chairperson of the State Executive Committee, ex officio.

(3) The Chairperson of the State Authority may designate one of the members nominated under clause (b) of sub-section (2) to be the Vice- Chairperson of the State Authority.

(4) The Chairperson of the State Executive Committee shall be the Chief Executive Officer of the State Authority, the Chief Minister shall be the Chairperson of the Authority established under this section.

(5) The term of office and conditions of service of members of the State Authority shall be such as may be prescribed.

C. Command & Control at the National, State & District Level

The mechanism to deal with natural as well as manmade crisis already exists and that it has a four tier structure as stated below:-

(1) National Crisis Management Committee (NCMC) under the chairmanship of Cabinet Secretary

(2) Crisis Management Group (CMG) under the chairmanship of Union Home Secretary.

(3) State Level Committee under the chairmanship of Chief Secretary.

(4) District Level Committee under the Chairmanship of District Magistrate.

All agencies of the Government at the National, State and district levels will function in accordance with the guidelines and directions given by these committees.

D. Plans by Different Authorities at District Level and their Implementation

Every office of the Government of India and of the State Government at the district level and the local authorities shall, subject to the supervision of the District Authority:-

(a) Prepare a disaster management plan setting out the following, namely:-

(i) Provisions for prevention and mitigation measures as provided for in the District Plan and as is assigned to the department or agency concerned;

(ii) Provisions for taking measures relating to capacity-building and preparedness as laid down in the District Plan;

(iii)The response plans and procedures, in the event of, any threatening disaster situation or disaster;

(b) Coordinate the preparation and the implementation of its plan with those of the other organizations at the district level including local authority, communities and other stakeholders;

(c) Regularly review and update the plan; and

(d) Submit a copy of its disaster management plan, and of any amendment thereto, to the District Authority.

18.6 PROVISIONS AT METRO STATIONS/OTHER INSTALLATIONS

To prevent emergency situations and to handle effectively in case 'one arises' there needs to be following provisions for an effective system which can timely detect the threats and help suppress the same.

i) Fire detection and suppression system
ii) Smoke management
iii) Environmental control system (ECS)
iv) Tunnel ventilation system
v) Track-way exhaust system (TES)
vi) Station power supply system
vii) DG sets & UPS
viii) Lighting system
ix) Station area lights
x) Tunnel lighting
xi) Tunnel lighting control from BMS
xii) Seepage system
xiii) Water supply and drainage system
xiv) Sewage system
xv) Any other system deemed necessary

The above list is suggestive not exhaustive actual provisioning has to be done based on site conditions and other external and internal factors.

18.7 PREPAREDNESS FOR DISASTER MANAGEMENT

Being a technological complex system worked by new set of staff, with a learning curve to improve and stabilize with time, intensive mock drills for the staff concerned is very essential to train them to become fully conversant with the action required to be taken while handling emergencies.

They also need to be trained in appropriate communication skills while addressing passengers during incident management to assure them about their well being seeking their cooperation.

Since learning can only be perfected by 'doing' the following Mock Drills are considered essential:

a. Fire Drill
b. Rescue of a disabled train
c. Detrainment of passengers between stations
d. Passenger evacuation from station
e. Drill for use of rescue & relief train
f. Hot line telephone communication with state disaster management authority.

Chapter -19

Disabled Friendly Features

Chapter – 19

DISABLED FRIENDLY FEATURES

19.1 INTRODUCTION

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

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

The access standards given here are extracted from Indian Roads Congress Code, IRC 103: 2012, Guidelines for Pedestrian Facilities; Model Building Bye-Laws, 2011 and National Building Code, 2005. Central Public Works Department's (CPWD) "Space Standards for Barrier Free Built Environment for Disabled and Elderly Persons", 1998 and 2013 edition (under revision by MoUD), and international best practices / standards. Further, it has also been attempted to provide guidelines/ standards for alighting and boarding area, approach to station, car parking area, drop-off and pick-up areas, taxi/auto rickshaw stand, bus stand/stop, footpath (sidewalk), kerb ramp, road intersection, median/pedestrian refuge, traffic signals, subway and foot over bridge etc. to achieve a seamless development around metro stations.

19.2 CONTENT

1. **Rail Transport**

2. **Metro Rail Station**

   - Way finding
   - Signage
   - Automated Kiosks
   - Public Dealing Counters
   - Audio-visual Displays
   - Public Telephones
   - Rest Areas/Seating
   - Tactile Paving - Guiding & Warning

- Doors
- Steps & Stairs
- Handrails
- Ramps
- Lifts/Elevators
- Platform/Stair Lift
- General and Accessible toilets
- Drinking Water Units
- Visual Contrasts
- Emergency Egress/Evacuation

3. Street Design

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

4. Alighting and Boarding Area

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

19.3 RAIL TRANSPORT

1. General

- Whether over-ground or underground, rail travels is a highly effective mode of transport.
- Every train should contain fully accessible carriages.
- Staff should be trained in methods of assistance and be at hand on request.
- Stations for all rail travel should be fully accessible with extra wide turnstiles where possible alongside wheelchair accessible doorways
- Staff should be on hand to assist persons with disabilities and elderly to enter or exit through convenient gates.
- All new railway stations should be designed to be fully accessible.

- For persons with hearing impairments, an electronic sign board (digital display) should be displayed on each platform at conspicuous location for all announcements made by the railways.
- For persons with visual impairments audio system announcing the station names and door location should be available.

2. Accessible Railway Cars

The railway cars should have the following features:

- Railway car doors should be at least 900 mm wide;
- The gap between the car doors and the platform should preferably be less than 12 mm;
- Identification signage should be provided on the doors of wheelchair accessible coach
- If the car door and the platform cannot be at the same level, then at least one car doors should have apparatus such as a hydraulic lift or pull-out ramp installed in the doorway for wheelchair users.

3. Wheel Chair Space

- Space for a wheel chair should be available at the side of the door:-
- The space should be indicated inside and outside the car by using the international symbol of access; and
- Wheel stoppers and ring-strap or other appropriate safety grip should be provided for wheelchair users.

4. Seats

- An appropriate number of designated seats for passengers with disabilities and elderly people should be provided near the doors.

5. Aisles

- Aisles should be at least 900 mm wide.

19.4 INFORMATION SIGNS AND ANNOUNCEMENTS

A map of train routes should be installed. This should be in Braille/raised numbers as well. In each car, there should be an announcement and provision of a visual display of the names of stations route. This display should be in raised numbers with sharp contrast from the background.

19.5 Metro Railway Stations

1. Level Approach

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

2. Station Entrances and Exits

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

3. Reservation and Information Counters

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

4. Toilet Facilities

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

At least one of the ticket gates should:

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

5. Platforms

The Platforms should:

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

- All platforms should inter-connect by means of an accessible routes or lifts; and provide accessible level entrance to the train coach.

6. WAY FINDING

- Way finding references should be available at decision points.
- Colour can be used to identify routes and provide assistance in locating doors, walls and hazards. Proper colour contrast between different elements greatly improves visibility for all users and is critical for persons with low vision. For example, colour contrasting of door frames can assist in locating doors, and likewise floors should be contrasted with walls. In addition, furniture should contrast with walls and floors so as not to create an obstacle.
- Structural elements such as columns should be colour contrasted or brightly marked so as to be visible to those who may have a visual disability.
- Generally, patterns on flooring should be avoided or else should be minimal and small to avoid visual confusion.
- In addition to identifying hazards or warnings, tactile floor surfaces can also be used to inform that there is a change in area (e.g. leaving a corridor and entering a boarding area).
- Tactile systems should be consistent throughout the building. For example, terminals should not have carpeting in some boarding areas and tile in others as this may create confusion for those who rely on tactile surfaces to guide them to their destination.
- Good lighting assists those with a visual disability to see better and allows people who have a hearing impairment to lip read easier. However, care should be taken to properly direct lighting and to use matte finishes on floors, walls and signage, so as not to create glare which may create difficulties for all travelers.
- Blinds can be used to adjust lighting levels in areas where the natural lighting changes significantly throughout the day.

7. SIGNAGE

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

8. SIGN DESIGN SPECIFICATIONS

- The sign should be in a prominent position.
- The face of the sign should be well-illuminated by natural or artificial light.

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

Fig. 19.1 - Way finding signage

Fig. 19.2 - International Symbol of Accessibility

9. Automated kiosks

- Automated kiosks should be accessible for wheelchair users.
- Should be clearly marked with international symbol of accessibility.
- Should have Braille buttons and audio announcement system for persons with vision impairments.
- Operations should be easy to understand and operate for persons with learning disabilities, intellectual disabilities, and elderly persons.

10. Public Dealing Counters

-
- Ticketing, Information, Check-in, Help desk, Restaurants, Shops, etc. should have public dealing counters.
- Information or help desks should be close to the terminal entrance, and highly visible upon entering the terminal. In addition, they should be clearly identified and accessible to both those who use wheelchairs and those who stand.

- It should provide information in accessible formats, viz. Braille leaflets for persons with vision impairments.
- Ideally, these desks should have a map of the facility that desk attendants can view with passengers, when providing directions.
- Staff manning the counters should know sign language.
- Information desk acoustics should be carefully planned and controlled as a high level of background noise is confusing and disorienting to persons with hearing impairment.
- Lighting should be positioned to illuminate the receptionist/person manning the counter and the desk top without creating glare.
- Lighting should not create shadows over the receptionist staff, obscuring facial detail and making lip reading difficult.
- There should be a hearing enhancement system such as a loop induction unit, the availability of which is clearly indicated with a symbol.
- One of the counters should not be more than 800mm from the floor, with a minimum clear knee space of 650mm high and 280mm- 300mm deep .

11. AUDIO-VISUAL DISPLAYS

- Terminal maps should be placed so that they are readily visible to persons who are standing and persons who use wheelchairs. They should also be accessible to persons with a visual disability (i.e. tactile maps). Other alternatives include electronic navigation systems or audio maps.
- Enable captioning at all times on all televisions and other audiovisual displays that are capable of displaying captions and that are located in any portion of the terminal.
- The captioning must be in high contrast for all information concerning travel safety, ticketing, check-in, delays or cancellations, schedule changes, boarding information, connections, checking baggage, individuals being paged by bus railway or airlines, vehicle changes that affect the travel of persons with disabilities, and emergencies (*e.g.*, fire, bomb threat).

12. REST AREAS/SEATING

- Seating area / benches should be provided along the circulation path at regular intervals so that passengers do not need to walk more than 50 to 60 metres before being able to sit and rest.
- Where seating is provided, designated seating for passengers with disabilities is to be provided at boarding gates and departure areas within viewing distance of communication boards and/or personnel and identified by the symbol of access.
- Public transit operators should provide seating in passenger service areas where there may be long waiting lines or times, including at ticket sales counters, check-in

counters, secured screening and during inter-country travel in customs areas and baggage retrieval areas.

- Designated seating should be provided for at boarding gates and departure areas within viewing distance of communication boards, and within hearing range of audio announcements as well. Such seating areas should be identified by the symbol of accessibility and shelter should be provided where this seating is outdoors.
- In outdoor settings, seating should be provided along with the planned hawker spaces.
- At waiting lounges for persons with disabilities chairs should have armrests and backrest.

19. Tactile Paving- Guiding & Warning[1]

(a) Tactile Guiding Paver (Line-Type)

It is recommended to install a row of tactile guidance paver along the entire length of the proposed accessible route for visual impaired persons. Care must be taken to ensure that there are no obstacles, such as wall, pillar, uneven surfaces, Soffit (underside /open area under the stairs, along the route traversed by the guidance paver. Also, there should be clear headroom of at least 2.1 meters height above the tactile guidance paver, free of protruding objects such as overhanging advertisement panel and signage, along the entire length of the walk.

(b) Tactile Warning Paver (Dot-Type)

Indicate an approaching potential hazard or a change in direction of the walkway, and serve as a warning of the approaching danger to persons with visual impairments, preparing them to tread cautiously and expect obstacles along the travel path, traffic intersections, doorways, stairs, etc. They are used to screen off obstacles, drop-offs or other hazards, to discourage movement in an incorrect direction, and to warn of a corner or junction. Two rows of tactile warning paver should be installed across the entire width of the designated accessible passenger pathway at appropriate places such as before intersections, terminal entrances, obstacles such as signage, and each time the walkway changes direction.

14. Places to install warning paver

- In front of an area where traffic is present.
- In front of an entrance/exit to and from a staircase or multi-level crossing facility.
- Entrances/exits at public transport terminals or boarding areas.

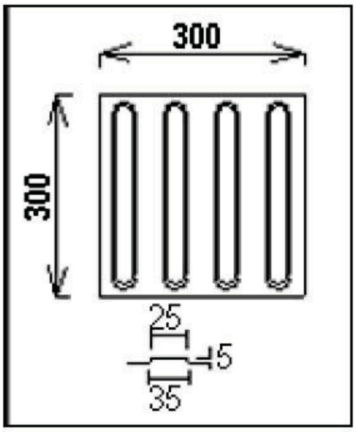

Fig. 19.3 - Guiding paver

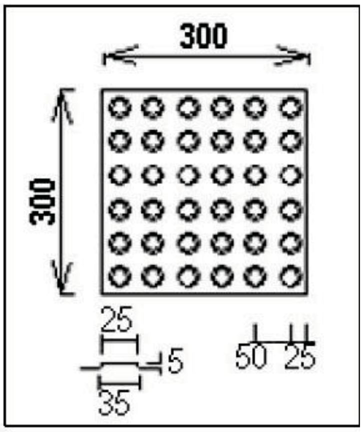

Fig. 19.4 - Warning paver

15. Doors

Whatever the type of entrance door, it must be wide enough to accommodate passenger traffic comfortably.

- The recommended minimum clear opening width of an internal door is 900mm minimum.
- Where doors comprise two leaves (i.e. double doors), each leaf should be 900mm min. wide, so that persons carrying large items and people using wheelchairs do not have to open both leaves.
- Manual doors should incorporate kick plates 300-400mm high to withstand impact of wheelchair footrest (this is especially important where doors are glazed).
  - Also be fitted with vision panels at least between 900mm and 1500mm from floor level.
  - Be color contrasted with the surrounding wall and should not be heavier than 22N to open.
  - Lever handles and push type mechanisms are recommended . When a sliding door is fully open, handles should be usable from both sides.

- Where revolving doors or turnstiles are used, an alternative wheelchair-accessible entrance must also be provided.
- A distance of 400mm should be provided beyond the leading edge of door to enable a wheelchair user to maneuver and to reach the handle.
- To ensure maximum clarity for persons with visual impairments, the entrance should be easily distinguishable from its surroundings by the effective use of landscaping, signage, colour (preferably yellow/orange), tonal contrast and tactile surfacing.
- Door hardware should be positioned between 900-1000mm above floor.
- Operable devices such as handles, pulls, latches and locks should:

  - Be operable by one hand
  - Not require fine finger control, tight grasping, pinching or twisting to operate

- Glazed doors and fixed glazed areas should be made visible by use of a clear, colour and tone contrasted warning or decorative feature that is effective from both inside and outside and under any lighting conditions, e.g. a logo, of minimum dimensions 150mm by 150mm (though not necessarily square), set at eye level.

16. Steps & Stairs

- Steps should be uniform with the tread not less than 300mm and the risers 150mm.
- The risers should not be open.
- The steps should have an unobstructed width of 1200mm minimum.
- All steps should be fitted with a permanent colour and tone contrasting at the step edge, extending the full width of the step, reaching a minimum depth of 50mm on both tread and riser.
- Have continuous handrails on both sides including the wall (if any) at two levels
- Warning paver to be placed 300mm at the beginning and at the end of all stairs.
- Nosing to be avoided.
- The staircase should be adequately and uniformly illuminated during day and night

(when in use). The level of illumination should preferably fall between 100-150 lux.

- The rise of a flight between landings must be no more than 1200mm.
- There should be no more than 12 risers in one flight run.
- The stair covering and nosing should be slip-resistant, non-reflective, firmly-fixed and easy to maintain.
- Soffit (underside /open area under the stairs) of the stairs should be enclosed or protected.

17. HANDRAILS

- Handrails should be circular in section with a diameter of 38-45mm and formed from materials which provide good grip such as timber, nylon or powder coating, matt finish metal finishes.
- The handrail should contrast in colour (preferably yellow/orange) with surrounding surfaces.
- At least 50mm clear of the surface to which they are attached and should be supported on brackets which do not obstruct continuous hand contact with the handrail.
- The handrail should be positioned at two levels- 760mm and 900mm above the pitch-line of a flight of stairs.
- Handrail at foot of the flight of stairs should extend 300mm beyond the stairs in the line of travel and returning to the wall or floor or rounded off, with a positive end that does not project into the route of travel.

18. RAMPS

- Ramps gradient should ideally be 1 in 20 and no greater than 1 in 12.
- Width of the ramp should not be less than 1200mm and preferred width is 1800mm.
- The steeper the gradient, the shorter the length of ramp between landings.
- On long ramps, a horizontal resting space should be provided every 6 meters.
- Surface materials should be slip-resistant, non-reflective, firmly-fixed and easily maintained
- The edge of the ramp should have an edge protection with a minimum height of 100mm.
- Landings every 750mm of vertical rise.
- A tapping or lower rail should be positioned so that its bottom edge is no higher than 200mm above ground level.
- Handrails on the ramps should be on both sides at two levels: upper at 900mm and lower at 760mm; both end to be rounded and grouted; extend 300 mm beyond top and bottom of ramp .
- A row of tactile warning paver should be placed 300mm beginning and end of each run.
- Landings should be provided at regular intervals as indicated in the table (Table 1).

Table 19.1 - Specifications for Ramps

Level difference	Minimum gradient of Ramp	Ramp Width	Handrail on both sides	Comments
≥ 150 mm ≤ 300 mm	1:12	1200 mm	√	
≥ 300 mm ≤ 750 mm	1:12	1500 mm	√	Landings every 5 meters of ramp run.
≥ 750 mm ≤ 3000mm	1:15	1800 mm	√	Landings every 9 meters of ramp run.
≥ 3000 mm	1:20	1800 mm	√	Landings every 9 meters of ramp run.

19. Lifts/Elevators

A carefully designed lift makes a huge contribution to the accessibility of a multi-storied terminal building for persons with disabilities.

- Lift locations should be clearly signposted from the main pedestrian route and recognizable through design and location.
- The colour and tone of the lift doors should contrast with the surrounding wall finish to assist in their location. Lift doors with metallic finishes such as steel grey and silver should be avoided as they are difficult to identify by persons with low vision.
- The lift lobby shall be of an inside measurement of 1800mm X 2000mm or more. A clear landing area in front of the lift doors of minimum dimensions 1500mm x 1500mm should be provided.
- By making the landing area distinguishable by floor surface and contrast, it will aid location and recognition of core areas. This could comprise a change in floor finish from thin carpet to vinyl/PVC, or cement/mosaic floor to carpet.
- Changes in floor finish must be flushed. There should be no level difference between lift door and the floor surface at each level; the gap if unavoidable should not be more than 12mm.
- The floor level/location should be indicated on the wall adjacent to or just above the call buttons, and opposite the lift doors where possible.

20. Lift Dimensions

- Provisions of at least one lift shall be made for people using wheelchairs with the following car dimensions:
  - Clear internal depth -1500 mm minimum
  - Clear internal width - 1500 mm minimum
  - Entrance door width - 900 mm minimum

21. Lift Controls

- The lift call button should be wall-mounted adjacent to the lift and should contrast with wall finish, either by using a contrasting panel, or a contrasting border around the button panel.
- The call buttons should be located within the range 800-1000mm above floor finish.
- Buttons should not be touch sensitive, but should require a light positive pressure and should ideally be large enough to be operable by the palm of the hand if required.
- The control buttons inside the lift should be positioned on the side wall rather than front wall to allow access from the back and front of the lift car, by mobility aid users like wheelchair users.
- The control buttons should contrast with their surroundings and illuminate when pressed and should incorporate highly visible tactile embossed (NOT engraved) characters and in Braille.
- Time of closing of an automatic door should be more than 5 seconds and the closing speed should not exceed 25 meters per second. There should be a provision of censor enabled closing.
- In larger lifts, controls should be positioned on both side walls, at least 400mm from front wall and between 800-1000mm above floor level.

22. Car Design

- Internal walls should have a non-reflective, matt finish in a colour and tone contrasting with the floor, which should also have a matt, non-slip finish.
- Use of reflective materials such as metal (stainless steel for example) can be problematic in creating sufficient contrast with control buttons, emergency telephone cabinet, etc. for persons with low vision and the use of such materials should be avoided wherever possible.
- A mirror (750mm above floor level) on the rear wall can be useful to persons using wheelchairs and other mobility aids should they need to reverse safely out of the lift car or view the floor numbers.
- Internal lighting should provide a level of illumination of minimum 100 lux (approximately 50-75 lux at floor level), uniformly distributed, avoiding the use of spotlights or down lighters.
- A grab bar should be provided along both sides and the back wall, 900mm above floor level.
- Handrails should be of tubular or oval cross section, in order to be easily gripped and capable of providing support.
- Handrails should be positioned so that there is a clear space behind the handrail to allow it to be grasped i.e. knuckle space should be 50mm.

19.6 Information Systems

- Lifts should have both visual and audible floor level indicators

- Audible systems are also usually capable of incorporating additional messages, such as door closing, or, in the case of an emergency, reassurance (with manual over-ride allowing communication with lift occupants).
- Announcement system should be of 50 decibel.
- The display could be digital or segmented LED, or an appropriate alternative. A yellow or light green on black display is preferred to a red on black display as it is easier to read.

19.7 GENERAL AND ACCESSIBLE TOILETS

1. SIGNAGES

- All signage of general toilets should be in bold and contrasting colors.
- For persons with low vision and vision impairments: male pictogram in triangle and female pictogram in circle, marked on plates along with Braille & raised alphabets, to be mounted on wall next to door near the latch side, at a height between 1400mm-1600mm.
- Warning strip/ thin rubber door mat to be provided 300mm before and after the toilet entrance.
- Tactile paver to be provided for urinals, WC and washbasins for persons with vision impairments.

2. ACCESSIBLE TOILETS

- Should have the international symbol of accessibility displayed outside for wheelchair access.
- The toilet door should be an outward opening door or two way opening or a sliding type and should provide a clear opening width of at least 900mm.
- It should have a horizontal pull-bar, at least 600mm long, on the inside of the door, located so that it is 130mm from the hinged side of the door and at a height of 1000mm.
-

3. WC COMPARTMENT DIMENSIONS

- The dimensions of a unisex toilet are critical in ensuring access. The compartment should be at least 2200mm and 2000mm. This will allow use by both manual and motorized wheelchair users.
- Layout of the fixtures in the toilet should be such that a clearing maneuvering space of 1500mm x 1500mm in front of the WC and washbasin.

4. WATER CLOSET (WC) FITTINGS

- Top of the WC seat should be 450-480mm above finished floor level, preferably be of wall hung or corbel type as it provides additional space at the toe level.
- An unobstructed space 900mm wide should be provided to one side of the WC for transfer, together with a clear space 1200mm deep in front of the WC.
- WC should be centred 500mm away from the side wall, with the front edge of the pan 750mm away from the back wall. Have a back support. The WC with a back support should not incorporate a lid, since this can hinder transfer.
- L-shape grab bar at the adjacent wall and on the transfer side (open side) swing up grab bar shall be provided.
- The cistern should have a lever flush mechanism, located on the transfer side and not on the wall side and not more than 1000mm from the floor.

5. Grab Bars

- Grab bars should be manufactured from a material which contrasts with the wall finish (or use dark tiles behind light colored rails), be warm to touch and provide good grip.
- It is essential that all grab rails are adequately fixed, since considerable pressure will be placed on the rail during maneuvering. Grab bars should sustain weight of 200kgs minimum.
- A hinged type moveable grab bar should be installed adjacent to the WC on the transfer side. This rail can incorporate a toilet tissue holder. A distance of 320mm from the centre line of the WC between heights of 200-250mm from the top of the WC seat. It should extend 100-150mm beyond the front of the WC.
- A fixed wall-mounted L- shape grab bar (600mm long horizontal and 700mm long vertical) on the wall side should be provided. It should be placed at a height of 200-250mm above the WC seat level.

6. Washbasins

- Hand washbasins should be fitted on cantilevered brackets fixed to the wall.
- The basin should be fixed no higher than 750mm above the finished floor level.
- Be of dimensions 520mm and 410mm, mounted such that the top edge is between 800-900mm from the floor; have a knee space of at least 760mm wide by 200mm deep by 650-680mm high.
- The position of the basin should not restrict access to the WC i.e. it should be located 900mm away from the WC.
- A lever operated mixer tap fitted on the side of the basin closest to the WC is useful as it allows hot and cold water to be used from a seated position on the WC.
- The hand drying facilities should be located close to the hand washbasin between 1000-1200mm.
- Lever type handles for taps are recommended.
- Mirror’s bottom edge to be 1000mm from the floor and may be inclined at an angle.

7. Fixtures and Fittings

- Contrast between fittings and fixtures and wall or floor finishes will assist in their location. For example, using contrasting fittings, or dark tiles behind white hand washbasins and urinals, contrasting soap dispensers and toilet roll holders. Contrast between critical surfaces, e.g. floors, walls and ceilings helps to define the dimensions of the room.
- Towel rails, rings and handrails should be securely fixed to the walls and positioned at 800-1000mm from the floor.
- The mirror should be tilted at an angle of 300 for better visibility by wheelchair users.
- It should have lower edge at 1000mm above floor finish and top edge around 1800mm above floor finish.
- Hooks should be available at both lower-1200mm and standard heights- 1400mm, projecting not more than 40mm from the wall.
- Where possible, be equipped with a shelf of dimensions 400mm x 200mm fixed at a height of between 900mm and 1000mm from the floor.
- Light fittings should illuminate the user's face without being visible in the mirror. For this reason, most units which have an integral light are unsatisfactory.
- Large, easy to operate switches are recommended, contrasting with background to assist location, at a maximum height of 1000mm above floor finish.
- All toilet facilities should incorporate visual fire alarms.
- Alarms must be located so that assistance can be summoned both when on the toilet pan i.e. at 900mm height and lying on the floor i.e. at 300mm, from floor surface. Alarms should be located close to the side wall nearest the toilet pan, 750mm away from rear wall and at 900mm and 200mm above floor finish

8. Signage of Accessible Toilets

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

Fig. 19.5 - Signage for accessible washroom

9. Accessible Urinal

- At least one of the urinals should have grab bars to support ambulant persons with disabilities (for example, people using mobility aids like crutches).
- A stall-type urinal is recommended.
- Urinals shall be stall-type or wall-hung, with an elongated rim at a maximum of 430mm above the finish floor. This is usable by children, short stature persons and wheelchair users.
- Urinal shields (that do not extend beyond the front edge of the urinal rim) should be provided with 735mm clearance between them.
- Grab bars to be installed on each side, and in the front, of the urinal.
- The front bar is to provide chest support; the sidebars are for the user to hold on to while standing.

19.8 DRINKING WATER UNITS

- Drinking water fountains or water coolers shall have up front spouts and control .
- Drinking water fountains or water coolers shall be hand-operated or hand and foot-operated.
- Conventional floor mounted water coolers may be convenient to individuals in wheelchairs if a small fountain is mounted on the side of the cooler 800mm above the floor.
- Fully recessed drinking water fountains are not recommended.
- Leg and knee space to be provided with basin to avoid spilling of water . This allows both front and parallel access to taps for persons using mobility aids like wheel chair, crutches etc.

19.9 VISUAL CONTRASTS

- Visual contrasts means adequate contrast created by difference of at least 30 LRV (Light Reflectance Value) of the two surfaces/ objects and it helps everyone especially persons with vision impairments.
- Visual contrast should be provided between:
    - Critical Surfaces (walls, ceiling and floor),
    - Signage and background sign frame/ wall,
    - Step edges and risers/ treads on steps,
    - Handrails and background walls,
    - Doors and surrounding walls,
    - Switches/ sockets and background wall,
    - Toilet fixtures and critical surfaces in toilet.

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

19.10 EMERGENCY EGRESS/EVACUATION

- Placement (accessibility) and visibility of such devices is very important. The following is to be considered for the installation of such alarm devices; fire alarm boxes, emergency call buttons and lit panels should be installed between heights of 800mm and 1000mm from the furnished floor surface. These should be adequately contrasted from the background wall and should be labelled with raised letters and should also be in Braille.
-
- A pre-recorded message, alerting an emergency to the control room or reception should be installed in the telephone and this should be accessible by a 'hotkey' on the phone keypad. This 'hotkey' should be distinct from the rest of the keypad.

19.11 Alerting Systems

- In emergency situations, it is critical that people are quickly alerted to the situation at hand, for persons with disability the following needs to be considered.
-
- Consider having audible alarms with 'voice instructions' that can help guide them to the nearest emergency exit. As an alternative to the pre-recorded messages, these alarms may be connected to the central control room for on-the-spot broadcasts.
-
- Non-auditory alarms (visual or sensory) to alert persons with hearing impairments should be installed at visible locations in all areas that the passengers may use (including toilet areas, etc).
-

Non-auditory alarms include:

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

13.12 Written Evacuation Procedure

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

19.13 Emergency Evacuation Route

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

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

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

19.14 WAY GUIDANCE SYSTEM

- Luminance on the floor should be 1lux minimum provided on along the centre line of the route and on stairs.
- Install clear illuminated sign above exit and also directional signage along the route.
- The directional exit signs with arrows indicating the way to the escape route should be provided at a height of 500mm from the floor level on the wall and should be internally illuminated by electric light connected to corridor circuits.

19.15 FIRE RESISTANT DOORS

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

19.16 STREET DESIGN

(a) Footpath (Sidewalk)

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

Footpath should:

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

Footpath should have:

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

(b) Kerb Ramp

- Kerb should be dropped, to be flush with walk way, at a gradient no greater than 1:10 on both sides of necessary and convenient crossing points. Width should not be less than 1200mm. If width (X) is less than 1200mm, then slope of the flared side shall not exceed 1:12.
- Floor tactile paving- Guiding & Warning paver shall be provided to guide persons with vision impairment so that a person with vision impairment does not accidentally walk onto the road.
- Finishes shall have non-slip surface with a texture traversable by a wheel chair.

(c) Road Intersections

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

(d) Median/Pedestrian Refuge

Raised islands in crossings should:

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

19.17 Traffic Signals

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

19.18 Subway and Foot Over Bridge

Subways and foot over bridges should be accessible for people with disabilities. This may be achieved by:

- Provision of signage at strategic location;
- Provision of slope ramps or lifts at both the ends to enable wheelchair accessibility ;
- Ensuring that the walkway is at least 1500 mm wide;
- Provision of tactile guiding and warning paver along the length of the walkway;
- Keeping the walkway; free from any obstructions and projections; and
- Providing for seats for people with ambulatory disabilities at regular intervals along the walkway and at landings.

19.19 ALIGHTING AND BOARDING AREAS

- All areas and services provided in the Mass Rapid Transit System (Metro/subway), bus terminuses, etc. that are open to the public should be accessible.

19.20 Approach

- Passenger walkways, including crossings to the bus stops, taxi stands, terminal / station building, etc. should be accessible to persons with disabilities.
- Uneven surfaces should be repaired and anything that encroaches on corridors or paths of travel should be removed to avoid creating new barriers. Any obstructions or areas requiring maintenance should be white cane detectable2.

- Access path from plot entry and surface parking to terminal entrance shall have even surface without any steps.
- Slope, if any, shall not have gradient greater than 5%. The walkway should not have a gradient exceeding 1:20. It also refers to cross slope.
- Texture change in walk ways adjacent to seating by means of tactile warning paver should be provided for persons with vision impairment.
- Avoid gratings in walks.

19.21 CAR PARK

(A) SIGNAGE

- International symbol of accessibility (wheelchair sign) should be displayed at approaches and entrances to car parks to indicate the provision of accessible parking lot for persons with disabilities within the vicinity.
- Directional signs shall be displayed at points where there is a change of direction to direct persons with disabilities to the accessible parking lot.
- Where the location of the accessible parking lot is not obvious or is distant from the approach viewpoints, the directional signs shall be placed along the route leading to the accessible parking lot.
- Accessible parking lot should be identifiable by the International Symbol of Accessibility. The signs should not be obscured by a vehicle parked in the designated lot.
- Vertical signs shall be provided, to make it easily visible, the sign should be at a minimum height of 2100 mm .

(B) SYMBOL

International Symbol of Accessibility should be clearly marked on the accessible parking lot for drivers/riders with disabilities only.

- A square with dimensions of at least 1000 mm but not exceeding 1500 mm in length;
- Be located at the centre of the lot; and
- The colour of the symbol should be white on a blue background.

(C) CAR PARK ENTRANCE

The car park entrance should have a height clearance of at least 2400 mm.

LOCATION

- Accessible parking lots that serve a building should be located nearest to an accessible entrance and / or lift lobby within 30 meters. In case the access is through lift, the parking shall be located within 30 meters.
- The accessible route of 1200 mm width is required for wheelchair users to pass behind vehicle that may be backing out.

(D) ACCESSIBLE CAR PARKING LOT

The accessible car parking lot should:

- Have minimum dimensions 5000 mm × 3600 mm;
- Have a firm, level surface without aeration slabs;
- Wherever possible, be sheltered;
- Where there are two accessible parking bays adjoining each other, then the 1200 mm side transfer bay may be shared by the two parking bays. The transfer zones, both on the side and the rear should have yellow and while cross-hatch road markings;
- Two accessible parking lots shall be provided for every 25 no of car spaces.
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(E) DROP OFF AND PICK UP AREAS

- Designated drop-off and pick-up spaces, to be clearly marked with international symbol of accessibility.
- Kerbs wherever provided, should have kerb ramps.

Chapter -20

Security Measures

CHAPTER -20

SECURITY MEASURES FOR A METRO SYSTEM

20.0 INTRODUCTION

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

20.1 NECESSSITY OF SECURITY

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

20.2 THREE PILLARS OF SECURITY

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

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

Staff engaging with the passengers create a sense of re-assurance which can not fully be achieved by technology. For human factor to be more effective staff has to be qualified, trained, well equipped and motivated. They should bs trained, drilled and tested. The security risk assessment is the first step for understanding the needs and prioritizing resources. The organization of security should be clear and consistent. Security incidents, especially major ones, often happen without warning. Emergency and contingency plans must be developed communicated and drilled in advance.

There are number of technologies which can be used to enhance security e.g. surveillance systems. The objectives of the security systems are to differ i.e., making planning or execution of on attack too difficult, detect the planned evidence before it occurs deny the access after in plan of attack has been made and to mitigate i.e. lessen the impact severity as the attack by appropriate digits.

20.3 PHASES OF SECURITY

There are three phases of security as under:

Prevention

These are the measures which can prevent a security incidence from taking place. These can be identified by conducting a risk assessment and gathering intelligence. Prevention begins with the daily operational security -problems. Uncared for dirty, damaged property is a breeding ground for more serious crime.

Preparedness

Plans must be prepared to respond to incidents, mitigate the impact. Train staff accordingly and carry out exercises. The results of the risk assessment give a basis for such plans.

Recovery

Transport system must have laid down procedures/instructions for the quick recovery of normal service after an incident. Recovery is important for the financial health of the operation, but it also sends a clear message to public, it reassures passengers and gives them confidence to continue using the system. Communication is key to the quick restoration after such incidents. Restoration should ^also include an evaluation process for the lessons learnt.

20.4 RESPONSIBILITIES AND PARTNERSHIPS

Security is a sovereign function and hence is the responsibility of the state. Security in public requires clear governance. Responsibility should be clearly defined. In the present scenario, this is the responsibility of the State Government/MHA in Lucknow to ensure secured travelling to the public including Lucknow Metro. In other states security would be the responsibility of the concerned state govt.

20.5 PROPOSED PROVISIONS FOR SECURITY SYSTEM:

1. CCTV coverage of all metro stations. With a provision of monitoring in the Station Security Room as well as at a Centralized Security Control Room with video wall, computer with access to internet TV with data connection, printer and telephone connection (Land Line and EPBX) for proper functioning, cluster viewing for stations. Cost of this is included in Telecom estimate.

2. Minimum one Baggage Scanners on all entry points (1 per AFC array). Additional requirement of baggage scanners at heavily crowed stations i.e at interchange may also be required. Cost of one baggage scanner is Rs. 15.0 Lacs approximately, on 2013 prices.

3. Multi-zone Door Frame Metal Detector (DFMD) minimum three per entry (2 per AFC array). The number can increase in view of the footfall at over crowed stations. Cost of one Multi-zone DFMD is Rs 2.15 Lacs approximately.

4. Hand held Metal Detector (HHMD) as per requirement of security agency, minimum two per entry, which varies from station to station with at least 1.5 per DFMD installed at the station. Cost of one HHMD is Rs 6000/- approximately at 2012 prices.

5. Bomb Detection Equipments with modified vehicle as per requirement of security agency. One BDS team per 25 - 30 station will be required at par with present criteria of DMRC. Cost 1.25 crores including vehicle.

6. Bomb Blanket at least one per station and Depots. Cost is Rs. 50,000/- per bomb blanket.

7. Wireless Sets (Static and Hand Held) as per requirement of security agency.

8. Dragon light at least one per station and vital installation.

9. Mobile phones, land lines and EPBX phone connections for senior security officers and control room etc.

10. Dog Squads (Sniffer Dog), at least one dog for 4 metro stations which is at par with current arrangement of Lucknow Metro. Cost of one trained sniffer dog is Rs 1.25 Lacs

approximately. Dog Kennels alongwith provision for dog handlers and MI room will also be provided by metro train depot administration including land at suitable places line wise.

11. Bullet proof Morcha one per security check point (i.e. AFC array) and entry gate of metro train depot administration metro station.

12. Bullet proof jackets and helmets for QRTs and riot control equipments including space at nominated stations. One QRT Team looks after 5-6 metro stations as per present arrangement. One QRT consist of 5 personnel and perform duty in three shifts.

13. Furniture to security agency for each security room, and checking point at every entry point at stations. Scale is one office table with three chairs for security room and office of GO and one steel top table with two chairs for checking point.

14. Ladies frisking booth - 1 per security check point (AFC Arrey)
    Wooden Ramp - 1 per DFMD for security check points.

15. Wall mounted/ pedestal fan at security check point, ladies frisking booth and bullet proof morcha, as per requirement.

16. Physical barriers for anti scaling at Ramp area, low height of via duct by providing iron grill of appropriate height & design/concertina wire.

17. Adequate number of ropes. Queue managers, cordoning tapes, dragon search lights for contingency.

18. Iron grill at station entrance staircases, proper segregation of paid and unpaid by providing appropriate design grills etc.

19. Proper design of emergency staircase and Fireman entry to prevent unauthorized entry.