Nagpur Improvement Trust

DETAILED PROJECT REPORT
FOR
NAGPUR METRO RAIL PROJECT

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DELHI METRO RAIL CORPORATION LTD.

NOVEMBER 2013

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SALIENT FEATURES

1. **GAUGE (STANDARD)** – **1435 mm**

2. **MAX. PERMISSIBLE SPEED** – **80kmph**

3. **ROUTE LENGTH (END TO END OF STATION)**

Description	Elevated (km)	At Grade (km)	Total (km)
Line 1 – North-South Corridor : Automotive Square to MIHAN	15.058	4.600	19.658
Line 2 – East West Corridor : Prajapati Nagar to Lokmanya Nagar	18.557	000	18.557
Total	33.615	4.600	38.215

4. **NUMBER OF STATIONS**

Description	Elevated	At Grade
Line 1 – North-South Corridor : Automotive Square to MIHAN	15	2
Line 2 – East West Corridor : Prajapati Nagar to Lokmanya Nagar	19	0
Total	34	2

5. TRAFFIC FORECAST – RIDERSHIP

BOARDING/RIDERSHIP (DAY)	2018	2021	2026	2031	2036	2041
ON LINE 1(AUTOMATIVE-KHAPRI)	168361	185551	203720	224016	248419	277734
ON LINE 2(PRAJAPATI-LOKMANYA)	184081	197908	215415	234577	260237	285631
TOTAL OF BOTH	352442	383459	419135	458593	508656	563135
AVERAGE TRIP LENGTH IN KM	6.415	6.453	6.494	6.533	6.521	6.522
MAXIMUM PHPDT ON LINE 1	10085	10936	11616	12634	14286	15725
MAXIMUM PHPDT ON LINE 2	7746	8460	9104	9900	10746	11882

6. TRAIN OPERATION

A) TRAIN FREQUENCY

<u>Line-1: North – South Corridor</u>

Sections	2018		2021		2026		2031		2036		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	Peak Hour h/w	Lean Hour h/w
Automotive Sq's to Congress Nagar Section	6 min	10 to 30 min	5 min	8 to 20 min	4.5min	5 to 25 min	4 min	8 to 20 min	3.3 min	5 to 15 min	3 min	5 to 15 min
Congress Nagar to Khapri Station Section	12 min	20 to 60 min	10 min	15 to 40 min	9 min	12 to 40 min	8 min	12 to 40 min	7 min	10 to 30 min	6 min	15 to 35 min

Line-2: East-West Corridor

Sections	2016		2021		2026		2031		2036		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	Peak Hour h/w	Lean Hour h/w
Prajapat Nagar to Agrasen Chowk Section	15 min	20 to 60 min	12 min	20 to 60 min	10 min	16 to 40 min	8 min	12 to 40 min	8 min	12 to 40 min	7 min	10 to 33 min
Agrasen Chowk to Subhash Nagar Section	6.5 min	10 to 30 min	6 min	10 to 30 min	5 min	8 to 20 min	4.5 min	8 to 20 min	4 min	6 to 20 min	3.5 min	5 to 15 min
Subhash Nagar to Lokmanya Nagar Section	15 min	20 to 60 min	12 min	20 to 60 min	10 min	16 to 40 min	8 min	12 to 40 min	8 min	12 to 40 min	7 min	10 to 33 min

B) RAKE REQUIREMENT

Corridor	Year	No. of Rakes	Rake Consist	No. of cars
North – South Corridor	2016	11	3 car	33
	2021	12	3 car	36
	2031	17	3 car	51
	2041	20	3 car	60
East – West Corridor	2016	12	3 car	36
	2021	13	3 car	39
	2031	17	3 car	51
	2041	20	3 car	60

7. TRACTION POWER SUPPLY

a) Voltage: 25 KV AC

b) Current Collection: Overhead Current Collection System

c) SCADA system: Provided

POWER DEMAND (MVA)

Power Demand Estimation (MVA)

Corridor		Year			
		2016	2021	2031	2041
North-South Corridor – 1 Automotive Sqre to Depot Station. [21.933 kms ; 16 elevated Stations &1 U/G Station]	Traction	4.32	5.01	5.84	7.10
	Auxiliary	7.72	7.84	9.14	11.43
	Total	12.04	12.85	14.98	18.53
East-West Corridor – 2 Prajapati Nagar to Lokmanya Nagar [18.266 kms ; 19 Elevated Stations]	Traction	4.24	4.57	5.73	7.01
	Auxiliary	8.34	8.46	9.08	12.48
	Total	12.58	13.03	15.81	19.49

8. ROLLING STOCK

i. Coach Size

Particular	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 (depending upon Kinematic Envelop)

ii. Train Composition 3-Car train: DMC+TC+ DMC

iii. Seating Arrangement Longitudinal

iv. Passenger Carrying Capacity (Crush @ 6 persons/sq. m)

PARTICULAR	SEATED	STANDING	TOTAL
DMC	43	204	247
TC/MC	50	220	270
3-CAR	136	628	764

v.	Axle load:	16T
vi.	Max Acceleration:	1.0 m/s2
vii.	Max Deceleration:	1.0 m/s2 (Normal Brake) > 1.3 m/s2 (Emergency Brake)
viii.	Maximum Design Speed:	90 kmph
ix.	Maximum Operating Speed:	80 kmph
x.	Schedule Speed (as per train operation in following lines):	
	a. Corridor I : North-South Corridor:	32-34 kmph
	b. Corridor II : East-West Corridor:	30 kmph

9. MAINTENANCE FACILITIES

Depot cum workshop near Khapri Station (MADC Land) and near Lokmanya Nagar Station (SRP Land).

10. SIGNALLING, TELECOMMUNICATION & TRAIN CONTROL

a)	Type of Signaling:	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

i. Viaduct: Pre-stressed concrete "Box" shaped Girders/Double U-Girder on Single pier with pile / Open foundations.

13. PROJECT COST

Total Estimated/Completion Cost

(Rs /Crore)

Corridor No.	Name of Corridor	Distance (KMs)	Estimated Cost without Central taxes at June-2013 Price Level	Estimated Cost with Central taxes at June-2013 Price Level	Completion Cost
I	North-South Corridor	19.658	3010.00	3,425.00	8680
II	East-West Corridor	18.557	2984.00	3,427.00	
	Total	38.215	5994.00	6852.00	

14. FINANCIAL INDICES

i. FIRR (Cost with central taxes) 18.33 %

ii. EIRR 17.70 %

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

0.1 INTRODUCTION

0.1.1 General

Nagpur is the third largest city of Maharashtra and also the winter capital of the state. With a population of approximately 25 lakhs, Nagpur Metropolitan Area is the 13th largest urban conglomeration in India. It has also recently been ranked as the cleanest city and the second greenest city of India, in addition to being the seat of annual winter session of Maharashtra state assembly "Vidhan Sabha". Nagpur is also a major commercial and political center of the Vidarbha region. It is also known as "Orange City" for being a major trade center of oranges that are cultivated in the region.

Nagpur lies precisely at the center of the country with the Zero Mile Marker indicating the geographical center of India. The city was founded by the Gonds but later became part of the Maratha Empire under the Bhonsales. The British East India Company took over Nagpur in the 19th century and made it the capital of the Central Provinces and Berar. After the first reorganisation of states, the city lost its capital status but according to the informal "Nagpur Pact" between political leaders, it was made the second capital of Maharashtra. **Nagpur** is also declared, "Tiger Capital of India " as it connects many Tiger Reserves in India to the world.

Nagpur lies on the Deccan plateau of the Indian Peninsula and has a mean altitude of 310 meters above sea level. The underlying rock strata are covered with alluvial deposits resulting from the flood plain of the Kanhan River. In some places these give rise to granular sandy soil. In low lying areas which are poorly drained, the soil is alluvial clay with poor permeability characteristics. In the eastern part of city crystalline metamorphic rocks such as gneiss, schist and granites are found, while in the northern part yellowish sand stones and clays of the lower Gondwana formations are found.

Nagpur city is dotted with natural and man-made lakes with Ambazari lake being the largest. Other natural lakes include Gorewada Lake and Telangkhedi lake. Sonegaon lake and Gandhisagar lake are man-made lakes created by the city's historical rulers. Nag river, Pili nadi along with nalas form the natural drainage pattern for the city. Nagpur is known for its greenery, and was judged as the cleanest and second greenest in India. Recently, Government of India selected Nagpur as a Model City for **National Clean Air Mission** by allocating 25 crores for the plan. This project will be handled by Nagpur's own NEERI.

As it is located at centre of Indian peninsula far from the Bay of Bengal and the Arabian Sea, Nagpur has a tropical wet and dry climate with dry conditions prevailing for most of the year. It receives an annual rainfall of 1,205 mm (47.44 in) from monsoon rains during June to September. The highest recorded rainfall was 304 mm on 14 July 1994. Summers are extremely hot lasting from March to June, with maximum temperatures occurring in May. Winter lasts from November to January, during which temperatures can drop below 10 °C (50 °F). The highest ever recorded temperature in the city was 48°C, while the lowest was 3°C.

0.1.2 Study Area

In early 2012 Nagpur Improvement Trust (NIT) requested DMRC to provide Consultancy services for preparation of a Detailed Project Report for Metro Rail System in Nagpur, Maharashtra initially for 20 Km which was revised to 42 Km in July 2012. Thereafter, DMRC conducted Traffic Surveys, Topographical Surveys, Geotechnical Investigations and Environment Impact Assessment Survey.

The study area consisted of Nagpur Municipal Corporation Area. The study area totaled to approximately 217 sq km.

Based on the different types of surveys done by DMRC, metro alignments were finalized after repeated inspection of the road network, intersections, passenger traffic flow, traffic congestion, connectivity to important land uses. Alignment of routes proposed by DMRC were as follows:

Table 0.1A: Alignments Proposed by DMRC (in July 2012)

Alignment (Proposed by DMRC)	Detail Route
Alignment-1 North-South Corridor (21.833 Km, 17 stations)	Automotive Square, along Kamptee Road, Wardha Road, Variety Square to Abhyankar Road, along Nag River alignment will fall on Humpyard Road, Rahate Colony Road, Wardha Road, Khamla Road, Airport, MIHAN Area
Alignment-2 East - West Corridor (18.286 Km, 19 stations)	From Prajapati Nagar, along Central Avenue Road, Railway Feeder Road, Munje Chowk, Jhansi Rani Chowk, North Ambazari Road, Hingna Road, Lokmanya Nagar

FINAL ALIGNMENT FOR NAGPUR METRO

On 03.08.2013, a meeting presided by Shri S K Lohia, JS-MoUD,GoI was held at Nagpur to discuss the DPR. In that meeting, JS-MoUD GoI expressed that the FIRR of the project should be at least 8%. Recently, MoUD has also issued advisory that FIRR of Metro Project should not be below 8%.

On 1.10.2013, a presentation on the DPR was made by M/s NIT to The Chief Minister, Government of Maharashtra. He was of the opinion to avoid underground alignment in MIHAN and also construct Maintenance Depot in the land belonging to State Govt Land. Subsequently, on 21.10.2013, a joint inspection of the NS corridor was done by VC&MD-MADC, Chairman-NIT, and Director Business Development-DMRC.

The original alignment of Corridor-I proposed was passing through Khamla Road, Airport Area after Sahakar Nagar and finally was ending at MIHAN. The alignment up to Old Airport Station was elevated, then for a length of 3.36 km, it was underground with one underground station named as New Airport Station and again elevated in MIHAN Area. Since the cost of underground section of the alignment is much more than the elevated section or the section at grade, alternative alignment was suggested for cost reduction, enhancement in PHPDT and to increase FIRR so that project becomes financially and economically viable.

The new proposed alignment suggested in the above inspection, was to pass through a 24m wide road adjacent to London Street after Sahakar Nagar Junction and was proposed to be taken to the east along 24m wide road and London Street up to Wardha Road. From the intersection of Wardha road, the elevated alignment was proposed to be on the central divider on the Wardha Road. After crossing existing intersection point of Wardha Road & Airport Road, the alignment was to be shifted to the MIHAN area. Alignment in this portion was proposed to be at grade and to run parallel to Wardha road upto ROB and abuting railway line thereafter up-to proposed Car depot.

But, while working on this modification of alignment, it was noticed that a very large number of properties were falling along the alignment due to sharp curve at the junction of Sahakar Nagar & 24 m wide road and also at the junction of 24m wide road & Wardha Road. Acquiring of these properties will be very tough and may delay the whole project.

Hence to avoid all such situation, it has been decided to take the alignment on Wardha Road only without going on Khamla Road.

Finally, NS Corridor will pass through Wardha Road after Congress Nagar Metro Station. After crossing existing intersection point of Wardha Road & Airport Road, the alignment will be shifted to the MIHAN area. Alignment in this portion will be at grade and will run parallel to Wardha road upto ROB and parallel to railway line thereafter up-to proposed Car depot. 14m wide stretch of land between the railway boundary line and the road near proposed Container Depot of Container Corporation of India Ltd. will be affected by this proposed alignment of the Metro Rail as the proposed alignment passes through this stretch of land. 73 Ha land is available on the west side of railway line and south of existing flyover near Khapri station. Average width of this land is about 80m and is about 1800m long. This MADC land may be utilized for Car Depot. Similarly, Depot of EW Corridor has also been shifted to SRP Land near proposed Lokmanya Nagar Metro Station.

This has caused deletion of few earlier proposed metro stations on NS Corridor and addition of new stations on the same.

Final alignment for both the corridors is as below :

Table 0.10
FINAL ALIGNMENT

Alignment	Detail Route
Alignment-1 North-South Corridor (19.658 km, 17 Stations)	Automotive Square, along Kamptee Road, Wardha Road, Variety Square to Abhyankar Road, along Nag River alignment will fall on Humpyard Road, Rahate Colony Road, Wardha Road, Parallel to Railway Line, Khapri Station and finally in MIHAN Area near concor depot.
Alignment-2 East – West Corridor (18.557 km, 19 Stations)	From Prajapati Nagar, along Central Avenue Road, Railway Feeder Road, Munje Chowk, Jhansi Rani Chowk, North Ambazari Road, Hingna Road, Lokmanya Nagar

0.2 TRAFFIC DEMAND

0.2.1 Traffic Study and Ridership estimation are the first tasks in DPR which imply finalizing a feasible alignment plan of the proposed metro network and then locating normal and interchange metro stations (if any). After that, Ridership Estimation is done. Estimating daily and peak hour boarding and alighting from each station, daily link load and PHPDT link loads (all together is called Ridership Estimation) are estimated. These estimates are primary inputs to other important estimates such as station design, train operation plan, estimates of revenue collection, benefits of metro, rolling stock and many other estimates including EIRR and FIRR.

0.2.2 Station Loading (Daily and Peak)

Total daily boarding ridership in 2016 is estimated as 3.52 lakhs in which share of line 1 as 47% and line 2 as 53%. Average trip length is 6.41km. The daily and peak station loads of the Metro System comprises of the following lines, are described as under in **Table 0.2.**

Table 0.2: Summary Output : Traffic

BOARDING/RIDERSHIP (DAY)	2018	2021	2026	2031	2036	2041
ON LINE 1(AUTOMATIVE-KHAPRI)	166361	185531	203728	224316	248419	277704
ON LINE 2(PRAJAPATI-LOKMANYA)	184081	197806	215415	234577	262237	286031
TOTAL OF BOTH	350442	383430	419135	458893	508656	563735
AVERAGE TRIP LENGTH IN KM	6.419	6.453	6.484	6.533	6.521	6.522
MAXIMUM PHPDT ON LINE 1	10088	10936	11915	12934	14286	15728
MAXIMUM PHPDT ON LINE 2	7740	8400	9104	9906	10748	11882

0.3 SYSTEM SELECTION

The population growth in cities and urban centers has put a lot of pressure on the infrastructure of these cities. In rapidly developing countries like India the urban infrastructure is stretched to limit and requires very effective solutions. The rapid development in India is not unprecedented and such development earlier took place in several nations of Europe, America and in Japan. So several modes of urban mass transit are now available for solution to the problem of Urban Transit.

0.3.1 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. Moreover, supply of metro rail system in Nagpur will mean a lot in terms of sustainable modes of transport that meets the mobility and accessibility needs of people.

0.3.2 Feasibility of Metro System:

From the 'Traffic Demand Forecast' it can be seen that peak hour peak direction trips (PHPDT) on the North South Corridor is 10086,10936,12934 and 15729 the year of 2016, 2021, 2031 and 2041 respectively. Similarly PHPDT on East West corridor in the year of 2016, 2021, 2031 and 2041 is 7746,8463,9306 and 11902 respectively.

Road-based systems can optimally carry up to a maximum of 8,000 PHPDT. Since the PHPDT assumed on the above corridors exceed 8,000, there can be two options namely 1) Mono Rail and 2) Light Capacity Metro. Mono rail can carry the PHPDT projected but this technology is not a tested one. The operation and maintenance cost is much higher that Light metro. The capital cost of Mono rail is also almost same as that of Light Metro with no experience of Mono rail in India. Even in the other countries, the Mono rail is being adopted only for small lengths and as feeder to Metro. Hence, keeping in view the above disadvantages, it is recommended to adopt an stable, tested and reliable Metro technology. However, for Nagpur it will be Light Capacity Metro System.

0.4 GEOMETRIC DESIGN NORMS

The geometrical design norms are based on international practices adopted for similar metro systems with standard gauge on the assumption that the maximum permissible speed on the section is limited to 80 kmph. Planning for any higher speed is not desirable as the average inter-station distance (37 stations in approx. 40 km) is about 1.10 km and trains will not be able to achieve higher speed.

0.4.1 GEOMETRIC DESIGN PARAMETERS

i) Horizontal Curves

Table 0.2: Horizontal Curve Parameters

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

ii) Transition Curves

- Length of Transitions of Horizontal curves (m):

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

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

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

iii) Gradients

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

iv) Vertical Curves

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

v) Radius of vertical curves:

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

0.4.2 Route Alignment

Two Corridors have been identified for implementation in phase I of Nagpur Metro Rail Project network as per details given as under:-

- Corridor I: North-South Corridor : Automotive Square to KHAPRI
- Corridor II: East-West Corridor : Prajapati Nagar to Lokmanya Nagar

0.4.2.1 North-South Corridor : Automotive Square to KHAPRI

This corridor originates from Automotive Square on Kamptee Road, move along Kamptee Road and reach the intersection point of Amravati Road and Wardha Road.

then after crossing Fly Over moves towards Munje Square, moves towards Dhantoli and along nala moves towards Empress/Dr. Munje Marg, leads towards Congress Nagar T-Point, then on Rahate Colony Road and then falls on Wardha Road, leads towards NEERI, then moves along Wardha Road and then west of Railway Track in MIHAN area. And passes through 14m wide stretch of land between the railway boundary line and the road near proposed Container Depot.

Entire length (19.658 Km.) of this corridor is proposed as elevated except in 4.6 Km at grade after Airport Station and in MIHAN area near Khapri Railway StatioN. There are 17 stations on this corridor of which 15 stations are elevated and 2 stations are at Grade. Sitaburdi Station is an inter-change station.

0.4.2.2 East West Corridor : Prajapati Nagar to Lokmanya Nagar

This corridor originates from Prajapati Nagar and runs westwards through Vaishnodevi Chowk, Ambedkar Chowk, Telephone Exchange, Chittar Oli Chowk, Agarsen Chowk, Doser Vaisya Chowk, Nagpur Railway Station, Sitaburdi, Jhansi Rani Square, Institute of Engineers, Shankar Nagar Square, Lad chowk, Dharampeth College, Subhash Nagar, Rachna (Ring road Junction), Vasudev Nagar, Bansi Nagar to Lokmanya Nagar. The entire corridor is elevated.

The total length of the corridor is 18.557 kilometer. There are 19 stations on this corridor. All stations are elevated stations and Sitaburdi station is an Interchange Station.

0.5 CIVIL ENGINEERING

0.5.1 Elevated Section - Choice of Superstructure

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

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

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

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

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

- Segments are easy to stack in the casting yard/stacking yard in more than one layer, thereby saving in requirement of space.
- It is easier to transport smaller segments by road trailers on city roads.
- It is easy to incorporate last minute changes in span configuration if the site situation so warrants.
- Interference to the traffic during construction is significantly reduced.
- Segmental construction contributes towards aesthetically pleasing structures and good finishes.
- The overall labour requirement is less than that for conventional methods.
- Better quality control is possible in the casting yard.
- During construction, the technique shows an exceptionally high record of safety.

0.6.2 Types of Superstructures for Elevated Section

- Pre-cast segmental box girder using external unbonded tendon.
- Pre-cast segmental U-Channel Superstructure with internal pre-stressing.

0.6.3 CONSTRUCTION METHODOLOGY

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

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

0.6.4 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 in the pipeline to avoid flooding of the cut/damage to the works.

0.6.6 Geo-Technical Investigations

0.6.6.1 Physiography

Nagpur is situated at 21° 09' N latitude and 79° 09' E longitude and a mean altitude of 310 meters above sea level. Being located far away from any major water body at the centre of the Indian peninsula, the Nagpur's climate is dry or mildly humid for most of the year except for the rainy season. The highest ever recorded temperature in the city was 48 °C, while the lowest was 3°C. The geology of the Nagpur region is famous for the metamorphic rocks, which occur in all the districts in the Nagpur region except Wardha and some part of Nagpur district. The other geological formation Deccan Traps occur in the Wardha and North and North West part of Nagpur District.

0.6.6.2 Objective of Geotechnical Investigation

The main objectives of Geo-Technical Investigation Services are:

- To determine the required strength characteristics of the underlying soil/rock strata to design the foundation of the structure proposed to be constructed at various locations.
- To determine the subsurface profile of the underlying strata.
- To decide the construction methodology.

0.6.6.3 Details of Bore Holes

Investigation Works

Geotechnical investigation work at site was carried out to determine the existing subsoil strata, proposed type & depth of foundations and safe bearing capacity of foundations required for the proposed two Metro Corridors in Nagpur based on the results of 80 boreholes. 41 bore holes were driven in AUTOMOTIVE SQUARE TO MIHAN alignment & 39 boreholes were driven in Lokmanya Nagar to Prospect Nagar alignment. However, due to the site condition, depth of drilling work ranging from 10.00m to 25m was carried out at the proposed locations.

Table 0.4
SUMMARY OF BORE HOLES
N.S.CORRIDOR

Sr. No.	Location Details	Total depth	Soil	Soft Rock	Hard Rock	Water Table (m)
1	Automotive Chowk	25.00	15.00	10.00	-	7.20
2	Go Gas Pump	16.50	6.50	10.00	-	7.10
3	Kelly Automobiles	17.00	7.00	10.00	-	7.20
4	Lal godown chowk	15.50	5.50	10.00	-	6.60
5	New India Hindi School	16.00	6.00	10.00	-	6.50
6	Oppt. Jaswant Tui Mall	16.00	6.00	10.00	-	7.10

Sr. No.	Location Details	Total depth	Soil	Soft Rock	Hard Rock	Water Table (m)
7	Bharat Petrol Pump (10 No. Pulia)	14.50	4.50	10.00	-	5.40
8	Kadbi Chowk	14.50	4.50	10.00	-	5.10
9	Gurudwara (Railway Line Near)	20.00	10.00	10.00	-	3.80
10	Gaddi Godam Chowk	12.00	2.00	10.00	-	4.20
11	L.I.C Chowk, AHM Church Campus	11.50	1.50	10.00	-	4.40
12	R.B.I Bank Chowk	12.00	2.00	10.00	-	4.50
13	Morrises College, T. Point	11.00	1.00	10.00	-	3.65
14	Sita Burdi Police Station	14.50	4.50	10.00	-	5.00
15	Rex Furniture, Oppt. Nangia Traders	16.00	6.00	10.00	-	4.70
16	Yeswant Stadium	17.00	7.00	10.00	-	4.80
17	Dhantoli P.S. Oppt. Green City Hotel	17.50	7.50	10.00	-	5.10
18	Madhusudan Arts (M. Printers)	15.00	5.00	10.00	-	3.20
19	Neha Towers	14.50	4.50	10.00	-	3.90
20	Hardikar Chowk	14.00	4.00	10.00	-	3.40
21	Central Jail	15.00	5.00	10.00	-	3.60
22	Clock Tower Rajiv Gandhi Chowk	11.50	1.50	10.00	-	3.25
23	Sanskar Vidhya Sagar School	12.50	2.50	10.00	-	4.80
24	Bharat Creations/Sanjay Traders	13.00	3.00	10.00	-	4.30
25	Sawarkar Chowk	12.50	2.50	10.00	-	2.90
26	Khamla Bus Stop	12.50	2.50	10.00	-	3.60
27	Balaji Hardware/Vijay Trading	13.00	3.00	10.00	-	3.00
28	Arun Rao Pamekar Chowk (Pulia)	13.00	3.00	10.00	-	2.10
29	Police/Dance Forest Area (Airport)	14.00	4.00	10.00	-	2.90
30	Parking Airport	14.50	4.50	10.00	-	2.10
31	Airport Boundry	14.00	4.00	10.00	-	3.70

Table 3.5
SUMMARY OF BORE HOLES
E W CORRIDOR

Sr. No.	Location Details	Total depth	Soil	Soft Rock	Hard Rock	Water Table (m)
1	Ajit Engineering Limited	11.00	1.00	5.00	5.00	3.80
2	C.R.P.F Gate No.-1	11.00	1.00	6.00	4.00	4.20
3	Mahindra Company	11.50	1.50	6.00	4.00	4.30
4	Ambazari Batti Chowk (Near Dharam kanta)	11.00	1.00	10.00	-	4.00
5	Toll Tax Naka	11.00	1.00	10.00	-	4.25
6	Super Enclave, Opp. Prabhat Trading	11.50	1.50	10.00	-	5.30
7	Hingna T. Point	10.50	0.50	10.00	-	4.70
8	[illegible] Hotel	11.00	1.00	10.00	-	4.60
9	Pump House (G.C.C.R.P.F) Nagpur	10.00	0.00	10.00	-	5.50
10	Subhash Nagar Chowk	12.00	3.00	8.00	1.00	4.20
11	Nagpur Improvement Trust, Cross Castle	13.00	3.00	10.00	-	4.40
12	Tomar Hotel	12.50	2.50	10.00	-	3.40
13	Laxmi house (Near Amrapali T Point)	12.00	2.00	9.00	1.00	3.60
14	L.A.D. Chowk	13.00	3.00	10.00	-	5.10
15	Shankar Nagar chowk	13.00	3.00	10.00	-	5.15
16	Adarsh S.B High School	12.00	2.00	10.00	-	5.10
17	Dharampeth Vidyalay	14.00	4.00	10.00	-	4.90
18	A.M.I.E (Nagpur Local Centre)	14.00	4.00	10.00	-	5.50

Sr. No.	Location Details	Total depth	Soil	Soft Rock	Hard Rock	Water Table (m)
19	MJ College	14.50	4.50	10.00	-	4.50
20	Jhansi Rani Chowk	14.00	4.00	10.00	-	5.10
21	Munje Chowk	14.00	4.00	10.00	-	5.70
22	Railway Push Box	14.50	4.50	10.00	-	4.60
23	Nagpur Corporation zone Naka - 10	16.00	6.00	10.00	-	4.20
24	Hotel Sona mahar	14.00	4.00	10.00	-	5.30
25	Mayo Hospital	12.00	2.00	10.00	-	3.90
26	Seeta Badal Chowk	13.00	3.00	10.00	-	4.50
27	Gandhi Bagh (Bus Stop)	12.00	2.00	10.00	-	4.35
28	Chittaroad Chowk	13.20	3.20	10.00	-	4.70
29	Gandhi Chowk	13.15	3.15	10.00	-	4.60
30	Rahate Hospital	14.50	4.50	10.00	-	4.75
31	Telephone Exchange	15.00	5.00	10.00	-	7.20
32	Chapra Nagar Chowk, Bharat Furniture	15.00	5.00	10.00	-	5.30
33	Ambedkar Chowk	17.50	7.50	10.00	-	4.50
34	Ali Electrical, Vardhman Nagar Chowk	16.50	6.50	10.00	-	7.40
35	Near Mahalaxmi Collection	18.50	8.50	10.00	-	6.40
36	Sapna Bar & Restrant	17.00	7.00	10.00	-	4.35
37	Radha Krishan Hospital Chowk	17.50	7.50	10.00	-	7.30
38	Desi Wine Shop	21.00	15.00	10.00	-	7.00
39	Gomti Hotel, Near P & B Bank	20.00	10.00	10.00	-	7.30

TYPE OF FOUNDATION : NORTH – SOUTH CORRIDOR

A : Bored Cast in situ RCC Pile

Depending on the field and laboratory observations of subsoil strata, test results and the type of structures proposed at site, the most feasible soil-foundation system is recommended as normal bored cast in situ R.C.C. piles foundations of 0.80m & 1.0m diameter at different depths with cutoff level at 1.50m to 2.0m depth below existing Ground level. The safe load carrying capacities of these piles are given in following table.

Table 5.4 RCC PILE DETAILS FOR NORTH – SOUTH CORRIDOR

Borehole Nos	Dia. of Pile	Cutoff level	Depth, m	Pile Capacity		
				Compression	Uplift	Lateral
1	0.80	1.50	15.00	185.0	90.0	9.0
	1.00	1.50	15.00	300.0	120.0	12.0
2, 3	0.80	1.50	11.00	170.0	40.0	9.0
	1.00	1.50	11.00	250.0	50.0	12.0
4,5,6	0.80	1.50	10.50	170.0	45.0	9.0

	1.00	1.50	10.50	230.0	50.0	12.0
7,8	0.80	1.50	10.00	150.0	35.0	9.0
	1.00	1.50	10.00	225.0	45.0	12.0
9	0.80	1.50	15.00	220.0	65.0	9.0
	1.00	1.50	15.00	320.0	100.0	12.0
14	0.80	1.50	10.00	150.0	35.0	9.0
	1.00	1.50	10.00	225.0	45.0	12.0
15,16	0.80	1.50	11.00	170.0	40.0	9.0
	1.00	1.50	11.00	250.0	50.0	12.0
17	0.80	1.50	12.00	180.0	45.0	9.0
	1.00	1.50	12.00	260.0	55.0	12.0
18 to 21	0.80	1.50	10.00	150.0	35.0	9.0
	1.00	1.50	10.00	225.0	45.0	12.0
22 to 28	0.80	1.50	10.00	140.0	33.0	9.0
	1.00	1.50	10.00	210.0	40.0	12.0
29 to 32	0.80	1.50	10.00	150.0	35.0	9.0
	1.00	1.50	10.00	225.0	45.0	12.0

B: Open square footing

Depending on the field and laboratory observations of subsoil strata, test results and the type of structures proposed at site, the types of foundations, depths and net safe bearing capacities recommended for design purposes are given in the following table. The net SBC/APl in the following table are the lower of the values obtained from shear failure criterion as per IS: 6403 and settlement failure criterion as per IS: 8009, Part-I.

Table 0.7 : OPEN FOUNDATION DETAILS FOR : NORTH – SOUTH CORRIDOR

For Permissible settlement < 40.0 mm

Type of Foundation	Depth of Foundation (m)	Size of Foundation (m)	Net Safe Bearing Capacity/ Allowable Pressure Intensity (t/m²)
For Bore Hole Nos. : 10 to 13, 22 & 33 to 41 :			
Square footing	2.00 to 3.0	3.0 to 6.0	20.00

Note: For design purpose water table shall be considered at foundation level.

TYPE OF FOUNDATION : EAST - WEST CORRIDOR

A : Bored Cast in situ RCC Pile

Depending on the field and laboratory observations of subsoil strata, test results and the type of structures proposed at site, the most feasible soil-foundation system is recommended as normal bored cast in situ R.C.C. piles foundations of 0.80m & 1.0m diameter at different depths with cut-off level at 1.00m to 2.0m depth below existing ground level. The safe load carrying capacities of these piles are given in following table.

Table 0.8 :RCC PILE DETAILS FOR EAST - WEST CORRIDOR

Borehole Nos	Dia. of Pile	Cutoff level	Depth, m	Pile Capacity		
				Compression	Uplift	Lateral
11	0.80	1.50	12.00	400.0	60.0	9.0
	1.00	1.50	12.00	600.0	90.0	12.0
17 – 22	0.80	1.50	14.00	135.0	50.0	9.0
	1.00	1.50	14.00	240.0	70.0	12.0
23 – 24	0.80	1.50	14.00	160.0	60.0	9.0
	1.00	1.50	14.00	230.0	70.0	12.0
25 – 29	0.80	1.50	12.00	150.0	40.0	9.0
	1.00	1.50	12.00	220.0	90.0	12.0
30 – 31	0.80	1.50	14.00	175.0	50.0	9.0
	1.00	1.50	14.00	240.0	70.0	12.0
32	0.80	1.50	12.00	175.0	40.0	9.0
	1.00	1.50	12.00	250.0	50.0	12.0
33 – 34	0.80	1.50	15.00	205.0	80.0	9.0
	1.00	1.50	15.00	300.0	100.0	12.0
35 – 37	0.80	1.50	15.00	190.0	75.0	9.0
	1.00	1.50	15.00	305.0	100.0	12.0
38	0.80	1.50	15.00	180.0	80.0	9.0
	1.00	1.50	15.00	250.0	100.0	12.0
39	0.80	1.50	20.00	200.0	80.0	9.0
	1.00	1.50	20.00	305.0	100.0	12.0

Note:

1. For design purpose, water table shall be considered at cut off level.
2. For design purpose, effective overburden pressure at pile tip should correspond to pile length equal to 15 times the diameter.
3. The above values should be confirmed through pile load tests in the field before adopting these values for design purposes.

B : Open square footing

Depending on the field and laboratory observations of subsoil strata, test results and the type of structures proposed at site, the types of foundations, depths and net safe bearing capacities recommended for design purposes are given in the following table. The net SBC/NPI in the following table are the lower of the values obtained from shear failure criterion as per IS: 6403 and settlement failure criterion as per IS: 8009, Part-I.

Table 0.9: OPEN FOUNDATION DETAILS FOR EAST-WEST CORRIDOR

For Permissible settlement = 40.0 mm

Type of Foundation	Bridge No.	Depth of Foundation (m)	Size of Foundation (m)	Net Safe Bearing Capacity/ Allowable Pressure Intensity (t/m²)
Square footing	1 – 9	2.00 - 3.0	5.0 to 6.0	25.00
	10 & 12	3.0	5.0 to 6.0	20.00
	12 – 13	3.0	5.0 to 6.0	20.00
	14 – 15	3.00 - 4.00	5.0 to 6.0	25.00
	16	3.0	5.0 to 6.0	20.00

Note: For design purpose water table shall be considered at foundation level.

0.5.6 LAND

Land Requirement for following Major Components

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

Table 0.10: Summary of Permanent Land Requirement*

LAND DETAILS	EAST-WEST CORRIDOR PRAJAPATI NAGAR TO LOKMANYA NAGAR		NORTH-SOUTH CORRIDOR AUTOMOTIVE SQUARE TO KHAPRI DEPOT	
	GOVT. LAND (in sqm)	PVT. LAND (in sqm)	GOVT. LAND (in sqm)	PVT. LAND (in sqm)
STATIONS/ENTRY/EXIT	9644.40	7799.40	7525.90	13812.50
RUNNING SECTION	3205.30	5680.00	101882.00	15025.00
DEPOT AREA	259673.00		330000.00	
TRAFFIC INTEGRATION/PARKING	4076.10	1463.70	53799.60	5179.20
TOTAL	274662.20	14913.90	502187.10	33017.60
TOTAL GOVT LAND	776849.30	SAY 77.69 HECTARES		
TOTAL PVT LAND	62933.60	SAY 6.2 HECTARES		

*Apart from this the State Government should provide 20 hectare land free of cost for PD activity. Also for construction depots, temporary land @2 hectares per 10 km. will be required on Temporary Basis.

0.8 STATION PLANNING

Line -1 (North-South Corridor) : Automotive Square to KHAPRI Depot

A total of 17 Stations have been planned along the proposed NS Corridor. This corridor originates starts from Automotive square and runs southwards on NH-7 through Nari Road, Indora chowk, Gaddi Godam Square, Kasturchand Park, Zero Mile, Sitabuldi, Congress Nagar, Rahate colony, Ajni Square Station, Chhatrapati Sq. Station, Jaiprakash Nagar, Ujjwal Nagar, Airport Station, New Airport Station and Khapri Station. The Corridor is partly elevated and partly at grade. Total Length of the corridor is 19.658 Km of which approximately 15.058 is elevated and 4.6 km is at grade. There are 17 stations on this corridor of which 15 stations are elevated and 2 stations are at grade. Sitabuldi Station is an Inter-change station. Average inter-station distance is 1.20km approximately varying from 0.54km to 2.4km depending upon the site, operational and traffic requirements. The sequence of stations with their respective chainages and locational and platform characteristics is presented in **Table 0.11A**.

Table 0.11A: NS Corridor :
Sequence of Stations with Chainages and Locational & Platform Characteristics

	Name of Station	Chainage (in m)	Distance from previous station (in m)	Rail level (in m)	Platform type	Alignment
	Dead End	-405.8				
1	AUTOMOTIVE SQUARE	0.0	405.8	333.800	Side	Elevated
2	NARI ROAD	875.8	875.8	330.350	Side	Elevated
3	INDORA CHOWK	2159.7	1183.8	319.150	Side	Elevated
4	KADVI CHOWK	3101.2	1341.5	318.400	Side	Elevated
5	GADDI GODAM SQUARE	4008.3	1217.0	321.300	Side	Elevated
6	KASTURCHAND PARK	4748.8	745.8	326.300	Side	Elevated
7	ZERO MILE	6175.6	1026.8	319.800	Side	Elevated
8	SITABULDI	6703.3	533.7	319.000	Side	Elevated
9	CONGRESS NAGAR	7851.2	1148.5	317.300	Side	Elevated
10	RAHATE COLONY	8602.6	750.4	320.400	Side	Elevated
11	AJNI SQUARE	10198.7	1622.1	316.300	Side	Elevated
12	CHHATRAPATI SQUARE	11166.3	1041.6	318.600	Side	Elevated
13	JAIPRAKASH NAGAR	11971.6	895.2	320.000	Side	Elevated
14	UJJWAL NAGAR	12986.6	1036.1	311.000	Side	Elevated

	Name of Station	Chainage (in m)	Distance from previous station (in m)	Rail level (in m)	Platform type	Alignment
15	AIRPORT	13754.9	926.8	313.000	Side	Elevated
16	NEW AIRPORT	15194.4	2396.5	298.000	Side	At-Grade
17	KHAPRI	16469.5	1275.2	308.700	Side	At-Grade
	Dead End	16290.0				

Line -2 (East-West Corridor) : Prajapati Nagar to Lokmanya Nagar

A total of 19 Stations have been planned along the proposed EW Corridor This corridor originates from Prajapati Nagar and runs westwards, through Vaishnodevi Chowk, Ambedkar Chowk, Telephone Exchange, Chitar Oli Chowk, Agrasen Chowk, Doser Vaisya Chowk, Nagpur Railway Station, Sitaburdi, Jhansi Rani Square, Institute of Engineers, Shankar Nagar Square, LAD chowk, Dharmpeth College, Subhash Nagar, Rachna (Ring road Junction), Vasudev Nagar, Bansi Nagar to Lokmanya Nagar. The entire corridor is elevated. The total length of the corridor is 18.288 kilometer. All stations are elevated stations and Sitaburdi station is an interchange Station. Average inter-station distance is 1.00km approximately varying from 0.65km to 1.29km depending upon the site, operational and traffic requirements. The sequence of stations with their respective chainages and locational and platform characteristics is presented in **Table 0.11B**

Table 0.11 B: EW Corridor :
Sequence of Stations with Chainages and Locational & Platform Characteristics

	Name of Station	Chainage (in m)	Distance from previous station (in m)	Rail level (in m)	Platform type	Alignment
	Dead End	-252.5				
1	Prajapati Nagar	0.0	252.5	301.0	Side	Elevated
2	Vaishno Devi Chowk	1228.3	1228.3	300.3	Side	Elevated
3	Ambedkar Chowk	1947.3	719.6	308.3	Side	Elevated
4	Telephone Exchange	3131.4	1186.6	311.8	Side	Elevated
5	Chitar Oli Chowk	3950.2	812.8	311.6	Side	Elevated
6	Agrasen Chowk	4763.9	803.6	315.6	Side	Elevated
7	Doser Vaisya Chowk	5580.4	813.8	321.8	Side	Elevated
8	Nagpur Railway station	6464.4	874.0	315.7	Side	Elevated
9	Sitaburdi Interchange	7707.7	1243.3	320.1	Side	Elevated
10	Jhansi Rani Square	8354.3	646.3	313.8	Side	Elevated

	Name of Station	Chainage (in m)	Distance from previous station (in m)	Rail level (in m)	Platform type	Alignment
11	Institute Of Engineers	9717.2	753.2	315.4	Side	Elevated
12	Shankar Nagar Square	10114.9	397.7	316.0	Side	Elevated
13	Lad Chowk	10873.1	758.2	313.1	Side	Elevated
14	Dharampeth College	12030.7	1157.6	320.6	Side	Elevated
15	Subhash Nagar	12847.1	816.4	326.0	Side	Elevated
16	Rachana Ring Road Jn.	14051.1	1204.0	336.8	Side	Elevated
17	Vasudev Nagar	15173.0	912.0	345.2	Side	Elevated
18	Bansi Nagar	16131.6	857.7	338.3	Side	Elevated
19	Lokmanya Nagar	17732.6	1601.0	333.4	Side	Elevated
	Dead end	18105.0	372.4			

Site specific plans for the stations were prepared and put up in the respective chapter.

0.7 TRAIN OPERATION PLAN

0.7.1 Operation Philosophy

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

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

0.7.2 Train Operation Plan

0.7.2.1 Salient Features

- Running of services for 19 hours of the day (5 AM to Midnight) with a station dwell time of 30 seconds. No services are proposed between 00.00 hrs to 5.00 hrs, which are reserved for maintenance of infrastructure and rolling stock.
- Make up time of 5-10% with 8-12% coasting.
- Scheduled speed for these corridors has been assumed as:

  Line 1: North – South Corridor

  - 'Automotive Sqre to Congress Nagar' section: 32 kmph
  - 'Congress Nagar to Depot Station' section: 35 kmph

Line-2: East-West Corridor

- Prajapati Nagar to Lokmanya Nagar section: 36 kmph
- Agrasen Chowk to Subhash Nagar section: 29 kmph

8.7.2.2 Train formation

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

Composition

DMC : Driving Motor Car

TC : Trailer Car

Capacity (@ 6 passengers per square meter of standee area)

Driving Motor Car (DMC) : 247 (43 seated + 204 standing)
Trailer Car (TC) : 270 (50 seated + 220 standing)
3 Car Train : 764 (136 seated + 628 standing)

8.7.2.3 PHPDT capacity provided

Table 8.13: PHPDT capacity provided

Description	YEAR			
	2018	2021	2031	2041
North – South Corridor				
Cars/trains	3	3	3	3
Head way (Minutes)	6.0/12	5/10	4/8	3/6
Max. PHPDT Demand	10089	10936	12604	10723
PHPDT Capacity Available	7640 (8730*)	9168 (10476*)	11460 (14560*)	15282 (19402*)
East – West Corridor				
Cars/trains	3	3	3	3
Head way (Minutes)	6.5/13	6/12	4.5/9	3.5/7
Max. PHPDT Demand	7748	6480	9906	11882
PHPDT Capacity Available	7052 (8062*)	7640 (8730*)	10187 (12973*)	13097 (16683*)

* @ 8 persons per square meter of standee area

0.7.2.4 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 in respective chapter & has been tabulated below:

Table 0.13 : Year wise rake requirement

Corridor	Year	No. of Rakes	Rake Consist	No. of cars
North – South Corridor	2016	11	3 car	33
	2021	13	3 car	39
	2031	18	3 car	61
	2041	20	3 car	63
East – West Corridor	2016	12	3 car	36
	2021	13	3 car	39
	2031	17	3 car	51
	2041	20	3 car	60

0.8 ROLLING STOCK

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

0.8.1 Coach Size

The following optimum size of the coach has been chosen for this corridor as mentioned in **Table 0.14**

Table 0.14: Size of the coach

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

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

0.8.2 Passenger Carrying Capacity

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

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

3-car Train: DMC + TC + DMC

Table 0.15: Carrying Capacity of Medium Rail Vehicles

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

NORMAL - 3 Person/sq. m of standee area, CRUSH - 6 Person/sq. m of standee area

0.9 SYSTEM OF TRACTION AND POWER TARIFF

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 400 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 1500 KW, which will increase to 2000 KW in the year 2041

Keeping in view of the train operation plan and demand of auxiliary and traction power requirements projected for the year 2016, 2021, 2031 and 2041 are summarized in **Table 0.16** -

Table 0.16: Power Demand Estimation (MVA)

Corridor		Year			
		2016	2021	2031	2041
North-South Corridor – 1 Automotive Square to KHAPRI [19.658 kms ; 15 elevated Stations & 2 at Grade Station]	Traction	4.32	5.01	5.84	7.20
	Auxiliary	7.72	7.84	9.14	11.43
	Total	12.04	12.85	14.98	18.63
East West Corridor – 2 Prajapati Nagar to Lokmanya Nagar [18.557 kms ; 19 Elevated Stations]	Traction	4.24	4.57	5.73	7.01
	Auxiliary	8.34	8.46	9.88	12.45
	Total	12.58	13.03	15.61	19.46

0.10 MAINTENANCE DEPOT

0.10.1 Depot-cum-Workshop

It is proposed to establish one depot- cum- workshop near Khapri Station in MADC Land for North South Corridor and one depot- cum- workshop in the land belonging to SRP near Lokmanya Nagar for East West Corridor with following functions:

a) **Depot- cum- workshop for North South Corridor (Line 1)**

(i) Major overhauls of all the trains of Line 1.
(ii) All minor schedules and repairs of Line 1.
(iii) Lifting for replacement of heavy equipment and testing thereafter of Line 1.
(iv) Repair of heavy equipments of Line 1.

b) **Depot- cum- workshop for East West Corridor (Line 2)**

(i) Major overhauls of all the trains of Line 2.
(ii) All minor schedules and repairs of Line 2.
(iii) Lifting for replacement of heavy equipment and testing thereafter of Line 2.
(iv) Repair of heavy equipments of Line 2.

0.10.2 The Depot planning near Khapri Station for North South Corridor and near Lokmanya Nagar for East West Corridor is based on following assumptions:

(i) Enough space should be available near Khapri Station for North South Corridor and near Lokmanya Nagar for East West Corridor for establishment of a Depot- Cum-workshop.
(ii) All inspection, workshop lines and stabling lines are designed to accommodate two trainsets of 3- car each.
(iii) All stabling lines are planned in the proposed depot-cum-workshop assuming adequate space availability. In case of space constraints, if any, stabling facilities may need to be created at terminal stations or elsewhere to cater to the required stabling 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.

0.11 SIGNALLING

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

0.11.1 Standards

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

Table 0.17: Standards of Signalling System

Description	Standards
• Interlocking	Computer based Interlocking adopted for station having switches and crossing. All related equipment as far as possible will be centralised in the equipment room at the station. The depot shall be interlocked except for lines mainly used for workshop lines, inspection shed lines etc.
• Operation of Points	With Direct current 110V D.C. point machines or 380 volts 3 phase, 50 Hz. AC point machines.
• Track Circuit (if used)	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

Description	Standards
• Train protection system	Automatic Train Protection system (CBCT based). The system architecture shall provide for redundancy.
• Train Describer System	Automatic Train Supervision system. Movement of all trains to be logged on to a central computer and displayed on workstations in the Operational Control Centre and at the SCR. Remote control of stations from the OCC. The system architecture shall provide for redundancy.
• Cables	Outdoor cables will be steel armoured as far as possible.
• Fail Safe Principles	SIL-4 safety levels as per CENELEC standard for signal application.
• Immunity to External Interface.	All data transmission on telecom cables/OFC/Radio. All Signaling and telecom cables will be separated from power cables. CENELEC standards to be implemented for EMC.
• Train Working under emergency	Running on site with line side signal with speed automatically restricted between 15-25 kmph.
• Environmental Conditions	Air-conditioners for all equipment rooms.
• Maintenance philosophy	Philosophy of continuous monitoring of system status and preventive & corrective maintenance of Signaling 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.

0.12 TELECOMMUNICATION AND AUTOMATIC FARE COLLECTION

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

0.12.1 Technology

The Technologies proposed to be adopted for telecommunication systems are shown in **Table 0.15** below:-

Table 0.15: Technologies Proposed for Telecommunication Systems

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. Larger exchange is required at OCC/Depot depending upon the actual users
• 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 synchronization 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 coordination. Card/module level replacement shall be done in the field and repairs undertaken in the central laboratory/manufacturer's premises.

0.12.2 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.

0.12.3 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.

0.12.4 Technology

The technology proposed for AFC systems are as given under in **Table 0.18**

Table 0.18: Technologies Proposed for AFC Systems

Standards	Description
• Fare media	a) Contactless smart card – For multiple journeys. b) Single Journey : Contactless Token
• 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 Hand capped Gate -gate for disabled people.

Standards	Description
• 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/Recharge value Machine and portable ticket decoder	Ticket reader shall be installed near EFO for passengers to check information stored in the ticket. This shall also be used as a Add Value Machine to allow passenger to tap and add value to his card which has been topped up through internet.
• UPS (uninterrupted power at stations as well as for OCC).	**Common UPS of S&T system will be utilised.**

8.13 DISABLED FRIENDLY FEATURES

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.

0.14 ENVIRONMENT IMPACT ASSESSMENT

0.14.1 Environmental Impacts

A total of 101 structures (74 in EW Corridor and 27 in NS Corridor) of various dimensions shall be affected by the proposed project. Majority of the structures are privately owned.

According to the results of the present study, it is found that about 387 trees are likely to be lost due to the project. Four trees have to be planted for each tree cut. Hence 1548 trees to be planted. These trees would have occupied about 50 ha in the forest. No non-forest land is available, hence 50 ha have to be re-afforested in degraded forests in or around Nagpur.

Utility/Drainage Problems: The alignment will cross drains/nallahs large number of sub-surface, surface and utility services, viz. sewer, water mains, storm water drains, telephone cables, overhead electrical transmission lines, electric pipes, traffic signals etc. These utilities/ services are essential and have to be maintained in working order during different stages of construction by temporary/permanent diversions or by supporting in position.

0.14.2 Positive Environmental Impacts

Employment Opportunities: Manpower will be needed in various activities during construction. In operation, about 40 persons per kilo meter length of the corridor, ie (approx. 1,765 persons) will be employed for operation and maintenance of the proposed system. Thus the project would provide substantial direct employment; besides, more people would be indirectly employed in allied activities and trades.

Enhancement of Economy: The construction of Nagpur Metro will facilitate the population to move from one end of the city to another. The proposed transport facility will facilitate rural population to move quickly towards urban centres and return there from. With the development of Nagpur Metro, it is likely that more people will be involved in trade, commerce and allied services.

Mobility: Metro lines will facilitate people to move quickly towards urban centres and return from there. Any reduction in number of private vehicles will results in reduction of accidents which will involve savings from damage to vehicles and savings towards medical and insurance expenses to persons involved in accidents.

Less Fuel Consumption: On implementation of the project both petrol and diesel consumption will get reduced due to shift of passengers from road to rail and also due to decongestion on road.

Less Air Pollution: With the construction of metro, there will be less vehicular traffic by road, and consequently less air pollution, and hence the air quality will improve.

Reduction in Traffic Congestion: Metro will reduce the congestion and journey time on roads because of diversion of some traffic to Metro. Reduction in traffic congestion will save the necessary capital investment and vehicle operating cost as well as increase in time saving per vehicle.

Environmental Management Plan: The project will provide higher living standard, better quality of life, less travel time, better connectivity and transport facilities. The management plans are essential to ensure that stress/ loads on the systems are within carrying capacity. The management plan aims at maintaining the environmental quality of project area minimal in pre-project stage. An environmental management strategy plans were developed to mitigate the adverse impacts.

0.15 SECURITY MEASURES FOR A METRO SYSTEM

Metro is emerging as the most favoured mode of urban transportation system. The inherent characteristics of metro system make it an ideal target for terrorists and miscreants. Metro systems are typically open and dynamic systems which carry thousands of commuters. Moreover the high cost of infrastructure, its economic importance, being the life line of city high news value, fear & panic and mass causalities poses greater threat to its security. Security is a relatively new challenge in the context of public transport. It addresses problems caused intentionally. Security differs from safety which addresses problems caused accidentally. Security problems or threats are caused by people whose actions aim to undermine or disturb the public transport system and/or to harm passengers or staff. These threats range from daily operational security problems such as disorder, vandalism and assault to the terrorist threat.

0.15.1 Necessity of Security

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

0.15.2 Three Pillars of Security

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

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

0.16 DISASTER MANAGEMENT PLAN FOR A METRO RAIL SYSTEM

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

0.16.1 Need for Disaster Management Measures

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

0.16.2 Objectives:

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

- Save life and alleviate suffering.
- Provide help to stranded passengers and arrange their prompt evacuation.
- Instil a sense of security amongst all concerned by providing accurate information.
- Protect Metro Rail property.
- Expedite restoration of train operation.
- Lay down the actions required to be taken by staff in the event of a disaster in

- Delhi Metro Rail Corporation in order to ensure handling of crisis situation in coordinated manner.

To ensure that all officials who are responsible to deal with the situation are thoroughly conversant with their duties and responsibilities in advance. It is important that these officials and workers are adequately trained in anticipation to avoid any kind of confusion and chaos at the time of the actual situation and to enable them to discharge their responsibilities with alertness and promptness.

0.17 MULTI MODAL TRANSPORT INTEGRATION

The Metro Transport Network in Nagpur will cover a length of approximately 38 kms. It will be augmented through enhanced facility of criss-cross interchanges to other modes and reduce the travel time of commuters. While Metro provides a high capacity corridor to carry the passengers, the need for integration of with other secondary/intermediate transport modes is getting highlighted more than ever to ensure a seamless transfer. This concept is to provide at least last mile or half mile connectivity to the commuters with in their places of stay. Accordingly top priority to this issue, MoUD has laid down policy guidelines to include the need and provisioning of all public, IPT and private modes in the DPRs for the Metro Systems. (Ref.: MoUD (Urban Transport Wing) Advisory Circular no. K-14011/1/2007-UT-IV dated 30.08.2013)

The share of various modes of secondary/ intermediary modes of travel is complex and debatable issue which is dependent on a large number of variables like available road width, penetration in the residential areas, Road condition, distance from the existing Metro Stations, availability of parking and lay out and availability of circulating areas at the Metro Stations, Business centre or markets & existing traffic densities. These factors relate with each other and evolve with development of new modal mix of transport, infrastructure and changes with the passage of time . Even though for a given urban transport scenario, optimal mode share may be determined from computer based models but actual optimal mode share is never achievable on the road due to dynamic nature of demand and supply of transport modes.

0.18 COST ESTIMATES

Cost estimates have been prepared based on the rates accepted for Delhi Metro duly escalated up to June 2012 level.

Corridor - 1: NORTH-SOUTH CORRIDOR (AUTOMOTIVE SQUARE TO KHAPRI)

The overall capital cost for Corridor 1 at June 2012 price level, works out to Rs. 3013 Crore, excluding taxes and duties, but including general charges & design charges @ 3% on all items except land and 3% contingencies on all items. Estimated total taxes & duties are Rs. 428Crore.

Corridor 2: EAST WEST CORRIDOR (LOKMANYA NAGAR TO PRAJAPATI NAGAR)

The overall capital cost for Corridor-2, at June 2012 price level, works out to Rs. 2584 Crore excluding taxes and duties, but including general charges & design charges @ 5% on all items except land and 3% contingencies on all items. Estimated total taxes & duties are Rs. 443 Crore.

0.19 FINANCING OPTIONS, FARE STRUCTURE AND FINANCIAL VIABILITY

0.19.1 The Nagpur Metro project- North South corridor (Automotive Square to KHAPRI) and East West corridor (Prajapati Nagar to Lokmanya Nagar), covering a total route length of 38.215 Kms is proposed to be constructed with an estimated cost as per details are shown in **Table 0.20** below:-

Table 0.20: Completion Cost

(Rs./Crore)

Corridor No	Name of Corridor	Distance (KMs)	Estimated Cost without Central taxes at June-2012 Price Level	Estimated Cost with Central taxes at June-2012 Price Level	Completion Cost
I	North-South Corridor	19.658	3015.00	3455.00	**8680**
II	East-West Corridor	18.557	2584.00	3427.00	
	Total	**38.215**	**5599.00**	**6882.00**	

The estimated cost at June-2012 price level also includes an amount of Rs.40 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.

0.19.2 Financial Internal Rate of Return (FIRR)

The Financial Internal Rate of Return (FIRR) obtained for 30 years business model including construction period is **10.35%**.

0.19.3 Funding Pattern

The funding pattern has been worked out under two models viz., SPV model and BOT Model.

a) The proposed funding with Central Taxes assumed under the SPV model is placed in Table 0.21 as under: -

Table 0.21: Funding pattern under SPV model

(Rs/Crore)

Particulars	With Taxes & Duties	
	Amount (Rs/Crore)	% of contribution
Equity by GOI	1114.00	12.83%
Equity by GOM	1114.00	12.83%
SD by GOM for central Taxes (50%)	441.00	5.08%
SD by GOI for Central Taxes (50%)	441.00	5.08%
SD by GOM for State Taxes	250.00	2.88%
SD by GOM for Land	644.00	7.42%
Nagpur Improvement Trust Contribution	421.00	4.85%
Nagpur Municipal Corporation Contribution	421.00	4.85%
JICA Loan @ 1.40% PA/Market Borrowing @12%	3825.00	44.07%
Total	8680.00	100%

ii) The proposed funding with Central Taxes assumed under the BOT model is placed in Table 0.22 as under: -

Table 0.22 Funding pattern under BOT model (with central taxes)

Particulars	Amount (Rs/Crore)	% of contribution
VGF by GOI	1555.40	20.00%
VGF by GOM	524.00	6.75%
Equity by Concessionaire	1899.00	24.42%
Concessionaire's debt @12% PA	3799.00	48.83%
Total	7777.88	100.00%
Land Free by GOM	644.00	
State Taxes by GOM	250.00	
IDC	445.00	
Total including IDC	9136.88	

0.19.4 Cost Investment Break Up

It is assumed that commercial operation shall start from April-2018. The Revenue Opening Date (ROD) has been assumed as 01.04.2018. The total completion costs duly escalated is shown in Finance Chapter, which has been taken as the initial investment. The cash flow of investments based on completion cost is in **Table 0.23** as below.

Table 0.23: Year wise Investment-With Central Taxes

Financial Year	Cost at June 2013 Price Level	Completion Cost
2013-14	447.00	452.00
2014-15	944.00	1021.00
2015-16	1550.00	1874.00
2016-17	1883.00	2412.00
2017-18	1430.00	1982.00
2018-19	497.00	740.00
2019-20	124.00	168.00
Total	**6883.00**	**8800.00**

0.20 ECONOMIC ANALYSIS

0.20.1 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 0.24 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 0.24**. 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 88% of the market cost.

Table 0.24: Benefit Components due to Metro

	Benefit Components	Economic Factors
1	Construction Cost	[illegible]
2	Maintenance Cost	[illegible]
3	Annual Time Cost Saved by Metro Passengers	[illegible]
4	Annual Fuel Cost Saved by Metro Passengers	[illegible]

	Benefit Components	Economic Factors
5	Annual Vehicle Operating Cost Saved saved by Metro Passengers	90%
6	Emission Saving Cost	100%
7	Accident Cost	100%
8	Annual Time Cost Saved by Road Passengers	90%
9	Annual Fuel Cost Saved by Road Passengers	90%
10	Annual Infra Structure Maintenance Cost	90%
11	Overall economic factor for the benefit components	90%

The project cost comprises capital cost, operation and maintenance cost including:

- Capital cost of infrastructure (civil engineering, land, track, power supply, traction system, signaling and telecommunications, etc.) and rolling stock.
- Operating cost of metro.

The benefit stream that has been evaluated and quantified includes:

- Capital and operating cost (on present congestion norms) of carrying the total volume of passenger traffic by existing bus system and private vehicles in case metro project is not taken up.
- Savings in operating costs of all buses and other vehicles due to de-congestion including those that would continue to use the existing transport network even after the metro is introduced.
- Savings in time of commuters using the metro over the existing transport modes because of faster speed of metro.
- Savings in time of those passengers continuing on existing modes, because of reduced congestion on roads.
- Savings on account of prevention of accidents and pollution with introduction of metro.
- Savings in road infrastructure and development costs that would be required to cater to increase in traffic, in case metro is not introduced.
- Savings in fuel consumption on account of less number of vehicles on road and decongestion effect with introduction of metro are included in those of vehicle operating cost.

The Economic Internal Rate of Return (EIRR) is worked out as 17.76% for this project.

0.21 IMPLEMENTATION STRATEGY AND PROJECT IMPLEMENTATION

0.21.1 To ensure that the project is implemented as targeted in this report it has to get the visible positive support from Nagpur Administration, GoM and GoI. To enable Nagpur metro project to be implemented without any loss of time and cost overrun, effective institutional arrangements would need to be set up. Presently, Nagpur Improvement Trust (NIT) is dealing with this Project but there is need to have an SPV responsible entirely for this project.

0.21.2 Special Purpose Vehicle

Special Purpose Vehicle (SPV) is a legal entity established for implementation of specific projects and is used to isolate the governing authority / stakeholder company from operational and financial risk. SPV has a management dedicated to the accomplishment of the specific objective. The SPV also allows securitization of assets without disturbing the managerial relationship. Under the arrangement, any predictable income stream generated by secure assets can be securitised. Three models have been analyzed and summarized below:-

a) Implementation through Government

Under this model, the entire project development, implementation and operation is undertaken and financed by the government authority. Some recent examples of metro rail projects implemented directly through Government agencies are as under:

- Delhi
- Bangalore
- Chennai
- Jaipur
- Kolkata

b) Implementation through BOT model

BOT approach assumes that the metro is given to a private partner (Concessionaire) to develop and operate over the concession period. The private partner brings requisite funds and the efficiency of private sector management in the implementation as well as operation of the project. NMRC's role in this option is limited to that of a regulatory authority. Thus NMRC would monitor the implementation of the project such as laying down the passengers fares, targets for the minimum number of services to be run by the private partner, frequency, punctuality and reliability of these services, etc. There are only two projects namely Hyderabad and Mumbai being implemented through BOT model. The success of this model in India is still to be known.

c) Implementation through PPP model

Under this mode, the government entity undertakes all civil works and the associated station work, while all other works like rolling stock, signaling and telecom, track laying work are undertaken by the private partner along with management of the metro service over the concession period. This enables the client to monitor and adhere to quality and construction timelines for the project in a better way. Implementation of airport express line in Delhi is the only example of this model in India.

d) Proposed Implementation Model

Due to very low FIRR and uncertainties of getting the agencies for taking up this work on BOT/PPP model, it is proposed that implementation of Nagpur Metro should be done on DMRC/BMRC model.

0.19 CONCLUSIONS AND RECOMMENDATIONS

i) It has been established that a Light Capacity Metro System (MRTS) with carrying capacity of about 20,000 PHPDT would be adequate to meet not only the present traffic demand but also cater to the demand for the next 30 years.

ii) After examining the various options for execution of Nagpur Metro Rail Project, it is recommended that the project be implemented through government funding, implementing through an SPV namely " Nagpur Metro Rail Corporation (NMRC)" registered under the Companies Act, 1956. This SPV should be a PSU of GoM and GoI. After the approval of State Government, DPR to be sent to the Secretary, Ministry of Urban Development, Government of India, advising GOI of the State Government's intention to take up the Project on government funding basis and requesting for the latter's "In Principle" clearance to go ahead with the Project.

Key plan of Nagpur Metro is shown in Fig-0.1

FIG : 0.1

CHAPTER 1

INTRODUCTION 

TABLES

FIGURES

CHAPTER-1

INTRODUCTION

1.1 BACKGROUND

1.1.1 FACTS ABOUT NAGPUR

Nagpur is the third largest city of Maharashtra and also the winter capital of the state. With a population of approximately 25 lakhs, Nagpur Metropolitan Area is the 13th largest urban conglomeration in India. It has also recently been ranked as the cleanest city and the second greenest city of India. In addition to being the seat of annual winter session of Maharashtra state assembly "Vidhan Sabha", Nagpur is also a major commercial and political center of the Vidarbha region. It is also known as "Orange City" for being a major trade center of oranges that are cultivated in the region.

Nagpur lies precisely at the center of the country with the Zero Mile Marker indicating the geographical center of India. The city was founded by the Gonds but later became part of the Maratha Empire under the Bhonsles. The British East India Company took over Nagpur in the 19th century and made it the capital of the Central Provinces and Berar. After the first reorganisation of states, the city lost its capital status but according to the informal "Nagpur Pact" between political leaders, it was made the second capital of Maharashtra. **Nagpur** is also declared, "Tiger Capital of India " as it connects many Tiger Reserves in India to the world.

Etymology

The Nag River, a tributary of the Kanhan River, flows in a serpentine path and is therefore named "Nag", the Marathi word for snake. And hence, the river and city is named as Nagpur. During British times the city used to be referred to as Nagpore. While others says that the river flows through the old city of Nagpur and hence the city is named after this river. "Pur" is a common suffix given to cities, villages and towns across India, and is often simply translated "city". The seal of Nagpur Municipal Corporation depicts a cobra in the water of a river.

Geography and Climate

Geography

Nagpur lies on the Deccan plateau of the Indian Peninsula and has a mean altitude of 310.0 meters above sea level.The underlying rock strata are covered with alluvial deposits resulting from the flood plain of the Kanhan River. In some places these give rise to granular sandy soil. In low lying areas which are poorly drained, the soil is alluvial clay with poor permeability characteristics. In the eastern part of city crystalline metamorphic rocks such as gneiss, schist and granites are found, while in the northern part yellowish sand stones and clays of the lower Gondwana formations are found.

Nagpur city is dotted with natural and man-made lakes with Ambazari lake being the largest. Other natural lakes include Gorewada Lake and Telangkhedi lake. Sonegaon lake and Gandhisagar lake are man-made lakes created by the city's historical rulers. Nag river, Pili nadi along with nalas form the natural drainage pattern for the city. Nagpur is known for its greenery, and was judged as the cleanest and second greenest in India after Chandigarh.. Recently, Government of India selected Nagpur as a Model City for **National Clean Air Mission** by allocating 25 crores for the plan. This project will be handled by Nagpur's own NEERI (National Environmental Engineering Research Institute).

Climate

As it is located at centre of Indian peninsula far from the Bay of Bengal and the Arabian Sea, Nagpur has a tropical wet and dry climate with dry conditions prevailing for most of the year. It receives an annual rainfall of 1,205 mm (47.44 in) from monsoon rains during June to September.The highest recorded rainfall was 304 mm on 14 July 1994.Summers are extremely hot lasting from March to June, with maximum temperatures occurring in May. Winter lasts from November to January, during which temperatures can drop below 10 °C (50 °F). The highest ever recorded temperature in the city is 48°C, while the lowest is 3°C.

1.1.2 DEMOGRAPHICS

As per provisional reports of Census India, population of Nagpur in 2011 is 2,405,421; of which male and female are 1,226,610 and 1,178,811 respectively. Although Nagpur city has population of 2,405,421; its urban UA / metropolitan population is 2,497,777 of which 1,275,750 are males and 1,222,027 are females[1]. Details of population of Nagpur city and Nagpur Metropolitan Area are given in Table 1.1 A, 1.1B

[1] http://www.census2011.co.in/census/city/353-nagpur.html

Table 1.1 A :Census India, population of Nagpur City in 2011

Nagpur City	Total	Male	Female
Population	2,405,421	1,226,610	1,178,811
Literates	2,016,588	1,060,339	956,249
Children (0-6)	237,888	122,851	114,034
Average Literacy (%)	93.13	95.19	89.29
Sex ratio	961		
Child Sex ratio	931		

Table 1.1 B :Census India, population of Nagpur Metropolitan in 2011

Nagpur Metropolitan	Total	Male	Female
Population	2,497,777	1,275,750	1,222,027
Literates	2,095,415	1,102,636	992,781
Children (0-6)	248,678	129,522	119,156
Average Literacy (%)	93.17	96.20	90.02
Sex ratio	958		
Child Sex ratio	920		

The population growth rate of Nagpur City for last five decades is given in Table 1.1 C below:

Table-1.1 C

Year	Population Nagpur City	Growth Rate (%)
1971	866000	34
1981	1317000	43
1991	1622618	34
2001	2051320	26
2011	2405421	17

1.1.3 VEHICLE POPULATION IN NAGPUR CITY (As per Motor Transport Statistics of Maharashtra)

Motor Vehicles Population on Road as on 31st March, 2011 & 31st March, 2012 in Nagpur City are as below:

Table.1.3*

Motor Vehicles Population in Nagpur City

S.No.	Category	31st March, 2011	31st March, 2012
1	Motor Cycles	356102	423607
2	Scooters	253320	318889
3	Mopeds	283310	283771
TOTAL OF TWO WHEELERS		**[illegible]**	**[illegible]**
4	Motor Cars	89479	95233
5	Jeeps	25244	25727
6	Station Wagons	842	842
7(A)	Taxi meter fitted	0	5
7(B)	Taxi Tourist Cabs	2881	2907
8	Autorickshaws	16417	17149
9	Stage Carriages	1741	1741
10	Contract Carriages	735	899
11	School Buses	376	613
12	Private Service Vehicles	1327	1314
13	Ambulances	526	567
14	Art. & Mult.Veh.	806	825
15	Trucks & Lorries	12058	13824
16	Tankers	2375	2532
17	Delivery Van (4 Wheelers)	12879	14183
18	Delivery Van (3 wheelers)	6161	6844
19	Tractors	5385	5402
20	Trailers	5263	5548
21	Others	1153	1245
TOTAL OF ALL TYPES		**[illegible]**	**[illegible]**

*RTO Nagpur figures

1.1.4 RAIL AND AIR TRANSPORT IN NAGPUR CITY

A total of 180 trains from various destinations halt at Nagpur. These include various passenger, express, mail,Duronto, Rajdhani, Garib Rath trains. Of these 26 terminates/originate from Nagpur. Almost 1.5 lakh passengers board/alight daily at different stations in Nagpur. Of which Nagpur Central Station alone is used by approximately 100,000 passengers. Ajni, Itwari and Kalamana are other important railway stations within Nagpur. Nagpur Central is mainly used for long distance travel, whereas Ajni, Itwari station are used for commuting nearby areas such as Butibori, Ramtek etc. The city is the Divisional Head Quarters for the Central Railway and South East Central Railway Zone of Indian Railways.

The Airport handles around 4,000 passengers per day and caters to 8 Domestic Airlines connecting Nagpur to 12 domestic destinations including Mumbai, Delhi, Pune, Kolkata, Hyderabad, Raipur etc and a few (connecting flights) international Airline to Singapore etc.

1.1.5 POINTS FROM OTHER FEASIBILITY SURVEY DONE FOR NAGPUR

1.1.5.1 The Nagpur Municipal Corporation (NMC) had awarded the project titled **"Preparation of Master Plan/Perspective Plan for Transportation System of Nagpur City 2031"** to L&T-Ramboll Consulting Engineers Limited in June 2007. The study aims to update the long-term transportation strategy for NMC and identify a practicable and effective investment programme up to 2031. Consultants commenced the study in the month of June,2007 and completed in June,2008. L&T Ramboll Consulting Engineers Limited had carried out the Comprehensive Traffic and Transportation Study and prepared Transportation Master Plan for Nagpur city commissioned by NMC. As a part of study consultants had:

1. Reviewed all the relevant secondary data related to landuse, travel pattern and demographics, supply of transport infrastructure and road safety etc.Major traffic generators such as MIHAN (Multi-modal International Cargo Hub and Airport at Nagpur), Industrial Areas such as Butibori and Hingna etc were taken into account to forecast future population and employment.
2. Conducted primary traffic surveys including household surveys (2% of sample households)
3. Developed Travel demand models using the TRIPS/CUBE Software and validated for the base year and using the validated software forecasted travel demand for 2011,2021 and 2031 for two scenarios (do nothing) and do something (improved public transportation scenario)
4. Based on the outputs of travel demand models and studying the availability of present transportation infrastructure consultants have recommended short term,medium term and long term improvement proposals to be implemented from 2008-2031.

1.1.5.2 Salient Features of Nagpur Current Traffic and Transportation Scenario (L&T-Ramboll study) :

- Nagpur is the second capital of Maharashtra and is located in the geo-graphical centre of India with good road and rail network.
- Nagpur acts as transhipment place for areas like Chattisgarh and Eastern Maharashtra.
- 2008 population of NMC as 24.47 lakhs and average density as 112 pph. (as per report)

- Main public transport providers are MSRTC,BOT bus operator (Star Bus).
- Poor public transportation system (less than 5% of the total trips).
- Non-motorised modes walk and bicycle constitutes 58% of total trips.
- Motorised transport is dominated by two wheelers (29%).
- Predominant on-street parking and absence of off-street parking facilities.
- Current Vehicle Ownership is 11.37 lakh in which 3.87 lakhs are two wheelers.
- Poor mobility in some of the areas such as Itwari.
- Absence of truck terminals as Nagpur is proposed as future Road Cargo hub.
- Development of Multi-Modal Hub Airport in Nagpur (MIHAN) in 4354 hectares is underway.

1.1.5.3 Some of the important findings of the L&T-Ramboll study are as follows :

- Forecasted population of NMC by for 2021 and 2031 is 33.4 lakhs and 46.7 lakhs respectively.
- Forecasted Employment of NMC by for 2021 and 2031 is 12.4 lakhs and 16.8 lakhs respectively.
- MIHAN is going to generate around 2.6 lakhs employment by 2015 (fully operational) and 4.3 lakhs by 2031.
- Total trips made by the residents of Nagpur in 2007 is 23.57 lakhs (without intra-zonal) and expected to increase to 56 lakhs by 2031.

1.1.5.4 Transportation improvement proposals (L&T-Ramboll study) are broadly classified into three categories based on the time horizon:

- Short Term Improvement Proposals (2008-2009)
- Medium Term Improvement Proposals (2009-2021)
- Phase-I (2009-2011)
- Phase-II (2012-2016)
- Phase-II (2017-2021)
- Long Term Improvement Proposals (2022-2031)

1.1.5.5 Some of the important proposals recommended by L&T-Ramboll Consulting Engineers Limited are:

- Improved bus system with a fleet comprising of Standard buses and Mini-buses. Standard buses will serve the major corridors whereas mini-bus services act as a feeder services and low demand corridors. In Short term (with in 2 year) fleet size of 375 buses (225 Standard buses and 150 mini buses) needs to be deployed to serve 2.5 lakhs passengers per day. In medium term (with 2 to 3 years) 500 buses needs to be deployed to serve 5 lakh passengers/day.In long term say by 2015, 750 buses needs to be deployed to serve 7.5 lakhs passengers/day.Coverage Area of Buses should be improved to 90% (At present it is less than 40%).
- Improved pedestrian facilities with min 2.5 m footpaths and FOBs/Subways.
- Bicycle lanes on pilot basis on several wide roads.

- Off-street parking facilities near important areas such as commercial areas, office areas, special generators such as religious places etc on PPP model especially in Sitabuldi, Sadar areas, transport terminals and at Ganeshpeth bus terminal.
- Construction of ROBs/RUBs/Bridges across rivers/flyovers.
- Development of Inner Circle ring road and Alternative north-South corridor to take predominately north-south demand.
- Improvement of Radial Roads such as Wardha Road to 6-lane configuration from existing 4-lane configuration by 2016.
- Inner Ring Road to be improved to 6-lane configuration with service road by 2016.
- Outer ring road to be planned after 2016 & will be funded by State and Central Governments.
- Construction of MRTS in phases 2012-16 and 2017-2021. It is envisaged 65 km of MRTS and 20 km commuter rail by 2031.
- Development of truck terminals at four places on PPP basis at Inner /Outer Ring Road.
- Creation of public transport infrastructure bus terminals/depots/bus procurement etc.
- Environment friendly policies such as use of CNG, favourable policies for public transport, more conducive environment for walking and bicycles.
- Development of Bus Terminals/Transport Terminals at Outer ring road.
- Additional BRTS/ MRTS Corridors in long term.
- Road Corridor parallel to Railway line to serve north-south traffic (feasibility to be ascertained).
- Development of Commuter rail system from Nagpur city to Butibori on the similar lines of Multi Modal Transport System (MMTS) in Hyderabad.
- Itwari Area redevelopment.

1.1.5.8 MRTS Corridors Proposed by L&T-Ramboll Consulting Engineers Limited

Several corridors of MRTS were studied and presented by L&T-Ramboll Consulting Engineers Limited, in their report.

Four different MRTS options were considered. The description of each alignment was presented in Chapter 4 of their report. Four different MRTS alignment options considered are :

Alignment-1 : Pardi Naka to Dahegaon (24.54 km with 23 Stations). The alignment option -1 starts at Pardi Naka and ends at Dahegaon. It passes through Central Avenue road, Central railway station, Ganeshpet Bus stand, Medical Chowk, Manewada Jn etc. **(Fig :1.2)**

Alignment-2 : Automotive Square to Dahegaon (23.54 km with 24 Stations) The alignment option -2 is starts at Automotive Square and ends at Dahegaon. It passes through Kamptee road, Itwari railway station, Central Avenue road, Medical Chowk, Manewada Jn etc., **(Fig :1.3)**

Alignment-3 : Transport Plaza to Dahegaon predominantly on NH-7 (27.3 km with 26 Stations) The alignment option 3 starts at Automotive Square and ends at Dahegaon. It passes through Indora, LIC Square, Kasturchand Park, Central railway station, Zero mile, Munje Chowk, NEERI, Chhatrapati Square, Manewada Jn etc. **(Fig :1.4)**

Alignment-4 : Transport Plaza to Dahegaon partially on NH-7 (24.2 km with 24 Stations) The alignment option 4 starts at Transport Plaza and ends at Dahegaon. This alignment option is combination of options 2 &3. It passes through Mahendra Nagar, Indora, Sadarbazar, Central railway station, CRS1 Depot, Medical Chowk, Manewada Jn etc **(Fig :1.5)**

1.1.6.7 From the study done by L&T-Ramboll Consulting Engineers Limited : Ridership for four MRTS alignments are worked out and presented in Table below. It can be observed that Alignment –3 is giving highest ridership compared to other three options. The ridership estimation for option 3 is 1.78 lakhs in 2011.

Table 1.3 Ridership Estimation for various Alignments

(Based on the study done by L&T-Ramboll Consulting Engineers Limited)

Year	Alignment - 1	Alignment - 2	Alignment - 3	Alignment - 4
2011	116400	122550	177269	171347
2021	230002	190801	333048	218813
2031	325746	279948	468172	311738

1.1.8 ALIGNMENTS PROPOSED BY DMRC IN JULY-2013 DPR

In early 2012 Nagpur Improvement Trust (NIT) requested DMRC to provide Consultancy services for preparation of a Detailed Project Report for Metro Rail System in Nagpur, Maharashtra initially for 30 Km which was revised to 42 Km in July 2012. Thereafter, DMRC has conducted Traffic Surveys, Topographical Surveys, Geotechnical Investigations and Environment Impact Assessment Survey.

Based on the different types of surveys done by DMRC, metro alignments has been finalized after repeated inspection of the road network, intersections, passenger traffic flow, traffic congestion, connectivity to important landuses.

Alignment of routes proposed by DMRC were as follows

Table 1.4 Alignment Proposed by DMRC

Alignment	Detail Route
Alignment-1 North-South Corridor (21.899 km, 17 Stations)	Automotive Square, along Kamptee Road, Wardha Road, Variety Square to Abhyankar Road, along Nag River alignment will fall on Humpyard Road, Rahate Colony Road, Wardha Road, Khamla Road, Airport, MIHAN Area
Alignment-2 East – West Corridor (18.265 km, 19 Stations)	From Prajapati Nagar, along Central Avenue Road, Railway Feeder Road, Munje Chowk, Jhansi Rani Chowk, North Ambajhari Road, Hingna Road, Lokmanya Nagar

1.3 FINAL ALIGNMENT FOR NAGPUR METRO

On 23.08.2013, a meeting presided by Shri S K Lohia, JS-MoUD,GoI was held at Nagpur to discuss the DPR. In that meeting, JS-MoUD,GoI expressed that the FIRR of the project should be at least 8%. Recently, MoUD has also issued advisory that FIRR of Metro Project should not be below 8%.

On 1.10.2013, a presentation on the DPR was made by M/s NIT to The Chief Minister, Government of Maharashtra. He was of the opinion to avoid underground alignment in MIHAN and also construct Maintenance Depot in the land belonging to State Govt Land. Subsequently, on 21.10.2013, a joint inspection of the NS corridor was done by VC&MD-MADC, Chairman-NIT, and Director Business Development-DMRC.

The original alignment of Corridor-I proposed was passing through Khamla Road, Airport Area after Sahakar Nagar and finally was ending at MIHAN. The alignment up to Old Airport Station was elevated, then for a length of 3.30 km, it was underground with one underground station named as New Airport Station and again elevated in MIHAN Area. Since the cost of underground section of the alignment is much more than the elevated section or the section at grade, alternative alignment was suggested for cost reduction, enhancement in PHPDT and to increase FIRR so that project becomes financially and economically viable.

The new proposed alignment suggested in the above inspection, was to pass through a 24m wide road adjacent to London Street after Sahakar Nagar Junction and was proposed to be taken to the east along 24m wide road and London Street up to Wardha Road. From the intersection at Wardha road, the elevated alignment was proposed to be on the central divider on the Wardha Road. After crossing existing intersection point of Wardha Road & Airport Road, the alignment was to be shifted to the MIHAN area. Alignment in this portion was proposed to be at grade and to run parallel to Wardha road upto ROB and existing railway line thereafter upto proposed Car depot.

But, while working on this modification of alignment, it was noticed that a very large number of properties were falling along the alignment due to sharp curve at the junction of Sahakar Nagar & 24 m wide road and also at the junction of 24m wide road & Wardha Road. Acquiring of these properties will be very tough and may delay the whole project.

Hence to avoid all such situation, it has been decided to take the alignment on Wardha Road only without going on Khamla Road.

Finally, NS Corridor will pass through Wardha Road after Congress Nagar Metro Station. After crossing existing intersection point of Wardha Road & Airport Road, the alignment will be shifted to the MIHAN area. Alignment in this portion will be at grade and will run parallel to Wardha road upto ROB and parallel to railway line thereafter up to proposed Car depot. 14m wide stretch of land between the railway boundary line and the road near proposed Container Depot of Container Corporation of India Ltd. will be affected by this proposed alignment of the Metro Rail as the proposed alignment passes through this stretch of land. 73 Ha land is available on the west side of railway line and south of existing flyover near Khapri station. Average width of this land is about 80m and is about 1800m long. This MADC land may be utilized for Car Depot. Similarly, Depot of EW Corridor has also been shifted to SRP Land near proposed Lokmanya Nagar Metro Station.

This has caused deletion of few earlier proposed metro stations on NS Corridor and addition of new stations on the same.

Final alignment for both the corridors is as below :

Table 1.8 FINAL ALIGNMENT

Alignment	Detail Route
Alignment-1 North-South Corridor (19.658 km, 17 Stations)	Automotive Square, along Kamptee Road, Wardha Road, Variety Square to Abhyankar Road, along Nag River alignment will fall on Humpyard Road, Ranade Colony Road, Wardha Road, Parallel to Railway Line, Khapri Station and finally in MIHAN Area near cancor depot
Alignment-2 East – West Corridor (18.557 km, 19 Stations)	From Prajapati Nagar, along Central Avenue Road, Railway Feeder Road, Munje Chowk, Jhansi Rani Chowk, North Ambajhari Road, Hingna Road, Lokmanya Nagar

Index Plan of the Proposed Nagpur Metro Rail is put up at Fig. No. 1.1

1.3 THE STRUCTURE OF THE DETAILED PROJECT REPORT

The report contains the chapters as mentioned below :-

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

Fig : 1.1

Index Plan of the Proposed Nagpur Metro Rail

Fig 1.3
Alignment-1 of MRTS Corridors Proposed by L&T-Ramboll Consulting Engineers Limited

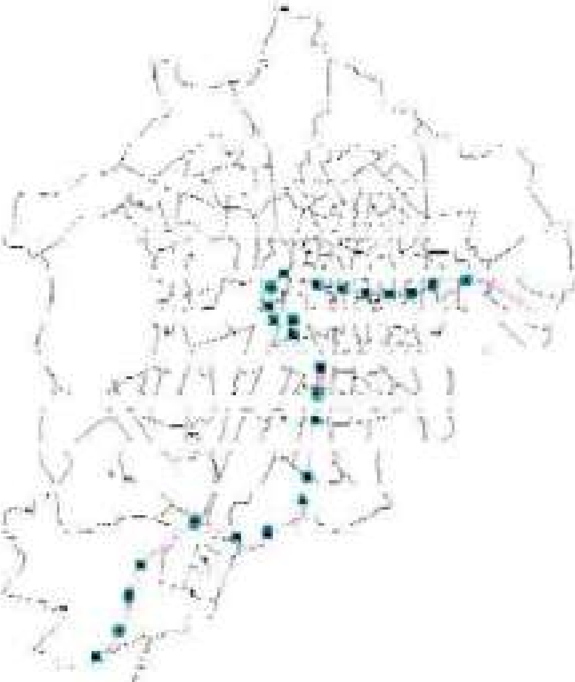


Fig :-1.3

Alignment-2 of MRTS Corridors Proposed by L&T-Ramboll Consulting Engineers Limited

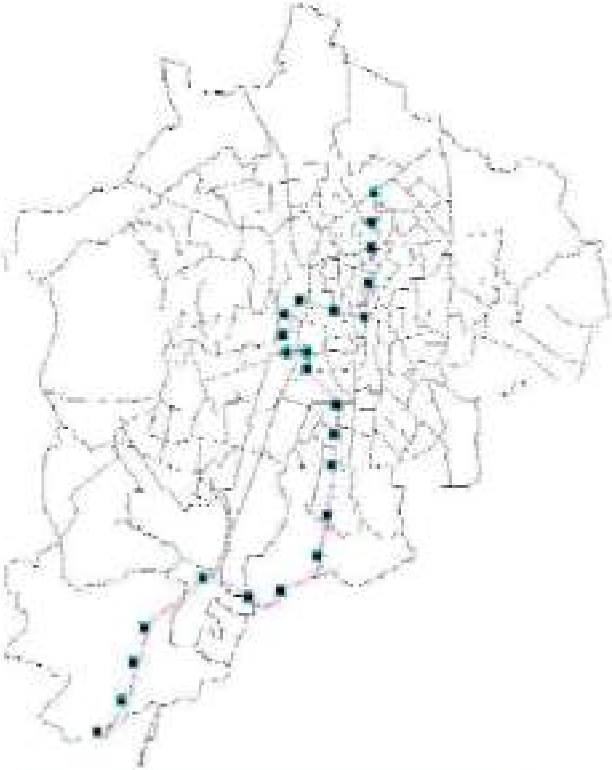


Fig :1.4

Alignment-3 of MRTS Corridors Proposed by L&T Ramboll Consulting Engineers Limited

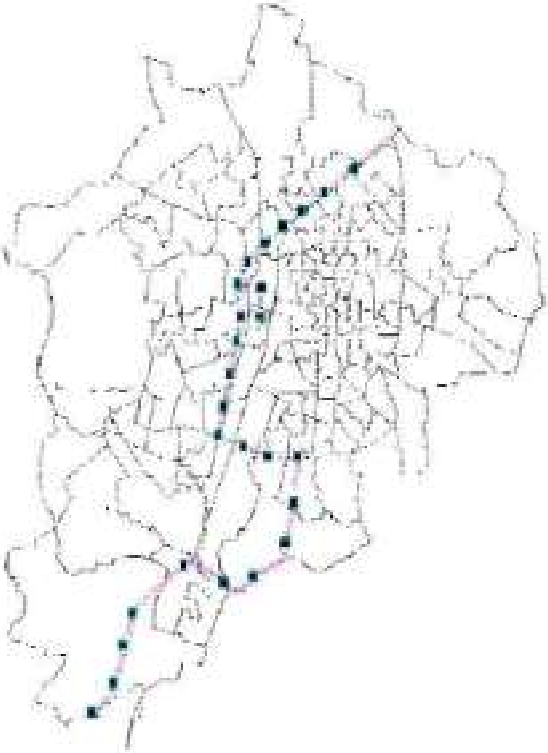


Fig :1.6

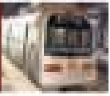
Alignment 4 of MRTS Corridors Proposed by L&T Ramboll Consulting Engineers Limited

CHAPTER 2

TRAFFIC DEMAND FORECAST

TABLES

FIGURES



CHAPTER 2

TRAFFIC DEMAND FORECAST

2.1 INTRODUCTION

Nagpur Improvement Trust (NIT) has entrusted the job of preparing Detail Project Report (DPR) for Nagpur Metro Rail[1] to Delhi Metro Rail Corporation (DMRC).
Traffic Study and Ridership estimation are the first tasks in DPR which imply finalizing a feasible alignment plan of the proposed metro network and then locating normal and interchange metro stations (if any). After that, Ridership Estimation is done. Estimating daily and peak hour boarding and alighting from each station, daily link load and PHPDT link loads (all together is called Ridership Estimation) are estimated. These estimates are primary inputs to other important estimates such as station design, train operation plan, estimates of revenue collection, benefits of metro, rolling stock and many other estimates including EIRR and FIRR.

Alignment is finalized after repeated inspection of the road network, intersections, passenger traffic flow, traffic congestion, connectivity to important landuses. Wide roads

[1] The Nagpur Metro Rail project is announced by the state government of Maharashtra for the city with the expense of [illegible] Cr and [illegible] Cr Rupees for its two phases of [illegible] km (from Sitabuldi to MIHAN and Sitabuldi via Dighori) and [illegible] km Sitabuldi to Automotive Square in Kamptee respectively. Consultants Delhi Metro Railway Corporation (DMRC) will study the alignment and submit a detailed project report.
The site inspection has already begun in March 2012 with the invitation from Nagpur Improvement Trust (NIT). The Rs. [illegible] crore project will be executed by a new company called Nagpur Metro Transport Co Ltd. (NMTCL), formed under the NIT, NMC, Maharashtra Airport Development Corporation (MADC) — that is currently developing the MIHAN project. — NMC and DCCI are the other participating organisations. Source: [illegible]

are normally selected for alignment to avoid relocation, land purchase and demolition of buildings. Sharp bends are avoided. Underground construction is considered only when necessary space for elevated line is not available or such construction is prohibited in the area.

Stations are located near large road intersections so that passenger from all direction can access the station. In general, interstation gap is kept between 0.5 to 1.5 km. Engineering feasibility of the alignment is considered simultaneously.
In this particular (Nagpur) study, a few traffic and land use related physical surveys were undertaken. These are (1) Traffic Volume Count (TVC) and Passenger Occupancy Surveys (POS) at mid block sections, screen lines and outer cordon points, (2) Bus and Rail Mode passenger Terminal Survey and (3) Work Place Survey. Several important output were derived which will be shown in subsequent paragraphs.

Secondary data which were collected include past and present population of Nagpur Urban Agglomeration, ward wise population of Nagpur City, Road and Rail Network within Nagpur and Future Land Use Map of Nagpur. For verification purpose, Google Earth website has been used.

Road Network and Landuse Map of Nagpur were geo coded and digitized layers were created using TransCad Software.

2.2 POPULATION OF NAGPUR

As per provisional reports of Census India, population of Nagpur in 2011 is 2,405,421; of which male and female are 1,226,610 and 1,178,811 respectively. The sex ratio of Nagpur city is 961 per 1000 males. In education section, total literates in Nagpur city are 2,016,998 of which 1,060,699 are males while 956,299 are females. Average literacy rate of Nagpur city is 93.13 percent of which male and female literacy was 96.15 and 89.99 percent. Total children (0-6) in Nagpur city are 237,864 as per figure from Census India report on 2011. There were 123,851 boys while 114,014 are girls. Child sex ratio of girls is 921 per 1000 boys. Nagpur city is governed by Municipal Corporation which comes under Nagpur Urban Agglomeration. Although Nagpur city has population of 2,405,421; its urban / metropolitan population is 2,497,777 of which 1,275,750 are males and 1,222,027 are females[1]

Another positive outcome for Nagpur region is the Decadal Growth Rate of population. It has come down from 23.74 in the last decade (1991-2001) to 14.39 in 2001-2011.Nagpur region added the least number of people in its population in this decade than any other[2]

[1] http://www.census2011.co.in/census/city/353-nagpur.html
[2] http://www.mh-31.com/nagpur/about-nagpur/nagpur-general/456-population-census-2011/

In 2001, the urban population was 2,129,500, and there were around 418,000 households in the city. 728,964 people lived in slums making Nagpur second-most slum-populated city in Maharashtra after Mumbai. Scheduled Castes and Scheduled Tribes accounted for around 50% of the population[1].

Figure 2.1:
Zero Mile Nagpur, is the Geographical center of India

2.3 ECONOMY OF NAGPUR[2]

Nagpur has been the main center of commerce in the Vidarbha region since early days and is an important trading location. However, Nagpur's economic importance has gradually declined relative to Mumbai and Pune after the merging of Vidarbha into the Maharashtra because of a period of neglect by the state government. During the slowdown, state and central government offices were a major source of employment in the city. Nagpur's economy is now recovering from past slowdowns and city has attracted Rupees 5,000 crore in investment in 2004. The city is important for the banking sector as it hosts the regional office of **Reserve Bank of India**, which was opened on September 15, 1956. **Sitabuldi** market in central Nagpur, known as the Heart of the city, is the major commercial market area of city.

The **Butibori** industrial area is the largest in all of Asia in terms of area. The estate's largest unit is of Indo Rama Synthetics, which manufactures synthetic polyester yarn. Other units in Butibori include the power transmission company KEC, Hyundai Unitech, ACC Nihon Castings Ltd. **Koradi Thermal Power Station** and **Khaperkheda Thermal**

[1] http://en.wikipedia.org/wiki/Nagpur
[2] http://nmc.org.in/economy.aspx

Power Station are the two major thermal power stations located near Nagpur and operated by **MSPGCL**.

The Hingna industrial estate located on the western fringes of the city is made up of around 900 small and medium industrial units. The major ones among them are tractor manufacturing plant of **Mahindra and Mahindra**, casting units of NECO Ltd. (the country's largest casting group), units of International Combustion, Bajaj Auto group, Candico (the SECOND largest confectionery manufacturing plant in India), Ajanta toothbrushes and Sanvijay Group (largest steel rolling group of companies for long products in Central India). Nagpur is home to ice-cream manufacturer Dinshaws, Indian dry food manufacturer Haldiram's and Ayurvedic product company Vicco.

2.4 CARGO HUB AND AIRPORT AT NAGPUR (MIHAN)

Nagpur is witnessing an economic boom as the "Multi-modal International Cargo Hub and Airport at Nagpur (MIHAN)" is being developed. MIHAN will be used for handling heavy cargo coming from south east Asia and the Middle East. The project will include Indian rupee ₹10,000 crore (US$2.17 billion) Special Economic Zone (SEZ) for Information Technology (IT) companies. Persistent Systems has one of the software development centers at Nagpur.

MIHAN - Multi-modal International Cargo Hub and Airport at Nagpur is the biggest economical development project currently underway in India in terms of investment. **MIHAN** is spread over an area of 4354 Hectares. MIHAN is an ideal business hub, located in **Nagpur**, the geometrical centre of India and easily accessible to all the metro cities of India as well as the world.

MIHAN Project consists of two parts namely **International airport** to act as a **cargo hub** and a **Special Economic Zone SEZ** with residential zone covering a total area of 40.25 sq. km on the southern end of Nagpur. Maharashtra Government formed a special purpose entity in the name of **Maharashtra Airport Development Company** (MADC) for development of **MIHAN**. The project is financed by multiple Indian banks with total loan amount of INR 3,000 million along with investment from state government and Airports Authority of India. With a projected target of serving 14 million passengers and handle 0.87 million tones of cargo this is one of largest aviation project in India. The estimated capital cost of the project is INR 2581 crores (by year 2035) and is supposed to generate revenues INR 5280 crores (**Nagpur**).

A new **Nagpur SEZ** of 2086 hectares, largest multi-product SEZ in India, would be built along side the airport. Out of 2086 hectares, 1472 hectares would be used by various processing units to be set-up and remaining 614 hectares for service sector unit. Like all SEZs it will have financial incentives and soft taxation policy to attract investment. The initial set-up material for these units and later raw material will be duty-free.

Figure2.2:
Buildings under construction MIHAN

Figure2.3: MIHAN Administrative Office

2.5 TRAFFIC VOLUME COUNT (TVC) AND PASSENGER OCCUPANCY SURVEYS (OCS)

To understand traffic characteristics in terms of vehicular, passenger and PCU, 40 traffic count stations were identified, some of which are mid block sections, some locations were fixed as screen line points and some were as outer cordon points[3]. In table 2.1, total traffic flow for all 40 locations and for both direction in terms of PCUs is given. In table 2.2, a grouped vehicular traffic volume of fast, slow (NMT) and goods vehicles for all 40 locations is given. Nagpur being located at a central position, many inter-city and inter-state bus routes pass, so separate columns are given for such trips (external buses). In figure 2.4, TVC locations are shown.

Figure 2.4 TVC points in Nagpur

Table 2.1

Direction wise PCU Traffic details at Nagpur

Loc.No.	Loc. Name		Direction	Traffic PCU	Peak PCUs	Peak Hour (%)
1	Wireless land hingna road	E-W	Nagpur to Hingna	5,486	680	5.93%
1	Wireless land hingna road	W-E	Hingna to Nagpur	5,273	638	8.63%
2	Ambazhari Tank North	E-W	Nagpur to	6,984	717	5.39%

[3] Location maps with ... given in Appendix

Loc. No.	Loc. Name		Direction	Traffic PCU	PEAK PCUs	Peak Hour (%)
			Hingna			
2	Ambajhari Tank North	W-E	Hingna to Nagpur	8,254	740	10.88%
3	CA road near Rly stn	E-W	Bhandara to Nagpur	14,440	1,174	8.10%
3	CA road near Rly stn	W-E	Nagpur to Bhandara	13,889	1,082	8.12%
4	Rajabaxa Road Central Jail	E-W	Ajni to Wardha	11,490	1,161	10.01%
4	Rajabaxa Road Central Jail	W-E	wardha to ajni	14,380	1,342	11.22%
5	Wireless - Amravati Road	E-W	nagpur to amravati	17,424	1,386	12.77%
5	Wireless - Amravati Road	W-E	amravati to nagpur	11,930	1,081	9.92%
6	Ghat Road – near subhash rd intersection	N-S	nagpur to wardha	13,360	1,183	8.87%
6	Ghat Road – near subhash rd intersection	S-N	wardha to nagpur	11,848	1,281	11.42%
7	Ansari road – near stadium	E-W	ganeshpeth to zero mile	13,300	1,394	12.88%
7	Ansari road – near stadium	W-E	zero mile to ganeshpeth	15,530	1,288	10.28%
8	Bus stand – Wardha road	N-S	zero mile to mumbai	18,274	1,303	9.93%
8	Bus stand – Wardha road	S-N	mumbai to zero mile	14,916	1,463	10.49%
9	Rabindranath Nath Tagore Marg	N-S	vca to maharajbagh	5,022	525	9.79%
9	Rabindranath Nath Tagore Marg	S-N	maharajbagh to vca	7,089	794	12.01%
10	Heli pad – Wardha road	N-S	delhi to zero mile	18,592	1,430	9.78%
10	Heli pad – Wardha road	S-N	zero mile to delhi	17,846	1,483	10.08%
11	Old secretariat – Palm road	E-W	nagpur to amravati	8,014	830	12.38%
11	Old secretariat – Palm road	W-E	amravati to nagpur	6,977	570	9.88%
12	Mankarchowda – Katol road	E-W	nagpur to katol	8,053	566	8.91%
12	Mankarchowda – Katol road	W-E	katol to nagpur	7,187	592	9.02%
13	Kasturchand park – palm road	N-S	nagpur ct to mumbai	8,308	745	9.49%
13	Kasturchand park – palm road	S-N	mumbai to nagpur ct	8,068	920	10.83%
14	Holy cross – Road along	E-W	nagpur ct to vca	11,874	870	9.44%

Loc No.	Loc. Name		Direction	Traffic PCU	PEAK PCUs	Peak Hour (%)
	Kastur park					
14	Holy cross – Road along Kastur park	W-E	vcs to nagpur st	12,062	974	8.03%
15	Chhindwara Road and Mount Road X	N-S	delhi to nagpur	17,293	1,157	6.69%
15	Chhindwara Road and Mount Road X	S-N	nagpur to delhi	13,525	1,237	9.30%
16	Chhindwara Road Raj Bhavan	N-S	delhi to nagpur	11,500	940	8.08%
16	Chhindwara Road Raj Bhavan	S-N	nagpur to delhi	13,230	1,199	10.09%
17	Near Rly stn – Gurudwara Kamptee road	N-S	kamptee to nagpur	13,194	1,210	9.01%
17	Near Rly stn – Gurudwara Kamptee road	S-N	nagpur to kamptee	13,794	2,015	14.44%
18	Craddock road – mominpura	E-W	bhandara to nagpur	5,361	340	6.17%
18	Craddock road – mominpura	W-E	nagpur to bhandara	4,293	408	9.32%
19	Indora – Kamptee road	E-W	kamptee to nagpur	18,733	1,133	5.89%
19	Indora – Kamptee road	W-E	nagpur to kamptee	15,604	1,835	7.69%
20	Adarsh Vidya Mandir society-CA Road	E-W	bhandara to nagpur	11,094	1,032	6.69%
20	Adarsh Vidya Mandir society-CA Road	W-E	nagpur to bhandara	13,900	1,094	7.89%
21	Before intersection of CA Road and Factory	E-W	bhandara to nagpur	12,892	1,282	11.34%
21	Before intersection of CA Road and Factory	W-E	nagpur to bhandara	11,312	940	8.72%
22	Jawahar Nagar – West Boundary road	E-W	bhandara to nagpur	8,026	1,216	14.61%
22	Jawahar Nagar – West Boundary road	W-E	nagpur to bhandara	11,837	925	9.93%
23	Ayu College – UMRED Road	E-W	umred to nagpur	8,032	730	8.90%
23	Ayu College – UMRED Road	W-E	nagpur to umred	7,267	795	10.45%
24	Somwaripeth – Ridge Road	E-W	umred to ajni	11,741	771	6.51%
24	Somwaripeth – Ridge Road	W-E	ajni to umred	13,898	1,669	11.58%
25	Railway quarters – Ajni Road	E-W	umred to ajni	17,430	1,239	10.59%
25	Railway quarters – Ajni	W-E	ajni to umred	13,141	1,132	10.27%

Loc.No	Loc. Name		Direction	Traffic PCU	PEAK PCUs	Peak Hour (%)
	Road					
26	Rahatey colony – Wardha Road	N-S	nagpur to wardha	16,441	1,294	9.79%
26	Rahatey colony - Wardha Road	S-N	wardha to nagpur	14,879	1,397	10.24%
27	Near SBI ATM – North Ambazhari Road	E-W	nagpur to hingna	13,913	1,030	10.34%
27	Near SBI ATM - North Ambazhari Road	W-E	hingna to nagpur	14,890	994	9.50%
28	Gorepeth – AMRAVATI road	E-W	nagpur to amravati	14,393	1,175	8.42%
28	Gorepeth – AMRAVATI road	W-E	amravati to nagpur	14,599	3	0.00%
29	Hindustan colony – Amravati road	E-W	nagpur to amravati	8,505	793	9.18%
29	Hindustan colony – Amravati road	W-E	amravati to nagpur	8,211	673	9.85%
30	PWD quarters - Katol road	E-W	nagpur to katol	9,545	721	8.44%
30	PWD quarters – Katol road	W-E	katol to nagpur	10,800	821	9.65%
31	Mental Hospital – Chhindwara road	N-S	delhi to nagpur	8,068	695	9.86%
31	Mental Hospital – Chhindwara road	S-N	nagpur to delhi	11,329	1,098	10.76%
32	Mankapur – Chhindwara road	N-S	delhi to nagpur	7,267	633	9.07%
32	Mankapur - Chhindwara road	S-N	nagpur to delhi	8,098	734	9.62%
33	Before intersection between Kamptee Road	E-W	kamptee to nagpur	18,231	1,803	9.87%
33	Before intersection between Kamptee Road	W-E	nagpur to kamptee	12,493	1,491	10.29%
34	Dharampeth Garden – CA road	E-W	bhandara to nagpur	10,730	783	8.21%
34	Dharampeth Garden – CA road	W-E	nagpur to bhandara	9,725	855	9.88%
35	Tajbagh – Umred Road	E-W	umred to nagpur	7,158	633	8.75%
35	Tajbagh – Umred Road	W-E	nagpur to umred	8,088	627	8.83%
36	Vivekanandnagar – Wardha road	N-S	nagpur to wardha	18,134	1,491	9.82%
36	Vivekanandnagar – Wardha road	S-N	wardha to nagpur	17,938	1,559	10.81%
37	Aerodrom – Wardha Road	N-S	nagpur to wardha	13,716	1,262	10.84%
37	Aerodrom - Wardha	S-N	wardha to	12,393	1,082	8.93%

Loc.No.	Loc. Name		Direction	Traffic PCU	PEAK PCUs	Peak Hour (%)
	Road		nagpur			
38	Vivekanand Nagar-Khamla Road	N-S	nagpur to hingna	7,208	594	10.83%
38	Vivekanand Nagar-Khamla Road	S-N	hingna to nagpur	7,078	504	9.98%
39	Untkhana- Nag Road	E-W	ajni to bhandara	9,060	1,283	10.75%
39	Untkhana- Nag Road	W-E	bhandara to ajni	8,773	698	8.59%
40	Raisoni College-Hingna Road	E-W	Nagpur to Hingna	10,347	675	8.40%
40	Raisoni College-Hingna Road	W-E	Hingna to Nagpur	8,033	710	9.87%

Table 2.2

Vehicular Traffic details at 40 different locations - Nagpur

TVC Location No	DIRECTION	FAST+SLOW TRAFFIC WITH EXTERNAL BUSES	FAST+SLOW TRAFFIC WITHOUT EXTERNAL BUSES	FAST MODE TRAFFIC WITH EXTERNAL BUSES	FAST MODE TRAFFIC WITHOUT EXTERNAL BUSES	GOODS VEHICLE
1	WIRELESS LAND-HINGNA ROAD	15,521	13,889	14867	14,220	647
2	AMBAZHARI TANK NORTH	14,233	13,398	13940	12,545	1,395
3	CA ROAD NEAR RLY STATION	24,034	22,648	23971	22,147	1,824
4	C ZAL RAJABHAI ROAD	25,461	23,816	24936	23,403	1,533
5	WIRELESS - AMRAVATI ROAD	22,523	22,049	19858	18,848	1,010
6	GHAT ROAD NEAR SUBHASH ROAD INTERSECTION	21,840	20,455	20909	18,937	1,972
7	ANSARI ROAD - NEAR SITA BULDI	26,531	24,828	26166	24,669	1,497
8	BUS STAND-WARDHA ROAD	27,831	25,825	27540	25,367	2,173
9	RAVINDRANATH TAGORE MARG	11,051	9,153	10763	10,348	415

TVC Location No	DIRECTION	FAST+SLOW TRAFFIC WITH EXTERNAL BUSES	FAST+SLOW TRAFFIC WITHOUT EXTERNAL BUSES	FAST MODE TRAFFIC WITH EXTERNAL BUSES	FAST MODE TRAFFIC WITHOUT EXTERNAL BUSES	GOODS VEHICLE
10	HELIPAD-WARDHA ROAD	31,498	29,279	30745	27,878	2,867
11	OLD SECRETARIAT-PALM ROAD	14,532	13,600	14105	13,778	327
12	MAKARDHOKDA-KATOL ROAD	12,772	11,781	12331	11,539	792
13	KASTURCHAND PARK-PALM ROAD	12,090	10,929	11786	11,325	461
14	HOLY CROSS ROAD-ALONG KASTUR PARK	20,794	18,290	20429	19,879	550
15	CHHINDWARA AND MOUNT ROAD X	29,996	27,782	29544	27,705	1,839
16	CHHINDWARA ROAD RAJBHAWAN	20,936	18,728	20534	19,154	1,380
17	NEAR RLY STN. GURDWARA KAMPTEE ROAD	21,733	19,390	20747	18,353	2,394
18	CRADDOCK ROAD-MOMINPURA	8,531	8,426	8519	8,493	26
19	INDORA-KAMPTEE ROAD	27,413	25,408	26132	25,180	952
20	ADARSH VIDYA MANDIR SOCIETY-CA ROAD	22,538	21,324	21536	20,822	714
21	INTERSECTION OF CA ROAD AND FACTORY	17,336	16,688	16604	15,858	746
22	JAWAHAR NAGAR-WEST BOUNDARY ROAD	18,489	17,898	17740	16,708	1,032
23	AYU COLLEGE-UMRED ROAD	14,146	12,995	13458	12,505	953
24	SOMWARI PETH-RIDGE ROAD	21,985	20,845	21606	21,166	440

TVC LOC ATION NO	DIRECTION	FAST+SLOW TRAFFIC WITH EXTERNAL BUSES	FAST+SLOW TRAFFIC WITHOUT EXTERNAL BUSES	FAST MODE TRAFFIC WITH EXTERNAL BUSES	FAST MODE TRAFFIC WITHOUT EXTERNAL BUSES	GOODS VEHICLE
25	RAILWAY QUATERS-AJNI ROAD	28,083	27,236	27559	27,074	485
26	RAILWAY COLONY-WARDHA ROAD	27,269	23,019	26561	25,688	873
27	NEAR SEVATM-NORTH AMBAJHERI ROAD	25,739	24,753	25624	24,734	890
28	GOREPATH-AMRAVATHI ROAD	25,455	22,275	25008	23,743	1,265
29	HINDUSTAN COLONY-AMRAVATHI ROAD	14,124	12,175	13530	12,645	885
30	PWD QUATERS-KATOL ROAD	17,050	15,555	16539	15,387	1,152
31	MENTAL HOSPITAL-CHINDWARA ROAD	18,007	17,075	17623	16,720	903
32	BABAKPUR-CHHINDWARA ROAD	13,668	13,034	13320	12,423	897
33	BEFORE INTERSECTION BETWEEN KAMPTEE ROAD	23,210	20,797	19897	17,394	2,503
34	DESHPANDEY GARDEN-CA ROAD	15,089	12,634	14064	13,513	551
35	TAJBAGH-UMRED ROAD	10,820	10,176	10244	9,199	1,045
36	VIVEKANAND NAGAR-WARDHA ROAD	34,778	32,476	33875	32,066	1,808
37	ABHOORAM WARDHA ROAD	24,603	22,466	22663	20,753	1,910
38	VIVEKANAND NAGAR-KHAMLA ROAD	11,344	10,720	10957	10,920	37

TVC Location No	DIRECTION	FAST+SLOW TRAFFIC WITH EXTERNAL BUSES	FAST+SLOW TRAFFIC WITHOUT EXTERNAL BUSES	FAST MODE TRAFFIC WITH EXTERNAL BUSES	FAST MODE TRAFFIC WITHOUT EXTERNAL BUSES	GOODS VEHICLE
39	UNTKHANA NAG ROAD	14,776	13,557	14003	12,077	1,926
40	HINGNA ROAD ROBONI COLLEGE	16,732	15,057	15197	15,669	528

In table 2.3 passengers traveled on fast modes, passenger vehicle flow and number of vehicles per passenger is given.

Table 2.3
Fast Mode Passenger details at 40 different locations - Nagpur

TVC Location No	DIRECTION	FAST MODE PASSENGER TRAFFIC WITH EXTERNAL BUSES	FAST MODE VEHICULAR TRAFFIC WITH EXTERNAL BUSES	VEHICLE / PASSENGER
1	WIRELESS LAND-HINGNA ROAD	93947	14857	0.158
2	AMBAZHARI TANK NORTH	59016	13940	0.236
3	CA ROAD, NEAR RLY SATION	127139	23971	0.189
4	C.DAL RAJABAKA ROAD	117720	24896	0.212
5	WIRELESS JAFRANTI ROAD	61180	19859	0.325
6	GHAT ROAD NEAR SUBHASH ROAD INTERSECTION	93156	20909	0.224
7	ANSARI ROAD – NEAR SITA BULDI	117906	26196	0.222
8	BUS STAND- WARDHA ROAD	148398	27540	0.185
9	RAVINDRANATH TAGORE MARG	95211	10783	0.113
10	HELIPAD-WARDHA ROAD	139831	30740	0.220
11	OLD SECRETARIAT-PALM ROAD	68088	14403	0.211
12	MAKARDHOKDA-KATOL ROAD	63403	12331	0.193
13	KASTUR CHAND PARK-PALM ROAD	78044	11788	0.151
14	HOLY CROSS ROAD ALONG KASTUR PARK	152690	20429	0.134
15	CHINDWARA AND MOUNT ROAD X	141858	29544	0.208
16	CHINDWARA ROAD	136751	20584	0.150

TVC Location No.	DIRECTION	FAST MODE PASSENGER TRAFFIC WITH EXTERNAL BUSES	FAST MODE VEHICULAR TRAFFIC WITH EXTERNAL BUSES	VEHICLE / PASSENGER
	RAJBHAWAN			
17	NEAR RLY STN. GURDWARA KAMPTEE ROAD	135365	20747	0.153
18	CRADDOCK ROAD-MOMINPURA	20387	8519	0.418
19	INDORA-KAMPTEE ROAD	145835	26132	0.183
20	ADARSH VIDYA MANDIR SOCIETY-CA ROAD	107110	21536	0.201
21	INTERSECTION OF CA ROAD AND FACTORY	67343	16634	0.247
22	JAWAHAR NAGAR-WEST BOUNDARY ROAD	61051	17740	0.285
23	VNIT COLLEGE-UMRED ROAD	73056	13439	0.183
24	SOMWARI PETH-RIDGE ROAD	78767	21600	0.274
25	RAILWAY QUATERS-AJNI ROAD	83028	27500	0.332
26	RAHATEY COLONY-WARDHA ROAD	234228	26491	0.113
27	NEAR SBI ATRA-NORTH AMBAJHERI ROAD	87031	25524	0.293
28	GOREPATH-AMRAVATHI ROAD	191285	25009	0.131
29	HINDUSTAN COLONY-AMRAVATHI ROAD	112388	13530	0.120
30	PWD QUATERS-KATOL ROAD	95052	16230	0.171
31	MENTAL HOSPITAL-CHHINDWARA ROAD	84059	17523	0.207
32	MANKAPUR-CHHINDWARA ROAD	67447	13320	0.197
33	BEFORE INTERSECTION BETWEEN KAMPTEE ROAD	136750	19897	0.145
34	DESHPANDEY GARDEN-CA ROAD	128240	14264	0.111
35	TAZBAGH-UMRED ROAD	50218	10244	0.204
36	VIVEKANAND NAGAR-WARDHA ROAD	107581	23675	0.213
37	NEERI-BRAMAN-WARDHA ROAD	120520	22583	0.187
38	VIVEKANAND NAGAR-KHAMLA ROAD	50103	10937	0.218
39	UNTKHANA-NAG ROAD	79822	14503	0.182
40	HINGNA ROAD-ROBICONI	97565	18497	0.190

TVC Location No	DIRECTION	FAST MODE PASSENGER TRAFFIC WITH EXTERNAL BUSES	FAST MODE VEHICULAR TRAFFIC WITH EXTERNAL BUSES	VEHICLE / PASSENGER
	COLLEGE			

In table 2.4 peak hour details of Vehicular, Passenger and PCU are shown.

Table 2.4
PEAK HOUR details at 40 different locations - Nagpur

TVC Location No	DIRECTION	VEH	PASS	PCU
1	WIRELESS LAND-HINGNA ROAD	8.80%	9.07%	8.32%
2	AMBAZHARI TANK NORTH	11.35%	0.00%	9.34%
3	CA ROAD NEAR RLY SATION	8.58%	8.86%	7.71%
4	C ZAIL RAJABAXA ROAD	9.46%	9.96%	9.45%
5	WIRELESS AMRAVATI ROAD	11.27%	8.47%	10.10%
6	GHAT ROAD NEAR SUBHASH ROAD INTERSECTION	9.81%	10.92%	8.87%
7	ANSARI ROAD - NEAR SITA BULDI	11.00%	9.05%	9.36%
8	BUS STAND- WARDHA ROAD	9.42%	8.93%	9.38%
9	RAVINDRANATH TAGORE MARG	10.57%	9.22%	10.35%
10	HELIPAD-WARDHA ROAD	9.35%	9.45%	9.28%
11	OLD SECRETARIAT-PALM ROAD	11.10%	11.40%	10.12%
12	MAKARDHOKDA-KATOL ROAD	8.48%	9.30%	8.19%
13	KASTUR CHAND PARK-PALM ROAD	8.79%	8.80%	9.08%
14	HOLY CROSS ROAD ALONG KASTUR PARK	9.29%	9.82%	9.03%
15	CHINDWARA AND MOUNT ROAD X	9.03%	9.17%	8.34%
16	CHINDWARA ROAD RAJBHAWAN	9.27%	9.37%	8.57%
17	NEAR RLY STN-GURDWARA KAMPTEE ROAD	11.51%	12.35%	12.14%
18	CRADDOCK ROAD-MOMINPURA	8.99%	10.69%	8.71%
19	INDORA-KAMPTEE ROAD	8.31%	9.50%	7.81%
20	ADARSH VIDYA MANDIR SOCIETY-CA ROAD	7.78%	9.84%	7.71%
21	INTERSECTION OF CA ROAD	8.81%	10.04%	8.23%

TVC Location No	DIRECTION	VEH	PASS	PCU
	AND FACTORY			
22	JAWAHAR NAGAR-WEST BOUNDARY ROAD	9.11%	8.76%	10.00%
23	AYU COLLEGE-UMRED ROAD	9.11%	8.70%	8.79%
24	SOMWARI PETH-RIDGE ROAD	10.00%	10.66%	9.31%
25	RAILWAY QUATERS-AJNI ROAD	10.76%	10.40%	9.75%
26	RAHATEY COLONY-WARDHA ROAD	9.11%	9.40%	9.06%
27	NEAR SBI ATM-NORTH AMBAJHERI ROAD	9.09%	10.81%	9.23%
28	GOREPETH-AMRAVATHI ROAD	8.92%	10.93%	8.87%
29	HINDUSTAN COLONY-AMRAVATHI ROAD	9.60%	10.79%	8.94%
30	PWD QUATERS-KATOL ROAD	8.46%	8.51%	8.23%
31	MENTAL HOSPITAL-CHINDWARA ROAD	9.29%	7.80%	8.72%
32	MANKAPUR-CHHINDWARA ROAD	7.79%	8.42%	7.92%
33	BEFORE INTERSECTION BETWEEN KAMPTEE ROAD	9.06%	9.24%	10.42%
34	DESHPANDEY GARDEN, CA ROAD	9.37%	7.89%	8.79%
35	TAJBAGH-UMRED ROAD	7.87%	9.99%	8.15%
36	VIVEKANAND NAGAR-WARDHA ROAD	10.08%	9.94%	9.67%
37	AERODRAM-WARDHA ROAD	9.97%	10.05%	9.47%
38	VIVEKANAND NAGAR-KHAMLA ROAD	10.23%	9.81%	10.11%
39	UNTKHANA NAG ROAD	8.99%	8.44%	9.16%
40	HINGNA ROAD RUKONI COLLEGE	8.77%	8.73%	8.48%

Through Nagpur, Delhi to Hyderabad National Highway has passed in North South direction, and Kolkata to Mumbai National Highway has passed in East-West direction and for that reason lot of goods traffic pass through Nagpur. In tables 2.5A and 2.5B Traffic Flow in PCU on NORTH-SOUTH and EAST-WEST direction are given. Corresponding bar diagrams are shown in figures 2.5 and 2.6.

Table 2.3A
Traffic Flow in PCU on NORTH→SOUTH direction

TVC Location	Name of Locations	FAST+SLOW TRAFFIC WITH EXTERNAL BUSES	FAST+SLOW TRAFFIC WITHOUT EXTERNAL BUSES	FAST MODE TRAFFIC WITH EXTERNAL BUSES	FAST MODE TRAFFIC WITHOUT EXTERNAL BUSES	GOODS VEHICLES
32	MANKAPUR-CHHINDWARA ROAD	13792	11457	13458	10590	2865
31	MENTAL HOSPITAL-CHINDWARA ROAD	17169	14629	16905	13602	3104
16	CHINDWARA ROAD RAJBHAVAN	22061	17341	22667	17999	4668
15	CHINDWARA AND MOUNT ROAD X	27028	22093	27383	21748	5516
10	HELIPAD-WARDHA ROAD	30571	25026	30203	20996	6009
8	BUS STAND-WARDHA ROAD	28891	22876	28770	22306	6465
25	RAHATEY COLONY-WARDHA ROAD	31183	20548	30787	28180	2607
36	VIVEKANAND NAGAR-WARDHA ROAD	31665	25915	31050	24765	6266
37	AERODRAM-WARDHA ROAD	24006	19263	23230	18701	6529

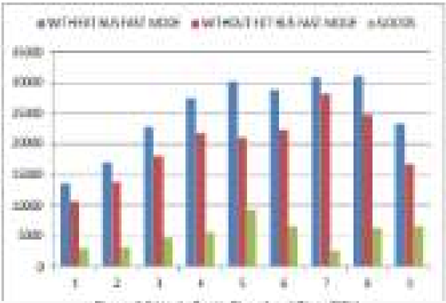


Figure 2.5 North-South Directional Flow (PCU)

(On Horizontal axis 1 stands for location 32 and 9 stands for location 17 as given in table 2.4)

TABLE 2.58

Traffic Flow in PCU on EAST—WEST direction

TVC Location ID	Name of Locations	FAST+SLOW TRAFFIC WITH EXTERNAL BUSES	FAST+SLOW TRAFFIC WITHOUT EXTERNAL BUSES	FAST MODE TRAFFIC WITH EXTERNAL BUSES	FAST MODE TRAFFIC WITHOUT EXTERNAL BUSES	GOODS VEHICLES
34	DESHPANDEY GARDEN-CA ROAD	14279	10142	13767	13908	1848
21	INTERSECTION OF CA ROAD AND FACTORY	15403	13033	14590	12600	2340
20	ADARSH VIDYA MANDIR SOCIETY-CA ROAD	21283	18036	20686	18025	2271
3	CA ROAD NEAR RLY STATION	24088	19053	24176	19086	3090
10	HELIPAD-WARDHA ROAD	30571	25024	30288	20946	5208
7	ANSARI ROAD - NEAR SITA BULDI	24915	20662	24655	19408	5134
5	WIRELESS - AMRAVATI	17807	16602	16056	13138	3338

	ROAD					
34	SONEGAON PETH-RIDGE ROAD	14080	13810	13664	14467	1397
2	AMBAZHARI TANK NORTH	14561	12693	14406	9854	4575
1	WIRELESS LAND-HINGNA ROAD	14843	10763	14488	12500	1996
40	COLLEGE	15427	11348	15140	13489	1647

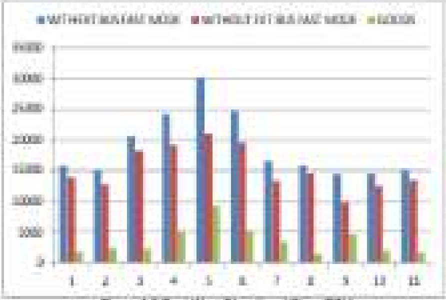


Figure 2.6 East West Directional Flow (PCU)

(X is Horizontal axis 1 stands for location 34 and 11 stands for location 40 as given in table 2.5) Finally passenger traffic flow observed on all 40 locations is shown in figure 2.7. Highest counts are observed at Wardha Road Rahate Colony (Loc 25), Amravati Road (Loc 28).

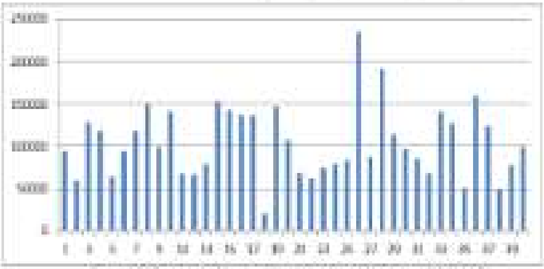


Figure 2.7 Passenger flow at different locations in Nagpur (16 hrs VC)

2.8 Mode Share and Modal Split within Nagpur City

2.8.1 Mode Share

In figure 2.8, average mode share observed on roads in terms of Vehicle, Passenger and PCU are shown. If external passenger is included, public mode share is high. However, if external trips are excluded different scenario will emerge.

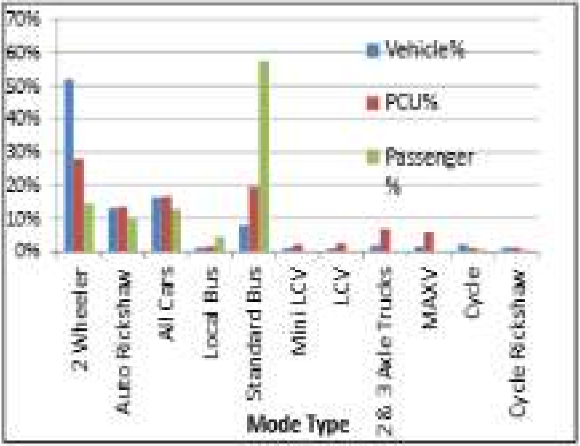


Figure 2.8 Overall Mode Share observed on Roads

In table 2.8, mode share of passenger trips observed on all 40 points are given.

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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2.6.2 Modal Split within Nagpur City

In tables 2.1, 2.2, 2.3 and 2.4 Vehicular and Passenger Traffic volume and Peak hour counts are shown which may reflect on the road traffic situation but the corresponding modal splits shown in table 2.7 does not reflect real modal split within the city. The reason is given as under.

Geographically Nagpur is not only the center of India, but also the center of commercial and economic activities of a vast area surrounding the city. In this area, smaller towns such as Bhandara, Umred, Butibori, Wardha, Hingna, [illegible], Kalmeshwar, Amravati, Kamptee, Ramtek, Bhilai, Raipur, Katol, Chhindwara etc. (all town names are not given) and villages in between Nagpur and these towns are included.

Naturally therefore, external trips to and from Nagpur are significant. To transport these trips, very good regional bus services exist apart from the Railways. Also long distance interstate bus services are available from different bus stands in Nagpur. In TVC survey, standard buses captured are mostly regional bus services[1]. In terminal survey, (table 2.6), it is seen 2.32 lakh trips are external trips out of which 62% were made by bus. Many of these bus passengers board and alight bus at city bus stands and not from the terminals. Train passengers usually walk or take shared auto to go and return from their destination. It was also noted that at present there is very limited city bus services[2]. Therefore if the external services are excluded from the TVC internal picture of Nagpur City passenger mode share will emerge.

To show the difference, average passenger trip modal splits between public, private and NMT are shown below. In this, Public mode includes local bus, auto, shared auto, taxis and shared taxis. Private mode includes Scooters, Motorcycles and cars. NMT includes cycles and cycle rickshaws. Intra-city passenger trip mode share of Nagpur excluding intercity bus trips will **64.01%** by private mode and **32.84%** by public mode and **3.15%** by slow mode. A pi diagram is shown in figure 2.9.

[1] We will in table 2.13, see that significant number of external trips for work are by bus.
[2] On record, there are 470 buses on PPP basis (a mix of 44 seater and 28 seater) in Nagpur but most of these (more than 300) are grounded due to low revenue generation.

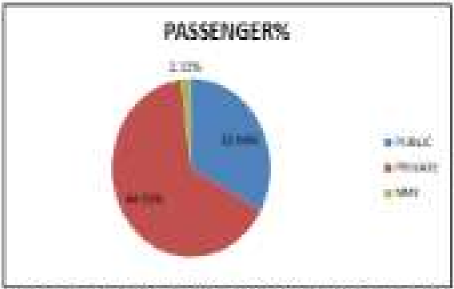

Figure 2.9 Public Private Modal split of passengers (excluding regional buses)

Out of the **64.91%** private mode passenger trips, about **33.79%** are two wheeler trips and **31.16%** are trips made by cars. Out of **32.96%** public trips, **22.88%** are made by Auto Rickshaws and **10.08%** are made by local buses. Vehicle-wise modal split of vehicles is shown in figure 2.10.

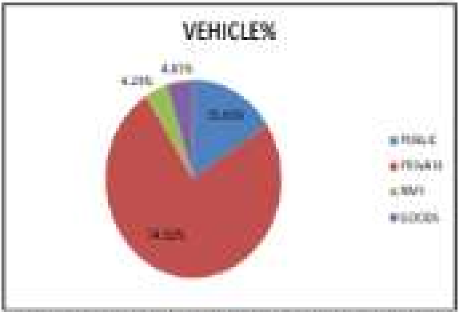

Figure 2.10 Public Private Modal split of vehicles (excluding regional buses)

In terms of vehicles, out of the 74.32% private mode trips, about 58.2% are two wheeler trips and 16.12% are trips made by cars. Out of 15.61% public trips, 14.3% are made by Auto Rickshaws and 1.01% are made by local buses.

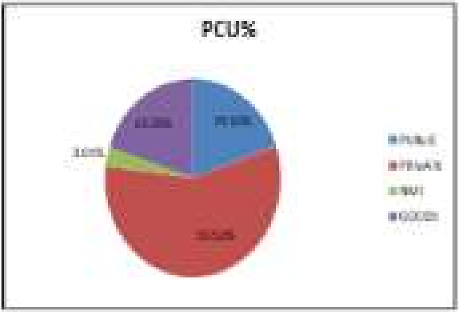

Figure 2.11 Public Private Modal split of PCU of vehicles (excluding regional buses)

In terms of vehicle PCUs, out of the 55.5% private mode trips, about 34.3% are two-wheeler trips and 21.2% are trips made by cars. Out of 19.10% public trips, 16.9% are made by Auto Rickshaws and 2.2% are made by local buses.

Analysis of data collected from TVC survey was for understanding the traffic flow characteristics on the Road Network. To determine amount of trip which may be diverted to Metro, Generalized cost based LOGIT model has been used. Details are given in section 4.4 and 4.5.

2.7 TERMINAL SURVEY RESULTS

Bus and Rail Terminal stations were surveyed mainly to understand the magnitude of external trips. There are 3 railway stations and 7 bus terminals. A summary of incoming and outgoing passengers is given in table 2.7.

Table 2.7
External Trips of Nagpur City

Terminal Name	In coming Passengers	In coming %	Out going Passengers	Out going %	Total
Nagpur Main Railway Station	32862	50.1	32757	49.9	65619
Ajni Railway Station	2263	27.9	5850	72.1	8113
Itwari Railway Station	5302	37.9	9001	62.1	14303

Terminal Name	In coming Passengers	In coming %	Out going Passengers	Out going %	Total
Sitabuldi Bus Stand	8360	45.0	10208	55.0	18568
Ganeshpeth Bus Terminal	32130	49.9	32282	50.1	64412
Ravi Nagar Bus Stand	9803	52.2	8973	47.8	18776
Chhatrapati Square	3720	33.2	7494	66.8	11214
Gandhibagh Bus Stand	1755	56.2	1368	43.8	3123
Indora Bus Stand	3395	55.0	2777	45.0	6172
Mor Bhavan Bus Stand	10580	62.0	6482	38.0	17062
MP Bus Stand	2984	54.6	2483	45.4	5467
	113534	**48.84**	**118860**	**51.16**	**232394**

Above data shows that 2.32 lakhs trips are external trips (which could be more as there are many boarding and alighting bus stops except main bus terminals) out of which 38% are by train and 62% are by regional and interstate bus service. Above data is for 16 hours (6AM-10PM). Many trips are purely external to external (incoming by bus and outgoing by train and vice versa). Quantum of external trips is about 10% which is expected for a city like Nagpur.

Hourly variation of incoming and outgoing passenger flow for Nagpur Railway Station is shown below in table 2.8.

Table 2.8

Hourly variation of traffic for Nagpur Railway Station

Time	IN	OUT	TOTAL
6.00 - 7.00	4.41%	4.20%	4.31%
7.00 - 8.00	7.94%	3.99%	5.96%
8.00 - 9.00	5.81%	7.23%	6.52%
9.00 - 10.00	5.72%	9.38%	7.54%
10.00 - 11.00	5.75%	5.98%	5.87%
11.00 - 12.00	4.74%	5.42%	5.08%
12.00 - 1.00	5.90%	6.74%	6.26%
1.00 - 2.00	6.53%	6.44%	6.48%
2.00 - 3.00	4.78%	5.63%	5.10%
3.00 - 4.00	5.07%	5.10%	5.08%

Time	IN	OUT	TOTAL
4:00 - 5:00	6.67%	5.08%	6.17%
5:00 - 6:00	8.38%	5.57%	6.97%
6:00 - 7:00	7.91%	7.48%	7.70%
7:00 - 8:00	7.56%	5.96%	6.90%
8:00 - 9:00	6.72%	6.94%	6.83%
9:00 - 10:00	5.77%	4.75%	5.25%

Hourly variation of incoming and outgoing passenger flow are not much and morning peaks for incoming and outgoing passengers are 7am-8am and 9am-10am respectively. Evening peaks for both incoming and outgoing are same at 5pm-6pm. Picture is totally different for Ajni and Itwari Railway stations as may be seen in table 3.9.

Table 3.9

Hourly variation of traffic for AJNI & ITWARI Railway Stations

	AJNI		ITWARI	
Time	IN	OUT	IN	OUT
6:00 - 7:00	3.99%	1.32%	17.81%	2.59%
7:00 - 8:00	16.48%	5.04%	7.91%	4.42%
8:00 - 9:00	9.10%	21.79%	3.18%	5.03%
9:00 - 10:00	3.67%	23.33%	4.82%	4.33%
10:00 - 11:00	5.21%	11.20%	6.05%	10.22%
11:00 - 12:00	2.44%	2.87%	6.56%	6.55%
12:00 - 1:00	1.69%	6.83%	8.45%	5.94%
1:00 - 2:00	1.81%	5.83%	5.18%	4.36%
2:00 - 3:00	2.83%	3.28%	3.08%	15.17%
3:00 - 4:00	5.08%	1.03%	4.36%	5.36%
4:00 - 5:00	9.28%	4.27%	4.27%	10.36%
5:00 - 6:00	14.58%	6.32%	5.73%	7.28%
6:00 - 7:00	11.08%	6.06%	7.36%	3.61%
7:00 - 8:00	4.63%	1.02%	7.05%	6.28%
8:00 - 9:00	4.86%	3.87%	3.64%	4.33%
9:00 - 10:00	3.43%	0.86%	2.45%	5.05%

Peak hours for inbound passenger are early morning (16.48% between 7am-8am for Ajni and 17.81% between 6am-7am for Itwari) and basically are factory workers. Outgoing passengers for Ajni are between 8am-10am and between 10 am -11 am for Itwari. Ajni rail station may be considered as an extended part of Nagpur Rail Station and many passenger interchange these two as per their convenience and train stoppage times. However, these two stations carry mostly commuters.

2.8 TERMINAL PASSENGER INTERVIEW

10881 passengers were interviewed at 8 main bus stands for knowing their travel characteristics. While most of the passengers use city bus for access and dispersal to and from bus stand large number of Auto Rickshaw users are also observed. Other mode users are insignificant. For rail passengers, for access and dispersal, auto rickshaw is used and low use of other modes (except train) indicates, people directly goes to their destination on foot.

Table 2.10
Mode used by external passengers

	BUS		RAIL	
MODE	Access	Dispersal	Access	Dispersal
1 - Two Wheeler	8.1%	3.3%	8.4%	1.2%
2 - Auto Rickshaw	23.2%	12.1%	23.7%	11.3%
3 - Shared Auto Rickshaw	1.4%	1.0%	3.4%	0.5%
4 - Car	2.6%	6.9%	5.9%	1.4%
5 - Taxi	1.1%	0.7%	3.0%	0.6%
6 - Mini Bus (Public)	0.8%	1.3%	1.0%	0.5%
7 - Mini Bus (Regional)	0.1%	0.0%	0.0%	0.1%
8 - Bus (Public)	48.5%	60.7%	12.1%	2.1%
9 - Bus (Regional)	6.5%	17.1%	0.6%	0.2%
10 - Cycle Rickshaw	0.3%	0.2%	0.3%	0.4%
11 - Cycle	0.2%	0.1%	0.4%	0.0%
12 - Train	3.6%	2.0%	32.2%	81.3%
13 - Walk	2.3%	0.7%	1.4%	0.1%

By bus, 38% passenger trips are daily and by rail, it is 15.5%, signifying a large number of persons living outside the city commute work by bus and other purposes.

Table 2.11
Frequency of trips made by external passengers

33.1%	15.6%	D - Daily
14.8%	10.9%	W - Weekly
34.5%	40.7%	M - Monthly
17.5%	32.5%	O - Occasionally

Regarding occupation, revealing part of the table 2.12, is over 60% are working in small establishments such as Shops, Hotels and Restaurants or repair as non permanent workers. Showing types of job which are available in the city. About 20% are employees of Government and Private Establishments.

Table 2.12

Occupation of external passengers

BUS	RAIL	OCCUPATION
1.4%	0%	0-Not stated
6.6%	3.8%	1 - Government Employee
5.1%	8.3%	2 - Private Employee
8.9%	5.1%	3 - Institute Employee
18.7%	19.5%	4 - Shops/ Malls/ Stores
31.2%	43.4%	5 - Hospitality
12.5%	3.8%	6- Services (Barber/ repair shop)
0.1%	3.5%	7 - Health
0.7%	1.1%	8 - Others (Mention)
10.9%	5.8%	9 - Student
0.1%	0%	Unemployed

Purpose wise trips made shows (in table 2.13) that more than 50% trips are work trips.

Table 2.13

Purpose wise external trips

BUS	RAIL	PURPOSE
0.1%	0.0%	0-Not Stated
41.2%	41.4%	1 - Work
10.0%	10.5%	2 - Business
11.3%	5.6%	3 - Education
2.2%	2.3%	4 - Social
4.3%	2.3%	5 - Shopping
3.1%	4.0%	6 - Recreation
1.2%	5.3%	7 - Religious
24.0%	26.7%	8 - Others

2.5 WORK PLACE SURVEY

Workplace survey was conducted in Nagpur City to know the concentration and type of workplaces and workers socio-economic conditions. In all 60 thousand workplaces were intercepted where1.94 lakh people are working. For a population of 24 lakhs, assuming 35% are workers, total workers are about 8 lakhs. In this manner, about 25% workers were recorded during the survey. This survey was aimed mainly to identify main work centers within the city and not for preparing an exhaustive list of workplaces. This survey has given a number of valuable information which is presented in the following tables:

Table 2.14 Type of work Establishments

Type of Establishments	Samples	Percent
Office (Private, Agency)	3008	5.50%
Factory (Small Scale Manufacturing)	238	0.40%
Institute (School, College, Coaching Center, Training Institute,)	1038	1.73%
Shopping (Retail and Wholesale Merchant)	47654	79.22%
Hospitality (Hotel, Restaurants, Eatery, Sweet meat shop etc.)	3155	5.52%
Services (Garage, Automobile Repair, Spare Parts, Mobile, Kirana store)	2634	4.38%
Health (Hospital, Nursing Home, Clinic, Medical Store, Gym)	2031	3.38%
Others (Marriage Hall, Sabhagriha, Temples)	191	0.32%
	60073	

Table 2.15 shows that overwhelming number (85%) of work places are shopping and hospitality business. This survey has depicted the status of retail type employment and not the status of basic type employments such as employments in Government Offices and Railways.

Table 2.15

Work Places as per number of employees

1	2	31106	51.26%
3	5	23201	38.62%
6	10	4157	6.90%
11	20	1290	2.15%
21	50	211	0.35%
51	100	17	0.03%
>100		8	0.01%

Classification as per employee size given in table 14 shows > 90% establishments have less or equal to 5 employees.

2.10 INTERVIEW OF WORKERS

13083 workers were interviewed and several interesting information were extracted from the interview. From table 2.16, it is observed 40.00% is one earning member family and 35% has two earners. From the table it is deduced workers population ratio is 0.35. It is also seen student / population ratio is 0.32 (within sample). But it is not possible to know whether all these workers make work trips using vehicle.

Table 2.16
Family details of workers

WORKERS IN FAMILY	NUMBER	PERCENT	FAMILY MEMBERS	STUDENTS IN FAMILY
1	6877	45.00%	27742	10020
2	5887	38.05%	33008	5842
3	2098	13.85%	12988	3415
4	240	1.59%	1813	628
ALL	15060		73002	23914

From sample data, trip length frequency is constructed and shown in table 2.17. Average trip length of workers was computed as 8.47 km.

Table 2.17
Trip length Frequency of workers

FROM KM	TO KM	PERCENT
1	5	28.8%
6	10	43.4%
11	15	18.2%
16	20	4.7%
21	25	1.4%
26	30	1.3%

Table 2.18
Monthly income of workers

RS	RS	Percent	
0	10000	49.5%	
10000	20000	30.7%	
20000	50000	15.8%	
50000	100000	5.5%	
100000	200000	1.3%	

As reported, 50% have income less than Rs. 10,000 per month. Average monthly income was computed as Rs. 22022.

As far as vehicle used for coming to work place is concerned, it is found 50% use two wheelers. Nearly 10% use public transport system. Frequency distribution is given in table 2.19.

Table 2.19
Mode used by the workers

Vehicle Type	Sample %
Two Wheeler	45.24%
Auto Rickshaw	26.17%
Shared Auto Rickshaw	3.41%

Vehicle Type	Sample %
Car	8.12%
Taxi	2.20%
Mini Bus (Public)	3.90%
Mini Bus (Regional)	1.20%
Bus (Public)	6.42%
Bus (Regional)	0.48%
Cycle Rickshaw	0.32%
Cycle	1.81%
Train	0.30%
Walk	0.47%
Total	100%

Average journey time (as reported) is 26.6 minute. Average expenditure on travel per day is Rs. 24.58.

As far as location of work place is concerned, 60% employment is concentrated in DHANTOLI, COTTON MARKET, ZERO MILE, SITABULDI areas which are within the core area of the city. Another 26% employment is in MAHAKPUR, MAHAL, LAW COLLEGE, BHANDARA ROAD, MANEWADA, FORT, GANESHPETH, SADAR and LAKDAGANJ areas. There are also a few isolated places such as INDORA, KHAMLA, ITWARI and KALMANA where work places exist. This is an important finding for fixing work trip attraction zones for trip distribution purpose.

2.11 TRIP FORECASTING USING TRAFFIC MOLELS

Four stage modeling procedure has been adopted which are known as trip generation, trip distribution, modal split and trip assignment. Many books and research papers are available in which basic theory and application are well explained. Depending upon the situation, different variations of the above stages are applied. A few references[2] are given in the footnote. To start with, a few basic data such as Traffic Zone System (TAZ), Road and Other Transport Network, Land use data are prepared.

[2] Ben-Akiva,M and Morikawa, T. 1990 Estimation of Travel Demand Models from Multiple Data Sources, Transportation and Traffic Theory, Cascetta, E., 2009 Transportation Systems Engineering: Theory and Methods, Kluwer Academic Publishers, Dordrecht. Koppelman, F. 1976 Guidelines for Aggregate Travel Prediction Using Disaggregate Choice Models Transportation Research Record 610

National Research Council (U.S.) Transportation Research Board (2000) Highway Capacity Manual, National Research Council (U.S.) Transportation Research Board

Sheffi, Y 1985 Urban Transportation Networks: Equilibrium Analysis with Mathematical Programming Methods, Englewood Cliffs, N.J., Prentice Hall

Wilson, A.G. 1974 Urban and Regional Models in Geography and Planning., Wiley London, New York

M.G.Bell & Y.Iida, 1997, Transport Network Analysis, John Wiley & Sons, England

2.12 TRIP ENDS ESTIMATION

After collecting necessary inputs from primary survey, secondary data as available were also investigated. Several rounds made in the city to physically verify concentration of residential population, work places and education centers and their connecting routes. A list of wards (136), list of group zones (defined as ZONES numbering 1-10) and ward wise population of 2001 was available. In 2001, total population of Nagpur 136 wards was 20,52,066 with average population density 247/hector. Maximum population of any ward was found to be 16986, minimum population was 13,831 and average 15,089. From this it appears, wards were fixed on the basis of uniform population and not according to landuse activities.

Such wards cannot be successfully used as traffic analysis zones (TAZ) for estimating ridership on proposed metro network. A map of Nagpur city was available where future allocation of landuses was clearly marked. This map become very helpful for creating TAZs. Nagpur and its adjoining areas were brought under new traffic zone system which had 269 internal and 10 external zones. These zones were classified as RESIDENTIAL, COMMERCIAL, MIXED, PUBLIC, GREEN and OTHER. From the names assigned to the classes, characteristics of the zones should be understood. Examples of MIXED zones are MOMINPURA, GANDHIBAG, MIDDLE, BAGADGANJ, BASTI, AZAMSHAH, DHANTOLI, DAGA LAYOUT, MOHAN NAGAR, SADAR, TEMPLE ROAD, VIJAY CLUB, RAVI NAGAR, HINGNA RD etc. which have both resident population and commercial activities. PUBLIC zones have mostly government offices, educational institutes, hospitals, courts etc. OTHER zones are Railway Stations & Yards, Government Lands, Bus Depots, Godowns, Wholesale Markets etc. GREEN zones are lakes, parks, forests, agriculture lands etc. Residential zones have habitat population. With this classification, it became logical to allocate population and to identify trip attraction zones. Ward wise population of 2001 was reallocated among the zones after verifying their geographical location and ZONES. External TAZs are entry points to the city namely the Roads: WARDHA, HINGNA, AMRAVATI, KATOL, KORADI, KAMPTEE, BHANDARA, and UMRED.

Total Population of the study area and estimated daily vehicular trip production from all the internal and external zones during different horizon years are given in table 2.21. Employments locations (Zones) were identified from work place survey and Per Capita Trip Rate for 2012 was also derived from the Workplace Survey Data. Concentration of educational institutes, and medical facilities were identified from map and physically verified. In this manner, trip attraction zones were identified for different purposes (work, education and other) and were assigned ranks. Zone attraction weights were then derived by multiplying zone ranks with zone areas and then by normalizing it. Total trips for different purposes (work, education and other) trips attracted to zones were then by multiplying total purpose wise trips with zonal weights. Trips to be attracted for other horizon years were also estimated. Estimate of total population and trips produced of the study area are shown in table 2.20.

Table 2.20

Population and Trip Production in lakhs during different horizon years

	2001	2006	2011	2016	2021	2026	2031	2036	2041
POP	21.40	23.01	24.77	26.62	28.60	30.40	32.27	34.20	36.18
TRIP	17.53	19.01	22.47	24.48	26.65	28.71	30.83	33.33	35.89
TRIP RATE	0.816	0.826	0.854	0.864	0.875	0.888	0.898	0.909	0.920

2.13 TRIP DISTRIBUTION

Trip ends are then distributed (using gravity model) among traffic zones according to the distance (or by GC). Inner philosophy of trip distribution is that a trip is originated due to population and is attracted to another zone due to facility available in that zone. Also if the cost of travel to that zone is higher than the cost of travel to another zone having the same facility, the trip will be attracted to another zone. Trip distribution (Gravity Model) model formula is given as under

$$T_{ij} = A_i P_j B_j C_j c_{ij}^{\alpha} e^{\beta c_{ij}} \text{——}(1)$$

where T_{ij} are trips from zone i to j, c_{ij} is cost of travel from i to j, P_j = trips produced from zone j, A_i = trips attracted to zone i, B_j = 1/ [$\Sigma^n{}_{i=1} P_i C_i c_{ij}^{\alpha} e^{\beta c_{ij}}$] & C_j = 1/ [$\Sigma^n{}_{j=1} A_j B_j c_{ij}^{\alpha} e^{\beta c_{ij}}$] and α, β are deterrence constants. B_j, C_j are model constants which are fixed through iterative proces.

2.14 MODAL SPLIT

Economics based modal share model is developed to determine realistic share between public and private transport for two options namely with metro and without metro. Utility cost or the generalized cost of travel for each link is derived by assuming certain values of the parameters which constitute the vehicle wise total economic cost (generalized) cost. Items which are used for constructing the utility function are given in the top row of table 3. All times are converted to money cost by using value of time. These values are obtained from sample survey.

Table 2.21: Utility Model Inputs

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Bus	30	10	10	18%	19%	3%	3	3	0.4	3.8
Car	40	0	0	0%	15%	0%	15	3	2	3.5
Taxi	40	0	0	0%	19%	0%	20	2	5	3.8
2 Wheeler	40	0	0	0%	19%	10%	2	3	1	3.8
Auto	30	0	0	0%	19%	1%	10	2	3	3.8
Metro	35	10	2.5	10%	3%	-10%	6	2	0.3	3.8

Discomfort cost is subjective which depends upon energy loss while availing the service of that particular mode. 10% is allotted to 2 wheelers due to the physical tension and safety of the driver.
(-) 10% to metro passengers is indicative of comfort for hustle free journey. For without metro situation, Metro is not considered in the model, and for with metro situation the same is considered. Logit model formulation is given by:

$$P_m = \frac{e^{U_m}}{\sum e^{U_i}}$$

Where U_m is utility function for mode m and P_m is share of mode m when number of competitive modes are 1, k.
In figure 5 mode share is shown for without metro situation. In figure 6 mode share between public and private modes is shown.

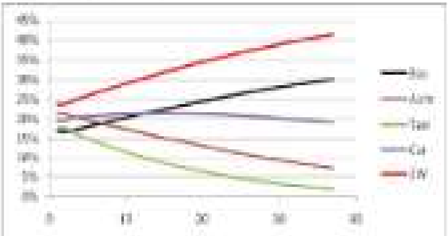

Figure 2.10: Mode share among passenger vehicles without metro

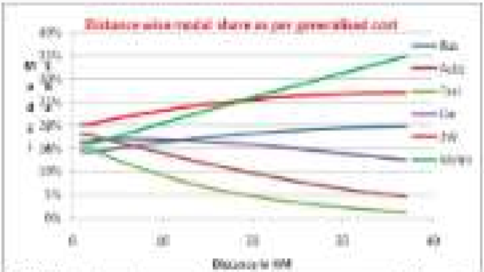

Figure 2.13 Mode share between public and private passenger vehicles with metro

2.15 SIMULTANEOUS MODAL SPLIT AND DISTRIBUTION

Trips between each zone pair are divided into public and private modes using logit model (Para 2.4.4). Cars and Two Wheelers together are private modes. All types of Buses, Auto Rickshaws and Taxis together are considered as Public Modes. Private mode trips use road only network while public modes trips use other mode network also. Rail and Metro both fall under public mode.

Trips for every zone pair for which distance is available are divided into public and private modes as per the distance for using Logit Model and distributed by using public and private network which are already separated from the complete transport Network. Before distribution, distribution parameters (β,α) are determined from observed average trip length (from work place survey average trip length was found as 8.47 km, see para 2.3.2). Thus Origin – Destination passenger trip matrices for all horizon years.

2.16 TRIP ASSIGNMENT

Several traffic assignment techniques such as capacity restrained, incremental loading, user equilibrium, dynamic assignment etc. are available. All of them are developed by considering (or hypothetically assuming) different kind of passenger behavior.

In this study, incremental loading assignment technique is used where OD matrix is partly assigned (10%-25% each time) and link cost is modified on the basis of the part assignment. Link loads obtained from each part assignment are added.

As metro is a part of the public network, a portion of the public trip matrix is separated for loading on metro network. If both origin and destination zone of a trip has at least one metro station, it is assumed shift from other modes to metro will be from 10%-30%

(longer the mutual distance of the OD pair, higher will be the shift to metro) from public OD. It is also assumed that trips from private OD will be shifted to metro OD.

This distribution cum assignment exercise will finally produce four OD matrices [(1) private mode to use road only network, (2) public mode to use road and rail only network, (3) public mode to use road, rail and metro network and (4) metro mode to use metro and road only network], assigned trips and routes for each OD pair.

2.17 DAILY RIDERSHIP ESTIMATION

Estimation of trips on metro line is done by using a special computer program which scans routes between each zone-pair which are generated from traffic assignment model during incremental loading traffic assignment algorithm. Each metro station is uniquely defined in the network and a continuous path from one metro station to another metro station (crossing several metro stations on the way) defines a metro route. Entry to and Exit from any other type of nodes (Road or Zone or Rail) are regarded as Boarding and Alighting of the concerned metro station.

2.18 NAGPUR METRO ALIGNMENT PLAN

For Nagpur city, two separate lines have been suggested with an interchange facility at SITABULDI. Length of line 1 (Automotive-Mihan) is 20.5 km and the length of line-2 (Prajapati-Lokmanya) is 18.6 km. Alignments have been finalized after many considerations which include, traffic flow path, core area, connectivity, future landuse development plan and existing infrastructure. Line 1 shall connect two important gateways (Kamptee and Wardha). Mihan and International Airport and Cargo HUB are dream projects will also be connected to this line. Line 2 will also connect another two gateways (Bhandara and Hingna) of the city. The line is passing through populated residential zones, business and education centers.

Figure 2.14 Alignment of Nagpur Metro

2.15 SUMMARY OUTPUT

Table 2.20: Summary Output(1)

YEAR	2018	2021	2026	2031	2036	2041
Population[10]	2962330	2834802	3029983	3226654	3428976	3617996

[10] Zone wise population was projected from the population density (PD) of the zone observed in 2008. Different growth rates (GR) were applied on PD of the zone according to the class of the zone as per PD. For instance, if PD of a residential zone is below 100, GR=2.55%; if PD is between 100 and 150, GR is 2.0% less and so on. The

YEAR	2016	2021	2026	2031	2036	2041
Overall ANNUAL GROWTH	3.92%	1.48%	1.26%	1.23%	1.25%	1.10%
All trips	2718643	2951773	3189873	3442617	3726524	3995288
Trip rate	1.02	1.03	1.05	1.07	1.08	1.10
Metro trips	323858	362399	409236	462918	529193	588183
% Of all trips	11.91%	12.28%	12.83%	13.45%	14.20%	14.72%

In NMC area, in 2011, 17.26% decadal growth rate of population is observed which was lower than previous decadal growth rate (26%) – L&T-Ramboll Report.

Table 2.23: Summary Output(2)

BOARDING/RIDERSHIP (DAY)	2016	2021	2026	2031	2036	2041
ON LINE 1 ([illegible]-[illegible])	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
ON LINE 2 ([illegible]-[illegible])	178302	199028	221241	252738	289937	320568
TOTAL OF BOTH	323858	362399	409236	462918	529193	588183
AVERAGE TRIP LENGTH IN KM	6.275	6.284	6.357	6.383	6.236	6.337
MAXIMUM PHPDT ON LINE 1	7545	8526	9658	10987	12441	14013
MAXIMUM PHPDT ON LINE 2	8087	8952	10170	11700	13468	15068

Total daily boarding ridership in 2016 is estimated as 3.24 lakhs in which share of line 1 as 45% and line 2 as 55%. Average trip length is 6.27 km. Interesting observation is trips between the lines are about 30%. As a standalone line, line 1 will carry 93 thousand and line 2 will carry 1.23 lakhs trips.

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scheme is applied for projecting population of different horizon years. Initial GR was adjusted to match population of 2011. In the table overall annual growth rate was shown.

Ambitious plan of creating New Nagpur International Airport & Mihan City has also been incorporated and it is seen about 20 thousand trips will be boarded from these two station in 2016.

Table 2.24: Summary Output(3)

	2016	2021	2026	2031	2036	2041
TRIPS WITHIN LINE 1	95401	109584	120056	141776	164018	182108
TRIPS WITHIN LINE 2	125249	144655	165349	189532	212865	235884
INTERCHANGE TRIP AT SITABULDI-RETAIL MARKET	95168	108084	117788	134838	152312	165572
TOTAL RIDERSHIP/DAY	315818	362299	403211	462921	529081	583096
PEAK HR RIDERSHIP	**35634**	**39864**	**45838**	**50921**	**58211**	**64708**
TRIPS FROM NEW AIRPORT & MIHAN	25452	27648	29776	31878	34453	37529
TO LINE 1	**20019**	**21931**	**23573**	**25536**	**27429**	**29615**
TO LINE 2	**5433**	**5717**	**6242**	**6384**	**7004**	**7914**

2.19 DAILY RIDERSHIP

TABLE 2.26A: DAY BOARDING ON LINE 1 FROM AUTOMATIVE TO MIHAN

STATION	2016	2021	2026	2031	2036	2041
AUTOMATIVE	12208	14753	16621	19151	23028	27268
NARI RD	7096	9067	11022	14088	16433	18027
INDORA	6226	6878	7656	8615	9620	10648
KADVI CHK	7136	7884	8879	9874	10742	12085
GADDI GODAM SQ	658	777	898	1089	1276	1347
KASTURCHAND PARK	8868	9862	10792	11881	13829	14287
ZERO MILE	5131	5272	5848	6830	7312	8053
SITABULDI	24133	27628	31289	35090	40283	44166
CONGRESS NAGAR	32826	36881	41787	47155	54080	60746
RAHATE COLONY	3465	3828	4097	5376	6482	[illegible]

STATION	2016	2021	2026	2031	2036	2041
NAARI	2309	3451	2826	4519	6308	6926
DEV NAGAR	2138	3425	2744	3436	4253	5275
MAYURESH APRTMNT	2305	2626	2801	3122	3502	3838
SAHAKAR NGR	3547	3766	4916	5320	6518	7898
OLD AIRPORT	1348	1462	1608	1735	1888	2040
NEW AIRPORT	8174	8922	9420	9894	10343	10736
MIHAN CITY	12740	13877	14933	16016	17228	18423
METRO DEPOT	4038	4840	5300	5808	6603	7352

TABLE 2.256: DAY BOARDING ON LINE 2 FROM PRAJAPATI NAGAR TO LOKMANYA NAGAR

STATION	2016	2021	2026	2031	2036	2041
PRAJAPATI NGR	928	1007	1074	1202	1328	1433
VAISHNO DEVI CHK	1204	1280	1381	1522	1678	1810
AMBEDKAR CHK	2952	3209	3581	3788	4212	4621
TEL EXCHANGE	10872	12358	15788	20264	23378	32477
CHITAR OLI CHK	3755	4968	7332	8367	11478	13634
AGRASEN CHK	7571	9328	10502	11218	13078	14733
MAYO HOPITAL	7563	11298	13948	18595	20907	18885
NAGPUR METRO ST	30888	34008	40413	43332	52026	58840
NETAJI MKT	26481	29503	33189	36437	39813	43293
JHANSI RANI SQ	17144	19072	22388	28374	29477	34378
INSTT OF ENGINEER	21393	22326	23938	24675	26088	27593
BANK OF INDIA	12455	13452	14401	15297	16061	17573
LAD CHK	3558	3981	4234	4602	4068	5434
DFC OF SCIENCE	8875	9676	10475	11343	12237	13140

STATION	2018	2021	2026	2031	2036	2041
SUBHAS NGR	1699	1624	2023	2150	2396	2574
RACHANA	1904	2233	2470	2740	3060	3404
VASUDEV NGR	2010	2272	2477	2746	3029	3346
BANSI NGR	1636	1907	2173	2442	2832	3176
MAHINDRA&MAHINDR	4385	4781	5115	5462	5897	6273
LOKMANYA NAGAR	7708	8362	9093	10014	10574	11593

TABLE 3.26-PEAK HOUR BOARDING ONLINE 1 FROM AUTOMATIVE TO MIHAN

STATION	2018	2021	2026	2031	2036	2041
LINE-1						
AUTOMATIVE	1343	1623	1828	2107	2533	2969
NARI RD	898	1051	1311	1583	1696	1818
INDORA	695	767	847	948	1056	1171
KADVI CHK	785	858	950	1064	1182	1320
GADDI GODAM SQ	72	85	98	118	140	148
KASTURCHAND PARK	975	1078	1187	1258	1453	1569
ZERO MILE	504	580	643	732	793	888
SITABULDI	2881	3040	3442	3857	4431	4858
CONGRESS NAGAR	3558	4057	4807	5187	5950	6083
RAHATE COLONY	348	388	451	613	830	1027
NEERI	243	273	311	497	697	752
DEV NAGAR	235	257	302	385	468	581
MAYURESH APRTMNT	239	288	314	343	392	425
SAHAKAR NGR	390	415	508	585	717	869
OLD AIRPORT	148	161	177	191	209	226
NEW AIRPORT	895	981	1035	1084	1138	1178
MIHAN CITY	1401	1525	1640	1752	1886	2027
METRO DEPOT	466	533	593	633	704	876

STATION	2018	2021	2026	2031	2036	2041
LINE-2						
PRAJAPATI NGR	102	111	118	132	146	163
VAISHNO DEVI CHK	132	141	153	167	184	205
AMBEDKAR CHK	323	355	385	417	463	508
TEL EXCHANGE	1156	1364	1734	2225	2751	3372
CHITAR OLI CHK	633	700	808	1030	1263	1500
AGRASEN CHK	833	1048	1155	1234	1536	1621
MAYO HOPITAL	835	1242	1534	1715	2003	2182
NAGPUR METRO ST	3376	3756	4445	5050	5622	6383
NETAJI MKT	3133	3246	3845	4610	4378	4753
JHANSI RANI SQ	1886	2068	2463	2901	3342	3803
INSTT OF ENGINEER	2353	2456	2564	2714	2869	3026
BANK OF INDIA	1374	1460	1584	1683	1808	1933
LAD CHK	391	436	468	506	540	594
DPC OF SCIENCE	976	1084	1152	1246	1346	1446
SUBHAS NGR	186	212	223	241	254	283
RACHANA	219	240	272	302	337	380
VASUDEV NGR	224	250	272	302	333	368
BANSI NGR	180	210	229	263	308	350
MAHINDRA&MAHINDR	482	520	563	603	649	690
LOKMANYA NAGAR	848	920	1000	1106	1207	1309

TABLE 2.27: PHPDT LINK LOAD ON LINE 1 FROM AUTOMATIVE TO MIHAN

STATION	STATION	2018	2021	2026	2031	2036	2041
AUTOMATIVE	NARI RD	2014	2454	2742	3160	3800	4459
NARI RD	INDORA	3333	4008	4708	5530	6345	7223
INDORA	KADVI CHK	4344	5141	5968	6831	7910	8858
KADVI CHK	GADDI GODAM SQ	5432	6323	7364	8385	9516	10701
GADDI GODAM SQ	KASTURCHAND PARK	5411	6287	7226	8300	9460	10737

STATION	STATION	2016	2021	2026	2031	2036	2041
KASTURCHAND PARK	ZERO MILE	6475	7433	8448	9071	10806	12234
ZERO MILE	SITABULDI	6928	7831	8871	10156	11409	12804
SITABULDI	CONGRESS NAGAR	7545	8526	9616	10987	12541	14032
CONGRESS NAGAR	RAHATE COLONY	2687	2939	3290	3944	4568	5442
RAHATE COLONY	NEERI	2203	2433	2708	3218	3884	4247
NEERI	DEV NAGAR	1944	2158	2312	2604	2932	3111
DEV NAGAR	MAYURESH APRTMNT	1646	1758	1920	2057	2385	2319
MAYURESH APRTMNT	SAHAKAR NGR	1310	1366	1517	1648	1760	1953
SAHAKAR NGR	OLD AIRPORT	1856	2041	2279	2527	2865	3257
OLD AIRPORT	NEW AIRPORT	1661	1818	2034	2264	2577	2948
NEW AIRPORT	MIHAN CITY	2624	3004	3320	3507	3844	4329
MIHAN CITY	METRO DEPOT	735	790	895	974	1123	1309

TABLE 2.20: PHPDT LINK LOAD ON LINE 2 FROM PRAJAPATI NAGAR TO LOKMANYA NAGAR

STATION	STATION	2016	2021	2026	2031	2036	2041
PRAJAPATI NGR	VAISHNO DEVI CHK	142	134	165	185	205	225
VAISHNO DEVI CHK	AMBEDKAR CHK	338	301	351	434	478	522
AMBEDKAR CHK	TEL EXCHANGE	818	881	960	1046	1163	1274
TEL EXCHANGE	CHITAR OLI CHK	2558	2871	3562	4325	5288	6558
CHITAR OLI CHK	AGRASEN CHK	3330	3700	4373	5422	6663	8035
AGRASEN CHK	MAYO HOPITAL	4371	5034	5767	6753	8125	9484
MAYO HOPITAL	NAGPUR METRO ST	4834	5767	6573	7537	9064	10090
NAGPUR METRO ST	SITABURDI	8087	8902	10370	11755	13468	15000
SITABURDI	JHANSI RANI SQ	5740	6806	7008	8857	9828	11307
JHANSI RANI SQ	INSTT OF ENGINEER	3310	4002	4501	5301	5881	6627

STATION	STATION	2016	2021	2026	2031	2036	2041
INSTT OF ENGINEER	BANK OF INDIA	6850	7462	8375	8758	9490	10244
BANK OF INDIA	LAD CHK	5060	5543	6040	6665	7199	7822
LAD CHK	DPC OF SCIENCE	4537	4996	5415	5927	6466	7028
DPC OF SCIENCE	SUBHAS NGR	3154	3609	3785	4162	4565	4984
SUBHAS NGR	RACHANA	2905	3184	3467	3835	4211	4624
RACHANA	VASUDEV NGR	2687	2838	3004	3463	3726	4054
VASUDEV NGR	BANSI NGR	2239	2471	2804	2963	3235	3513
BANSI NGR	MAHINDRA&MAHINDR	1996	2164	2344	2566	2783	2999
MAHINDRA&MAHINDR	LOKMANYA NAGAR	1272	1380	1501	1662	1811	1964

2.21 More About MIHAN

Some description about MIHAN project is already given in section 2.4. SEZ and International Cargo HUB are two important projects in MIHAN. NIT and GoM they are working hard to make the project successful.
L&T-Ramboll (see Study Report submitted by them) has worked out population and Employment for MIHAN when the project will be operational. Shown below are the salient points from that study report.

1. Population density of Nagpur mc is 94/hectare in 2001
2. Only 10 zones had population density over 600/ hectare
3. Residential area allocated in MIHAN = 414 hectare
4. SEZ area in MIHAN = 1472 hectare
5. Total area =4354 hectare
6. Assumed to be operational in 2015
7. Employment in 2015 = 1.56 lakh
8. Employment in 2021 = 3.60 lakh
9. Employment in 2031 = 4.30 lakh
10. 40% employees will commute from Nagpur
11. Employment growth 2015-2021 = 4.5% (cumulative)
12. Employment growth 2021-2031 = 5.2% (cumulative)
13. Maximum Population density assumed = 600/ hectare
14. Maximum population in MIHAN which can be accommodated is 2.40 lakhs

According to L&T-RAMBOLL report, a maximum of 2.4 lakh population (PD=600/Hectare) is expected to live in MIHAN and due to SEZ and Airport Centric activity, employment that will be generated in 2030 is 1.06 lakhs.
As on date, there is hardly any population living in MIHAN and economic activity has not started. Therefore keeping a modest view, most likely population and employment figures are worked out by **assuming Population density as 150/hectare and Employment density as 40/hectare in 2016 and shall grow with 5% growth rate.** In MIHAN, Population and Employment that are expected are given as under:

Table 2.32: Expected Population and Employment in MIHAN

	2016	2021	2026	2031	2036	2041
POPULATION	60600	77344	98711	125984	160790	205213
EMPLOYMENT	83440	106493	135915	173466	221391	282557

If, however, project is further delayed, these figures will be shifted towards right.

2.33 EFFECT OF MIHAN ON PROPOSED METRO RIDERSHIP

According to L&T-RAMBOLL report, 40% employees will commute here from outside MIHAN including Nagpur city but there is no mention of people who would likely to commute from MIHAN to Nagpur. Therefore, when completed, MIHAN will be a self sufficient industrial city where people will live and work.

It is expected there will be overall 30% commuting of both resident population and due to employment which will make an impact on the daily ridership of Metro.

This has been included in the forecasting process. Daily ridership projected from MIHAN stations are given in table 2.33 (already shown in bottom of table 2.30).

Table 2.33 Ridership from MIHAN Stations

STATIONS	2016	2021	2026	2031	2036	2041
NEW AIRPORT	4624	5232	5692	6161	6668	7214
MIHAN CITY	14111	14949	16565	18072	19964	21779

2.33 FURTHER DEVELOPMENTS

On 23.08.2013, a meeting presided by Shri S.K Lohia, JS-MoUD,GoI was held at Nagpur to discuss the DPR. In that meeting, JS-MoUD,GoI expressed that the FIRR of the project should be at least 8%. Recently, MoUD has also issued advisory that FIRR of Metro Project should not be below 8%.

On 1.10.2013, a presentation on the DPR was made by M/s NIT to The Chief Minister, Government of Maharashtra. He was of the opinion to avoid underground alignment in MIHAN and also construct Maintenance Depot in the land belonging to State Govt Land. Subsequently, on 21.10.2013, a joint inspection of the NS corridor was done by VC&MD-MADC, Chairman-NIT, and Director Business Development-DMRC. In the inspection, as desired by M/s NIT, NS corridor was slightly modified to move along Wardha Road and then west of Railway Track in MIHAN area. Location of Depot of NS Corridor has also been modified and now, depot has been located in MADC Land near Khapri Railway Station. Similarly, Depot of EW Corridor has also been shifted to SRP Land near proposed Lokmanya Nagar Metro Station.

This has caused deletion of few earlier proposed metro stations on NS Corridor and addition of new stations on the same.

2.34 ESTIMATION OF RIDERSHIP FOR FINAL ALIGNMENTS

After going through the DPR, NIT requested DMRC to provide an estimate of the daily ridership for the alternative alignment of line 1 (Automotive to Khapri). The new alignment of line 1 is same up to Ajni Chowk as before but now will go straight along Wardha Road up to Khapri Rail Station (instead of going along Khamla Road towards Mihan). A diagram of the new alignment is shown in figure 2.14.

List of station names, chainage (m) and inter station-distance(in km) between the stations are given in the table 2.31 Chainage and inter-station distances are shown as per map. Station names are given as per local area names.

Table 2.31: Nagpur Metro Rail Project N S Corridor

S.No	Station Name	Chainage(in mt)	Inter Distance Between Two Stations in KM
	DEAD END	-439.2	
1	AUTOMOTIVE SQAR	0.0	439.2
2	NARI ROAD	975.8	975.8
3	INDORA CHOWK	2139.7	1163.9
4	KADVI CHOWK	3181.2	1041.5
5	GADDI GODAM SQRE	4399.0	1217.8
6	KASTURCHAND PARK	5148.6	749.6
7	ZERO MILE	6175.5	1026.9
8	SITABURDI	6709.2	533.7
9	CONGRESS NAGAR	7897.2	1188.0
10	RAHATE COLONY	8682.6	785.4
11	AJNI SQUARE	10104.7	1422.1
12	CHHATRAPATI SQUARE	11146.3	1041.6

S.No	Station Name	Chainage (in m)	Inter Distance Between Two Stations in KM
13	JAIPRAKASH NAGAR	11611.3	801.1
14	UJWAL NAGAR	12646.6	1035.2
15	AIRPORT	13784.5	1346.1
16	NEW AIRPORT	16164.4	2780.1
17	KHAPRI	18460.5	2117.9
	DEAD END	19250.0	

In the above list it is seen that after NEERI station (old alignment), the line is going straight along Wardha Road up to Khapri. The alignment along Khamla Road is now modified to Wardha Road for the reason that earlier it was taken to Airport but now it is not considered necessary due to likely small ridership from Airport and high construction cost of Underground section. Hence the ridership has also got modified and given in the tables 2.32- 2.35. The modified phase-I metro network of Nagpur Metro is shown in fig 2.14

Figure 2.16
FINAL ALIGNMENT

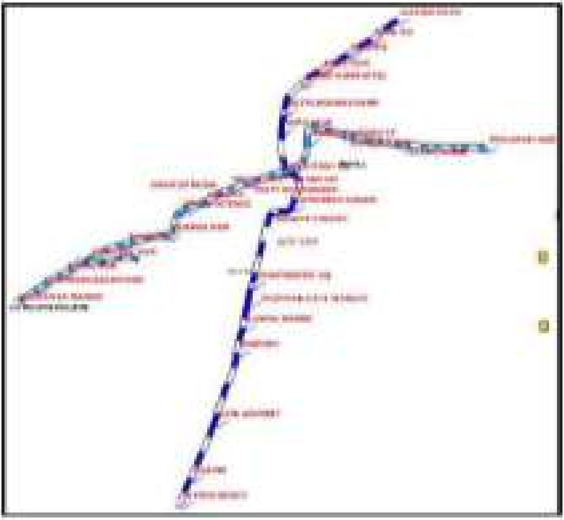


TABLE 2.32 SUMMERY OF RIDERSHIP ON LINE 1 AND LINE 2

BOARDING RIDERSHIP (DAY)	2016	2021	2026	2031	2036	2041
ON LINE 1(AUTOMATIVE-KHAPRI)	168361	185531	200720	224316	248415	277704
ON LINE 2(PRAJAPATI-LOKMANYA)	184081	197908	215415	234577	260237	286031
TOTAL OF BOTH	352442	383439	416135	458893	508652	563735
AVERAGE TRIP LENGTH IN KM	6.419	6.455	6.484	6.503	6.521	6.522
MAXIMUM PHPDT ON LINE 1	10080	10936	11515	12834	14288	15729
MAXIMUM PHPDT ON LINE 2	7740	8460	9154	9806	10748	11882
TRIPS WITHIN LINE 1	104350	117025	128863	141968	158181	178897
TRIPS WITHIN LINE 2	120074	129402	140555	152253	170013	187224
INTERCHANGE TRIP AT SITABULDI-NETAJI MARKET	128016	137010	146716	164680	180438	197612
TOTAL TRIPS	352440	383437	416134	458891	508637	563733

2.35 DAY BOARDING AND PHPDT

Day boarding on line 1 and line 2 stations estimated for different horizon years are shown in table 2.33.

TABLE 2.33 DAY BOARDING ON LINE 1 AND LINE 2 STATIONS

STATION	2016	2021	2026	2031	2036	2041
LINE 1	DAY	DAY	DAY	DAY	DAY	DAY
AUTOMOTIVE	16526	18254	20941	24527	27996	31877
NARI RD	7341	8853	10080	11619	13237	15415
INDORA	6966	7963	8833	9871	11166	12417
KADVI CHK	8031	8978	9851	10874	12137	13006
GADDI GODAM SQR	1227	1394	1566	1793	2146	2562
KASTURCHAND PARK	10196	10709	12193	14289	15896	17698
ZERO MILE	9066	9506	8567	9704	10636	10058
SITABULDI	23382	32903	33906	39152	42010	47138
CONGRESS NAGAR	33551	38285	41307	44414	48044	53055
RAHATE COLONY	8119	8880	9892	10869	12261	13458
AJNI SQR	5028	5723	6253	6862	7643	8429
CHHATRAPATI SQR	3123	3449	3743	4057	4413	4733
JAIPRAKASH NAGAR	2028	2233	2387	2588	2875	3158
UJWAL NAGAR	3041	3234	3585	3911	4287	4761
AIRPORT	1756	1856	2039	2238	2441	2694
NEW AIRPORT	5474	5898	6363	6927	7488	9014
KHAPARI	16409	17216	18823	20635	22643	26406

LINE 2	DAY	DAY	DAY	DAY	DAY	DAY
PRAJAPATI NGR	3308	3542	3793	4011	4265	4528
VAISHNO DEVI CHK	2979	3195	3430	3637	3893	4153
AMBEDKAR CHK	3390	3614	3867	4142	4430	4731
TEL EXCHANGE	11406	11810	12858	14016	15878	16779
CHITAR OLI CHK	9078	9787	10514	11341	12737	14846
AGRASEN CHK	6332	6791	7290	7828	8501	9347
MAYO HOPITAL	4798	5107	5522	5978	8712	10497
NAGPUR METRO ST	21637	24026	26863	35459	35430	40845
NETAJI MKT	23767	24697	27273	29908	32621	34899
JHANSI RANI SQR	17031	17651	19833	21944	24245	26591
INSTT OF ENGINEER	23642	25423	27198	28660	30446	31749
BANK OF INDIA	17778	19026	20676	22215	23691	25584
LAD CHK	3508	3803	4103	4413	4777	5136
DPC OF SCIENCE	9811	10756	11693	12714	13772	14853
SUBHAS NGR	1918	2120	2297	2472	2681	2898
RACHANA	2173	2450	2728	2987	3473	3944
VASUDEV NGR	4858	5366	5826	6326	6821	7449
BANSI NGR	3083	3441	3771	4121	4481	4806
MAHINDRA&MAHINDR	4737	5154	5546	5956	6362	6817
LOKMANYA NAGAR	8863	9628	10488	11309	12098	13754

Change about the boarding pattern is also investigated. On line 1, boarding from Automotive to Kasturba Chk is increased from 45663 to 50100 (+4537), from Zero mile to Congress Nagar is increased from 85791 to 96802 (+11011), from Rahate Colony to Khapri is increased from 40917 to 45539 (+4622). Total increase is 22130.

On line 2 boarding from Prajapati to Agrasen Chowk is increased from 33791 to 38742 (+4951), from Mayo Hospital to Netaji Market boarding is decreased from 75299 to 53984 (-21315), from Jhansi Rani Sqr to DPC of science boarding is increased from 68489 to 77053 (+8564) and from Subhash Nagar to Lokmanya Nagar boarding is increased from 21446 to 28129 (+6683). Increase of boarding at Sitabuldi is 5213 and decrease at Netaji Market is 4846.

PHPDT on line 1 is increased from 8525 to 10506 (between Sitabuldi and Congress Nagar) while on line 2 PHPDT is decreased from 8062 to 7010 (between Netaji Market and Nagpur Railway Station) as the stretch will not be used by line 1 passengers as in old alignment. Maximum PHPDT on line 2 is between Institute of Engineers and Bank of India Stations. PHPDT is 8400 (old alignment PHPDT was 7402 on this stretch). Interchange trip is increased from 53675 to 68565 (one way).

It is seen that in old alignment (via Khamla Road) case, trips from line 1 were diverting to line 2 via Sitabuldi-Netaji Market interchange and in new alignment (via Wardha Road) trips are going straight to Sitabuldi and beyond due to change of influenced zones. Hence this dip of PHPDT on this stretch is expected. The stretches on line 1 from Zero mile to Sitabuldi and on line 2 from Mayo Hospital to Netaji Market are parallel with average distance between them is 0.8 km. Traffic zones falling in this area are commercial and office zones including Nagpur rail station.

PHPDT load on line 1 (from Automotive to Khapri) is given in table 2.34.

TABLE 2.34 LINE 1 PHPDT FROM AUTOMATIVE TO KHAPRI

STATION	STATION	2018	2021	2026	2031	2036	2041
AUTOMOTIVE	NARI RD	2501	3016	3433	4049	4611	5274
NARI RD	INDORA	3754	4476	5113	5960	6752	7815
INDORA	KADVI CHK	4865	5767	6547	7562	8609	9833
KADVI CHK	GADDI GODAM SQR	6039	7042	7945	9068	10325	11716
GADDI GODAM SQR	KASTURCHAND PARK	6059	7021	7914	9062	10333	11743
KASTURCHAND PARK	ZERO MILE	7329	8313	9379	10804	12132	13724
ZERO MILE	SITABULDI	8272	9226	10297	11631	13032	14673
SITABULDI	CONGRESS NAGAR	10068	10930	11916	12934	14266	15728
CONGRESS NAGAR	RAHATE COLONY	5269	5728	6393	6918	7688	8477
RAHATE COLONY	AJNI SQR	4513	4876	5339	5854	6478	7149
AJNI SQR	CHHATRAPATI SQR	3935	4241	4641	5084	5607	6195
CHHATRAPATI SQR	JAIPRAKASH NAGAR	3561	3822	4185	4560	5070	5606
JAIPRAKASH NAGAR	UJJWAL NAGAR	3289	3520	3851	4241	4680	5175
UJJWAL NAGAR	AIRPORT	2939	3136	3441	3787	4177	4624
AIRPORT	NEW AIRPORT	2733	2911	3193	3513	3878	4302
NEW AIRPORT	KHAPRI	2143	2287	2483	2743	3048	3390

PHPDT load on line 2 (from Prajapati nagar to Lokmanya nagar) is given in table 2.36.

TABLE 2.36 LINE 2 PHPDT FROM PRAJAPATI NAGAR TO LOKMANYA NAGAR

STATION	STATION	2016	2021	2026	2031	2036	2041
PRAJAPATI NGR	VAISHNO DEVI CHK	481	517	549	585	621	650
VAISHNO DEVI CHK	AMBEDKAR CHK	903	971	1033	1102	1174	1250
AMBEDKAR CHK	TEL EXCHANGE	1378	1473	1528	1685	1800	1923
TEL EXCHANGE	CHITAR OLI CHK	2919	3084	3353	3607	4003	4661
CHITAR OLI CHK	AGRASEN CHK	4030	4358	4703	5004	5342	5332
AGRASEN CHK	MAYO HOSPITAL	4843	5157	5572	6037	6544	7086
MAYO HOSPITAL	NAGPUR METRO ST	5288	5649	6087	6619	7540	8287
NAGPUR METRO ST	SITA BURDI	7341	7976	8754	9676	10748	11882
SITA BURDI	JHANSI RANI SQR	6141	6601	7346	8168	9030	10004
JHANSI RANI SQR	INSTT OF ENGINEER	4238	4486	4912	5408	6001	6642
INSTT OF ENGINEER	BANK OF INDIA	7746	8468	9154	9906	10716	11528
BANK OF INDIA	LAD CHK	6114	6663	7275	7968	8610	9314
LAD CHK	DFC OF SCIENCE	5501	6147	6684	7205	7936	8588
DFC OF SCIENCE	SUBHAS NGR	4072	4472	4876	5311	5806	6297
SUBHAS NGR	RACHANA	3787	4157	4538	4934	5410	5871
RACHANA	VASUDEV NGR	3404	3628	4188	4527	4932	5341
VASUDEV NGR	BANSI NGR	2714	2966	3217	3504	3819	4136
BANSI NGR	MAHINDRA& MAHINDR	2212	2408	2583	2833	3082	3349
MAHINDRA& MAHINDR	LOKMANYA NAGAR	1436	1558	1688	1882	2042	2236

Salient features of the two alternatives are shown in table 2.35.

TABLE 2.36 COMPARISON OF SALIENT FEATURES BETWEEN TWO ALTERNATIVES (Year 2021)

SUMMERY	NEW ALIGNMENT (STRAIGHT ALONG WARDAHA ROAD)	OLD ALIGNMENT (ALONG KHAMLA ROAD)
LINE 1 LENGTH	19.250 KM	21.920 KM
LINE 2 LENGTH	18.557 KM	19.266, KM
BOARDING/RIDERSHIP (DAY)	**YEAR 2021**	**YEAR 2021**
ON LINE 1 (AUTOMATIVE-MIHAN/KHAPRI)	185531	163371
ON LINE 2(PRAJAPATI-LOKMANYA)	197898	199028
TOTAL OF BOTH	383429	362399
AVERAGE TRIP LENGTH IN KM	6.453	6.264
MAXIMUM PHPDT ON LINE 1	10006	8526
MAXIMUM PHPDT ON LINE 2	8493	8902
TRIPS WITHIN LINE 1	117025	109036
TRIPS WITHIN LINE 2	125402	144035
INTERCHANGE TRIP AT SITABULDI-NETAJI MARKET	137910	108988
AVERAGE TRIP LENGTH IN KM	6.45	5.78

It is observed that ridership wise there shall be no loss (rather a net gain of 22190 trips). On line-1 maximum PHPDT will increase but on line 2 maximum PHPDT will be on another line. Maximum PHPDT will decrease on previous line (old alignment) due to shift of boarding from line 2 to line 1 in the CBD area as explained before. Some trips from/to Khamla side (stations from Dev Nagar to Old Airport) will now use line-1 stations from Chhatrapati Square to Airport. In 2021, average trip length will be 6.45 km for new alignment as against of 5.78 km in old alignment. Length of line-1 will decrease by around 2.5 km and also there will be cost reduction due to avoidance of the underground portion. Original alignment of line 1 was planned on the assumption of full development Mihan Industrial Area, Cargo Hub and International Airport and if these projects are not completed in time, original alignment of line 1 via old air port may not be so useful and economically not viable. Hence pragmatically speaking, the new alignment of line-1 is better.

CHAPTER 3

SYSTEM SELECTION

TABLES

FIGURES

Chapter - 3

SYSTEM SELECTION

3.1 GENERAL

The population growth in cities and urban centres has put a lot of pressure on the infrastructure of these cities. In rapidly developing countries like India the urban infrastructure is stretched to limit and requires very effective solutions. The rapid development in India is not unprecedented and such development earlier took place in several nations of Europe, America and in Japan. So several modes of urban mass transit are now available for solution to the problem of Urban Transit in Nagpur.

L&T Ramboll Consulting Engineers Limited had carried out the Comprehensive Traffic and Transportation Study and prepared Transportation Master Plan for Nagpur city commissioned by NMC. As a part of study they also recommended four Metro Corridors which have been discussed in Chapter-1 of this DPR.

3.2 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. Moreover, supply of metro rail system in Nagpur urban complex will mean a lot in terms of sustainable means of transport that meets the mobility and accessibility needs of people.

3.3 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 Bangalore. Metro projects are taken in various cities like, Mumbai, Chennai, Hyderabad, Jaipur, Kolkata, Kochi.

A summary of metro network developed worldwide is given below in **Table 3.1**.

Table 3.1: Spread of World Metro Rail Systems

City	Country	Continent	Commencement	Network Length (km)	Daily ridership (million)
Adana	Turkey	Asia	18-Mar-10	13.5	
Amsterdam	Netherlands	Europe	16-Oct-77	32.7	0.233
Ankara	Turkey	Asia	30-Aug-96	22.1	0.31
Antwerp	Belgium	Europe	25-Mar-75	7.6	
Athens	Greece	Europe	1904	52.0	0.872
Atlanta	USA	America	30-Jun-79	76.2	0.2932
Baku	Azerbaijan	Asia	6-Nov-67	32.9	0.482
Baltimore	USA	America	21-Nov-83	24.6	0.0398
Bangkok	Thailand	Asia	5-Dec-99	55.6	0.592
Barcelona	Spain	Europe	30-Dec-24	119.4	1.1
Beijing	China	Asia	1-Oct-69	337.0	3.88
Belo Horizonte	Brazil	America	1-Aug-86	28.1	
Berlin	Germany	Europe	18-Feb-02	147.4	1.38
Bielefeld	Germany	Europe	21-Sep-71	5.2	
Bilbao	Spain	Europe	11-Nov-95	40.8	0.238
Bochum	Germany	Europe	26-May-79	21.6	
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	0.384
Bucharest	Romania	Europe	16-Nov-79	67.7	0.308

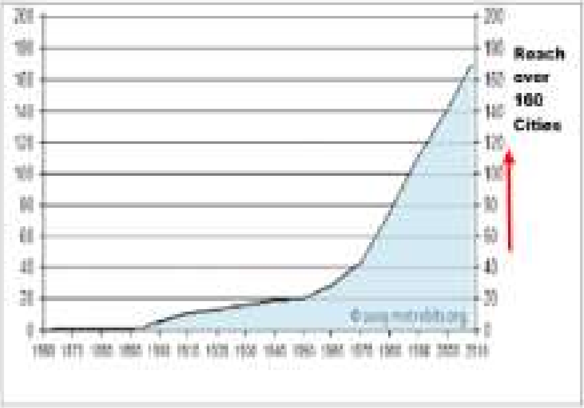
City	Country	Continent	Commencement	Network Length (km)	Daily Ridership (million)
Budapest	Hungary	Europe	2 May 1896	33.0	0.874
Buenos Aires	Argentina	America	1-Dec-13	48.1	0.780
Buffalo	USA	America	18-May-85	6.4	
Bursa	Turkey	Asia	19-Aug-02	20.4	
Busan	South Korea	Asia	19-Jul-85	95.0	0.708
Cairo	Egypt	Africa	27-Sep-87	65.5	1.92
Caracas	Venezuela	America	27-Mar-83	60.5	1.26
Catania	Italy	Europe	27-Jun-99	3.8	
Changchun	China	Asia	Oct-02	17.0	
Charleroi	Belgium	Europe	21-Jun-76	17.6	
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	188.0	0.642
Chongqing	China	Asia	18-Jun-05	19.5	
Cleveland	USA	America	15-Mar-55	31.0	0.0117
Cologne	Germany	Europe	11-Oct-68	46.0	
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	0.0118
Dalian	China	Asia	1-May-03	63.0	
Delhi	India	Asia	24-Dec-02	187.2	0.808
Detroit	USA	America	Jul-87	4.8	
Dnipropetrovsk	Ukraine	Europe	29-Dec-95	7.1	0.0384
Dortmund	Germany	Europe	17-May-76	26.5	
Dubai	United Arab Emirates	Asia	9-Sep-09	52.1	
Düsseldorf	Germany	Europe	4-Oct-81	8.8	
Duisburg	Germany	Europe	11-Jul-92	14.1	
Edmonton	Canada	America	22-Apr-78	20.4	
Essen	Germany	Europe	3-Oct-67	20.2	
Frankfurt	Germany	Europe	4-Oct-68	35.6	
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	1.84
Gwangju	South Korea	Asia	28-Apr-04	20.1	0.0486
Haifa	Israel	Asia	1959	1.8	
Hamburg	Germany	Europe	1-Mar-12	100.7	0.518
Hanover	Germany	Europe	26-Sep-75	18.8	
Helsinki	Finland	Europe	2-Aug-82	21.0	0.155
Hiroshima	Japan	Asia	20-Aug-94	18.4	0.0481
Hong Kong	China	Asia	1-Oct-79	168.1	3.63
Incheon	South Korea	Asia	6-Oct-99	29.4	0.2
Istanbul	Turkey	Europe	16-Sep-00	50.9	0.326
Izmir	Turkey	Asia	22-May-00	11.6	0.0822
Jacksonville	USA	America	30-May-89	4.0	
Kamakura	Japan	Asia	7-Mar-70	6.6	
Kaohsiung	Taiwan	Asia	9-Mar-08	42.7	0.0922

City	Country	Continent	Commencement	Network Length (km)	Daily Ridership (million)
Kazan	Russia	Europe	27-Aug-05	15.8	0.0192
Kharkiv	Ukraine	Europe	23-Aug-75	37.4	0.962
Kiev	Ukraine	Europe	22-Oct-60	62.7	1.19
Kitakyushu	Japan	Asia	9-Jan-85	8.8	
Kobe	Japan	Asia	13-Mar-77	30.6	0.320
Kolkata	India	Asia	24-Oct-84	22.5	0.410
Kryvyi Rih	Ukraine	Europe	26-Dec-86	18.0	
Kuala Lumpur	Malaysia	Asia	16-Dec-98	64.0	0.200
Kyoto	Japan	Asia	1-Apr-81	31.2	0.346
Las Vegas	USA	America	15-Jul-04	6.2	
Lausanne	Switzerland	Europe	24-May-91	13.7	
Lille	France	Europe	25-Apr-83	45.3	0.323
Lima	Peru	America	13-Jan-03	10.0	
Lisbon	Portugal	Europe	29-Dec-59	41.0	0.490
London	United Kingdom	Europe	10 Jan 1863	408.0	2.9
Los Angeles	USA	America	30-Jan-93	28.0	0.126
Ludwigshafen	Germany	Europe	29-May-69	4.0	
Lyon	France	Europe	28-Apr-78	30.7	0.460
Madrid	Spain	Europe	17-Oct-19	286.3	1.78
Manila	Philippines	Asia	1-Dec-84	33.5	0.545
Maracaibo	Venezuela	America	8-Jul-06	6.5	
Marseille	France	Europe	26-Nov-77	21.8	0.180
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	38.2	0.0463
Milan	Italy	Europe	1-Nov-64	93.4	0.950
Minsk	Belarus	Europe	29-Jun-84	30.3	0.776
Monterrey	Mexico	America	25-Apr-91	31.5	
Montreal	Canada	America	14-Oct-66	69.2	0.8
Moscow	Russia	Europe	15-May-35	300.1	6.6
Mulheim	Germany	Europe	3-Nov-79	8.0	
Mumbai	India	Asia		171.0	
Munich	Germany	Europe	19-Oct-71	94.2	0.950
Nagoya	Japan	Asia	15-Nov-57	89.0	1.17
Naha	Japan	Asia	10-Aug-03	12.9	
Nanjing	China	Asia	27-Aug-05	84.7	0.4
Naples	Italy	Europe	28-Mar-93	31.8	0.0180
New York	USA	America	27-Oct-04	368.0	4.23
Newark	USA	America	26-May-35	2.2	
Newcastle	United Kingdom	Europe	11-Aug-80	76.5	0.104
Nizhny Novgorod	Russia	Europe	20-Nov-85	15.5	0.0964
Novosibirsk	Russia	Asia	7-Jan-86	15.4	0.192
Nuremberg	Germany	Europe	1-Mar-72	38.8	0.315
Oporto	Portugal	Europe	7-Dec-02	21.7	
Osaka	Japan	Asia	20-May-33	137.8	2.38
Oslo	Norway	Europe	22-May-66	62.0	0.214
Palma de Mallorca	Spain	Europe	25-Apr-07	8.2	
Paris	France	Europe	19-Jul-00	213.3	4.5
Perugia	Italy	Europe	29-Jan-08	3.0	

City	Country	Continent	Commencement	Network Length (km)	Daily Ridership (million)
Philadelphia	USA	America	4-Mar-07	63.0	0.782
Pittsburgh	USA	America	3-Jul-85	2.0	
Porto Alegre	Brazil	America	2-Mar-85	33.8	
Poznan	Poland	Europe	1-Mar-97	8.1	
Prague	Czech Republic	Europe	9-May-74	59.1	1.6
Pyongyang	North Korea	Asia	6-Sep-73	22.5	0.0548
Recife	Brazil	America	11-Mar-85	39.7	
Rennes	France	Europe	15-Mar-02	9.0	0.085
Rio de Janeiro	Brazil	America	5-Mar-79	42.0	0.57
Rome	Italy	Europe	10-Feb-55	38.0	0.907
Rotterdam	Netherlands	Europe	10-Feb-68	47.0	0.278
Rouen	France	Europe	17-Dec-94	3.2	
Saint Louis	USA	America	31-Jul-93	73.4	
Saint Petersburg	Russia	Europe	15-Nov-55	110.2	2.15
Samara	Russia	Europe	26-Dec-87	10.3	0.0328
San Francisco	USA	America	11-Sep-72	168.9	0.293
San Juan	Puerto Rico	America	6-Jun-05	17.2	0.0247
Santiago	Chile	America	15-Sep-75	102.0	1.67
Santo Domingo	Dominican Republic	America	30-Jan-09	14.5	0.3
Sao Paulo	Brazil	America	14-Sep-74	65.7	1.93
Sapporo	Japan	Asia	16-Dec-71	48.0	0.575
Seattle	USA	America	18-Jul-09	22.2	
Sendai	Japan	Asia	15-Jul-87	14.8	0.162
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	3.48
Shenyang	China	Asia	27-Sep-10	27.8	
Shenzhen	China	Asia	28-Dec-04	95.1	0.962
Singapore	Singapore	Asia	7-Nov-87	129.7	1.87
Sofia	Bulgaria	Europe	28-Jan-98	18.3	0.0739
Stockholm	Sweden	Europe	1-Oct-50	105.7	0.867
Stuttgart	Germany	Europe	10-Jun-66	24.0	
Sydney	Australia	Oceania	1926	22.1	
Taipei	Taiwan	Asia	28-Mar-96	109.8	1.27
Tama	Japan	Asia	27-Nov-98	16.0	
Tashkent	Uzbekistan	Asia	6-Nov-77	36.2	0.156
Tbilisi	Georgia	Asia	11-Jan-66	26.3	0.252
Tehran	Iran	Asia	21-Feb-00	89.0	1.28
The Hague	Netherlands	Europe	10-Oct-04	20.9	
Tianjin	China	Asia	28-Mar-06	72.0	0.0411
Tokyo	Japan	Asia	30-Dec-27	304.5	8.7
Toronto	Canada	America	30-Mar-54	71.3	0.952
Toulouse	France	Europe	26-Jun-93	27.3	0.175
Turin	Italy	Europe	4-Feb-06	9.6	
Valencia	Venezuela	America	18-Oct-06	6.2	0.0685
Valencia	Spain	Europe	3-Oct-88	31.8	
Valparaiso	Chile	America	23-Nov-05	43.0	
Vancouver	Canada	America	3-Jan-86	68.6	0.322
Vienna	Austria	Europe	25-Feb-78	74.6	1.3
Volgograd	Russia	Europe	5-Nov-84	5.5	

City	Country	Continent	Commencement	Network Length (km)	Daily Ridership (million)
Warsaw	Poland	Europe	7-Apr-95	22.6	0.345
Washington	USA	America	27-Mar-76	171.2	0.877
Wuhan	China	Asia	28-Sep-04	28.9	0.0358
Wuppertal	Germany	Europe	1-Mar-01	13.3	
Yekaterinburg	Russia	Asia	26-Apr-91	8.5	0.128
Yerevan	Armenia	Asia	7-Mar-81	12.1	0.0466

5.4 WORLD METRO GRAPH



3.6 FAMOUS METRO SYSTEMS:-

London

Medellin

Taipei

Paris

Delhi

Kolkata

3.6 OPTIONS FOR PUBLIC TRANSPORT SYSTEM

3.6.1 The following systems are mainly available for Urban Mass Transit:

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

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

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

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

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

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

(v) **Monorail:** Monorail trains operate on grade separated dedicated corridors with sharp curves of up to 70m radius. This is a rubber tyred based rolling stock, electrically propelled on concrete beams known as guide-ways. This system is extremely suitable in narrow corridors as it requires minimum right of way on existing roads and permits light and air and is more environmental friendly. This is prevalent in several countries for traffic densities of over 20,000 PHPDT.

(vi) **Bus Rapid Transit System:** This system involves operation of buses on a dedicated corridor (except at traffic integration) at a high frequency to achieve PHPDT.

For providing a very high transport capacity say 20,000 PHPDT, about 200 buses shall be required per hour i.e., at headway of 20 seconds. Such a high PHPDT can be achieved by providing two lanes of traffic in each direction and elimination of traffic intersection on the route.

(vii) **Automated Guide way Transit System:** The term is used for systems other than conventional rail based system on grade separated guide ways. The system can be rail based or rubber tire based but fully automated guided systems with driver less operation.

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

System	LRT (Light Rail Transit) (elevated)	AGT (Automated Guide way Transit)	Straddle type Monorail
Exterior of Vehicle	 It is a transport system that runs on the exclusive beam slab track mostly built over highways.	 It is a new transport system that runs on the exclusive track built on elevated structure with lightweight vehicle.	 It is a new transport system that runs straddling on the exclusive beam track mostly built over highways.
Rolling stock			
Length (m)	30.0 (articulated type)		
Width (m)	2.3		
Height (m)	3.7		
Number of doors	3		
Wheel arrangement	2-2-2		
Weight (tare) (ton)	44		
Axle load (ton)	10.7		
Type of rail load	Concentrated load	Concentrated load	Concentrated load
Running gear and track structure			
Traction system	Rotary Motor and steel wheel	Rotary Motor and rubber tire	Rotary Motor and rubber tire
Brake system	Electric brake and hydraulic brake	Electric brake and air brake	Electric brake and air brake
Guidance System	Steel rail	Lateral pinched Guidance	Guide Wheel (Rubber)
Power collector	Catenary	Conductor rail	Conductor rail
Voltage	D.C. 750 V	A.C. 750 V (three phase)	D.C. 1,500 V
Track	Steel rail	Concrete slab	Track beam

System	LRT (Light Rail Transit) (elevated)	AGT (Automated Guide way Transit)	Straddle type Monorail
Switch			
Construction	Switch and crossing	Lateral pitched switch	Flexible track beam
Train Operation Characteristic			
Maximum speed	80 km/h	60 km/h	80 km/h
Schedule speed	30 km/h	30 km/h	30 km/h
Minimum curve radius	30m	30m	70m
Maximum gradient	4 %	6 %	6 %
Acceleration	3 km/h/s	3 km/h/s	3 km/h/s
Deceleration: Service brake	3 km/h/s	4.0 km/h/s	4 km/h/s
Emergency brake	4 km/h/s	5.0 km/h/s	4 km/h/s
Automatic train operation	There is few example of it.	It has been developed aiming for automated operation. There are many examples of automated operation including driverless operation.	There are three cases of ATO operation in Japan.
Transportation capacity			
1 car seat	60		49
standing	90		80
total	150 (30m)	60 (L=9m)	129 (L=15m)
4 car seat	120		180
standing	180		240
total	300 (30m+30m)	350 (6-car L=54m)	420 (L=60m)
8 car seat	240		360
standing	360		480
total	600 (30m+30m+30m+30m)	720 (12 car L=108m)	840 (L=120m)
8 car PHPDT (110%, headway 2.5 min)	24,480	17,300 (100%)	24,300
	It is possible to deal with over 24,480 PHPDT of demand. (train length 120m)	It is possible to deal with up to 17,800 PHPDT of demand. (train length 108m)	It is possible to deal with over 24,300 PHPDT of demand. (train length 120m)
Structure			
Superstructure	Concrete slab	Concrete slab	Track beam
Pier and foundation	Concrete	Concrete	Concrete
Maintainability and cost			
Track	In addition to grinding of surface of rails, track maintenance work will require	It has small maintenance of track.	It has small maintenance of track.

System	LRT (Light Rail Transit) (elevated)	AGT (Automated Guide way Transit)	Straddle type Monorail
	much time.		
Vehicle	Maintenance of rotary motor and greasing of steel wheels shall be necessary.	Maintenance of rotary motor and exchange of rubber tires after every 120,000 km running shall be necessary.	Maintenance of rotary motor and exchange of rubber tires after every 120,000 km running shall be necessary.
Effect on ambient surrounding and harmony with urban landscape			
Effect on ambient surrounding	Its soundproof wheels make as small noise as rubber tires make.	Level Crossing between AGT and road is not available. This system, with rubber tires, makes small noise and vibration. Because its running surfaces are made of concrete slab, there remain problems like inhibition of sunshine or radio disturbance.	This system, with rubber tires, makes small noise and vibration.
urban landscape	This system is inferior to other systems in terms of landscape because overhead wires for power collection must be installed.	Because its superstructure is made of concrete slab, oppressing feeling of view is an issue.	This system is superior to AGT or LRT than in terms of landscape because its superstructure consists of only track beams that have small section.
Emergency evacuation			
	Evacuation other train (end to end or side by side)	Evacuation other train (end to end or side by side)	Evacuation other train (end to end or side by side)
	Walk way	Walk way	Evacuation device
	In case of emergency, supporting vehicles will engage in rescue activities. If supporting vehicles cannot do that, it is possible for passengers to evacuate to nearest stations through evacuation passage by walk.	In case of emergency, supporting vehicles will engage in rescue activities. If supporting vehicles cannot do that, it is possible for passengers to evacuate to nearest stations through evacuation passage by walk.	In this system, supporting vehicles are needed for passengers' emergency evacuation, which is of no matter because this straddle type system have many actual performances of running in Japan and has a established method for rescue.
Operation cost			
Electric energy			2.2kWh/car-km
Rolling stock cost			
1 car			7.5 Crore

System	Urban Maglev (HSST)	Metro/Subway	Bus Rapid Transit
Exterior of Vehicle	 It is a new transport system that rides on the exclusive beam slab track mainly built over highways.	 It is Medium To Heavy Rail Transit (HRT) is a specialized electrically powered rail system carrying passengers within urban areas.	 It is a bus operation generally characterized by use of exclusive or reserved rights-of-way (bus ways) that permit higher speeds and avoidance of delays from general traffic flows.
Rolling stock			
Length (m)			18 (articulated type)
Width (m)			2.5
Height (m)			3.5
Number of doors			4
Wheel arrangement	3 module / car	2-2 or 3-3	Independent Axle
Weight (tare) (car)	15.0	47	12 to 18
Axle load (max)	2.3t/m	17t/m	8t to 14.3t
Type of car load	Uniform load	Concentrated Load	Concentrated load
Running gear and track structure			
Traction system	Linear Induction Motor and Electromagnetic levitation system	Rotary Motor and steel wheel	Rubber tyre
Brake system	Electric brake and air brake	Electric brake and hydraulic brake and Regenerative brakes	Hydraulic Brakes
Guidance System	Electromagnetic levitation system	Steel Rail	Some special guide wheels on kerbs
Power collector	Conductor rail	Catenary or Conductor rail	Not applicable
Voltage	D.C. 1,500 V	D.C. 1500 V & A.C. 25kv	None
Track	Steel rail (Electromagnetic levitation system)	Steel rail	Road
Switch			
Installation	Flexible track beam	Switch and crossing	Road Crossings
Train Operation Characteristics			
Maximum speed	80 km/h	80 to 100 km/h	80 km/h

System	Urban Maglev (HSST)	Metro Subway	Bus Rapid Transit
Schedule speed	30 km/h	33 km/h	20 km/h
Minimum curve radius	50m	100m	12m
Maximum gradient	6 %	6 %	
Acceleration	3 km/h/s	3 km/h/s	
Deceleration Service brake	3 km/h/s	3 km/h/s	
Emergency brake	4 km/h/s	4 km/h/s	
Automatic Train operation	There are cases of ATO operation in Nagoya Japan.	Automatic Train operation	No
Transportation capacity			
1 car seat	32	70	70
standing	42	125	40
total	74 (L=14m)	200(L=20m)	110(L=12)
4 car seat	128	300	
standing	172	500	
total	300 (L=56m)	800(L=86m)	
6 car seat	256	600	
standing	344	1000	
total	600 (L=112m)	1500(L=128m)	
6 car PHPDT (110%, Headway 2.5 min)	23,100 (max 160%)	50,000	
	It is possible to deal with over 23,100 PHPDT of demand (train length 112m)	It is possible to deal with over 50,000 PHPDT of demand (train length 112m)	It is possible to deal with max 8,000 PHPDT of demand
Structure			
Superstructure	Concrete slab	Concrete slab	Roads
Pier and foundation	Concrete	Concrete	
Maintainability and cost			
Track	It has less maintenance of track as there is less physical movement.	It has less maintenance of track.	It requires maintenance of roads.
Vehicle	As it has no rotary motor, it is excellent in maintenance.	Maintenance of rotary motor and grinding of steel wheels shall be necessary.	Maintenance of engine and rubber tyres shall be necessary.
Effect on ambient surrounding and harmony with urban landscape			

System	Urban Maglev (HSST)	Metro Subway	Bus Rapid transit
Effect on ambient surrounding	There remain problems like inhibition of satellite or radio disturbance, because its running surfaces are made of concrete slab.	This system is noisy due to steel wheel arrangement.	Noise and Pollution Problems
Urban landscape	This system is inferior to other systems in terms of landscape because overhead wires for power collection must be installed.	Because its superstructure is made of concrete slab, oppressing feeling of view is [illegible]. This system is inferior to other systems in terms of landscape because overhead wires for power collection must be installed.	No such issues
Emergency evacuation			
	Evacuation after train (end to end or side by side)	Evacuation after train (end to end or side by side)	No problems
	Walk way	Walk way	
	In case of emergency, supporting vehicles will engage in rescue activities. If supporting vehicles cannot do that, it is possible for passengers to evacuate to nearest stations through evacuation passage by walk.	In case of emergency, supporting vehicles will engage in rescue activities. If supporting vehicles cannot do that, it is possible for passengers to evacuate to nearest stations through evacuation passage by walk.	
Operation cost			
Electric energy	2.0kwh/car-km		
Rolling stock cost			
1 car		8 to 9 Crores	Few Lakhs

3.7 CHARACTERISTICS OF URBAN TRANSIT SYSTEM

3.7.1 Transport Capacity

It is product of passenger carrying capacity of a train and maximum permissible frequency of train operation. The passenger carrying capacity is determined by number of cars (units/ coaches), which can be clubbed to form a train and dimensions of each car. To compare different systems uniform packing density is considered although for different systems different crush loading may be permissible. The passenger carrying capacity is dependent on the following:

(a) **Dimensions of vehicle:** Length and breadth, useful area. The cars vary from about 9m to 24m for most of systems. The width varies from 2.0m to 3.6m.

(b) **Passengers per m²:** The normal to crush loading of most systems varies from 4 to 7 passengers per m².

(c) **No of Cars per train:** The cars can be from 1 to 15 for most of the systems and the train length can be up to 310m.

Table 3.2: Passenger carrying Capacity per Train (typical) for different Transit Systems

S. No.	Transit System	Car Size (length 'm' x breadth 'm')	Car Capacity (No. of passengers /car)	No of Cars /Train	Train Length 'm'	Train Capacity passenger /Train
1	Large-type monorail	15 x 3	175	2 to 8	120	1400 for 8cars
2	Heavy Metro Rail	21 to 24 x 2.8 to 3.6	250	8 to 15	190 to 315	2000 for 8cars
3	Bus	18 x 2.5 to 3	70 to 100	1 to 2	18	100 per bus
4	AGT	9 to 13 x 2.5 to 3	60 to 120	2 to 12	108	720
5	LRT	18* x 2.65	145*	2 to 8	72	710*
6	Maglev	16 x 2.8	170	2 to 8	128	1360 for 8 cars

(Standee Occupancy rate: 0.14 m²/passenger)

* Smallest combination of modules for an independent LRT

(d) **Headway:** The headway and frequency of train operation depends on Signaling and Rolling Stock characteristics viz. control systems, acceleration (tractive effort) and maximum permissible speed (adhesion). A graph showing the carrying capacity of different modes and passenger capacity is given below (see next page).

(e) **Train Signaling and Control Systems:** The various train Signaling and control systems which help in increasing frequency of operation are:

- **Automatic Train Operation and Control System (ATO)**
- **Automatic Train Supervision System (ATS)**

➤ Automatic Train Protection System (ATP)

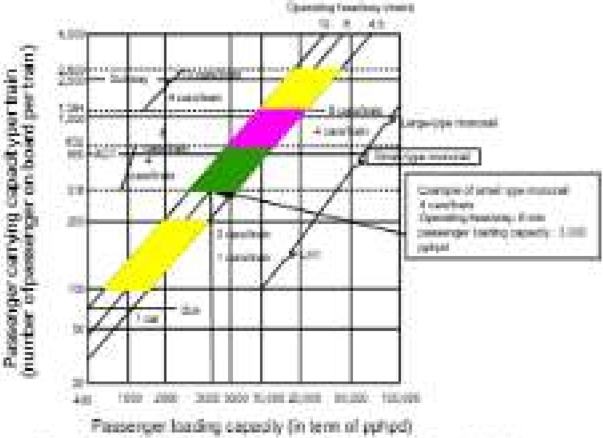


Figure 3.1 Transport Capacity of Different Modes as a Function of Headway

(f) **Tractive effort and Acceleration:** By increasing the tractive effort and acceleration it is possible to increase transportation capacity both by improving the average speed and also by permitting higher frequency of train operation. The factors influencing tractive effort acceleration speed are:

- ➤ Adhesion
- ➤ Ratio of Motor coaches to trailer coaches
- ➤ Traction Motor Rating
- ➤ No of Traction Motors per car
- ➤ Drive System

3.7.2 Geometric Characteristics:

(i) **Minimum Radius:** Varies from 25m minimum for LRT, 70m for Monorail to 120m for Metro.

(ii) **Right of Way:** The Right of way required for a Grade Separated (elevated) system is solely determined by the building line provided the piers can be accommodated on the central verge. For an At Grade system the Right of Way required is determined by lanes required for motorized/ non motorized vehicles in addition to width of road required for the mass transit system. The minimum right of way required is about 22.5m.

(iii) **Gradient**: Ruling gradient varies from system to system.

➤ **Environmental Characteristics Noise:**

Rubber tyre on road is less noisy as compared to steel wheels on rails.

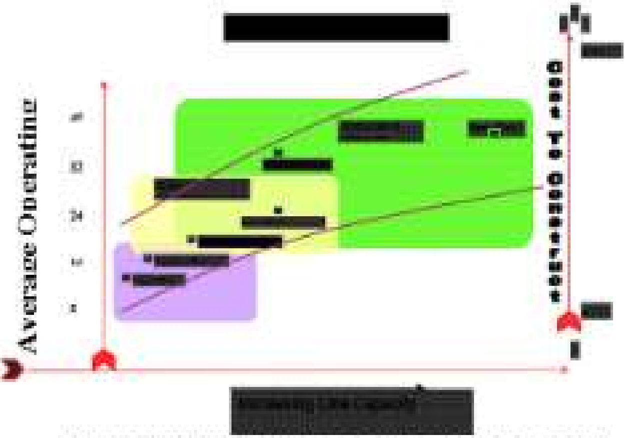
➤ **Aesthetics-Air and Sunshine**: The at grade systems are least restrictive in exposing the corridors, buildings next to these corridors and people (on these corridors/ inhabiting buildings next to these corridors) to natural air and sunshine.

The effect of elevated systems on the existing buildings and their inhabitants is the worst. Comparatively the best system as far as this factor is considered is underground metro rail system.

➤ **Pollution:** All electrically driven systems are better than diesel operated systems. This is where Rail based systems score over the Road based vehicles.

Graphical comparisons of the most important characteristics which influence selection of different technologies are depicted in the Figure 3.2 below:-

Fig-3.2



As shown, carrying capacity increases with the speed of the service and the cost to construct. The rail family can carry more passengers per hour at a faster speed, but most systems cost more to construct than do bus-based systems.

3.7.3 Need for a Grade Separated Transit System

a) A large number of inter change points.

b) High vehicular density.

c) Excessive congestion and delays on the corridors, especially during peak hours.

d) As the corridors are normally following busy areas of the city, it is not easy to find the required areas for depots, workshops.

Additional capacity needs to be created on the corridors to accommodate more traffic on the roads. Mere re-allocation of road space to provide for dedicated bus lanes for public transport may not serve the purpose due to presence of large number of private vehicles, which will continue to operate, and whose numbers will continue to rise.
Further presence of large number of inter change points will severely restrict speed of operation of public transit system employing dedicated lanes. Considering projections of travel demand on these corridors it is essential to provide grade separated transit system for these corridors.

In view of levels of services that will be required to meet the travel demand on the corridors, a fixed guide way, grade separated system is unavoidable.

3.7.4 Discussions on suitability of various modes

The following shows the suitability of various modes of public transport in terms of parameters.

Table 3.3: Suitability Matrix of Public Transport Modes

Mode of transport	Noise Generation	Noise Effect on Road users	Noise Effect on Inhabitants	Aesthetics-Exposure to Sunshine	Aesthetics-Effect on Skyline	Energy Efficiency	Pollution
Metro Rail elevated	√	x	√	√	√	x	x
Metro Rail underground	x	x	x	x	x	x	x
LRT elevated	√	x	√	√	√	x	x
LRT at Grade	√	√	√	x	x	x	x
Monorail	x	x	x	x	x	√	x
Subway elevated	√	x	√	√	√	x	x
AGT elevated	x	x	x	√	√	√	x
LIM/Maglev elevated	x	x	x	√	√	√	x
Bus At Grade	√	√	√	x	x	√	√
Bus Elevated	x	x	x	√	√	√	√
√	Adverse						
X	No Adverse Effect						

3.7.5 Feasibility of other systems:

Maglev is an energy guzzler and the AGT is primarily a proprietary system. Sky train is yet on experimental stages.

3.7.6 LRT and Monorail System:

From traffic point of view LRT and monorail systems appears to be good enough to meet requirement of traffic.

3.7.7 Feasibility of Metro System for Nagpur:

From the 'Traffic Demand Forecast' it can be seen that peak hour peak direction trips (PHPDT) on the North South Corridor is 7375, 8526, 10987 and 14352 the year of 2016, 2021, 2031 and 2041 respectively. Similarly PHPDT on East West corridor in the year of 2016, 2021, 2031 and 2041 is 6087, 8062, 11765 and 15060 respectively.

Road-based systems can optimally carry up to a maximum of 8,000 PHPDT. Since the PHPDT assumed on the above corridors exceed 8,000, there can be two options namely 1) Mono Rail and 2) Light Capacity Metro. Mono rail can carry the PHPDT projected but this technology is not a tested one. The operation and maintenance cost is much higher that Light metro. The capital cost of Mono rail is also almost same as that of Light Metro with no experience of Mono rail in India. Even in the other countries, the Mono rail is being adopted only for small lengths and as feeder to Metro. Hence, keeping in view the above disadvantages, it is recommended to adopt an stable, tested and reliable Metro technology. However, for Nagpur it will be Light Capacity Metro System.

CHAPTER 4

GEOMETRIC DESIGNING PARAMETERS & ALIGNMENT DESCRIPTION

TABLES

Chapter - 4

GEOMETRIC DESIGNING PARAMETERS AND ALIGNMENT DESCRIPTION

4.1 GENERAL

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

The geometrical design norms are based on international practices adopted for similar metro systems with standard gauge on the assumption that the maximum permissible speed on the section is limited to 80kmph. Planning for any higher speed is not desirable as the average inter-station distance is about 1.30km and trains will not be able to achieve higher speed.

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

The underground tracks will be carried in separate tunnels to be drilled by Tunnel Boring Machine. Stations will, however, be constructed by cut and cover method.

4.2 GEOMETRIC DESIGN PARAMETERS

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

4.2.1 Horizontal Alignment

As far as possible, the alignment follows the existing roads. This leads to introduction of horizontal curves. On consideration of desirable maximum cant of 110 mm and cant deficiency of 85 mm on Metro tracks, the safe speed on curves of radii of 400 m or more is 80 km/h. On elevated sections minimum radius of 160 m has been used at one location having speed potential upto 40 km/h. However in underground section desirable minimum radius of curve shall be 300 m for ease of working of Tunnel Boring Machine (TBM). However in exceptional situation on this project, curves of 200 m radius (safe speed of 30 km/h) have been adopted where New Austrian Tunneling Machine (NATM) shall be used.

For maximum permissible speed on curve with various radii, Table 4.1 may be referred.

Horizontal Curves

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

4.2.2 Transition Curves

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

- Length of Transitions of Horizontal curves (m)

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

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

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

4.3.3 Vertical Alignment and Track Centre

(a) Elevated Sections

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

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

(b) Underground sections

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

Track center in underground sections are follows:

Sections where stations are to be constructed by cut & cover and running section by TBM to Accommodate 12 m wide platform:	: 15.03 m (for lesser width of platform, track center to be reduced.)
Sections where stations are to be constructed by NATM and running section by TBM to facilitate Construction of stations:	: 22.00 m
Sections where stations as well as running section both are to be constructed by cut and cover method	: 4.50 m

(c) Gradients

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

(d) Vertical Curves

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

(e) Radius of vertical curves:

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

4.2.4 Design Speed

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

Table 4.1: Cant, Permitted Speed & Minimum Transition Length for Curves

RADIUS	CANT	MAXIMUM PERMISSIBLE SPEED	MINIMUM DISTANCE BETWEEN ADJACENT TRACKS	
			UNDERGROUND	ELEVATED AND AT-GRADE
meters	mm	km/ph	mm	Mm
3000	15	80	3500	3650
2800	15	80	3500	3650
2400	20	80	3500	3650
2000	20	80	3500	3650
1800	25	80	3500	3650
1500	30	80	3500	3650
1200	35	80	3500	3650
1000	45	80	3500	3700
800	55	80	3550	3700
600	70	80	3550	3750
500	85	80	3600	3750
450	95	80	3600	3800
400	105	80	3650	3800
350	110	75	3650	3800
300	110	70	3700	3850
200	110	55	3800	3900
150*	110	45	4000	4000
150*	0	30	4000	4000
120*	110	40	4000	4150
120*	0	25	4000	4150
100*	110	40		

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

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

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

4.2.5 Station Locations

Stations have been located so as to serve major passenger destinations and to enable convenient integration with other modes of transport. However effort has also been made to propose station locations, such that inter station distances are as uniform as possible. The average spacing of stations is close to 1.2 km.

4.3 TRACK STRUCTURE

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

Two types of track structures are proposed for the corridors under Nagpur Metro Rail Project network. The normal ballasted track in Depot (except inside the Workshops, inspection lines and washing plant lines). The ballastless track is recommended on Viaducts and inside tunnels as the regular cleaning and replacement of ballast at such locations will not be possible.

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

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

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

4.4 RAIL SECTION

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

4.5 BALLASTLESS TRACK ON MAIN LINES

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

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

4.6 BALLASTLESS/BALLASTED TRACK IN DEPOT

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

- Supported on steel pedestals for Inspection lines.
- Embedded rail type inside the Workshop.

- Plinth type for Washing line.
- Track is to be laid on PRC sleepers with sleeper spacing of 60 cm. All the rails are to be converted into rail panels by doing flash butt/Thermit welding.

4.7 TURNOUTS

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

Table 4.2: Turn-Outs

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

4.8 BUFFER STOPS

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

4.9 RAIL STRUCTURE INTERACTION

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

4.10 ROUTE ALIGNMENT

Two Corridors have been identified for implementation in phase I of Nagpur Metro Rail Project network as per details given underneath:-

i) Automotive Square to KHAPRI
ii) Prajapati Nagar to Lokmanya Nagar

The main features of these corridors along with the details of route alignment have been described below:-

4.10.1 Alignment from Automotive Square to KHAPRI

This corridor originates from Automotive Square on Kamptee Road, move along Kamptee Road and reach the intersection point of Amravati Road and Wardha Road, then after crossing Fly Over moves towards Munje Square, moves towards Dhantoli and along nala moves towards Empress/Dr Munje Marg, leads towards Congress Nagar T-Point, then on Rahate Colony Road and then falls on Wardha Road, leads towards NEERI, then moves along Wardha Road and then west of Railway Track in MIHAN area. And passes through 14m wide stretch of land between the railway boundary line and the road near proposed Container Depot.

There are 17 Stations proposed on this alignments.

4.10.2 Prajapati Nagar to Lokmanya Nagar

This Corridor originates from Prajapati Nagar (meeting point of CA Road and Ring Road), then along Central Avenue Road moves towards Vaishno Devi Chowk, then Mayo Hospital and then takes left turn towards Nagpur Station Entry on Railway Feeder Road, then on Ghat Road alignment takes right turn and crosses over box culvert on existing railway line and falls on State Highway 255. Then after crossing Wardha Road alignment moves along North Ambazari Road upto Ambazari Lake and takes left State Highway 255. Then falls on Hingna Road and moves towards Lokmanya Nagar. There are 19 Stations proposed on this alignments.

4.10.3 Main features of Alignment from Automotive Square to KHAPRI (North-South Corridor)

Main features of Alignment from Automotive Square to KHAPRI are detailed below:

a) This corridor provides direct metro connectivity to Automotive Square, RBI, Vidhan Sabha, MIT, Zero Mile, Nagpur University, Sitaburdi, Yashwant Stadium, Central Jail, NEERI, Wardha Road, Chhatrapati Shivaji Chowk, Airport, Khapri, MIHAN. Many other prominent places and Government offices are covered in this Corridor.

b) Corridor is integrated with East West corridor at Sitaburdi and this integration provides metro connectivity to new development at Lokmanya Nagar.

c) Corridor integrates with other modes of transport. Bus Terminus near Jhansi Chowk.

d) Entire length (19.658 Km.) of this corridor is proposed as elevated except in 4.6 Km. at grade after Airport Station and in MIHAN area near Khapri Railway Station.

e) Total 17 stations have been proposed on this corridor, out of these stations 15 stations are elevated and remaining 2 stations are at grade.

f) Future extension of corridor in both directions is feasible.

4.10.4 Main features of Alignment from Prajapati Nagar to Lokmanya Nagar (East-West Corridor)

Main features of Alignment from Prajapati Nagar to Lokmanya Nagar are detailed below:

a) This corridor provides direct metro connectivity to Central Avenue Road and North Ambazari Road. This corridor covers many important location like Vardhman Nagar, Mangalwari, Mayo Hospital, Nagpur Railway Station, Santara Market, Sitaburdi, Jhansi Rani Chowk, LAD Square, Ambazari Lake, Hingna Road, Lokmanya Nagar.

b) Corridor is integrated with North South corridor at Sitaburdi and through that integration prominent location falling on NS Corridor get connected.

c) Corridor integrates with other modes of transport such as Bus Stand near Jhansi Rani Square and Nagpur railway station.

d) Entire length of this corridor is proposed as elevated.

e) There are total 19 stations on this corridor and all are elevated.

4.11 TECHNICAL FEATURES

4.11.1 Automotive Square to KHAPRI (North-South Corridor)

(a) Horizontal Curves : Horizontal curve details are as per the table below :

Table 4.3: Statement of Horizontal Curves (North-South Corridor)

Curve No.	Direction	Radius	Deflection Angle	Transition Length		Tangent	Curve Length	Total Curve Length	Straight between	Remarks
			[illegible]							Start of Alignment [illegible]
1	Right	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
2	Left	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
3	Left	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
4	Right	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
5	Right	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
6	Left	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
7	Left	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
8	Right	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
9	Left	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
10	Left	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
11	Right	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
12	Left	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
13	Left	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
14	Left	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
15	Left	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
16	Right	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
17	Left	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
18	Right	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
19	Left	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
20	Left	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
21	Right	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
22	Left	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
23	Left	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
24	Right	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
25	Left	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
26	Right	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
27	Left	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	

Curve No.	Direction	Radius	Deflection Angle	Transition Length		Tangent	Curve Length	Total Curve Length	Straight between	Remarks
[illegible]	Left	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	Right	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	Right	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	Left	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	Left	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	Right	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	Right	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	Left	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	Left	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	Right	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	Right	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	Left	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	Left	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	Right	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	Left	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	Right	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	Left	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	Right	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	Right	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	Right	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	Left	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	Right	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	Left	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	Right	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	Left	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]	Left	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	End of alignment [illegible]

Abstract of Horizontal Curves(N-S Corridor)				
S. No.	Radius (m)	Nos. Occurrences	Curved Length (m)	% w. r. t. total curved length
1	>100m -200m	9	1748.707	24.10%
2	>200m - 500m	10	1409.104	19.41%
3	>500m - 1000m	16	2894.008	39.89%
4	>1000m - 1500m	3	512.223	7.06%
5	>1500m - 2000m	1	67.798	0.93%
6	>2000m - 5000m	6	440.001	6.07%

7	>3000m	3	155.243	2.33%
	Total	83	7206.75	100.00%

(iii) Gradient

A statement showing details of gradients provide along the N-S corridor is given in the following Table No. 4.4.

Table 4.4: Statement of Gradients (N-S Corridor)

S. No.	Chainage		Length	Rail Level		Gradient	Remarks
	From	To		From	To		
1	-406.2	300.0	706.119	303.9	303.9	0.000%	Level
2	300.0	480.0	180.000	303.9	303.5	-0.217%	Fall
3	480.0	840.0	360.000	303.5	308.8	1.540%	Rise
4	840.0	1110.0	270.000	308.8	308.8	0.000%	Level
5	1110.0	1410.0	300.000	308.8	309.3	0.400%	Rise
6	1410.0	1740.0	330.000	309.3	311.3	0.606%	Rise
7	1740.0	2020.4	280.403	311.3	314.4	1.104%	Rise
8	2020.4	2270.0	249.598	314.4	314.4	0.000%	Level
9	2270.0	2460.0	190.000	314.4	310.7	-1.947%	Fall
10	2460.0	2820.0	360.000	310.7	310.1	-0.167%	Fall
11	2820.0	3040.0	220.000	310.1	316.4	2.859%	Rise
12	3040.0	3312.0	272.018	316.4	316.4	0.000%	Level
13	3312.0	3660.0	347.900	316.4	315.3	-0.327%	Fall
14	3660.0	3910.0	250.000	315.3	320.0	1.100%	Rise
15	3910.0	4080.0	170.000	322.3	322.3	0.000%	Level
16	4080.0	4230.4	150.443	322.3	323.2	1.289%	Rise
17	4230.4	4500.0	281.537	323.2	323.2	0.000%	Level
18	4500.0	4768.4	268.494	323.2	322.2	-0.484%	Fall
19	4768.4	5030.0	273.598	322.2	326.3	1.480%	Rise
20	5030.0	5280.0	250.000	326.3	326.3	0.000%	Level
21	5280.0	5800.0	520.000	326.3	322.4	-0.750%	Fall
22	5800.0	6050.0	250.000	322.4	319.8	-1.120%	Fall
23	6050.0	6284.0	234.000	319.8	319.8	0.000%	Level
24	6284.0	6572.6	288.748	319.8	313.5	-2.819%	Fall
25	6572.6	6920.0	347.344	313.5	313.5	0.000%	Level
26	6920.0	7200.0	270.000	313.5	305.2	-3.117%	Fall
27	7200.0	7430.0	230.000	305.2	313.5	2.850%	Rise
28	7430.0	7780.0	350.000	313.5	317.8	1.244%	Rise
29	7780.0	8030.0	250.000	317.8	317.8	0.000%	Level
30	8030.0	8240.0	210.000	317.8	317.4	-0.200%	Fall
31	8240.0	8430.0	190.000	317.4	321.6	2.158%	Rise
32	8430.0	8840.0	370.000	321.6	321.6	0.000%	Level
33	8840.0	9121.7	281.717	321.6	322.4	0.378%	Rise
34	9121.7	9340.0	218.283	322.4	320	-1.150%	Fall
35	9340.0	9680.0	340.000	320	316.1	-1.147%	Fall
36	9680.0	9900.0	220.000	316.1	315.3	-0.364%	Fall
37	9900.0	10225.0	325.000	315.3	315.3	0.000%	Level

S. No.	Chainage		Length	Rail Level		Gradient	Remarks
	From	To		From	To		
38	10209.3	10730.3	521.000	316.3	313.9	0.855%	Rise
39	10730.3	11283.4	553.429	313.9	313.9	0.000%	Level
40	11283.4	11610.3	326.913	313.9	320	0.126%	Rise
41	11610.3	11920.3	250.000	320	320	0.000%	Level
42	11920.3	12385.3	600.000	320	311	-1.429%	Fall
43	12385.3	12685.3	400.000	311	311	0.000%	Level
44	12685.3	13155.3	540.000	311	307.1	-0.789%	Fall
45	13155.3	13385.3	250.000	307.1	307.3	0.134%	Rise
46	13385.3	13885.3	380.000	307.3	313.3	1.575%	Rise
47	13885.3	14300.8	415.820	313.3	313.3	0.000%	Level
48	14300.8	14575.3	271.680	313.3	307.8	-2.102%	Fall
49	14575.3	14725.3	350.000	307.8	304.8	-0.857%	Fall
50	14725.3	15485.3	760.000	304.8	296.4	-1.118%	Fall
51	15485.3	15685.3	200.000	296.4	296.4	0.000%	Level
52	15685.3	16035.3	350.000	296.4	299	0.858%	Rise
53	16035.3	16285.3	250.000	299	299	0.000%	Level
54	16285.3	17035.3	750.000	299	307.8	1.147%	Rise
55	17035.3	17324.6	244.627	307.8	316	3.434%	Rise
56	17324.6	17550.3	225.376	316	316	0.000%	Level
57	17550.3	17740.3	190.000	316	308.3	-4.047%	Fall
58	17740.3	18020.3	280.000	308.3	313.1	1.738%	Rise
59	18020.3	18232.3	212.000	313.1	306.1	-3.342%	Fall
60	18232.3	18615.1	375.100	306.1	306.1	0.000%	Level
61	18615.1	19245.3	630.000	306.1	302.6	-0.560%	Fall
62	19245.3	20347.3	1107.382	302.6	293	-0.848%	Fall

Abstract of Gradients(N-S Corridor)				
S. No.	Description	Nos. Occurrences	Length (m)	% w. r. t. total Alignment length
1	Level	20	5233.013	26.62%
2	> 0% to <= 1%	22	9040.247	45.58%
3	> 1% to <= 2%	11	3340.393	16.09%
4	> 2% to <= 3%	5	1108.730	5.84%
5	> 3% to <= 4%	4	935.707	4.79%
	Total	62	19868.2	100.00%

4.11.2 Prajapati Nagar to Lokmanya Nagar (East-West Corridor)

(a) Horizontal Curves: The details of horizontal curves is shown in Table 4.6

Table 4.6: Statement of Horizontal Curves (East-West Corridor)

Table 4.6

Curve No.	Direction	Radius	Deflection Angle	Transition Length		Tangent	Curve Length	Total Curve Length	Straight between	Remarks
			D.M. 0						55.702	
1	Right	202.05	37 15 48.600	55	55	87.057	131.112	241.112	113.075	Start of Alignment -DMC
2	Right	402.05	29 42 33.988	50	50	132.411	207.498	307.498	217.875	
3	Right	8002.05	00 15 18.132	15	15	13.51	37.621	57.621	381.278	
4	Right	1002.05	02 01 05.827	20	20	11.881	35.238	55.238	271.038	
5	Right	1180.05	00 03 37.798	20	20	0.02	0.041	40.041	25.448	
6	Left	1102.05	00 54 37.908	18	18	13.4	26.120	62.780	252.892	
7	Right	10002.05	00 12 45.221	10	10	15.004	37.107	57.107	269.622	
8	Left	1002.05	00 13 18.422	15	15	13.560	27.128	57.128	80.829	
9	Right	1002.05	00 13 08.202	20	20	13.33	26.66	66.66	1027.177	
10	Right	580.05	00 00 27.879	60	60	0.338	0.075	120.078	43.927	
11	Left	1012.05	01 25 23.108	25	25	12.566	25.137	75.137	25.097	
12	Right	380.05	00 00 13.078	55	55	0.013	0.028	110.028	63.8	
13	Left	502.05	03 17 15.702	50	50	14.408	28.838	128.838	182.403	
14	Right	207.75	00 00 08.433	48	48	0.383	0.084	96.084	5.208	
15	Right	3002.05	01 38 38.068	18	18	43.408	87.837	123.837	128.748	
16	Left	2002.05	00 45 17.113	20	20	12.761	25.213	66.372	191.053	
17	Left	1002.05	03 46 34.123	25	25	33.213	66.121	116.121	181.875	
18	Right	802.05	02 52 04.284	45	45	15.768	30.31	120.31	258.323	
19	Right	802.05	02 28 40.900	35	35	14.782	28.321	98.321	34.748	
20	Left	802.05	03 42 06.602	40	40	14.798	28.387	108.387	327.175	
21	Left	202.05	81 04 18.041	35	35	112.788	263.294	333.294	493.752	
22	Left	1002.05	01 38 56.798	20	20	14.602	29.102	73.102	8.117	
23	Right	1200.05	01 18 48.608	25	25	13.786	37.608	77.608	154.363	
24	Right	202.05	40 37 42.941	55	55	82.901	173.349	283.349	562.961	
25	Right	252.05	06 27 18.083	48	48	14.212	28.394	124.394	144.127	
26	Left	202.05	00 01 02.052	53.1	53.1	0.02	0.067	106.267	33.394	
27	Left	1002.05	02 02 21.590	25	25	11.89	35.857	85.857	149.878	
28	Right	802.05	02 52 15.798	40	40	20.05	40.171	120.171	64.329	
29	Left	852.05	01 56 34.348	25	25	14.446	28.892	78.892	249.573	
30	Left	1002.05	01 57 14.752	25	25	17.059	34.115	84.115	121.202	
31	Right	1002.05	02 20 41.034	25	25	23.277	48.349	98.349	372.888	
32	Right	802.05	02 41 41.339	50	50	14.187	28.118	128.118	284.321	
33	Left	1162.05	13 08 27.837	25	25	135.418	264.023	444.023	888.118	
34	Right	202.05	00 01 45.120	50.7	50.7	0.051	0.103	111.503	148.823	
35	Right	202.05	14 23 13.403	35	35	25.581	50.633	180.633	25.807	

Curve No	Direction	Radius	Deflection Angle	Transition Length		Tangent	Curve Length	Total Curve Length	Straight between	Remarks
36	Left	175.00	73 38 36.753	98	98	126.871	321.130	333.130	493.268	
37	Right	182.00	11 47 33.843	66	66	18.8	37.487	167.487	26.418	
38	Right	242.00	31 18 55.273	66	66	45.31	66.475	198.475	224.703	
39	Left	222.00	00 32 56.604	50	50	1.089	3.18	103.18	317.528	
40	Left	10000.00	00 07 55.174	75	75	11.721	24.213	84.213	260.096	
41	Left	8302.28	00 08 05.222	75	75	14.558	20.117	58.117	677.116	
42	Left	402.00	07 43 58.044	60	60	27.161	58.219	154.219	500.084	
43	Right	202.00	13 12 12.983	55	55	23.264	46.582	156.582	56.253	
44	Left	202.00	25 22 28.928	55	55	45.557	89.521	199.521	209.216	
45	Right	242.5	04 35 33.480	50	50	14.462	20.046	120.046	346.64	
46	Left	502.00	03 20 48.408	40	40	14.609	23.321	103.321	161.201	
47	Left	1000.00	10 56 55.015	25	25	83.059	165.27	215.27	0	18182 End of Alignment

Abstract of Horizontal Curves(E-W Corridor)				
S. No.	Radius (m)	Nos. Occurrences	Curved Length (m)	% w. r. t. total curved length
1	>150m -200m	3	679.881	10.64%
2	>200m - 500m	17	2918.441	45.72%
3	>500m - 1000m	13	1453.44	22.77%
4	>1000m - 1500m	5	720.751	11.30%
5	>1500m - 2000m	2	125.172	2.62%
6	>2000m - 5000m	1	119.887	1.88%
7	>5000m	6	357.356	5.60%

(a) Gradient

A statement showing details of gradients provide along the corridor is given in the following Table No. 4.6: -

Table 4.6: Statement of Gradients (East-West Corridor)

S. No.	Chainage		Length	Rail Level		Gradient	Remarks
	From	To		From	To		
1	-592.00	180.00	772.000	301	301	0.000%	Level
2	180.00	430.00	250.000	301	297.2	1.520%	Fall
3	430.00	700.00	270.000	297.2	300.5	1.222%	Rise
4	700.00	1087.36	387.360	300.5	305.1	1.200%	Rise

S. No.	Chainage		Length	Rail Level		Gradient	Remarks
	From	To		From	To		
5	1087.35	1320.00	232.652	305.3	305.3	0.000%	Level
6	1320.00	1570.00	250.000	305.3	304.6	-0.280%	Fall
7	1570.00	1820.00	250.000	304.6	308.3	1.473%	Rise
8	1820.00	2078.75	258.750	308.3	308.3	0.000%	Level
9	2078.75	2440.00	361.250	308.3	308.5	0.100%	Rise
10	2440.00	2640.00	200.000	308.5	309.7	0.600%	Rise
11	2640.00	3020.00	380.000	309.7	311.6	0.500%	Rise
12	3020.00	3235.00	215.000	311.6	311.6	0.000%	Level
13	3235.00	3384.00	149.000	311.6	310.9	-0.470%	Fall
14	3384.00	3772.20	388.200	310.9	311.5	0.150%	Rise
15	3772.20	4180.00	407.800	311.5	311.5	0.000%	Level
16	4180.00	4340.00	160.000	311.5	311	-0.313%	Fall
17	4340.00	4652.53	312.525	311	319.5	2.720%	Rise
18	4652.53	4922.00	269.475	319.5	319.5	0.000%	Level
19	4922.00	5190.00	268.000	319.5	316.7	-1.045%	Fall
20	5190.00	5490.00	300.000	316.7	321.9	1.733%	Rise
21	5490.00	5750.00	260.000	321.9	321.9	0.000%	Level
22	5750.00	5940.00	190.000	321.9	325.5	1.895%	Rise
23	5940.00	6350.00	410.000	325.5	319.7	-1.415%	Fall
24	6350.00	6580.00	230.000	319.7	319.7	0.000%	Level
25	6580.00	6890.00	310.000	319.7	313.1	-2.129%	Fall
26	6890.00	7130.00	240.000	313.1	313.1	0.000%	Level
27	7130.00	7290.00	160.000	313.1	310.2	-1.813%	Fall
28	7290.00	7615.00	325.000	310.2	320.1	3.046%	Rise
29	7615.00	7856.60	241.600	320.1	320.1	0.000%	Level
30	7856.60	8200.00	343.400	320.1	313.9	-1.805%	Fall
31	8200.00	8523.50	323.465	313.9	313.9	0.000%	Level
32	8523.50	8770.00	246.500	313.9	311.8	-0.852%	Fall
33	8770.00	8965.00	195.000	311.8	315.4	1.846%	Rise
34	8965.00	9241.43	276.430	315.4	315.4	0.000%	Level
35	9241.43	9490.00	248.567	315.4	312.6	-1.126%	Fall
36	9490.00	9770.00	280.000	312.6	316.1	1.250%	Rise
37	9770.00	9965.00	195.000	313.3	316.9	1.846%	Rise
38	9965.00	10190.00	225.000	316.9	316.9	0.000%	Level
39	10190.00	10500.00	310.000	316.9	314.8	-0.677%	Fall
40	10500.00	10793.00	293.000	314.8	319.1	1.523%	Rise

S. No.	Chainage		Length	Rail Level		Gradient	Remarks
	From	To		From	To		
41	10765.00	10990.00	225.000	319.1	319.1	0.000%	Level
42	10990.00	11360.00	370.000	319.1	318.8	-0.081%	Fall
43	11360.00	11845.00	485.000	318.8	329.5	2.206%	Rise
44	11845.00	12135.00	290.000	329.5	329.5	0.000%	Level
45	12135.00	12375.00	240.000	329.5	325	-1.875%	Fall
46	12375.00	12715.00	340.000	325	336	3.235%	Rise
47	12715.00	13165.00	450.000	336	336	0.000%	Level
48	13165.00	13555.00	390.000	336	333.2	-0.718%	Fall
49	13555.00	14065.00	510.000	333.2	338.8	1.098%	Rise
50	14065.00	14305.00	240.000	338.8	338.8	0.000%	Level
51	14305.00	14585.00	280.000	338.8	339.4	0.214%	Fall
52	14585.00	14875.00	290.000	339.4	340.4	0.345%	Rise
53	14875.00	15050.00	175.000	340.4	345.2	2.743%	Rise
54	15050.00	15275.00	225.000	345.2	345.2	0.000%	Level
55	15275.00	15532.00	257.000	345.2	342.5	-1.051%	Fall
56	15532.00	15770.00	238.000	342.5	339.2	-1.387%	Fall
57	15770.00	16020.00	250.000	339.2	336.3	-1.160%	Fall
58	16020.00	16289.74	269.742	336.3	336.3	0.000%	Level
59	16289.74	16505.00	215.258	336.3	332.4	-1.812%	Fall
60	16505.00	16805.00	300.000	332.4	332.2	-0.067%	Fall
61	16805.00	16965.00	160.000	332.2	333.3	0.688%	Rise
62	16965.00	17165.00	200.000	333.3	330.4	-1.450%	Fall
63	17165.00	17496.76	331.758	330.4	330.4	0.000%	Level

Abstract of Gradients(E-W Corridor)				
S. No.	Description	Nos. Occurrences	Length (m)	% w. r. t. total Alignment length
1	Level	20	6054.412	33.59%
2	+ 0% to + 1%	16	4519.547	24.80%
3	+ 1% to + 2%	21	5642.583	31.07%
4	+ 2% to + 3%	4	1282.525	7.06%
5	+ 3% to + 4%	2	645	3.66%
	Total	63	18145	100.00%

CHAPTER 5

CIVIL ENGINEERING

TABLES

FIGURES

Chapter - 5

CIVIL ENGINEERING

5.1 GENERAL

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

5.2 CIVIL STRUCTURES

5.2.1 Underground Section

Presently, there is no "Underground Section" and as such this para is not required. But, there may be some underground section at a later stage. Keeping in view of the same, this has been included.

Tunnel excavation for underground section is generally carried out by Tunnel Boring Machines. Tunnel boring machines (TBMs) capable of drilling in soft and hard rocks can be successfully employed for boring tunnels through the rocky stratum.

5.2.2 Underground Stations

The underground station has 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. By resorting to top-down method the surface could be restored quickly and further excavations and construction of the station will not hamper the surface activity.

5.2.3 Cut and Cover Method of Construction of Underground Station

Cut and Cover mainly consists of following steps.

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

E. Back filling and restoration of the surface

6.2.4 Utility Diversion:

It is suggested that all utilities falling within excavation area are diverted away in advance to avoid damage to such utilities during the excavation/ construction phase. The cross utilities, however have 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.

6.2.6 Support Walls:

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

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

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

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

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

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

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

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

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

5.2.8 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.

6.2.7 Elevated Section : Choice of Superstructure

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

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

- Segmental construction is an efficient and economical method for a large range of span lengths and types of structures. Structures with sharp curves and variable super elevation can be easily accommodated.
- Segmental construction permits a reduction of construction time as segments may be manufactured while substructure work proceeds and assembled rapidly thereafter.
- Segmental construction protects the environment as only space required for foundation and sub-station is required at site. The superstructure is manufactured at a place away from busy areas and placement of superstructure is done with the system erected from piers at heights.
- Segments are easy to stack in the casting yard/stacking yard in more than one layer, thereby saving in requirement of space.
- It is easier to transport smaller segments by road trailers on city roads.
- It is easy to incorporate last minute changes in span configuration if the site situation so warrants.
- Interference to the traffic during construction is significantly reduced.
- Segmental construction contributes towards aesthetically pleasing structures and good finishes.
- The overall labour requirement is less than that for conventional methods.
- Better quality control is possible in the casting yard.
- During construction, the technique shows an exceptionally high record of safety.

6.2.8 Types of Superstructures for Elevated Section

(A) Pre-cast segmental box girder using external unbounded tendon.
(B) Pre-cast segmental U-Channel Superstructure with internal pre-stressing.

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

A. Precast Segmental Box Girder using External Unbounded Tendon.

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

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

- Simplification of all post-tensioning operations, especially installation of tendons.
- Reduction in structural concrete thickness as no space is occupied by the tendons inside the concrete.
- Good corrosion protection due to tendons in polyethylene ducts; the grout inspection is easier and leaks, if any, can be identified during the grouting process.
- Simplified segment casting. There is no concern about alignment of tendons. Increased speed of construction.
- The elimination of the epoxy from the match-cast joints reduces costs and increases speed of construction further.
- Replacement of tendons in case of distress is possible and can be done in a safe and convenient manner.
- Facility for inspection and monitoring of tendons during the entire service life of the structure.

Precast Segmental Box Girder using internal tendon is also use.

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

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

1. Built in sound barrier.
2. Built in cable support and system function.

3. Possibility to lower the longitudinal profile by approximately 1m compared to conventional design.

4. Built in structural elements capable to maintain the trains on the bridge in case of derailment (a standard barrier design allow this)

5. Built in maintenance and evacuation path on either side of the track.

6.3 CONSTRUCTION METHODOLOGY

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

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

6.4 PRE-CAST CONSTRUCTION

6.4.1 Casting of Segments

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

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

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

5.4.2 Launching Scheme

Launching girder is specially designed for launching of segments. The suggested launching scheme is designed in such a way that initially the launching girder is erected on pier head at one end of the work. The segments are lifted in sequence and when the lifting is over, they are dry matched while hanging from the launching girder. After dry matching, the

Segments are glued with epoxy and pre-stressed from one end. The girder is lowered on the temporary / permanent bearings after pre-stressing. The launching girder then moves over the launched span to next span and the sequence continue.

5.5 STRUCTURAL SYSTEM OF VIADUCT

5.5.1 Superstructure

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

Normally the U-Channel girder having a soffit width of 9.0 m (approx) accommodates the two tracks situated at 3.7m (Tangent & upto 150m curvature) to 4.0m (90m curvature) c/c. The U-Channel superstructure for almost all the simply supported standard spans will be constructed by pre-cast pre-stressed segmental construction with epoxy bonded joints.

The max spans c/c of piers of standard simply supported spans constructed by pre-cast 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 1.8m each. The other standard spans (c/c of pier) comprises of 25.0m, 31.0m, 22.0m, 19.0m & 16.0m, which shall be made by removing/adding usual segments of 3.0m each from the center of the span. Depth of the superstructure is so chosen that top of flange of U-Channel will be used as a evacuation walkway in an emergency.

The dimensions of end diaphragm will be finalized based on simply supported span of 31.0m and the same will be also kept for all simply supported standard span. The top level of both the end diaphragms of adjoining spans on the same piers is kept same so that expansion joint can be installed at top and continuity of profile of end diaphragm on the same pier can be maintained. The arrangement has been selected from aesthetic considerations.

The economical span (i.e. with optimum pre-stressing ratio) will be designed for the 25m situation.

Standard span up to 28.0m will be provided throughout the viaduct as far as possible. At crossings, where spans requires to be increased upto 31.0m, simply supported spans will be provided.

The location where the open foundations are possible, the spans of 16m will be provided.

For major crossing having spans greater than 31.0m, special 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. The top profile of superstructure of continuous unit (for the full length) will be retained the same as for standard spans so that evacuation walkway will be available even in continuous units. The increase in depth of U-channel will be accomplished by thickening the soffit slab (towards downside). At the end of continuous unit, the profile and thickness of soffit slab will be done to the extent that it will match with the profile and depth of end diaphragm of adjoining simply supported spans. The thickness of soffit slab will be increased smoothly toward penultimate support. In order to reduce the dead weight of the girder, voids will be also provided in the thickened soffit slab at bottom. These will be circular near the end of continuous unit and oblong near the penultimate support.

6.5.2 Substructure

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

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

The longitudinal center to center spacing of elastomeric/pot bearing over a pier would be about 1.8 m. The space between the elastomeric bearings will be utilized for placing the lifting jack required for the replacement of elastomeric bearing. An outward slope of 1:200 will be provided at pier top for the drainage due to spilling of rainwater, if any.
The transverse spacing between bearings would be 3.2 m (to be studied in more details). The orientation and dimensions of the piers for the continuous units or steel girder (simply supported span) have to be carefully selected to ensure minimum occupation at

ground level traffic. Since the vertical and horizontal loads will vary from pier to pier, this will be catered to by selecting the appropriate structural dimensions.

5.5.3 Foundation Recommendation

Depending on the nature of soil, type of proposed structure and expected loads on foundations, the recommended type of foundation is generally pile foundation except for a few locations where hard strata was located close to ground level. Pile capacities have been calculated as per IS 2911 Part 2 and IRC 78 while allowable bearing capacity for shallow open footing has been computed from the equation as per IS: 6403 – 1981.

- **PILE FOUNDATION**

Pile foundation is a feasible foundation scheme that may be designed where the loadings are heavy/medium, upper strata are loose/soft or filled up, and depth of water table is less. The pile load bearing capacity is calculated in as per IS 2911 Part 2 & IRC: 78-2000.

- **OPEN FOUNDATION**

For the prevailing soil conditions and type of structures, it was observed that shallow open footings can be provided at certain locations. Allowable bearing capacity for shallow open footing has been computed from the equation as per IS: 6403 – 1981 & Settlement shall be determined for unit pressure for a specified width of footing based on Corrected SPT values between the level of base of footing and the depth equal to 1.5 to 2.0 times the width of footing. Corrections shall be applied as applicable. Refer; IS: 8009 (Part-1).

5.5.4. Deck – Simple Spans

5.5.4.1 Deck – Simple Spans 'U' Girder

Salient features of the precast segmental construction method technique as envisaged for the project under consideration are indicated below:
Salient features of the pre-cast 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.

The suggested method of erection will be detailed in drawings to be prepared. 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 greater 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 affected by appropriately designed low-bodied trailers (tyre-mounted). The segments can be lifted and erected using erection portal gantry moving on launching girder.

U-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 pre-cast segmental construction only one-end pre-stressing shall be used.

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

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

5.5.4.2 Deck – Simple Spans Box Girder

The superstructure shall be constructed "span by span" sequentially, starting at one end of a continuous stretch and finishing at the other end. Nos. of launching girders may be required so as to work on different stretches simultaneously to enable completion of the project in time.

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

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

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

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

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

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

5.5.5 Epoxy Bonded Joints and Shear Keys

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

The purpose of the epoxy joint, which is about 1mm on each mating surface, shall be to serve as lubricant during segment positioning, to provide:

Waterproofing of the joints for durability in service conditions and to provide a seal to avoid cross-over of grout during grouting of one cable into other ducts.

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

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

5.8 CONSTRUCTION OF STATIONS

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

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

5.8.1 Grade of Concrete

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

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

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

5.8.2 Reinforcement and pre-stressed Steel

It is proposed to use HYSD 500 or TMT steel as reinforcement bars.
For pre-stressing work, low relaxation high tensile steel strands with the configuration 12 K 13 and or 19 K 13 is recommended (confirming to IS:14268).

5.8.3 Road width required during construction

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

All these actions will require a minimum period of about 6 to 8 months. During this period, the implementing agency can go ahead with the following preliminary works:

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

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

The new SPV for the implementation of Nagpur metro rail project has to take action for appointment of consultant for Project Management and proof checking including preparation of tender documents. Simultaneously action is also to be taken for detailed design for structures for elevated corridor.

5.7 GEO-TECHNICAL INVESTIGATIONS

The geological investigation was carried out by DMRC aiming to understand the geology of areas along with their alignment. The purpose of doing the geotechnical investigation is to identify the soil type with a view of design the safe & economical foundations for their structures and to propose the ground improvement methods to known troublesome spots like swampy areas, soft ground and peat land etc., if found any.

Prior to construction, it is necessary to estimate the geological phenomena, based on interpretation of geological information such as boring log, physical and mechanical property. Accordingly, quality and quantity of geological investigation highly affect to civil engineering work.

5.7.1 Physiography

Nagpur is situated at 21° 09' N latitude and 79° 03' E longitude and a mean altitude of 310 meters above sea level. Being located far away from any major water body at the centre of the Indian peninsula, the Nagpur's climate is dry or mildly humid for most of the year except for the rainy season. The highest recorded temperature in the city was 48.6 °C, while the lowest was 3°C.

5.7.2 General Geology and Related Characteristics

The Geo technical site investigation carried out from AUTOMOTIVE SQUARE TO MIHAN alignment & 39 boreholes were driven in Lokmanya Nagar to Prajapati Nagar alignment with in the Nagpur City of Maharashtra.

Nagpur lies on the Deccan plateau of the Indian Peninsula and has a mean altitude of 310.5 meters above sea level. The underlying rock strata are covered with alluvial deposits resulting from the flood plain of the Kanhan River. In some places these give rise to granular sandy soil. In low lying areas which are poorly drained, the soil is alluvial clay with poor permeability characteristics. In the eastern part of city crystalline metamorphic rocks such as gneiss, schist and granites are found, while in the northern part yellowish sand stones and clays of the lower Gondwana formations are found.

Latitude 78°15' to 88°45'E, Longitude 16°45' to 21°35'N

Physiography and Climate: The city is generally having warm tropical climate with the temperature in summer varying between 41°C to 45°C and in winter between 32°C to 37°C. The period between January to April and Nov to December is generally dry whereas in June to October it is rainy season. The city has an average annual rainfall of 1112.0 mm.

SEISMICITY : According to studies, Nagpur region lies in between Zone 1 and Zone 2 of Earthquake Zones in the country. It means that Nagpur has close to zero chances of getting a major earthquake which may cause huge devastation. Recent history also supports the fact that Nagpur region is relatively very safe as far as earthquakes are concerned. Though city has not recorded any seismic activity of magnitude above 4 on Richter scale since 1938 and falls under safest earthquake zone area, the possibilities of a low to moderate earthquake cannot be ruled out completely. A study of active faults conducted by the Geological Survey of India (GSI), central region in city in last ten years, has shown presence of predominant features of neo-tectonic activity in vicinity (200 plus km) of Nagpur which could reactivate and trigger low to moderate quakes in the area. Active faults studies conducted by GSI department from 2002 to March 2012 has shown that the entire stretch starting from Shadol district in Madhya Pradesh in the Son river basin to Narmada banks in Jabalpur, the Son Narmada South Fault (SNSF) which continues westward to become Gavilgarh fault (north of Pandharkawda in Maharashtra) has shown presence of proterozoic metamorphic rocks along the banks of the rivers which are known for tectonic activity.

GEOGRAPHY: The Nagpur region has complex topography of hilly terrain, undulating terrain & plains. Nearly 40% area is occupied by forests having hilly terrains. The Wardha, Wainganga, Penganga, Pranhita, Indravati rivers are forming major basins in the area. The drainage pattern is dendritic to sub parallel.

GEOLOGY: The geology of the Nagpur region is famous for the metamorphic rocks, which occur in all the districts in the Nagpur region except Wardha and some part of Nagpur district. The other geological formation Deccan Traps occur in the Wardha and North and North-West part of Nagpur District. The stratigraphic succession of the geologic formations in the region is given below.

Stratigraphy of the rock types occurring in the Nagpur Region

Table 5.1: ROCK TYPES

Age	Rock Type	Geology	Geographical distribution in Nagpur Region.
Lower Eocene to Upper cretaceous	Igneous Rocks	Deccan Trap, Volcanic lava flows with inter trappean beds	Wardha and Some parts of Nagpur district & Chandrapur
		Lameta and Bagh Beds	Parts of Nagpur
Jurassic upper Gondwana	Metamorphic	Chikiala & Kota stages, Lime stone	Sironcha taluka of Gadchiroli district.
Triassic	Sedimentary Rocks	Pachmari & Maleri stages, Clays, Sandstones.	Sironcha taluka of Gadchiroli district.
Permian Lower Gondwana	Sedimentary Rocks	Mangli Beds – Sandstone	Warora Taluka of Chandrapur district.
		Kamptee series – Sandstone, Shale, Coal	Nagpur & Chandrapur district.
		Barakar Series – Sandstone, Shales and Coal	Nagpur & Chandrapur district.
Upper Carboniferous	Metamorphic Rocks	Talchir series – Boulders, Green shale, Sand stones, Shales, Chert	Nagpur & Chandrapur district.
Proterozoic	Sedimentary Rocks	Vindhyan super group (Lime stones, Shales & Sandstones)	Chandrapur district.
		Cuddapah equivalent Limestones & shales	Sironcha Taluka of Gadchiroli district.
Precambrian	Metamorphic Rocks	Sakoli Series Quartzites schists,Phyllites, Iron ore series Quartzites schists,Phyllites,	Gadchiroli, Chandrapur, Nagpur & Bhandara districts.
		Sausar Series Marbles gneisses,schists granite	Nagpur & Bhandara districts.
		Peninsular Basement complex (Archaeans) Gneisses, schists,Granites	Gadchiroli, Chandrapur, Nagpur and Bhandara Districts

6.7.3 FIELD INVESTIGATION

Field investigation at the site were planned to determine the required strength characteristics of the underlying soil/rock strata to design the foundations of the proposed structure to be constructed. The geotechnical investigation work includes:

1. Drilling of 150mm diameter boreholes in all kind of soil including gravels and cobbles and Nx size borehole in boulders and rock strata. All boreholes shall be extend upto depths of 30 m in soil (up to N>=100) or 10 m in weathered rock (RQD <=50%) or 5 m in hard rock (RQD>50%).

   However the maximum depth of bore hole does not exceed 30 m. If strata having a standard Penetration Test value greater than 100 with characteristics of rock are met earlier, the borehole shall not be advanced further. When the boreholes are to be terminated in soil strata, the Standard Penetration Test shall be carried out at the termination depth and recorded.

2. Conducting Standard penetration test (SPT) at every 1.5m interval starting from 1.5m from natural ground level or every change of stratum as per IS:2131.

3. Collection of disturbed, undisturbed soil samples and water sample as per IS: 2132, IS: 1892 & IS: 3025 should be followed.

4. The following laboratory tests were conducted on collected soil/water samples.

Table 6.3 : LABORATORY TESTS-SOIL/WATER

SL. NO.	PARTICULARS OF PROPERTIES	DISTURBED SOIL SAMPLE	UNDISTURBED SOIL SAMPLES
1.	Sieve Analysis	√	√
2.	Hydrometer Analysis	√	√
3.	Natural Moisture Content		√
4.	Bulk / Dry Density		√
5.	Specific Gravity	√	√
6.	Atterberg's Limit	√	√
7.	Direct Shear Test (for non cohesive soils)		√
8.	UU Tests (for cohesive samples)		√
9.	UCS Tests (for cohesive samples)		√
10.	Field permeability test in soil		√
11.	Chemical test on soil & water sample for pH value, carbonate, sulphate (SO_3 and SO_4)		√

5. The following laboratory tests were conducted on collected rock sample

Table 5.3 : LABORATORY TESTS ROCK SAMPLES

SL NO.	PARTICULARS OF PROPERTIES
1	Permeability test by Packer method
2.	Density Test
3.	Water absorption
4.	Porosity
5.	Hardness
6.	Atterberg's Limit
7.	Unconfined compression test
8.	Point load index
9.	Modulus of elasticity
10.	Abrasion Testing

5.7.4 DETAILS OF GEOTECHNICAL INVESTIGATION

5.7.4.1 GENERAL

Six boring rigs were deployed with all requisite equipments and accessories at project sites. Total 80 boreholes have been drilled at an average distance of 0.5 km each, all along the length of the proposed Metro corridor.

41 bore holes were driven in AUTOMOTIVE SQUARE TO MIHANalignment & 39 boreholes were driven in Lokmanya Nagar to Prajapati Nagar alignment. However, due to the site condition, depth of drilling work ranging from 10.50m to 25m was carried out at the proposed locations. Details of Boreholes are given below in Table no 5.4 & Table no 5.5

5.7.4.2 DETAILS FOR NORTH – SOUTH CORRIDOR

Necessary plant, equipment and personnel for conducting the requisite field work were mobilized to the site. These were shifted from one test location to another location during execution of the field work and demobilized on satisfactory completion of the entire field work.

Forty one bore holes (BH-1 to BH-41) carried out.

The bore holes were bored at the site using Rotary drilling method as per IS: 1892-1979. Casing as required was used to retain the bore holes.

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

Undisturbed soil samples were collected from the bore holes at every 3.0 m interval in depth & at change of strata as per sampling specifications, in thin walled sampling tubes of 100 mm dia and 450 mm length fitted to an adapter with ball and socket arrangement. These sampling tubes after retrieval from the bore holes were properly waxed and sealed at both ends. These were carefully labeled and transported to the laboratory for testing. Undisturbed soil samples wherever slipped during lifting, were duly marked in the field bore logs as well as in the soil profile.

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

Conducting field permeability test in same bore holes in overburden using falling head and in rock with packer.

The depth of ground water table was checked / measured in all bore holes. The ground water table was encountered in some bore holes during the boring activity.

Summary of Bore Holes for this corridor is as below :

Table 5.4 – SUMMARY OF BORE HOLES
N-S CORRIDOR

BH No.	Location Details	Total depth	Soil	Soft Rock	Hard Rock	Water Table (m)
1	Automotive Chowk	25.00	15.00	10.00	-	7.20
2	Go Gas Pump	16.00	6.00	10.00	-	7.10
3	Jolly Automobiles	17.00	7.00	10.00	-	7.20
4	Lal godown Chowk	15.50	5.50	10.00	-	5.60
5	New India Hindi School	16.00	6.00	10.00	-	5.50
6	Oppt. Jaswant Tuli Mall	16.00	6.00	10.00	-	7.10
7	Bharat Petrol Pump (10 No. Pulia)	14.50	4.50	10.00	-	5.40
8	Kadbi Chowk	14.30	4.30	10.00	-	3.15
9	Gandhibaag (Railway Line Near)	25.00	15.00	10.00	-	3.60
10	Gaddi Godown Chowk	12.00	2.00	10.00	-	4.25
11	L.I.C. Chowk, AHM Church Campus	11.50	1.50	10.00	-	4.40
12	R.B.I Bank Chowk	12.00	2.00	10.00	-	4.00
13	Morris College, T. Point	11.00	1.00	10.00	-	3.85
14	Sita Burdi Police Station	14.50	4.50	10.00	-	5.00
15	Ras Furniture, Oppt. Nanga Traders	16.00	6.00	10.00	-	4.70
16	Yeswant Stadium	17.00	7.00	10.00	-	4.60
17	Dhantoli P.S. Oppt. Green City Hotel	17.50	7.50	10.00	-	5.10
18	Madhukar Arts (M. Printers)	15.00	5.00	10.00	-	3.20
19	Asha Towers	14.50	4.50	10.00	-	3.50
20	Hotikar Chowk	14.00	4.00	10.00	-	3.40
21	Central Jail	15.00	5.00	10.00	-	3.60
22	Clock Tower Rajiv Gandhi Chowk	11.00	1.00	10.00	-	3.25
23	Sanskar Vidhya Sagar School	12.50	2.50	10.00	-	4.00
24	Bharat Creations/Sanjay Traders	13.00	3.00	10.00	-	4.10
25	Sawarkar Chowk	12.50	2.50	10.00	-	2.90
26	Khamla Bus Stop	12.00	2.00	10.00	-	3.60
27	Bora Hardware/Vijay Trading	13.00	3.00	10.00	-	3.00
28	Arun Rao Pumpkar Chowk (Pulya)	13.00	3.00	10.00	-	2.15
29	Park/Dance Forest Area (Airport)	14.00	4.00	10.00	-	2.95
30	Parking Airport	14.50	4.50	10.00	-	2.10
31	Airport Boundry	14.50	4.50	10.00	-	3.70
32	Mihan Entry	13.50	3.50	10.00	-	2.65
33	Mihan Road	11.50	1.50	10.00	-	2.60
34	Mihan Road	11.00	1.00	10.00	-	3.70
35	Mihan Road	10.50	0.50	10.00	-	3.25
36	Mihan Road	11.00	1.00	10.00	-	3.15
37	Mihan Road	10.00	0.00	10.00	-	3.25
38	Mihan Road	11.00	1.00	10.00	-	4.05
39	Mihan Road	10.50	0.50	10.00	-	4.00
40	Mihan Depot	11.00	1.00	10.00	-	3.10
41	Mihan Depot	11.00	1.00	10.00	-	2.40

5.7.4.3 DETAILS FOR EAST - WEST CORRIDOR

Thirty nine bore holes (BH-1 to BH-39) were carried out. The bore holes were bored at this site using Rotary drilling method as per IS: 1892-1979. Casing as required was used to retain the bore holes.

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

Undisturbed soil samples were collected from the bore holes at every 3.0 m interval in depth & at change of strata as per sampling specifications, in thin walled sampling tubes of 100 mm dia and 450 mm length fitted to an adapter with ball and socket arrangement. These sampling tubes after removal from the bore holes were properly waxed and sealed at both ends. These were carefully labelled and transported to the laboratory for testing. Undisturbed soil samples wherever slipped during lifting, were duly marked in the field bore logs as well as in the soil profile.

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

Conducting field permeability test in same bore holes in overburden using falling head and in rock with packer.

The depth of ground water table was checked / measured in all bore holes. The ground water table was encountered in some bore holes during the boring activity.

Summary of Bore Holes is given in Table : 5.5

Table 6.6 – SUMMARY OF BORE HOLES
E W CORRIDOR

BH No.	Location Details	Total depth	Soil	Soft Rock	Hard Rock	Water Table (m)
1	AM Engineering Limited	11.00	1.00	5.00	5.00	3.50
2	C.R.P.F Gate No-1	11.00	1.00	6.00	4.00	4.20
3	Mahindra Company	11.50	1.50	6.00	4.00	4.30
4	Ambu. Bazi Chowk (Near Dharam kanta)	11.00	1.00	10.00	-	4.05
5	Toll Tax Naka	11.00	1.00	10.00	-	4.25
6	Super Enclave, Opp. Prashant Trading	11.00	1.00	10.00	-	3.30
7	Hingna T. Point	10.50	0.50	10.00	-	4.70
8	Kasturi Hotel	11.00	1.00	10.00	-	4.80
9	Pump House (G.C.C.R.P.F) Nagpur	10.50	0.50	10.00	-	5.10
10	Subhash Nagar Chowk	12.50	2.50	9.00	1.00	4.20
11	Nagpur Improvement Trust, Chaju Castle	13.00	3.00	10.00	-	4.40
12	Tanveer Hotel	12.30	2.30	10.00	-	3.40
13	Lada house (Near Ambajhari T Point)	12.00	2.00	9.00	1.00	3.60
14	L.A.D. Chowk	13.00	3.00	10.00	-	5.10
15	Shankar Nagar chowk	13.00	3.00	10.00	-	5.15
16	Adarsh S.S High School	12.00	2.00	10.00	-	3.10
17	Dharampeth Vidyalay	14.00	4.00	10.00	-	4.50
18	A.M.I.E (Nagpur Local Center)	14.00	4.00	10.00	-	3.50
19	M.J. College	14.50	4.50	10.00	-	4.80
20	Jhansi Rani Chowk	14.00	4.00	10.00	-	5.10
21	Munje Chowk	14.00	4.00	10.00	-	5.70
22	Railway Push Box	14.50	4.50	10.00	-	4.80
23	Nagpur Corporation octroi Naka - II	14.00	4.00	10.00	-	4.20
24	Hazrat baba nagar	14.00	4.00	10.00	-	5.30
25	Mayo Hospital	12.00	2.00	10.00	-	3.80
26	Seva Sadan Chowk	13.50	3.50	10.00	-	4.50
27	Gandhi Bagh (Bus Stop)	12.50	2.50	10.00	-	4.35
28	Chittaroli Chowk	13.20	3.20	10.00	-	4.70
29	Darodkar Chowk	13.15	3.15	10.00	-	4.80
30	Rahate Hospital	14.50	4.50	10.00	-	4.75
31	Telephone Exchange	16.00	6.00	10.00	-	7.20
32	Chapru Nagar Chowk, Bharat Furniture	16.00	6.00	10.00	-	5.30
33	Ambedkar Chowk	17.50	7.50	10.00	-	4.50
34	All Electrical, Vardhman Nagar Chowk	16.50	6.50	10.00	-	7.40
35	Near Mahalaxmi Collection	16.50	6.50	10.00	-	6.40
36	Sapna Bar & Restaurant	17.00	7.00	10.00	-	4.30
37	Radha Krishan Hospital Chowk	17.50	7.50	10.00	-	7.20
38	Desi Wine Shop	21.00	10.00	10.00	-	7.80
39	Gomti Hotel, Near F & B Bank	20.00	10.00	10.00	-	7.20

5.7.4.4 TYPE OF FOUNDATION :

TYPE OF FOUNDATION :NORTH – SOUTH CORRIDOR

A : Bored Cast in situ RCC Pile

Depending on the field and laboratory observations of subsoil strata, test results and the type of structures proposed at site, the most feasible soil-foundation system is recommended as normal bored cast in situ R.C.C. piles foundations of 0.80m & 1.0m diameter at different depths with cut-off level at 1.50m to 2.0m depth below existing Ground level.

The safe load carrying capacities of these piles are given in following table.

Table :5.6 RCC PILE DETAILS FOR NORTH – SOUTH CORRIDOR

Borehole Nos	Dia. of Pile	Cutoff level	Depth, m	Pile Capacity		
				Compression	Uplift	Lateral
1	0.80	1.50	19.00	185.0	80.0	9.0
	1.00	1.50	19.00	300.0	120.0	12.0
2,3	0.80	1.50	11.00	170.0	40.0	9.0
	1.00	1.50	11.00	230.0	50.0	12.0
4,5,6	0.80	1.50	10.50	170.0	45.0	9.0
	1.00	1.50	10.50	250.0	50.0	12.0
7,8	0.80	1.50	10.00	150.0	35.0	9.0
	1.00	1.50	10.00	225.0	45.0	12.0
9	0.80	1.50	15.00	230.0	85.0	9.0
	1.00	1.50	15.00	330.0	100.0	12.0
14	0.80	1.50	10.00	150.0	35.0	9.0
	1.00	1.50	10.00	225.0	45.0	12.0
15,16	0.80	1.50	11.00	170.0	40.0	9.0
	1.00	1.50	11.00	250.0	50.0	12.0
17	0.80	1.50	12.00	180.0	45.0	9.0
	1.00	1.50	12.00	260.0	55.0	12.0
18 to 21	0.80	1.50	10.00	150.0	35.0	9.0
	1.00	1.50	10.00	225.0	45.0	12.0
23 to 28	0.80	1.50	10.00	140.0	30.0	9.0
	1.00	1.50	10.00	210.0	40.0	12.0
29 to 32	0.80	1.50	10.00	150.0	35.0	9.0
	1.00	1.50	10.00	225.0	45.0	12.0

Note:

1. For design purpose, water table shall be considered at cut off level.
2. For design purpose, effective overburden pressure at pile tip should correspond to pile length equal to 15 times the diameter.
3. The above values should be confirmed through pile load tests in the field before adopting these values for design purposes.

B: Open square footing

Depending on the field and laboratory observations of subsoil strata, test results and the type of structures proposed at site, the types of foundations, depths and net safe bearing capacities recommended for design purposes are given in the following table. The net SBC/API in the following table are the lower of the values obtained from shear failure criterion as per IS: 6403 and settlement failure criterion as per IS: 8009, Part-I.

For Bore Hole Nos : 10 to 13, 22 & 33 to 41 :

Table .5.7 OPEN FOUNDATION DETAILS FOR NORTH – SOUTH CORRIDOR

For Permissible settlement = 40.0 mm

Type of Foundation	Depth of Foundation (m)	Size of Foundation (m)	Net Safe Bearing Capacity/ Allowable Pressure Intensity (t/m^2)
Square footing	2.00 to 3.0	5.0 to 6.0	20.00

Note: For design purpose water table shall be considered at foundation level.

TYPE OF FOUNDATION : EAST - WEST CORRIDOR

A : Bored Cast in situ RCC Pile

Depending on the field and laboratory observations of subsoil strata, test results and the type of structures proposed at site, the most feasible soil foundation system is recommended as normal bored cast in situ R.C.C. piles foundations of 0.80m & 1.0m diameter at different depths with cut-off level at 1.50m to 2.0m depth below existing Ground level.

The safe load carrying capacities of these piles are given in following table.

Table :5.3 RCC PILE DETAILS FOR EAST - WEST CORRIDOR

Borehole Nos.	Dia. of Pile	Cutoff level	Depth, m	Pile Capacity		
				Compression	Uplift	Lateral
11	0.80	1.50	12.00	400.0	60.0	9.0
	1.00	1.50	12.00	600.0	90.0	12.0
17 – 22	0.80	1.50	14.00	155.0	50.0	9.0
	1.00	1.50	14.00	340.0	70.0	12.0
23 – 24	0.80	1.50	14.00	185.0	60.0	9.0
	1.00	1.50	14.00	250.0	75.0	12.0
25 – 29	0.80	1.50	12.00	150.0	40.0	9.0
	1.00	1.50	12.00	225.0	50.0	12.0
30 – 31	0.80	1.50	14.00	170.0	50.0	9.0
	1.00	1.50	14.00	340.0	70.0	12.0
32	0.80	1.50	12.00	175.0	40.0	9.0
	1.00	1.50	12.00	250.0	50.0	12.0
33 – 34	0.80	1.50	15.00	200.0	80.0	9.0
	1.00	1.50	15.00	300.0	100.0	12.0
35 – 37	0.80	1.50	15.00	190.0	75.0	9.0
	1.00	1.50	15.00	300.0	100.0	12.0
38	0.80	1.50	15.00	180.0	80.0	9.0
	1.00	1.50	15.00	250.0	100.0	12.0
39	0.80	1.50	20.00	200.0	80.0	9.0
	1.00	1.50	20.00	300.0	100.0	12.0

Note:

1. For design purpose, water table shall be considered at cut off level.
2. For design purpose, effective overburden pressure at pile tip should correspond to pile length equal to 15 times the diameter.
3. The above values should be confirmed through pile load tests in the field before adopting these values for design purposes.

B : Open square footing

Depending on the field and laboratory observations of subsoil strata, test results and the type of structures proposed at site, the types of foundations, depths and net safe bearing capacities recommended for design purposes are given in the following table. The net SBC/APP in the following table are the lower of the values obtained from shear failure criterion as per IS: 6403 and settlement failure criterion as per IS: 8009, Part-I.

Table :5.9 OPEN FOUNDATION DETAILS FOR EAST-WEST CORRIDOR

For Permissible settlement = 40.0 mm

Type of Foundation	Simple No	Depth of Foundation (m)	Size of Foundation (m)	Net Safe Bearing Capacity/ Allowable Pressure Intensity (t/m^2)
Square footing	1 - 9	2.50 - 3.0	5.0 to 6.0	25.00
	10 & 12	3.0	5.0 to 6.0	20.00
	12 - 13	3.0	5.0 to 6.0	20.00
	14 - 15	3.00 - 4.00	5.0 to 6.0	25.00
	16	3.0	5.0 to 6.0	20.00

Note: For design purpose water table shall be considered at foundation level.

6.5 LAND

6.5.1 The alignment and profile

Both the alignments are elevated except around 4.0 Km at Grade alignment. Total 36 stations are proposed in both corridors. Out of which 02 are at grade and 35 are elevated.

6.5.2 Land Requirement for following Major Components

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

6.5.3 Land for Underground stretches

No land at surface is required permanently for underground section, except for small areas for entry/exit structures, traffic integration, chilling plant and ventilation shafts at stations. These will be located either on footpath edge or in front marginal open setback of the building along the road.

6.5.4 Land required for elevated stretches

For elevated section, single pier supporting the viaduct will be located on the middle of road so that the existing roads remain in use as usual. Accordingly, necessary permission for using such right-of-way will have to be obtained from the concerned authorities. Elevated station is generally proposed with elevated concourse so that land is required only for locating the entry/exit structures. Traffic integration facilities are provided wherever the same are required and, but no land is proposed for acquisition.

The normal viaduct structure of elevated Metro is about 10 m (edge to edge) wide. Ideally the required right of way is 16m. However, for reasons of safety a clear 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. This is necessary as the traction system as proposed is overhead 25 kV ac systems with masts fixed on the parapets. Also, it ensures road access and working space all along the viaduct for working of emergency equipments and fire brigade. In stretches, where the elevated alignment has to be located away from road, a strip of 20-m width is proposed for acquisition.

5.3.5 Land for Switch-over Ramps

Switch-over ramps are required for transition from the underground to elevated section or vice versa. The ramp covers a stretch at ground for the whole width of structure for two tracks (about 10.5m including the protection works). The length of ramp above ground depends on the existing ground slope and the gradient provided on Metro alignment (normally 3% to 4%). Thus the ramp is to be located in an area where sufficient road width is available or in an open area. On this corridor, three such ramps are provided on the both the corridors.

5.3.6 Land for Traffic Integration

Certain land is required for traffic integration at the each station. Efforts have been made to identify land required for traffic integration at each station to facilitate park and ride facility, but it is not possible to find open space at all the locations. Hence land for traffic integration has been marked in the drawing wherever is available.

5.3.7 Land for Traction and Receiving Substation and Radio Towers

Four RSS are proposed to be located for both the corridors. Hence, an area has to be earmarked at Kadumhond Park. The exact location will be decided at the time of implementation of the project. Similarly, four radio towers are also being proposed to be located at four locations occupying an area of 100 m^2 (10 m X 10 m each plot) for each radio tower.

6.3.3 Land Requirement for Stations & Running section

The station is generally located on the road median. Total length of the station is ~140m. All the stations are two-level stations. The concourse is planned along the whole length of the platform with staircases leading from either side of the road. The maximum width of the station at concourse is ~22m. Passenger facilities like ticketing, information, etc as well as operational areas are provided at the concourse level. The staircase giving access to concourse area from ground will be located at the edge of footpaths or in front marginal open setback of the buildings in the as far as possible in the open space. Nevertheless it is not possible to find open space at all the locations therefore acquisition of certain private structures is inevitable. At curved portions, the alignment could not be kept in the centre of the road and land acquisition at such locations is inevitable in spite of introduction of sharper curves.

To the extent possible the Entry and Exit points of stations (underground and elevated) were planned on the foot paths. But, for locating other station facilities such as chiller plants, ventilation shafts, underground water tanks, generator set room etc., land acquisition is proposed. The details of land permanently required for depot, running sections and stations are indicated in the **Table 6.10, Table 6.10 A, 6.10 C, 6.10 D and Table 6.10E.**

Table 6.10: Details of Land Required for Depot

S. No.	Plot No.	Location	Area (approx)	Ownership	Purpose
1	DP1	[illegible]	33.00 hectare	Government	Depot
2	DP2	DSP LAND	20.00 hectare	Government	Depot

Table 6.10 A: Details of Land Required for Running Section
EAST-WEST CORRIDOR

EAST-WEST CORRIDOR			
S.NO.	PLOT NO.	AREA(Sqm)	OWNERSHIP
1	ES-1	61	Govt.
2	ES-2	255.8	Pvt.
3	ES-3	34.7	Govt.
4	ES-4	3318.2	Pvt.
5	ES-5	125.5	Pvt.
6	ES-6	86.8	Pvt.
7	ES-7	25.8	Pvt.
8	ES-8	332.7	Pvt.
9	ES-9	2054.8	Govt.
10	ES-10	545.6	Govt.
11	ES-11	526.0	Pvt.
12	ES-12	332.5	Pvt.

EAST WEST CORRIDOR			
S.NO	PLOT NO	AREA(Sqm)	OWNERSHIP
13	RS-13	568.3	Pvt.
14	RS-14	176.8	Pvt.
15	RS-15	40.2	Pvt.
16	RS-16	123.1	Pvt.
17	RS-17	11.6	Pvt.
18	RS-18	21.3	Pvt.
19	RS-19	14.7	Pvt.
20	RS-20	3.8	Pvt.
21	RS-21	4.8	Pvt.
22	RS-22	14.8	Pvt.
23	RS-23	3.9	Pvt.
24	RS-24	3.9	Pvt.

Total Land = 3938.15sqm
Govt. = 2255.3 Sqm
Pvt. =1628.85sqm

Table 5.10 B: Details of Land Required for Running Section
NORTH SOUTH CORRIDOR

RUNNING SECTION OF NAGPUR METRO RAIL PROJECT			
NORTH SOUTH CORRIDOR			
S.NO	PLOT NO	AREA(Sqm)	OWNERSHIP
1	RS-1	25.2	Pvt.
2	RS-2	105.8	Pvt.
3	RS-3	11.4	Govt.
4	RS-4	9.9	Pvt.
5	RS-5	55.1	Pvt.
6	RS-6	83.2	Pvt.
7	RS-7	53.1	Govt.
8	RS-8	156.6	Govt.
9	RS-9	152.8	Govt.
10	RS-10	31.2	Pvt.
11	RS-11	25.2	govt.
12	RS-12	29.1	govt.
13	RS-13	126.6	Pvt.
14	RS-14	1746.8	Pvt.
15	RS-15	103.1	Govt.
16	RS-16	87.4	Govt.
17	RS-17	122.1	Govt.

18	RS-18	663.1	Govt.
19	RS-19	138.2	Govt.
20	RS-20	655.1	Govt.
21	RS-21	950.8	Govt.
22	RS-22	8087.7	Pvt.
23	RS-23	873.8	Pvt.
24	RS-24	55	Pvt.
25	RS-25	245.9	Govt.
26	RS-26	4845.6	Govt.
27	RS-27	202.7	Pvt.
28	RS-28	42.8	Pvt.
29	RS-29	735.9	Pvt.
30	RS-30	627.5	Govt.
31	RS-31	1760.7	Pvt.
32	RS-32	1778.6	Pvt.
33	RS-33	1319.3	Pvt.
34	RS-34	735.8	Pvt.
35	RS-35	781	Pvt.
36	RS-36	675.8	Pvt.
37	RS-37	76	Pvt.
38	RS-38	138	Pvt.
39	RS-39	10458.7	Govt.
40	RS-40	26654.0	Govt.
41	RS-41	283.7	Govt.
42	RS-42	40346.4	Govt.
43	RS-43	2248.7	Govt.
44	RS-44	13485.5	Govt.
Total Land -120898.66sqm			
Govt. – 102882.75sqm.			
Pvt. – 18015.95sqm.			

Table 5.10 C: Details of Land Required For Stations

S. No	Name of Station	PLOT NO	AREA	OWNERSHIP	REMARKS
North South corridor: Automotive Square to Khapri Station					
1	AUTOMOTIVE SQRE.	AS-1	221.8	Pvt.	Open/Shed
		AS-2	228.1	Pvt.	Structure
2	NARI ROAD	NR-1	284.3	Pvt.	Structures
		NR-2	223.8	Pvt.	Structure

S. No.	Name of Station	PLOT NO.	AREA	OWNER-SHIP	REMARKS
3	INDORA CHOWK	IC-1	237.3	Pvt.	Structure
		IC-2	237.3	Pvt.	Shops
4	KADVI CHOWK	KC-1	240.2	Govt.	Open
		KC-2	223.7	Pvt.	Residential/Shops
5	GADDI GODAM SQRE.	GGS-1	234.8	Pvt.	Shops
		GGS-2	234.8	Pvt.	Shops
6	KASTURCHAND PARK	KP-1	233.2	Govt.	Open/Parking
		KP-2	239.2	Pvt.	Residential
7	ZERO MILE	ZM-1	237.3	Pvt.	Structure
		ZM-2	237.3	Govt.	Open
8	SITABURDI	SB-1	388.1	Pvt.	Shops/House
		SB-2	70.8		Residential
		SB-3	241.3		Restaurant
9	CONGRESS NAGAR	CON-1	235.1	Govt.	Open
		CON-2	234.7	Pvt.	Residential
10	RAHATE COLONY	RC-1	237.3	Govt.	Open
		RC-2	237.3		Open
11	AJNI SQUARE	AS-1	237.3	Pvt.	Shopping Complex
		AS-2	700.2	Govt.	Road
12	CHHATRAPATI SQUARE	CS-1	385	Govt.	Open
		CS-2	333.2	Pvt.	Open
13	JAIPRAKASH NAGAR	JPN-1	245	Govt.	Open
		JPN-2	333.2	Pvt.	Water Chamber
14	UJWAL NAGAR	UN-1	385	Govt.	Open Ground
		UN-2	320.2	Pvt.	Shopping Complex
15	AIRPORT	A-1	339.2	Govt.	Open
		A-2	375.2		Open Airport Land
16	NEW AIRPORT	NAP-1	5515.1	Govt.	Open
17	KHAPRI	KP-1	7878.1	Govt.	Railway Land
Total Land = 21237.8sqm		Govt.=7525.3sqm		Pvt. = 13712.5sqm	

S. No.	Name of Station	PLOT NO	AREA	OWNERSHIP	REMARKS
East West corridor: Prajapati Nagar to Lokmanya Nagar					
1	PRAJAPATI NAGAR	PN-1	270.0	Pvt.	Residential
		PN-2	276.7	Govt.	Open
2	VAISHNO DEVI CHOWK	VDC-1	272.8	Pvt.	Residential
		VDC-2	259.5		Residential/ Shops
3	AMBEDKAR CHOWK	AC-1	276.8	Govt.	Colleges/ Residential
		AC-2	287.1	Pvt.	Shops
4	TELEPHONE EXCHANGE	TE-1	271.8	Pvt.	Residential/ Shops
		TE-2	270.4		Residential
5	CHITAR OLI CHOWK (GANDHI PUTALA)	COC-1	294.1	Pvt.	Residential
		COC-2	273.8		Residential/ Shops
6	AGRASEN CHOWK	AGC-1	288.8	Pvt.	Residential/ Shops
		AGC-2	272.8		Petrol Pump/ Structure
7	DOSER VAISYA CHOWK (MAYO HOSPITAL)	DVC-1	271.7	Pvt.	Residential
		DVC-2	271.4		
8	NAGPUR RAILWAY STATION	NRS-1	280.0	Govt.	School
		NRS-2	280.7		Railway land
9	SITABULDI	SLB-1	288.4	Pvt.	Residence
		SLB-2	288.5		
10	JHANSI RANI SQRE.	JRS-1	282.8	Pvt.	Residence
		JRS-2	282.8	Govt.	Open
11	INSTITUTIONS OF ENGINEERS	IOE-1	272.5	Govt.	Open
		IOE-2	278.2		
12	SHANKAR NAGAR SQRE. (BANK OF INDIA)	SNS-1	276.2	Govt.	Petrol Pump + Residential
		SNS-2	280.4		Residential
13	LAD CHOWK	LC-1	409.8	Pvt.	Residential
		LC-2	409.8		
14	DHARAMPETH COLLEGE	DC-1	276.3	Pvt.	Open
		DC-2	284.2	Govt.	
15	SUBHASH NAGAR	SN-1	273.5	Govt.	Open
		SN-2	276.9		
16	RACHANA(RING RD JN)	RJ-1	306.4	Govt.	Open
		RJ-2	331.5	Pvt.	Residential/ Shops
17	VASUDEV NAGAR	VN-1	308.8	Pvt.	Residential
		VN-2	280.4	Govt.	Open
18	BANSI NAGAR	BN-1	409.7	Pvt.	Petrol pump
		BN-2	287.5		Structure
19	LOKMANYA NAGAR	LN-1	276.4	Govt.	Open

S. No	Name of Station	PLOT NO	AREA	OWNERSHIP	REMARKS
		15-9	2712		

Table 5.10 D: DETAILS OF LAND REQUIRED FOR PARKING

PARKING LAND OF NAGPUR METRO RAIL PROJECT				
EAST - WEST CORRIDOR				
S.No	Station Name	Parking Land (Sqm.)	Ownership	Remarks
1	PRAJAPATI NAGAR	8991.7	Govt.	Open
2	JHANSI RANI SQRE	5403	Govt.	Open
3	DHARAMPETH COLLEGE	1752.6	Govt.	Open
4	RACHANA (RING RD JNC)	5461.7	Pvt.	Open
5	LOKMANYA NAGAR	5346.8	Govt.	Open
	Total	23554.8		
NORTH-SOUTH CORRIDOR				
1	KADVI CHOWK	8237.5	Govt.	Open
2	KASTURCHAND PARK	5752.2	Govt.	Park
3	SITABURDI	6982.7	Govt.	Open
4	RAHATE COLONY	2693.3	Govt.	Field
5	AJNI SQUARE	33733.2	Pvt.	Shops+open
6	CHHATRAPATI SQUARE	8305.8	Govt.	Open
7	JAIPRAKASH NAGAR	17230.4	Govt.	Open
8	UJWAL NAGAR	6781.3	Govt.	Open
9	AIRPORT	4604.5	Govt.	Open
	Total	98828		

Table 5.10E: Abstract of Land Required for Stations and Running Section

LAND REQUIREMENT DETAILS				
NAGPUR METRO RAIL PROJECT				
LAND DETAILS	EAST-WEST CORRIDOR PRAJAPATI NAGAR TO LOKMANYA NAGAR		NORTH-SOUTH CORRIDOR AUTOMATIVE SQUARE TO KHAPRI DEPOT	
	GOVT. LAND (in sqm)	PVT. LAND (in sqm)	GOVT. LAND (in sqm)	PVT. LAND (in sqm)
STATIONS EXIT/ENTRY	3644.80	7786.40	7925.30	10812.50
RUNNING SECTION	3255.30	5280.80	101882.00	16025.00
DEPOT AREA	258973.00		374900.00	
TRAFFIC INTEGRATION/PARKING	8779.10	1445.70	43756.80	5179.20
TOTAL	274652.20	14516.90	502187.10	33017.60
TOTAL GOVT LAND	776819.30	SAY 77.68 HECTARES		
TOTAL PVT LAND	43903.60	SAY 5.2 HECTARES		

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

A large number of officers and staff will be required to be deployed permanently to take care of project implementation and post construction operational activities. Moreover metro office complex and metro operation control centre will also be required. It is proposed to keep the provision of **6.0 ha** of government land for this purpose. Exact location of land has not been identified at this stage. It may be decided at the time of project implementation.

6.8.10 Temporary Construction Depot/office accommodation

During construction period, huge quantities of construction materials like reinforcing bars, cement, steel sections, shutters, pre-cast segments etc. are to be stored and sufficient land is required for storage of these materials. The areas may be identified based on availability as vacant on sites nearer to the corridors. At the time of construction, depending up on the need the location and size can be reassessed and temporary land acquisitions can be made accordingly.

Since the area of land being acquired permanently at most of the stations is bare minimum, the land required for construction depots purpose has been considered throughout the corridor @ 2hect. at every 10 km. These sites will be obtained on lease temporarily for the construction period. After completion of construction, these will be handed over back to the land owning agency. The location of these sites will be finalized with NIT before the commencement of Tendering Work.

6.8.11 Segment Casting Yard

Large numbers of pre-cast segments are required for construction of elevated structures for which a large open area is required for setting up of casting yard. As far as possible, this area should be close to the site, easily accessible and away from habitation. Considering the various factors, it is proposed to setup one yard for both the corridors. It is proposed to setup two segment casting yards one for underground sections and another elevated sections. Provision of **6.0 ha** of land for both the casting yards on temporary basis has been made.

6.9 UTILITY DIVERSIONS

6.9.1 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 parts, there are a number of other engineering issues, which are required to be considered in sufficient details before really deciding on taking up any infrastructure project of such magnitude. Accordingly, following engineering items have been studied and described in this para.

- Existing underground and at surface utilities and planning for their diversion during construction, if necessary.

6.5.2 Utility and Services

The DMRC has collected details of various utilities through topography survey.
Large number of sub-surface, surface and over head utility services viz. sewers, water mains, storm water drains, telephone cables, O.H electrical transmission lines, electric poles, traffic signals, etc. are existing along the proposed alignment. These utility services are essential and have to be maintained in working order during different stages of construction, by temporary/permanent diversions or by supporting in position. Since these may affect construction and project implementation time schedule/costs, for which necessary planning/action needs to be initiated in advance.

Organizations/Departments with concerned utility services in Nagpur are mentioned in **Table 6.11.**

Table 6.11: Utility Responsibility Departments

Sr. No.	ORGANIZATION/DEPARTMENT	UTILITY SERVICES
1.	Nagpur Municipal Corporation (NMC)	Roads, surface water drains, nallahs, Sewerage and drainage conduits, sewerage treatment plants, pumping stations, Water mains and their service lines, including hydrants, water treatment plants, pumping stations, Gardens etc.
2.	NIT	Road construction & maintenance of State highways. Overall co-ordination among all concerned departments.
3.	Water Works, Nagpur Municipal Corporation	Nallahs/flood water drains etc.
4.	MSEDCL	Power cables and their appurtenances H.T. and L.T. lines, their pylons, electric light posts, pole mounted transformers, etc.

Sr. No.	ORGANIZATION/DEPARTMENT	UTILITY SERVICES
5.	Bharat Sanchar Nigam Ltd. (BSNL)	Telecommunication cables, junction boxes, telephone posts, O.H. lines, etc.
6.	Nagpur Traffic Police	Traffic signal posts, junction boxes and cable connections, etc.

Assessment of the type and location of underground utilities running along and across the proposed route alignment at Nagpur will be undertaken with the help of data available with concerned authorities, who generally maintain plans and data of such utility services. Particulars of main utilities i.e. trunk and main sewers/drainage conduits, water mains, OH & UG Electric cable, Telecom cable etc. have been marked on alignment plans.

5.9.2 Diversion of Underground Utilities

While planning for diversion of underground utility services viz. sewer lines, water pipelines, cables, etc., during construction of MRTS alignment, following guidelines have been adopted:

- Utility services have to be kept operational during the entire construction period and after completion of project. All proposals should, therefore, ensure their uninterrupted functioning.
- Sewer lines and water supply lines are mainly affected in underground cut and cover construction. These services are proposed to be maintained by temporarily replacing them with CI/Steel pipelines and supporting them during construction, these will be encased in reinforced cement concrete after completion of construction and retained as permanent lines.
- Where permanent diversion of the affected utility is not found feasible, temporary diversion with CI/Steel pipes without manholes is proposed during construction. After completion of construction, these will be replaced with conventional pipes and manholes.
- The elevated viaduct does not pose much of a difficulty in negotiating the underground utility services, especially those running across the alignment. The utilities infringing at pier location can be easily diverted away from the pile cap location.
- In case a major utility is running along/across the alignment which cannot be diverted or the diversion of which is difficult, time consuming and uneconomical, the spanning arrangement of the viaduct and layout of piles in the foundation may be suitably adjusted to ensure that no foundation needs be constructed at the location, where utility is crossing the proposed alignment. The utility service can also be encased within the foundation piles.

5.3.4 Underground Stretch and Switch Over Ramp

The underground section in both the corridor is for a length of approx 3 km. As indicated in the previous paras due to various reasons, the entire length of underground section is proposed to be constructed with tunneling keeping a minimum cover of about 5m above the tunnel, except at stations which will be constructed by cut and cover method. Hence, the utility services existing in above ground or below ground position are not likely to be affected in underground stretch of the alignment except at station locations. Details of such affected utility services at station locations are indicated in **Table 5.12 to Table 5.17**.

5.3.5 Elevated Stretch

The stretch of both the corridors is elevated and is almost in the center of the road except at few locations as detailed in the Alignment description.

5.3.6 Sewer Lines, Storm Water Drains and Water Lines

The sewer/drainage lines generally exist in the service lanes i.e. away from main carriageway. However, in certain stretches, these fall 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. Details of such utilities is given below.

Table 5.15
List of Affected Water Supply Lines North South Corridor

S. No.	Chainage	Dia (inches)	Description	Diversion Proposal
1	136.424	12	Alignment Crossing the Pipe Line	To be shifted /Diverted
2	444.170 to 2650	24	Alignment Crossing the Pipe Line	To be shifted /Diverted
3	1155.377	3	Alignment Crossing the Pipe Line	To be shifted /Diverted
4	1644.371	16	Alignment Crossing the Pipe Line	To be shifted /Diverted
5	1811.535	8	Alignment Crossing the Pipe Line	To be shifted /Diverted
6	1983.385	4	Alignment Crossing the Pipe Line	To be shifted /Diverted
7	2015.335	4	Alignment Crossing the Pipe Line	To be shifted /Diverted
8	2214.300	10	Alignment Crossing the Pipe Line	To be shifted /Diverted
9	2215.000	12	Alignment Crossing the Pipe Line	To be shifted /Diverted
10	3111.382	10	Alignment Crossing the Pipe Line	To be shifted /Diverted
11	3000 to 3100	24	Alignment Crossing the Pipe Line	To be shifted /Diverted
12	3381.7	30	Alignment Crossing the Pipe Line	To be shifted /Diverted

S. No.	Chainage	Dia (inches)	Description	Diversion Proposal
13	3917.3 to 3943.4	24	Alignment Crossing the Pipe Line	To be shifted/ Diverted
14	4086.8	24	Alignment Crossing the Pipe Line	To be shifted/ Diverted
15	4158.3	12	Alignment Crossing the Pipe Line	To be shifted/ Diverted
16	4462.2	12	Alignment Crossing the Pipe Line	To be shifted/ Diverted
17	4478.3 to 4581.4	24	Alignment Crossing the Pipe Line	To be shifted/ Diverted
18	4650 to 4710	6	Alignment Crossing the Pipe Line	To be shifted/ Diverted
19	5130.8	4	Alignment Crossing the Pipe Line	To be shifted/ Diverted
20	5132.5	21	Alignment Crossing the Pipe Line	To be shifted/ Diverted
21	5550 to 6110	21	Alignment Crossing the Pipe Line	To be shifted/ Diverted
22	5975.2	6	Alignment Crossing the Pipe Line	To be shifted/ Diverted
23	6501.6	10	Alignment Crossing the Pipe Line	To be shifted/ Diverted
24	6601.6	4	Alignment Crossing the Pipe Line	To be shifted/ Diverted
25	6582.4	10	Alignment Crossing the Pipe Line	To be shifted/ Diverted
26	6676.6	10	Alignment Crossing the Pipe Line	To be shifted/ Diverted
27	6742.3	4	Alignment Crossing the Pipe Line	To be shifted/ Diverted
28	6774.9	12	Alignment Crossing the Pipe Line	To be shifted/ Diverted
29	7378.8	6	Alignment Crossing the Pipe Line	To be shifted/ Diverted
30	7378.6	3	Alignment Crossing the Pipe Line	To be shifted/ Diverted
31	7493.3	12	Alignment Crossing the Pipe Line	To be shifted/ Diverted
32	7578.3	2	Alignment Crossing the Pipe Line	To be shifted/ Diverted
33	7848.3	3	Alignment Crossing the Pipe Line	To be shifted/ Diverted
34	7896.4	6	Alignment Crossing the Pipe Line	To be shifted/ Diverted
35	7949.0 to 7997.9	10	Alignment Crossing the Pipe Line	To be shifted/ Diverted
36	8149.2	20	Alignment Crossing the Pipe Line	To be shifted/ Diverted
37	8175.2	8	Alignment Crossing the Pipe Line	To be shifted/ Diverted
38	8572.7	20	Alignment Crossing the Pipe Line	To be shifted/ Diverted
39	8931.8	3	Alignment Crossing the Pipe Line	To be shifted/ Diverted
40	9180.4	8	Alignment Crossing the Pipe Line	To be shifted/ Diverted
41	9245.2	6	Alignment Crossing the Pipe Line	To be shifted/ Diverted
42	10020.7	4	Alignment Crossing the Pipe Line	To be shifted/ Diverted
43	10035.5	12	Alignment Crossing the Pipe Line	To be shifted/ Diverted
44	10240.3	8	Alignment Crossing the Pipe Line	To be shifted/ Diverted
45	10567.3	12	Alignment Crossing the Pipe Line	To be shifted/ Diverted

S. No.	Chainage	Dia (inches)	Description	Diversion Proposal
[illegible]	[illegible]	24	Alignment Crossing the Pipe Line	To be shifted /Diverted
[illegible]	[illegible]	[illegible]	Alignment Crossing the Pipe Line	To be shifted /Diverted
[illegible]	[illegible]	31	Alignment Crossing the Pipe Line	To be shifted /Diverted
[illegible]	[illegible]	27	Alignment Crossing the Pipe Line	To be shifted /Diverted
[illegible]	[illegible]	12	Alignment Crossing the Pipe Line	To be shifted /Diverted
[illegible]	[illegible]	4	Alignment Crossing the Pipe Line	To be shifted /Diverted
[illegible]	[illegible]	14	Alignment Crossing the Pipe Line	To be shifted /Diverted
[illegible]	[illegible]	4	Alignment Crossing the Pipe Line	To be shifted /Diverted
[illegible]	[illegible]	4	Alignment Crossing the Pipe Line	To be shifted /Diverted
[illegible]	[illegible]	14	Alignment Crossing the Pipe Line	To be shifted /Diverted
[illegible]	[illegible]	[illegible]	Alignment Crossing the Pipe Line	To be shifted /Diverted
[illegible]	[illegible] To [illegible]	[illegible]	Alignment Crossing the Pipe Line	To be shifted /Diverted
[illegible]	[illegible]	6	Alignment Crossing the Pipe Line	To be shifted /Diverted

Table 6.12

List of Affected Water Supply Lines on East West Corridor

S.No.	Chainage	Dia (inches)	Description	Diversion Proposal
1	230.1	8	Alignment Crossing the Pipe Line	To be shifted /Diverted
2	295.1	28	Alignment Crossing the Pipe Line	To be shifted /Diverted
3	435.0	8	Alignment Crossing the Pipe Line	To be shifted /Diverted
4	551.8	6	Alignment Crossing the Pipe Line	To be shifted /Diverted
5	1086.4	38	Alignment Crossing the Pipe Line	To be shifted /Diverted
6	1087.7	4	Alignment Crossing the Pipe Line	To be shifted /Diverted
7	1102.1	4	Alignment Crossing the Pipe Line	To be shifted /Diverted
8	1131.6	6	Alignment Crossing the Pipe Line	To be shifted /Diverted
9	1408.3	12	Alignment Crossing the Pipe Line	To be shifted /Diverted
10	1486.3	8	Alignment Crossing the Pipe Line	To be shifted /Diverted
11	2462.8	12	Alignment Crossing the Pipe Line	To be shifted /Diverted
12	2815.3	24	Alignment Crossing the Pipe Line	To be shifted /Diverted
13	2965.4	28	Alignment Crossing the Pipe Line	To be shifted /Diverted
14	2986.8	12	Alignment Crossing the Pipe Line	To be shifted /Diverted
15	3520.7	18	Alignment Crossing the Pipe Line	To be shifted /Diverted

S.No.	Chainage	Dia	Description	Diversion Proposal
16	3502.0	15	Alignment Crossing the Pipe Line	To be shifted /Diverted
17	3563.7	6	Alignment Crossing the Pipe Line	To be shifted /Diverted
18	3782.1	8	Alignment Crossing the Pipe Line	To be shifted /Diverted
19	4029.0	5	Alignment Crossing the Pipe Line	To be shifted /Diverted
20	4085.1	18	Alignment Crossing the Pipe Line	To be shifted /Diverted
21	4087.8	6	Alignment Crossing the Pipe Line	To be shifted /Diverted
22	4133.7	4	Alignment Crossing the Pipe Line	To be shifted /Diverted
23	4787.8	6	Alignment Crossing the Pipe Line	To be shifted /Diverted
24	4461.3	4	Alignment Crossing the Pipe Line	To be shifted /Diverted
25	4662.0	12	Alignment Crossing the Pipe Line	To be shifted /Diverted
26	4926.8	4	Alignment Crossing the Pipe Line	To be shifted /Diverted
27	5055.8	24	Alignment Crossing the Pipe Line	To be shifted /Diverted
28	5321.4	6	Alignment Crossing the Pipe Line	To be shifted /Diverted
29	5461.1	12	Alignment Crossing the Pipe Line	To be shifted /Diverted
30	5567.3	10	Alignment Crossing the Pipe Line	To be shifted /Diverted
31	5758.4	7	Alignment Crossing the Pipe Line	To be shifted /Diverted
32	5767.7 to 5878.2	24	Alignment Crossing the Pipe Line	To be shifted /Diverted
33	5980.1	15	Alignment Crossing the Pipe Line	To be shifted /Diverted
34	6067.8	6	Alignment Crossing the Pipe Line	To be shifted /Diverted
35	6082.3	15	Alignment Crossing the Pipe Line	To be shifted /Diverted
36	6096.4	6	Alignment Crossing the Pipe Line	To be shifted /Diverted
37	6502.4 to 6505.5	15,12 & 6	Alignment Crossing the Pipe Line	To be shifted /Diverted
38	6534.5 to 6684.1	4	Alignment Crossing the Pipe Line	To be shifted /Diverted
39	7033.8	4	Alignment Crossing the Pipe Line	To be shifted /Diverted
40	7086.8	6	Alignment Crossing the Pipe Line	To be shifted /Diverted
41	7076.5 to 7264.1	12 & 5	Alignment Crossing the Pipe Line	To be shifted /Diverted
42	7711.2	6	Alignment Crossing the Pipe Line	To be shifted /Diverted
43	7793.3	6	Alignment Crossing the Pipe Line	To be shifted /Diverted
44	7103 to 7108	12 & 15	Alignment Crossing the Pipe Line	To be shifted /Diverted
45	8766.2	3	Alignment Crossing the Pipe Line	To be shifted /Diverted
46	9289.3	5	Alignment Crossing the Pipe Line	To be shifted /Diverted
47	9599.4	6	Alignment Crossing the Pipe Line	To be shifted /Diverted
48	10112.8	8	Alignment Crossing the Pipe Line	To be shifted /Diverted
49	10146.8 to 10186.3	24 & 36	Alignment Crossing the Pipe Line	To be shifted /Diverted

S.No.	Chainage	Dia	Description	Diversion Proposal
50	113543	28	Alignment Crossing the Pipe Line	To be shifted /Diverted
51	11457.2	6	Alignment Crossing the Pipe Line	To be shifted /Diverted
52	117683.2	10	Alignment Crossing the Pipe Line	To be shifted /Diverted
53	12201.8	27	Alignment Crossing the Pipe Line	To be shifted /Diverted
54	12423.1	27	Alignment Crossing the Pipe Line	To be shifted /Diverted
55	13334.3	4	Alignment Crossing the Pipe Line	To be shifted /Diverted
56	13802.5	8	Alignment Crossing the Pipe Line	To be shifted /Diverted
57	14272.7	6	Alignment Crossing the Pipe Line	To be shifted /Diverted
58	14395.1	10	Alignment Crossing the Pipe Line	To be shifted /Diverted
59	14973.9	6	Alignment Crossing the Pipe Line	To be shifted /Diverted

Table 5.14: List of Affected H.T. Line on North – South Corridor

S. No.	Chainage (m)	Description	Diversion Proposal	Remarks
1	117.224	H.T. Line	To be shifted /Diverted	Across the alignment
2	1393.655	H.T. Line	To be shifted /Diverted	Across the alignment
3	1807.176	H.T. Line	To be shifted /Diverted	Across the alignment
4	3445.134	H.T. Line	To be shifted /Diverted	Across the alignment
5	4773.475	H.T. Line	To be shifted /Diverted	Across the alignment
6	5593.203 to 6723.776	H.T. Line	To be shifted /Diverted	Along the alignment
7	8242.548	H.T. Line	To be shifted /Diverted	Across the alignment
8	8813.576	H.T. Line	To be shifted /Diverted	Across the alignment
9	9175.838	H.T. Line	To be shifted /Diverted	Across the alignment
10	9853.768	H.T. Line	To be shifted /Diverted	Across the alignment
11	10115.265	H.T. Line	To be shifted /Diverted	Across the alignment
12	10320.875	H.T. Line	To be shifted /Diverted	Across the alignment
13	10985.930	H.T. Line	To be shifted /Diverted	Across the alignment
14	11042.330	H.T. Line	To be shifted /Diverted	Across the alignment
15	11070.389	H.T. Line	To be shifted /Diverted	Across the alignment
16	11123.420	H.T. Line	To be shifted /Diverted	Across the alignment
17	11428.930	H.T. Line	To be shifted /Diverted	Across the alignment
18	11465.337	H.T. Line	To be shifted /Diverted	Across the alignment
19	11854.383	H.T. Line	To be shifted /Diverted	Across the alignment

S. No.	Chainage (m)	Description	Diversion Proposal	Remarks
20	[illegible]	H.T. Line	To be shifted /Diverted	Across the alignment
21	[illegible]	H.T. Line	To be shifted /Diverted	Across the alignment
22	[illegible]	H.T. Line	To be shifted /Diverted	Across the alignment
23	[illegible]	H.T. Line	To be shifted /Diverted	Across the alignment
24	[illegible]	H.T. Line	To be shifted /Diverted	Across the alignment
25	[illegible]	H.T. Line	To be shifted /Diverted	Across the alignment
26	[illegible]	H.T. Line	To be shifted /Diverted	Across the alignment

Table [illegible]: List of Affected H.T. Poles on North – South Corridor

S. No.	Chainage (m)	Description	Nos.	Remarks
1	[illegible]	HT Line pole	1	To be shifted /Diverted
2	[illegible]	HT Line pole	1	To be shifted /Diverted
3	[illegible]	HT Line pole	1	To be shifted /Diverted
4	[illegible]	HT Line pole	1	To be shifted /Diverted
5	[illegible]	HT Line pole	1	To be shifted /Diverted
6	[illegible]	HT Line pole	1	To be shifted /Diverted
7	[illegible]	HT Line pole	2	To be shifted /Diverted
8	[illegible]	HT Line pole	1	To be shifted /Diverted
TOTAL			9	

Table [illegible]: List of Affected H.T. Line East West Corridor

S.No.	Chainage (m)	Description	Diversion Proposal	Remarks
1	[illegible] to [illegible]	H.T. Line	To be shifted /Diverted	Along the alignment
2	[illegible]	H.T. Line	To be shifted /Diverted	Across the alignment
3	[illegible]	H.T. Line	To be shifted /Diverted	Across the alignment
4	[illegible]	H.T. Line	To be shifted /Diverted	Across the alignment
5	[illegible]	H.T. Line	To be shifted /Diverted	Across the alignment
6	[illegible]	H.T. Line	To be shifted /Diverted	Across the alignment
7	[illegible]	H.T. Line	To be shifted /Diverted	Across the alignment
8	[illegible]	H.T. Line	To be shifted /Diverted	Across the alignment
9	[illegible]	H.T. Line	To be shifted /Diverted	Across the alignment

S.No.	Chainage (m)	Description	Diversion Proposal	Remarks
10	1201.523	H.T.Line	To be shifted /Diverted	Across the alignment
11	1547.307	H.T.Line	To be shifted /Diverted	Across the alignment
12	1561.701	H.T.Line	To be shifted /Diverted	Across the alignment
13	1757.588	H.T.Line	To be shifted /Diverted	Across the alignment
14	1793.575	H.T.Line	To be shifted /Diverted	Across the alignment
15	7814.073	H.T.Line	To be shifted /Diverted	Across the alignment
16	10126.008	H.T.Line	To be shifted /Diverted	Across the alignment
17	11103.141	H.T.Line	To be shifted /Diverted	Across the alignment
18	12199.371	H.T.Line	To be shifted /Diverted	Across the alignment
19	13070.542	H.T.Line	To be shifted /Diverted	Across the alignment
20	14319.303	H.T.Line	To be shifted /Diverted	Across the alignment
21	15580.202	H.T.Line	To be shifted /Diverted	Across the alignment
22	16208.568	H.T.Line	To be shifted /Diverted	Across the alignment
23	16546.141	H.T.Line	To be shifted /Diverted	Across the alignment
24	16920.882	H.T.Line	To be shifted /Diverted	Across the alignment

Table 5.17: List of Affected H.T. Line Poles East West Corridor

S.No.	Chainage (m)	Description	NOs.	Remarks
1	6754.178	HT Line Pole	1	To be shifted /Diverted
2	2828.077	HT Line Pole	1	To be shifted /Diverted
3	8703.985	HT Line Pole	1	To be shifted /Diverted
4	9380.073	HT Line Pole	1	To be shifted /Diverted
5	1391.255	HT Line Pole	1	To be shifted /Diverted
6	11565.204	HT Line Pole	3	To be shifted /Diverted
7	11726.948	HT Line Pole	4	To be shifted /Diverted
TOTAL			12	To be shifted /Diverted

Apart from this some other ground utilities, interfering with the proposed alignments, namely street light poles, traffic signal posts, telecommunication posts, junction boxes, etc. are also required to be shifted and relocated suitably during construction of elevated viaduct.

Figure 5.1

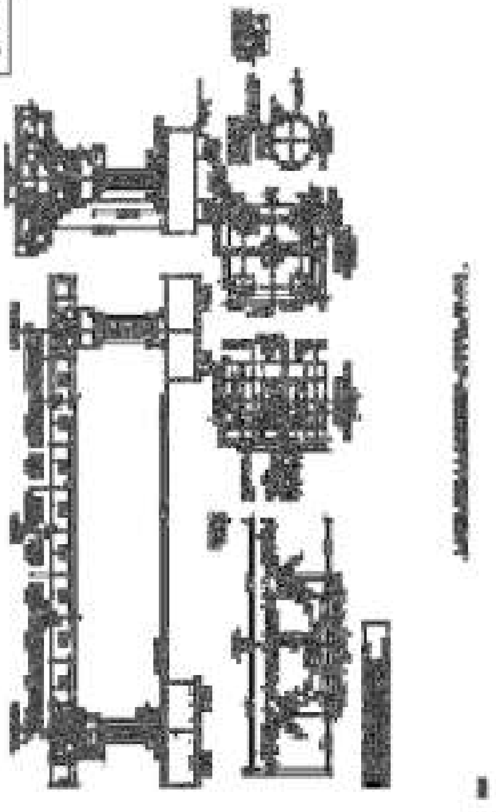
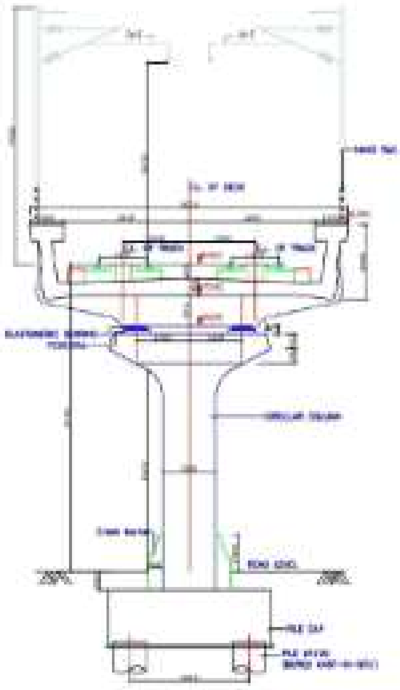
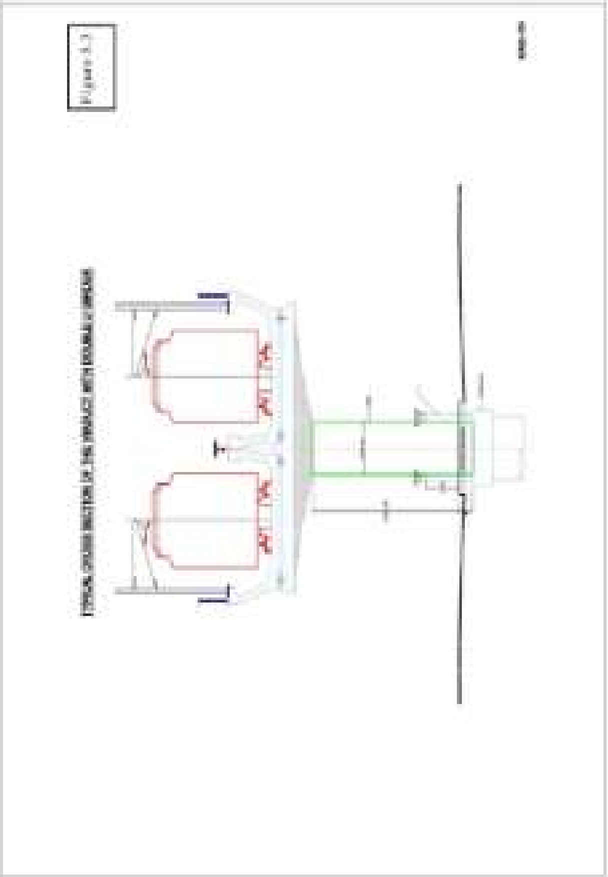


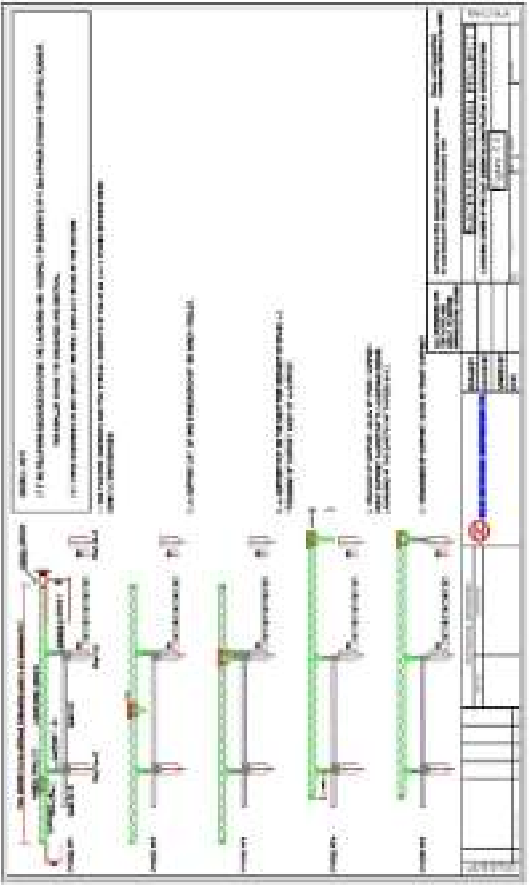
Figure 5.2

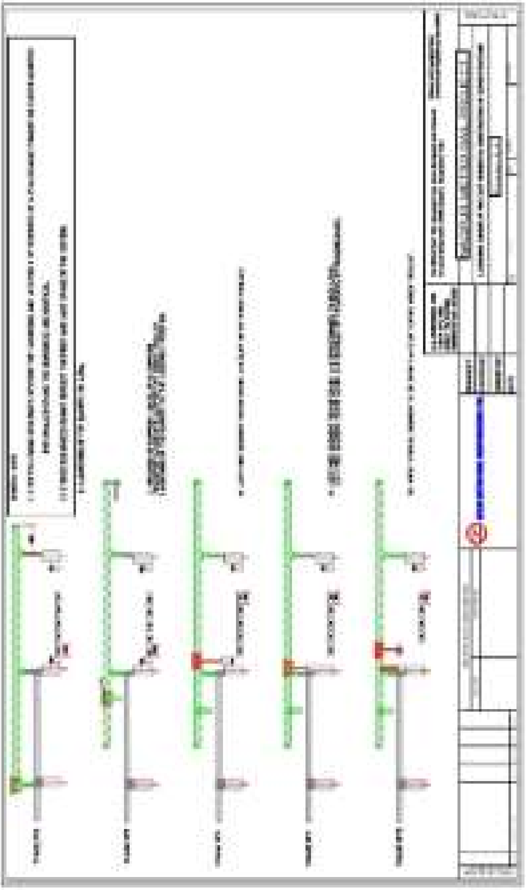
VIADUCT WITH 25 Kv. O H E

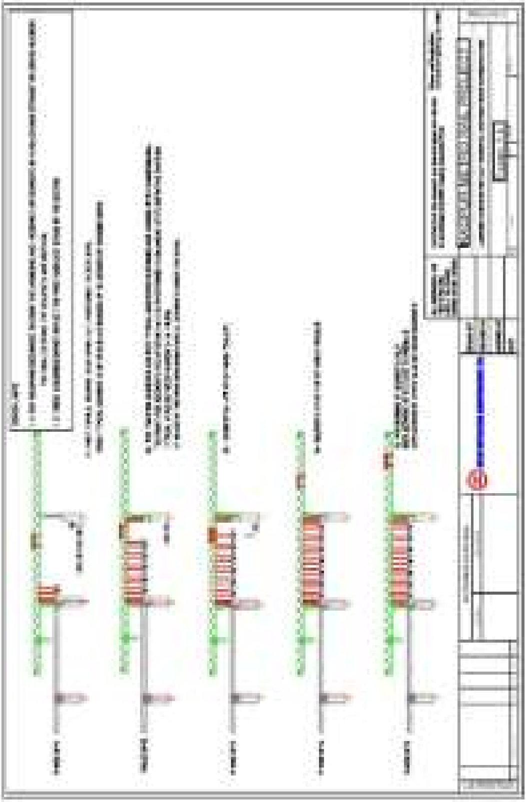


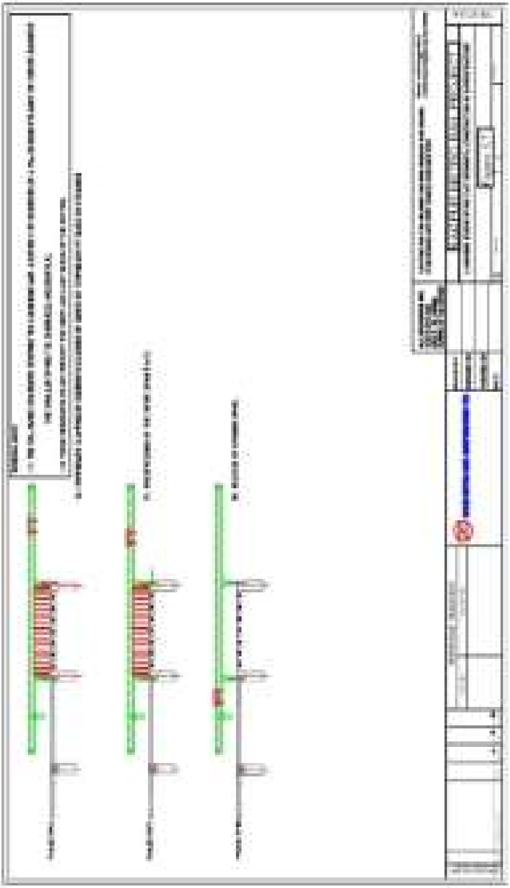
TYPICAL SECTION OF VIADUCT WITH U GIRDER

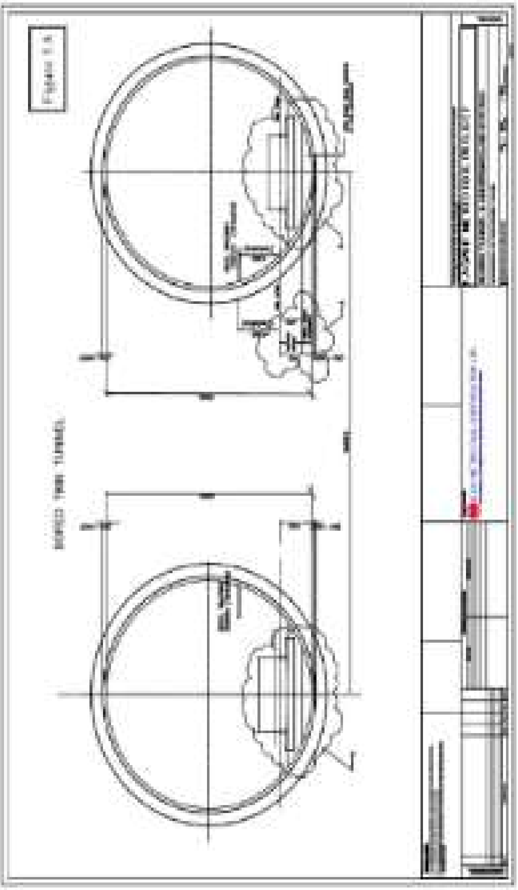


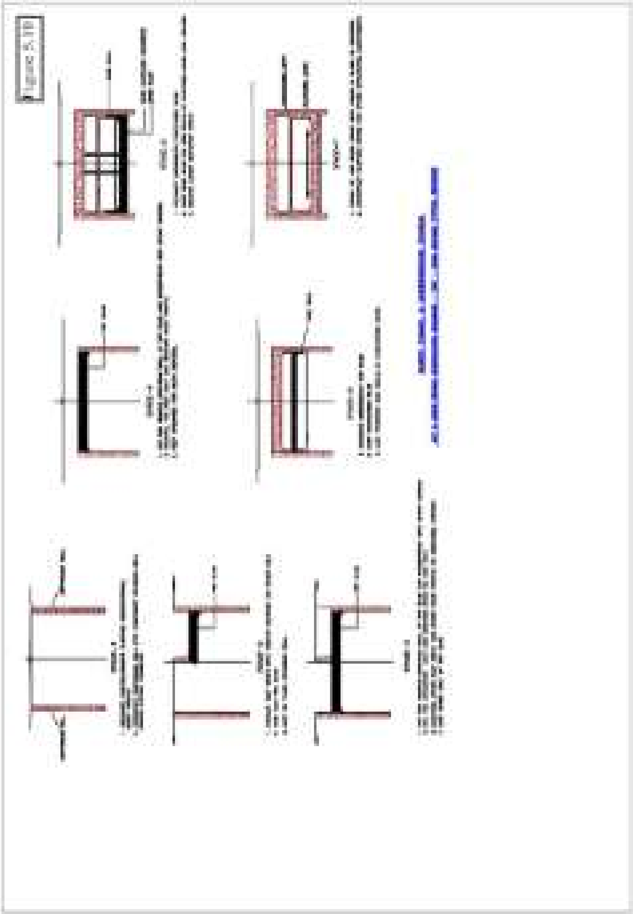


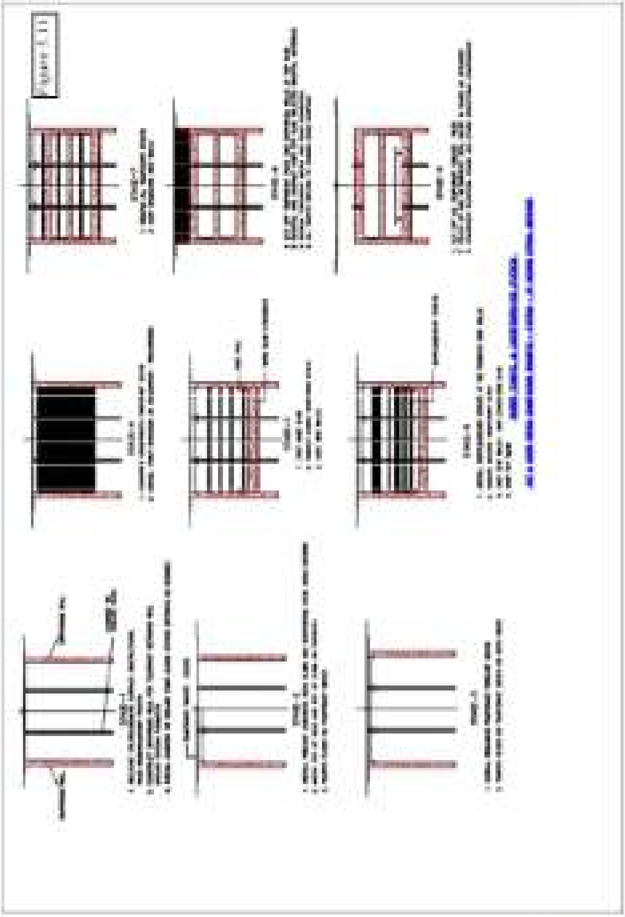


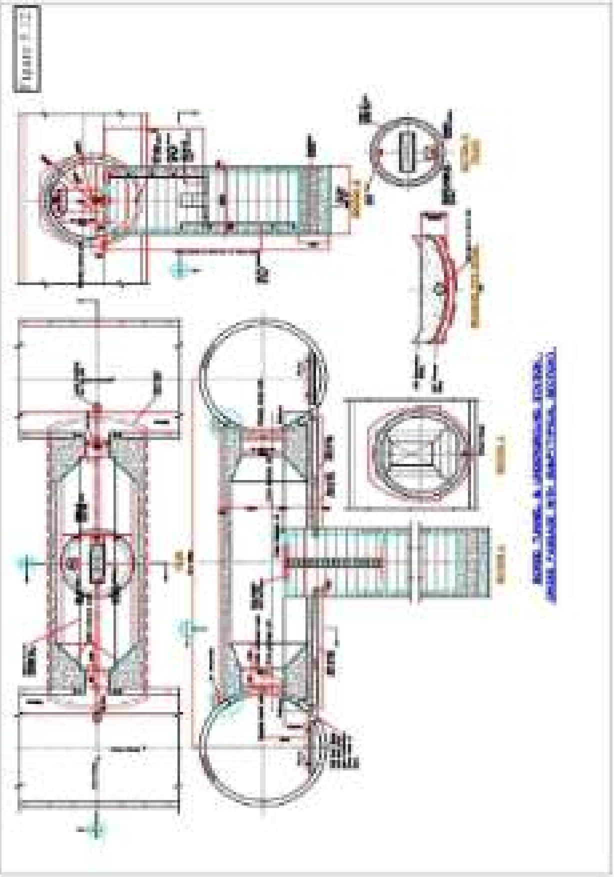


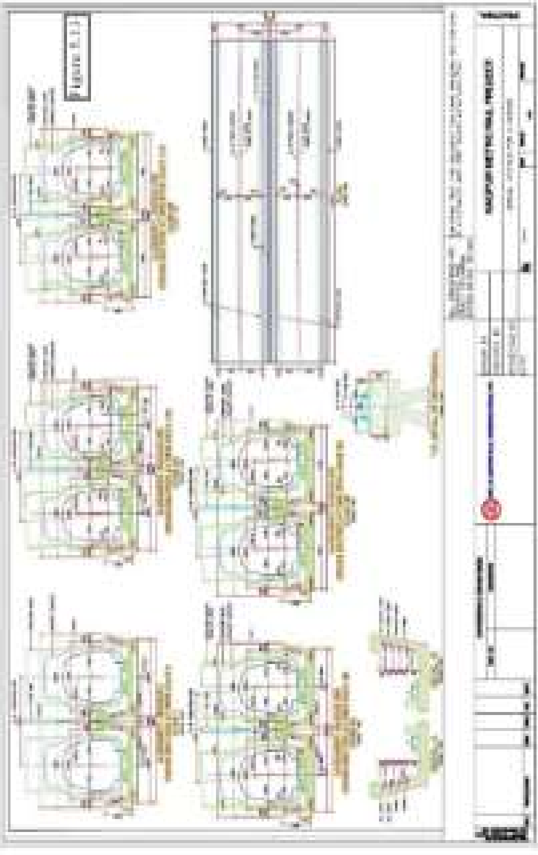


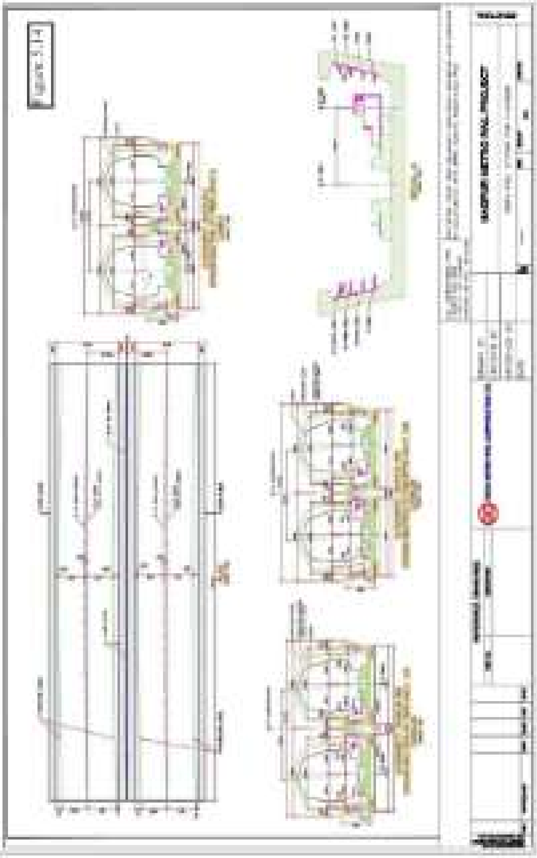

BORED TWIN TUNNEL

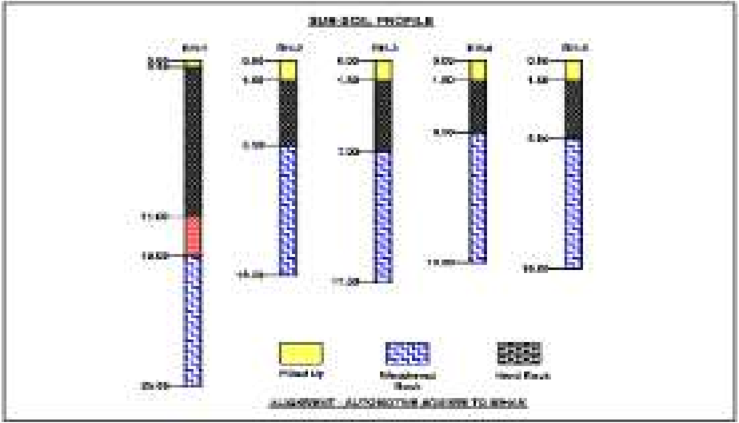


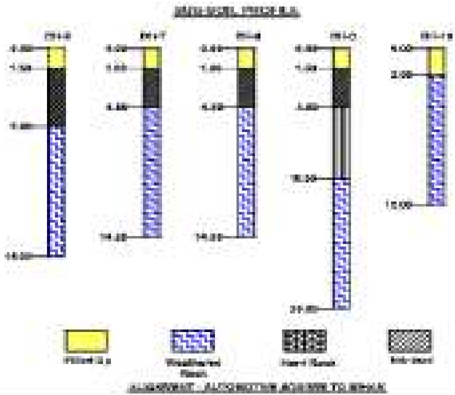


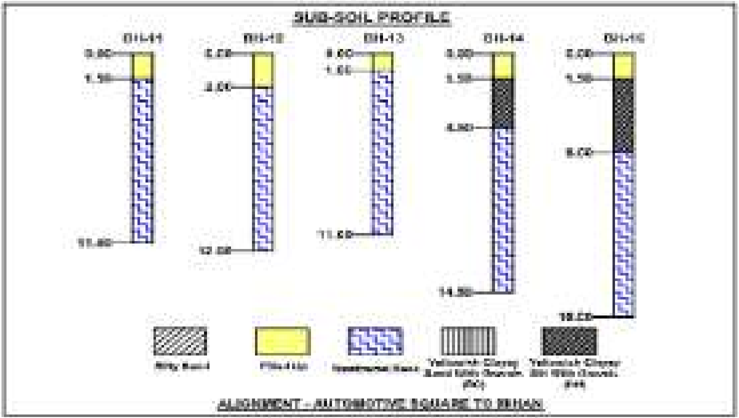


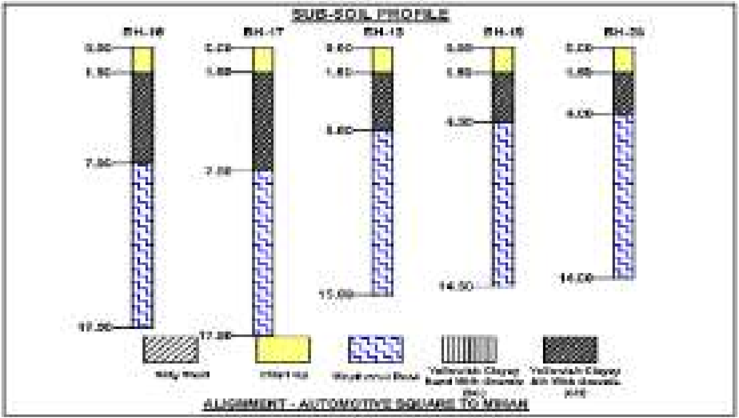





SUB-SOIL PROFILE
Filled Up
Weathered Rock
Hard Rock




SUB-SOIL PROFILE



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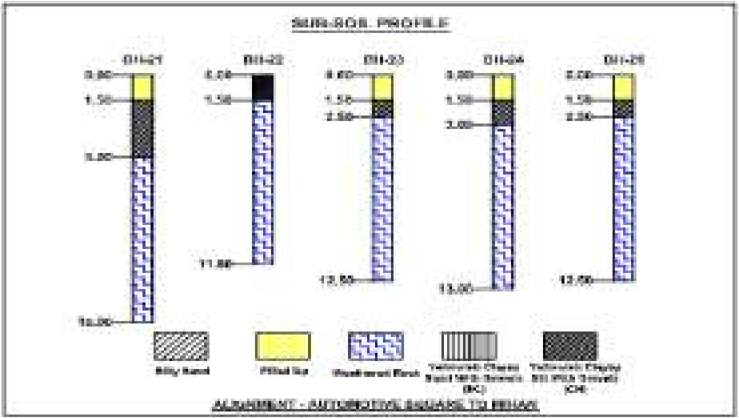
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BH-22
BH-23
BH-24
BH-25
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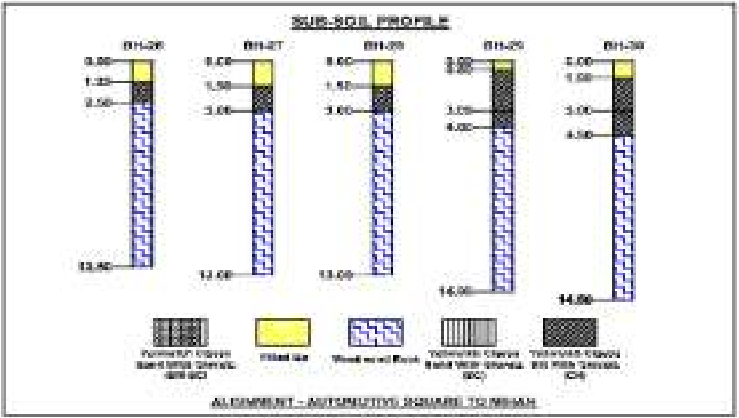
Filled Up
Weathered Rock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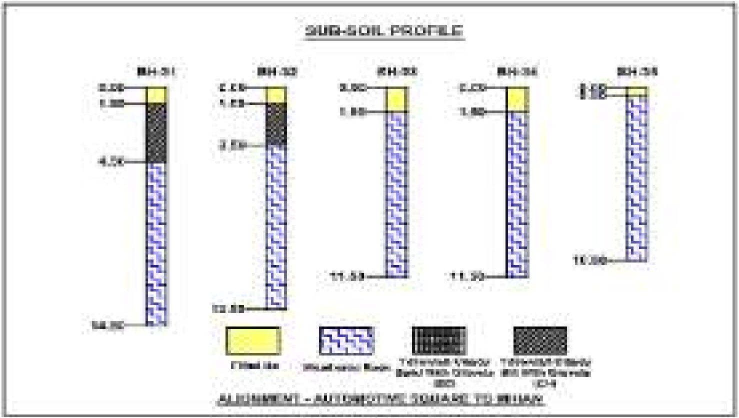
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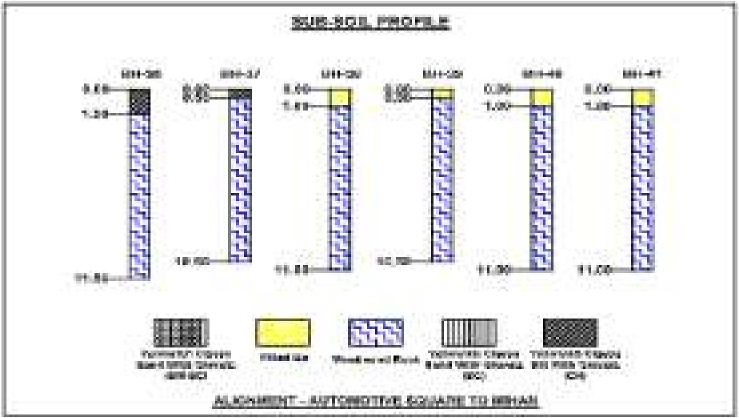
BH-32
BH-33
BH-34
BH-35



SUB-SOIL PROFILE
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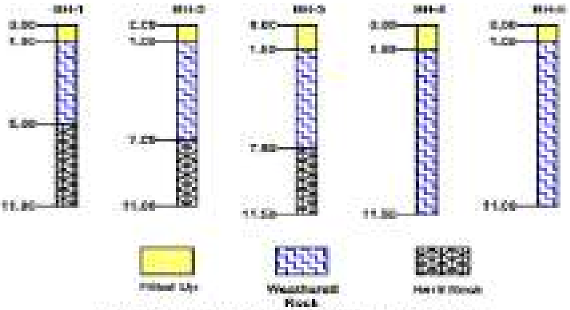
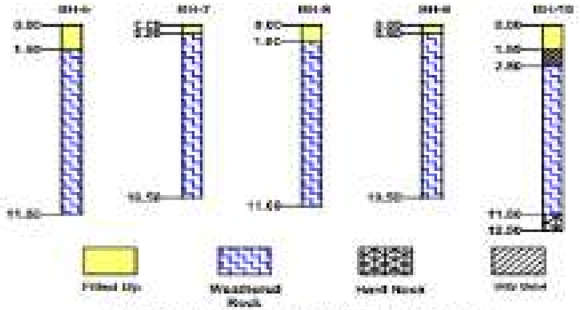
11.00
ALIGNMENT - AUTOMOTIVE SQUARE TO MIHAN

SUB-SOIL PROFILE



ALIGNMENT - LOKMANYA NAGAR TO PRAJAPATI NAGAR

SUB-SOIL PROFILE



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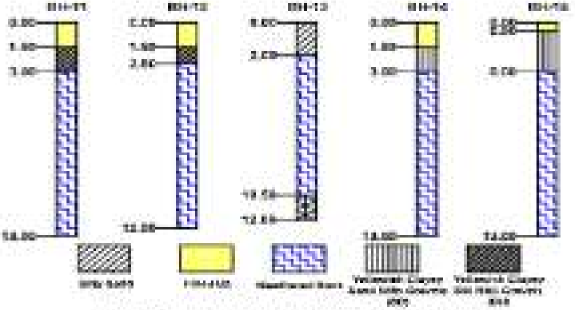
SUB-SOIL PROFILE



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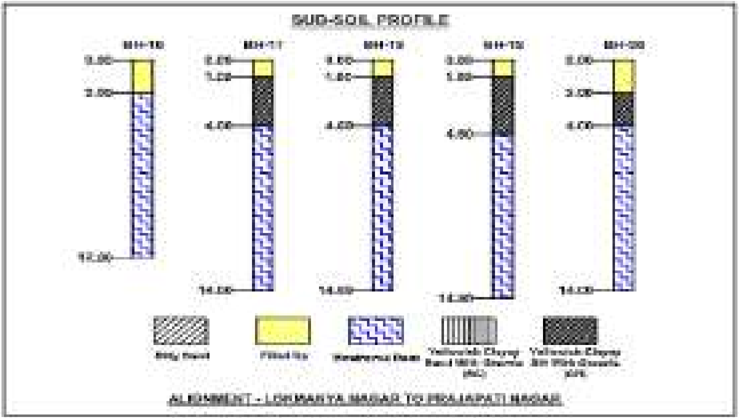
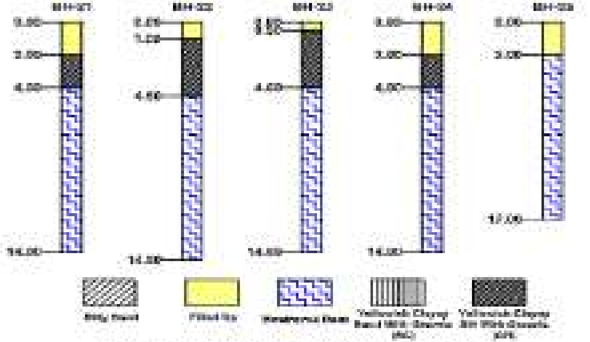

SUB-SOIL PROFILE

SUB-SOIL PROFILE



ALIGNMENT - LOKMANYA NAGAR TO PRAJAPATI NAGAR

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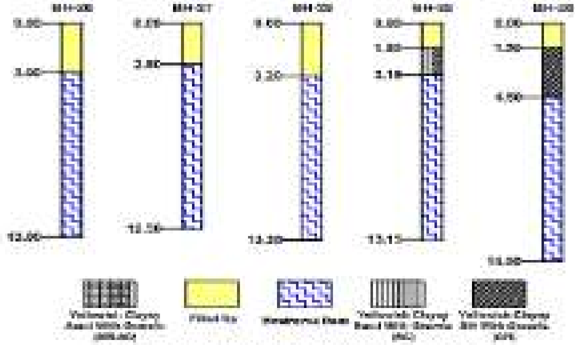
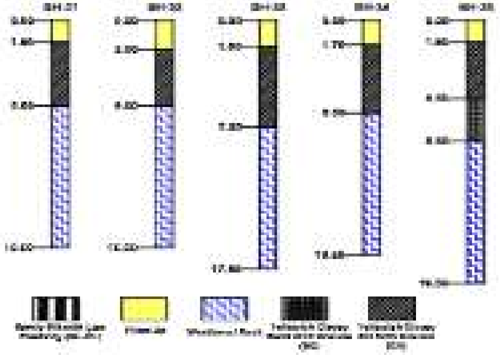


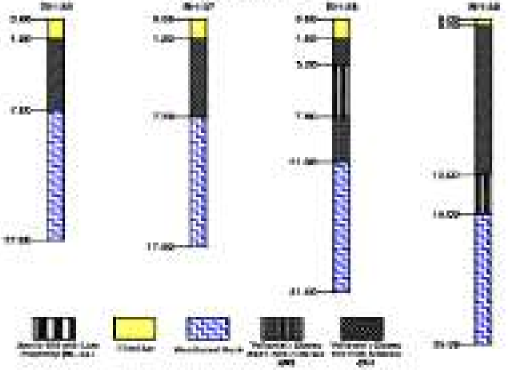
ALIGNMENT - LOKMANYA NAGAR TO PRAJAPATI NAGAR

SUB-SOIL PROFILE



ALIGNMENT - LOKMANYA NAGAR TO PRAJAPATI NAGAR

SUB-SOIL PROFILE



CHAPTER 6

STATION PLANNING

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FIGURE 6.34 SITE CONDITIONS- PANDIT NAGAR
FIGURE 6.35 SITE CONDITIONS- SANGI NAGAR
FIGURE 6.36 SITE CONDITIONS- LOKMANYA NAGAR

Chapter - 6

STATION PLANNING

6.1 General

The proposed metro for Nagpur consists of two corridors namely:

1. North-South Corridor : Automotive Square to Khapri
2. East-West Corridor : Prajapati Nagar to Lokmanya Nagar

The length of the proposed N-S corridor is 19.658km and that of E-W corridor is 18.557km from end to end. Along the proposed North-South corridor 17 stations have been planned. 19 stations have been planned along the East-West corridor. The locations of the station have been identified taking into consideration the constraints in land acquisition and congestion issues. Stations are proposed in such a way so as to attract maximum demand from the traffic nodal points.

6.2 Station Planning

6.2.1 Stations

Line – 1 starts at Automotive square an runs southwards on NH-7 through Kari Road, Indora chowk, Gaddi Godam Square, Kasturchand Park, Zero Mile, Sitabuldi, Congress Nagar, Rahate colony, Ajni Sqr. Station, Chhatrapati Sqr. Station, Jaiprakash Nagar, Airport, New Airport to Khapri Station. The Corridor is partly elevated and partly at grade.

Total Length of the corridor is 19.658 Km of which approximately 15.058 is elevated and 4.6 km is at Grade. There are 17 stations on this corridor of which 15 stations are elevated and 2 stations are at Grade. Sitabuldi Station is an Interchange station.

Line -2 starts at Prajapati Nagar and runs through Vaishnodevi Chowk, Ambedkar Chowk, Telephone Exchange, Chittar Oli Chowk, Agarsen Chowk, Dosar Vaisya Chowk, Nagpur Railway Station, Sitabuldi, Jhansi Rani Square, Institute of Engineers, Shankar Nagar Square, Lad chowk, Dharampeth College, Subhash Nagar, Rachna (Ring road Junction), Vasudev Nagar, Bansi Nagar to Lokmanya Nagar. The entire corridor is elevated.

The total length of the corridor is 18.557 kilometer. There are 19 stations on this corridor. All stations are elevated stations and Sitabuldi station is an Interchange Station.

6.2.2 Rail Levels and Alignment

In underground sections, the rail level is about 18.00 m below the ground level governed by a ground clearance of 2 m. and a station box of about 16 m depth. In the elevated section, rail level is generally about 13.00 m above ground in order to maintain a clearance of 5.50 m between the road and the station structure. In order to keep the land acquisition to minimum, alignment is planned generally in middle of the road and a two level station design has been proposed in both elevated and underground sections. Entry/exit structures to the proposed stations and traffic integration areas have been planned in the open space available.

6.2.3 Platforms

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

6.2.4 Sequence of Stations

The sequence of stations along with their respective chainages, site and platform characteristics are presented in the Table 6.1.

Table 6.1
STATION LOCATION CHARACTERISTICS

	Name of Station	Chainage (in m)	Distance from previous station (in m)	Rail level (in m)	Platform type	Alignment
Line -1 (North-South Corridor) Automotive Square to MIHAN Depot						
	Dead End	-409.2				
1.	AUTOMOTIVE SQRE	0.0	409.2	303.000	Side	
2.	NARI ROAD	975.8	975.8	308.900	Side	Elevated
3.	INDORA CHOWK	2139.7	1163.9	314.100	Side	Elevated
4.	KADVI CHOWK	3181.2	1041.5	318.400	Side	Elevated
5.	GADDI GODAM SQRE	4399.0	1217.8	323.200	Side	Elevated
6.	KASTURCHAND PARK	5148.6	749.6	326.300	Side	Elevated
7.	ZERO MILE	6175.3	1026.7	315.000	Side	Elevated
8.	SITABURDI	6709.2	533.7	310.000	Side	Elevated
9.	CONGRESS NAGAR	7897.2	1188.0	317.300	Side	Elevated
10.	RAHATE COLONY	8682.6	785.4	321.300	Side	Elevated
11.	AJNI SQUARE	10104.7	1422.1	315.300	Side	Elevated
12.	CHHATRAPATI SQUARE	11146.3	1041.6	316.500	Side	Elevated
13.	JAIPRAKASH NAGAR	11811.5	665.2	320.000	Side	Elevated
14.	UJWAL NAGAR	12846.6	1035.1	311.000	Side	Elevated
15.	AIRPORT	13794.9	948.3	313.300	Side	Elevated
16.	NEW AIRPORT	16184.4	2389.5	305.000	Side	At-Grade
17.	KHAPRI	18462.6	2278.2	308.750	Side	At-Grade
	Dead End	19258.0	795.4			

	Name of Station	Chainage (in m)	Distance from previous station (in m)	Rail level (in m)	Platform type	Alignment
Line -2 (East-West Corridor) Prajapati Nagar to Lokmanya Nagar						
	Dead End	-322.5				
1	Prajapati Nagar	0.0	322.5	301.9	Side	Elevated
2	Vaishno Devi Chowk	1220.1	1220.1	309.3	Side	Elevated
3	Ambedkar Chowk	1947.3	1118.8	308.3	Side	Elevated
4	Telephone Exchange	3315.4	1186.4	311.9	Side	Elevated
5	Chittar Oli Chowk	3950.2	912.8	311.5	Side	Elevated
6	Agrasen Chowk	4753.5	808.8	315.5	Side	Elevated
7	Doser Vaisya Chowk	5550.4	808.8	321.9	Side	Elevated
8	Nagpur Railway station	6404.4	874.0	316.7	Side	Elevated
9	Sitabuldi (Interchange)	7707.7	1243.3	320.1	Side	Elevated
10	Jhansi Rani Square	8254.5	546.2	312.9	Side	Elevated
11	Institute Of Engineers	9171.2	783.2	315.4	Side	Elevated
12	Shankar Nagar Square	10044.8	867.7	318.9	Side	Elevated
13	Lad Chowk	10873.1	798.3	310.1	Side	Elevated
14	Dharampeth College	12021.7	1147.8	326.4	Side	Elevated
15	Subhash Nagar	12847.1	826.4	336.3	Side	Elevated
16	Rachna Ring Road Jn.	14201.1	1284.0	336.8	Side	Elevated
17	Vasudev Nagar	15173.8	972.8	345.2	Side	Elevated
18	Bansi Nagar	16131.6	957.7	336.3	Side	Elevated
19	Lokmanya Nagar	17152.5	991.0	335.4	Side	Elevated
	Dead end	18183.3	1024			

6.2 Planning and Design Criteria for Stations

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

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

3. The platform level at elevated stations is determined by a critical clearance of 5.5-m under the concourse above the road intersection, allowing 3.5-m for the concourse height, about 1-m for concourse floor and 2.2-m for structure of tracks above the concourse. Further, the platforms are 1.09-m above the tracks. This would make the rail level in an elevated situation at least 13.4 m above ground.

4. The concourse contains automatic fare collection system in a manner that divides the concourse into distinct areas. The 'unpaid area' is where passengers gain access to the system, obtain travel information and purchase tickets. On passing through the ticket gates, the passenger enters the 'paid area', which includes access to the platforms.

5. The arrangement of the concourse is assessed on a station-by-station basis and is determined by site constraints and passenger access requirements. However, it is planned in such a way that maximum surveillance can be achieved by the ticket hall supervisor over ticket machines, automatic fare collection (AFC) gates, stairs and escalators. Ticket machines and AFC gates are positioned to minimize cross flows of passengers and provide adequate circulation space.

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

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

8. Office accommodation, operational areas and plant room space is required in the non-public areas at each station. The functions of such areas are given below in Table 6.2

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

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

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

12. Following requirements have been taken into account:
   - Minimum capital cost is incurred consistent with maximizing passenger attraction.
   - Minimum operating costs are incurred consistent with maintaining efficiency and the safety of passengers.

- Flexibility of operation including the ability to adapt to different traffic conditions changes in fare collection methods and provision for the continuity of operation during any extended maintenance, repair period, etc.
- Provision of good visibility of platforms, fare collection zones and other areas, thus aiding the supervision of operations and monitoring of efficiency and safety.
- Provision of display of passenger information and advertising.

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

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

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

6.4 Typical Station

6.4.1 Typical Elevated Station

The station is generally located on the road median. Total length of the station is ~140m. All the stations are two-level stations. The concourse is planned along the whole length of the platform with staircases leading from either side of the road. The maximum width of the station at concourse is ~22m. Passenger facilities like ticketing, information, etc as well as operational areas are provided at the concourse level.

Typically, the concourse is divided into public and non-public zones. The non-public zone or the restricted zone contains station operational areas such as Station Control Room, Station Master's Office, Waiting Room, Meeting Room, UPS & Battery Room, Signaling Room, Train Crew Room & Supervisor's Office, Security Room, Station Store Room, Staff Toilets, etc. The public zone is further divided into paid and unpaid areas. Auxiliary Service station is provided on the ground under the entry/ exit structure.

Since the station is in the middle of the road, minimum vertical clearance of 5.5m has been provided under the concourse. Platforms are at a level of about 14.5m from the road. To reduce physical and visual impact of the elevated station, stations have been designed as cantilevered structures with single column located at the central verge of the road.

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

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

6.4.2 Typical At-Grade Station

6.4.3 Typical Interchange Station

The Sitabuldi Station is located at the intersection of the Line-1 and Line-2 of the Nagpur Metro System. The station has an interchange type configuration, and many passengers will change from one line to the other. This interchange will provide great utility and flexibility for the system as a whole, and it will decrease the time required for travel within the city.

The easternmost Line-1 Station is Prajapati Nagar, and the line extends westward through Sitabuldi to Lokmanya Nagar. Line-2 has its northernmost station at Automotive Square, and it connects locations toward the south through the Zero Mile, Sitabuldi, Ajni Sqr., the Airport, and the finally Khapri Station.

Passengers traveling on both lines have the option to change their direction of travel at Sitabuldi, thus requiring larger concourses and platforms in the station for pedestrian movements. In addition to providing interchange connections between Line-1 and Line-2, the station accommodates a busy area of the city next to the Stadium, which will generate large numbers of passengers during special events.

The station is composed of a Concourse Level 8.60 meters above the ground. Above the Concourse is the Line-1 Platform at an elevation of 14.5 meters, and Line-2 Platform passes over Line-1 at the height of 20.5 meters.

Passengers entering Sitabuldi Station may go directly to either Line-1 or Line-2 platform from which they may board a train in any of four directions.

Passengers arriving at the station on a train on either Line-1 or Line-2 may transfer between lines in a direct manner by means of convenient escalators and stairs that lead to trains in the other three directions.

Table 6.2

STATION ACCOMMODATION

For Elevated and at grade Stations	
1. Station Control Room	2. Cleaner's Room
3. Station Master's Office	4. Security Room
5. Information & Enquiries	6. First Aid Room
7. Ticket Office	8. Miscellaneous Operations Room
9. Ticket Hall Supervisor & Excess Fare Collection (Passenger Office)	10. Platform Supervisor's Booth
11. Cash and Ticket Room	12. Auxiliary Substation / DG Room
13. Staff Area	14. Fire Tank and Pump Room
15. Staff Toilets	16. Commercial Outlets and Kiosks
17. Station Store Room	18. UPS and Battery Room
19. Refuse Store	20. Signaling / Communication Room

6.5 Passenger Amenities

Passenger amenities such as ticketing counters/automatic ticket vending machines, ticketing gates, etc. are provided in the concourse. Uniform numbers of these facilities have been provided for system wide uniformity, although the requirement of the facilities actually varies from station to station. The same applies to provision of platform widths and staircase/escalators. Maximum capacity required at any station by the year 2031 for emergency operation has been adopted for all stations.

For this purpose, **peak minute traffic** is assumed to be 2% of the **peak hour traffic**. For checking the adequacy of platform area, stair widths and requirement additional of emergency evacuation stairs, a maximum accumulation of passengers in the station has been considered to be comprising waiting passengers at the platform (including two missed headways) and section load expected to be evacuated at the station in case of an emergency.

6.5.1 Concourse

Concourse forms the interface between street and platforms. In elevated stations, this is contained along the full length of the station. This is where all the passenger amenities are provided. The concourse contains automatic fare collection system in a manner that divides the concourse into distinct **paid** and **unpaid** areas. The '**unpaid area**' is where passengers gain access to the system, obtain travel information and purchase tickets. On passing through the ticket gates, the passenger enters the '**paid area**', which includes access to the platforms.

The concourse is planned in such a way that maximum surveillance can be achieved by the ticket hall supervisor over ticket machines, automatic fare collection (AFC) gates, stairs and escalators. Ticket machines and AFC gates are positioned to minimise cross flows of passengers and provide adequate circulation space. Sufficient space for queuing and passenger flow has been allowed in front of the AFCs.

6.6.2 Ticketing Gates

Ticketing gates' requirement has been calculated taking the gate capacity as 45 persons per minute per gate. Passenger forecast for the horizon year 2031 has been used to compute the maximum design capacity. At least two ticketing gates shall be provided at any station even if the design requirement is satisfied with only one gate. Uniform space has been provided in all stations where gates can be installed as and when required.

6.6.3 Ticket Counters and Ticket Issuing Machines (TIMs)

It is proposed to deploy manual ticket issuing in the beginning of the operation of the line. At a later stage, automatic TIMS would be used for which space provision has been made in the concourse. At present, ticket counters would be provided, which would be replaced with TIMS in future. Capacity of manual ticket vending counters is taken to be 10 passengers per minute and it is assumed that only 40% of the commuters would purchase tickets at the stations while performing the journey. The rest are expected to buy prepaid tickets or prepaid card, etc. Accordingly, the requirement of ticket counters has been calculated and the same provided for in the plans.

6.6.4 Platforms

A uniform platform width of 13 m wide is proposed for the island stations. In elevated stations, 5.5m wide side platforms have been proposed. In interchange station the platform width is kept as 5.0m in order to cater to a large number of interchanging passengers. These platform widths also have been checked for holding capacity of the platform for worst-case scenario.

6.6.5 Stairs, Escalators and Lifts

Provisions have been made for escalators in the paid area i.e. from concourse to platforms. On each platform, one escalator has been proposed. In addition, two staircases with a combined width of 5 m are provided on each platform connecting to the concourse. These stairs and escalator together provide an escape capacity adequate to evacuate maximum accumulated passengers in emergency from platforms to concourse in 5.5 minutes. Lifts have been provided one each on either platform, to provide access for elderly and disabled. Since the rise to road from the concourse is about 8m, it is proposed to provide escalators and lifts in addition to stairs for vertical movement of passengers from street to concourse.

6.5.6 Fire Fighting Measures

Fire fighting provisions for Elevated & at Grade metro stations is in accordance with the National Building Code of India 1983 (part IV, Fire protection) amendment no. 3 under Fire protection Annexure 6.

National Building Code (clause 6.4.6), Fire protection and fire fighting system for metro stations stipulates: -

1) Wet riser system:
   a. Main and diesel pump of 1800 l/min capacity to support 3 to 4 hydrant at a time (station building is split into two halves. It is presumed that fire will not break in the two parts simultaneously. There are 3 hydrants in one part. Therefore pump capacity as above are proposed.
   b. Jockey pump 180 l/min shall also have DG back up.

2) Internal Hydrant:
The internal hydrant is provided with 2 nos RRL hose pipes of 38 mm Ø with 63 mm standard instantaneous coupling along with associated branch pipe and cabinet and a first aid hose reel of 25 mm Ø length 45m fitted with 6.5 mm nozzle. One hydrant each at ground level, passage level and platform level in each half of the station building and so located that every part of station is within 30 m radius.

3) Sprinklers are provided in the property development area only. Additional sprinkler pump is not provided as these are not required being the integral part of the station. The two pumps already provided will take care of sprinkler flow requirements.

4) Detectors are provided in the operational areas only, and above false ceiling if the gap is > 750 mm.

5) One manual call box at each level in each half of the station building is provided.

6) The HT panels, LT panels, main LT distribution board and essential power panels shall be provided with linear heat sensing tubes with CO_2 cylinder.

7) A two way fire brigade inlet at ground level on each rising main for hydrants is provided.

8) Draw off connection is provided on the fire water tank for fire brigade.

9) Water tank of 50,000 liters capacity if permit since commercial development is restricted to 200 Sqm.

10) Portable fire extinguishers (CO_2) a set of two is provided in each of the equipment room.

Summary of passenger amenities required and proposed at stations based on projected traffic for the year 2025 is given in the Table 6.2

Table 6.2

PASSENGER TRAFFIC AND REQUIREMENT OF AMENITIES IN STATIONS (Projections for Year 2041)

Line-I N-S corridor (Automotive Square to Khapri Station)

Station	Peak hour boarding + alighting	Ticketing gates required for each side G-C-A	Lifts (Numbers)	Platform width (m)	Escalators Provided in Each Station G-C	C-P	Provision of Lifts at Each station G-C-P
1. Automotive Square	5274	2 - 2 - 2	2	4.80	2	2	2
2. Nari Road	7815	2 - 2 - 2	2	4.80	2	2	2
3. Indora Chowk	9833	2 - 2 - 2	2	4.80	2	2	2
4. Kadvi Chowk	11710	2 - 2 - 2	2	4.80	2	2	2
5. Gaddi Godam Square	11540	2 - 2 - 2	2	4.80	2	2	2
6. Kasturchand Park	13134	2 - 2 - 2	2	4.80	2	2	2
7. Zero Mile	14572	2 - 2 - 2	2	4.80	2	2	2
8. Sitabuldi	13220	2 - 2 - 2	2	4.80	2	0	2
9. Congress Nagar	9877	2 - 2 - 2	2	4.80	2	2	2
10. Rahate Colony	7643	2 - 2 - 2	2	4.80	2	2	2
11. NEERI Station	6595	2 - 2 - 2	2	4.80	2	2	2
12. Dan Nagar	5609	2 - 2 - 2	2	4.80	2	2	2
13. Sahkar Nagar	5373	2 - 2 - 2	2	4.80	2	2	2
14. Old Airport	4624	2 - 2 - 2	2	4.80	2	2	2
15. New Airport	4303	2 - 2 - 2	2	4.80	2	2	2
16. MIHAN City	3962	2 - 2 - 2	2	4.80	2	2	2
17. Khapri Station		2 - 2 - 2	2	4.80	2	2	2

Note: G- Ground/ street level

C- Passage level

A- Platform

*- Interchange station

Line-2 E-W corridor (Prajapati Nagar to Lokmanya Nagar)

Station	[illegible]	Following [illegible] required on each side C-A-E	[illegible]	[illegible]	Each lane Provided to Each Station		Provision of Lifts in Each Station
					U.C	U.F	1.2.4
1. Prajapati Nagar	6??	2-2-2	2	0.00	2	2	2
2. Vaishnodevi Chowk	1218	2-2-2	2	0.00	2	2	2
3. Ambedkar Chowk	1513	2-2-2	2	0.00	2	2	2
4. Telephone Exchange	4600	2-2-2	2	0.00	2	2	2
5. Chitar Oli Chowk	6158	2-2-2	2	0.00	2	2	2
6. Agrasen Chowk	7386	2-2-2	2	0.00	2	2	2
7. Doser Vaisya Chowk	8237	2-2-2	2	0.00	2	2	2
8. Nagpur Railway Station	11882	2-2-2	6	0.00	2	2	2
9. Sitaburdi	22064	4-4-4	7	0.00	2	2	2
10. Jhansi Rani Square	6642	4-4-4	3	0.00	2	2	2
11. Institute of Engineers	17526	2-2-2	3	0.00	2	2	2
12. Shankar Nagar Square	5514	2-2-2	2	0.00	2	2	2
13. LAD Chowk	8588	2-2-2	2	0.00	2	2	2
14. Dharampeth College	8207	2-2-2	2	0.00	2	2	2
15. Subhash Nagar	5875	2-2-2	2	0.00	2	2	2
16. Rachna (Ring Road Jn.)	5443	2-2-2	2	0.00	2	2	2
17. Vasudev Nagar	4136	2-2-2	2	0.00	2	2	2
18. Bansi Nagar	2046	2-2-2	2	0.00	2	2	2
19. Lokmanya Nagar		2-2-2	2	0.00	2	2	2

1. Automotive square

Chainage	:	0.00
Inter Station Distance	:	First Station
Rail Level	:	13.11m
Station type	:	Elevated
Entry / Exits	:	On both sides of road
Location	:	The station is proposed on Kamptee road.
Catchment Area		The main source of passengers to this station is the residents of surrounding residential colonies and the industrial areas in.

Figure 6.1: Site Conditions- Automotive square Station

2. Nari Road

Chainage	:	975.86m
Inter Station Distance	:	975.86M
Rail Level	:	12.92 m
Station type	:	Elevated
Entry / Exits	:	On both sides of road
Location	:	The station is proposed on Kamptee road.
Catchment Area		The main source of passengers to this station is the residents of Shinde Nagar, PWS College, and other surrounding residential colonies.

Figure 6.2: Site Conditions- Nari Road Station

5. Indore Chowk

Chainage	:	21135.70m
Inter Station Distance	:	1050.30 m
Rail Level	:	12.50 m
Station type	:	Elevated
Entry / Exits	:	On both sides of road
Location	:	The station is proposed on Kamptee road.
Catchment Area		The main source of passengers to this station is the residents of Indora Nagar, Jharipatka, Kamal Square & surrounding residential colonies.

Figure 6.3: Site Conditions- Indore Chowk Station

4. Kadvi Chowk

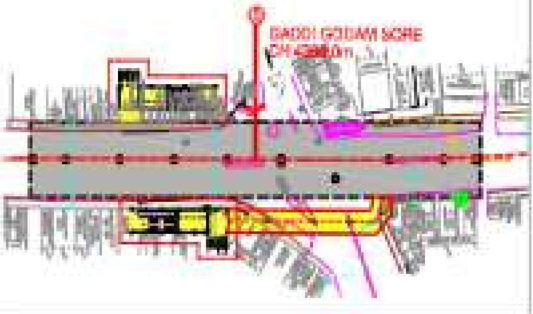
Chainage	:	3191.29 m
Inter Station Distance	:	1061.43 m
Rail Level	:	13.57 m
Station type	:	Elevated
Entry / Exits	:	On both sides of road
Location	:	The station is proposed on NH-44.
Catchment Area		The main source of passengers to this station is the residents of Gautam Nagar, Mohan Nagar, St. Michael School and the residents of the surrounding areas.

Figure 6.4: Site Conditions- Kadvi Chowk Station

6. Gaddi Godam Square

Chainage	:	4000.00 m
Inter Station Distance	:	1217.00 m
Rail Level	:	12.00 m
Station type	:	Elevated
Entry / Exits	:	On both sides of road
Location	:	The station is proposed on NH-44.
Catchment Area		The main source of passengers to this station is the residents of Gautam Nagar, Sadar, and residents of surrounding areas.

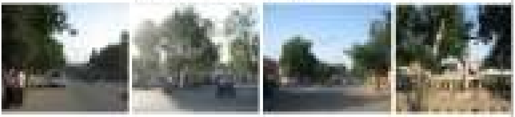
Figure 6.6: Site Conditions- Gaddi Godam Square Station

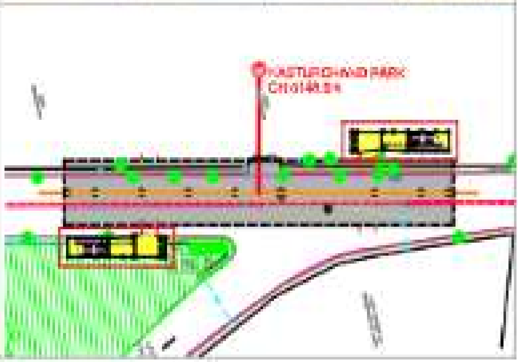


8. Kasturchand Park

Chainage	:	9148.80 m
Inter Station Distance	:	793.60 m
Rail Level	:	12.99 m
Station type	:	Elevated
Entry / Exits	:	On both sides of road
Location	:	The station is proposed on NH-44.
Catchment Area		The main source of passengers to this station is the residents of surrounding areas and people working in NMC office, Reserve Bank Of India, and other Government Offices.

Figure 6.5: Site Conditions- Kasturchand Park Station





7. Zero Mile

Chainage	:	6175.00 m
Inter Station Distance	:	1026.00 m
Rail Level	:	13.30 m
Station type	:	Elevated
Entry / Exits	:	On both sides of road
Location	:	The station is proposed on NH-44
Catchment Area		The main source of passengers to the station is the residents of surrounding areas and people working in NMC office, Reserve Bank Of India, and other Government Offices.

Figure 6.7: Site Conditions- Zero Mile Station

5. Sitaburdi

Chainage	:	9815.80m
Inter Station Distance	:	933.70m
Rail Level	:	12.84M
Station type	:	Elevated
Entry / Exits	:	On both sides of road
Location	:	The station is proposed on the crossing of NH-44 and State Highway No. 255.
Catchment Area		The main source of passengers to this station is the residents of surrounding Commercial and residential areas, People visiting Stadium during special events, interchanging from EW Line to NS line.

Figure 6.5: Site Conditions: Sitaburdi Station

8. Congress Nagar

Chainage	:	7697.20 m
Inter Station Distance	:	1168.00 m
Rail Level	:	12.85 m
Station type	:	Elevated
Entry / Exits	:	On both sides of road
Location	:	The station is proposed on NH-44.
Catchment Area		The main source of passengers to this station is the residents of Congress Nagar and the residents of surrounding residential colonies.

Figure 6.8 Site Conditions- Congress Nagar Station

Line -1 (N-S Corridor)

13. Rahate Colony

Chainage	:	8682.60 m
Inter Station Distance	:	793.40 m
Rail Level	:	13.80 m
Station type	:	Elevated
Entry / Exits	:	On both sides of road
Location	:	The station is proposed on NH-44.
Catchment Area		The main source of passengers to this station is the residents of Rahate Colony and the residents of surrounding residential areas.

Figure 6.10: Site Conditions- Rahate Colony Station

Line -1 (N-S Corridor)

11. Ajni Square

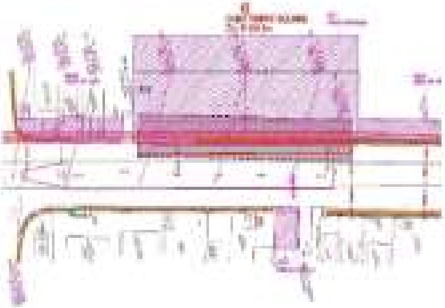
Chainage	:	10104.7 m
Inter Station Distance	:	1422.1 m
Rail Level	:	13.064 m
Station type	:	Elevated
Entry / Exits	:	On both sides of road
Location	:	The station is proposed on NH-44 near NEERI Institute and Central Jail, Nagpur.
Catchment Area		The main source of passengers to this station is the residents & Students of NEERI, Modern School, and people visiting Central Jail Nagpur.

Figure 6.11: Ajni Square Station

12. CHHATRAPATI SQUARE

Chainage	:	11146.3 m
Inter Station Distance	:	1041.0 m
Rail Level	:	14.900 m
Station type	:	Elevated
Entry / Exits	:	On both sides of road
Location	:	The station is proposed on NH-44
Catchment Area		The main source of passengers to this station is the residents of Vivekanand Nagar, Dev Nagar, Sawarkar Nagar and residents of surrounding areas.

Figure 6.12: CHHATRAPATI SQUARE STATION



Line -1 (N-S Corridor)

13. JAIPRAKASH NAGAR

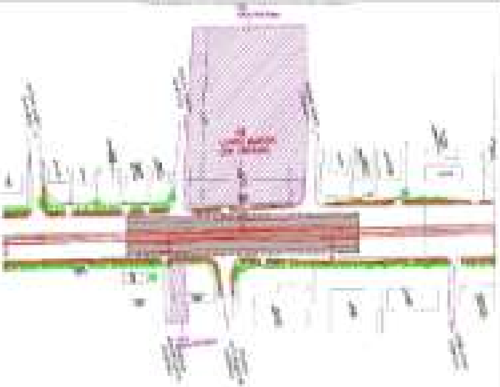
Chainage	:	11611.5 m
Inter Station Distance	:	905.2 m
Rail Level	:	12.577m
Station type	:	Elevated
Entry / Exits	:	On both sides of road
Location	:	The station is proposed on NH-44
Catchment Area		The main source of passengers to the station is the residents of Sahkar Nagar and workers of surrounding industrial units.

Figure 6.13: JAIPRAKASH NAGAR STATION

14. UJJWAL NAGAR

Chainage	:	12646.6 m
Inter Station Distance	:	1035.1 m
Rail Level	:	12.300 m
Station type	:	Elevated
Entry / Exits	:	On both sides of road
Location	:	Fore-court of Nagpur Airport
Catchment Area		The main source of passengers to this station is the passengers and staff of present Airport of Nagpur.

Figure 5.14: UJJAWAL NAGAR STATION



15. Airport Chainage	:	13784.0 m
Inter Station Distance	:	558.3 m
Rail Level	:	13.483 m
Station type	:	Elevated
Entry / Exits	:	On both sides of road.
Location	:	New Airport of Nagpur.
Catchment Area		The main source of passengers to this station is the Passengers and staff of the proposed New Airport of Nagpur.

Figure 6.15: Airport Station

18. NEW AIRPORT

Chainage	:	19,584.4 m
Inter Station Distance	:	2308.5 m
Rail Level	:	2.478 m
Station type	:	Elevated
Entry / Exits	:	On both sides of the road
Location	:	Central Avenue of MIHAN City.
Catchment Area	:	The main source of passengers to this station is the residents of Newly developing MIHAN City and the people visiting MIHAN Commercial/Industrial town

Figure 5.18: New Airport Station

17 Khapri Station

Chainage	:	21065.20 m
Inter Station Distance	:	1535.40 m
Rail Level	:	350.7 m
Station type	:	Elevated
	:	On both sides of road
Location	:	Located on the outskirts of MIHAN city
Catchment Area		The main source of passengers to this station is the residents of

Figure 6.17: Khapri Station

1. Prajapati Nagar

Chainage	:	0.00 m
Inter Station Distance		992.00m
Rail Level	:	12.84 m
Station type	:	Elevated
Entry / Exits	:	On both sides of the road.
Location	:	The station is located on NH-6 across the railway line near Old Pardi Naka.
Catchment Area		The station is proposed in the residential area of Ramanuj Nagar, HB Town, Chandan Nagar, Ram Nagar, Surya Nagar & the residents of the surrounding colonies.

Figure 5.15: Site Conditions: Prajapati Nagar Station

2. Vaishnodevi Chowk

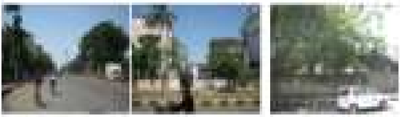
Chainage	:	1225.33 m
Inter Station Distance	:	1220.33 m
Rail Level	:	12.32 m
Station type	:	Elevated
Entry / Exits	:	On both sides of the road.
Location	:	The station is located on NH-6 on Vaishnodevi Chowk near old Bhandra road and Mahal Road.
Catchment Area		Main source of passengers to this station is residents of the Hasan Nagar, Surrounding residential areas and industrial areas.

Figure 6.16: Site Conditions- Vaishnodevi Station

5. Ambedkar Chowk

Chainage	:	1947.50 m
Inter Station Distance	:	718.63 m
Rail Level	:	12.82 m
Station type	:	Elevated
Entry / Exits	:	On both sides of the road.
Location	:	The station is located on NH-6 near Dr. Bhimrao Ambedkar Chowk.
Catchment Area	:	The main source of passengers to this station is the residents of the Sonzari Nagar, Shastri Nagar, Hiwari Nagar and the other surrounding areas.

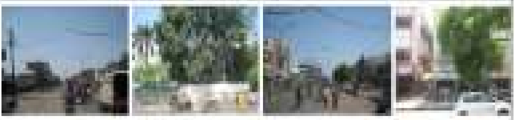
Figure 6.20 Site Conditions- Ambedkar Chowk Station



4. Telephone exchange

Chainage	:	3137.40 m
Inter Station Distance	:	1185.30 m
Rail Level	:	12.84 m
Station type	:	Elevated
Entry / Exits	:	On both sides of road.
Location	:	The station is located on NH-6 opposite Telephone exchange, Nagpur.
Catchment Area		The main source of passengers to this station is the residents of Mangal Wari, Bongi Pura, Jagnath Square, and surrounding residential & commercial areas.

Figure 6.21: Site Conditions- Telephone Exchange Station



5. Chitar Oli Chowk (Gandhi Putala)

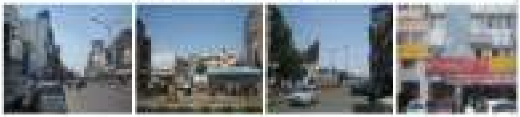
Chainage	:	3945.70 m
Inter Station Distance	:	812.30 m
Rail Level	:	12.30 m
Station type	:	Elevated
Entry / Exits	:	On both sides of road.
Location	:	The station is located on NH-[illegible] near Chitar Oli Chowk.
Catchment Area		The main source of passengers to this station is the residents of [illegible] Market, [illegible] Square, nearby Apartments and the residents of the surrounding areas.

Figure 6.22: Site Conditions - Chitar Oli Chowk Station

6. Agrasen Chowk

Chainage	:	4759.20 m
Inter Station Distance	:	800.50 m
Rail Level	:	12.60 m
Station type	:	Elevated
Entry / Exits	:	On both sides of road.
Location	:	The station is located on NH-6 near Agrasen Chowk.
Catchment Area		The main source of passengers to this station is the residents of Gandhi Bagh, Jaistpura, Hansapuri, Bhaldarpura and the residents of the surrounding residential areas.

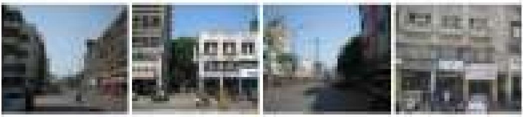
Figure 6.23: Site Conditions- Agrasen Chowk Station

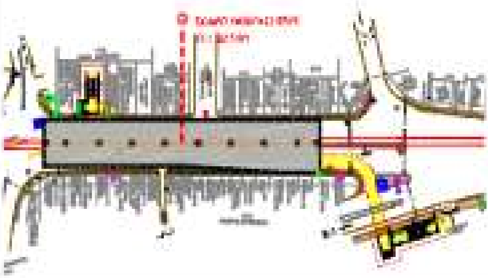


7. Dosar Vaisya Chowk

Chainage	:	9611.00 m
Inter Station Distance	:	951.80 m
Rail Level	:	12.00 m
Station type	:	Elevated
Entry / Exits	:	On both sides of road.
Location	:	The proposed station is located on NH-6 near Masjid Gorit Nawaj.
Catchment Area		The station is supposed to cater the people visiting the mosque, the Medical College hostel and the Orange Market and the residential areas located in the surroundings.

Figure 6.24: Site Conditions- Vaisya Chowk Station





5. Nagpur Railway Station

Chainage	:	9464.40 m
Inter Station Distance	:	953.40 m
Rail Level	:	12.07 m
Station type	:	Elevated
Entry / Exits	:	On both sides of road.
Location	:	The proposed station is located on the eastern side of the Nagpur Junction Railway station.
Catchment Area		Nagpur Railway station is a very busy Junction Railway station of Western railway the proposed station will cater to the passengers using the Railway station to and from the Nagpur City.

Figure 6.26: Site Conditions- Nagpur Railway Station

Line-1 & Line-2 (Interchange station)

6. Stadium

Chainage	:	2580.30 m
Inter Station Distance	:	1240.30 m
Rail Level	:	22.25 m
Station type	:	Elevated (Interchange station)
Entry / Exits		On both sides of the road
Location	:	The station is located on the crossing of NH40 and NH44, in the area called Stadium.
Catchment Area		The main source of passengers to this station is the residents of surrounding Commercial and residential areas, People visiting Stadium during special events, interchanging from EW Line to NS line.

Figure 6.26: Site Conditions- Stadium Station

18. Jhansi Rani Chowk

Chainage	:	6300.70 m
Inter Station Distance	:	640.00 m
Rail Level	:	13.77 m
Station type	:	Elevated
Entry / Exits	:	On both sides of the road
Location	:	The station is located on NH-44 in the institutional area having Hospitals and other Institutes.
Catchment Area	:	The main source of passengers to this station is the residents of surrounding areas and people visiting Mehrauli nagar, MLB-Specialty Hospital and other Institutes & school in the surroundings.

Figure 6.37: Site Conditions- Jhansi Rani Chowk Station

11. Institutions of Engineers

Chainage	:	9117.20 m
Inter Station Distance	:	763.60 m
Rail Level	:	12.50 m
Station type	:	Standard
Entry / Exits		On both sides of the road
Location	:	The station is located on NH-44 near the Institutions of Engineers and Indian Medical Association.
Catchment Area		The main source of passengers to this station is the people coming to Institutions of Engineers, Hadas school and the residents of surrounding areas.

Figure 6.25: Site Conditions- Institutions of Engineers Station

12. Shankar Nagar Square (Bank Of India)

Chainage	:	10074.90 m
Inter Station Distance	:	967.70 m
Rail Level	:	12.86 m
Station type	:	Elevated
Entry / Exits	:	On both sides of the road
Location	:	The proposed station is located near Swami Vivekanand Square Chowk.
Catchment Area	:	The main source of passengers to this station is the residents of Ram Nagar, Bajaj Nagar, Gokulpeth and residents of surrounding colonies.

Figure 6.32: Site Conditions- Shankar Nagar Square Station

10. Lad Chowk

Chainage	:	10870.10 m
Inter Station Distance	:	786.20 m
Rail Level	:	12.61 m
Station type	:	Elevated
Entry / Exits		On both sides of the road
Location	:	The station is located on NH-44 near Lad chowk crossing.
Catchment Area		The main source of passengers to this station is the residents of Abhyankar Nagar, Lad Nagar, Gandhi Nagar and the colonies in the surrounding areas.

Figure 5.38: Site Conditions- LAD Chowk Station

14. Dharampeth College

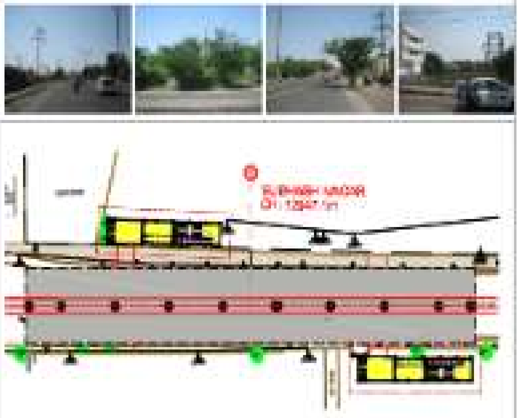
Chainage	:	12020.70 m
Inter Station Distance	:	1147.60 m
Rail Level	:	13.20 m
Station type	:	Elevated
Entry / Exits		On both sides of the road
Location	:	The station is located on NH-44 near Ambazari Lake.
Catchment Area		The main source of passengers to this station are the students of Dharampeth college, the residents of Ambazari layout and surrounding colonies.

Figure 6.31: Site Condition: Dharampeth College Station

15. Subhash Nagar

Chainage	:	12947.10 m
Inter Station Distance	:	926.43 m
Rail Level	:	12.94 m
Station type	:	Elevated
Entry / Exits		On both sides of the road
Location	:	The station is located on NH-44 near CRPF Camp and Subhash Nagar.
Catchment Area		The main source of passengers to this station is the residents of Subhash Nagar, Pandod and residents of the surrounding residential areas.

Figure 6.32: Site Conditions- Subhash Nagar Station



15. Rachna Ring Road

Chainage	:	14168.60 m
Inter Station Distance	:	1361.60 m
Rail Level	:	12.30 m
Station type	:	Elevated
Entry / Exits		On both sides of the road
Location	:	The station is located on NH-44 and Ring Road SH-260 crossing
Catchment Area		The main source of passengers to this station is the residents of Priya Vidya Vihar, surrounding industrial and residential areas.

Figure 6.22: Site Conditions- Rachna Ring Road Station

17. Vasudev Nagar

Chainage	:	15175.30 m
Inter Station Distance	:	985.00 m
Rail Level	:	12.85 m
Station type	:	Elevated
Entry / Exits		On both sides of the road.
Location	:	The station is located on NH-44.
Catchment Area		The main source of passengers to this station is the residents of Vasudev Nagar, Vinayak Nagar and the residents of surrounding residential areas.

Figure 6.34: Site Conditions- Vasudev Nagar Station

13. Bansi Nagar

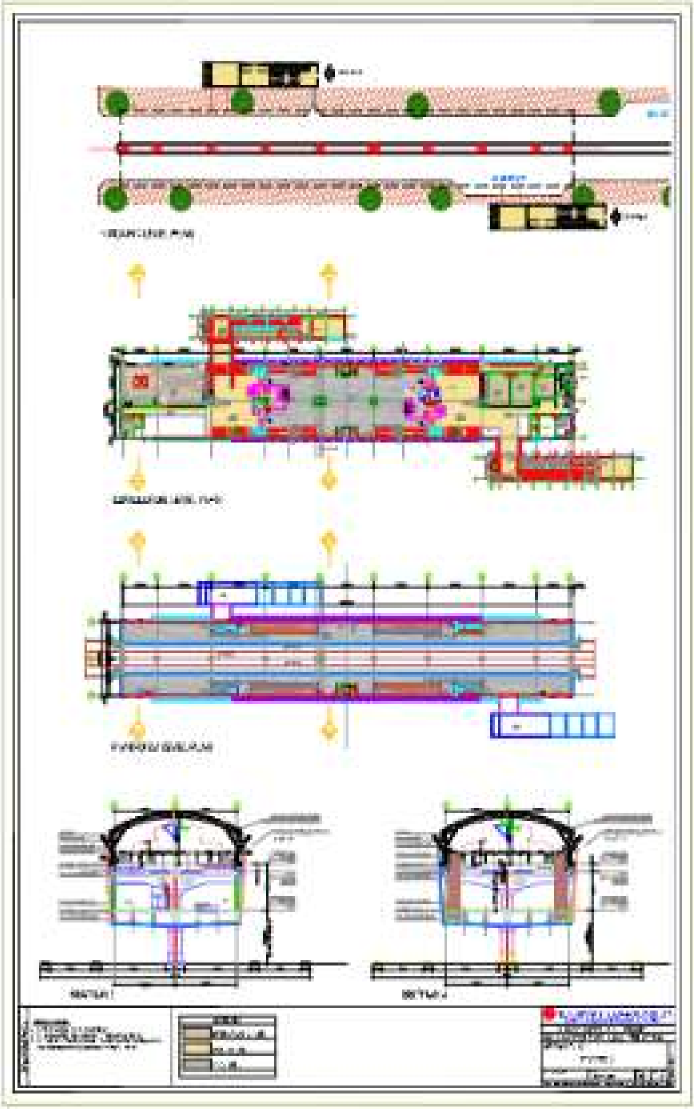
Chainage	:	18131.50 m
Inter Station Distance	:	997.35 m
Rail Level	:	13.50 m
Station type	:	Elevated
Entry / Exits	:	On both sides of the road
Location	:	The station is located on NH-44.
Catchment Area	:	The main source of passengers to this station is the residents of Bansi Nagar and surrounding residential colonies and commercial areas.

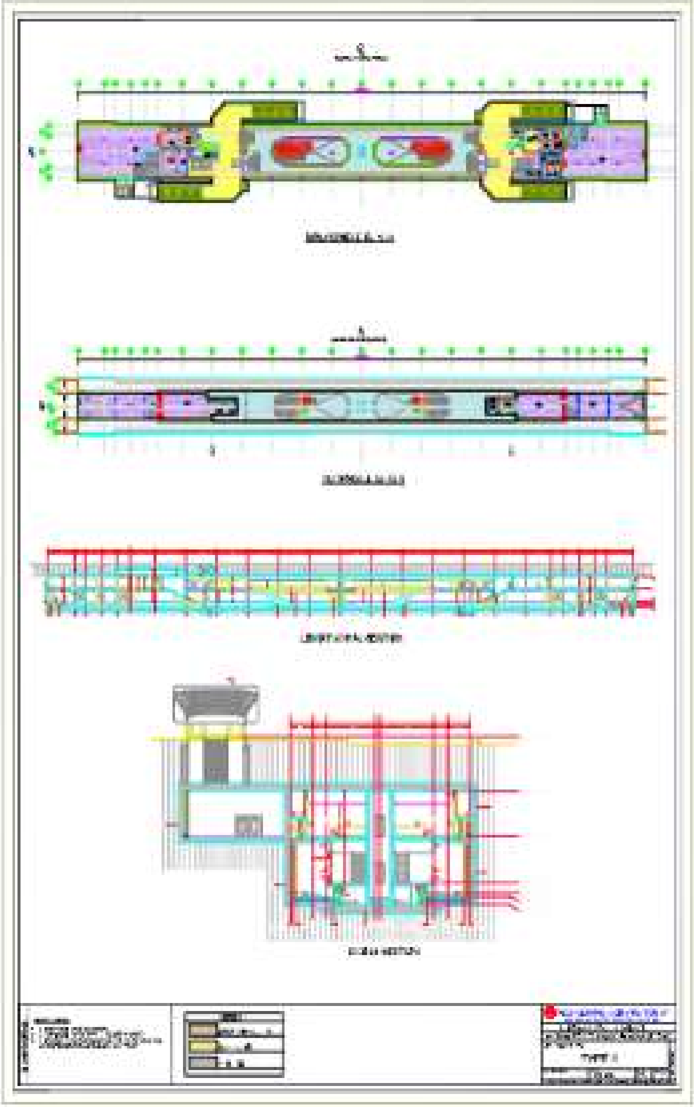
Figure 6.58: Site Conditions- Bansi Nagar Station

18 Lokmanya Nagar

Chainage	:	17752.5 m
Inter Station Distance	:	1001 m
Rail Level	:	13.36 m
Station type	:	Elevated
Entry / Exits	:	On both sides of the road
Location	:	The station is located on NH-44.
Catchment Area		The main source of passengers to this station is the residents & people visiting surrounding residential areas and Lata Mangeshkar Hospital.

Figure 6.28: Lokmanya Nagar Station





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CHAPTER 7

TRAIN OPERATION PLAN

TABLES

ATTACHMENTS

Chapter - 7

TRAIN OPERATION PLAN

7.1 Operation Philosophy

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

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

7.2 Stations

List of stations for the two Corridors of Nagpur Metro are given below:

TABLE 7.1 : STATIONS

LINE-1 : NORTH-SOUTH CORRIDOR				
S. No.	Name of Station	Chainage (in m)	Inter – Station Distance (in m)	Remarks
	DEAD END	-145.00		
1	AUTOMOTIVE SQRE	0.0	406.2	Elevated
2	NARI ROAD	975.8	975.8	Elevated
3	INDORA CHOWK	2139.7	1163.9	Elevated
4	KADVI CHOWK	3181.2	1041.5	Elevated
5	GADDI GODAM SQRE	4399.0	1217.8	Elevated
6	KASTURCHAND PARK	5148.8	749.8	Elevated
7	ZERO MILE	6175.3	1026.5	Elevated
8	SITABURDI	6709.2	533.9	Elevated
9	CONGRESS NAGAR	7897.2	1188.0	Elevated

LINE-1 : NORTH-SOUTH CORRIDOR				
S. No	Name of Station	Chainage (in m)	Inter – Station Distance (in m)	Remarks
10	RAHATE COLONY	8682.6	795.4	Elevated
11	AJNI SQUARE	10104.7	1422.1	Elevated
12	CHHATRAPATI SQUARE	11146.3	1041.6	Elevated
13	JAIPRAKASH NAGAR	11811.5	661.1	Elevated
14	UJWAL NAGAR	12846.8	1069.2	Elevated
15	AIRPORT	13784.9	1344.1	Elevated
16	NEW AIRPORT	16188.4	2783.1	At Grade
17	KHAPARI	18460.6	2117.9	At Grade
	DEAD END	19050.0		

LINE-2 : EAST-WEST CORRIDOR				
S. No	Name of Station	Chainage (in m)	Inter – Station Distance (in m)	Remarks
	DEAD END	-300.0		
1	PRAJAPATI NAGAR	0.0		Elevated
2	VAISHNO DEVI CHOWK	1229.3	1229.3	Elevated
3	AMBEDKAR CHOWK	1947.5	718.2	Elevated
4	TELEPHONE EXCHANGE	3137.4	1189.9	Elevated
5	CHITAR OLI CHOWK (GANDHI PUTALA)	3949.7	812.3	Elevated
6	AGRASEN CHOWK	4759.2	809.5	Elevated
7	DOSAR VAISYA CHOWK(MAYO HOSPITAL)	5611.0	851.8	Elevated
8	NAGPUR RAILWAY STATION	6464.4	853.4	Elevated
9	SITABURDI	7707.7	1243.3	Elevated
10	JHANSI RANI SQRE	8353.7	646.0	Elevated
11	INSTITUTIONS OF ENGINEERS	9117.2	763.5	Elevated
12	SHANKAR NAGAR SQRE(BANK OF INDIA)	10074.9	957.7	Elevated
13	LAD CHOWK	10873.1	798.2	Elevated
14	DHARAMPETH COLLEGE	12020.7	1147.6	Elevated
15	SUBHASH NAGAR	12947.1	926.4	Elevated
16	RACHANA (RING RD JNC)	14188.9	1241.8	Elevated
17	VASUDEV NAGAR	15173.9	985.0	Elevated
18	BANSI NAGAR	16131.6	957.7	Elevated

LINE 2 : EAST WEST CORRIDOR				
S. No.	Name of Station	Chainage (in m)	Inter – Station Distance (in m)	Remarks
19	LOKMANYA NAGAR	17424.1	1252.3	Elevated
	DEAD END	18165.0		

7.5 TRAIN OPERATION PLAN :

7.5.1 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:

  Line-1: North – South Corridor

  - 'Automotive Sqre to Congress Nagar' section: 32 kmph
  - 'Congress Nagar to Khapri Station' section: 34 kmph

  Line-2: East-West Corridor

  - 'Prajapati Nagar to Lokmanya Nagar' section: 35 kmph
  - 'Agrasen Chowk to Subhash Nagar' section: 35 kmph

7.5.2 Traffic Demand

Peak hour peak direction traffic demands (PHPDT) for the Nagpur Metro 'Line-1: North-South Corridor' & 'Line-2: East- West Corridor' for the year 2016, 2021, 2026, 2031, 2036 and 2041 for the purpose of planning are indicated in Attachment I/A1, B1 & C1, D1, E1, F1, Attachment I/A2, B2, C2, D2, E2, & F2 respectively.

7.5.3 Train formation

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

Composition

DMC : Driving Motor Car
TC : Trailer Car

Capacity (@ 6 passengers per square meter of standee area)

Driving Motor Car (DMC) - 247 (43 seated + 204 standing)
Trailer Car (TC) - 270 (50 seated + 220 standing)
3 Car Train - 764 (136 seated + 628 standing)

7.3.4 Train Operation Plan

Based on the projected PHPDT demand, Train operation plan with train carrying capacity @ 6 persons per square meter of standee area for the Nagpur Metro 'Line 1: North-South Corridor' & 'Line 2: East West Corridor' for the year 2018, 2021, 2026, 2031, 2036 and 2041 are given below:

7.3.4.1 Line-1: North – South Corridor

Train Operation Plan for Line 1: North-South Corridor has been planned in such a way that there are two loops of train operation. In one loop, trains run from 'Automotive Sqre to Congress Nagar' at a given headway and in other loop trains run from 'Automotive Sqre to Khapri Station' at the same headway, thus resulting in half the headway in 'Automotive Sqre to Congress Nagar' Section as compared to 'Congress Nagar to Khapri Station' Section. For this Train Operation Plan, reversal facility is required at Congress Nagar.

i) Year 2018:

Train operation in 'Automotive Sqre to Congress Nagar' Loop at 12 min headway with 3-Car train and in 'Automotive Sqre to Khapri Station' Loop at 12 min headway with 3-Car train. This results in following train operation in different section:

(a) 'Automotive Sqre to Congress Nagar' Section (Refer Attachment I/A1)

- 6 min Effective Headway with 3-car train.
- Available Peak Hour Peak Direction Capacity of 7840 @ 6 persons per square meter of standee area.
- Available Peak Hour Peak Direction Capacity of 9730 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 10089 is in the Section between Sitabuldi to Congress Nagar and demand in the remaining sections is in the range of 8272 to 2561 only. The planned capacity of 7840 (9730 under dense loading) is less than the PHPDT demand in two (one, with dense loading capacity) sections out of eight sections.

(b) 'Congress Nagar to Khapri Station' Section (Refer Attachment I/A1)

- 12 min Headway with 3-car train.
- Available Peak Hour Peak Direction Capacity of 3920 @ 6 persons per square meter of standee area.
- Available Peak Hour Peak Direction Capacity of 4865 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 5288 is in the Section between Congress Nagar to Rahate Colony and demand in the remaining sections is in the range of 4513 to 2140 only. The planned capacity of 3920 (4865 under dense

loading) is less than the PHPDT demand in two (one, with dense loading capacity) sections out of eight sections.

Traffic demand and train capacity for this corridor in the year 2016 is tabulated and represented on a chart enclosed as Attachment I/A1.

ii) Year 2021:

Train operation in 'Automotive Sqre to Congress Nagar' Loop at 10 min headway with 3-Car train and in 'Automotive Sqre to Khapri Station' Loop at 10 min headway with 3-Car train. This results in following train operation in different section:

(a) 'Automotive Sqre to Congress Nagar' Section (Refer Attachment I/B1)

- 5 min Effective Headway with 3-car train.
- Available Peak Hour Peak Direction Capacity of 9198 @ 6 persons per square meter of standee area.
- Available Peak Hour Peak Direction Capacity of 11676 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 10538 is in the Section between Sitabuldi to Congress Nagar and demand in the remaining sections is in the range of 5225 to 3619 only. The planned capacity of 9198 (11676 under dense loading) is less than the PHPDT demand in two (zero, with dense loading capacity) sections out of eight sections.

(b) 'Congress Nagar to Khapri Station' Section (Refer Attachment I/B1)

- 10 min Headway with 3-car train.
- Available Peak Hour Peak Direction Capacity of 4594 @ 6 persons per square meter of standee area.
- Available Peak Hour Peak Direction Capacity of 5838 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 5726 is in the Section between Congress Nagar to Rahate Colony and demand in the remaining sections is in the range of 4876 to 2267 only. The planned capacity of 4594 (5838 under dense loading) is less than the PHPDT demand in two (zero, with dense loading capacity) sections out of eight sections.

Traffic demand and train capacity for this corridor in the year 2021 is tabulated and represented on a chart enclosed as Attachment I/B1.

iii) Year 2031:

Train operation in 'Automotive Sqre to Congress Nagar' Loop at 8 min headway with 3-Car train and in 'Automotive Sqre to Khapri Station' Loop at 8 min headway with 3-Car train. This results in following train operation in different section:

(a) 'Automotive Square to Congress Nagar' Section (Refer Attachment I/C1)

- 4.5 min Effective Headway with 3-car train.
- Available Peak Hour Peak Direction Capacity of 10167 @ 6 persons per square meter of standee area.
- Available Peak Hour Peak Direction Capacity of 12973 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 11156 is in the Section between Sitabuldi to Congress Nagar and demand in the remaining sections is in the range of 10207 to 3400 only. The planned capacity of 10167 (12973 under dense loading) is less than the PHPDT demand in two (zero, with dense loading capacity) sections out of eight sections.

(b) 'Congress Nagar to Khapri Station' Section (Refer Attachment I/C1)

- 8 min Headway with 3-car train.
- Available Peak Hour Peak Direction Capacity of 5083 @ 6 persons per square meter of standee area.
- Available Peak Hour Peak Direction Capacity of 6487 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 5366 is in the Section between Congress Nagar to Rahate Colony and demand in the remaining sections is in the range of 5336 to 2480 only. The planned capacity of 5083 (6487 under dense loading) is less than the PHPDT demand in two (zero, with dense loading capacity) sections out of eight sections.

Traffic demand and train capacity for this corridor in the year 2021 is tabulated and represented on a chart enclosed as Attachment I/C1.

c) Year 2031:

Train operation in 'Automotive Square to Congress Nagar' Loop at 8 min headway with 3-Car train and in 'Automotive Square to Khapri Station' Loop at 8 min headway with 3-Car train. This results in following train operation in different section:

(a) 'Automotive Square to Congress Nagar' Section (Refer Attachment I/D1)

- 4 min Effective Headway with 3-car train.
- Available Peak Hour Peak Direction Capacity of 11400 @ 6 persons per square meter of standee area.
- Available Peak Hour Peak Direction Capacity of 14300 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 12504 is in the Section between Sitabuldi to Congress Nagar and demand in the remaining sections is in the range of 11031

to 4045 only. The planned capacity of 11460 (14592 under dense loading) is less than the PHPDT demand in two (zero, with dense loading capacity) sections out of eight sections.

(b) 'Congress Nagar to Khapri Station' Section (Refer Attachment I/D1)

- 8 min Headway with 3-car train.
- Available Peak Hour Peak Direction Capacity of 5730 @ 6 persons per square meter of standee area.
- Available Peak Hour Peak Direction Capacity of 7296 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 6916 is in the Section between Congress Nagar to Rahate Colony and demand in the remaining sections is in the range of 6604 to 3746 only. The planned capacity of 5730 (7296 under dense loading) is less than the PHPDT demand in two (zero, with dense loading capacity) sections out of eight sections.

Traffic demand and train capacity for this corridor in the year 2021 is tabulated and represented on a chart enclosed as Attachment I/D1.

c) Year 2026:

Train operation in 'Automotive Sqre to Congress Nagar' Loop at 7 min headway with 3-Car train and in 'Automotive Sqre to Khapri Station' Loop at 7 min headway with 3-Car train. This results in following train operation in different section:

(a) Automotive Sqre to Congress Nagar' Section (Refer Attachment I/E1)

- 3.5 min Effective Headway with 3-car train.
- Available Peak Hour Peak Direction Capacity of 13097 @ 6 persons per square meter of standee area.
- Available Peak Hour Peak Direction Capacity of 16680 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 14286 is in the Section between Sitabuldi to Congress Nagar and demand in the remaining sections is in the range of 13932 to 4611 only. The planned capacity of 13097 (16680 under dense loading) is less than the PHPDT demand in one (zero, with dense loading capacity) sections out of eight sections.

(b) Congress Nagar to Khapri Station' Section (Refer Attachment I/E1)

- 7 min Headway with 3-car train.
- Available Peak Hour Peak Direction Capacity of 6549 @ 6 persons per square meter of standee area.
- Available Peak Hour Peak Direction Capacity of 8340 @ 8 persons per square meter of standee area under dense loading conditions.

- The maximum PHPDT demand of 7688 is in the Section between Congress nagar to Rahate Colony and demand in the remaining sections is in the range of 6470 to 3040 only. The planned capacity of 6040 (8340 under dense loading) is is less than the PHPDT demand in one (zero, with dense loading capacity) sections out of eight sections.

Traffic demand and train capacity for this corridor in the year 2036 is tabulated and represented on a chart enclosed as Attachment I/E1.

vii) Year 2041:

Train operation in 'Automotive Sqre to Congress Nagar' Loop at 3 min headway with 3-Car train and in 'Automotive Sqre to Khapri Station' Loop at 6 min headway with 3-Car train. This results in following train operation in different section:

(a) Automotive Sqre to Congress Nagar' section (Refer Attachment I/F1)

- 3 min Effective Headway with 3-car train.
- Available Peak Hour Peak Direction Capacity of 15280 @ 6 persons per square meter of standee area.
- Available Peak Hour Peak Direction Capacity of 19460 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 15729 is in the Section between Sitaburdi to Congress Nagar and demand in the remaining sections is in the range of 14372 to 5274 only. The planned capacity of 15280 (19460 under dense loading) is less than the PHPDT demand in one (zero, with dense loading capacity) sections out of eight sections.

(b) Congress Nagar to Khapri Station' section (Refer Attachment I/F1)

- 6min Headway with 3-car train.
- Available Peak Hour Peak Direction Capacity of 7640 @ 6 persons per square meter of standee area.
- Available Peak Hour Peak Direction Capacity of 9730 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 8477 is in the Section between Congress nagar to Rahate Colony and demand in the remaining sections is in the range of 7149 to 3860 only. The planned capacity of 7640 (9730 under dense loading) is less than the PHPDT demand in one (zero, with dense loading capacity) sections out of eight sections.

Traffic demand and train capacity for this corridor in the year 2041 is tabulated and represented on a chart enclosed as Attachment I/F1

7.3.4.3 Line 2: East–West Corridor

Train Operation Plan for Line 2: East-west Corridor has been planned in such a way that there are two loops of train operation. In one loop, trains run from 'Prajapati Nagar to Lokmanya Nagar' at a given headway and in other loop trains run from 'Agrasen Chowk to Subhash Nagar' at the same headway, thus resulting in half the headway in 'Agrasen Chowk to Subhash Nagar' Section as compared to 'Prajapati Nagar to Agrasen Chowk' Section & 'Subhash Nagar to Lokmanya Nagar' Section. For this Train Operation Plan, reversal facilities are required at Agrasen Chowk and Subhash Nagar.

i) Year 2018:

Train operation in 'Prajapati Nagar to Lokmanya Nagar' Loop at 13 min headway with 3-Car train and in 'Agrasen Chowk to Subhash Nagar' Loop at 13 min headway with 3-Car train. This results in following train operation in different section:

(a) 'Prajapati Nagar to Agrasen Chowk' Section and 'Subhash Nagar to Lokmanya Nagar' Section (Refer Attachment IXA1)

- 13 min Headway with 3-car train.
- Available Peak Hour Peak Direction Capacity of 3526 @ 6 persons per square meter of standee area.
- Available Peak Hour Peak Direction Capacity of 4491 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 4090 is in the Section between Chitar Oli Chowk (Gandhi Putala) to Agrasen Chowk and demand in the remaining sections is in the range of 3767 to 481 only. The planned capacity of 3526 (4491 under dense loading) is less than the PHPDT demand in two (zero, with dense loading capacity) out of nine sections sections of 'Prajapati Nagar to Agrasen Chowk' Section and 'Subhash Nagar to Lokmanya Nagar' Section.

(b) 'Agrasen Chowk to Subhash Nagar' Section (Refer Attachment IXA2)

- 6.5 min Effective Headway with 3-car train.
- Available Peak Hour Peak Direction Capacity of 7052 @ 6 persons per square meter of standee area.
- Available Peak Hour Peak Direction Capacity of 8982 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 7746 is in the Section between Institute of Engineers to Shankar Nagar Square and demand in the remaining sections is in the range of 7341 to 4372 only. The planned capacity of 7052 (8982 under dense loading) is less than the PHPDT demand in two (zero, with dense

loading capacity) sections out of nine sections of 'Agrasen Chowk to Subhash Nagar' Section.

Traffic demand and train capacity for this corridor in the year 2016 is tabulated and represented on a chart enclosed as Attachment IIA2.

II) **Year 2021:**

Train operation in 'Prajapati Nagar to Lokmanya Nagar' Loop at 12 min headway with 3-Car train and in 'Agrasen Chowk to Subhash Nagar' Loop at 12 min headway with 3-Car train. This results in following train operation in different section:

(a) **'Prajapati Nagar to Agrasen Chowk' Section and 'Subhash Nagar to Lokmanya Nagar' Section (Refer Attachment IIB2)**

- 12 min Headway with 3-car train.
- Available Peak Hour Peak Direction Capacity of 3820 @ 6 persons per square meter of standee area.
- Available Peak Hour Peak Direction Capacity of 4865 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 4384 is in the Section between Chitar Oli Chowk (Gandhi Putala) to Agrasen Chowk and demand in the remaining sections is in the range of 4157 to 517 only. The planned capacity of 3820 (4865 under dense loading) is less than the PHPDT demand in two (zero, with dense loading capacity) out of nine sections sections of 'Prajapati Nagar to Agrasen Chowk' Section and 'Subhash Nagar to Lokmanya Nagar' Section.

(b) **'Agrasen Chowk to Subhash Nagar' Section (Refer Attachment IIB2)**

- 6 min Effective Headway with 3-car train.
- Available Peak Hour Peak Direction Capacity of 7640 @ 6 persons per square meter of standee area.
- Available Peak Hour Peak Direction Capacity of 9730 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 8400 is in the Section between Institute of Engineers to Shankar Nagar Square and demand in the remaining sections is in the range of 7970 to 4473 only. The planned capacity of 7640 (9730 under dense loading) is less than the PHPDT demand in two (zero, with dense

loading capacity) sections out of nine sections of 'Agrasen Chowk to Subhash Nagar' Section.

Traffic demand and train capacity for this corridor in the year 2021 is tabulated and represented on a chart enclosed as Attachment I/B2.

iii) Year 2026:

Train operation in 'Prajapati Nagar to Lokmanya Nagar' Loop at 10min headway with 3-Car train and in 'Agrasen Chowk to Subhash Nagar' Loop at 10 min headway with 3-Car train. This results in following train operation in different section:

(a) 'Prajapati Nagar to Agrasen Chowk' Section and 'Subhash Nagar to Lokmanya Nagar' Section (Refer Attachment I/C3)

- 10 min Headway with 3-car train.
- Available Peak Hour Peak Direction Capacity of 4584 @ 6 persons per square meter of standee area.
- Available Peak Hour Peak Direction Capacity of 5838 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 4703 is in the Section between Chitar oli Chowk (Gandhi Putala) to Agrasen Chowk and demand in the remaining sections is in the range of 4030 to 549 only. The planned capacity of 4584 (5838 under dense loading) is less than the PHPDT demand in one (zero, with dense loading capacity) out of nine sections sections of 'Prajapati Nagar to Agrasen Chowk' Section and 'Subhash Nagar to Lokmanya Nagar' Section.

(b) 'Agrasen Chowk to Subhash Nagar' Section (Refer Attachment I/C3)

- 5 min Effective Headway with 3-car train.
- Available Peak Hour Peak Direction Capacity of 9168 @ 6 persons per square meter of standee area.
- Available Peak Hour Peak Direction Capacity of 11676 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 9154 is in the Section between Institute of Engineers to Shankar Nagar Square and demand in the remaining sections is in the range of 6734 to 4670 only. The planned capacity of 9168 (11676 under dense loading) is less than the PHPDT demand in one (zero, with dense loading capacity) sections out of nine sections of 'Agrasen Chowk to Subhash Nagar' Section.

Traffic demand and train capacity for this corridor in the year 2026 is tabulated and represented on a chart enclosed as Attachment I/D2.

iv) Year 2031:

Train operation in 'Prajapati Nagar to Lokmanya Nagar' Loop at 5 min headway with 3-Car train and in 'Agrasen Chowk to Subhash Nagar' Loop at 9 min headway with 3-Car train. This results in following train operation in different section:

(a) 'Prajapati Nagar to Agrasen Chowk' Section and 'Subhash Nagar to Lokmanya Nagar' Section (Refer Attachment I/D3)

- 5 min Headway with 3-car train.
- Available Peak Hour Peak Direction Capacity of 5093 @ 6 persons per square meter of standee area.
- Available Peak Hour Peak Direction Capacity of 6487 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 5096 is in the Section between Chitar oli Chowk (Gandhi Putala) to Agrasen chowk and demand in the remaining sections is in the range of 4034 to 565 only. The planned capacity of 5093 (6487 under dense loading) is less than the PHPDT demand in one (zero, with dense loading capacity) sections out of nine sections of 'Prajapati Nagar to Agrasen Chowk' Section and 'Subhash Nagar to Lokmanya Nagar' Sections.

(b) 'Agrasen Chowk to Subhash Nagar' Section (Refer Attachment I/D3)

- 4.5 min Effective Headway with 3-car train.
- Available Peak Hour Peak Direction Capacity of 10187 @ 6 persons per square meter of standee area.
- Available Peak Hour Peak Direction Capacity of 12973 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 9906 is in the Section between Institute of Engineers to Shankar Nagar Square and demand in the remaining sections is in the range of 9675 to 536 only. The planned capacity of 10187 (12973 under dense loading) is more than the PHPDT demand in nine sections of 'Agrasen Chowk to Subhash Nagar' Sections.

Traffic demand and train capacity for this corridor in the year 2031 is tabulated and represented on a chart enclosed as Attachment I/D3.

v) Year 2036:

Train operation in 'Prajapati Nagar to Lokmanya Nagar' Loop at 8 min headway with 3-Car train and in 'Agrasen Chowk to Subhash Nagar' Loop at 8 min headway with 3-Car train. This results in following train operation in different section:

(a) 'Prajapati Nagar to Agrasen Chowk' Section and 'Subhash Nagar to Lokmanya Nagar' Section (Refer Attachment IIE2)

- 8 min Headway with 3-car train.
- Available Peak Hour Peak Direction Capacity of 5730 @ 6 persons per square meter of standee area.
- Available Peak Hour Peak Direction Capacity of 7298 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 5642 is in the Section between Chitar oli Chowk (Gandhi putala) to Agrasen Chowk and demand in the remaining sections is in the range of 0416 to 621 only. The planned capacity of 5730 (7298 under dense loading) is more than the PHPDT demand in nine sections of 'Prajapati Nagar to Agrasen Chowk' Section and 'Subhash Nagar to Lokmanya Nagar' Sections.

(b) 'Agrasen Chowk to Subhash Nagar' Section (Refer Attachment IIE2)

- 4 min Effective Headway with 3-car train.
- Available Peak Hour Peak Direction Capacity of 11460 @ 6 persons per square meter of standee area.
- Available Peak Hour Peak Direction Capacity of 14595 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 10746 is in the Section between Nagpur Railway Station to Sitaburdi and demand in the remaining sections is in the range of 1071 to 9868 only. The planned capacity of 11460 (14595 under dense loading) is more than the PHPDT demand in nine sections of 'Agrasen Chowk to Subhash Nagar' Sections.

Traffic demand and train capacity for this corridor in the year 2036 is tabulated and represented on a chart enclosed as Attachment IIE2.

vii) Year 2041:

Train operation in 'Prajapati Nagar to Lokmanya Nagar' Loop at 7 min headway with 3-Car train and in 'Agrasen Chowk to Subhash Nagar' Loop at 7 min headway with 3-Car train. This results in following train operation in different section:

(a) 'Prajapati Nagar to Agrasen Chowk' Section and 'Subhash Nagar to Lokmanya Nagar' Section (Refer Attachment I/P2)

- 7 min Headway with 3-car train.
- Available Peak Hour Peak Direction Capacity of 6540 @ 6 persons per square meter of standee area.
- Available Peak Hour Peak Direction Capacity of 8340 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 6020 is in the Section between Chitar oli Chowk (Gandhi Putala) and demand in the remaining sections is in the range of 5871 to 655 only. The planned capacity of 6540 (8340 under dense loading) is more than the PHPDT demand in nine sections of 'Prajapati Nagar to Agrasen Chowk' Section and 'Subhash Nagar to Lokmanya Nagar' Sections.

(b) Agrasen Chowk to Subhash Nagar' Section (Refer Attachment I/P2)

- 3.5 min Effective Headway with 3-car train.
- Available Peak Hour Peak Direction Capacity of 13087 @ 6 persons per square meter of standee area.
- Available Peak Hour Peak Direction Capacity of 16680 @ 8 persons per square meter of standee area under dense loading conditions.
- The maximum PHPDT demand of 11882 is in the Section between Nagpur Railway Station to Sitabuldi and demand in the remaining sections is in the range of 11528 to 6237 only. The planned capacity of 13087 (16680 under dense loading) is more than the PHPDT demand in nine sections of 'Agrasen Chowk to Subhash Nagar' Sections.

Traffic demand and train capacity for this corridor in the year 2041 is tabulated and represented on a chart enclosed as Attachment I/P2.

The above Train Operation Plan is based on calculations on the back of available traffic data. In case of any mismatch in the capacity provided and the actual traffic, the capacity can be moderated suitably by adjusting the Headway. The PHPDT capacity provided on the two corridors in different years of operation is tabulated below:

TABLE 7.3

Capacity Provided for Line-1: North – South Corridor

Sections	Year	Headway (min)	No. of Rakes	Rake Consist	No. of Coaches	Max. PHPDT Demand	PHPDT Capacity Available
Automotive Sqra to Congress Nagar Section	2018	6	11 Rakes of 3-car	3-car	33	10583	7640 (9730*)
Congress Nagar to Khapri Station Section		12		3-car		5298	3820 (4865*)
Automotive Sqra to Congress Nagar Section	2021	5	13 Rakes of 3-car	3-car	39	10936	9168 (11676*)
Congress Nagar to Khapri Station Section		10		3-car		5728	4584 (5838*)
Automotive Sqra to Congress Nagar Section	2026	4.5	15 Rakes of 3-car	3-car	45	11613	10187 (12973*)
Congress Nagar to Khapri Station Section		9		3-car		6305	5093 (6487*)
Automotive Sqra to Congress Nagar Section	2031	4	17 Rakes of 3-car	3-car	51	12834	11460 (14595*)
Congress Nagar to Khapri Station Section		8		3-car		6918	5730 (7298*)
Automotive Sqra to Congress Nagar Section	2036	3.5	20 Rakes of 3-car	3-car	60	14288	13097 (16680*)
Congress Nagar to Khapri Station Section		7		3-car		7668	6549 (8340*)
Automotive Sqra to Congress Nagar Section	2041	3	21 Rakes of 3-car	3-car	63	15723	15280 (19460*)
Congress Nagar to Khapri Station Section		6		3-car		8477	7640 (9730*)

TABLE 7.5 : Capacity Provided for Line-2: East-West Corridor

Sections	Year	Headway (min)	No. of Rakes	Rake Consist	No. of Coaches	Max. PHPDT Demand	PHPDT Capacity Available
Prajapati Nagar to Agrasen Chowk Section	2016	13	12 Rakes of 3-car	3-car	36	4093	3526 (4491*)
Agrasen Chowk to Subhash Nagar Section		6.5		3-car		7766	7052 (8982*)
Subhash Nagar to Lokmanya Nagar Section		13		3-car		3767	3526 (4491*)
Prajapati Nagar to Agrasen Chowk Section	2021	12	13 Rakes of 3-car	3-car	39	4206	3820 (4865*)
Agrasen Chowk to Subhash Nagar Section		6		3-car		8403	7640 (9730*)
Subhash Nagar to Lokmanya Nagar Section		12		3-car		4157	3820 (4865*)
Prajapati Nagar to Agrasen Chowk Section	2026	10	15 Rakes of 3-car	3-car	45	4703	4584 (5838*)
Agrasen Chowk to Subhash Nagar Section		5		3-car		9154	9168 (11676*)
Subhash Nagar to Lokmanya Nagar Section		10		3-car		4538	4584 (5838*)
Prajapati Nagar to Agrasen Chowk Section	2031	9	17 Rakes of 3-car	3-car	51	5294	5093 (6487*)
Agrasen Chowk to Subhash Nagar Section		4.5		3-car		9909	10187 (12973*)
Subhash Nagar to Lokmanya Nagar Section		9		3-car		4924	5093 (6487*)
Prajapati Nagar to Agrasen Chowk Section	2036	8	18 Rakes of 3-car	3-car	54	5542	5730 (7298*)
Agrasen Chowk to Subhash Nagar Section		4		3-car		10748	11460 (14595*)
Subhash Nagar to Lokmanya Nagar Section		8		3-car		5418	5730 (7298*)
Prajapati Nagar to Agrasen Chowk Section	2041	7	20 Rakes of 3-car	3-car	60	6000	6549 (8340*)
Agrasen Chowk to Subhash Nagar Section		3.5		3-car		11602	13097 (16680*)
Subhash Nagar to Lokmanya Nagar Section		7		3-car		5971	6549 (8340*)

* @ 8 persons per square meter of standee area

7.3.6 Train frequency

TABLE 7.4

Train Frequency Line-1: North – South Corridor

Sections	2016		2021		2026		2031		2036		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	Peak Hour h/w	Lean Hour h/w
Automotive Sqre to Congress Nagar Section	8 min	15 to 30 min	6 min	9 to 20 min	4.5min	9 to 20 min	4 min	8 to 20 min	3.5 min	5 to 15 min	3 min	5 to 15 min
Congress Nagar to Khapri Station Section	12 min	20 to 60 min	10 min	16 to 40 min	9 min	12 to 40 min	8 min	12 to 40 min	7 min	10 to 30 min	6 min	10 to 30 min

TABLE 7.5

Train Frequency Line-2: East-West Corridor

Sections	2016		2021		2026		2031		2036		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	Peak Hour h/w	Lean Hour h/w
Prajapati Nagar to Agrasen Chowk Section	13 min	20 to 60 min	12 min	20 to 60 min	10 min	16 to 40 min	9 min	12 to 40 min	8 min	12 to 40 min	7 min	10 to 30 min
Agrasen Chowk to Subhash Nagar Section	6.5 min	15 to 30 min	6 min	10 to 30 min	5 min	8 to 20 min	4.5 min	8 to 20 min	4 min	6 to 20 min	3.5 min	5 to 15 min
Subhash Nagar to Lokmanya Nagar Section	13 min	20 to 60 min	12 min	20 to 60 min	10 min	16 to 40 min	9 min	12 to 40 min	8 min	12 to 40 min	7 min	10 to 30 min

No services are proposed between 23:00 hrs to 5:00 hrs, which are reserved for maintenance of infrastructure and rolling stock.

7.3.6 Hourly Train Operation plan

The hourly distribution of daily transport capacity is presented in **Table 1.1A, 1.1B, 1.2A, 1.2B, 1.3A, 1.3B, 1.4A, 1.4B, 1.5A, 1.5B, 1.6A, & 1.6B** for 'Automotive Sqr to Congress Nagar' Section and 'Congress Nagar to Khapari' Section (Line-1: North – South Corridor) and **Table 1.7A, 1.7B, 1.7C, 1.8A, 1.8B, 1.8C, 1.9A, 1.9B, 1.9C, 1.10A, 1.10B, 1.10C, 1.11A, 1.11B, 1.11C, 1.12A, 1.12B, & 1.12C** for 'Prajapati Nagar to Agrasen Chowk' Section, 'Agrasen Chowk to Subhash Nagar' Section and 'Subhash Nagar to Lokmanya Nagar' Section (Line-2: East- West Corridor) respectively for years 2016, 2021, 2026, 2031, 2036, 2041 and enclosed as **Attachment II**.

Number of train trips per direction per day for 'Automotive Sqr to Congress Nagar' Section and 'Congress Nagar to Khapari' Section (Line-1: North – South Corridor) is worked out as 108 & 54 in the year 2016, 120 & 60 in the year 2021 and 158 & 79 in the year 2026, 168 & 84 in the year 2031, 200 & 100 in the year 2036 and 216 & 108 in the year 2041 respectively. Number of train trips per directions per day for 'Prajapati Nagar to Agrasen Chowk' Section, 'Agrasen Chowk to Subhash Nagar' Section and 'Subhash Nagar to Lokmanya Nagar' Section (Line-2: East- West Corridor) is worked out as 51,102 & 51 in the year 2016, 54, 108 & 54 in the year 2021 and 70,140 & 70 in the year 2026, 74, 148 & 74 in the year 2031, 83, 166 & 83 in the year 2036 and 99, 198 & 99 in the year 2041 respectively. The directional splits for Line-1: North – South Corridor and Line-2: East- West Corridor is presented in **Table 2.1 and 2.2** enclosed as **Attachment III**.

7.3.7 Vehicle Kilometer

Based on above planning, after considering maintenance period and assuming 340 days in service in a year, Vehicle Kilometers for Nagpur Metro Rail Network is given in **Table 3.1** for Line 1: North-South corridor and **Table 3.2** for Line 2: East-West Corridor enclosed as **Attachment IV**.

7.4 YEAR WISE RAKE REQUIREMENT

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

Requirements of coaches is calculated based on following assumptions:

Assumptions –

(i) Train Composition planned as under

3-car Train Composition	: DMC +TC +DMC
Train Carrying Capacity of 3 Car Train (@6 passengers per square meter of standee area)	: 764 passengers @6 standees/sqm

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

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

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

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

(vi) Schedule speed is taken as:

Line-1: North-South Corridor

- 'Automotive Sqre to Congress Nagar' Section: 32 kmph
- 'Congress Nagar to Khapri Station' Section: 36 kmph

Line-2: East-West Corridor

- 'Prajapati Nagar to Lokmanya Nagar' Section: 30 kmph
- 'Agrasen Chowk to Subhash Nagar' Section: 29 kmph

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

7.8 Cost Estimate

The estimated cost per coach at June 2012 Price level exclusive of taxes and duties may be assumed as INR 8.5 Crores per Coach. Total 33+36 = 69 coaches are required in year 2016 for the two lines in Nagpur Metro Rail Network.

PHPDT Demand and Capacity Chart
Nagpur Metro Rail Network
Line I : North - South Corridor

Year	[illegible]
No. of Cars per train	[illegible]
Passenger Capacity @ [illegible] persons/sqm of a 3-Car train	[illegible]
Passenger Capacity @ [illegible] persons/sqm of a 3-Car train	[illegible]
Headway (min)	[illegible]
Headway (min)	[illegible]

S.N.	FROM	TO	Traffic Demand in PHPDT	PHPDT capacity @ [illegible] of standee area	PHPDT capacity @ [illegible] of standee area
1	AUTOMOTIVE SQUARE	NARI ROAD	[illegible]	[illegible]	[illegible]
2	NARI ROAD	INDORA CHOWK	[illegible]	[illegible]	[illegible]
3	INDORA CHOWK	KADVI CHOWK	[illegible]	[illegible]	[illegible]
4	KADVI CHOWK	GADDI GODAM SQRE	[illegible]	[illegible]	[illegible]
5	GADDI GODAM SQRE	KASTURCHAND PARK	[illegible]	[illegible]	[illegible]
6	KASTURCHAND PARK	ZERO MILE	[illegible]	[illegible]	[illegible]
7	ZERO MILE	SITABURDI	[illegible]	[illegible]	[illegible]
8	SITABURDI	CONGRESS NAGAR	[illegible]	[illegible]	[illegible]
9	CONGRESS NAGAR	RAHATE COLONY	[illegible]	[illegible]	[illegible]
10	RAHATE COLONY	AJNI SQUARE	[illegible]	[illegible]	[illegible]
11	AJNI SQUARE	CHHATRAPATI SQUARE	[illegible]	[illegible]	[illegible]
12	CHHATRAPATI SQUARE	JAIPRAKASH NAGAR	[illegible]	[illegible]	[illegible]
13	JAIPRAKASH NAGAR	UJWAL NAGAR	[illegible]	[illegible]	[illegible]
14	UJWAL NAGAR	AIRPORT	[illegible]	[illegible]	[illegible]
15	AIRPORT	NEW AIRPORT	[illegible]	[illegible]	[illegible]
16	NEW AIRPORT	[illegible]	[illegible]	[illegible]	[illegible]

Note: Reversal facility required at Congress Nagar.

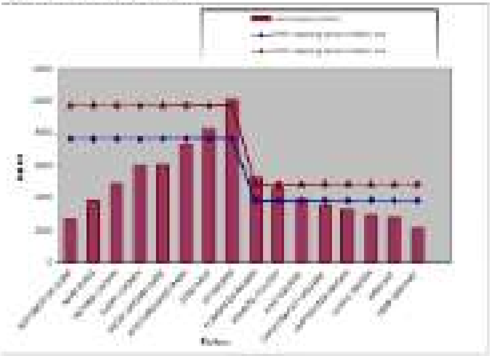

Fig 1.1

PHPDT Demand and Capacity Chart

Nagpur Metro Rail Network

Line 2 : East - West Corridor

Year:	2016
No. of Cars per train:	3
Passenger Capacity @ 6 persons/sqm of a 3-Car train:	764
Passenger Capacity @ 8 persons/sqm of a 3-Car train:	973
Headway (min):	6.3
Headway (min):	13

S.N.	FROM	TO	Traffic Demand in PHPDT	PHPDT capacity @ 6p/sqm of standee area	PHPDT capacity @ 8p/sqm of standee area
1	PRAJAPATI NAGAR	VAISHNO DEVI CHOWK	[illegible]	[illegible]	[illegible]
2	VAISHNO DEVI CHOWK	AMBEDKAR CHOWK	[illegible]	[illegible]	[illegible]
3	AMBEDKAR CHOWK	TELEPHONE EXCHANGE	[illegible]	[illegible]	[illegible]
4	TELEPHONE EXCHANGE	CHITAR OLI CHOWK	[illegible]	[illegible]	[illegible]
5	CHITAR OLI CHOWK	AGRASEN CHOWK	[illegible]	[illegible]	[illegible]
6	AGRASEN CHOWK	DOSER VAISYA CHOWK	[illegible]	[illegible]	[illegible]
7	DOSER VAISYA CHOWK	NAGPUR RAILWAY STATION	[illegible]	[illegible]	[illegible]
8	NAGPUR RAILWAY STATION	SITABURDI INTERCHANGE	[illegible]	[illegible]	[illegible]
9	SITABURDI INTERCHANGE	JHANSI RANI SQUARE	[illegible]	[illegible]	[illegible]
10	JHANSI RANI SQUARE	INSTITUTE OF ENGINEERS	[illegible]	[illegible]	[illegible]
11	INSTITUTE OF ENGINEERS	SHANKAR NAGAR SQUARE	[illegible]	[illegible]	[illegible]
12	SHANKAR NAGAR SQUARE	LAD CHOWK	[illegible]	[illegible]	[illegible]
13	LAD CHOWK	DHARAMPETH COLLEGE	[illegible]	[illegible]	[illegible]
14	DHARAMPETH COLLEGE	SUBHASH NAGAR	[illegible]	[illegible]	[illegible]
15	SUBHASH NAGAR	RACHANA RING ROAD JN.	[illegible]	[illegible]	[illegible]
16	RACHANA RING ROAD JN.	VASUDEV NAGAR	[illegible]	[illegible]	[illegible]
17	VASUDEV NAGAR	BANSI NAGAR	[illegible]	[illegible]	[illegible]
18	BANSI NAGAR	LOKMANYA NAGAR	[illegible]	[illegible]	[illegible]

Note: Reversal facility required at Agrasen Chowk and Subhash Nagar.

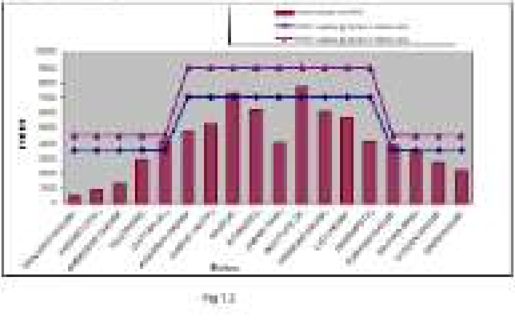

Fig 1.2

Attachment - [illegible]

PHPDT Demand and Capacity Chart

Nagpur Metro Rail Network

Line 1 : North - South Corridor

Year:	[illegible]
No. of Cars per Train:	[illegible]
Passenger Capacity @ [illegible] of a 3-Car Train:	[illegible]
Passenger Capacity @ [illegible] of a 3-Car Train:	[illegible]
Headway (min):	[illegible]
Headway (min):	[illegible]

S.N.	FROM	TO	Traffic Demand in PHPDT	PHPDT capacity @ [illegible]	PHPDT capacity @ [illegible]
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Note: [illegible] facility required at Congress Nagar.

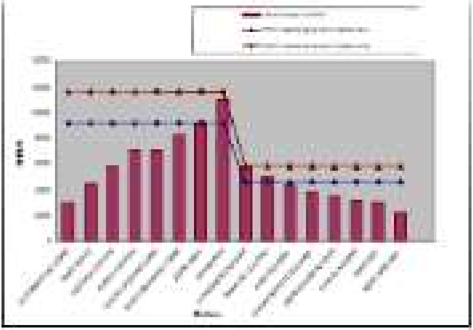

Fig [illegible]

Attachment - [illegible]

PHPDT Demand and Capacity Chart
Nagpur Metro Rail Network
Line 1 : East - West Corridor

Year	[illegible]
No. of Cars per Train	[illegible]
Passenger Capacity @ 6 persons/sqm of a 3-Car Train	[illegible]
Passenger Capacity @ 8 persons/sqm of a 3-Car Train	[illegible]
Headway (min)	[illegible]
Headway (min)	[illegible]

[illegible]

S.N.	FROM	TO	Traffic Demand in PHPDT	PHPDT capacity @ 6p/sqm of standee area	PHPDT Capacity @ 8p/sqm of standee area
1	PRAJAPATI NAGAR	VAISHNO DEVI CHOWK	[illegible]	[illegible]	[illegible]
2	VAISHNO DEVI CHOWK	AMBEDKAR CHOWK	[illegible]	[illegible]	[illegible]
3	AMBEDKAR CHOWK	TELEPHONE EXCHANGE	[illegible]	[illegible]	[illegible]
4	TELEPHONE EXCHANGE	CHITAR OLI CHOWK	[illegible]	[illegible]	[illegible]
5	CHITAR OLI CHOWK	AGRASEN CHOWK	[illegible]	[illegible]	[illegible]
6	AGRASEN CHOWK	[illegible] CHOWK	[illegible]	[illegible]	[illegible]
7	[illegible] CHOWK	NAGPUR RAILWAY STATION	[illegible]	[illegible]	[illegible]
8	NAGPUR RAILWAY STATION	SITABULDI - INTERCHANGE	[illegible]	[illegible]	[illegible]
9	SITABULDI INTERCHANGE	JHANSI RANI SQUARE	[illegible]	[illegible]	[illegible]
10	JHANSI RANI SQUARE	INSTITUTE OF ENGINEERS	[illegible]	[illegible]	[illegible]
11	INSTITUTE OF ENGINEERS	SHANKAR NAGAR SQUARE	[illegible]	[illegible]	[illegible]
12	SHANKAR NAGAR SQUARE	LAD CHOWK	[illegible]	[illegible]	[illegible]
13	LAD CHOWK	DHARAMPETH COLLEGE	[illegible]	[illegible]	[illegible]
14	DHARAMPETH COLLEGE	SUBHASH NAGAR	[illegible]	[illegible]	[illegible]
15	SUBHASH NAGAR	RACHNA RING ROAD JN	[illegible]	[illegible]	[illegible]
16	RACHNA RING ROAD JN	VASUDEV NAGAR	[illegible]	[illegible]	[illegible]
17	VASUDEV NAGAR	BANSI NAGAR	[illegible]	[illegible]	[illegible]
18	BANSI NAGAR	LOKMANYA NAGAR	[illegible]	[illegible]	[illegible]

Note: Reversal Facility required at Agrasen Chowk and Subhash Nagar

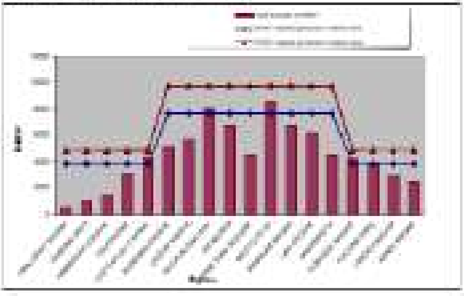

Fig 3.3

Annexure - 2.1

PHPDT Demand and Capacity Chart

Nagpur Metro Rail Network

Line 1 - North - South Corridor

Year	[illegible]
No. of Cars per Train	3
Passenger Capacity @ 6persons/sqm of a 3-Car Train	764
Passenger Capacity @ 8persons/sqm of a 3-Car Train	973
Headway (min)	4.5
Headway (min)	[illegible]

S.N	FROM	TO	Traffic Demand in PHPDT	PHPDT capacity @ 6p/sqm of standee area	PHPDT capacity @ 8p/sqm of standee area
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Note: Reversal facility required at Congress Nagar

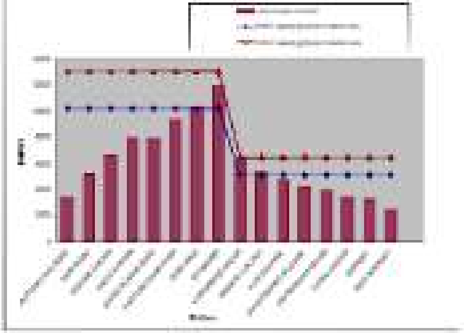

Fig 2.1

Annexure - [illegible]

PHPDT Demand and Capacity Chart
Nagpur Metro Rail Network

[illegible]

Year	[illegible]
No. of Cars per Train	[illegible]
Passenger Capacity @ [illegible]	[illegible]
Passenger Capacity @ [illegible]	[illegible]
Headway (min)	[illegible]
Headway (min)	[illegible]

S.N.	FROM	TO	Traffic Demand in PHPDT	PHPDT capacity @ [illegible]	PHPDT capacity @ [illegible]
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Note: [illegible]

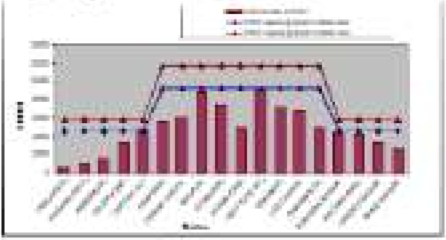

Fig. [illegible]

PHPDT Demand and Capacity Chart
Nagpur Metro Rail Network
Line 1 : North - South Corridor

Year	[illegible]
No. of Cars per Train	3
Passenger Capacity @ 6 persons/sqm of a 3-Car Train	[illegible]
Passenger Capacity @ 8 persons/sqm of a 3-Car Train	[illegible]
Headway (min)	4
Headway (min)	8

S.N.	FROM	TO	Traffic Demand (in PHPDT)	PHPDT capacity @ 6p/sqm of standee area	PHPDT capacity @ 8p/sqm of standee area
1	AUTOMOTIVE SQUARE	NARI ROAD	[illegible]	11460	14595
2	NARI ROAD	INDORA CHOWK	[illegible]	11460	14595
3	INDORA CHOWK	KADVI CHOWK	[illegible]	11460	14595
4	KADVI CHOWK	GADDI GODAM SQUARE	[illegible]	11460	14595
5	GADDI GODAM SQUARE	KASTURCHAND PARK	[illegible]	11460	14595
6	KASTURCHAND PARK	ZERO MILE	[illegible]	11460	14595
7	ZERO MILE	SITABULDI	[illegible]	11460	14595
8	SITABULDI	CONGRESS NAGAR	[illegible]	11460	14595
9	CONGRESS NAGAR	RAHATE COLONY	[illegible]	5730	7298
10	RAHATE COLONY	AJNI SQUARE	[illegible]	5730	7298
11	AJNI SQUARE	CHHATRAPATI SQUARE	[illegible]	5730	7298
12	CHHATRAPATI SQUARE	JAIPRAKASH NAGAR	[illegible]	5730	7298
13	JAIPRAKASH NAGAR	UJWAL NAGAR	[illegible]	5730	7298
14	UJWAL NAGAR	AIRPORT	[illegible]	5730	7298
15	AIRPORT	NEW AIRPORT	[illegible]	5730	7298
16	NEW AIRPORT	MIHAN	[illegible]	5730	7298

Note: Reversal facility required at Congress Nagar

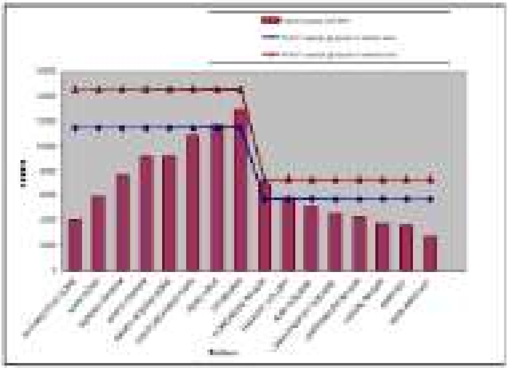

Fig [illegible]

Attachment - [illegible]

PHPDT Demand and Capacity Chart
Nagpur Metro Rail Network
Line 2 : East - West Corridor

Year	[illegible]
No. of Cars per Train	3
Passenger Capacity @ 6 persons/sqm of a 3-Car Train	[illegible]
Passenger Capacity @ 8 persons/sqm of a 3-Car Train	[illegible]
Headway (min)	4.5
Headway (min)	8

S.N	FROM	TO	Traffic Demand in PHPDT	PHPDT Capacity @ 6p/sqm of standee area	PHPDT Capacity @ 8p/sqm of standee area
1	PRAJAPATI NAGAR	VAISHNO DEVI CHOWK	[illegible]	[illegible]	[illegible]
2	VAISHNO DEVI CHOWK	AMBEDKAR CHOWK	[illegible]	[illegible]	[illegible]
3	AMBEDKAR CHOWK	TELEPHONE EXCHANGE	[illegible]	[illegible]	[illegible]
4	TELEPHONE EXCHANGE	CHITTAR OLI CHOWK	[illegible]	[illegible]	[illegible]
5	CHITTAR OLI CHOWK	AGRASEN CHOWK	[illegible]	[illegible]	[illegible]
6	AGRASEN CHOWK	DOSAR VAISYA CHOWK	[illegible]	[illegible]	[illegible]
7	DOSAR VAISYA CHOWK	NAGPUR RAILWAY STATION	[illegible]	[illegible]	[illegible]
8	NAGPUR RAILWAY STATION	SITABULDI (INTERCHANGE)	[illegible]	[illegible]	[illegible]
9	SITABULDI (INTERCHANGE)	JHANSI RANI SQUARE	[illegible]	[illegible]	[illegible]
10	JHANSI RANI SQUARE	INSTITUTE OF ENGINEERS	[illegible]	[illegible]	[illegible]
11	INSTITUTE OF ENGINEERS	SHANKAR NAGAR SQUARE	[illegible]	[illegible]	[illegible]
12	SHANKAR NAGAR SQUARE	LAD CHOWK	[illegible]	[illegible]	[illegible]
13	LAD CHOWK	DHARAMPETH COLLEGE	[illegible]	[illegible]	[illegible]
14	DHARAMPETH COLLEGE	SUBHASH NAGAR	[illegible]	[illegible]	[illegible]
15	SUBHASH NAGAR	RACHNA (RING ROAD JN)	[illegible]	[illegible]	[illegible]
16	RACHNA (RING ROAD JN)	VASUDEV NAGAR	[illegible]	[illegible]	[illegible]
17	VASUDEV NAGAR	BANSI NAGAR	[illegible]	[illegible]	[illegible]
18	BANSI NAGAR	LOKMANYA NAGAR	[illegible]	[illegible]	[illegible]

Note: Reversal facility required at Agrasen Chowk and Subhash Nagar.

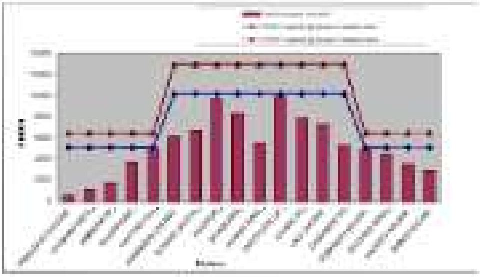

Fig 4.2

PHPDT Demand and Capacity Chart
Nagpur Metro Rail Network
Line 1 : North - South Corridor

Year	2028
No. of Cars per Train	3
Passenger Capacity @ 6 persons/sqm of a 3-Car Train	758
Passenger Capacity @ 8 persons/sqm of a 3-Car Train	973
Headway (min)	3.5
Headway (min)	7

(= Automotive Sq. to Congress Nagar Section)

(= Congress Nagar to Khapri Section)

S.N.	FROM	TO	Traffic Demand in PHPDT	PHPDT capacity @ 6p/sqm of standee area	PHPDT capacity @ 8p/sqm of standee area
1	AUTOMOTIVE SQRE	NARI ROAD	4611	12995	16680
2	NARI ROAD	INDORA CHOWK	6702	12995	16680
3	INDORA CHOWK	KADVI CHOWK	8609	12995	16680
4	KADVI CHOWK	GADDI GODAM SQRE	10333	12995	16680
5	GADDI GODAM SQRE	KASTURCHAND PARK	10322	12995	16680
6	KASTURCHAND PARK	ZERO MILE	12113	12995	16680
7	ZERO MILE	SITABURDI	13003	12995	16680
8	SITABURDI	CONGRESS NAGAR	14289	12995	16680
9	CONGRESS NAGAR	RAHATE COLONY	7555	6498	8340
10	RAHATE COLONY	AJNI SQUARE	6476	6498	8340
11	AJNI SQUARE	CHHATRAPATI SQUARE	5627	6498	8340
12	CHHATRAPATI SQUARE	JAIPRAKASH NAGAR	5070	6498	8340
13	JAIPRAKASH NAGAR	UJWAL NAGAR	4850	6498	8340
14	UJWAL NAGAR	AIRPORT	4177	6498	8340
15	AIRPORT	NEW AIRPORT	3976	6498	8340
16	NEW AIRPORT	KHAPRI	3040	6498	8340

Note: Reversal facility required at Congress Nagar

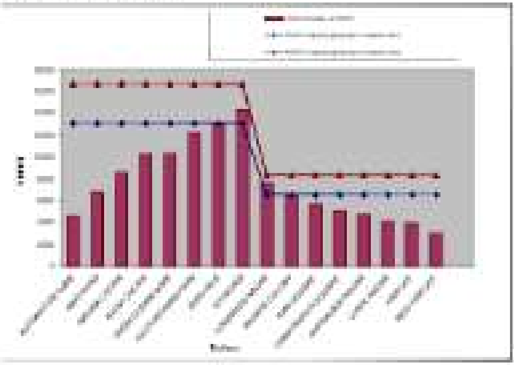

Fig 5.1

PHPDT Demand and Capacity Chart
Nagpur Metro Rail Network
Line 2 : East - West Corridor

Year	[illegible]
No. of Cars per Train	[illegible]
Passenger Capacity @ 6 persons/sqm of a 3-Car Train	[illegible]
Passenger Capacity @ 8 persons/sqm of a 3-Car Train	[illegible]
Headway (min)	[illegible]
Headway (min)	[illegible]

S.N.	FROM	TO	Traffic Demand in PHPDT	PHPDT capacity @ 6 pass/sqm of standee area	PHPDT capacity @ 8 pass/sqm of standee area
1	PRAJAPATI NAGAR	VAISHNO DEVI CHOWK	[illegible]	[illegible]	[illegible]
2	VAISHNO DEVI CHOWK	AMBEDKAR CHOWK	[illegible]	[illegible]	[illegible]
3	AMBEDKAR CHOWK	TELEPHONE EXCHANGE	[illegible]	[illegible]	[illegible]
4	TELEPHONE EXCHANGE	CHITTAR OLI CHOWK	[illegible]	[illegible]	[illegible]
5	CHITTAR OLI CHOWK	AGRASEN CHOWK	[illegible]	[illegible]	[illegible]
6	AGRASEN CHOWK	DOSAR VAISYA CHOWK	[illegible]	[illegible]	[illegible]
7	DOSAR VAISYA CHOWK	NAGPUR RAILWAY STATION	[illegible]	[illegible]	[illegible]
8	NAGPUR RAILWAY STATION	SITABURDI INTERCHANGE	[illegible]	[illegible]	[illegible]
9	SITABURDI INTERCHANGE	JHANSI RANI SQUARE	[illegible]	[illegible]	[illegible]
10	JHANSI RANI SQUARE	INSTITUTE OF ENGINEERS	[illegible]	[illegible]	[illegible]
11	INSTITUTE OF ENGINEERS	SHANKAR NAGAR SQUARE	[illegible]	[illegible]	[illegible]
12	SHANKAR NAGAR SQUARE	LAD CHOWK	[illegible]	[illegible]	[illegible]
13	LAD CHOWK	DHARAMPETH COLLEGE	[illegible]	[illegible]	[illegible]
14	DHARAMPETH COLLEGE	SUBHASH NAGAR	[illegible]	[illegible]	[illegible]
15	SUBHASH NAGAR	RACHNA RING ROAD JN	[illegible]	[illegible]	[illegible]
16	RACHNA RING ROAD JN	VASUDEV NAGAR	[illegible]	[illegible]	[illegible]
17	VASUDEV NAGAR	BANSI NAGAR	[illegible]	[illegible]	[illegible]
18	BANSI NAGAR	LOKMANYA NAGAR	[illegible]	[illegible]	[illegible]

Note: Reversal facility required at Agrasen Chowk and Subhash Nagar

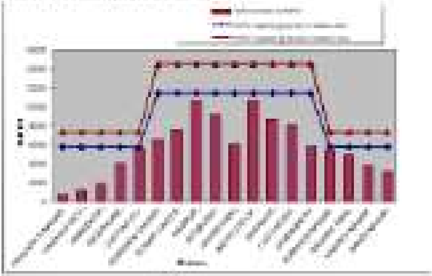

Fig 5.2

Annexure - IP1

PHPDT Demand and Capacity Chart

Nagpur Metro Rail Network

Line 1 - North - South Corridor

Year:	2011
No. of Cars per Train:	3
Passenger Capacity @ 6 persons/sqm of a 3-Car Train:	764
Passenger Capacity @ 8 persons/sqm of a 3-Car Train:	873
Headway (min):	3
Headway (min):	6

(for Automotive Square to Congress Nagar Section)

(for Congress Nagar to Khapri Section)

S.N	FROM	TO	Traffic Demand in PHPDT	PHPDT capacity @ 6p/sqm of standing area	PHPDT capacity @ 8p/sqm of standing area
1	AUTOMOTIVE SQUARE	NARI ROAD	[illegible]	15280	17460
2	NARI ROAD	INDORA SQUARE	[illegible]	15280	17460
3	INDORA SQUARE	KADVI CHOWK	[illegible]	15280	17460
4	KADVI CHOWK	GADDI GODAM SQUARE	[illegible]	15280	17460
5	GADDI GODAM SQUARE	KASTURCHAND PARK	[illegible]	15280	17460
6	KASTURCHAND PARK	ZERO MILE	[illegible]	15280	17460
7	ZERO MILE	SITABURDI	[illegible]	15280	17460
8	SITABURDI	CONGRESS NAGAR	[illegible]	15280	17460
9	CONGRESS NAGAR	RAHATE COLONY	[illegible]	7640	8730
10	RAHATE COLONY	AJNI SQUARE	[illegible]	7640	8730
11	AJNI SQUARE	CHHATRAPATI SQUARE	[illegible]	7640	8730
12	CHHATRAPATI SQUARE	JAIPRAKASH NAGAR	[illegible]	7640	8730
13	JAIPRAKASH NAGAR	UJWAL NAGAR	[illegible]	7640	8730
14	UJWAL NAGAR	AIRPORT	[illegible]	7640	8730
15	AIRPORT	NEW AIRPORT	[illegible]	7640	8730
16	NEW AIRPORT	KHAPRI	[illegible]	7640	8730

Note: Turnback facility required at Congress Nagar

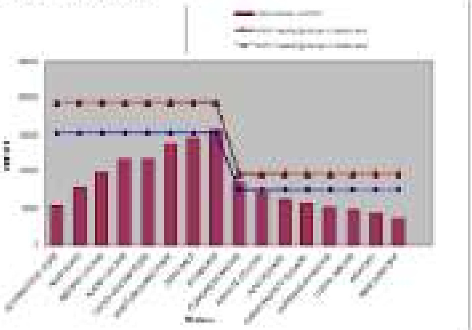

Fig [illegible]

Attachment - [illegible]

PHPDT Demand and Capacity Chart

Nagpur Metro Rail Network

Line 2 : East – West Corridor

Year	[illegible]
No. of Cars per Train	[illegible]
Passenger Capacity @ 6 persons/sqm of a 3-Car Train	[illegible]
Passenger Capacity @ 8 persons/sqm of a 3-Car Train	[illegible]
Headway (min)	[illegible]
Headway (min)	[illegible]

S.N	FROM	TO	Traffic Demand in PHPDT	PHPDT capacity @ 6p/sqm of standee area	PHPDT capacity @ 8p/sqm of standee area
1	PRAJAPATI NAGAR	VAISHNO DEVI CHOWK	[illegible]	[illegible]	[illegible]
2	VAISHNO DEVI CHOWK	AMBEDKAR CHOWK	[illegible]	[illegible]	[illegible]
3	AMBEDKAR CHOWK	TELEPHONE EXCHANGE	[illegible]	[illegible]	[illegible]
4	TELEPHONE EXCHANGE	CHITTAR OLI CHOWK	[illegible]	[illegible]	[illegible]
5	CHITTAR OLI CHOWK	AGRASEN CHOWK	[illegible]	[illegible]	[illegible]
6	AGRASEN CHOWK	DOSAR VAISYA CHOWK	[illegible]	[illegible]	[illegible]
7	DOSAR VAISYA CHOWK	NAGPUR RAILWAY STATION	[illegible]	[illegible]	[illegible]
8	NAGPUR RAILWAY STATION	SITABURDI INTERCHANGE	[illegible]	[illegible]	[illegible]
9	SITABURDI INTERCHANGE	JHANSI RANI SQUARE	[illegible]	[illegible]	[illegible]
10	JHANSI RANI SQUARE	INSTITUTE OF ENGINEERS	[illegible]	[illegible]	[illegible]
11	INSTITUTE OF ENGINEERS	SHANKAR NAGAR SQUARE	[illegible]	[illegible]	[illegible]
12	SHANKAR NAGAR SQUARE	LAD CHOWK	[illegible]	[illegible]	[illegible]
13	LAD CHOWK	DHARAMPETH COLLEGE	[illegible]	[illegible]	[illegible]
14	DHARAMPETH COLLEGE	SUBHASH NAGAR	[illegible]	[illegible]	[illegible]
15	SUBHASH NAGAR	RACHANA RING ROAD JN.	[illegible]	[illegible]	[illegible]
16	RACHANA RING ROAD JN.	VASUDEV NAGAR	[illegible]	[illegible]	[illegible]
17	VASUDEV NAGAR	BANSI NAGAR	[illegible]	[illegible]	[illegible]
18	BANSI NAGAR	LOKMANYA NAGAR	[illegible]	[illegible]	[illegible]

Note: Reversal facility required at Agrasen Chowk and Subhash Nagar

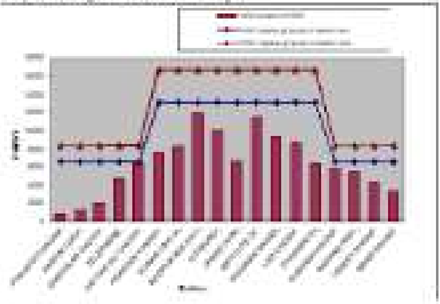

Fig 6.2

Attachment 6

Nagpur Metro Rail Network

Line 1 : North - South Corridor

TABLE 1.1 A

Hourly Train Operation Plan for AUTOMOTIVE SQRE to CONGRESS NAGAR

Year: 2016

Configuration: 3 Car

Headway(min): 6

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	24	3	2
6 to 7	20	3	3
7 to 8	10	6	6
8 to 9	6	10	10
9 to 10	6	10	10
10 to 11	6	10	10
11 to12	10	6	6
12 to 13	20	3	3
13 to 14	24	3	2
14 to 15	24	2	3
15 to 16	20	3	3
16 to 17	10	6	6
17 to 18	6	10	10
18 to 19	6	10	10
19 to 20	6	10	10
20 to 21	10	6	6
21 to 22	20	3	3
22 to 23	24	2	3
23 to 24	30	2	2
Total No. of train trips per direction per day		108	108

Attachment I

Nagpur Metro Rail Network

Line 1 : North - South Corridor

TABLE 1.2 A

Hourly Train Operation Plan for AUTOMOTIVE SQRE to CONGRESS NAGAR

Year: 2021

Configuration: 3 Car

Headway(min): 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	8	8	7
8 to 9	5	12	12
9 to 10	5	12	12
10 to 11	5	12	12
11 to12	8	7	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	7
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		138	138

Attachment 6

Nagpur Metro Rail Network

Line 1 : North - South Corridor

TABLE 1.3 A

Hourly Train Operation Plan for AUTOMOTIVE SQRE to CONGRESS NAGAR

Year: 2026

Configuration: 3 Car

Headway(min): 4.5

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	16	3	4
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	4	3
23 to 24	20	3	3
Total No. of train trips per direction per day		158	158

Attachment I

Nagpur Metro Rail Network

Line 1 : North - South Corridor

TABLE 1.4 A

Hourly Train Operation Plan for AUTOMOTIVE SQRE to CONGRESS NAGAR

Year: 2031

Configuration: 3 Car

Headway(min): 4

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

Attachment II

Nagpur Metro Rail Network

Line 1 : North - South Corridor

TABLE 1.5 A

Hourly Train Operation Plan for AUTOMOTIVE SQRE to CONGRESS NAGAR

Year: 2026

Configuration: 3 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

Nagpur Metro Rail Network

Line 1 : North - South Corridor

TABLE 1.6 A

Hourly Train Operation Plan for AUTOMOTIVE SQRE to CONGRESS NAGAR

Year: 2041

Configuration: 3 Car

Headway(min): 3

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	12	5	5
6 to 7	10	6	6
7 to 8	5	12	12
8 to 9	3	20	20
9 to 10	3	20	20
10 to 11	3	20	20
11 to12	5	12	12
12 to 13	10	6	6
13 to 14	12	5	5
14 to 15	12	5	5
15 to 16	10	6	6
16 to 17	5	12	12
17 to 18	3	20	20
18 to 19	3	20	20
19 to 20	3	20	20
20 to 21	5	12	12
21 to 22	10	6	6
22 to 23	12	5	5
23 to 24	15	4	4
Total No. of train trips per direction per day		216	216

Attachment II

Nagpur Metro Rail Network

Line 1 : North - South Corridor

TABLE 1.1 B

Hourly Train Operation Plan for CONGRESS NAGAR to KHAPARI

Year: 2016

Configuration: 3 Car

Headway(min): 12

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	45	1	1
6 to 7	40	2	1
7 to 8	20	3	3
8 to 9	12	5	5
9 to 10	12	5	5
10 to 11	12	5	5
11 to12	20	3	3
12 to 13	40	1	2
13 to 14	45	1	2
14 to 15	45	2	1
15 to 16	40	2	1
16 to 17	20	3	3
17 to 18	12	5	5
18 to 19	12	5	5
19 to 20	12	5	5
20 to 21	20	3	3
21 to 22	40	1	2
22 to 23	45	1	1
23 to 24	60	1	1
Total No. of train trips per direction per day		54	54

Attachment II

Nagpur Metro Rail Network

Line 1 : North - South Corridor

TABLE 1.2 B

Hourly Train Operation Plan for CONGRESS NAGAR to KHAPARI

Year: 2021

Configuration: 3 Car

Headway(min): 10

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	16	4	3
8 to 9	10	6	6
9 to 10	10	6	6
10 to 11	10	6	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	10	6	6
18 to 19	10	6	6
19 to 20	10	6	6
20 to 21	16	3	4
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		69	69

Attachment II

Nagpur Metro Rail Network

Line 1 : North - South Corridor

TABLE 1.3 B

Hourly Train Operation Plan for CONGRESS NAGAR to KHAPARI

Year: 2026

Configuration: 3 Car

Headway(min): 3

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	32	2	2
6 to 7	24	3	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

Nagpur Metro Rail Network

Line 1 : North - South Corridor

TABLE 1.4 B

Hourly Train Operation Plan for CONGRESS NAGAR to KHAPARI

Year: 2031

Configuration: 3 Car

Headway(min): 8

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	32	2	2
6 to 7	24	3	2
7 to 8	12	5	5
8 to 9	8	7	8
9 to 10	8	8	7
10 to 11	8	7	8
11 to12	12	5	5
12 to 13	24	2	3
13 to 14	32	2	1
14 to 15	32	1	2
15 to 16	24	3	2
16 to 17	12	5	5
17 to 18	8	8	7
18 to 19	8	7	8
19 to 20	8	8	7
20 to 21	12	5	5
21 to 22	24	2	3
22 to 23	32	2	2
23 to 24	40	2	2
Total No. of train trips per direction per day		84	84

Attachment II

Nagpur Metro Rail Network

Line 1 : North - South Corridor

TABLE 1.5 B

Hourly Train Operation Plan for CONGRESS NAGAR to KHAPARI

Year: 2036

Configuration: 3 Car

Headway(min): 7

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	7	8	9
9 to 10	7	9	9
10 to 11	7	8	9
11 to12	10	6	6
12 to 13	20	3	3
13 to 14	24	2	3
14 to 15	24	3	2
15 to 16	20	3	3
16 to 17	10	6	6
17 to 18	7	9	8
18 to 19	7	9	9
19 to 20	7	9	8
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		100	100

Attachment II

Nagpur Metro Rail Network

Line 1 : North - South Corridor

TABLE 1.6 B

Hourly Train Operation Plan for CONGRESS NAGAR to KHAPARI

Year: 2041

Configuration: 3 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 8

Nagpur Metro Rail Network

Line 2 : East - West Corridor

TABLE 1.7 A

Hourly Train Operation Plan for PRAJAPATI NAGAR to AGARSEN CHOWK

Year: 2016

Configuration: 3 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**	**4**	**5**
9 to 10	**13**	**5**	**4**
10 to 11	**13**	**4**	**5**
11 to 12	20	3	3
12 to 13	40	1	2
13 to 14	48	1	2
14 to 15	48	2	1
15 to 16	40	2	1
16 to 17	20	3	3
17 to 18	**13**	**5**	**4**
18 to 19	**13**	**4**	**5**
19 to 20	**13**	**5**	**4**
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		51	51

TABLE 1.8 A

Hourly Train Operation Plan for PRAJAPATI NAGAR to AGARSEN CHOWK

Year: 2021

Configuration: 3 Car

Headway(min): 12

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	48	1	1
6 to 7	40	2	1
7 to 8	20	3	3
8 to 9	**12**	**5**	**5**
9 to 10	**12**	**5**	**5**
10 to 11	**12**	**5**	**5**
11 to12	20	3	3
12 to 13	40	1	2
13 to 14	48	2	1
14 to 15	48	1	2
15 to 16	40	2	1
16 to 17	20	3	3
17 to 18	**12**	**5**	**5**
18 to 19	**12**	**5**	**5**
19 to 20	**12**	**5**	**5**
20 to 21	20	3	3
21 to 22	40	1	2
22 to 23	48	1	1
23 to 24	60	1	1
Total No. of train trips per direction per day		**54**	**54**

TABLE 1.9 A

Hourly Train Operation Plan for PRAJAPATI NAGAR to AGARSEN CHOWK

Year: 2026

Configuration: 3 Car

Headway(min): 10

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	16	4	3
8 to 9	10	6	6
9 to 10	10	6	6
10 to 11	10	6	6
11 to12	16	4	3
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	16	3	4
17 to 18	10	6	6
18 to 19	10	6	6
19 to 20	10	6	6
20 to 21	16	3	4
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		70	70

Attachment 8

TABLE 1.10 A

Hourly Train Operation Plan for PRAJAPATI NAGAR to AGARSEN CHOWK

Year: 2031

Configuration: 3 Car

Headway(min): 9

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	32	1	2
6 to 7	24	3	2
7 to 8	12	5	5
8 to 9	9	6	6
9 to 10	9	6	6
10 to 11	9	6	6
11 to12	12	5	5
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	12	5	5
17 to 18	9	6	6
18 to 19	9	6	6
19 to 20	9	6	6
20 to 21	12	5	5
21 to 22	24	3	3
22 to 23	32	2	1
23 to 24	40	2	2
Total No. of train trips per direction per day		74	74

Attachment 8

TABLE 1.11 A

Hourly Train Operation Plan for PRAJAPATI NAGAR to AGARSEN CHOWK

Year: 2036

Configuration: 3 Car

Headway(min): 8

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	8	7	8
9 to 10	8	8	7
10 to 11	8	7	8
11 to12	12	5	5
12 to 13	24	2	3
13 to 14	32	1	2
14 to 15	32	2	1
15 to 16	24	3	2
16 to 17	12	5	5
17 to 18	8	8	7
18 to 19	8	7	8
19 to 20	8	8	7
20 to 21	12	5	5
21 to 22	24	2	3
22 to 23	32	1	2
23 to 24	40	2	2
Total No. of train trips per direction per day		83	83

Attachment [illegible]

TABLE 1.12 A

Hourly Train Operation Plan for PRAJAPATI NAGAR to AGARSEN CHOWK

Year: 2041

Configuration: 3 Car

Headway(min): 7

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	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	2
23 to 24	30	2	2
Total No. of train trips per direction per day		99	99

Attachment 9

Nagpur Metro Rail Network

Line 2 : East - West Corridor

TABLE 1.7 B

Hourly Train Operation Plan for AGARSEN CHOWK to SUBHASH NAGAR

Year: 2016

Configuration: 3 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**	**9**
9 to 10	**6.5**	**9**	**9**
10 to 11	**6.5**	**9**	**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	**6.5**	**9**	**9**
18 to 19	**6.5**	**9**	**9**
19 to 20	**6.5**	**9**	**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		102	102

Attachment 8

TABLE 1.8 B

Hourly Train Operation Plan for AGARSEN CHOWK to SUBHASH NAGAR

Year: 2021

Configuration: 3 Car

Headway(min): 6

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	24	3	2
6 to 7	20	3	3
7 to 8	10	6	6
8 to 9	6	10	10
9 to 10	6	10	10
10 to 11	6	10	10
11 to 12	10	6	6
12 to 13	20	3	3
13 to 14	24	3	2
14 to 15	24	2	3
15 to 16	20	3	3
16 to 17	10	6	6
17 to 18	6	10	10
18 to 19	6	10	10
19 to 20	6	10	10
20 to 21	10	6	6
21 to 22	20	3	3
22 to 23	24	2	3
23 to 24	30	2	2
Total No. of train trips per direction per day		108	108

TABLE 1.3 B

Hourly Train Operation Plan for AGAR SEN CHOWK to SUBHASH NAGAR

Year: 2026

Configuration: 3 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	6	7
8 to 9	**5**	**12**	**12**
9 to 10	**5**	**12**	**12**
10 to 11	**5**	**12**	**12**
11 to12	8	6	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	6
17 to 18	**5**	**12**	**12**
18 to 19	**5**	**12**	**12**
19 to 20	**5**	**12**	**12**
20 to 21	8	7	6
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

TABLE 1.16 B

Hourly Train Operation Plan for AGARSEN CHOWK to SUBHASH NAGAR

Year: 2031

Configuration: 3 Car

Headway(min): 4.5

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	16	3	4
6 to 7	12	5	5
7 to 8	6	10	10
8 to 9	**4.5**	**14**	**13**
9 to 10	**4.5**	**13**	**14**
10 to 11	**4.5**	**14**	**13**
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**	**13**	**14**
18 to 19	**4.5**	**14**	**13**
19 to 20	**4.5**	**13**	**14**
20 to 21	6	10	10
21 to 22	12	5	5
22 to 23	16	4	3
23 to 24	20	3	3
Total No. of train trips per direction per day		168	168

TABLE 1.11 B

Hourly Train Operation Plan for AGARSEN CHOWK to SUBHASH NAGAR

Year: 2036

Configuration: 3 Car

Headway(min): 4

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	16	3	3
6 to 7	12	5	5
7 to 8	6	10	10
8 to 9	4	15	15
9 to 10	4	15	15
10 to 11	4	15	15
11 to12	6	10	10
12 to 13	12	5	5
13 to 14	16	4	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	3	3
23 to 24	20	3	3
Total No. of train trips per direction per day		166	166

Attachment 8

TABLE 1.12 B

Hourly Train Operation Plan for AGARSEN CHOWK to SUBHASH NAGAR

Year: 2041

Configuration: 3 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	17
9 to 10	3.5	17	17
10 to 11	3.5	17	17
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	17	17
18 to 19	3.5	17	17
19 to 20	3.5	17	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		198	198

Attachment 8

Nagpur Metro Rail Network

Line 2 : East - West Corridor

TABLE 1.7 C

Hourly Train Operation Plan for SUBHASH NAGAR to LOKMANYA NAGAR

Year: 2016

Configuration: 3 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	4	5
9 to 10	13	5	4
10 to 11	13	4	5
11 to 12	20	3	3
12 to 13	40	1	2
13 to 14	48	1	2
14 to 15	48	2	1
15 to 16	40	2	1
16 to 17	20	3	3
17 to 18	13	5	4
18 to 19	13	4	5
19 to 20	13	5	4
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		51	51

Attachment 8

TABLE 1.8 C

Hourly Train Operation Plan for SUBHASH NAGAR to LOKMANYA NAGAR

Year: 2021

Configuration: 3 Car

Headway(min): 12

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	48	1	1
6 to 7	40	2	1
7 to 8	20	3	3
8 to 9	**12**	**5**	**5**
9 to 10	**12**	**5**	**5**
10 to 11	**12**	**5**	**5**
11 to12	20	3	3
12 to 13	40	1	2
13 to 14	48	2	1
14 to 15	48	1	2
15 to 16	40	2	1
16 to 17	20	3	3
17 to 18	**12**	**5**	**5**
18 to 19	**12**	**5**	**5**
19 to 20	**12**	**5**	**5**
20 to 21	20	3	3
21 to 22	40	1	2
22 to 23	48	1	1
23 to 24	60	1	1
Total No. of train trips per direction per day		**54**	**54**

Attachment [illegible]

TABLE 1.5 C

Hourly Train Operation Plan for SUBHASH NAGAR to LOKMANYA NAGAR

Year: 2026

Configuration: 3 Car

Headway(min): 10

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	16	4	3
8 to 9	10	6	6
9 to 10	10	6	6
10 to 11	10	6	6
11 to12	16	4	3
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	16	3	4
17 to 18	10	6	6
18 to 19	10	6	6
19 to 20	10	6	6
20 to 21	16	3	4
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		70	70

Attachment 8

TABLE 1.10 C

Hourly Train Operation Plan for SUBHASH NAGAR to LOKMANYA NAGAR

Year: 2031

Configuration: 3 Car

Headway(min): 5

Time of Day	Headway in Minutes	No. of Trains per day	
		UP	DN
5 to 6	32	1	2
6 to 7	24	3	2
7 to 8	12	5	5
8 to 9	**9**	**6**	**6**
9 to 10	**9**	**6**	**6**
10 to 11	**9**	**6**	**6**
11 to12	12	5	5
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	12	5	5
17 to 18	**9**	**6**	**6**
18 to 19	**9**	**6**	**6**
19 to 20	**9**	**6**	**6**
20 to 21	12	5	5
21 to 22	24	2	3
22 to 23	32	2	1
23 to 24	40	2	2
Total No. of train trips per direction per day		74	74

Attachment 8

TABLE 1.11 C

Hourly Train Operation Plan for SUBHASH NAGAR to LOKMANYA NAGAR

Year: 2036

Configuration: 3 Car

Headway(min): 8

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	6	6
8 to 9	8	7	8
9 to 10	8	8	7
10 to 11	8	7	8
11 to12	12	5	5
12 to 13	24	2	3
13 to 14	32	1	2
14 to 15	32	2	1
15 to 16	24	3	2
16 to 17	12	5	5
17 to 18	8	8	7
18 to 19	8	7	8
19 to 20	8	8	7
20 to 21	12	5	5
21 to 22	24	2	3
22 to 23	32	1	2
23 to 24	40	2	2
Total No. of train trips per direction per day		83	83

TABLE 1.12 C

Hourly Train Operation Plan for SUBHASH NAGAR to LOKMANYA NAGAR

Year: 2041

Configuration: 3 Car

Headway(min): 7

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	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	2
23 to 24	30	2	2
Total No. of train trips per direction per day		99	99

[illegible]

TABLE 2.1

Line 1 : North - South Corridor

PHPDT for the Year [illegible]

S.No	From Station	To Station	Maximum PHPDT	Unidirectional Split to KHAPRI	Unidirectional Split to AUTOMOTIVE SQUARE
1	AUTOMOTIVE SQUARE	NARI ROAD	[illegible]	50%	50%
2	NARI ROAD	INDORA CHOWK	[illegible]	50%	50%
3	INDORA CHOWK	KADVI CHOWK	[illegible]	50%	50%
4	KADVI CHOWK	GADDI GODAM SQURE	[illegible]	50%	50%
5	GADDI GODAM SQURE	KASTURCHAND PARK	[illegible]	50%	50%
6	KASTURCHAND PARK	ZERO MILE	[illegible]	50%	50%
7	ZERO MILE	SITABULDI	[illegible]	50%	50%
8	SITABULDI	CONGRESS NAGAR	[illegible]	50%	50%
9	CONGRESS NAGAR	RAHATE COLONY	[illegible]	50%	50%
10	RAHATE COLONY	AJNI SQUARE	[illegible]	50%	50%
11	AJNI SQUARE	CHHATRAPATI SQUARE	[illegible]	50%	50%
12	CHHATRAPATI SQUARE	JAIPRAKASH NAGAR	[illegible]	50%	50%
13	JAIPRAKASH NAGAR	UJWAL NAGAR	[illegible]	50%	50%
14	UJWAL NAGAR	AIRPORT	[illegible]	50%	50%
15	AIRPORT	NEW AIRPORT	[illegible]	50%	50%
16	NEW AIRPORT	KHAPRI	[illegible]	50%	50%

TABLE 2.2

Line 2 : East - West Corridor

PHPDT for the Year [illegible]

S.No	From Station	To Station	Maximum PHPDT	Unidirectional Split to LOKMANYA NAGAR	Unidirectional Split to PRAJAPATI NAGAR
1	PRAJAPATI NAGAR	VAISHNO DEVI CHOWK	[illegible]	50%	50%
2	VAISHNO DEVI CHOWK	AMBEDKAR CHOWK	[illegible]	50%	50%
3	AMBEDKAR CHOWK	TELEPHONE EXCHANGE	[illegible]	50%	50%
4	TELEPHONE EXCHANGE	CHITAR OLI CHOWK	[illegible]	50%	50%
5	CHITAR OLI CHOWK	AGRASEN CHOWK	[illegible]	50%	50%
6	AGRASEN CHOWK	DOSAR VAISHA CHOWK	[illegible]	50%	50%
7	DOSAR VAISHA CHOWK	NAGPUR RAILWAY STATION	[illegible]	50%	50%
8	NAGPUR RAILWAY STATION	SITABULDI (INTERCHANGE)	[illegible]	50%	50%
9	SITABULDI (INTERCHANGE)	JHANSI RANI SQUARE	[illegible]	50%	50%
10	JHANSI RANI SQUARE	INSTITUTE OF ENGINEERS	[illegible]	50%	50%
11	INSTITUTE OF ENGINEERS	SHANKAR NAGAR SQUARE	[illegible]	50%	50%
12	SHANKAR NAGAR SQUARE	LAD CHOWK	[illegible]	50%	50%
13	LAD CHOWK	DHARAMPETH COLLEGE	[illegible]	50%	50%
14	DHARAMPETH COLLEGE	SUBHASH NAGAR	[illegible]	50%	50%
15	SUBHASH NAGAR	RACHANA RING ROAD JN.	[illegible]	50%	50%
16	RACHANA RING ROAD JN.	VASUDEV NAGAR	[illegible]	50%	50%
17	VASUDEV NAGAR	BANSI NAGAR	[illegible]	50%	50%
18	BANSI NAGAR	LOKMANYA NAGAR	[illegible]	50%	50%

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]	[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	**[illegible]**	**[illegible]**	**[illegible]**	**[illegible]**	**[illegible]**	**[illegible]**	**[illegible]**	**[illegible]**	**[illegible]**	**[illegible]**	**[illegible]**	**[illegible]**

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]	[illegible]				[illegible]				[illegible]			[illegible]			[illegible]		[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Rake Requirement

Nagpur Metro Rail Network

Line 1 : North - South Corridor Year : 2018

Section	Distance (kms)	Schedule Speed in km/ph	Headway (min)	Rake Requirement: Bare	Traffic Reserve	R&M	Total No of Rakes	No. of Cars per rake	No. of Cars
Automotive Sqre to Khapari	19.48	34.00	11	8	1	1	8	3	24
Automotive Sqre to Congress Nagar	7.92	33.00	11	3	0	0	3	3	9
				11	1	1	11		33

Note: Reversal facility required at Congress Nagar.

Above with Operation resulting in:

Section	Effective headway	No. of Rakes	No. of Car
Automotive Sqre to Congress Nagar	5	11 Rakes of 3 cars	33
Congress Nagar to Khapari	10		
Total Turn Round Time(mins)	2		

Line 1 : North - South Corridor Year : 2021

Section	Distance (kms)	Schedule Speed in km/ph	Headway (min)	Rake Requirement: Bare	Traffic Reserve	R&M	Total No of Rakes	No. of Cars per rake	No. of Cars
Automotive Sqre to Khapari	19.48	34.00	10	7	1	1	9	3	27
Automotive Sqre to Congress Nagar	7.92	33.00	10	4	0	0	4	3	12
				11	1	1	13		39

Note: Reversal facility required at Congress Nagar.

Above with Operation resulting in:

Section	Effective headway	No. of Rakes	No. of Car
Automotive Sqre to Congress Nagar	5	13 Rakes of 3 cars	39
Congress Nagar to Khapari	10		
Total Turn Round Time(mins)	2		

Line 1 : North - South Corridor Year : 2026

Section	Distance (kms)	Schedule Speed in km/ph	Headway (min)	Rake Requirement: Bare	Traffic Reserve	R&M	Total No of Rakes	No. of Cars per rake	No. of Cars
Automotive Sqre to Khapari	19.48	34.00	8	8	1	1	10	3	30
Automotive Sqre to Congress Nagar	7.92	33.00	8	4	0	1	5	3	15
				12	1	2	15		45

Note: Reversal facility required at Congress Nagar.

Above with Operation resulting in:

Section	Effective headway	No. of Rakes	No. of Car
Automotive Sqre to Congress Nagar	4.0	15 Rakes of 3 cars	45
Congress Nagar to Khapari	8		
Total Turn Round Time(mins)	2		

Rake Requirement

Nagpur Metro Rail Network

Line 1 : North – South Corridor, Year : [illegible]

Section	Distance (kms)	Schedule Speed in kmph	Headway (min)	Rake Requirement					
				Base	Traffic Reserve	R&M	Total No. of Rakes	No. of Cars per rake	No. of Cars
Automotive Sqre to Khapari	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Automotive Sqre to Congress Nagar	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
				[illegible]	[illegible]	[illegible]	[illegible]		[illegible]

Note: Reversal facility required at Congress Nagar.

Above with Operation resulting in:

Section	Effective headway	No. of Rakes	No. of Car
Automotive Sqre to Congress Nagar	[illegible]	[illegible] Rakes of 3 cars	[illegible]
Congress Nagar to Khapari	[illegible]		
Total Turn Round Time(min)	[illegible]		

Line 1 : North – South Corridor, Year : [illegible]

Section	Distance (kms)	Schedule Speed in kmph	Headway (min)	Rake Requirement					
				Base	Traffic Reserve	R&M	Total No. of Rakes	No. of Cars per rake	No. of Cars
Automotive Sqre to Khapari	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Automotive Sqre to Congress Nagar	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
				[illegible]	[illegible]	[illegible]	[illegible]		[illegible]

Note: Reversal facility required at Congress Nagar.

Above with Operation resulting in:

Section	Effective headway	No. of Rakes	No. of Car
Automotive Sqre to Congress Nagar	[illegible]	[illegible] Rakes of 3 cars	[illegible]
Congress Nagar to Khapari	[illegible]		
Total Turn Round Time(min)	[illegible]		

Line 1 : North – South Corridor, Year : [illegible]

Section	Distance (kms)	Schedule Speed in kmph	Headway (min)	Rake Requirement					
				Base	Traffic Reserve	R&M	Total No. of Rakes	No. of Cars per rake	No. of Cars
Automotive Sqre to Khapari	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Automotive Sqre to Congress Nagar	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
				[illegible]	[illegible]	[illegible]	[illegible]		[illegible]

Note: Reversal facility required at Congress Nagar.

Above with Operation resulting in:

Section	Effective headway	No. of Rakes	No. of Car
Automotive Sqre to Congress Nagar	[illegible]	[illegible] Rakes of 3 cars	[illegible]
Congress Nagar to Khapari	[illegible]		
Total Turn Round Time(min)	[illegible]		

Rake Requirement

Nagpur Metro Rail Network

Line 2 : East - West Corridor, Year - [illegible]

Section	Distance (km)	Schedule Speed in kmph	Headway (min)	Rake Requirement					
				Line	Traffic Reserve	R&M	Total No. of Rakes	No. of Cars per rake	No. of Cars
Prajapati Nagar to Lokmanya Nagar	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Agrasen Chowk to Subhash Nagar	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
				[illegible]	[illegible]	[illegible]	[illegible]		[illegible]

Note: Reversal facility required at Agrasen Chowk and Subhash Nagar

Above with Operation resulting in:

Section	Effective Headway	No. of Rakes	No. of Car
Agrasen Chowk to Subhash Nagar	[illegible]	[illegible] Rakes of [illegible] cars	[illegible]
Prajapati Nagar to Agrasen Chowk and Subhash Nagar to Lokmanya Nagar	[illegible]		
Total Turn Round Time(min)	[illegible]		

Line 2 : East - West Corridor, Year - [illegible]

Section	Distance (km)	Schedule Speed in kmph	Headway (min)	Rake Requirement					
				Line	Traffic Reserve	R&M	Total No. of Rakes	No. of Cars per rake	No. of Cars
Prajapati Nagar to Lokmanya Nagar	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Agrasen Chowk to Subhash Nagar	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
				[illegible]	[illegible]	[illegible]	[illegible]		[illegible]

Note: Reversal facility required at Agrasen Chowk and Subhash Nagar

Above with Operation resulting in:

Section	Effective Headway	No. of Rakes	No. of Car
Agrasen Chowk to Subhash Nagar	[illegible]	[illegible] Rakes of [illegible] cars	[illegible]
Prajapati Nagar to Agrasen Chowk and Subhash Nagar to Lokmanya Nagar	[illegible]		
Total Turn Round Time(min)	[illegible]		

Line 2 : East - West Corridor, Year - [illegible]

Section	Distance (km)	Schedule Speed in kmph	Headway (min)	Rake Requirement					
				Line	Traffic Reserve	R&M	Total No. of Rakes	No. of Cars per rake	No. of Cars
Prajapati Nagar to Lokmanya Nagar	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Agrasen Chowk to Subhash Nagar	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
				[illegible]	[illegible]	[illegible]	[illegible]		[illegible]

Note: Reversal facility required at Agrasen Chowk and Subhash Nagar

Above with Operation resulting in:

Section	Effective Headway	No. of Rakes	No. of Car
Agrasen Chowk to Subhash Nagar	[illegible]	[illegible] Rakes of [illegible] cars	[illegible]
Prajapati Nagar to Agrasen Chowk and Subhash Nagar to Lokmanya Nagar	[illegible]		
Total Turn Round Time(min)	[illegible]		

Attachment -9

Rake Requirement

Nagpur Metro Rail Network

Line 2 : East - West Corridor, Year : [illegible]

Section	Distance (kms)	Schedule Speed in kmph	Headway (min)	Rake Requirement					
				Runs	Traffic Reserve	R&M	Total No. of Rakes	No. of Cars per rake	No. of Cars
Prajapati Nagar to Lokmanya Nagar	[illegible]	[illegible]	8	[illegible]	1	1	[illegible]	3	[illegible]
Agrasen Chowk to Subhash Nagar	[illegible]	[illegible]	8	[illegible]	[illegible]	1	[illegible]	3	[illegible]
				[illegible]	1	2	[illegible]		[illegible]

Note: Reversal facility required at Agrasen Chowk and Subhash Nagar

Above train Operation resulting in:

Section	Effective headway	No. of Rakes	No. of Car
Agrasen Chowk to Subhash Nagar	[illegible]	[illegible] Rakes of 3 cars	[illegible]
Prajapati Nagar to Agrasen Chowk and Subhash Nagar to Lokmanya Nagar	[illegible]		
Total Turn Round Time(min)	[illegible]		

Line 2 : East - West Corridor, Year : [illegible]

Section	Distance (kms)	Schedule Speed in kmph	Headway (min)	Rake Requirement					
				Runs	Traffic Reserve	R&M	Total No. of Rakes	No. of Cars per rake	No. of Cars
Prajapati Nagar to Lokmanya Nagar	[illegible]	[illegible]	[illegible]	[illegible]	1	1	[illegible]	3	[illegible]
Agrasen Chowk to Subhash Nagar	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	[illegible]	3	[illegible]
				[illegible]	1	2	[illegible]		[illegible]

Note: Reversal facility required at Agrasen Chowk and Subhash Nagar

Above train Operation resulting in:

Section	Effective headway	No. of Rakes	No. of Car
Agrasen Chowk to Subhash Nagar	[illegible]	[illegible] Rakes of 3 cars	[illegible]
Prajapati Nagar to Agrasen Chowk and Subhash Nagar to Lokmanya Nagar	[illegible]		
Total Turn Round Time(min)	[illegible]		

Line 2 : East - West Corridor, Year : [illegible]

Section	Distance (kms)	Schedule Speed in kmph	Headway (min)	Rake Requirement					
				Runs	Traffic Reserve	R&M	Total No. of Rakes	No. of Cars per rake	No. of Cars
Prajapati Nagar to Lokmanya Nagar	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	[illegible]	3	[illegible]
Agrasen Chowk to Subhash Nagar	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	[illegible]	3	[illegible]
				[illegible]	1	2	[illegible]		[illegible]

Note: Reversal facility required at Agrasen Chowk and Subhash Nagar

Above train Operation resulting in:

Section	Effective headway	No. of Rakes	No. of Car
Agrasen Chowk to Subhash Nagar	[illegible]	[illegible] Rakes of 3 cars	[illegible]
Prajapati Nagar to Agrasen Chowk and Subhash Nagar to Lokmanya Nagar	[illegible]		
Total Turn Round Time(min)	[illegible]		

CHAPTER 8

ROLLING STOCK

Chapter - 08

ROLLING STOCK

8.1 INTRODUCTION

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

8.2 OPTIMISATION OF COACH SIZE

The following optimum size of the coach has been chosen for this corridor as mentioned in Table 8.1.

Table 8.1

Size of the coach

	Length*	Width	Height
Driving Motor Car (DMC)	21.84 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

8.3 PASSENGER CARRYING CAPACITY

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

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

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

Table 8.2 shows the carrying capacity of Medium Rail Vehicles.

Table 8.2

Carrying Capacity of Medium Rail Vehicles

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

NORMAL-3 Person/sqm of standee area

CRUSH - 6 Person/sqm of standee area

8.4 WEIGHT

The weights of motorcar and trailer cars have been estimated as in Table 8.3, referring to the experiences in Delhi Metro. The average passenger weight has been taken as 65 kg.

Table 8.3: Weight of Light Rail Vehicles (Tonnes)

	DMC	**TC**	**3 Car Train**
TARE (maximum)	40	40	120
Passenger			
(Normal)	9.425	10.4	29.25
(Crush @6p/sqm)	16.055	17.55	49.66
(Crush @8p/sqm)	20.475	22.295	63.245
Gross			
(Normal)	49.425	50.4	149.25
(Crush @6p/sqm)	56.055	57.55	169.66
(Crush @8p/sqm)	60.475	62.295	183.245
Axle Load @6 person/sqm	14.014	14.388	
Axle Load @8 person/sqm	15.119	15.077	

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.

5.8 PERFORMANCE PARAMETERS

The recommended performance parameters are:

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

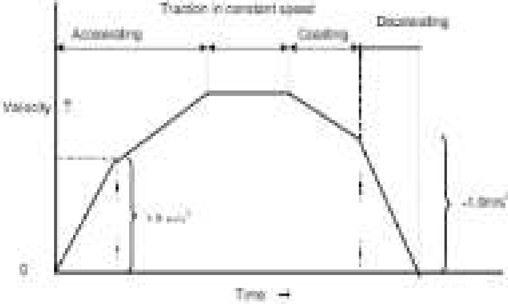

Fig. 5.1 : PERFORMANCE PARAMETERS

5.9 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.

5.7 SELECTION OF TECHNOLOGY

5.7.1 Low life cycle cost

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

5.7.2 Car body

In the past carbon high tensile steel was invariable 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.

5.7.3 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 improves the curve running performance by reducing lateral forces through application of conical rubber spring. A smooth curving performance with better ride index is being ensured by provision of above type of bogies.

5.7.4 Braking System

The brake system shall consist of –

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

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.

5.7.5 Propulsion System Technology

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

The brush less 3 phase induction motors has now replaced the D.C. Series motors in traction applications. The induction motor, for the same power output, is smaller and lighter in weight and ideally suited for rail based 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/slide 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.

6.7.6 Interior and Gangways

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

Fig.6.3 Interior View of the Car

6.7.7 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.

Fig.7.3 : View of the Passenger Doors

7.7.3 Air–conditioning

With heavy passenger loading of 8 persons/sqm for standee area and doors being closed from consideration of safety and with windows being sealed type to avoid transmission of noise, air conditioning of coaches has been considered essential. Each coach shall be provided with two air conditioning units capable of cooling, heating and dehumidifying and thus automatically controlling interior temperature throughout the passenger area at 25°C with 65% RH all the times under varying ambient conditions up to full load. For emergency situations such as power failure or both AC failures etc, ventilation provision supplied from battery will be made. Provision shall be made to shut off the fresh air intake and re-circulate the internal air of the coach, during an emergency condition, such as fire outside the train causing excessive heat and smoke to be drawn in to the coach.

8.7.9 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.

Fig.8.4 : View of the Driving Cab

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

8.7.10 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.

8.7.11 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 viaduct 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.

6.7.12 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.

Fig.8.5 : View of the Gangway

The salient features of the proposed Rolling Stock are enclosed as Attachment-I

Attachment I

Salient Features of Rolling Stock for MRTS

S.No.	Parameter		Details
1	**Gauge** (Nominal)		1435mm
2	**Traction system**		
2.1	Voltage		25 KV AC
2.2	Method of current collection		Overhead Current Collection System
3	**Train composition**		
3.1	3 car trainset		DMC+TC+DMC
4	**Coach Body**		Stainless Steel
5	**Coach Dimensions**		
5.1	Height		3.9 m
5.2	Width		2.9 m
5.3	Length over body (approx)		
	- Driving Motor Car (DMC)		21.64 m
	- Trailer Car (TC)		21.34 m
	Maximum length of coach over couplers/buffers:		22 to 22.6 m (depending upon Kinematic Envelope)
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/ m²
6.2	Design of Mechanical systems		10 Passenger/ m²
7	**Carrying capacity- @ 6 standees/sqm**		
7.1	Coach carrying capacity		
		DMC	247 (seating - 43 ; standing - 204)
		TC	270 (seating - 50 ; standing - 220)
7.2	Train Carrying capacity		
		3 car train	764 (seating - 136 ; standing - 628)
8	**Weight (Tonnes)**		
8.1	Tare weight (maximum)		
		DMC	40
		TC	40
8.2	Passenger Weight in tons @ 6 standees/sqm		@ 0.065 T per passenger
		DMC	16.055
		TC	17.55
8.3	Gross weight in tons		
		DMC	56.055
		TC	57.55
9	**Axle load(T)@ 8 persons per sqm of standee area**		**16 (System should be designed for 16T axleload)**
10	**Maximum Train Length - Approximate**		
10.1	3 car trainset		≈68

11	**Speed**	
11.1	Maximum Design Speed	90 Kmph
11.2	Maximum Operating Speed	85 Kmph
12	**Wheel Profile**	UIC 510-2
13	**Noise Limits (ISO 3381 and 3095 - 2005)**	
13.1	Stationary (Elevated and at grade)	
13.1.1	Internal (cab and saloon)	L_{pAFmax} 65 dB(A)
13.1.2	External (at 7.5 mtr from centre line of track)	L_{pAFmax} 68 dB(A)
13.2	Running at 85 kmph (Elevated and at grade)	
13.2.1	Internal (cab and saloon)	L_{pAFmax} 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
16	**Deceleration 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
	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 at the times under varying ambient conditions up to full load.
29	**PA/PIS including PSSS (CCTV)**	Required
30	**Passenger Surveillance**	Required
31	**Battery**	Lead Acid Maintenance Free
32	**Headlight type**	LED
33	**Coasting**	8% (Run time with 8% coasting shall be the Run Time in All out mode **plus** 8%)
34	**Gradient (max)**	3%
35	**Average Cost per car exclusive of taxes and duties at May 2011 Price level in INR Crores**	10.3

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CHAPTER 9

POWER SUPPLY, SYSTEM OF TRACTION AND POWER TARIFF

TABLES

FIGURES

Chapter - 9

POWER SUPPLY

SYSTEM OF TRACTION AND POWER TARIFF

9.1 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) 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 – 75 KWh/1000 GTKM

(ii) Regeneration by rolling stock – 30%

(iii) Elevated station load – initially 250KW, which will increase to 400 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 2000 KW, 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 requirements projected for the year 2016, 2021, 2031 and 2041 are summarized in table **Table 9.1** below:-

Table 9.1: Power Demand Estimation (MVA)

Corridor		Year			
		2016	2021	2031	2041
North South Corridor – 1 Automotive Sqre to Khapri Station [19.658 kms & 17 Stations (15 Elevated, 2 at Grade)]	Traction	4.32	5.01	5.84	7.16
	Auxiliary	7.72	7.94	9.14	11.49
	Total	12.04	12.95	14.98	18.65
East West Corridor – 2 Prajapati Nagar to Lokmanya Nagar [18.557 kms & 19 Elevated Stations]	Traction	4.24	4.57	5.73	7.01
	Auxiliary	8.34	8.46	9.88	12.48
	Total	12.58	13.03	15.61	19.49

Detailed calculations of power demand estimation are attached at **Annexure 9.1**

9.2 NEED FOR HIGH RELIABILITY OF POWER SUPPLY

The Nagpur metro system is being designed to cater to crush load about 17000 passengers per direction during peak hours when trains are expected to run at 3.5 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. It is desirable to obtain power supply at grid voltage of 220KV, 132 KV or 66KV from stable grid sub-stations and further transmission & distribution is done by the Metro Authority themselves.

9.3 SELECTION OF TRACTION SYSTEM

On techno-economic consideration, it is recommended to adopt 25 KV single phase AC Traction. In addition it has the following merits.

- Lower initial cost.
- Lower operating and maintenance cost as in case of 25 KV ac traction the regeneration is up-to 30% and the line losses are around 0.5% in comparison to D.C. losses up-to 6 – 7%.

- A.C. system poses lesser fire hazards as current levels are much lower than D.C.
- No Stray current problems and hence the corrosion is controlled.

9.4 SOURCES OF POWER SUPPLY

The high voltage power supply network of Nagpur City has only 220kV and 132kV network on the periphery of the city to cater to various types of demand in vicinity of the proposed corridor. 220/132 kV sub stations are far away from the alignment and therefore, it involves substantial cable and it's laying cost.

Keeping in view the reliability requirements, two input sources of 220 kV or 132KV Voltage level are normally considered for each corridor. Therefore, to achieve the desired reliability, two Receiving Sub Stations (132/33/25 kV or 220/33/25 KV) are proposed to be set up for each Corridor – 1 & Corridor – 2. The intersection of the two corridors will be at Sitabuldi station (Elevated station of Corridor – 1).

It is proposed to avail power supply for traction as well as auxiliary services from the following grid sub-stations at 220/132kV through cable feeders.

A meeting was convened by with the officials of Maharashtra State Electricity Board and DMRC on dated 09.10.2012. As per MSEDCL letter No./CE/NUZ/Tech/1379, dated 01.12.2012 has confirmed the following power sources for the Nagpur Metro.

Table 9.3: Sources of Power Supply

Corridor	Grid sub-station (with input voltage)	Location of RSS of Metro Authority	Approx. length of cables
North-South Corridor – 1 Automotive Square to Khapri Station.	1. 132 KV Uppalwadi Grid Sub-station.	2 x 132 KV bays near Automotive station	7 route km, 132 kV (Double Circuit cables).
	2. Proposed 220 KV Butibori Grid Sub-station.	2 x 220 KV bays at Khapri Station	4 route km, 220kV, (Double Circuit cables).
East-West Corridor – 2 Prajapati Nagar to Lokmanya Nagar.	3. LILO of proposed 132 KV Pardi-Jatarodi ckt.	2 X 132 KV bays near Prajapati Nagar station	4 route km, 132 kV (Double Circuit Cables).
	LILO of proposed 132 KV Hingna – Lendra Ckt.	2 x 132 KV bays near Subhash Nagar station	10 route km, 132 kV (Double Circuit Cables).

As the power supply is available at 220 KV and 132 KV levels that too at a substantial distance from the alignment, one sub-station of each line to be considered with one set of transformers and add another set as the traffic grows.

The above sub-stations are being considered as a conventional sub-station. In case a 220 KV or 132KV GIS is to be provided, there will be an additional cost of Rs. 20 Crores or 15 Crores per sub-station respectively.

Summary of expected power demand at various sources is given in **Table 9.3**.

Table 9.3: Power Demand Projection for various sources

Corridor	Input Source / Receiving Sub station (RSS)	Peak Demand – Normal (MVA)				Peak Demand – Emergency (MVA)			
		2016	2021	2031	2041	2016	2021	2031	2041
North-South Corridor – 1 Automotive Sqre to Khapari	**At Depot near Khapri station**								
	Traction	2.60	2.76	3.50	4.30	4.32	4.65	5.84	7.16
	Auxiliary	4.62	4.70	5.54	6.89	7.72	7.84	9.14	11.49
	Sub – Total (A)	7.22	7.46	9.04	11.19	**12.04**	**12.50**	**14.98**	**18.65**
	Near automotive station								
	Traction	1.72	1.90	2.36	2.88	04.32	04.65	05.84	07.16
	Auxiliary	3.10	3.14	3.60	4.60	07.72	07.84	09.14	11.49
	Sub – Total (B)	4.82	5.04	5.96	7.48	**12.04**	**12.50**	**14.58**	**18.65**
	TOTAL (A + B)	**12.04**	**12.48**	**14.98**	**18.65**				
East-West Corridor – 2 Prajapati Nagar to Lokmanya Nagar	**Near Subhash Nagar station**								
	Traction	2.54	2.77	3.40	4.21	4.21	4.57	5.73	7.01
	Auxiliary	5.00	5.06	5.98	7.48	7.48	8.46	9.88	12.48
	Total	7.54	7.83	8.41	11.69	**12.58**	**13.03**	**16.61**	**19.49**
	Near Prajapati Nagar station								
	Traction	1.70	1.80	2.30	2.80	4.21	4.57	5.73	7.01
	Auxiliary	3.34	3.40	3.90	5.00	7.48	8.46	9.88	12.48
	Total	5.04	5.20	6.20	7.80	**12.58**	**13.03**	**16.61**	**19.49**
	TOTAL (A + B)	**12.58**	**13.03**	**16.61**	**19.49**				

The 220 kV or 132 KV power supply will be stepped down to 25kV single phase for traction purpose at the RSS of Nagpur Metro and the 25kV traction supply will be fed to the OHE at viaduct through cable feeders. For feeding the auxiliary loads, the 220/33 kV or 132/33 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 along the viaduct and tunnel walls. If one RSS trips on fault or input supply failure, train services can be maintained from the other RSS. 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.

Fig. 9.1 : Typical High Voltage Receiving Sub-station

The 220 kV or 132 KV cables will be laid through public pathways of Maharashtra Grid Sub-stations to RSS of Metro Authority. For corridor – 1, one substation near Automotive station shall be provided with 2nos. (one as standby) 132/25 kV, 10 MVA single-phase traction Transformers for feeding Traction and 132/33 KV, 15 MVA three phase Transformers for feeding auxiliary loads and other near Khapri Depot shall be provided with 2nos. (one as standby) 220/25 kV, 10 MVA single-phase traction Transformers for feeding Traction and 220/33 KV, 15 MVA three phase Transformers for feeding auxiliary loads. For corridor – 2, one RSS near Subhash Nagar and other RSS near Prajapati Nagar station shall be provided with 2nos. (one as standby) 132/25 kV, 10MVA single phase traction Transformers for feeding Traction supply and 132/33 KV, 15 MVA three phase Transformers for feeding auxiliary loads. Interconnection will provide at 33KV & 25KV level to meet emergency requirement at Sitaburdi in case of failure of two RSS of any one corridor. The capacity of transformers may be reviewed considering the load requirement/distribution of both the corridors at the time of detailed design.Conventional Outdoor type 132 kV Switchgear is proposed for RSS's to be located in approx. 100 X 100 m (10000 sq. mtr.) land plot and for 220 KV

Conventional Outdoor type switchgear is proposed for RSS to be located in 120 x 100 m (12000 sq.mtr.). The availability of land in depot area may not be a constraint.The land at Automotive station, Subhash Nagar and near Prajapati Nagar station to be allocated. Requirement of land for 220 KV GIS substation will be approx. 70 X 80 m (5600 sq. m) and for 132 KV GIS substation land requirement will be approx. 60 X 70 m (4200 sq. m) but the cost of substation works will increase by nearly Rs. 20 Crore and 15 Crores respectively. 220/132 kV Grid sub stations are far away from the alignment and therefore, it involves approx. Rs.20 Crores extra cable and it's laying cost.

9.6 AUXILIARY SUPPLY ARRANGEMENTS FOR STATIONS & DEPOT

Auxiliary sub-stations (ASS) are envisaged to be provided at each station (2 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 station ASS's will be located at mezzanine or platform level inside a room. The auxiliary load requirements have been assessed at 250kW for elevated / at-grade stations which is likely to increase up to 400 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 dry type cast resin transformers (33/0.415kV) of 500kVA capacity are proposed to be installed at the elevated stations (one transformer as standby) and two transformer of 2.5 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.

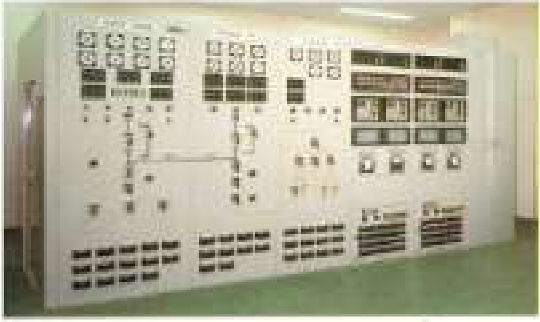


Fig. 9.3 : Typical Indoor Auxiliary Sub-station

9.6 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 equi-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.

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

9.7 25KV FLEXIBLE OVERHEAD EQUIPMENT (OHE) SYSTEM

25kV ac flexible OHE system shall comprise 150/107 sqmm Hard drawn 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.

9.8 RATING OF MAJOR EQUIPMENT

25kV ac Overhead Equipment (OHE) shall comprise 107mm² HD-copper contact wire and 65 mm² 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 9.3, 2 nos. 220 or 132/25kV traction transformers of 10 MVA capacity and 2 nos. 132/33 KV, 15 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. 132/33 KV, 15 MVA capacity Auxiliary transformers shall be provided at each RSS in

Corridor -4, being standard design (one to be in service and second one to serve as standby). The 132kV incoming cable 3-phase single core XLPE insulated with 630 mm^2 Aluminum conductor for corridor-1 & Corridor-2 and 220kV, 3-phase single core XLPE insulated with 800 mm^2 Aluminum conductor for corridor-1 shall be used to meet the normal & emergency loading requirements and fault level of the 132 kV and 220 KVsupply.

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 150 mm^2 FRLSH Aluminum conductor cable XLPE insulated 33kV cable is proposed for ring main network.

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

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

9.9 STANDBY DIESEL GENERATOR (DG) SETS

In the unlikely event of simultaneous tripping of all the input power sources or grid failure, the power supply to stations as well as to trains will be interrupted. It is, therefore, proposed to provide a standby DG set of 200 KVA capacity at the elevated stations and 2 X 1250/750 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.

9.10 SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA) SYSTEM

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

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

9.11 ENERGY SAVING MEASURES

Energy charges of any metro system constitute a substantial portion of its operation & maintenance (O & M) costs. Therefore, it is imperative to incorporate energy saving measures in the system design itself. The auxiliary power consumption of metros is generally more than the traction energy consumed by train movement during initial years of operation. Subsequently, traction power consumption increases with increase in train frequency/composition in order to cater more traffic. The proposed system of Nagpur 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.

(viii) LED lighting is proposed in certain areas.

9.12 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 38 million units in initial years (2016), which will increase to about 58 Million Units by year 2041 for Corridor – 1 and about 31 million units in initial years (2016), which will increase to 62 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 132/220 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. 5.00 per unit with Rs.125/KVA/month fixed charges. It is proposed that Government of Maharashtra will take necessary steps to fix power tariff for Nagpur 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.

M. S. ELECTRICITY DISTRIBUTION CO. LTD.

[illegible] No. 13792 Date: [illegible]

To,
The Executive Director / Electrical
Delhi Metro Rail Corporation Ltd.
Metro Bhawan, Fire Brigade Lane,
Barakhamba Road,
New Delhi - 110001

Subject: Power Supply requirement for Metro Railway at Nagpur City

Ref: (1) [illegible]
(2) [illegible]

Dear Sir,

With ref. to above subject and as discussed by Transmission authority, for North – South & East – West Corridor of proposed Nagpur Metro Railway project, the possible 132 KV sources are identified as follows:

i) [illegible] MVA requirements for North South Corridor :

(1) From [illegible] KV [illegible] to Metro Receiving Station at [illegible] (North Point)

(2) From proposed 220 KV [illegible] to Metro Receiving Station at [illegible] (South Point)

ii) [illegible] MVA requirement for East – West Corridor

(1) The LILO of proposed 132 KV [illegible] at Metro Receiving Station at [illegible] Nagar (East Point)

(2) The LILO of proposed 132 KV [illegible] at Metro Receiving Station at [illegible] Nagar (West Point)

Further details will be confirmed after receipt of result of Load Flow Studies by State Transmission Utility.

Submitted for further needful please.

CHIEF ENGINEER
NAGPUR URBAN ZONE
NAGPUR

Copy [illegible]:
The Regional Executive Director, MSEDCL, Nagpur
[illegible]:
The Chief Engineer, EHV CC (O&M) Zone, MSETCL, Nagpur
Copy to:
(1) The Superintending Engineer, Nagpur Urban [illegible] Circle, MSEDCL, Nagpur
(2) The Superintending Engineer, EHV (O&M) Circle, MSETCL, Nagpur

OFFICE OF THE CHIEF ENGINEER
NAGPUR URBAN ZONE
"PRAKASH BHAVAN", Link Road, Sadar, NAGPUR - [illegible]
Phone : [illegible] Fax : [illegible]
Email: [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

CHAPTER 10

MAINTENANCE DEPOT

FIGURES

Chapter - 10

MAINTENANCE DEPOT

10 MAINTENANCE DEPOT

10.1 NAGPUR METRO PROJECT CORRIDORS : The Nagpur Metro Project comprises of following corridors:

S. No.	Corridor	Gauge (mm)	Route Length (KMs)
1.	North-South Corridor	1435	19.658
2.	East-West Corridor	1435	18.280

10.2 DEPOT- CUM- WORKSHOP

10.2.1 (A) It is proposed to establish one depot- cum- workshop near Khapri Station for North South Corridor and one depot- cum- workshop in SRP Land near Lokmanya Nagar Station for East West Corridor with following functions:

a) **Depot- cum- workshop near Khapri Station for North South Corridor (Line 1)**

(i) Major overhauls of all the trains of Line 1.
(ii) All minor schedules and repairs of Line 1.
(iii) Lifting for replacement of heavy equipment and testing thereafter of Line 1.
(iv) Repair of heavy equipments of Line 1.

b) **Depot- cum- workshop in SRP Land near Lokmanya Nagar Station for East West Corridor (Line 2)**

(i) Major overhauls of all the trains of Line 2.
(ii) All minor schedules and repairs of Line 2.
(iii) Lifting for replacement of heavy equipment and testing thereafter of Line 2.

(iv) Repair of heavy equipments of Line 2.

10.2.2 The Depot planning near Khapri Station for North South Corridor and in SRP Land near Lokmanya Nagar Station for East West Corridor is based on following assumptions:

(i) Enough space should be available near Khapri Station for North South Corridor and in SRP Land near Lokmanya Nagar Station for East West Corridor for establishment of a Depot- Cum- workshop.
(ii) All inspection, workshop lines and stabling lines are designed to accommodate two train-sets of 3- car each.
(iii) All stabling lines are planned in the proposed depot-cum-workshop assuming adequate space availability. In case of space constraints, if any, stabling facilities may need to be created at terminal stations or elsewhere to cater to the required stability facilities.
(iv) Provision of transfer line from one corridor to another corridor.

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

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

10.3 MAINTENANCE PHILOSOPHY

- Monitoring of the performance of equipment by condition monitoring of key parameters. The concept is to evolve the need based maintenance regime, which can be suitably configured in the form of schedules like daily check, "A" checks, "B" type checks, "IOH" and "POH".
- Labour intensive procedures are kept to the minimum. Automation with state of the art machinery to ensure quality with reliability.
- Multi skilling of the Maintenance staff to ensure quality and productivity in their performance.
- Energy conservation is given due attention.

10.4 ROLLING STOCK MAINTENANCE NEEDS

10.4.1 **Maintenance Schedule**: The following maintenance schedule has been envisaged for conceptual design of depots assuming approx. 300 kms running per train per day, taking in consideration the passenger load of 2016, 2021, 2026, 2031, 2036 and 2041 respectively.

Table 10.1 : Maintenance Schedule

Type of Schedule	Interval	Work Content	Locations
Daily	Daily	Check on the train condition and function at every daily service completion. Interval cleaning/mopping of floor and walls with vacuum cleaner.	Stabling Lines
"A" Service Check	5,000 Km (approx. 15 days)	Detailed inspection and testing of sub - systems, under frame, replacement/ topping up of oils & lubricants.	Inspection Bays
"B" Service Check	15,000 Km (approx. 45 days)	Detailed inspection of 'A' type tasks plus items at multiples of 15,000 Km ('B' type tasks)	Inspection Bays
Intermediate Overhaul (IOH)	420,000 Km. (3 and half Years approx.)	Check and testing of all sub-assemblies (Electrical + Mechanical). Overhaul of pneumatic valves, Compressor. Condition based maintenance of sub-systems to bring them to original condition. Replacement of parts and rectification, trial run.	Workshop
Periodical Overhaul (POH)	840,000 Km. (7 Years approx.)	Dismantling of all sub-assemblies, bogies suspension system, traction motor, gear, control equipment, air-conditioning units etc. Overhauling to bring them to original condition. Checking repair and replacement as necessary. Inspection and trial.	Workshop
Heavy Repairs	-	Changing of heavy item such as bogies, traction motor, axles, gear cases & axle boxes etc.	Workshop

The above Schedule may need slight revision based on the actual carried kilometers per train and the specific maintenance requirements of Rolling Stock finally procured.

10.4.2 Washing Needs of Rolling Stock

Cleanliness of the trains is essential. Following schedules are recommended for Indian environment.

Table 10.2 :Train Cleaning Schedule

S.N.	Kind Inspection	Maint. Cycle	Time	Maintenance Place
1.	Outside cleaning (wet washing on automatic	3 Days	10 mins.	Single Pass through Automatic washing

S.N.	Kind Inspection	Maint. Cycle	Time	Maintenance Place
	washing plant)			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

10.5 YEAR-WISE PLANNING OF MAINTENANCE FACILITY :

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
2016	11	33
2021	12	36
2026	15	45
2031	16	48
2036	18	54
2041	20	60

b) Planned rakes as TOP for E- W Corridor:

Year	No. of Rakes	No. of coaches
2016	12	36
2021	13	39
2026	15	45
2031	17	51
2036	18	54
2041	20	60

(ii) Average earning/day/rake based on TOP:

a) Average earning/day/rake for N- S Corridor:

Year	Average earning/day/rake
2016	255
2021	261
2026	270
2031	276
2036	267

2041	257

b) Average earning/day/rake for E- W Corridor:

Year	Average earning/day/rake
2016	216
2021	213
2026	239
2031	230
2036	236
2041	254

(iii) Requirement of Stabling Lines (SBL),Inspection Lines (IBL) and Workshop Lines(WSL) in the Depot

a) Requirement of Stabling Lines (SBL), Inspection Lines (IBL) and Workshop Lines (WSL) in the Depot -cum -Workshop near Khapri Station for North South Corridor.

Table 19.3
Requirement of Stabling Lines (SBL), Inspection Lines (IBL) and Workshop Lines (WSL)
NS Corridor

Year	No. of Trains	SBLs	IBLs	WSLs
2016	11	6 lines x two trains of 3-car	One bay of 3 lines each with two trains of 3-cars each on each line with space earmarked for future extension	One bay of 3 lines each with two trains of 3-cars each on each line with space earmarked for future extension
2021	12	7 lines x two trains of 3-car	-do-	-do-
2026	15	8 lines x two trains of 3-car	-do-	-do-
2031	16	8 lines x two trains of 3-car	-do-	-do-
2036	18	9 lines x two trains of 3-car	-do-	-do-
2041	20	10 lines x two trains of 3-car	-do-	-do-

All lines shall be suitable for placement of two trains of 3-car trains on each line.

b) Requirement of Stabling Lines (SBL), Inspection Lines (IBL) and Workshop Lines (WSL) in the Depot -cum -Workshop in SRP Land near Lokmanya Nagar Station for East West Corridor.

Table 10.4

Requirement of Stabling Lines (SBL), Inspection Lines (IBL) and Workshop Lines (WSL)

EW Corridor

Year	No. of Trains	SBLs	IBLs	WSLs
2016	12	6 lines x two trains of 3-car	One bay of 3 lines each with two trains of 3-cars each on each line with space earmarked for future extension	One bay of 3 lines each with two trains of 3 cars each on each line with space earmarked for future extension
2021	13	7 lines x two trains of 3-car	-do-	-do-
2026	15	8 lines x two trains of 3-car	-do-	-do-
2031	17	9 lines x two trains of 3-car	-do-	-do-
2036	18	10 lines x two trains of 3-car	-do-	-do-
2041	20	11 lines x two trains of 3-car	-do-	-do-

All lines shall be suitable for placement of two trains of 3-car trains on each line

10.6 REQUIREMENT OF MAINTENANCE / INSPECTION LINES FOR DEPOT-CUM-WORKSHOP

a) **Requirement of maintenance / inspection lines for depot-cum-workshop Depot -cum –Workshop near Khapri Station for North South Corridor (Line 1):**

Table 10.5

Requirement of maintenance / inspection lines (NS Corridor)

Schedule	Maintenance Requirement (No. of Cars)	Lines Needed
i) Year 2016 - Maximum no. of rake holding is 11TS x3 (= 33 Cars)		
A Checks (5000 km) approx. 15 days	(11X3) Cars = 33 Cars	1 Line x two trains of 3- cars(with Sunken Floor
B Checks (15000 km) approx. 45 days	(11X3) Cars = 33 Cars	1 Line x two trains of 3- cars(with Sunken Floor)

Schedule	Maintenance Requirement (No. of Cars)	Lines Needed
Unscheduled line & adjustment lines	For minor repairs, testing and after IOH/POH adjustments	1 Line x two trains of 3- cars(with sunken Floor)
Requirement		1 bay of 3 lines with provision of space for additional bay of 3 lines for work load in future
ii) Year 2021 - Maximum no. of rake holding is (12T 3 x3 = 36 Cars)		
'A' Checks (5000 km) approx. 15 days	(12X3) Cars = 36 Cars	1 Lines X two trains of 3- cars(with sunken floor)
'B' Checks (15000 km) approx. 45 days	(12X3) Cars = 36 Cars	1 Lines X two trains of 3- cars(with sunken floor)
Unscheduled line & adjustment lines	For minor repairs, testing & adjustments post major repairs / IOH & POH	1 Line X two trains of 3- cars(with sunken floor)
Requirement		1 bay of 3 lines with provision of space for additional bay of 3 lines for work load in future
iii) Year 2026 -Maximum no. of rake holding is (15x3 = 45 Cars)		
'A' Checks (5000 km) 15 days	(15X3) Cars = 45 Cars	1 Lines X two trains of 3- cars(with sunken floor)
'B' Checks (15000 km) 45 days	(15X3) Cars = 45 Cars	1 Lines X two trains of 3- cars(with sunken floor)
Unscheduled line & adjustment lines	For minor repairs, testing & adjustments post major repairs / IOH & POH	1 Line X two trains of 3- cars(with sunken floor)
Requirement		1 bay of 3 lines with provision of space for additional bay of 3 lines for work load in future
iv) Year 2031 -Maximum no. of rake holding is (16x3 = 48 Cars)		
'A' Checks (5000 km) 15 days	(16X3) Cars = 48 Cars	1 Lines X two trains of 3- cars(with sunken floor)

Schedule	Maintenance Requirement (No. of Cars)	Lines Needed
'B' Checks (15000 km) 45 days	(16X3) Cars = 48 Cars	1 Lines X two trains of 3- cars(with sunken floor)
Unscheduled line & adjustment lines	For minor repairs, testing & adjustments post major repairs / IOH & POH	1 Line X two trains of 3- cars(with sunken floor)
Requirement		1 bay of 3 lines with provision of space for additional bay of 3 lines for work load in future
v) Year 2036 -Maximum no. of rake holding is (18x3 = 54 Cars)		
'A' Checks (5000 km) 15 days	(18X3) Cars = 54 Cars	1 Lines X two trains of 3- cars(with sunken floor)
'B' Checks (15000 km) 45 days	(18X3) Cars = 54 Cars	1 Lines X two trains of 3- cars(with sunken floor)
Unscheduled line & adjustment lines	For minor repairs, testing & adjustments post major repairs / IOH & POH	1 Line X two trains of 3- cars(with sunken floor)
Requirement		1 bay of 3 lines with provision of space for additional bay of 3 lines for work load in future
vi) Year 2041 -Maximum no. of rake holding is (20x3 = 60 Cars)		
'A' Checks (5000 km) 15 days	(20 X 3) Cars = 60 Cars	2 Lines X two trains of 3- cars(with sunken floor)
'B' Checks (15000 km) 45 days & Unscheduled line & adjustment lines	(20 X 3) Cars = 60 Cars For minor repairs, testing & adjustments post major repairs / IOH & POH	1 Lines X two trains of 3- cars(with sunken floor)
Requirement		1 bay of 3 lines with provision of space for additional bay of 3 lines for work load in future

All lines shall be suitable for placement of two 3- car trains on same line.

b) Requirement of maintenance / inspection lines for depot-cum-workshop in SRP Land near Lokmanya Nagar Station for East West Corridor (Line-2):

Table 10.6

Requirement of maintenance / inspection lines(EW Corridor)

Schedule	Maintenance Requirement (No. of Cars)	Lines Needed
i) Year 2016 - Maximum no. of rake holding is 12T.S x3 (= 36 Cars)		
'A' Checks (5000 km) approx. 15 days	(12X3) Cars = 36 Cars	1 Line x two trains of 3- cars(with Sunken Floor
'B' Checks (15000 km) approx. 45 days	(12X3) Cars = 36 Cars	1 Line x two trains of 3- cars(with Sunken Floor)
Unscheduled line & adjustment lines	For minor repairs, testing and after IOH/POH adjustments	1 Line x two trains of 3- cars(with sunken Floor)
Requirement		1 bay of 3 lines with provision of space for additional bay of 3 lines for work load in future
ii) Year 2021 - Maximum no. of rake holding is (13T.S x3 = 39 Cars)		
'A' Checks (5000 km) approx. 15 days	(13X3) Cars = 39 Cars	1 Lines X two trains of 3- cars(with sunken floor)
'B' Checks (15000 km) approx. 45 days	(13X3) Cars = 39 Cars	1 Lines X two trains of 3- cars(with sunken floor)
Unscheduled line & adjustment lines	For minor repairs, testing & adjustments post major repairs / IOH & POH	1 Line X two trains of 3- cars(with sunken floor)
Requirement		1 bay of 3 lines with provision of space for additional bay of 3 lines for work load in future
iii) Year 2026 -Maximum no. of rake holding is (15x3 = 45 Cars)		
'A' Checks (5000 km) 15 days	(15X3) Cars = 45 Cars	1 Lines X two trains of 3- cars(with sunken floor)
'B' Checks (15000 km) 45 days	(15X3) Cars = 45 Cars	1 Lines X two trains of 3- cars(with sunken floor)

Schedule	Maintenance Requirement (No. of Cars)	Lines Needed
Unscheduled line & adjustment lines	For minor repairs, testing & adjustments post major repairs / IOH & POH	1 Line X two trains of 3- cars(with sunken floor)
Requirement		1 bay of 3 lines with provision of space for additional bay of 3 lines for work load in future
iv) Year 2031 -Maximum no. of rake holding is (17x3 = 51 Cars)		
'A' Checks (5000 km) 15 days	(17X 3) Cars = 51 Cars	1 Lines X two trains of 3- cars(with sunken floor)
'B' Checks (15000 km) 45 days	(17X3) Cars = 51 Cars	1 Lines X two trains of 3- cars(with sunken floor)
Unscheduled line & adjustment lines	For minor repairs, testing & adjustments post major repairs / IOH & POH	1 Lines X two trains of 3- cars(with sunken floor)
Requirement		1 bay of 3 lines with provision of space for additional bay of 3 lines for work load in future
v) Year 2036 -Maximum no. of rake holding is (18x3 = 54 Cars)		
'A' Checks (5000 km) 15 days	(18X3) Cars = 54 Cars	2 Lines X two trains of 3- cars(with sunken floor)
'B' Checks (15000 km) 45 days & Unscheduled line & adjustment lines	(18X3) Cars = 54 Cars For minor repairs, testing & adjustments post major repairs / IOH & POH	1 Lines X two trains of 3- cars(with sunken floor)
Requirement		1 bay of 3 lines with provision of space for additional bay of 3 lines for work load in future
vi) Year 2041 -Maximum no. of rake holding is (20x3 = 60 Cars)		
'A' Checks (5000 km) 15 days	(20X3) Cars = 60 Cars	2 Lines X two trains of 3- cars(with sunken floor)

Schedule	Maintenance Requirement (No. of Cars)	Lines Needed
'B' Checks (15000 km) 45 days & Unscheduled line & adjustment lines	(20X3) Cars = 60 Cars For minor repairs, testing & adjustments post major repairs / IOH & POH	1 Lines X two trains of 3- cars(with sunken floor)
Requirement		1 bay of 3 lines with provision of space for additional bay of 3 lines for work load in future

All lines shall be suitable for placement of two 3- car trains on same line

10.7 INSPECTION REQUIREMENTS AT DEPOTS NEAR KHAPRI STATION FOR NORTH SOUTH CORRIDOR (LINE-1) AND IN SRP LAND NEAR LOKMANYA NAGAR STATION FOR EAST WEST CORRIDOR (LINE-2):

Facilities for carrying out inspection activities shall be provided in the inspection bay for following Systems / Equipments of a train:

- Electronics; PA/PIS
- Mechanical components, couplers etc.
- Batteries
- Air conditioner
- Brake modules
- 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.

10.8 DESIGN OF DEPOT- CUM- WORKSHOP FACILITIES

10.8.1 Stabling lines at depots near Khapri Station for North South Corridor (Line-1) and in SRP Land near Lokmanya Nagar Station for East West Corridor (Line-2):

As per advised dimensions of the Rolling Stock, the length of 3-Car train would be Approx.67.8 mts. For the design of the stabling lines in the depot and terminal stations or elsewhere (as may be required), following approximates lengths have been taken in consideration:

(i) Length of one 3- car taken 67.8 m

(ii) Gap between two trains 3-car takes = 10m

(iii) Free length at outer ends of two trains of 3- cars (for cross pathway, Signal and Friction buffers)= 10m each side

(iv) Total length of Stabling lines = (iii)+(i)+(ii)+(i)+(iii)= 10+ 67.8+ 10+ 67.8+ 10= 165.6m = 166m

Looking to the car width of 2700mm 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.

10.8.2 Inspection Bay at depot-cum-workshop near Khapri Station for North South Corridor (Line-1) and in SRP Land near Lokmanya Nagar Station for East West Corridor (Line-2):

The length of Inspection shed is computed as below:

(i) Length of a 3-car rake= 67.8 m.

(ii) Gap between two trains of 3- cars= 10 m

(iii) Cross- path at each end= 10 m

(iv) Length of Inspection line= (iii)+ (i)+(ii)+ (i)+ (iii) = 10+ 67.8 + 10+ 67.8 + 10= 165.6m = 166m

The width of the Inspection bay in computed as below:

(i) Centre – to- centre spacing between the three lines= 7.5 m.

(ii) Centre line of outer lines to column of Shed= 3m

(iii) Width of a 3 line Inspection Bay= (ii)+(i)+(i)+(ii)= 3+ 7.5+ 7.5+ 3= 21 m

a) There shall be one inspection bay of 168 m X 21 m size each with provision of accommodating three inspection lines each having sunken floor and overhead roof inspection platforms at each of the depot. The floor will be sunken by 1100mm. The track spacing between the adjacent IBLs shall be 7.5 m. For rake requirements in future, there shall be provision of space for extension by one bay of three lines to cater the workload of inspection in future.

b) Roof inspection platforms and walkways for roof inspection supported on the columns shall be provided. There would be lighting below the rail level to facilitate the under frame inspection. Ramps of 1:8 slopes, 3 meter wide should be provided with sunken floor system for movement of material for the cars. Further, 10m cross pathways are left at each end for movement of material by fork lifter/Leader/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.

10.8.3 Workshop Shed depots near Khapri Station for North South Corridor (Line-1) and in SRP Land near Lokmanya Nagar Station for East West Corridor (Line-2):

Requirement of workshop lines is planned as under:

a) Requirement of workshop lines near Khapri Station for North South Corridor (Line 1):

Table 10.7 :
Requirement of workshop lines near Khapri Station for North South Corridor

Year	IOH & POH	Wheel / Bogie storage	Unschedule repairs /lifting	Total	Remarks
2016	1	1 line of 3-car trains and free space of 3-car length for storage of other equipments	1 line x two trains of 3-car	3-lines	The size of workshop shall be the same as inspection bay i.e. 160X21 m with one working bay comprising of two trains lines capable of accommodating two trains 3 car rakes with Bogie turning facility, one line of 3-car rake length with free space of 3-car rake length for storage of wheel/ bogie/ equipments etc.
2021	1	-do-	1	3-lines	
2026	1	-do-	1	3-lines	
2031	1	-do-	1	3-lines	
2036	1	-do-	1	3-lines	
2041	1	-do-	1	3-lines	

B) Requirement of workshop lines in SRP Land near Lokmanya Nagar Station for East West Corridor (Line-2)

Table 10.8 :
Requirement of workshop lines near Khapri Station for East West Corridor

Year	IOH & POH	Wheel / Bogie storage	Unscheduled repairs /lifting	Total	Remarks
2016	1	1 line of 3-car trains and free space of 3-car length for storage of other equipments	1 line x two trains of 3-car	3-lines	The size of workshop shall be the same as inspection bay i.e. 160X21 m with one working bay comprising of two trains lines capable of accommodating
2021	1	-do-	1	3-lines	

2026	1	-do-	1	3 lines	two trains 3-car rakes with Bogie turning facility, one line of 3-car rake length with free space of 3-car rake length for storage of wheel/ bogie/ equipments etc.
2031	1	-do-	1	3 lines	
2036	1	-do-	1	3 lines	
2041	1	-do-	1	3 lines	

(a) There shall be one bay comprising of three lines each (as detailed in 'Remarks' above). Size of the workshop bay is proposed to be 168m x 21m.The unscheduled lifting and heavy repair line shall be fitted with jack system capable to lift the 3-Car unit simultaneously for quick change of bogie, thereby saving down time of Rolling Stock. The arrangement of jack system shall be such that lifting of any coach in train formation for replacement of bogie/equipments is also individually possible. One line shall be available for stocking of Bogies and wheels. These lines are to be provided with pits at regular intervals for inspection of undercarriage with turn tables. Each workshop bay shall be equipped with two trains 15T and 3T overhead cranes, each spanning the entire length of the workshop bay.

(b) There shall be provided space for repairs of HVAC, Door, and Traction motor etc. repairs. Distinct spaces shall be earmarked for dismantling/repairs/ assembling and testing of each of these equipments. Related machinery for Overhauling / Repairs & testing activities of every equipment are also to be housed in the space earmarked.

(c) There shall be washing and cleaning equipments on the workshop floor. Bogie test stand shall be provided in the workshop. Other heavy machinery shall also be suitably installed on the workshop floor. Air-circulators, lights, Powers supply points and compressed air supply line shall be provided on each workshop column.

(d) Workshop lines shall be inter-linked through turn tables, each suitable for movement of a train in AW0 (unloaded) condition and shall also be capable to rotate with a fully loaded bogie on it. Repair of heavy equipments such as air conditioners shall be so located so that it does not affect the movement inside workshop.

(e) There shall be walkways on columns for roof inspections, along the workshop lines. These walkways shall not infringe with cars being lifted/ lowered by means of mobile jacks. Suitable space between the nearest exterior of a car and farthest edge of the walkway has to be ensured to avoid conflict in lifting and lowering of cars.

(f) The small component, bogie painting and battery maintenance cells will be located in the workshop with arrangement that fumes are extracted by suitable exhaust systems.

(g) Workshop will have service building with array of rooms along its length. Total size is proposed to be 168 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 wall/naves 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, overhaul, 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 Khapri Station for North South Corridor (Line-1) and in SRP Land near Lokmanya Nagar Station for East West Corridor (Line-2):

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).

10.9 CAR DELIVERY AREA

There shall be rail connectivity between the Depot-cum- Workshop and mainline and all trains due for scheduled/ unscheduled works shall reach the depot-cum-Workshop by rail.

However in case of newly procured coaches, which are transported by road, these shall reach the Depot-cum Workshop by the road on trailers. To unload the coaches and bring them to the track, provision of space, along the side of shunting neck, has to be made for unloading of cars and other heavy materials. This area shall have an insulated track embedded in the floor facilitating the movement of road trawler, which brings in the cars. The length of the track embedded area shall be about 40m long. There should be enough space available for movement of heavy cranes for lifting of coaches. The unloading area should be easily accessible for heavy duty hydraulic trailers.

10.10 OPERATIONAL FEATURES

The rake induction and withdrawal to main line will be primarily from the stabling shed. Further, provisions are there for direct rake induction and withdrawal to main line from Inspection Shed/workshop area. Movement from depot to the main line is so planned that the headway of main line is not affected. Simultaneous receipt and dispatch of trains from depot to main line is feasible in the present site scenario. Both of these activities will be done effectively without effecting the train operation on the main line. The stabling lines would be interlocked with the main line thereby induction of train from the stabling would be safe and without loss of time. The proposition for a transfer track on the incoming line as well as on the outgoing line to facilitate the movement of rake in the depot by Operation Control Centre (OCC) even though the further path inside the depot is not clear shall be explored in the detailed design stage depending on the actual availability of land.

An emergency line is also provided from which an emergency rescue vehicle may be dispatched to main line in the event of emergency if necessary.

10.11 INFRASTRUCTURE FACILITIES

10.11 INFRASTRUCTURE FACILITIES : Infrastructure Facilities in depots near Khapri Station for North South Corridor (Line 1) and in SRP Land near Lokmanya Nagar Station for East West Corridor (Line 2)

I. **Inspection and Workshop facilities**:

As indicated in 10.8.2 & 10.8.3 above.

II. **Stabling Lines in Depot**:

a) The requirement of lines shall be in accordance with the details indicated in para 10.8.1 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 adjacent 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 Para 10.12.1 (a) & 10.12.1 (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 twins 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 emphasis to charge the under ground reserves.

X. **Ancillary Workshop**

This workshop will have a line at floor level with provision of pits. Arrangement for repairs of Shunters, Rail Road Vehicles and other ancillary vehicles will be provided. These vehicles will also be housed here itself. Heavy lifting works can be carried out in main workshop.

Ancillary workshop will be used for storing OHE/rigid OHE parts and their maintenance/ repair for restoration of 25 kV feed system.

XI. **Watch Towers**

There shall be provision of adequate number of watchtowers for the vigilance of depot boundary.

XII. **Administrative Building**

An administrative building close to the main entrance is planned. It can be suitably sized and architecturally designed at the detailed design stage. A time and security office is also provided close to main entrance. It shall be equipped with suitable Access control system for all the staff working in the complex.

XIII. **Parking Facilities**

a) Ample parking space shall be provided for the two trains wheelers and four wheelers at the following points.
   i) Close to the depot entry.
   ii) Close to the stabling lines.
   iii) Close to the Workshop/IBL.
b) Space for parking of road and re-railing equipments.
   Enough space for parking of road vehicles/ 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 10.12.1 (a) & 10.12.1 (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 10.12.1(a), 10.12.1 (b), Para 10.12.2 (a) & 10.12.2(b).

10.11.1 Following safety features should be incorporated in the design of the Maintenance Depot-cum-Workshop near Khapri Station for North South Corridor (Line-1) and in SRP Land near Lokmanya Nagar Station for East West Corridor (Line-2):

a) 1.5 DOT 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.

10.12 LIST OF BUILDINGS

10.12.1 List of Buildings at Depot- Cum- Workshop at Khapri Station near Khapri Station for North South Corridor (Line) :

Table 10.5
List of Buildings at Depot- Cum- Workshop (N S Corridor)

S.No	Name of Building	Size	Remarks
1.	Inspection Shed	168m x 21m • One bay of 3 lines (3 trains of 3 cars in each line)	Servicing of Cars for 15 days & 45 days inspection. This shed will have scope of expansion by 3 lines (1 additional bay of 3 lines for future requirement).
	Workshop Shed	168m x 21m	Major repair & overhaul of rolling stocks, diesel shunters, electric tractors, tower wagons. All heavy lifting jobs.
	Associated Sections	168m x 8m	Rooms for carrying out the inspection & workshop activity.
	Stabling line shed	168m x 66m (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 12 rakes only).

S.No	Name of Building	Size	Remarks
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	60m x 30m (partly double storey)	Stabling and routine maintenance of shunting engine etc. & Traction maintenance depot. For maintenance of lifts/escalators and other General service works.
5.	Cycle / Scooter / Car Parking	100m x 6m 60m x 6m	i. Close to the depot entry. ii. Close to the stabling lines.
6.	Auto coach washing 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	60m 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	1,00,000 Ltrs.	For Storage of water.

S.No	Name of Building	Size	Remarks
	Tank	Capacity	
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	10m x 10m	For Storage of paints, inflammables & Lubricants
16.	a) Traction 25/33kV/66kV sub station b) Feeding Post	a) 120m x 80m b) 15m x30m	Traction Power Supply
17.	Waste Collection Bin	10m x 10m	Garbage dumping
18.	Repair shops for S & T	40m x 20m	For the AFC gates, Signaling and telecom equipment.
19.	Work shop Manager Office	30m x 20m	Office of Depot in charge
20.	ATP & ATO Room	10m x 8m	To keep equipments of ATP/ATO
21.	Waste Water Treatment Plant	10m x 8m	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.

18.12.1 List of Buildings at Depot- Cum- Workshop at Khapri Station in SRP Land near Lokmanya Nagar Station for East West Corridor (Line-2)

Table 18.18

List of Buildings at Depot- Cum- Workshop (EW Corridor)

S.No	Name of Building	Size	Remarks
1.	Inspection Shed	166m x 21m • One way of 3 lines (2 trains of 3-cars in each line)	Servicing of Cars for 15 days & 45 days inspection. This shed will have scope of expansion by 3 lines (1 additional bay of 3 lines for future requirement).

S.No	Name of Building	Size	Remarks
	Workshop Shed	168m x 21m	Major repair & overhaul of rolling stocks, diesel shunters, electric tractors, tower wagons. All heavy lifting jobs.
	Associated Sections	168m x 8m	Rooms for carrying out the inspection & workshop activity.
	Stabling line shed	168m x 60m (for 23 trains)	Provisional for total area as per requirement of stabling of 23 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	50m 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 Interior Cleaning	168m 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	60m 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 &	15m x 8m	For security personnel.

S.No	Name of Building	Size	Remarks
	Time Office		For time punching
	Garages (4 Nos.)		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.)	3.0m x2.5 m	For security of the depot especially during night time.
12.	Depot control centre & Crew booking centre	25mx20m (double storey)	To control movement of trains in and out of the depot and for crew booking.
13.	O.H raw water Tank	1,00,000 Ltrs. Capacity	For Storage of water.
14.	Pump house Bore well	7.3mx5.4m (200 mm bore)	Submersible type pump planned with 200 mm diameter bore well.
15.	Dangerous goods Store	15m x 10m	For Storage of paints, inflammables & Lubricants
16.	a)Traction 25/33kV/66kV sub station b) Feeding Post	a)120m x 80m b) 15m x30m	Traction Power Supply
17.	Waste Collection Bin	10m x 10m	Garbage dumping
18.	Repair shops for S & T	40m x 20m	For the AFC gates, Signaling and telecom equipment.
19.	Work shop Manager Office	30m x 20m	Office of Depot in charge
20.	ATP & ATO Room	10m x 8m	To keep equipments of ATP/ATO
21.	Waste Water Treatment Plant	10m x 8m	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.

10.13 LIST OF PLANTS & EQUIPMENTS AT DEPOT-CUM-WORKSHOP

10.7.6.1 List of Plants & Equipments at Depot-cum-Workshop near Khapri Station for North South Corridor (Line 1).

Table 10.11

List of Plants & Equipments at Depot- Cum- Workshop (NS Corridor)

S. No.	Equipment	Qty.	Unit
1.	Under floor Pit wheel lathe, Chip crusher and conveyor for lathe on pit, Electric tractor for movement over under floor wheel lathe	1	No.
2.	Under floor lifting systems for 3-car unit for replacement of bogie	1	Set
3.	Mobile jacks 15T for lifting cars (set of 12 jacks)	1	No.
4.	Rerailing equipment consisting of rail cum road vehicle and associated jack system etc.	1	Set
5.	Run through type Automatic Washing plant for Metro cars	1	No.
6.	Rail fed Bogie wash plant	1	No.
7.	Bogie test stand	1	No.
8.	Work lift platform	4	No.
9.	Electric bogie tractor for pulling cars and bogies inside workshop	1	No.
10.	Chemical cleaning tanks, ultrasonic cleaning tanks, etc.	1	Set
11.	Compressor for Inspection shed & shop air supply	2	No.
12.	(i) Travelling O/H crane Workshop 15T/3 T (ii) 1.5T Capacity (IBL) - 2 Nos.	2 2	No. No.
13.	Mobile jib crane	2	No.
14.	Mobile lifting table	4	No.
15.	Carbody stands	24	No.
16.	Bogie turn tables	2	No.
17.	Underframe & Bogie blowing plant & small parts/equipment	2	No.
18.	AC filter cleaning machine	1	No.
19.	Portable cleaning plant for rolling stock	1	No.
20.	High pressure washing pump for front and rear end cleaning of car	2	No.
21.	Industrial furniture (Work Test Benches)	1	L.s.
22.	Minor diagnostic equipment and collective tools	-	Set
23.	Induction heater	1	No.
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

S. No.	Equipment	Qty.	Unit
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.	Vertical Boring Machine for wheel discs	1	No.
37.	Press for removal and pressing of the wheel on axle	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		-

10.13.2 List of Plants & Equipments at Depot-cum-Workshop in SRP Land near Lokmanya Nagar Station for East West Corridor (Line 2):

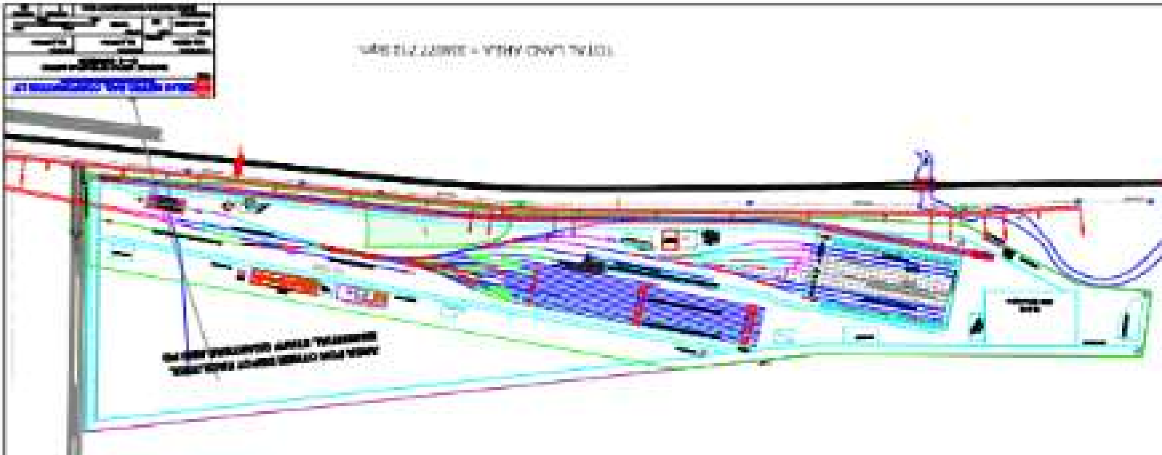
Table 10.12

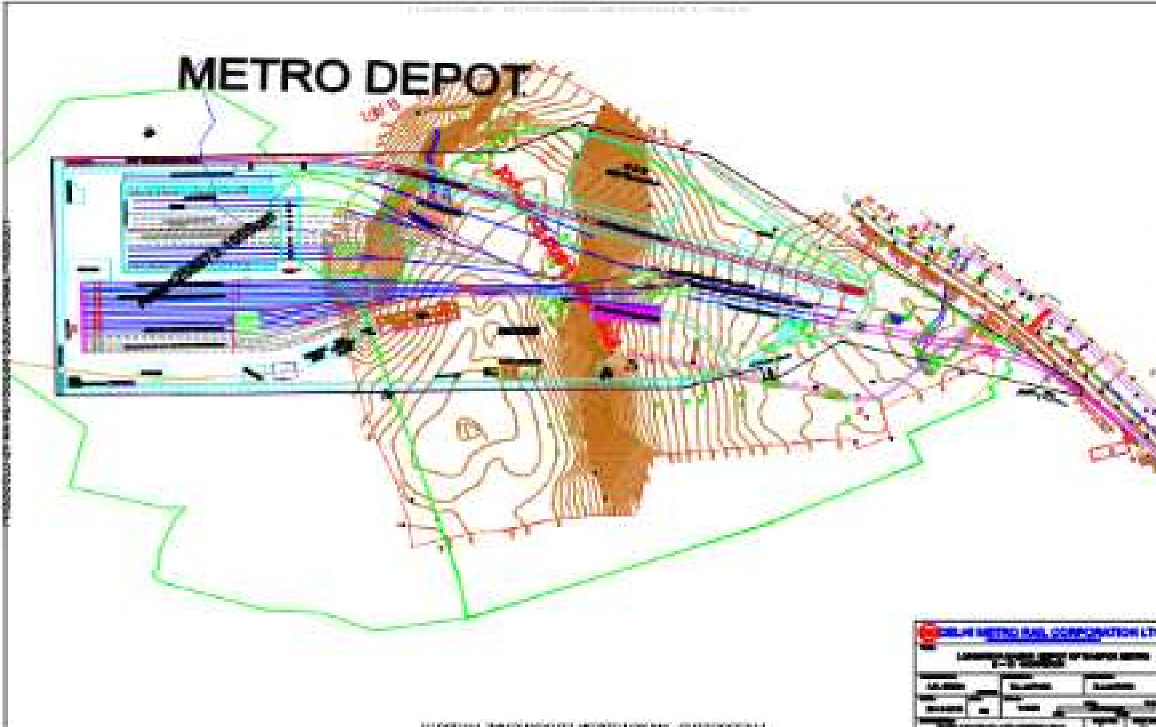
List of Plants & Equipments at Depot- Cum- Workshop (EW Corridor)

S. No.	Equipment	Qty.	Unit
1.	Under floor Pit wheel lathe, Chip crusher and conveyor for lathe on pit, Electric tractor for movement over under floor wheel lathe	1	No.
2.	Under floor lifting systems for 3-car unit for replacement of bogie	1	Set
3.	Mobile jacks 15T for lifting cars (set of 12 jacks)	1	No.
4.	Rerailing equipment consisting of rail cum road vehicle and associated jack system etc.	1	Set
5.	Run through type Automatic Washing plant for Metro cars.	1	No.
6.	Rail fed Bogie wash plant	1	No.
7.	Bogie test stand	1	No.
8.	Work lift platform	4	No.
9.	Electric bogie tractor for pulling cars and bogies inside workshop.	1	No.

S. No.	Equipment	Qty.	Unit
10.	Chemical cleaning tanks, ultrasonic cleaning tanks, etc	1	Set
11.	Compressor for Inspection shed & shop air supply	2	No.
12.	(i) Travelling O/H crane Workshop 15T/3 T (ii) 1.5T Capacity (IBL) : 2 Nos.	2 2	No. No.
13.	Mobile jib crane	2	No.
14.	Mobile lifting table	4	No.
15.	Carbody stands	24	No.
16.	Bogie turn tables	2	No.
17.	Underframe & Bogie blowing plant & small parts/equipment	2	No.
18.	AC filter cleaning machine	1	No.
19.	Portable cleaning plant for rolling stock	1	No.
20.	High-pressure washing pump for front and rear end cleaning of car	2	No.
21.	Industrial furniture (Work Test Benches)	1	L.s.
22.	Minor diagnostic equipment and collective tools	-	Set
23.	Induction heater	1	No.
24.	Oven for the motors	1	No.
25.	EMU battery charger	2	No.
26.	Welding equipments (Mobile welding, oxyacetylene, fixed arc welding)	3	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.	Vertical Boring Machine 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

S. No.	Equipment	Qty.	Unit
43.	Auto panto strip thickness meter		-
44.	Vehicle mounted crane		-
45.	Impulse Tester for TMs		-
46.	Bearing puller		-




METRO DEPOT

CHAPTER 11

SIGNALLING SYSTEM

TABLES

Chapter - 11

SIGNALLING SYSTEM

11.0 SIGNALLING

11.1 Introduction

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

11.2 SIGNALLING AND TRAIN CONTROL

11.2.1 Overview

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

This will:

- Provide high level of safety with trains running at close headway ensuring continuous safe train separation and for bidirectional working.
- Eliminate accidents due to driver passing Signal at Danger by continuous speed monitoring and automatic application of brake in case of disregard of signal / warning by the driver.
- Provides safety and enforces speed limit on section having permanent and temporary speed restrictions.
- Improve capacity with safer and smoother operations. Driver will have continuous display of Target Speed / Distance to Go status in his cab enabling him to optimize

the speed potential of the track section. It provides signal / speed status in the cab even in bad weather.

- Increased productivity of rolling stock by increasing line capacity and train speeds, and enabling train to arrive at its destination sooner. Hence more trips will be possible with the same number of rolling stock.
- Improve maintenance of Signaling and telecommunication equipments by monitoring system status of trackside and train born equipments and enabling preventive maintenance.

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

Radio for CBTC shall work in License free ISM band.

11.2.2 System Description and Specifications

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

a. Continuous Automatic Train Control

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

(i) Automatic Train Protection (ATP)

Automatic Train Protection is the primary function of the train control systems. This sub-system will be inherently capable of achieving the following objectives in a fail-safe manner. Line side signals will be provided at diverging routes (i.e. at points & crossings) as well as other required locations, which shall serve as backup signaling in case of failure of ATP system.

- Cab Signaling
- Track Related Speed Profile generation based on line data and train data continuously along the track
- Continuous monitoring of braking curve with respect to a defined target point
- Monitoring of maximum permitted speed on the line and speed restrictions in force
- Detection of over-speed with audio-visual warning and application of brakes, if necessary
- Maintaining safety distance between trains
- Monitoring of stopping point
- Monitoring of Direction of Travel and Rollback.

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

(ii) Automatic Train Operation (ATO)

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

(iii) Automatic Train Supervision (ATS)

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

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

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

5. Interlocking System:

(i) Computer Based Interlocking (CBI)

The entire line including turnback track, transfer track, sidings will be equipped with CBI system for operation of points and crossings and setting of routes.

The setting of the route and clearing of the signals will be done by workstation, which can be either locally (at station) operated or operated remotely from the OCC.

This sub-system is used for controlling vehicle movements into or out of stations automatically from a workstation. All stations having points and crossings will be provided with workstations for local control. Track occupancy, point position, etc. will be clearly indicated on the workstation. It will be possible to operate the workstation locally, if the central control hands over the operation to the local station. The interlocking system design will be on the basis of fail-safe principle.

The equipment will withstand tough environmental conditions encountered in a Mass Transit System. Suitable IS, IRS, BS standards or equivalent international standards will be followed in case wiring, installation, earthing, cabling, power supply and for material used in track circuits, axle counters, relays, point operating machines, power supply etc.

(ii) Track Vacancy Detection

Primary mode for track vacancy detection system on main line may be through radio and for secondary detection it can be through Track circuit / Axle Counter.

(iii) Signals

Line side Signals: Multi Aspect Colour Light (LED) type Line side signals shall be installed on the Main Line and depot entry/ exit.

(a) At stations with point and crossing for point protection catering for bidirectional working.

(b) At departure location at stations for normal direction of working.

(iv) 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/ Axle Counter will be used in the depot as well.

3. Signalling Scheme Plan

Conceptual Signalling Scheme Plan based on P. Way Plan dated 16.01.2013 for Line -1 and Line -2 of Nagpur Metro Rail Project from Automotive Square to Khapri (Line-1) and Prajapati Nagar to Lokmanya Nagar (Line-2) is enclosed at Annexure 1.

11.2.3 Standards

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

TABLE 11.1
Signalling System Standards

Description	Standards
• Interlocking	Computer based Interlocking adopted for station having switches and crossing. All related equipment as far as possible will be centralised in the equipment room at the station. The depot shall be interlocked except for lines mainly used for workshop lines, inspection shed lines etc.

Description	Standards
• Block Working	Moving Block working concept may be followed.
• Operation of Points	With Direct current 110V D.C. point machines or 380 volts 3 phase, 50 Hz. AC point machines.
• Track Vacancy Detection System	Primary mode for track vacancy detection system on main line and test track in depot may be through radio and for depot and secondary detection it can be through Track circuit / Axle Counter.
• Signals at Stations with point & crossings	Line Side signals to protect the points (switches). LED type signals for reliability and reduced maintenance cost.
• UPS (uninterrupted power at stations as well as for OCC)	For Signalling and Telecommunications.
• Train protection system	Train Protection system shall be based on CBTC (Communication based Train Control) System. The system architecture shall provide for redundancy.
• Train Describer System	Automatic Train Supervision system. Movement of all trains to be logged on to a central computer and displayed on workstations in the Operational Control Centre and at the SCR. Remote control of stations from the OCC. The system architecture shall provide for redundancy.
• Cables	Outdoor cables will be steel armoured as far as possible.
• Fail Safe Principles	SIL-4 safety levels as per CENELEC standard for signal application. Computer based Interlocking and for ATP System.
• Immunity to External Interface.	All data transmission on telecom cables/OFC/Radio. All Signalling and telecom cables will be separated from power cables. CENELEC standards to be implemented for EMC.
• Train Working under emergency	Running on site with line side signal with speed automatically restricted between 15-25 kmph.
• Environmental Conditions	Air-conditioners for all equipment rooms.
• Maintenance philosophy	Philosophy of continuous monitoring of system status and preventive & corrective maintenance of Signalling equipments shall be followed. Card / module / sub-system level replacement shall be done in the field and repairs under taken in the central laboratory/ manufacturer's premises.
• Sidings	P.Way Plan of Line -1 and Line -2 of Nagpur Metro Rail Project from 'Automotive Sqr. to Metro Depot Stn. (Line -1) and Prajapati Nagar to Lokmanya Nagar (Line -2) does show any siding. The same may be planned and provided on both the lines to take out the defective Trains during revenue hour.

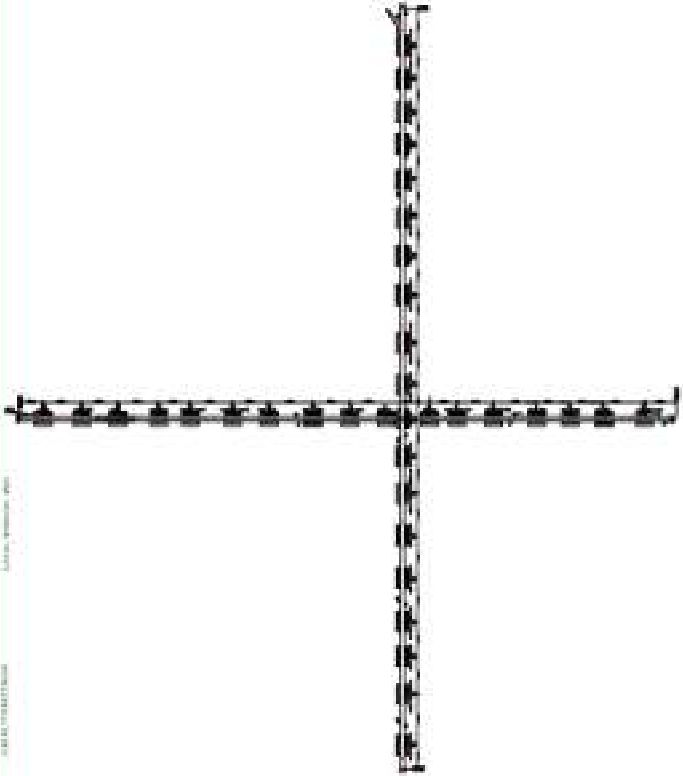
11.3 SPACE REQUIREMENT FOR SIGNALLING INSTALLATIONS

Adequate space for proper installations of all Signalling equipment at each of the stations has to be provided keeping in view the ease of maintenance and use of instrumentation set up for regular testing and line up of the equipment/system. The areas required at each of the stations for Signalling equipment shall be generally 60 sqm. for UPS Room (common for signalling and telecom) and for Signalling Equipment Room 50 sqm. at 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.

11.4 Maintenance Philosophy for Signalling systems

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

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



CHAPTER 12

TELECOMMUNICATION & AUTOMATIC FARE COLLECTION

Chapter – 12

Telecommunication & Automatic Fare Collection

12.1 TELECOMMUNICATION

12.1.1 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.

12.1.2 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.
- Centralized 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.

12.1.2 Telecommunication System And Transmission Media

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

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

SDH (minimum STM-16) based system shall be adopted with SDH nodes at every station, depot and OCC. The SDH equipment shall be equipped with Ethernet Card to provide channels to other Interfacing Contractors of SCADA, PA/PIDS etc. Further small routers and switches shall be provided for LAN network at stations/depot. Alternatively a totally IP Based High Capacity, highly reliable and fault tolerant, Ethernet Network (MAN/LAN) can be provided in lieu of SDH backbone.

ii) Telephone Exchange

For an optimized cost effective solution, Small exchanges of 30 port each shall be planned at each station and a 60 Port Exchange at the Terminal Stations shall be provided. The exchanges at Central Control and Depots shall be of larger sizes as per the actual number of users. The Exchanges will serve the subscribers at all the stations and Central Control. The exchanges will be interconnected at the channel level on optical backbone. The exchanges shall be software partitioned for EPABX and Direct Line Communication from which the phones shall be extended to the stations.Alternatively only for non-operational (other than Direct Line Communication), a separate IP Based Phone System can be implemented.

iii) Mobile Radio Communication

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

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

To provide adequate coverage, based on the RF site survey to be carried out during detailed Design stage, base stations for the system will be located at sites conveniently selected after detailed survey. Tentatively minimum 6 sites with towers with Base Stations shall be required along the East – West (EW) Corridor at Mahindra & Mahindra, Rachna (Ring RD JNC), Lal Chowk, Jhansi Rani SQRE, Dosar Vaisya Chowk (Mayo Hospital) and Telephone Exchange Stations. For the North – South (NS) Corridor, at least 5 Base Station with Towers shall be required at Mihan City, Mayurosh Station, Rahate Colony, Zero Mile and Kadvi Chowk Stations.

For the Underground Section of North-South corridor, one Base Station shall be required at New Airport feeding through Leaky Coaxial Cables, the adjacent tunnels.

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. 30 sq. m) at the underground station to the Mobile Operator Group. The Mobile Operators shall install all their repeater equipment in this room and then extend the coverage inside the tunnel by laying their own LCX cable in each tunnel and through antennas strategically placed in the concourse area. Further, for City Emergency Services like Police, the mobile operators shall also design their LCX network to support the police wireless coverage in the tunnels /station area. The detailed Agreement covering both the Mobile / Emergency Service Radio Coverage shall have to be finalised by the Metro Authority with the respective parties, at the time of implementation.

iv) **Passenger Announcement System**

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

v) **Passenger Information Display System**

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

vi) Centralized Clock System

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

vii) Closed Circuit Television (CCTV) System

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

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.

For monitoring of inside of Train, a wireless CCTV System from Train to nearest station shall be provided. For this a wifi Broad Band network will be provided at each station, so as to automatically upload On-Board CCTV Video from the Train to the OCC at each station. The Broad Band Radio System shall be based on unlicensed wifi Band and shall use the Optical fibre backbone network to transfer video from the station to the OCC. The On- Board Train Cameras shall be provided as part of the Rolling Stock Contract and they shall interface with a On-Board wifi equipment provided by Telecom Contractor to transmit video to station equipment.

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.

Technology

The Technologies proposed to be adopted for Telecommunication systems are shown in below:

Table12.1 : Technologies for Telecommunication systems

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

System	Standards
▪ 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 synchronization system of slave clocks driven from a master clock at the OCC and sub – master clock in station. This shall also be used for synchronization other systems.
▪ Passenger Announcement System	Passenger Announcement System covering all platform and concourse areas with local as well as Central Announcement.
▪ Redundancy (Major System)	Redundancy on Radio's in the Base Stations. Path Redundancy for Optical Fibre Cable by provisioning in ring configuration.
▪ Environmental Conditions	All equipment rooms to be air conditioned.
▪ Maintenance Philosophy	System to have, as far as possible, automatic switching facility to alternate routes/circuits in the event of failure. Philosophy of preventive checks of maintenance to be followed. System networked with NMS for diagnosing faults and co-ordination. Card/module level replacement shall be done in the field and repairs undertaken in the central laboratory/manufacturer's premises.

x) **Space Requirement for Telecom Installations**

Adequate space for proper installations of all Telecommunication equipment at each of the stations has to be provided keeping in view the ease 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 shall be generally 30 sq.m each for Telecom Room and 50 sq.m. for UPS Room (common for signal, Telecom and AFC). These areas shall also cater to local storage and space for maintenance personnel to work. At the OCC, the areas required shall be as per the final configuration of the equipment and network configuration keeping space for further expansion.

xi) **Maintenance Philosophy for Telecom systems**

The philosophy of continuous monitoring of system status and preventive & corrective maintenance of 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.

12.3 AUTOMATIC FARE COLLECTION

11.3.1 Introduction

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

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

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

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

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

B) Automatic fare collection systems have the following advantages:

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

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

C) Choice of Control Gates

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

D) Passenger Operated Machine

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

E) Ticket Reader/Add Value Machines

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

13.2.2 AFC equipment Requirement

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

13.3.2 Technology

The technology proposed for AFC systems are as under:

Table13.3 : Technology proposed for AFC systems

Standards	Description
• Fare media	a) Contactless smart card – For multiple journeys. It is desirable to use a card of similar specifications as being used for other Transport modes (at City or National level), so as to have future interoperability integration possible. b) Single Journey: Contactless smart token captured at exit gates.
• Gates	Computer controlled automatic gates at entry and exit. There will be following types of gates: • Entry • Exit • Reversible (if required as per final station layout) – can be set to entry or exit • Reversible Handicapped Gate–gate for disabled people.

Standards	Description
• 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 machines shall be installed in the stations for selling tickets to the passengers. Also TVM's shall be provided for Automatic Ticket Vending.
• Ticket reader and portable ticket decoder	Ticket reader shall be installed near AFC 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.

Fig 12.1 Entry/Exit Gates

Fig 12.2 : Ticket Office Machine

PASSENGER TRAFFIC AND REQUIREMENT OF AMENITIES IN STATIONS
(Projections for Year 2041)

Table 13.3
AMENITIES AT STATIONS
Line-1   N-S corridor (Automotive Square to Khapri Station)

Station	Peak Hour Boarding (or Alighting)	Ticketing Gates required (in each line)	TOMs Required	[illegible]	Escalators Provided in Each Station		Number of Lifts in Each Station
		[illegible]			G-C	C-P	G-P
AUTOMOTIVE SQRE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
NARI ROAD	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
INDORA CHOWK	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
KADVI CHOWK	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
GADDI GODAM SQRE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
KASTURCHAND PARK	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
ZERO MILE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SITABURDI	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
CONGRESS NAGAR	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
RAHATE COLONY	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
AJNI SQUARE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
CHHATRAPATI SQUARE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
JAIPRAKASH NAGAR	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
UJWAL NAGAR	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
AIRPORT	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
NEW AIRPORT	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
KHAPRI	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Note: G- Ground (street level)
C- Passage level
P- Platform
* Interchange station

Table 10.4
AMENITIES AT STATIONS
Line-2 E-W corridor (Prajapati Nagar to Lokmanya Nagar)

Station	[illegible]	Ticketing Gates required at each with E-X-D	TOM [illegible]	[illegible]	Staircases Provided in Each Station		Provision of Lifts in Each Station
					[illegible]	[illegible]	[illegible]
1. Prajapati Nagar	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2. Vaishnodevi Chowk	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3. Ambedkar Chowk	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4. Telephone Exchange	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5. Chitar Oli Chowk	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6. Agrasen Chowk	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7. Dosar Vaisya Chowk	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8. Nagpur Railway Station	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9. Sitabuldi	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10. Jhansi Rani Square	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11. Institute of Engineers	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12. Shankar Nagar Square	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13. Lad Chowk	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14. Dharampeth College	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15. Subhash Nagar	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16. Rachna (Ring Road Jn.)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17. Vasudev Nagar	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18. Bansi Nagar	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19. Lokmanya Nagar	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Assumptions:
1. Each station has only 2 access
2. Minimum AFC equipments at a station with "2 access- 1 for entry, 1 for exit": 2 entry gates, 2 exit gates, 2 EFO, 2 TOM, 4 TR, 2 TVM
3. One Disabled gate at each station.
4. Throughput of gate 25 passengers per minute, TOM 10 transactions per minute.
5. 50 % passenger are assumed on Smart Card and 50% on single journey token.

CHAPTER 13

DISABLED FRIENDLY FEATURES

Chapter – 13

DISABLED FRIENDLY FEATURES

13.1 INTRODUCTION

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

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

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

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

13.2 CONTENT

1. **Rail Transport**

2. **Metro Rail Station**

    - Way finding
    - Signage
    - Automated Kiosk

- Public Dealing Counters
- Audio-visual Displays
- Public Telephones
- Rest Areas/Seating
- Tactile Paving – Guiding & Warning
- Doors
- Steps & Stairs
- Handrails
- Ramps
- Lifts/Elevators
- Platform/Stair Lift
- General and Accessible toilets
- Drinking Water Units
- Visual Contrasts
- Emergency Egress/Evacuation

3. **Street Design**

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

4. **Alighting and Boarding Area**

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

13.3 Rail Transport

1. **General**

- Whether overground or underground, rail travel 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-grips or other appropriate safety grip should be provided for wheelchair users.

4. Seats

- An appropriate number of designated seats for passengers with disabilities and elderly people should be provided near the doors.

5. Aisles

- Aisles should be at least 900 mm wide.

13.4 INFORMATION SIGNS AND ANNOUNCEMENTS

A map of train routes should be installed. This should be in Braille/raised numbers as well. In each car, there should be an announcement and provision of a visual display of the names of stations route. This display should be in raised numbers with sharp contrast from the background.

13.8 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 760 mm to 800 mm from the floor with clear knee space of 760 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 8);

- Have non-slip and level flooring.
- Have seating areas for people with ambulatory disabilities.
- Be well illuminated lux level 35 to 40.
- There should be no gap or difference in level between the train entry door and the platform.
- All platforms should inter-connect by means of an accessible routes or lifts; and provide accessible level entrance to the train coach.

6. WAY FINDING

- Way finding references should be available at decision points.
- Colour can be used to identify routes and provide assistance in locating doors, walls and hazards. Proper colour contrast between different elements greatly improves visibility for all users and is critical for persons with low vision. For example, colour contrasting of door frames can assist in locating doors, and likewise floors should be contrasted with walls. In addition, furniture should contrast with walls and floors so as not to create an obstacle.
- Structural elements such as columns should be colour contrasted or brightly marked so as to be visible to those who may have a visual disability.
- Generally, patterns on flooring should be avoided or else should be minimal and small to avoid visual confusion.
- In addition to identifying hazards or warnings, tactile floor surfaces can also be used to inform that there is a change in area (e.g. leaving a corridor and entering a boarding area).
- Tactile systems should be consistent throughout the building. For example, terminals should not have carpeting in some boarding areas and tile in others as this may create confusion for those who rely on tactile surfaces to guide them to their destination.
- Good lighting assists those with a visual disability to see better and allows people who have a hearing impairment to lip read easier. However, care should be taken to properly direct lighting and to use matte finishes on floors, walls and signage, so as not to create glare which may create difficulties for all travelers.
- Blinds can be used to adjust lighting levels in areas where the natural lighting changes significantly throughout the day.

7. SIGNAGE

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

8. Sign Design Specifications

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

Fig. 13.1 : Way finding signage

Fig. 13.2 : International Symbol of accessibility

9. Automated Kiosks

- Automated kiosks should be accessible for wheelchair users.
- Should be clearly marked with international symbol of accessibility.
- Should have Braille buttons and audio announcement system for persons with vision impairments.
- Operations should be easy to understand and operate for persons with learning disabilities, intellectual disabilities, and elderly persons.

10. Public Dealing Counters

-
- Ticketing, Information, Check-in, Help desk, Restaurants, Shops, etc. should have public dealing counters.

- Information or help desks should be close to the terminal entrance, and highly visible upon entering the terminal. In addition, they should be clearly identified and accessible to both those who use wheelchairs and those who stand.
- It should provide information in accessible formats, viz. Braille leaflets for persons with vision impairments.
- Ideally, these desks should have a map of the facility that desk attendants can view with passengers, when providing directions.
- Staff manning the counters should know sign language.
- Information desk acoustics should be carefully planned and controlled as a high level of background noise is confusing and disorienting to persons with hearing impairment.
- Lighting should be positioned to illuminate the receptionist/person manning the counter and the desk top without creating glare.
- Lighting should not create shadows over the receptionist staff, obscuring facial detail and making lip reading difficult.
- There should be a hearing enhancement system such as a loop induction unit, the availability of which is clearly indicated with a symbol.
- One of the counters should not be more than 800mm from the floor, with a minimum clear knee space of 650mm high and 280mm- 300mm deep.

11. Audio-visual displays

- Terminal maps should be placed so that they are readily visible to persons who are standing and persons who use wheelchairs. They should also be accessible to persons with a visual disability (i.e. tactile maps). Other alternatives include electronic navigation systems or audio maps.
- Enable captioning at all times on all televisions and other audio-visual displays that are capable of displaying captions and that are located in any portion of the terminal.
- The captioning must be in high contrast for all information concerning travel safety, ticketing, check-in, delays or cancellations, schedule changes, boarding information, connections, checking baggage, individuals being paged by bus railway or airlines, vehicle changes that affect the travel of persons with disabilities, and emergencies (e.g., fire, bomb threat).

12. Rest areas/seating

- Seating area / benches should be provided along the circulation path at regular intervals so that passengers do not need to walk more than 50 to 60 metres before being able to sit and rest.
- Where seating is provided, designated seating for passengers with disabilities is to be provided at boarding gates and departure areas within viewing distance of communication boards and/or personnel and identified by the symbol of access.
- Public transit operators should provide seating in passenger service areas where there may be long waiting lines or times, including at ticket sales counters, check-

in counters, security screening and during inter-country travel in customs areas and baggage retrieval areas.

- Designated seating should be provided for at boarding gates and departure areas within viewing distance of communication boards, and within hearing range of audio announcements as well. Such seating areas should be identified by the symbol of accessibility and shelter should be provided where this seating is outdoors.
- In outdoor settings, seating should be provided along with the planned hawker spaces.
- At waiting lounges for persons with disabilities chairs should have armrests and backrest.

13. Tactile Paving- Guiding & Warning

(a) Tactile Guiding Paver (Line-Type)

It is recommended to install a row of tactile guidance paver along the entire length of the proposed accessible route for visual impaired persons. Care must be taken to ensure that there are no obstacles, such as wall, pillar, uneven surfaces, Soffit (underside /open area under the stairs, along the route traversed by the guidance paver. Also, there should be clear headroom of at least 2.1 meters height above the tactile guidance paver, free of protruding objects such as overhanging advertisement panel and signage, along the entire length of the walk.

(b) Tactile Warning Paver (Dot-Type)

Indicate an approaching potential hazard or a change in direction of the walkway, and serve as a warning of the approaching danger to persons with visual impairments, preparing them to tread cautiously and expect obstacles along the travel path, traffic intersections, doorways, stairs, etc. They are used to screen off obstacles, drop-offs or other hazards, to discourage movement in an incorrect direction, and to warn of a corner or junction. Two rows of tactile warning paver should be installed across the entire width of the designated accessible passenger pathway at appropriate places such as before intersections, terminal entrances, obstacles such as signage, and each time the walkway changes direction.

14. Places to Install Warning Paver

- In front of an area where traffic is present.
- In front of an entrance/exit to and from a staircase or multi-level crossing facility.
- Entrances/exits at public transport terminals or boarding areas.

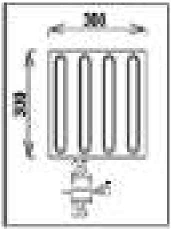


Fig. 13.3 - Guiding paver

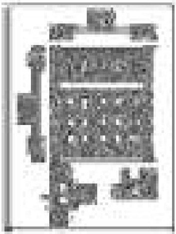


Fig. 13.4 - Warning paver

15. Doors

Whatever the type of entrance door, it must be wide enough to accommodate passenger traffic comfortably.

- The recommended minimum clear opening width of an internal door is 900mm minimum.
- Where doors comprise two leaves (i.e. double doors), each leaf should be 900mm min. wide, so that persons carrying large items and people using wheelchairs do not have to open both leaves.
- Manual doors should incorporate kick plates 300-400 mm high to withstand impact of wheelchair footrest (this is especially important where doors are glazed).
  - Also be fitted with vision panels at least between 900mm and 1500mm from floor level.
  - Be color contrasted with the surrounding wall and should not be heavier than 22N to open.
  - Lever handles and push type mechanisms are recommended . When a sliding door is fully open, handles should be usable from both sides.

- Where revolving doors or turnstiles are used, an alternative wheelchair-accessible entrance must also be provided.
- A distance of 400mm should be provided beyond the leading edge of door to enable a wheelchair user to maneuver and to reach the handle.
- To ensure maximum clarity for persons with visual impairments, the entrance should be easily distinguishable from its surroundings by the effective use of landscaping, signage, colour (preferably yellow/orange), tonal contrast and tactile surfacing.
- Door hardware should be positioned between 900-1000mm above floor (figure 28).
- Operable devices such as handles, pulls, latches and locks should:

  - Be operable by one hand
  - Not require fine finger control, tight grasping, pinching or twisting to operate.

- Glazed doors and fixed glazed areas should be made visible by use of a clear, colour and tone contrasted warning or decorative feature that is effective from both inside and outside and under any lighting conditions, e.g. a logo, of minimum dimensions 150mm by 150mm (though not necessarily square), set at eye level.

16. Steps & Stairs

- Steps should be uniform with the tread not less than 300mm and the risers 150mm.

- The risers should not be open.
- The steps should have an unobstructed width of 1200mm minimum.
- All steps should be fitted with a permanent colour and tone contrasting at the step edge, extending the full width of the step, reaching a minimum depth of 50mm on both tread and riser.
- Have continuous handrails on both sides including the wall (if any) at two levels.
- Warning paver to be placed 300mm at the beginning and at the end of all stairs.
- Nosing to be avoided.
- The staircase should be adequately and uniformly illuminated during day and night (when in use). The level of illumination should preferably fall between 100-150 lux.
- The rise of a flight between landings must be no more than 1200mm.
- There should be no more than 12 risers in one flight run.
- The stair covering and nosing should be slip-resistant, non-reflective, firmly-fixed and easy to maintain.
- Soffit (underside /open area under the stairs) of the stairs should be enclosed or protected.

17. Handrails

- Handrails should be circular in section with a diameter of 38-45mm and formed from materials which provide good grip such as timber, nylon or powder coating, matt finish metal finishes.
- The handrail should contrast in colour (preferably yellow/orange) with surrounding surfaces.
- At least 50mm clear of the surface to which they are attached and should be supported on brackets which do not obstruct continuous hand contact with the handrail.
- The handrails 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 13.1 - Specifications for Ramps

Level difference	Minimum gradient of Ramp	Ramp Width	Handrail on both sides	Comments
≥ 150 mm ≤ 300 mm	1:12	1200 mm	✓	
> 300 mm ≤ 750 mm	1:12	1500 mm	✓	Landings every 5 meters of ramp run.
≥ 750 mm ≤ 3000mm	1:15	1800 mm	✓	Landings every 9 meters of ramp run.
≥ 3000 mm	1:20	1800 mm	✓	Landings every 9 meters of ramp run.

18. 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 sensor enabled closing.
- In larger lifts, controls should be positioned on both side walls, at least 400mm from front wall and between 800-1000mm above floor level.

22. Car Design

- Internal walls should have a non-reflective, matt finish in a colour and tone contrasting with the floor, which should also have a matt, non-slip finish.
- Use of reflective materials such as metal (stainless steel for example) can be problematic in creating sufficient contrast with control buttons, emergency telephone cabinet, etc. for persons with low vision and the use of such materials should be avoided wherever possible.
- A mirror (750mm above floor level) on the rear wall can be useful to persons using wheelchairs and other mobility aids should they need to reverse safely out of the lift car or view the floor numbers.
- Internal lighting should provide a level of illumination of minimum 100 lux (approximately 50-75 lux at floor level), uniformly distributed, avoiding the use of spotlights or down lighters.

- A grab bar should be provided along both sides and the back wall, 900mm above floor level.
- Handrails should be of tubular or oval cross section, in order to be easily gripped and capable of providing support.
- Handrails should be positioned so that there is a clear space behind the handrail to allow it to be grasped i.e. knuckle space should be 50mm.

13.6 Information Systems

- Lifts should have both visual and audible floor level indicators.
- Audible systems are also usually capable of incorporating additional messages, such as door closing, or, in the case of an emergency, reassurance (with manual over-ride allowing communication with lift occupants).
- Announcement system should be of 80 decibel.
- The display could be digital or segmented LED, or an appropriate alternative. A yellow or light green on black display is preferred to a red on black display as it is easier to read.

13.7 General and Accessible Toilets

1. Signages

- All signage of general toilets should be in bold and contrasting colors.
- For persons with low vision and vision impairments, male pictogram in triangle and female pictogram in circle, marked on plates along with Braille & raised alphabets, to be mounted on wall next to door near the latch side, at a height between 1400mm-1600mm.
- Warning strip/ thin rubber door mat to be provided 300mm before and after the toilet entrance.
- Tactile paver to be provided for urinals, WC and washbasins for persons with vision impairments.

2. Accessible toilets

- Should have the international symbol of accessibility displayed outside for wheelchair access.
- The toilet door should be an outward opening door or two way opening or a sliding type and should provide a clear opening width of at least 900mm.
- It should have a horizontal pull-bar, at least 600mm long, on the inside of the door, located so that it is 130mm from the hinged side of the door and at a height of 1000mm.
-

3. WC Compartment Dimensions

- The dimensions of a unisex toilet are critical in ensuring access. The compartment should be at least 2200mm and 2000mm. This will allow use by both manual and motorized wheelchair users.
- Layout of the fixtures in the toilet should be such that a clear turning manoeuvring space of 1500mm x 1500mm in front of the WC and washbasin.

4. Water Closet (WC) Fixtures

- Top of the WC seat should be 400-480mm 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 manoeuvring. 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 controls should be securely fixed to the walls and positioned at 800-1000mm from the floor.
- The mirror should be tilted at an angle of 300 for better visibility by wheelchair users.
- It should have lower edge at 1000mm above floor finish and top edge around 1800mm above floor finish.
- Hooks should be available at both lower-1200mm and standard heights- 1400mm, projecting not more than 40mm from the wall.
- Where possible, be equipped with a shelf of dimensions 400mm x 200mm fixed at a height of between 900mm and 1000mm from the floor.
- Light fittings should illuminate the user's face without being visible in the mirror. For this reason, most units which have an integral light are unsatisfactory.
- Large, easy to operate switches are recommended, contrasting with background to assist location, at a maximum height of 1000mm above floor finish.
- All toilet facilities should incorporate visual fire alarms.
- Alarms must be located so that assistance can be summoned both when on the toilet pan i.e. at 900mm height and lying on the floor i.e. at 300mm, from floor surface. Alarms should be located close to the side wall nearest the toilet pan, 750mm away from rear wall and at 900mm and 200mm above floor finish.

8. Signage of Accessible Toilets

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

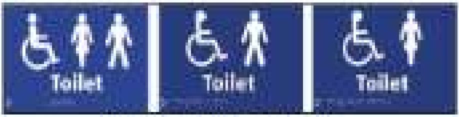


Fig. 13.5 - Signage for accessible washroom

B. 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 400mm 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.

15.8 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.

15.9 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:
  - a. Critical Surfaces (walls, ceiling and floor),
  - a. Signage and background sign frame/ wall,
  - a. Step edges and risers/ treads on steps,
  - a. Handrails and background walls,
  - a. Doors and surrounding walls,
  - a. Switches/ sockets and background wall,
  - a. Toilet fixtures and critical surfaces in toilet.

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

13.10 Emergency Egress/Evacuation

- Placement (accessibility) and visibility of such devices is very important. The following is to be considered for the installation of such alarm devices; fire alarm boxes, emergency call buttons and lit panels should be installed between heights of 800mm and 1000mm from the furnished floor surface. These should be adequately contrasted from the background wall and should be labeled with raised letters and should also be in Braille.
-
- A pre-recorded message, alerting an emergency to the control room or reception should be installed in the telephone and this should be accessible by a 'hotkey' on the phone keypad. This 'hotkey' should be distinct from the rest of the keypad.

13.11 Alarm Systems

- In emergency situations, it's critical that people are quickly alerted to the situation at hand. For persons with disability the following needs to be considered:
-
- Consider having audible alarms with 'voice instructions' that can help guide them to the nearest emergency exit. As an alternative to the pre-recorded messages, these alarms may be connected to the central control room for on-the-spot broadcasts.
-
- Non-auditory alarms (visual or sensory) to alert persons with hearing impairments should be installed at visible locations in all areas that the passengers may use (including toilet areas, etc).
-

Non-auditory alarms include:

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

13.12 Written Evacuation Procedure

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

13.13 Emergency Evacuation Route

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

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

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

13.14 Way Guidance System

- Luminance on the floor should be 1lux minimum provided on along the centre line of the route and on stairs.
- Install clear illuminated sign above exit and also directional signage along the route.
- The directional exit signs with arrows indicating the way to the escape route should be provided at a height of 500mm from the floor level on the wall and should be internally illuminated by electric light connected to corridor circuits.

13.15 Fire Resistant Doors

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

13.16 STREET DESIGN

(a) Footpath (Sidewalk)

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

Footpath should:

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

Footpath should have:

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

(b) Kerb Ramp

- Kerb should be dropped, to be flush with walk way, at a gradient no greater than 1:10 on both sides of necessary and convenient crossing points. Width should not be less than 1200mm. If width (X) is less than 1200mm, then slope of the flared side shall not exceed 1:12.
- Floor tactile paving- Guiding & Warming paver shall be provided to guide persons with vision impairment so that a person with vision impairment does not accidentally walk into 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.

15.17 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.

15.18 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.

15.19 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.

15.20 Approach

- Passenger walkways, including crossings to the bus stops, taxi stands, terminal / station building, etc. should be accessible to persons with disabilities.
- Uneven surfaces should be repaired and anything that encroaches on corridors or paths of travel should be removed to avoid creating new barriers. Any obstructions

or areas requiring maintenance should be white cane detectable.

- Access path from plot entry and surface parking to terminal entrance shall have even surface without any steps.
- Slope, if any, shall not have gradient greater than 5%. The walkway should not have a gradient exceeding 1:20. It also refers to cross slope.
- Texture change in walk ways adjacent to seating by means of tactile warning paver should be provided for persons with vision impairment.
- Avoid gratings in walks.

13.21 Car Park

(A) Signage

- International symbol of accessibility (wheelchair sign) should be displayed at approaches and entrances to car parks to indicate the provision of accessible parking lot for persons with disabilities within the vicinity.
- Directional signs shall be displayed at points where there is a change of direction to direct persons with disabilities to the accessible parking lot.
- Where the location of the accessible parking lot is not obvious or is distant from the approach viewpoints, the directional signs shall be placed along the route leading to the accessible parking lot.
- Accessible parking lot should be identifiable by the International Symbol of Accessibility. The signs should not be obscured by a vehicle parked in the designated lot.
- Vertical signs shall be provided, to make it easily visible, the sign should be at a minimum height of 2100 mm.

(B) Symbol

International Symbol of Accessibility should be clearly marked on the accessible parking lot for drivers/riders with disabilities only.

- A square with dimensions of at least 1000 mm but not exceeding 1500 mm in length,
- Be located at the centre of the lot, and
- The colour of the symbol should be white on a blue background.

(C) Car Park Entrance

The car park entrance should have a height clearance of at least 2400 mm.

Location

- Accessible parking lots that serve a building should be located nearest to an accessible entrance and / or lift lobby within 30 meters. In case the access is through lift, the parking shall be located within 30 meters.

- The accessible route of 1200 mm width is required for wheelchair users to pass behind vehicle that may be backing out.

(D) Accessible Car Parking Lot

The accessible car parking lot should:

- Have minimum dimensions 5000 mm × 3600 mm.
- Have a firm, level surface without aeration slabs.
- Wherever possible, be sheltered.
- Where there are two accessible parking bays adjoining each other, then the 1200 mm side transfer bay may be shared by the two parking bays. The transfer zones, both on the side and the rear should have yellow and white cross-hatch road markings.
- Two accessible parking lots shall be provided for every 25 no of car spaces.
-

(E) DROP OFF AND PICK UP AREAS

- Designated drop-off and pick-up spaces, to be clearly marked with international symbol of accessibility.
- Kerbs wherever provided, should have kerb ramps.

CHAPTER 14

ENVIRONMENTAL IMPACT ASSESSMENT

TABLES

CHAPTER 14

ENVIRONMENTAL IMPACT ASSESSMENT

14.0 INTRODUCTION

The Ministry of Environment and Forests (MoEF), Government of India issued notification on 14th September 2006 superseding the earlier notification No. SO 60(E) dated 27th January 1994 for getting Environmental Clearance. All new projects/expansion and modernization of existing projects or related activities listed in the schedule 1 of the notifications are required to obtain prior environmental clearance from MoEF. The proposed Nagpur Metro rail project does not fall in the schedule requiring the prior environmental clearance. Still, DMRC being an environmental conscious organization has undertaken EIA study to mitigate/reduce the environmental impacts arising from construction and operation of the project.

DMRC appointed M/s Consulting Engineering Services (India) Private Limited for carrying out the EIA study for the proposed Nagpur Metro. The objective of the EIA study is as follows:

- Ascertain positive and negative environmental and social impacts of the project.
- Mitigate negative environmental and social impacts.
- Enhance environmental quality in and around the project area by adopting mitigation and conservation measures.

14.1 BASELINE ENVIRONMENTAL CONDITIONS

The development / compilation of environmental baseline data are essential to assess the impact on environment due to the project. The environment includes water, land, air, ecology, noise, vibration etc. The information presented in this section stems from various sources such as reports, field surveys and monitoring.

Climatologically data was collected from regional meteorological department at Nagpur. This data has been further utilized to assess the incremental impact if any due to the project. Socio-Economic assessment has also been done. Study area consists of the following two metro alignments for the proposed metro rail project in Nagpur:

- Automotive Square to KHAPRI (North – South Corridor) – 19.658 Km including one depot.
- Prajapati Nagar to Lokmanya Nagar (East – West Corridor) – 18.557 Km including one depot.

14.1.1 Physiography

Nagpur district lies on the Deccan Plateau of Indian peninsula and has a mean altitude of 310.0 mean above sea level. It is situated at latitude between 20°35'N and 21°44'N and longitude between 78°15'E and 79°40'E. The district is situated on the eastern part of the State abutting the state of Madhya Pradesh in north and is bounded by Wardha and Amravati districts in the west, Bhandara district in the east and Chandrapur district in the south. The district has a geographical area of 9892 sq. km. Nag River a tributary of Kanhan river flows through the project alignment. The district forms part Godavari Terrain of the project area is plain.

14.1.2 Geology and Soil

The city of Nagpur lies on the basaltic flow known geologically as Deccan Traps. The parent basalt is very dark grey in colour, compact, dense and very hard in nature. It is very difficult to break this rock and it breaks up with sharpconchoidal fractures confirming to be of igneous origin. Nagpur city lies in the neighbourhood of the classical geological areas of India. More than half of the whole district of Nagpur is covered by basaltic and doleritic lava flows known as Deccan Traps. The main soil types present in the region are kali soils, morand soils, khardi soils, bardi soils, kachchar soils and wardi soils.

14.1.3 Hydrology

Nagpur city is located on a basaltic plateau and the topography in and around the city is plain & gently rolling. The north-eastern and eastern parts of Nagpur district are drained by Wainganga river and its tributaries of which Kanhan forms the major. The central and western portion of the district is drained by Wena river which is main tributary of Wardha river.

There are several natural water bodies within the city limits including 12 lakes, two rivers and five nallahs. The lakes (Gorewada, Futala, Ambazari, Sonegaon, Sakkardara, Gandhisagar, LendiTalao, NaikTalao, DobTalao, Pandharabodi, Sanjay Nagar Khadan and Pardi) cover an area of about 3.13 sq. km. The Nag and Pili

Rivers cut across the city and are 15.73 km. and 12.11km. in length respectively. Besides these, Chamar Nallah, Shakti Nagar Nallah, Hudkeshwar Nallah, Swawalambi Nagar Nallah and Sahakar Nagar Nallah also flow through the city.

14.1.4 Land Use Pattern

The land use/land cover pattern of a region is an outcome of natural and socio – economic factors and their utilisation by man in time and space. Hence, information on land use / land cover is essential for the selection, planning and implementation of land use which can be further used to meet the increasing demands for basic human needs and welfare. Land use pattern along both the alignment is generally residential and commercial, with some part of the alignment having plantation, institutions, water bodies etc.

The different categories of land use of the study region are given in the Table 14.1 below:

Table 14.1: Land Use Categories

S. No.	Land Use Category	Area (sq.km)	Area Percentage (%)
1	Agricultural Land	11.34	14.52
2	Built-up Area	38.85	49.75
3	Open Area	7.31	9.36
4	Plantation	8.26	10.58
5	Institute	0.51	0.65
6	Industry	6.79	8.70
7	Lake	1.57	2.01
8	Water body	0.42	0.54
9	Canal	0.20	0.26
10	Ground	0.19	0.24
11	Wasteland	2.63	3.37
Total		78.09	100.00

14.2 Meteorology and Climate

The climate of Nagpur can be broadly divided into three important seasons of summer, winter and monsoon. Almost throughout the summer (March-June), the maximum temperature remains beyond 40 degree Celsius. Sometimes it may be as high as 48 degree Celsius. Monsoons (July-September) take its charge in the month of June. It showers maximum in the months of July and August. The minimum temperature recorded around 12 degree Celsius in winters (October-January) and sometimes even dips down below that level in the month of February. Nagpur city experiences a low pressure in the end of May month resulting in the wind blowing at a speed of 6 m/s or more and for the rest part of the year, the speed remains 2 to 3 m/s.

14.2.1 Temperature

The temperature generally rises from the beginning of March till June, which is the hottest month of the year with mean minimum and maximum temperatures of 20.3°C and 30.7°C respectively. With the onset of monsoons by the end of June, temperature begins to fall. The drop in day temperature is much more than the drop in night temperature.

The night temperature falls rapidly after the withdrawal of monsoons by mid-September. The month of December is coolest month with the mean maximum and minimum temperatures being 28.9°C and 12.1°C respectively.

Sky is generally clear with light surface winds blow from North or Northeasterly direction. The normal minimum temperature is 12.0°C to 14.0°C with slight rise in the mean daily minimum temperature. The mean maximum temperature is around 29.0°C.

14.2.2 Humidity

Except during monsoon months is generally low throughout the year. During summer season, humidity is lowest (20.7%). During monsoon months, it goes as high as 80-90%. The highest level of humidity (88%) is observed in the month of August.

14.2.3 Rainfall

At Nagpur, the annual rainfall is 1250.7 mm. About 68 to 70 % of the annual rainfall is received in the monsoon months. The rain in Nagpur is heavily dominated by the south-westerly monsoon winds. Precipitation in form of rain is received during monsoon months. The number of rainy days in a year is about 56.9 at Nagpur.

14.2.4 Seismicity

The project area falls in **Zone-II** of Seismic Zoning Map of India. This is a least active zone from seismic point of view. Nagpur has close to zero chances of getting a major earthquake which may cause huge devastation. Recent history also supports the fact that Nagpur region is relatively very safe as far as earthquakes are concerned. But still, as per the Seismic Zoning Map of India (IS-1893, Part-I, 2002) necessary seismic factors suggested by Indian Meteorology Department (IMD) shall be incorporated suitably while designing the structures to safeguard against earthquake risks.

14.3 Ambient Air Quality

As a part of this study ambient air quality monitoring (AAQM) has been carried out by setting up ambient air quality monitoring stations at four locations. The baseline data pertaining to the existing air quality will help mitigate impact on air quality during construction stage and operation stage of the project. The prominent source of air pollution in urban area is vehicular traffic.

Monitoring was done as per the guidelines for Ambient Air Quality Monitoring, National Ambient Air Quality Series NAAQMS/25/2003-04. The following parameters were measured:

- Respirable Suspended Particulate Matter (RSPM/PM_{10})
- Fine Particulate Matter (FPM/$PM_{2.5}$)
- Sulphur Dioxide (SO_2)
- Nitrogen Dioxide (NO_2)
- Carbon Monoxide (CO, 1 hourly)
- Hydrocarbons (HC 1 hourly)

Air quality monitoring results are summarized in the following Table 14.2.

Table 14.2: Summary of Air Quality Monitoring Results

Parameter	Proposed Rahti Chowk Station (Residential/Commercial area)	Near proposed Mayuresh Station (Residential/Commercial area)	Ambedkar Chowk (Residential/Commercial area)	Near Proposed Subhash Nagar Station (Residential/Commercial area)
PM_{10} µg/m^3				
No. of Samples	8	8	8	8
Range	26-52	32-51	29-64	27-43
Mean	42.8	38.2	47.8	33
98 percentile	49.6	40.7	61.3	38.6
$PM_{2.5}$ µg/m^3				
No. of Samples	8	8	8	8
Range	25-48	23-37	70-83	25-33
Mean	38.2	30.5	77.0	30.7
98 percentile	55.0	36.4	82.1	33.1

NO_2 µg/m³				
No. of Samples	8	8	8	8
Range	37-48	23-45	23-44	23-47
Mean	42.4	39.6	33.0	41.6
98 percentile	47.6	48.6	42.9	48.5
SO_2 µg/m³				
No. of Samples	8	8	8	8
Range	9-23	11-26	9-26	13-24
Mean	16.3	17.3	17.6	17.9
98 percentile	22.0	24.6	25	23.5
CO mg/m³				
No. of Samples	8	8	8	8
Range	1.1-1.17	1.12-1.31	1.15-1.34	1.15-1.23
Mean	1.13	1.24	1.21	1.20
98 percentile	1.17	1.3	1.31	1.23
Hydrocarbons (µg/m3)				
No. of Samples	8	8	8	8
Concentration	<1.0	<1.0	<1.0	<1.0

The maximum value of PM_{10} found at Kabbi Chowk station (42.6 µg/m³) followed by Ambedkar Chowk (41.6 µg/m³), Mayuresh Station (36.3 µg/m³) and Subhash Nagar Station (33 µg/m³).

The mean Nitrogen Dioxide concentrations were measured as 42.4 µg/m³, 39.6 µg/m³, 33.0 µg/m³ and 41.6 µg/m³ at Kabbi Chowk, Mayuresh station, Ambedkar Chowk and Subhash Nagar station. These concentrations are well within the standards i.e. 80 µg/m³ as prescribed by National Ambient Air Quality Standards. The low level of the Nitrogen Dioxide concentration may be attributed to better traffic management.

The average concentration of Sulphur Dioxide generated at various monitoring stations were recorded 16-18 µg/m³. The values are also well within the specified limit i.e.80 µg/m³ at all the monitoring stations.

The mean Carbon Monoxide values at all four monitoring sites were recorded as 1.15 mg/m³, 1.24 mg/m³, 1.21 mg/m³ and 1.20 mg/m³ at Kabbi Chowk station, Mayuresh Station, Ambedkar Chowk and Subhash nagar station which is well within the National Ambient Air Quality Standards of 2mg/m³.

As per the quantitative analysis of Hydrocarbons in air samples it may be concluded that hydrocarbons are present in minimum concentration (<1.0 µg/m³) in the air environment of the study area. The concentration of Hydrocarbons measured at all four stations throughout the winter season was very well below the limit of 5 µg/m³.

14.4 Ambient Noise Quality

Noise levels are measured at different places (16 locations) in Nagpur along the corridor at building lines away from source as per standard practice. Noise monitoring locations are presented in following Table 14.3 below.

Statistical indicators worked out for establishing the baseline conditions along the project corridor is presented in Table 14.3 below.

Table 14.3: Statistical Indicators for Noise Quality

Sl. No.	Station id	L_{max}	L_{min}	Leq	L_{10}	L_{50}	L_{90}
1	Automotive Square	78.00	61.40	67.50	70.00	65.00	63.60
2	Sri Guru Govind Singh Educational Institute	73.00	60.00	70.20	74.70	68.30	63.50
3	Z.P School Prasenfun Technical High School & College	64.00	53.20	61.34	64.00	55.44	53.64
4	Bank of Maharashtra near proposed Sitaburdi station (Munje Chowk)	70.00	58.00	67.26	72.08	64.36	61.08
5	NEERI Campus	71.20	63.80	68.17	74.57	65.67	65.40
6	Mayuresh Apartment at proposed mayuresh station	62.80	48.60	58.90	62.25	56.85	54.75
7	Existing Terminal Building	71.50	43.70	68.50	70.0	67.5	63.2
8	Open land of MIHAN SEZ	65.00	34.28	52.03	55.38	45.03	45.50
9	Sabco Hospital	72.50	62.70	68.42	72.31	65.22	63.47
10	Ashish Tower	68.50	55.00	65.68	70.08	63.89	63.48
11	Mayo Hospital	76.00	62.00	67.93	71.03	66.69	64.43
12	Ram Mandir	73.50	67.40	71.44	75.00	68.14	66.34
13	Govardhan Das Rawal High School	67.00	52.80	64.15	67.00	63.15	58.75
14	Saipekar's Brother's Petrol Pump	74.00	65.70	71.50	75.44	68.84	68.88
15	Dharampeth Polytechnic & Science College	69.00	48.50	66.03	71.29	63.09	61.83
16	St. Xaviers High School	68.00	52.30	65.11	66.61	42.86	62.11

Highest value of Leq, day has been obtained at NQ 13 (74 dB A) and minimum value has been obtained at NQ 7 (67 dB A) along the East – West corridor. Whereas, maximum day time L_{eq} has been obtained at NQ2 (73 dB A) and minimum value is obtained at NQ5 (62.5 dB A) along the North South corridor.

14.6 Water Quality

It is reported that five rivers are intercepting the project road. The other hydrological features are irrigation canal which intercepted the project road at five locations. The ponds are existing along either side of the project road provide requirements to village communities. The flow of river in the project site is seasonal and remains dry throughout the year. The underground water is the only important source for catering to needs of water demand for village's communities falling along the project road.

Water quality monitoring was carried out at four location covering two surface water sources and two groundwater sources. The results of the groundwater analysis obtained are presented below in Table 14.4.

Table 14.4: Water quality monitoring results

Parameter and unit	Station code			Limits as per IS 10500
	Gandhi Bagh Garden (GW1)	Automotive Square (GW2)	Mayurash Station (GW3)	
Colour (Hazen units)	<5	<5	<5	5
Taste	Agreeable	Non-Agreeable	Non-Agreeable	Agreeable
Temperature (°C)	28	28.4	27.8	-
Ph	8.6	8	8.5	6.5-8.5
Conductivity (µS/cm)	950	835.2	665.2	-
TDS (mg/L)	31.5	30.5	16.8	500
TSS (mg/L)	2	3	1	-
Total hardness(mg/l)	426.4	313.2	199.6	300
Total alkalinity(mg/l)	152.63	58.88	101.73	200
Chloride (mg/l)	67.10	73.07	77.04	250
Sulphate (mg/l)	7.28	4.28	5.06	200
Nitrate (mg/l)	0.011	BDL	BDL	45
Fluoride (mg/l)	0.78	BDL	BDL	1
Calcium (mg/l)	75.2	270	81	75
Magnesium (mg/l)	62.99	10.56	28.67	30
Sodium (mg/l)	497	477	430	-
Potassium (mg/l)	108	155	206	-

Parameter and unit	Station code			Limits as per IS-10500
	Gandhi Bagh Garden (GW1)	Automotive Square (GW2)	Mayuresh Station (GW3)	
Phosphate (mg/l)	0.04	0.32	2.47	-
Silica (mg/l)	0.18	0.73	0.11	-
Arsenic (mg/l)	<0.01	<0.01	<0.01	0.01
Lead (mg/l)	<0.05	<0.05	<0.05	0.05

14.6.1 Physical Parameters

The quality of the ground water is showing alkaline trend as the pH value ranges from 8-8.8 which is not within the desirable limit for Automotive Square and Mayuresh Station permitting non-aggressive taste used for drinking purpose. The water contains no color, turbidity free and is odourless serving the most important source for drinking. Electrical Conductivity is a useful tool to evaluate the purity of water. The groundwater is fresh and potable with electrical conductivity ranging between 905.2µS/cm to 965µS/cm at 25°C.

Total dissolved solids (TDS) is a measure of the combined content of all inorganic and organic substances contained in a liquid in molecular, ionized or micro granular suspended form. The limit of 500mg/l for potable water is based primarily on the taste threshold. TDS ranges between 14.5mg/L to 31.5mg/L which is well in the permissible limit.

TSS varies from 1mg/L to 3 mg/L while Total Hardness in the ground water samples vary from 198.8mg/L to 328.4mg/L as $CaCO_3$.All the ground water samples were found to be moderately hard. Maximum Total hardness is reported in Gandhi Bagh Garden whereas minimum total hardness is reported in Mayuresh Station. Though hard water has no harmful effects on health but it restricts its use for other purposes.

14.6.2 Chemical Parameters

Chloride content in the water samples was low in the winter season. The concentration of chloride in the groundwater is found in the range of 37.1mg/L to 77.04 mg/L which is within the limit of all groundwater stations.

The sulphate content varies between 4.29mg/l to 7.29mg/l and the fluoride content is 0.76mg/l at Gandhi Bagh Garden which is within the desirable limit of 1mg/l. Maximum Sulphate concentration is observed in Gandhi Bagh Garden but very well below the desirable limit.

Total Alkalinity in terms of $CaCO_3$ varies from 50.08mg/l to 152.03mg/l which is within the desirable limit of 200mg/l as prescribed by Indian Standards of Drinking Water.

Nitrate is well within the limits of IS: 10500 at all the stations. Its concentration at Gandhi Bagh Garden is 0.01 mg/l while it is below detection limit at other sites which is within the permissible limit of 45mg/l.

Fluoride content at Gandhi Bagh garden is 0.76mg/l which is well below the desirable limit 1.0mg/l.

Calcium is a major cation found in ground water. Its concentration varies between 70.2mg/l to 270 mg/l. The concentration of calcium at Automotive Square and Mayuresh Station exceeds the limit of 75mg/l.

Magnesium concentration in the groundwater is high ranging between 10.5mg/l to 62.46mg/l. Mayuresh Station exceeds the permissible limit of 30mg/l.

14.8.3 Heavy metals

Arsenic and lead concentration at all the GW stations is below the desirable limit of 0.01mg/l and 0.05mg/l respectively.

14.8.4 Microbiological parameters

Total coliform and fecal coliform are absent in the groundwater samples.

The results of the surface water sample analysis obtained are presented below in Table 14.6.

Table 14.6: Surface water sample analysis results

Parameter and unit	Station code	Limits as per IS:2296
	Ambazhari lake (SW1)	Class D
Colour (Hazen units)	<5	-
Taste	Non-Agreeable	-
Temperature (°C)	28	-
Ph	6.2	8.5
Conductivity (µS/cm)	1366.1	1000
TDS (mg/L)	83.8	-
TSS (mg/L)	20	-
Dissolved Oxygen (mg/l)	5.0	4
Total hardness(mg/L)	286.2	-
Total alkalinity(mg/L)	254.38	-
Chloride (mg/L)	206.26	-
Sulphate (mg/L)	33.84	-
Nitrate (mg/L)	0.023	-
Fluoride (mg/L)	0.94	-
Calcium (mg/L)	17.20	-
Magnesium (mg/L)	33.045	-

Parameter and unit	Station code	Limits as per IS:2296
	Ambazhari lake (SW1)	Class D
Sodium (mg/L)	14.36	-
Potassium (mg/L)	167	-
Phosphate (mg/L)	0.02	-
Silica (mg/L)	3.86	-
Nitrite mg/l	BDL	-
COD	12	-
BOD mg/ml	5.0	-
Oil & Grease mg/l	6	0.1
Arsenic (mg/L)	<0.01	-
Lead (mg/L)	<0.05	-
Total Coliform (MPN/100ml)	110	-

14.6.6 Physical Parameters

The pH value of SW1 is 9.2. The alkaline pH in lake water might be due to presence of alkalinity minerals in water. Higher values of pH also reduce germicidal potential of chloride. **The electrical conductivity of the surface water is 1906.1 µS/cm. Electrical** conductivity at the **site was found to exceed the limit of 1000µS/cm. High value of** conductivity recorded at SW1 (Ambazhari Lake) indicates a high concentration of soluble salts in water. The water contains color, therefore do not serve the drinking purpose of the local population dwelling in the area.

The value of TDS 88.8 mg/L. TSS is found in natural surface water. TSS value of water sample is 20 mg/l.

The value of DO is 5.6 mg/l indicating low levels of organic matter in the water. The principal natural physical factors affecting the concentration of oxygen in the marine environment are temperature and salinity. DO concentrations decrease with increasing temperature and salinity.

14.6.8 Chemical Parameters

Total Hardness in the surface water sample is 266.2mg/L as $CaCO_3$. Sulphate is present in the surface water within the permissible limit. Its concentration is 33.64mg/l.

Total Alkalinity in terms of $CaCO_3$ of the water sample is 254.38mg/l indicating high concentration of carbon based molecules suspended in that water. Chloride is an important anion present in the water. Its concentration is 200.8mg/L showing high chloride content. Elevated levels may also harm aquatic life.

Nitrates are used as indicators of nutrient levels and as a guide for the algal blooms and hence eutrophication. Its concentration beyond permissible limit leads to methaemoglobinemia, which is blue baby disease. Its concentration in the surface water samples is 0.023 mg/l. Fluoride content is 0.34mg/l.

Calcium is a major cation found in water. Its concentration in the water sample is 17.28 mg/l.

Chemical Oxygen Demand value is 12 mg/l in the water sample which indicates that the Lake water is unpolluted. Low Total Phosphate content of the water sample is 0.02mg/l indicates there is no phosphorous loss from agricultural sites entering lakes.

BOD concentration in the water sample is 5.0mg/l. The BOD value indicates less quantity of organic waste in the Lake water making it moderately clean.

14.6.7 Heavy metals

Arsenic and Lead contamination in the water sample is <0.01mg/l and <0.05 mg/l respectively.

Coliform analysis can indicate the degree of possible contamination by human sewage, and possible presence of other pathogens present in the water. Total Coliform in SW1 is 110 MPN/100ml.

14.8 Soil quality

Soil samples were collected from selected locations to establish the baseline soil conditions in the study area. Representative soil samples from depth (15cm) were collected for estimation of physic-chemical characteristics of soil.

14.8.1 Physical properties

Results indicate that the clay content is 22% at SQ1, 29% at SQ2, 10% at SQ3 and 54% at SQ4. The sand content varies from 34-62% while silt content is varying from 12-35%. The porosity is ranging from 7.4% by mass to 10.5% by mass. Lower values of bulk density varying from 1.17 to 1.24gm/cc, indicate good soil structure.

Texture of SQ1(Automotive Square) is classified as Sandy Clay Loam, SQ2 as Medium Loam, SQ3 as Sandy Loam and SQ4 as Clayey. The soils varied in moisture content from dry through moist to wet types. Moisture content varies from 3.7% to 31.2%.

14.8.2 Chemical Properties

The collected soil samples were analyzed for various chemical properties. The parameters selected were pH, electrical conductivity, Organic Matter, Nitrogen, Exchangeable Potassium, Phosphorus, Sulphate and Sodium. pH is an important factor which indicates the alkaline and acidic nature of soil and gives the idea of nutrient availability, microbial activity and physical condition of the soil. The soil in the study area is alkaline in nature as the pH value is varying from 7.75 to 8.58. Conductivity is ranging from 60 to 175µS/cm. The total Nitrogen in the soil samples in the study area varies from 728mg/100g to 1784mg/100g.The substantial amount of the nitrogen in the soils of the study area is contributed by nitrogen fixing bacteria of the genus **Rhizobium** associated with the leguminous plants of the area which constitute an appreciable proportion of the plant species.

Organic matter is an important soil health indicator as it contributes to the biological, chemical, and physical properties of the soil. Organic matter serves as a reservoir of nutrients and water in the soil, aids in reducing compaction and surface crusting, and increases water infiltration into the soil. The organic matter in the soil samples is ranging from 1.6% to 2.6%. It is also responsible for the stability of soil aggregates.

The phosphorus concentrations ranged from 33mg/100g to 94mg/100g. The total content of the basic chemicals like K, gives the extent of leaching of the soil where the concentration of exchangeable Potassium varies from 77.1mg/1000g to 231.8mg/1000g.

The analytical results of the soil samples are presented in the Table 14.8.

Table 14.8: Soil samples analysis results

Parameter & unit	Monitoring location			
	SQ1 Automotive Square	SQ2 Near Airport Area	SQ3 Between Pratap Nagar and Vaishnav Devi Chowk	SQ4 Between Subhash Nagar & Rachana Ring Road
pH	7.75	7.84	8.58	8.02
Electrical Conductivity (µS/cm)	175	59	60	66
Sand (%)	52	48	42	34
Silt (%)	26	23	39	12
Clay (%)	22	29	19	54
Moisture Content (%)	21.2	6.2	3.7	8.9
Infiltration rate (cm/hr)	14.5	10.3	11.2	8.6
Bulk Density (gm/cc)	1.24	1.19	1.21	1.17

Parameter & unit	Monitoring location			
	SQ1 Automotive Square	SQ2 New Airport Area	SQ3 Between Prajapati Nagar and Vaishno Devi Chowk	SQ4 Between Subhash Nagar & Rachana Ring Road
Porosity (%)	9.2	9	10.5	7.4
Organic Matter (%)	1.7	2.1	2.6	1.5
Nitrogen (mg/100 g)	178.4	102.4	142.9	72.6
Exchangeable Potassium (mg/1000g)	200.3	177.8	201.8	77.1
Phosphorus (mg/100 g)	54	57	72	33
Sulphate (as SO_4) (mg/kg)	296	7.9	51.9	16.2
Sodium as (Na) (mg/kg)	207	94.1	140.2	40

14.6.3 Biological Environment

The main impact on biological environment will be from the tree felling. Data pertaining to the field survey indicates that total 41 species will be felled due to the project. Primary survey of the terrestrial ecology indicates that no rare endangered species listed in the IUCN are getting affected due to the project. The main species are given in Table 14.7.

Table 14.7: Summary of Trees

Corridor	Location	Length	Trees to be felled
Corridor – 1 (North – South)	Automotive Square to Depot at KHAPRI	19.658 Km	85 Nos.
Corridor – 2 (East – West)	Prajapati Nagar to Lokmanya Nagar	18.557 Km	74 Nos.

Hence, a total of 159 trees are likely to be felled for the project construction.

14.7 POSITIVE IMPACTS DUE TO THE PROJECT

The metro rail will not only offer commuters a more secure and comfortable travel experience that comes with world class facilities, but it will also reduce the time of travelling and rush hour commuting. Its wide network coverage and connections will provide a very positive impact on daily commute of the people of Nagpur city. Some of the positive environmental impacts are as follows.

- Employment opportunities

- Enhancement of Economy
- Less fuel consumption
- Traffic congestion reduction
- Less GHG emissions
- Reduction in Air pollutant emission

The different components of benefits include:

- Vehicles off the Road due to Metro
- Vehicle KM Saved by Metro passengers
- Amount of travel time saved by Metro Passengers and by the Remaining Road Passengers (due to reduced congestion and increased speed on the road)
- Fuel consumption saved due to shifting to Metro
- Reduction in vehicular emissions in tonnes and the reduction in related emission cost
- Reduction in fatal and fatal accidents and savings in Accident Costs
- Reduction in Vehicle maintenance and operation Cost.
- Travel time savings to remaining road users due to release of road space, reduced congestion and improved speeds.

14.3 ANTICIPATED IMPACTS AND MITIGATION MEASURES

The environmental impact assessment of the project is based on the Baseline Environmental Status of the Area. The proposed project will have impacts on the environmental attributes in construction and operation phase. During construction phase which may be regarded as temporary or short-term, and the operation phase impacts may have long term effects. The environmental impacts due to construction phase and operation phase are discussed in the following subsections.

14.3.1 Impacts during Construction Phase

Potential sources of the construction phase environmental impacts are earthwork, bituminous work, concreting, setting up of labour camps etc. However, the construction phase impacts will be short-term and localised and can be mitigated by adopting appropriate mitigation measures.

14.3.2 Traffic Diversion and Risks to Existing Buildings

During construction, traffic diversions on roads will be essentially required. As most of the construction activities will be confined to centre of the road and most of the roads are four lanes, it will be appropriate that the side lanes may also be utilised for traffic and also for smooth progress of construction activities. Advance information/signboards/warning signs will be an advantage to users of any particular road. As most of the proposed sections are elevated and located in the middle of the road with deck width being much less than the existing road width, hence risk to the existing buildings all along the route will be practically negligible. In underground portion, whether by cut and cover or by tunneling, the building line is considerably away from the proposed cut and cover and tunnels. Hence no risk is foreseen to adjacent buildings. Some of the measures are as follows:

- At the points where traffic is to deviate from its normal path (whether on temporary diversion or part width of the carriageway) the channel for traffic will be clearly marked with the aid of pavement markings, painted drums or a similar device to the directions of the Engineer in Charge.
- One-way traffic operation will be established whenever the traffic is to be passed over part of the carriageway inadequate for two-lane traffic. This will be done with the help of temporary traffic signals or flagmen kept positioned on opposite sides during all hours.
- For regulation of traffic, the flagmen will be equipped with red and green flags and lanterns/lights.
- On both sides, suitable regulatory/warning signs as approved by the Engineer will be installed for the guidance of road users. On each approach, at least two signs will be put up, one close to the point where transition of carriageway begins and the other 120 m away. The signs will be of approved design and of reflectory type, or as directed by the Engineer.

14.3.3 Air Quality

Potential impacts on existing air quality during the construction phase would be due to dust generated during excavation, earth work, vehicles movement, loading and unloading of the construction materials.

Fugitive emissions generated due to vehicular movement are not expected to travel beyond a distance of 50 to 100 m from the point of their origin. Since, there is no habitation within 200 to 300m of the project site the impact on air environment during the construction phase is not expected to be significant as far as air pollution is concerned. Combustion of diesel in different construction equipment could be one of the possible sources of incremental air pollution during the construction phase.

Mitigation measures for minimizing impact on air quality during construction phase shall comprise:

- Vehicles with an open load carrying shall not be used for moving potentially dust-producing materials. Vehicles shall have properly fitting side and tailboards.
- Materials having the potential to generate dust shall not be loaded to a level higher than the side and tail boards, and shall be carried in vehicles fitted with cover lids / tarpaulin cover.
- Excavated materials shall be placed in the designated dumping/disposal areas.
- Material shall be stabilized during summer season, each day, by watering at every two hours interval.
- The heights from which materials are dropped shall be limited to 1.5 m. to restrict fugitive dust generation.
- Water shall be sprayed at construction sites once every hour for period of two minutes to suppress dust, during handling of excavated dry soil or debris.
- Water sprays shall be used during the delivery and handling of all raw sand, and aggregate and other similar materials, when dust is likely to be created and to dampen all stored materials during dry and windy weather.
- All motorized vehicles on kachha roads on the Site shall be allowed a maximum speed of 15–20 kilometers per hour.
- Concrete batching plant sites and ancillary areas shall be cleaned frequently and water shall be sprayed to minimize any dust emissions. Tentative sites for locating the construction camps have been identified at the following locations:
  - Lokmanya Nagar (proposed metro depot) – Government Land
  - KHAPRI Depot Land – Government Land
  - Automotive Square – Private Land
- Barriers/hoarding shall be provided securely around all construction work sites during the main construction activity, when reasonably practicable, to contain dust within the site area and also to reduce air turbulence caused by wind or passing traffic.

Workers working in dust generating areas shall use nose masks. Placards advising workers to use nose masks shall be displayed.

14.3.4 Noise Quality

During the construction phase, noise will be generated due to movement of vehicles, and operation of light & heavy construction machineries including pneumatic tools (dozers, tippers, loaders, excavators, graders, roller, concrete mixer, generators, concreting pumps, vibrators, cranes, compressors etc.). The construction activities are expected to produce noise levels in the range of 75 – 95 dB (A).

The construction works will be carried out during the day time in residential areas. The impact of noise produced during the construction will, however, be limited to a distance of about 75 meters at which the noise level of various equipment will come down below 55 dB(A). It could therefore be concluded that the construction activities would not have a significant impact on existing ambient noise levels.

Workers working at noisy areas may be affected (if they do not use ear muffs/plugs), if actual exposures exceeds the prescribed safety limits (8-hour long limit of 90 dB (A)) as per Factories Act / BOCW Act 1996.

Mitigation measures for minimizing noise levels during construction phase are as follows:

- ✓ Stationary equipment shall be located so as to minimize noise impact on the neighbouring community.
- ✓ Plant and equipment known to emit noise strongly in one direction shall be oriented, wherever possible, in a direction away from noise sensitive receptor;
- ✓ Silencers and mufflers shall be fitted and maintained on construction equipments.
- ✓ Work shall be scheduled in such a way that activities that generate high noise levels shall not be done simultaneously;
- ✓ Truck loading, unloading, and hauling operations shall be scheduled so as to minimize noise impact near noise sensitive locations and surrounding communities;
- ✓ Equipment and plant will not be kept idling when not in use
- ✓ Plant at site shall be serviced regularly
- ✓ Placards shall be displayed near high noise areas
- ✓ Earmuffs/Earplugs shall be made mandatory for workers working in high noise areas.

14.3.5 Vibration

Construction activities can result in varying degrees of ground vibration, depending on the equipment and methods employed. Ground vibrations from construction activities do not often reach the levels that can damage structures, but they can achieve the audible and feasible ranges in buildings very close to the site. The construction activities that typically generate the most severe vibrations are blasting and impact pile.

The following mitigation measures will be adopted to reduce the degree of impact due to vibration during construction phase.

- Avoid impact piling in vibration sensitive areas. Drill pile or sonic piling will be employed in such areas to reduce the impacts on nearby buildings.
- Vibration monitoring will be undertaken as suggested in the environmental monitoring plan and a plan shall be prepared by the contractor to control the damage due to vibration.

Nighttime pile driving operation or other high vibration generation activities will not be allowed in vibration sensitive areas.

14.3.6 Soil Quality

Site Runoff from unprotected excavated areas can result in excessive soil erosion, especially when soil is highly erodible. Mitigation measures include careful planning, timing of cut and fill operations and re-vegetation. Problems could arise from dumping of construction spoils (concrete, bricks), waste materials (from contractor's camp) etc. causing surface and ground water pollution.

The proposed North-West corridor has a construction of underground metro of about 3Km. Underground construction is a specialized and complex task. This is safety reasons near airport. Elaborate measures need to be adopted for collection, transfer and disposal of excavated soil as suggested below.

- Soil collection, transportation, disposal and its treatment needs to be carried out in a systematic manner.
- Soil collection should be in containers from the construction sites. These containers should be such that soil should not spill during movement to disposal site.
- The excavated soil will be first collected at dumping ground and then transferred to disposal sites.
- Dumping areas shall be approved by the engineer before its disposal.
- Surplus earth may be used with prior approval by the engineer to the nearby site requiring earth filling.

14.3.7 Impact on Terrestrial Ecology

The main impact on biological environment will be from the tree felling. Data pertaining to the field survey indicates that total 41 species will be felled due to the project. Primary survey of the terrestrial ecology indicates that no rare endangered species listed in the IUCN are getting affected due to the project. The main species are given in baseline section of this report. About 150 trees are to be cut due to the project on the following corridors:

Necessary permission from Nagpur Municipal Corporation (NMC) garden department is to be obtained for trees cutting. Compensatory tree plantation will be done in ratio of trees to be cut: 10 trees to be planted (1:10).

14.2.2 Impact on Water Quality

Construction activities may have an adverse impact on water bodies due to disposal of waste. The waste could be due to the spillage of construction materials, dumping of used water from the stone crusher, oils and greases and labour camp. But the quantities of such spills are very negligible. Care, however, needs to be taken to provide adequate sanitary facilities and drainage in the temporary colonies of the construction workers. Provision of adequate washing and toilet facilities with septic tanks and appropriate refuse collection and disposal system should be made obligatory. Contamination of ground water can take place, if the dump containing above substances gets leached and percolates into the ground water table. This is not the case with the present project, as the activity does not involve usage of any harmful ingredients. Moreover, activities are of short duration. Hence, no adverse impact on either ground or surface water quality is anticipated in the present project.

14.3 OTHER IMPACTS

14.3.1 Impact due to Construction Camp

Influx of construction workforce and supplier who are likely to construct temporary tents in the vicinity may be a source of impact on the existing environment. Likely sanitation, health hazards may impact the surrounding environment due to influx of construction labourers.

14.3.2 Mitigation Measures

- Construction camps sites will be properly demarcated, fenced and access controlled.
- Adequate provision of sanitation, drinking water supply, and primary health facilities.
- Regular health check-ups of worker shall be organized.
- Proper accommodation amenities will be provided to the workers.
- Crèche arrangement for the kids of women labour shall be made.
- Contractor will make arrangement for cooking gas to the workers to prevent illegal tree cutting.
- The construction camps will be located away from the residential areas.
- Awareness program for workers will be arranged.
- Preferably local labour will be employed.

14.9.5 Impact due to Equipment Storage and Machinery Maintenance

Proper maintenance shed for regular maintenance of the construction vehicles will be provided in the construction yards. Waste emanating from the maintenance shed should not be allowed to spread over to the nearby areas. Oil and grease separator will be provided. Oil and grease change of equipment and vehicles should be carried out in the service areas designated for vehicles. Wastes should be collected and disposed of properly and expeditiously.

14.10 SOCIAL IMPACTS

14.10.1 Socio-Economic Profile of PAPs/ PAHs

The following sections present socio-economic profile of the households likely to be affected by the proposed project. The baseline information collected through household survey provides the socio-economic conditions of affected households. A wide range of data including religion, social category, loss of land and structures, present usage of structures, education, occupation, sources of income, etc. have been collected through the socio-economic survey of households likely to be affected. The data base provides broad understanding of social and economic conditions of project affected households and the likely impacts that people would experience due to proposed project. The Summary of Socio-Economic profile of PAHs is given in table 14.8

Table 14. 8 – Socio-Economic Profile of PAHs

Particulars		E-W	N-S	Total	
				No.	%
Male		138	33	171	53.94
Female		123	23	146	46.06
Total		**261**	**56**	**317**	**100.00**
PAPs by age group	Less than 6 years	19	3	22	6.94
	7 to 14 years	28	5	33	10.41
	15 to 59 years	184	44	228	71.92
	> 59 years	30	4	34	10.73
Total		**261**	**56**	**317**	**100.00**
Religion					
	Hindu	35	7	42	85.71
	Muslim	3	0	3	6.12
	Both	2	2	4	8.16
	Total	**40**	**9**	**49**	**100.00**
Social group					
	General	11	6	17	34.69

Particulars		S.W	N-S	Total	
				No.	%
	OBC	10	1	11	22.45
	SC	5	3	8	16.33
	ST	3	0	3	6.12
	Total	**40**	**9**	**49**	**100.00**
Occupation					
	Agriculture / Animal husbandry	2	0	2	0.63
	Govt. Service	4	3	7	2.21
	Housewife	71	12	83	26.18
	Private service	9	0	9	2.84
	Rent/ Pension	7	3	10	3.15
	Self employed	39	3	42	13.25
	Business	37	10	47	14.83
	Student	74	21	95	29.97
	Unemployed	2	0	2	0.63
	Skilled Worker	2	1	3	0.95
	Unskilled Worker	6	0	6	1.89
	Children	10	1	11	3.47
	Total	**261**	**56**	**317**	**100.00**
Education (excluding children below 5 years)					
	Illiterate	14	1	15	5.08
	Literate	11	2	13	4.41
	Primary	8	2	10	3.39
	Middle	40	8	48	16.27
	Matric	32	8	40	13.56
	Higher secondary	39	10	49	16.61
	Graduate	74	12	86	29.15
	Post Graduate	27	7	34	11.53
	Total	**242**	**53**	**295**	**100.00**
Household income (Rs.)					
	< 5000	8	1	9	18.37
	5001 – 10000	14	2	16	32.65
	10001 – 20000	15	2	17	34.69
	20001 – 50000	3	3	6	12.24
	50001 – 100000	0	1	1	2.04
	100000 +	0	0	0	0.00
	Total	**40**	**9**	**49**	**100.00**

Of the total PAPs, majority (15-59 years) are in the prime age of working. Hindus comprise 95% of the total households likely to be affected. As regards, social category of project affected households is concerned General category of households constitute (55%). Major occupations of PAPs are business, self-employment and service (govt. & private). Women members are mainly housewives. Students comprise about 30% of the total PAPs. As regards qualification of PAPs, it may be observed that graduate and post-graduate comprise 41% followed by those having completed higher secondary, matric, middle, etc. Indicative household incomes were also ascertained through survey. None of the households qualify for consideration as below poverty line family. Monthly income of majority of households is more than Rs. 15000/-. In fact, almost all the households possess assets and consumer durables like, Fridge, TV, Computer, Mobiles, two wheelers, washing machine, micro oven, etc. Overall, economic conditions of PAPs likely to be affected are very good. Adverse impacts of proposed project are not likely to result in impoverishment of PAPs but would have significant financial problems if not compensated as per the prevailing market price.

14.10.3 Impact on Structures

A total of 101 structures (74 in EW Corridor and 27 in NS Corridor) of various dimensions shall be affected by the proposed project. Majority of the structures are privately owned. Distribution of structures likely to be affected is summarized in Table 14.9. It may be observed that majority of structures are likely to be affected in east-west corridor. More than 53% of the total structures are single storied followed by double storied structures. Further, multi storied structures (upto 5 floors) comprise about 26.73% of the total structures likely to be affected. Most of the multi storied structures are in CA Road falling in east-west corridor.

Table 14.9: Structures Affected

Structures Affected (Source: Primary Survey)				
Structures affected	Corridor		Total	
	E-W	N-S	No.	%
Single storied	40	14	54	53.47
Double storied	16	4	20	19.80
Multi storied (3 to 5 floors)	18	9	27	26.73
Total	74	27	101	100.00
%	73.27	26.73	100.00	

Structures likely to be affected are of three categories (pucca, semi-pucca and kutcha) as per the building materials used for the construction. Semi-pucca structures are those which do not have RCC roof whereas kutcha structures are those which are made of wood, bamboo, straw, GI sheet, etc. and can be shifted from the existing place to another location without much damage. Pucca structures constitute about 77.23% of the structures whereas semi-pucca and kutcha together comprise the remaining structure (22.77%). Kutcha structures are located at Prajapati Nagar in East-West corridor. This list is tentative and exact number of structures likely to be affected can be worked out during detailed planning stage before taking-up of construction activity.

Table 14.10: Typology of Structures Affected

Typology of Structures Affected (source: CES Primary Survey 2013)				
Typology of structure	EW	NS	Total	
			No.	%
Pucca	57	21	78	77.23
Semi- pucca	13	6	19	18.81
Kutcha	4	0	4	3.96
Total	74	27	101	100.00

Structures likely to be affected have been identified as per the present use. Majority of the structures in both the corridors is being used for commercial purposes. Structures used for residential and residential cum commercial purposes comprise 25.74% and 25.74% respectively. Structures used for commercial purposes comprise 48.51% of the total structures. (Refer Table 14.11)

Table 14.11: Structures Affected Corridor-Wise

Structures Affected by Use (source CES Primary Survey 2013)				
Present use	E-W	N-S	Total	
			No.	%
Residential	20	6	26	25.74
Commercial	35	14	49	48.51
Residential cum commercial	19	7	26	25.74
Total	**74**	**27**	**101**	**100.00**

Extent of impacts on individual structures was assessed based on drawings as well as site verification. Out of the total structures likely to be affected, in 101 structures, the extent of impact is more than 35% and as a consequence occupants of these structures will be displaced. In 19 structures, safety of individual structure after dismantling will determine the continuance or displacement of the occupants. Extent of impact on structures is given in Table 14.12.

Table 14.12: Extent of Impacts on Structures

Extent of Impacts on Structures (source CES Primary Survey 2013)				
Extent of impact (in %)	Corridor		Total	
	E-W	N-S	No.	%
Less than equal to 35	17	2	19	18.81
More than 35	57	25	82	81.19
Total	74	27	101	100.00
%	73.27	26.73	100	

14.10.3 Impacts on Common Property Resources (CPRs)

Besides, impacts on structures and land area the proposed project will also affect several common property resources (government structures, community, religious, etc). Distribution of CPRs affected as per ownership is given in Table 14.13. Majority of the common property resources likely to be affected belong to different departments/agencies. These structures comprise boundary walls, office buildings, guard room and structures used for other purposes. Similarly, boundary walls and other structures of educational institutions are also likely to be affected. Further, a few temples (3 in E-W corridor and 1 in N-S corridor), one hand pump and one Piau (drinking water post) are also likely to be affected. In both the corridors, major portions of the structures would be affected.

Table 14.13: Common Property Resources

Common Property Resources [illegible]				
CPRs	E-W	N-S	Total	
			No.	%
Govt. structures				
Boundary Wall	10	5	15	31.25
Guard room	1	0	1	2.08
Other structures	6	6	12	25.00
Educational Institutions			0	0.00
Boundary Wall	6	2	8	16.67
Others	2	4	6	12.50
Religious (Temple)	3	1	4	8.33
Piau/ Well	1	1	2	4.17
Total	**29**	**19**	**48**	**100.00**

14.10.4 Impacts on Land

Metro stations have been planned within the road land mostly and as such additional land area is not proposed for it. But, additional land area is required for providing access to metro stations, parking facilities near stations, running sections, yards, curves, etc. Land area required for the proposed project has been worked out as per the design. Distribution of land area required for various purposes is presented in Table 14.14.

Table 14.14 - Area Likely to be Affected (Sqm)

LAND REQUIREMENT DETAILS				
NAGPUR METRO RAIL PROJECT				
LAND DETAILS	EAST-WEST CORRIDOR PRAJAPATI NAGAR TO LOKMANYA NAGAR		NORTH-SOUTH CORRIDOR AUTOMOTIVE SQUARE TO MIHAN DEPOT	
	GOVT. LAND (in sqm)	PVT. LAND (in sqm)	GOVT. LAND (in sqm)	PVT. LAND (in sqm)
STATIONS EXIT/ENTRY	3044.80	7705.40	7525.30	10612.50
RUNNING SECTION	3235.30	5060.80	101882.00	10628.30
DEPOT AREA	258973.00		329800.00	
TRAFFIC INTEGRATION/PARKING	4779.10	1455.70	33759.80	3175.20
TOTAL	274662.50	14816.90	603167.10	25817.90
TOTAL GOVT LAND	778819.50	SAY 77.88 HECTARES		
TOTAL PVT LAND	40592.80	SAY 8.3 HECTARES		

Additional private land required for the project shall be acquired as per the provisions of Land Acquisition Act, 1894. The Act provides for compulsory acquisition of land which includes vacant as well as built up properties. Private land constitutes about 4.83% of the total land requirement. Majority of the land required (94.88%) is government land. Government land shall be transferred as per the established procedure. Besides, 0.17% of the land likely to be affected belongs to religious institutions.

14.11 Impacts during Operation Phase

The operation phase impacts are as follows:

14.11.1 Water Quality

During operation phase the main source of water pollution will be Oil spillage during change of lubricants, cleaning and repair processes, in the maintenance Depot cum workshop for maintenance of rolling stock. The spilled oil will be trapped in grit chamber for settling of suspended matter. The collected oil should either be auctioned or incinerated, so as to avoid any underground water contamination.

14.11.2 Water Supply

Water requirement at railways stations will be 45 lit as per the recommendation of CPHEEO. Since all the station are locate in the urban areas, water requirement meeting the need has been take for personal use of staff, fire demand, make up water for air conditioning and ventilation and water loss. The water demand for each station will be approximately 100m^3 per day. Adequate provisions for meeting the water demand at each station have been taken. Platform washing requirement has been worked out at metro stations has been taken at the rate of 2 liter per m^2. Fire fighting requirement has been taken as per the existing norms of Maharashtra Government.

14.11.3 Waste Disposal

The refuse from railway station includes, Garbage, Rubbish, and Floor Sweepings. The collection and removal of refuse in a sanitary manner from the Station is of importance for effective vector control, aesthetic improvement, and nuisance and pollution abatement.

For the maintenance of adequate sanitary facilities, containers/collection bins not exceeding 100-litres and equipped with side handles will be appropriately designed and installed at stations and platforms.

14.11.4 Noise Quality

During the operation phase the main source of noise will be from running of metro trains. Noise radiated from train operations and track structures generally constitute the major noise sources. Airborne noise is radiated from at-grade and elevated structures, while ground-borne noise and vibration are of primary concern in underground operations.

The wayside noise levels (Leq) has been worked out for peak headway to be 68.52 dB (A) for North South Corridor and 77.03 dB (A) for at 10m distance in 2041. The noise levels have been worked at elevated section for different distance from the metro is given in the following table 14.15.

Table 14.15: Cumulative Impact due to Increase Noise

Locations	Project Noise level at 10m distance (Peak Headway)	Ambient noise level L_{eq}	Cumulative impact
Automotive Square	74.00	70.00	75.60
Sri Guru Govind Singh Educational Institute	74.00	74.7	77.4
Z.P. School Pohaswardhan Technical High School & College	74.00	56.08	74.47
Bank of Maharashtra near	74.00	72.00	76.18

Locations	Project Noise level at 10m distance (Peak hour/day)	Ambient noise level L_{eq}	Cumulative impact
proposed Sitabuldi station (Munje Chowk)			
NEERI Campus	74.06	74.37	77.07
Mayuresh Apartment (at proposed mayuresh station)	74.06	63.25	74.33
Existing Terminal Building	74.06	75.6	75.49
Barren land of MIHAN SEZ	74.06	55.38	74.09
Saboo Hospital	80.24	72.31	80.88
Aakash Tower	80.24	70.08	80.71
Mayo Hospital	80.24	71.03	80.73
Ram Mandir	80.24	75.38	81.40
Govardhan Das Rawal High School	80.24	67.56	80.24
Supreme Brother's Petrol Pump	80.24	75.44	81.48
Dharampeth Polytechnic & Science College	80.24	71.23	80.73
St. Xavier's High School	80.24	65.01	80.42

It is observed from the above table that there will be significant increase in noise levels during in 2041 due to the operation of metro.

It may be inferred from the above that there will be significant impact due to increase in the sound level. Therefore it is proposed to provide 6mm thick Poly-carbonated solid Plate may be provided as noise barriers. The noise transmission loss due to these barriers will be about 20dB (A).

Stretches identified for the provision of Noise Barriers are presented in Table 14.18.

Table 14.18: Provision of Noise Barriers in Different Stretches

Sl. No.	Name of Stretch	Length of Noise Barrier (km)
1	**East-West Corridor**	
1.1	Ambedkar Chowk - Jhansi Rani Chowk	5.5
1.2	Jhansi Rani Chowk-Dharampeth College	4.9
2	**North-South Corridor**	
2.1	Kam Chowk-Kasturchand Park	2.3
2.2	Sitabuldi-Shankar Nagar	6.0
	Total length of Noise barrier	**18.8**

14.11.8 Vibration

As discussed earlier, it is observed that the vibration is ranging from 25 VdB to 66 VdB along the project corridor. High vibrations (76VdB-84.7VdB) were recorded along the sections which are passing through existing NH7 and Hingna Road. It is due to movement of heavy vehicles on the highway. It is expected that vibration levels are likely to be increased due to operation of the Metro. Past studies (Source: http://indiatoday.intoday.in/story/delhi-metro-line-tremors-every-three-minutes/1/198027.html) have shown that the vibrations have been recorded between 60VdB and 72VdB due to operation of the Metro. It is also recorded that vibration levels have reached up to 85VdB when metro is running at a high speed 75-80Km/h. Therefore it is suggested that following mitigation measures are to be adopted to reduce the intensity of impact due to vibration.

- Metro underground lines should be laid at least 30 meter below.
- If this is not possible, mass spring system should be provided in the underground section.
- Rubber pads should be provided to reduce the intensity of the vibration.
- To keep vibration minimum at elevated section, foundation system shall be designed in such a way that vibration can be suppressed at source by providing rubber pads or sand filling.
- Speed reduction upto 30 Km/h may also be considered at critical section.

14.12 Impact on Terrestrial Ecology

There will no impact on terrestrial ecology due to operation of the project.

14.12.1 Accidental Hazards

In view of the hazards potential involved due to failure of system and accident the on-site and off- site emergency measures have been formulated and will be implemented.

14.12.2 Visual Impacts

The construction of the above corridor will bring about a change in visual look of the streets through which it will operate. An architecturally well-designed structure, which could be aesthetically pleasing and able to reduce impact due to visual configuration have been incorporated in present corridor. Since a low profile will cause least intrusion, the basic elevated section should be optimised at the design stage itself.

14.15 ENVIRONMENTAL MANAGEMENT PLAN

The proposed Nagpur Metro Project (east-west & north- south corridor) will provide quick service and safety, traffic congestion reduction, less fuel consumption, employment opportunity, and less air pollution on one hand and problems of Rehabilitation and Resettlement (R&R), soil disposal, etc. on other hand. The environmental issues likely to develop during project construction and operation phases could be minimized by making necessary provision in the project design and adopting Environmental Management Plan (EMP). Summary of Environmental management plan is given in Table 14.17.

Table 14.17: Environmental Management Plan

Environmental Impact	Mitigation Measures Taken or To Be Taken	Time Frame	Implementing Organization	Responsible Organization
DESIGN PHASE				
Metro Alignment	The proposed corridor alignment was selected to minimize the land disturbance to avoid archaeological sites, temples and other environmentally sensitive areas in least.	During Design	DPR and design consultant	PIU of NIT
Cultural Heritage	Avoided by adjustment of alignment	During Design	DPR and design consultant	PIU of NIT
Loss of Water Bodies	Utmost care taken to avoid alignment crossing water bodies.	During Design	DPR and design consultant	PIU of NIT
Inadequate design provision for safety against seismological hazard	Make sure that design provides for safety of structures against worst combination of forces in the probability of an earthquake likely to occur in seismic zone-III.	DPR and detailed design stage	DPR and design consultant	PIU of NIT
PRE –CONSTRUCTION STAGE				
Water requirement	The requirement of water shall be for construction purpose etc., shall be planned and shall be arranged in order to avoid digging of Tube wells.	Pre construction stage	Contractor	PIU of NIT (implementing agency)
Disposal of final treated effluent from treatment	Options for final disposal shall be studied and the suitable	During design stage / and pre	Contractor	PIU of NIT (implementing agency)

Environmental Impact	Mitigation Measures Taken or To Be Taken	Time Frame	Implementing Organization	Responsible Organization
soil	disposal route shall be decided carefully to minimize the impact of receiving bodies. As far as possible zero discharge rules may be adopted	construction of treatment plant		
CONSTRUCTION PHASE				
Environmental Management and Monitoring	This will include institutional requirements, training, environmental management and monitoring	During and after construction	Contractor	PIU of NIT (implementing agency)
Dust	Water should be sprayed during construction phase, wherever it is required to avoid dust. Vehicles delivering materials should be covered to reduce spills and dust blowing off the load.	During construction	Contractor	PIU of NIT (implementing agency)
Air Pollution	Vehicles and machinery are to be regularly maintained so that emissions conform to National and State AAQ Standards.	Beginning with and continuing throughout construction	Contractor	PIU of NIT (implementing agency)
Equipment Selection maintenance and operation	Construction plants and equipment will meet recognized international standards for emissions and will be maintained and operated in a manner that ensures relevant air, noise, and discharge regulations are met.	During construction	Contractor	PIU of NIT (implementing agency)
Noise	Noise standard at processing sites, will be strictly enforced as per GOI noise standards. Workers in vicinity of strong noise will wear earplugs and their working time should be limited as a safety measure. At construction sites within	Beginning and through construction	Contractor	PIU of NIT (implementing agency)

Environmental Impact	Mitigation Measures Taken or To Be Taken	Time Frame	Implementing Organization	Responsible Organization
	150m of sensitive receptors construction will be stopped from 22:00 to 06:00. Machinery of noise barriers (Stone walls and plantation) for silence zones including schools and hospitals.			
Vibration	The vibration level limits at work sites adjacent to the alignment shall conform to the permitted values of peak p velocity as given in article project SHE Manual)	Beginning and through construct on	Contractor	PIU of NIT (implementing agency)
WATER				
Contamination from Wastes	All justifiable measures will be taken to prevent the wastewater produced in construction from entering directly into rivers and irrigation system.	Througho ut construct on period	Contractor	PIU of NIT (implementing agency)
Wastage of water	Measures shall be taken to avoid misuse of water. Construction agency shall be instructed accordingly to follow strict procedures while using the water for construction and drinking purpose.	Beginning with and continuing throughou t construct on	Contractor	PIU of NIT (implementing agency)
Sewerage disposal during construction at Service Centres	A minimum distance of any sewage or toilet facility from water sources should be 200 meters.	Througho ut construct on period	Contractor	PIU of NIT (implementing agency)
Sanitation and Waste Disposal in Construction Camps	Sufficient measures will be taken in the construction camps, i.e. provision of garbage tank and sanitation facilities. Waste in septic tanks will be cleared periodically. Drinking water will meet Indian National Standards.	Before and during building of construct on camps	Contractor	PIU of NIT (implementing agency)

Environmental Impact	Mitigation Measures Taken or To Be Taken	Time Frame	Implementing Organization	Responsible Organization
	Garbage will be collected in a tank and disposed of daily. Special attention shall be paid to the sanitary condition of camps. Camps will be located at a minimum distance of 200 m from water sources.			
SOIL				
Quarrying	Quarrying will be carried out at approved and licensed quarries only.	During construction	Contractor	PIU of NIT (implementing agency)
FLORA AND FAUNA				
Loss of trees and Avenue Plantation	Areas of tree plantation cleared will be replaced according to Compensatory afforestation Policy under the Forest Conservation Act. Trees will be planted against every tree cut as per norms.	After completion of construction activities	Forest Department	PIU of NIT (implementing agency)
SOCIAL				
Loss of Access	Temporary access should be built at the interchange and other roads.	During construction	Contractor	PIU of NIT (implementing agency)
Traffic jams and congestion	If there are traffic jams during construction, measures should be taken to relieve the congestion with the co-ordination of transportation and traffic police department	During construction	Contractor	PIU of NIT (implementing agency)

Environmental Impact	Mitigation Measures Taken or To Be Taken	Time Frame	Implementing Organization	Responsible Organization
Safety with vehicles, people and livestock and signage	• Safety education and fines. • Allow for adequate traffic flow around construction areas • Provide adequate signage, barriers and flag persons for safety precautions. • Communicate to the public through radio, TV & newspaper announcements regarding the scope and timeframe of projects, as well as certain construction activities causing disruptions or access restrictions.	During construction	Contractor	PIU of NIT (implementing agency)
Increase in disease Water-borne Insect-borne Communicable diseases	• Make certain that there is good drainage at all construction areas, to avoid creation of stagnant water bodies. • Provide adequate sanitation and waste disposal at construction camps. • Provide adequate health care for workers and locate camps away from vulnerable groups.	During construction At start-up Throughout construction	Contractor	PIU of NIT (implementing agency)
Location of camps depots and storage areas	Location of camps depots and storage areas shall be as per the contract specifications.	Throughout construction	Contractor	PIU of NIT (implementing agency)
OPERATION PHASE				
Noise and Vibration	Suitable measures should be considered where warranted. The public shall be educated about the regulations of noise and vibration pollution and its implications.	After completion of construction	PIU/MMP implementing agency	PIU of NIT (implementing agency)

Environmental Impact	Mitigation Measures Taken or To Be Taken	Time Frame	Implementing Organization	Responsible Organization
WATER				
Oil pollution	Suitable treatment shall be taken for treatment oil before discharging the wastewater specially in depot areas.	During operation of the treatment plant	PIU/EMP implementing agency	PIU of NIT (implementing agency)
Maintenance of Storm Water Drainage System	The urban drainage systems will be periodically checked and cleaned so as to ensure adequate storm water flow.	Beginning and end of monsoon	PIU/EMP implementing agency	PIU of NIT (implementing agency)
Disposal of final treated effluent from treatment plant	Options for final disposal shall be studied and the suitable disposal route shall be decided carefully to minimize the impact of receiving bodies. As far as possible zero discharge rules may be adopted.	During operation of the treatment plant	PIU/EMP implementing agency	PIU of NIT (implementing agency)
SOCIAL				
Safety and noise disturbances	New buildings should be prohibited within 50 m of the edge of carriageway. No new schools and hospitals should be allowed within 200 m of carriageway.	Throughout and after project development period	Planning Department /PIU	PIU of NIT (implementing agency)

14.14 MITIGATION MEASURES

The main aim of mitigation measures is to protect and enhance the existing environment of the project. These measures should have positive effects on environment. Environmental mitigations are essential and shall be undertaken in various phase of project cycle viz. preconstruction, construction and operation stage of the project. Some of these have been described in the following section, which includes measures for:

- Compensatory Afforestation and Fencing
- Construction Material Management
- Labour Camp
- Hazardous Waste Management
- Archaeological and Historical Preservation

- Air Pollution Control Measures,
- Noise Control Measures,
- Vibration Control Measures
- Muck Disposal
- Soil Erosion Control
- Water Supply, Sanitation and Solid Waste management
- Traffic Diversion/Management
- Disposing of Water from Tunnel
- Rain water harvesting
- Management Plans for Depot
- Utility Plan
- Energy Management
- Training and Capacity Building

14.16 Environmental Monitoring Programme

The environmental monitoring is required for the construction and operational phases. The parameters need to be monitored are water quality, air quality, Noise levels Erosion and Siltation, ecology and vibration levels. The detail monitoring programmes during construction and operational stages are presented in Table 14.8.

Table 14.16: Environmental Monitoring Programme

Sl. No.	Environment Component	Environmental Monitoring Programme			Institutional Responsibility	
		Parameters	Locations	Frequency	Implementation	Supervision
DURING PROJECT CONSTRUCTION PHASE						
1	Air Quality	PM_{10}, $PM_{2.5}$, SO_2, NOx, CO, HC	Total 4 suitable locations. Plant Sites i.e. HMP/Crusher, Construction sites, Settlements	24 hourly samples. Twice a week every season during construction Period except monsoon season. One hourly, twice a week every season during Construction Period except monsoon season.	Concessionaire	MT

Sl No	Environment Component	Environmental Monitoring Programme: Parameters	Locations	Frequency	Institutional Responsibility: Implementation	Supervision
DURING PROJECT CONSTRUCTION PHASE						
2	Water Quality	As per relevant IS Codes 10500	At 5 suitable locations. Ground water sampling.	Quarterly. Once in every season.	Concessionaire	NIT
3	Noise Level	Noise levels on dB (A) scale Leq (dB(A)) Day /Night Day: Max & Min Night: Max & Min.	At 15 suitable locations i.e. At equipment yards, sensitive sites.	Quarterly. Once in every season.	Concessionaire	NIT
4	Vibration Level	Noise levels on VdB (A) scale, Day /Night Max & Min	At 10 locations i.e. Sensitive sites and residential area.	Once in every years.	NIT	NIT
5	Soil Erosion	Visual Observation	Entire length of alignment and agricultural fields	Pre-monsoon and post-monsoon season.	Concessionaire	NIT
6	Compensatory Afforestation	No. of roadside plantation	Along the side of the carriageway	Comparison should be done for every six months.	Concessionaire	NIT
7	Flora & Fauna	Aquatic ecosystem	At crossings of surface water bodies along the road and project influence area.	Two times in a month. Periodically inspections of environmentally sensitive sites.	Concessionaire	NIT
8	Borrow Area Management	Borrow areas redevelopment and Top soil Management	Identified borrow areas	Once in a week	Concessionaire	NIT
DURING OPERATION PHASE						

Sl No	Environment Component	Environmental Monitoring Programme: Parameters	Environmental Monitoring Programme: Locations	Environmental Monitoring Programme: Frequency	Institutional Responsibility: Implementation	Institutional Responsibility: Supervision
DURING PROJECT CONSTRUCTION PHASE						
1	Air Quality	PM_{10}, $PM_{2.5}$, SO_2, NOx, CO	At 4 suitable locations	24 hours samples, Twice a week every season during construction Period except monsoon season. One hourly, twice a week every season during Construction Period except monsoon season.	NIT	NIT
2	Water Quality	PH, SS, $CaCo_3$, Alkalinity, Cl, F, So_4, No	At 3 suitable locations of Ground water	Pre-monsoon & post-monsoon, once in every two years	NIT	NIT
3	Noise Level	Noise levels on dB (A) scale Leq dB(A) Day /Night, Days, Max & Min Night Max & Min.	At 15 suitable locations i.e. Sensitive sites and residential area.	Once in every years.	NIT	NIT
Sl. No.	**Environment Component**	**Parameters**	**Locations**	**Frequency**	**Implementation**	**Supervision**
DURING OPERATION PHASE						
4	Vibration Level	Noise levels on VdB (A) scale, Day /Night, Max & Min	At 20 locations i.e. Sensitive sites and residential area.	Once in every years.	NIT	NIT
5	Erosion and siltation	Soil erosion rates, stability of bank embankment etc.	High Emb of Bridge, shoulders and slopes	Twice a year	NIT	NIT

8	Ecology	Status of Afforestation programmes of green belt	All along available land either side of the project road	Once every year	NIT	NIT

14.18 ENVIRONMENTAL BUDGET

A budgetary cost estimate for environmental monitoring is suggested for construction phase period assuming 3 years and per annum cost for operation phase. Construction phase monitoring cost (tentatively) is worked out to be INR **6.004 million** and operation phase monitoring cost per annum is worked to be INR **1.133 million.**

R&R Provisions have been made according to the existing Govt. Policies such as NRRP, 2007 and policies followed for Maharashtra Urban Transport Project. Budgetary estimate for R&R Provisions (tentatively) is estimated as **Rs. 289 Crore**

A budget of **Rs. 87.263 million** has tentatively been kept towards the Environmental Management Plan of the Nagpur Metro project. The cost for Dust suppression during Construction, Solid Waste Management Facilities & equipment and Cooking Fuel for construction workers is incidental to the Concessionaire.

CHAPTER 15

SECURITY MEASURES FOR A METRO SYSTEM

Chapter -15

SECURITY MEASURES FOR A METRO SYSTEM

15.1 INTRODUCTION

Metro is emerging as the most favoured mode of urban transportation system. The inherent characteristics of metro system make it an ideal target for terrorists and miscreants. Metro systems are typically open and dynamic systems which carry thousands of commuters. Moreover the high cost of infrastructure, its economic importance, being the life line of city high news value, fear & panic and mass casual ties poses greater threat to its security. Security is a relatively new challenge in the context of public transport. It addresses problems caused intentionally. Security differs from safety which addresses problems caused accidentally. Security problems or threats are caused by people whose actions aim to undermine or disturb the public transport system and/or to harm passengers or staff. These threats range from daily operational security problems such as disorder, vandalism and assault to the terrorist threat.

15.2 NECESSSITY OF SECURITY

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

15.3 THREE PILLARS OF SECURITY

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

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

Staff engaging with the passengers 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 be trained, drilled and tested. The security risk assessment is the first step for understanding the needs and prioritizing resources. The organization of security should be clear and consistent. Security incidents, especially major ones, often happen without warning. Emergency and contingency plans must be developed communicated and drilled in advance.

There are number of technologies which can be used to enhance security e.g. surveillance systems. The objectives of the security systems are to differ i.e., making planning or execution of an attack too difficult, detect the planned evidence before it occurs deny the access after in plan of attack has been made and to mitigate i.e. lessen the impact severity as the attack by appropriate digits.

15.4 PHASES OF SECURITY

There are three phases of security as under:

(i) Prevention

These are the measures which can prevent a security incidence from taking place. These can be identified by conducting a risk assessment and gathering intelligence. Prevention begins with the daily operational security problems. Uncared for dirty, damaged property is a breeding ground for more serious crime.

(ii) Preparedness

Plans must be prepared to respond to incidents, mitigate the impact. Train staff accordingly and carry out exercises. The results of the risk assessment give a basis for such plans.

(iii) Recovery

Transport system must have laid down procedures/instructions for the quick recovery of normal service after an incident. Recovery is important for the financial health of the operation, but it also sends a clear message to public. It reassures passengers and gives them confidence to continue using the system. Communication is key to the quick restoration after such incidents. Restoration should "also include an evaluation process for the lessons learnt.

15.5 RESPONSIBILITIES AND PARTNERSHIPS

Security is a sovereign function and hence is the responsibility of the state. Security in public requires clear governance. Responsibility should be clearly defined. In the present scenario, this is the responsibility of the Central Government/MHA in Delhi to ensure secured travelling to the public including Delhi Metro. In other states security would be the responsibility of the concerned state govt.

CISF has been entrusted with the job of providing security to Delhi Metro and law & order/ prevention & detection of crime are under the domain of Delhi Police.

15.6 PROPOSED PROVISIONS FOR SECURITY SYSTEM

1. CCTV coverage of all metro stations. With a provision of monitoring in the Station Security Room as well as at a Centralized Security Control Room with video wall, computer with access to internet TV with data connection, printer and telephone connection (Land Line and EPBX) for proper functioning, cluster viewing for stations. Cost of this is included in Telecom estimate.

2. Minimum one Baggage Scanners on all entry points (1 per AFC array). Additional requirement of baggage scanners at heavily crowed stations i.e at interchange may also be required. Cost 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 (3 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 Delhi 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 Array)

Wooden Ramp : 1 per DFMD for security check points.

15. Wall mounted pedestal fan at security check point, ladies frisking booth and bullet proof morcha, as per requirement.

16. Physical barriers for anti scaling at Ramp area, low height of via duct by providing iron grill of appropriate height & design/concertina wire.

17. Adequate number of ropes, Queue managers, cordoning tapes, dragon search lights for contingency.

18. Iron grill at station entrance staircases, proper segregation of paid and unpaid by providing appropriate design grills etc.

19. Proper design of emergency staircase and Fireman entry to prevent unauthorized entry.

CHAPTER 16

DISASTER MANAGEMENT MEASURES

CHAPTER- 16

DISASTER MANAGEMENT MEASURES

16.1 INTRODUCTION

"Disaster is a crisis that results in massive damage to life and property, uproots the physical and psychological fabric of the affected communities and outstrips the capacity of the local community to cope with the situation." Disasters are those situations which cause acute distress to passengers, employees and outsiders and may even be caused by external factors. As per the disaster management act, 2005 "disaster" means a catastrophe, mishap, calamity or *grave occurrence in any area, arising from natural or manmade causes, or by accident or negligence which results in substantial loss of life or human suffering or damage to, and destruction of, property, or damage to, or degradation of, environment, and is of such a nature or magnitude as to be beyond the coping capacity of the community of the affected area".* As per world health organization (who):

"Any occurrence that causes damage, economic disruption, loss of human life and deterioration of health and services on a scale sufficient to warrant an extra ordinary response from outside the affected community or area."

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

16.2 NEED FOR DISASTER MANAGEMENT MEASURES

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

16.3 OBJECTIVES:

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

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

16.4 LIST OF SERIOUS INCIDENTS REQUIRING USE OF PROVISIONS OF THE DISASTER MANAGEMENT MEASURES

Metro specific disasters can be classified into two broad categories e.g.: Man-made and Natural.

a. Man Made Disaster

1. Terrorist attack
2. Bomb threat/ Bomb blast
3. Hostage
4. Release of Chemical or biological gas in trains, stations or tunnels

5. Fire in metro buildings, underground/ elevated infrastructures, power stations, train depots etc.
6. Train accident and train collision/derailment of a passenger carrying train
7. Sabotage
8. Stampede

B. Natural Disaster

1. Earthquakes
2. Floods

16.5 PROVISIONS UNDER DISASTER MANAGEMENT ACT, 2005

A. The National Disaster Management Authority (NDMA)

Establishment of National Disaster Management Authority:-

(1) With effect from such date as the Central Government may, by notification in the Official Gazette appoint in this behalf, there shall be established for the purposes of this Act (*The Disaster Management Act, 2005*), an authority to be known as the National Disaster Management Authority.

(2) The National Authority shall consist of the Chairperson and such number of other members, not exceeding nine, as may be prescribed by the Central Government and, unless the rules otherwise provide, the National Authority shall consist of the following:-

(a) The Prime Minister of India, who shall be the Chairperson of the National Authority, ex officio;

(b) Other members, not exceeding nine, to be nominated by the Chairperson of the National Authority.

(3) The Chairperson of the National Authority may designate one of the members nominated under clause (b) of sub-section (2) to be the Vice-Chairperson of the National Authority.

(4) The term of office and conditions of service of members of the National Authority shall be such as may be prescribed.

B. State Disaster Management Authority:

Establishment of State Disaster Management Authority-

(1) Every State Government shall, as soon as may be after the issue of the notification under sub-section (1) of section 3, by notification in the Official Gazette, establish a State Disaster Management Authority for the State with such name as may be specified in the notification of the State Government.

(2) A State Authority shall consist of the Chairperson and such number of other members, not exceeding nine, as may be prescribed by the State Government and, unless the rules otherwise provide, the State Authority shall consist of the following members, namely:- The Chief Minister of the State, who shall be Chairperson, ex officio.

(a) Other members, not exceeding eight, to be nominated by the Chairperson of the State Authority.

(b) 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, ex officio: Provided that in the case of a Union territory having Legislative Assembly, except the Union territory of Delhi, the Chief Minister shall be the Chairperson of the Authority established under this section and in case of other Union territories, the Lieutenant Governor or the Administrator shall be the Chairperson of that Authority: Provided further that the Lieutenant Governor of the Union territory of Delhi shall be the Chairperson and the Chief Minister thereof shall be the Vice-Chairperson of the State Authority.

(5) The term of office and conditions of service of members of the State Authority shall be such as may be prescribed.

C. Command & Control at the National, State & District Level

The mechanism to deal with natural as well as manmade crisis already exists and that it has a four tier structure as stated below:-

(1) National Crisis Management Committee (NCMC) under the chairmanship of Cabinet Secretary

(2) Crisis Management Group (CMG) under the chairmanship of Union Home Secretary.

(3) State Level Committee under the chairmanship of Chief Secretary.

(4) District Level Committee under the Chairmanship of District Magistrate.

All agencies of the Government at the National, State and district levels will function in accordance with the guidelines and directions given by these committees.

D. Plans by Different Authorities at District Level and their Implementation

Every office of the Government of India and of the State Government at the district level and the local authorities shall, subject to the supervision of the District Authority:-

(a) Prepare a disaster management plan setting out the following, namely:-

(i) Provisions for prevention and mitigation measures as provided for in the District Plan and as is assigned to the department or agency concerned;

(ii) Provisions for taking measures relating to capacity-building and preparedness as laid down in the District Plan;

(iii) The response plans and procedures, in the event of, any threatening disaster situation or disaster;

(b) Coordinate the preparation and the implementation of its plan with those of the other organizations at the district level including local authority, communities and other stakeholders;

(c) Regularly review and update the plan; and

(d) Submit a copy of its disaster management plan, and of any amendment thereto, to the District Authority.

16.6 PROVISIONS AT METRO STATIONS/OTHER INSTALLATIONS

To prevent emergency situations and to handle effectively in case 'one arises' there needs to be following provisions for an effective system which can timely detect the threats and help suppress the same.

(A) FIRE DETECTION AND SUPPRESSION SYSTEM
(B) SMOKE MANAGEMENT
(C) ENVIRONMENTAL CONTROL SYSTEM (ECS)
(D) TUNNEL VENTILATION SYSTEM
(E) TRACKWAY EXHAUST SYSTEM (TES)
(F) STATION POWER SUPPLY SYSTEM
(G) DG Sets & UPS
(H) LIGHTING SYSTEM
(I) STATION AREA LIGHTS
(J) TUNNEL LIGHTING
(K) TUNNEL LIGHTING CONTROL FROM BMS
(L) SEEPAGE SYSTEM
(M) WATER SUPPLY AND DRAINAGE SYSTEM
(N) SEWAGE SYSTEM
(O) ANY OTHER SYSTEM DEEMED NECESSARY

The above list is suggestive not exhaustive actual provisioning has to be done based on site conditions and other external and internal factors.

16.7 PREPAREDNESS FOR DISASTER MANAGEMENT

Being a technological complex system worked by new set of staff, with a learning curve to improve and stabilize with time, intensive mock drills for the staff concerned is very essential to train them to become fully conversant with the action required to be taken while handling emergencies.

They also need to be trained in appropriate communication skills while addressing passengers during incident management to assure them about their well being seeking their cooperation.

Since learning can only be perfected by 'doing' the following Mock Drills are considered essential:

a. Fire Drill
b. Rescue of a disabled train
c. Detrainment of passengers between stations
d. Passenger evacuation from station
e. Drill for use of rescue & relief train
f. Hot line telephone communication with state disaster management authority

CHAPTER 17

MULTI MODAL TRAFFIC INTEGRATION AT METRO STATIONS

Chapter - 17

MULTI MODAL TRAFFIC INTEGRATION AT METRO STATIONS

17.1 INTRODUCTION

The Metro Transport Network in Nagpur will cover a length of approximately 38 kms. It will be augmented through enhanced feasibility of criss-cross interchanges to other modes and reduce the travel time of commuters. While Metro provides a high capacity corridor to carry the passengers, the need for integration of with other secondary/intermediate transport modes is getting highlighted more than ever to ensure a seamless transfer. This concept is to provide at least first mile and last mile connectivity to the commuters with in their places of stay. According top priority to this issue, MoUD has laid down policy guidelines to include the need and provisioning of all public, IPT and private modes in the DPRs for the Metro Systems. *(Ref: MoUD (Urban Transport Wing) Advisory Circular no. K-14011/1/2007-UT-IV dated 30.08.2013).*

The share of various modes of secondary/ intermediary modes of travel is complex and debatable issue which is dependent on a large number of variables like available road width, penetration in the residential areas, Road condition, distance from the existing Metro Stations, availability of parking and lay out and availability of circulating areas at the Metro Stations, Business centre or markets & existing traffic densities. These factors relate with each other and evolve with development of new modal mix of transport, infrastructure and changes with the passage of time. Even though for a given urban transport scenario, optimal mode share may be determined from computer based models but actual **optimal mode share** is never achievable on the road due to dynamic nature of demand and supply of transport modes.

17.2 PRESENT CONDITION OF TRANSPORT ON CITY ROADS

At present the various mode coming to Metro Stations comprise of State Transport buses, Midi/Mini buses, RTVs, Autos, Rickshaws, C- Rickshaws, Private cars, Two Wheelers and Bi-Cycles. These can be classified in three groups of transport modes namely, Public, IPT and Private.

In public transport group there are Mini City Buses (20 seaters), and large buses of State Transport (50 seaters) and Chartered Buses hired by schools and private offices. Buses form neighbouring states are no less in numbers. Generally the public transports in Nagpur comprises of the buses which are operated by the Maharashtra State Road Transport Corporation.

Auto rickshaws are also an important part of public transports at Nagpur. Earlier, there used to be six seater auto rickshaws but after the restriction laid on its usage by the High Court, only three seater auto rickshaws ply on the roads of Nagpur. After bus, it is these auto rickshaws which are the most important modes of public transport in Nagpur even though they are little expensive. Auto Rickshaw are Intermediate Public Transport (IPT) Modes. Another public transport at Nagpur which can be ranked third among all is the cabs or taxis that run on the streets of Nagpur. Though these are also less in number and the majority of them ply from airport and railways.

In the personalized transport modes, there are Bicycles, Two wheelers and Cars of all possible sizes.

A chaotic situation is observed when all the above mentioned transport vehicles are seen jostling to each other for space for moving forward. More pathetic conditions are seen at the Road Intersections.

The solutions lies in showcasing a workable arrangement of co-existence through identification of good points of each mode and then utilize the same to get the attention and embedding it in public psyche.

Because of high traffic and less capacity as well as length of the roads, average distance between two consecutive vehicles becomes very less. Such situation does not permit speed higher than 15-20 km/hr. This indicates that unless there is some solution to reduce this unmanageable mix of the vehicle fleet, real transport integration may not be possible. While the Road length on main & arterial Roads may not see significant increase and relieve the congestive/ chaotic/ slow moving road traffic, a divergent policy of linking commuters directly through E-Rickshaw or Mini/Midi size feeder buses using the service/inner road length to supplement the main road traffic will impact the congestion and provide relief to the Metro commuters in reaching out to Metro Stations.

17.3 IMPACT OF BUS/CLUSTERS IN MODE SHARE

Primary reason for using personal vehicle (for buying vehicle) is **to save travel time** during journey. On the other hand, government has tried to increase number of public buses on the road in many different ways.

City bus service in Nagpur has never been consistent. First, it was MSRTC that withdrew the service citing losses as the main reason. This created room for NMC to run the service by roping in a private player. Central Government's changed norms regarding public transport in areas of urban local bodies selected under Jawaharlal Nehru National Urban Renewal Mission (JNNURM) proved a great help. With buses received from the Centre, NMC entered into an agreement with VNIL to operate city bus service. As per the agreement, NMC would get Rs 3,700 per bus per month as royalty. A fleet of new low-floor buses, increased number of frequency, new routes, and brand new service evoked a very good response from Nagpur residents. Within almost no time, Starbus service (as the city bus service is popularly known after the brand of buses) became the most widely used mode of public transport in the city.

However, as time passed, condition of buses deteriorated. Poor maintenance resulted in broken seats, broken handles, damaged wind-shields, mostly non-working digital signs, unclean and unhygienic passenger areas, non-working window panes. Of course, these are only major problems commuters have to put up with. 'Starbus' is driven by ill-trained persons, posing threat to plying of other vehicles and people on roads. At many places with heavy traffic throughout the day, it is very difficult for these drivers to man oeuvre wide buses safely.

Government has tried hard to popularize public bus by subsidizing the fare but could not bring higher (and middle) income group to use public bus simply because it is slow. BRT system was introduced with the intention of running public bus through dedicated pathway. But the overall impact has not provided synergy between the user & the Public Transport System in a seamless manner. Therefore objective of achieving optimal mode share remained elusive than reality.

17.4 BALANCING ACT OF METRO RAIL

After introduction of Metro Rail in the city, Traffic and Transportation scenario will significantly change. People will no longer afraid to travel a much longer distance. It is now possible to cover a length of 30-35 km below or within one hour time if main journey is made by metro rail. This is the fastest, safest and most reliable and comfortable mode now available in the city.

In Delhi, in 1980's average passenger trip length was 7-8 km in 1990-2000 average trip length was 8-10 km. After 2000, average trip length started increasing and in 2012-13 it was 15-16 km. It is expected this trip length will increase to 17-18 km after Phase III lines become operational from 2016 and after Phase IV in 2021 trip length may be about 20 km. This shows that the city gets expanded in terms of residential locations and work centers as metro network increases. In a recent survey conducted by one of the most circulated newspaper (Times of India) citizens have expressed maximum satisfaction for DMRC services. Nevertheless, city roads are more congested and the situation is getting worse every day. The benefit of time saving due to metro is very much diluted because of the problem of reaching the metro station and then to the platform to catch the metro.

For Nagpur also, average trip length will be around 7 kms. Hence Metro will definitely help in providing a balancing act.

17.5 TRANSPORT INTEGRATION BY DMRC

If we mean that transport integration is smooth transition from one mode (road based) to the other (metro rail) then it is important that the road based mode should reach the metro station in time, at regular interval so that passenger need not walk long distance to enter the station.

Several measures at Metro may be undertaken for smooth transition for the passengers using metro. Stations are designed user friendly, ambience is kept clean, cold and attractive. User needs like Snack bars, ATMs are available at many stations. Elevator and lift is provided at every station to avoid climbing through stair case. Parking facility, Feeder Bus & Bus stops are three most significant services given by DMRC. In addition, pilot projects for E- Rickshaws and cycle shelters have also been taken up.

The feeder buses, E- Rickshaws & cycle shelters would be expanded based on user demands, service ability and patronage.

The extent of need for above modes depends on the type of stations viz. Interchange Stations, stations with extensive Property Development/ close to Business Centers/ Activity Hubs, stations located on the road medians.

The need for provisioning bus stops/parking areas also differ in case of elevated/underground stations and at the terminal stations.

17.6 METRO FEEDER BUS SERVICE

In Delhi, up to Phase III DMRC will have a total of 236 stations out of which 21 are interchange stations. Many stations are with extensive property development near activity hubs or business centres and that are located on road medians or under the road. To cater to these stations, DMRC has so far deployed 117 feeder buses with a sitting capacity of 18 passengers and total capacity of 30 passengers. The present sanctioned routes are 98 which cover roughly 73 metro stations.

Additional 400 feeder buses have already been ordered through two selected bus operators and these midi buses will have a sitting capacity of 28 and total capacity of 50. The present peak ridership is 58,000 per day and monthly average of 50000 per day. The maximum revenue so far is 4.6 Lakhs per day with a monthly average revenue 4.6 Lakhs per day. It is expected that with additional buses the peak ridership per day will touch around 3.5 lakhs per day. For the stabling and maintenance of these buses a total of 8 feeder bus depots have been planned to keep the ideal run to the minimum and provide safe stabling and upkeep.

Existing Feeder Buses New Feeder Buses Being Introduced

Fig. 17.2 - Model of Feeder Buses

However, feeder bus service facility is still not attained perfection. Bus conditions are not good to travel; service headway is long as it is handled by private operators who would like to wait to fetch more passengers. Services at some routes are very irregular as not many passengers are available during non-peak hours. Passengers have to bank upon auto rickshaws. At some stations entry and exit gates are blocked by waiting buses, rickshaw pullers and vendors. This is irritating and some action is required.

Purchasing only one ticket for a complete journey by using any one or more transport mode is still a dream in India because of multiple ownership/agency control or lack of will to implement such system. In Europe, USA this system is working very well and almost eliminated unhealthy competition. True transport integration will be possible when such system will be operational in Indian cities.

17.7 WAY FORWARD

In view of above deliberations in back ground, along with 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 in ridership to the Metro system and provide ease of using the Metro system by the public at large.

Therefore, there is a need for doing more scientific study exclusively for this. To achieve this goal, Metro Rail Stations influenced zone need to be defined which can be taken as approximately 5 kms for the motorised 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 motorised and non-motorised mode with main consideration of the streets/roads adjoining literally to the stations and also to examine adequacy of availability of pedestrian/bicycle 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 finalized.

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 mile 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 Total Cost of all items except Land has been considered sufficient and included in the project cost of proposed Metro Rail System of Nagpur Metro. If at any stage more feeder services etc. will be required, same can be augmented by concerned City transportation authorities.

CHAPTER 18

COST ESTIMATES

TABLES

CHAPTER - 18

COST ESTIMATES

18.1 INTRODUCTION

Detailed cost estimates for Nagpur Metro Rail Project has been prepared corridor wise covering civil, electrical, signaling and telecommunications works, rolling stock, environmental protection, rehabilitation, etc. considering 25 kv ac Overhead Traction System at June 2012 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 rates accepted for Delhi Metro. A suitable escalation factor has been applied to bring these costs to June 2013 price level. The details of taxes and duties are worked out separately.

The capital cost has been worked out for Corridor-1: NORTH-SOUTH CORRIDOR (AUTOMOTIVE SQUARE TO KHAPRI) and Corridor-2: EAST-WEST CORRIDOR (LOKMANYA NAGAR TO PRAJAPATI NAGAR). One depot cum maintenance workshop on each corridor has been planned.

18.2 CAPITAL COST ESTIMATE

CORRIDOR - 1: NORTH-SOUTH CORRIDOR (AUTOMOTIVE SQUARE TO KHAPRI)

The capital cost estimates is shown at Table 18.1

Table 18.1

NAGPUR METRO					
Capital Cost Estimate					
					June 2013 price level
CORRIDOR - I NORTH-SOUTH CORRIDOR (AUTOMOTIVE SQUARE TO KHAPRI)					
Total length = 19.658 Km, Elv = 15.058 Km At Grade: 4.600 Km					
Total Station = 17 nos, Elv = 15, At Grade 2					

S. No.	Item	Unit	Rate	Qty.	Amount (Rs. in Cr.)
				Without taxes	
1.0	**Land**				
1.1	Permanent				
a	Government	ha	6.00	60.200	361.19
b	Private	ha	36.65	3.680	134.88
1.2	Temporary				
a	Government	ha	1.20	20.000	24.00
	Private	ha			
	Subtotal (1)				**419.88**
2.0	**Alignment and Formation**				
2.1	Underground section by T.B.M excluding station length (260m each)	R. Km.	110.00	0.000	0.00
2.2	Underground section by Cut & Cover excluding Station length (260m each) RAMP PORTION	R. Km.	100.00	0.000	0.00
2.3	Elevated section including station length	R. Km.	29.00	15.058	436.68
2.4	At-Grade section including station length	R. Km.	2.90	4.600	13.34
2.5	Entry to depot	R. Km.	2.90	1.000	2.90
	Subtotal (2)				**452.92**
3.0	**Station Buildings**				
3.1	**Underground Station** (260 m length) incl. EM works, lifts, escalators, VAC etc.	Each			
a	Underground Station- Civil works	Each	100.00	0	0.00
b	Underground Station- EM works etc.	Each	55.40	0	0.00

S. No.	Item	Unit	Rate	Qty.	Amount (Rs. in Cr.)
3.2	**Elevated stations** (including finishes)	Each			
a	Type (A) way side- civil works	Each	17.00	10	170.00
b	Type (A) way side- EM works etc	Each	7.02	10	70.20
c	Type (B) Way side with signaling- civil works	Each	18.70	4	74.80
d	Type (B) Way side with signaling- EM works etc	Each	7.02	4	28.08
e	Type (C), Terminal station -civil works	Each	20.00	1	20.00
f	Type (C), Terminal station -EM works	Each	7.02	1	7.02
3.3	**At grade Stations (including finishes)**				
a	Type (A) way side- civil works	LS	13.600	2.000	27.20
b	Type (A) way side- EM works etc	LS	5.616	2.000	11.23
3.4	Metro Bhawan & OCC bldg	LS			
a	Metro Bhawan & OCC bldg -civil works	LS			41.35
b	Metro Bhawan & OCC bldg -EM works etc	LS			7.25
	Subtotal (3)				**467.16**
4.0	**Depot**	LS			
a	Civil works	LS			58.40
b	EM works etc	LS			87.60
	Subtotal (4)				**146.00**
5.0	**P-Way**				
5.1	Ballastless track for elevated & underground Section	R. Km.	6.48	15.008	97.30
5.2	Ballasted track for (a) at grade alignment and (b) in depot	R. Km.	2.31	10.000	24.60
	Subtotal (5)				**122.96**
6.0	**Traction & power supply incl. OHE, ASS etc. Excl. lifts & Escalators**				
6.1	U/G Section	R.Km.	16.88	0.000	0.00
6.1	Elevated & at grade section	R.Km.	16.88	20.658	348.71
	Subtotal (6)				**348.71**
7.0	**Signalling and Telecom.**				
7.1	Sig. & Telecom.	R. Km.	14.00	20.658	291.87
7.2	Automatic fare collection	Stn.			
	At Grade Station	Each	5.00	2	10.00
	Elevated stations	Each	5.00	15	75.00
	Subtotal (7)				**376.87**
8.0	**R & R incl. Hutments etc.**	LS			60.00
	Subtotal (8)				**60.00**
9.0	**Misc. Utilities, roadworks, other civil works such as median stn. signages Environmental protection**	R. Km.			

S. No.	Item	Unit	Rate	Qty.	Amount (Rs. in Cr.)
a	Civil works+E&M works	R. Km	4.65	20.858	96.92
	Subtotal (9)				96.92
10.0	Rolling Stock	Each	8.50	33.000	280.50
	Subtotal (10)				280.50
11.0	Capital expenditure on security	LS			
a	Civil works	LS			6.00
b	EM works etc	LS			4.00
	Sub Total (11)				10.00
12.0	Capital expenditure on Feeder buses				
	Feeder Buses @ 2% of Total Cost of all items except Land	LS			47.01
13.0	Total of all items except Land				2350.32
	Total of all items except Land but including Feeder Buses				2397.34
14.0	General Charges incl. Design charges @ 5 % on all items except land				119.87
15.0	Total of all items including G. Charges except land				2517.21
16.0	Contingencies @ 3 %				75.52
17.0	Gross Total				2592.73
		Cost without land		=	2593
		Cost with land		=	3019

CORRIDOR - II: EAST-WEST CORRIDOR (LOKMANYA NAGAR TO PRAJAPATI NAGAR)

The capital cost estimates is shown at Table 18.2

Table 18.2

NAGPUR METRO					
Capital Cost Estimate					
					June 2012 price level
CORRIDOR - II EAST-WEST CORRIDOR (LOKMANYA NAGAR TO PRAJAPATI NAGAR)					
Total length = 18.557 Km, Elv = 18.557 Km					
Total station = 19 nos, Elv = 19					
S. No.	**Item**	**Unit**	**Rate**	**Qty.**	**Amount (Rs. in Cr.)**
				Without taxes	
1.0	**Land**				
1.1	Permanent				
a	Government	ha	8.00	27.460	197.33
b	Private	ha	35.82	1.460	52.30
1.2	Temporary				
a	Government	ha	1.20	20.000	24.00
	Private	ha			
	Subtotal (1)				**314.33**
2.0	**Alignment and Formation**				
2.1	Underground section by TBM excluding station length (260m each)	R. Km.	150.00	0.000	0.00
2.2	Underground section by Cut & Cover excluding Station length (260m each) RAMP PORTION	R. Km.	100.00	0.000	0.00
2.3	Elevated section including station length	R. Km.	29.00	18.557	538.15
2.4	At-Grade section including station length	R. Km.	2.50	0.000	0.00
2.5	Entry to depot	R. Km.	2.50	1.000	2.50
	Subtotal (2)				**540.65**
3.0	**Station Buildings**				
3.1	**Underground Station**(260 m length) incl. EM works, lifts, escalators, VAC etc.	Each			
a	Underground Station- Civil works	Each	100.00	0	0.00
b	Underground Station- EM works etc.	Each	54.40	0	0.00

S. No.	Item	Unit	Rate	Qty	Amount (Rs. in Cr.)
3.2	**Elevated stations** (including finishes)	Each			
a	Type (A) way side- civil works	Each	17.00	13	221.00
b	Type (A) way side- EM works etc	Each	7.92	13	51.20
c	Type (B) Way side with signaling- civil works	Each	18.70	4	74.80
d	Type (B) Way side with signaling- EM works etc	Each	7.92	4	28.08
e	Type (C), Terminal station -civil works	Each	20.00	2	40.00
f	Type (C), Terminal station -EM works	Each	7.02	2	14.04
3.3	**At grade Stations (including finishes)**				
a	Type (A) way side- civil works	LS	10.600	0.000	0.00
b	Type (A) way side- EM works etc	LS	6.016	0.000	0.00
3.5	Metro Bhawan & OCC bldg	LS			
a	Metro Bhawan & OCC bldg -civil works	LS			41.30
b	Metro Bhawan & OCC bldg -EM works etc	LS			7.25
	Subtotal (3)				**917.83**
4.0	**Depot**	LS			
a	Civil works	LS			58.40
b	EM works etc	LS			87.60
	Subtotal (4)				**146.00**
5.0	**P-Way**				
5.1	Ballastless track for elevated & underground Section	R. Km.	0.46	16.307	120.23
5.2	Ballasted track in depot	R. Km.	2.31	5.000	11.55
	Subtotal (5)				**131.88**
6.0	**Traction & power supply incl. OHE, ASS etc. Excl. lifts & Escalators**				
6.1	UG Section	R.Km.	18.08	0.000	0.00
6.1	Elevated & at grade section	R.Km.	18.08	19.307	356.12
	Subtotal (6)				**356.12**
7.0	**Signalling and Telecom.**				
7.1	Sig. & Telecom.	R. Km.	14.00	19.307	270.30
7.2	Automatic fare collection	Stn.			
	At Grade Station	Each	5.00	0	0.00
	Elevated stations	Each	5.00	19	95.00
	Subtotal (7)				**375.00**
8.0	**R & R incl. Hutments etc.**	LS			80.00
	Subtotal (8)				**80.00**
9.0	**Misc. Utilities, roadworks, other civil works such as median stn. signages Environmental protection**	R. Km.			

S. No.	Item	Unit	Rate	Qty.	Amount (Rs. in Cr.)
B	Civil works+E&M works	R. Km.	4.00	15.327	61.75
	Subtotal (9)				61.75
10.0	Rolling Stock	Each	8.50	36.000	306.00
	Subtotal (10)				306.00
11.0	Capital expenditure on security	LS			
a	Civil works	LS			6.00
b	E&M works etc	LS			4.00
	Sub Total (11)				10.00
12.0	Capital expenditure on Feeder buses				
	Feeder Buses @ 3% of Total Cost of all items except Land	LS			80.10
13.0	Total of all items except Land				2608.09
	Total of all items except Land but including Feeder Buses				2688.19
14.0	General Charges incl. Design charges @ 5 % on all items except land				127.75
15.0	Total of all items including G. Charges except land				2682.86
16.0	Contingencies @ 3 %				80.48
17.0	Gross Total				2763.44
		Cost without land		=	2763
		Cost with land		=	2884

18.3 LAND

i) Land requirements have been kept to the barest minimum & worked out on area basis. For underground and elevated alignment, no land is proposed to be acquired permanently, except small areas for locating entry/exit structures, traffic integration, etc. at stations, and wherever the alignment is off the road.

ii) To workout cost of land its rates have been assumed as Rs. 3.00 Crore per hectare for government land and rates for private land have been taken as Rs. 35.52 Crore per hectare.

iii) Land required for Property Development for funding the project after its commercial exploitation has not been taken in to account while working out project cost.

18.4 FORMATION, ALIGNMENT

i) **Elevated Section**: The basis of rate is as accepted for Delhi Metro duly escalated to June 2012 price level.

18.5 STATION BUILDINGS

i) **Underground Stations**: The basis of rate is as accepted for Delhi Metro duly escalated to June 2012 price level. The work cover U.G. alignment, as well as, other civil electrical works like ventilation, air-conditioning, lifts & escalators, but does not cover P-way, O.H.E., signaling and interlocking works, AFC installations.

ii) **Elevated Stations**: Rates are based on accepted rates of Delhi metro, duly updated to June 2012 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. One station is planned at double height. The extra cost on double height account to be charged to contingency.

18.6 PERMANENT WAY

For elevated and underground sections, ballastless track and for at-grade section and Depot ballasted track has been planned. Rates are based on accepted rates of Delhi Metro, duly updated to June 2012 price level.

18.7 DEPOT

One Car Maintenance Depot-cum-Workshop serving both the corridors have been proposed at KHAPRI (for NS Corridor) and at Subhash Nagar (for EW Corridor). The depot is planned at ground level. Costs have been worked out for various items of building, elevated structures, tracks, boundary wall & plants machinery etc.

18.8 UTILITY DIVERSIONS

The costs of utility diversions involved in the stretch have been considered separately and provided for in the estimate. In addition to sewer/drainage/water pipelines other important utilities works considered are road diversions, road restoration etc. Cost provision has been made on route km basis based on experience of Delhi Metro.

18.9 ENVIRONMENTAL IMPACT ASSESSMENT

Provision for environmental impacts of the proposed two Corridors has been made to cover various protection works, additional compensatory measures, and compensation for loss of trees, compensatory afforestation and fencing, monitoring of water quality, air/noise pollution during construction, establishment of Environmental Division.

18.10 REHABILITATION & RESETTLEMENT

Provision towards compensation/rehabilitation of structure likely to be affected has been assessed. Sufficient provision is kept in the estimate to cover the cost of shifting of structures.

18.11 TRACTION & POWER SUPPLY

Provisions have been made to cover following subheads:

- OHE
- Receiving-cum-Traction Sub-stations including cables.
- ASS for elevated and at-grade stations.
- Service connection charges for Receiving Sub-stations.
- SCADA augmentation.
- Miscellaneous items e.g. illumination, lifting T&P, etc.

The rates adopted for various items are based on costs of works being done for Delhi Metro, duly updated to June 2012 level.

18.12 ELECTRICAL SERVICES AT STATIONS

These are included in estimated costs of stations. Cost of escalators for elevated stations have not been included in station costs, and therefore, are provided under electrical estimates & shown separately.

18.13 SIGNALLING & TELECOMMUNICATION WORKS

The rates adopted are based on assessment done considering rates of similar sub-system as accepted for Delhi Metro, duly updated to June 2012 price level and TPWS works. These rates include escalation during manufacture & supply of equipment and their installation at site, but exclude CD and IRT.

18.14 AUTOMATIC FARE COLLECTION

Adopted rates are based on assessment done considering rates of similar works in Delhi Metro /other metro projects, duly updated to June 2012 price level. These rates exclude

CD & WT, but include escalation during the period of equipment manufacture and their supply, including installation.

18.15 ROLLING STOCK

The estimated cost per coach at June 2013 price level exclusive of taxes and duties has been taken as Rs. 8.5 Crores per coach.

18.16 CAPITAL EXPENDITURE ON SECURITY

A lump-sum cost of 10 crore has been considered for this purpose.

18.17 CAPITAL EXPENDITURE ON FEEDER BUSES

A lump-sum cost of Feeder Buses @ 2% of Total Cost of all items except Land has been considered.

18.18 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 for various corridors are given in the following tables.

Details of Taxes and duties for Corridor-I and Corridor-II are provided in table 18.3 and 18.4 respectively.

TABLE 10.3

Details of Taxes and Duties (N-S CORRIDOR)

Details of Taxes and Duties (N-S CORRIDOR)

	Customs duty =	22.8501	%			
	Excise duty =	12.36	%			
	Sale tax =	6.25	%			
	Works tax =	6.25	%			
	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.)	VAT(Cr.)	
1	**Alignment & Formation**					
	Underground	0.00	0.00	0.00	0.00	0.00
	Elevated, at grade & entry to Depot	402.32		39.19	22.26	61.45
2	**Station Buildings**					
	a) Underground station-civil works	0.00	0.00	0.00	0.00	0.00
	b) Underground station-EM works	0.00	0.00	0.00	0.00	0.00
	Elevated station - civil works	292.50		25.29	14.35	39.63
	Elevated station-EM works	116.53	5.35	9.79	5.08	20.99
	e) Metro bhawan & OCC bldg-civil works	41.33		3.58	2.03	5.61
	f) Metro bhawan & OCC bldg-EM works	7.29	0.35	0.61	0.33	1.29
3	**Depot**					
	Civil works	59.40	4.30	5.54	2.01	9.55
	EM works	87.60	4.30	7.38	4.18	15.86
4	**P-Way**	122.06	22.37	2.58	1.46	26.04
5	**Traction & power supply**					
	Traction and power supply	348.71	31.80	21.58	12.43	66.35
6	**S &T Works**					
	S & T	201.07	53.23	7.20	4.06	64.60
	AFC	80.30	14.37	2.63	1.48	18.89
7	**R & R hutments**	60.00			3.75	3.75
8	**Misc.**					
	Civil works	72.69		6.29	3.57	9.86
	EM works	24.23		2.55	1.43	3.99
9	**Rolling stock**	390.30	30.41	2.70	1.54	66.66
10	**Security**					
	Civil works	6.00		0.52	0.38	0.90
	EM works	4.00		0.49	0.36	0.85
11	Feeder Buses	47.91		5.61	4.21	10.04
	Total	2207.34	193.36	142.66		419.67
	Total taxes & Duties					420

TABLE 10.4

Details of Taxes and Duties (EW CORRIDOR)

	Details of Taxes and Duties (N S CORRIDOR)					
	Customs duty =	22.8531	%			
	Excise duty =	12.36	%			
	Sale tax =	6.25	%			
	Works tax =	6.25	%			
	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.)	VAT(Cr.)	
1	**Alignment & Formation**					
	Underground	0.00	0.00	0.00	0.00	0.00
	Elevated, at grade & entry to Depot	541.05		45.61	26.00	75.41
2	**Station Buildings**					
	a) Underground station-civil works	0.00	0.00	0.00	0.00	0.00
	b) Underground station-EM works	0.00	0.00	0.00	0.00	0.00
	Elevated station - civil works	335.90		29.65	16.31	46.66
	Elevated station-EM works	130.38	6.10	11.21	6.37	23.88
	e) Metro bhawan & OCC bldg-civil works	41.33		3.68	2.03	5.61
	f) Metro Bhawan & OCC bldg-EM works	7.20	0.20	0.61	0.30	1.20
3	**Depot**					
	Civil works	39.40	4.00	3.54	2.01	9.88
	EM works	87.90	4.00	7.36	4.18	15.88
4	**P-Way**	131.80	24.10	2.77	1.57	28.44
5	**Traction & power supply**					
	Traction and power supply	330.12	30.10	20.81	11.82	62.81
6	**S &T Works**					
	S & T	275.94	56.30	5.81	3.87	61.08
	AFC	95.00	16.20	2.54	1.67	20.38
7	**R & R hutments**	60.00			3.75	3.75
8	**Misc.**					
	Civil works	95.82		3.55	3.30	8.84
	EM works	22.54		2.41	1.37	3.78
9	**Rolling stock**	300.00	61.54	2.95	1.68	66.17
10	**Security**					
	Civil works	5.00		0.52	0.30	0.80
	EM works	4.00		0.49	0.30	0.36
11	Feeder Buses	90.10		8.18	4.50	16.78
	Total	2968.18	168.81	164.61		443.22
	Total taxes & Duties					443

CHAPTER 19

FINANCING OPTIONS, FARE STRUCTURE AND FINANCIAL VIABILITY

TABLES

FIGURES

CHAPTER 19

FINANCING OPTIONS, FARE STRUCTURE AND FINANCIAL VIABILITY

19.1 INTRODUCTION

The Nagpur Metro consisting of two corridors are proposed to be constructed with an estimated cost of Rs 6862.00 Crore with Central Taxes, State Taxes and land cost. The corridor-wise length, estimated cost at June-2012 price level without taxes and with all taxes is placed in **Table 19.1** as under:

Table 19.1
Cost Details

Rs. in Crore

Corridor No.	Name of Corridor	Distance (KMs)	Estimated Cost without Central taxes at June-2012 Price Level	Estimated Cost with all taxes at June-2012 Price Level
I	North-South Corridor	19.658	3015.00	3,435.00
II	East-West Corridor	18.557	2584.00	3,427.00
Total		**38.215**	**5599.00**	**6862.00**

The estimated cost at June-2012 price level includes Rs. 413.00 Crore and Rs.214.00 Crore as land cost respectively for Corridor I and II. The estimated cost at June-2012 price level also includes an amount of Rs.20 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 been in to account in FIRR calculation with an assumption that the required police personnel will be provided free of cost by the state government since it is as state subject.

19.2 COSTS

19.2.1 Investment Cost

For the purpose of calculating the Financial Internal Rate of Return (FIRR), the completion costs with central taxes & state taxes have been taken with an escalation factor @7.50% PA.

The construction work is expected to get completed by 31.03.2018. The Revenue Opening Date (ROD) has been assumed as 01.04.2018. The total completion costs duly escalated and shown in the table 19.2 have been taken as the initial investment. The year-wise cash outgo is shown in **Table 19.2** as below.

Table 19.2
Year-wise Investment

Rs. in Crore

Financial Year	Cost at June 2013 Price Level	Completion Cost
2013-14	447.00	452.00
2014-15	944.00	1021.00
2015-16	1550.00	1874.00
2016-17	1965.00	2412.00
2017-18	1430.00	1980.00
2018-19	497.00	743.00
2019-20	126.00	188.00
Total	**[illegible]**	**[illegible]**

Although the construction is expected to get over by 31st March 2018, the cash flow spill over up to March 2020 is necessary on account of payment normally required to be made to the various contractors up to that period necessitated by contractual clauses.

The land cost is divided into two initial years during which it is expected that the land acquisition work would be over and related payments would have to be released. Therefore, no escalation has been considered on it.

19.2.2 Additional Investment

Total investment provided in the FIRR calculation towards requirement of additional rolling stock to take care of incremental traffic, duly escalated @5% PA is placed in **Table 19.3** as under: -

Table 19.3

Additional Investment towards Rolling Stock

Rs. in Crore

Year	No. of Cars	Amount with Taxes
2021-22	15	241.00
2026-27	9	164.00
2031-32	6	157.00
2036-37	12	400.00
2041-42	12	511.00

15.3.3 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 staffs are assumed to be provided @ 35 persons per kilometre. The escalation factor used for staff costs is 9% per annum to provide for both escalation and growth in salaries.

The cost of other expenses is based on the actual O & M unit cost for the Delhi Metro Phase-II project. The average rate of electricity being paid by Delhi Metro for its Phase-I and Phase-II operations in Delhi is Rs. 5.80 per unit whereas in Nagpur the applicable rate is Rs. 6.00 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 which has been calculated on life cycle cost basis is tabulated in Table 15.4 as below:-

Table 15.4

Operation and Maintenance Costs

Rs. in Crore

YEAR			Staff	Maintenance Expenses	Energy	Total
[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

YEAR			Staff	Maintenance Expenses	Energy	Total
[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

19.2.4 Depreciation

Although depreciation does not enter the FIRR calculation (not being a cash outflow) unless a specific depreciation reserve fund has been provided, in the present calculation, depreciation calculations are placed for purpose of record.

19.2.5 Replacement Cost

The replacement costs are provided for meeting the cost on account of replacement of equipment due to wear and tear. With the nature of equipment proposed to be provided, it is expected that only 30% of the Signalling and Telecom and 25% of electrical works would require replacement after 20 years. Further, 30% of the Signalling and Telecom and 20% of electrical works would require replacement after 30 years. These costs have been provided duly escalated @ 5% per annum.

19.3 REVENUES

The Revenue of Nagpur metro mainly consists of fare box collection and other incomes from property development, advertisement, parking etc.

19.3.1 Fare box

The Fare box collection is the product of projected ridership per day and applicable fare structure based on assumed trip distribution at different distance zones.

19.3.2 Traffic

The year-wise projected ridership figures are as indicated in **Table 19.8** as below: -

Table 19.8
Projected Ridership

Year	Corridor-1 & 2 Trips Per Day (lakhs)
2018-19	3.67
2021-22	3.83
2026-27	4.15

Year	Corridor-1 & 2 Trips Per Day (lakhs)
2031-32	4.59
2036-37	5.03
2041-42	5.64

b. The growth rate for traffic is assumed at 2.15% Per Annum.

19.2.3 Trip Distribution

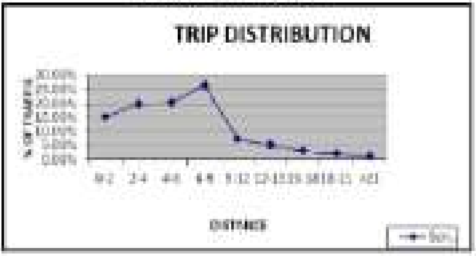
The trip distribution has been worked out by considering average lead of 6.28 KM which is placed in **Table 19.6** below: -

Table 19.6
Trip Distribution

Distance in kms.	Percent distribution
0-2	15.00%
2-4	20.00%
4-6	20.50%
6-9	26.50%
9-12	7.00%
12-15	5.00%
15-18	3.00%
18-21	2.00%
>21	1.00%
Total	100.00%

The graphic presentation of the same is placed below in **Figure-19.1**.

Figure 19.1 –Trip Distribution



19.3.4 Fare Structure

The Delhi Metro Fares structures fixed by fare fixation committee in 2009 have been assumed, which have been duly escalated @10% for every two years to arrive at the initial fare structure for Nagpur Metro, which is placed in **Table 19.7.**

Table 19.7

Fare Structure in 2018-19

Distance in Kms	DMRC Fare as Revised in 2009	Nagpur Metro Fare (Rs.) in 2018-19
0-2	8	15
2-4	10	18
4-6	12	23
6-9	15	28
9-12	16	30
12-15	18	34
15-18	19	36
18-21	21	39
>21	22	41

19.3.5 Other sources of revenues

19.3.5.1 Property Business:- Other revenues from Property business i.e. advertisement, Kiosk, ATM etc. 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.

19.3.5.2 Additional Taxes:- Income assumed from additional taxes i.e. FSI, Additional Stamp Duty, Development Fund as proposed by Nagpur Improvement Trust vide letter dated 26.09.2013 is placed at Table no. 19.8. The amount of taxes as provided by Nagpur Improvement Trust has been considered from 2018-19 for FIRR calculations.

Table 19.8 : Income assumed from additional taxes

Rs. in Crore

Year			FSI	Additional Stamp Duty@1%	Development Fund Revenue	Total
2016	-	2017	-	[illegible]	3.00	[illegible]
2017	-	2018	-	[illegible]	3.00	[illegible]
2018	-	2019	[illegible]	[illegible]	3.00	[illegible]
2019	-	2020	[illegible]	[illegible]	3.00	[illegible]
2020	-	2021	[illegible]	[illegible]	3.00	[illegible]
2021	-	2022	[illegible]	[illegible]	3.00	[illegible]
2022	-	2023	[illegible]	[illegible]	3.00	[illegible]
2023	-	2024	[illegible]	[illegible]	3.00	[illegible]

2024	-	2025	[illegible]	[illegible]	3.00	[illegible]
2025	-	2026	[illegible]	[illegible]	3.00	[illegible]
2026	-	2027	[illegible]	[illegible]	3.00	[illegible]
2027	-	2028	[illegible]	[illegible]	3.00	[illegible]
2028	-	2029	[illegible]	[illegible]	3.00	[illegible]
2029	-	2030	[illegible]	[illegible]	3.00	[illegible]
2030	-	2031	[illegible]	[illegible]	3.00	[illegible]
2031	-	2032	[illegible]	[illegible]	3.00	[illegible]
2032	-	2033	[illegible]	[illegible]	3.00	[illegible]
2033	-	2034	-	[illegible]	3.00	[illegible]
2034	-	2035	-	[illegible]	3.00	[illegible]
2035	-	2036	-	[illegible]	3.00	[illegible]
2036	-	2037	-	[illegible]	3.00	[illegible]
2037	-	2038	-	[illegible]	3.00	[illegible]
2038	-	2039	-	[illegible]	3.00	[illegible]
2039	-	2040	-	[illegible]	3.00	[illegible]
2040	-	2041	-	[illegible]	3.00	[illegible]
2041	-	2042	-	[illegible]	3.00	[illegible]
2042	-	2043	-	[illegible]	3.00	[illegible]
Total			[illegible]	[illegible]	[illegible]	[illegible]

19.4 FINANCIAL INTERNAL RATE OF RETURN (FIRR)

The Financial Internal Rate of Return (FIRR) and costs for 30 years business model including construction period is [illegible]. The FIRR with all taxes is produced in **Table 19.8**

Table 19.8
FIRR (with all taxes)

Rs. in Crore

Year			Completion Cost	Additional Cost	Running & Maintenance	Replacement costs	Total Costs	Fare Box Revenue	PD & Advt	Revenue from Rentals and Taxes	Total Revenue	Net Cash flow for IRR
2013	-	2014	[illegible]				[illegible]				[illegible]	[illegible]
2014	-	2015	[illegible]				[illegible]				[illegible]	[illegible]
2015	-	2016	[illegible]				[illegible]				[illegible]	[illegible]
2016	-	2017	[illegible]				[illegible]				[illegible]	[illegible]
2017	-	2018	[illegible]				[illegible]				[illegible]	[illegible]
2018	-	2019	[illegible]		[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2019	-	2020	[illegible]		[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2020	-	2021	[illegible]		[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2021	-	2022	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2022	-	2023	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2023	-	2024	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2024	-	2025	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2025	-	2026	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Year			[illegible]	[illegible]	[illegible]	[illegible]	Total Costs	[illegible]	[illegible]	[illegible]	Total Revenue	Net Cash flow for IRR
[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Total			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	10.33%

The various sensitivities with regard to increase/decrease in capital costs, O&M costs and revenues are placed in **Table 18.10** below: -

Table 18.10
FIRR Sensitivity

CAPITAL COSTS with all Taxes			
10% increase in capital cost	20% increase in capital cost	10% decrease in capital cost	20% decrease in capital cost
9.44%	8.63%	11.28%	12.28%
REVENUE			
20% decrease in Traffic revenue	10% decrease Traffic in revenue	10% increase in Traffic revenue	20% increase in Traffic revenue
8.83%	9.67%	10.98%	11.58%
O&M COSTS			
10% increase in O&M cost		10% decrease in O&M cost	
10.03%		10.66%	

These sensitivities have been carried out independently for each factor.

19.6 FINANCING OPTIONS

19.6.1 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:-

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

Rail based mass transit systems are characterized 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 subsidized. 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. In India also, GOI & concerned state government have contributed entire equity capital and equally provided interest free subordinate debts for land and central taxes along with ODA loan from JICA for Delhi, Chennai, and Bangalore metros.

19.6.2 Alternative Models Of Financing

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

(i) Special Purpose Vehicle under the State Control (Delhi Metro Rail Corporation (DMRC) /Bangalore Metro Rail Corporation (BMRC) model)
(ii) Public-Private Partnership (PPP) mode
   - Built Operate and Transfer (BOT) model
   - Other PPP Model

19.6.3 DMRC/BMRC/CMRL pattern of Financing

A Special Purpose Vehicle (SPV) is set up for the implementation of the project and for its subsequent Operation & Maintenance. Under this arrangement Government of India and Government of Maharashtra shall make equal equity contribution and run the SPV as a commercial enterprise as a joint venture of GOI & GOM. As per the prevalent practice, Central Government may be willing to contribute 15% to 20% of the project cost as their equity contribution. An equal amount can be contributed by Government of Maharashtra aggregating the total equity to 40%. With the equal ownership of the SPV, both the governments nominate their representatives as members of the Board of Directors, which in turn select functional directors. Such a SPV has a benefit of independent management under the aegis of Indian Companies Act, 1956. Delhi Metro Rail Corporation, Chennai & Bangalore metro corporations are shining example of success of such SPV. For the balance 80% funding requirement, options available are as follows: -

(i) **Subordinate Debt** - For Delhi Metro, land and rehabilitation and resettlement cost have been borne by GOI & GNCTD equally as interest free subordinate debt. Now, MOUD have changed the policy under which the cost of land for Bangalore Metro was borne by Government of Karnataka as interest free subordinate debt. Similarly, the cost of Land including rehabilitation and resettlement cost amounting to Rs.944.00 Crore may be contributed as interest free subordinate debt by GOM. This mezzanine financing is of extreme help in quickening the pace of land acquisition, since the compensation amount is released to evacuate instantaneously. The loan is of longer duration and becomes repayable only after other long term loans raised for the project is repaid.

(ii) **Debt:** - The balance cost is to be met through loans from various institutions namely JICA, Local borrowing, loans from ADB/World Bank and Suppliers Credit.

JICA Loan: -Overseas Development assistance from Japan International Cooperation Agency (JICA) may be availed of for metro rail projects with interest @ 1.40%PA and it to the SPV on back to back basis. The loan is repayable in 30 years including moratorium period of 10 years. The loan is being provided by JICA to GOI which in turn releases the same to SPV under a Pass Through Assistance (PTA) mechanism. Normally, JICA funds for underground civil works, Electrical, Signalling &Telecom and Rolling Stock only. Since the loan will be in Japanese Yen, fluctuation in exchange rate at the time of repayment shall be borne by the Central Government and Government of Maharashtra in proportion to which their share holding. Alternatively, JICA can release the loan to the SPV for which a sovereign guarantee will be required from Central Government. Foreign exchange variation in such eventuality will be borne either by the SPV or GOM. In either case, loan shall be repaid by SPV from the income streams of metro operations.

Loan from Asian Development Bank (ADB)/World Bank: - The Loan shall be available from ADB/World Bank, but as per the experience its processing and approval normally takes 8-10 months. The interest rate is linked with periodically LIBOR. These bilateral funding institutions also charge some margin ranging from 200 basis points to 300 basis points. This may delay the implementation of the project resulting in avoidable increase in the completion cost. Recently, Bangalore Metro availed ADB loan.

Loan from Bank and Financial Institutions: - Funds can be arranged from domestic Financial Institutions like India Infrastructure Finance Company Limited (IIFCL), India Development Financing Corporation (IDFC), Life Insurance Corporation of India (LIC), IDBI Bank, ICICI Bank Ltd etc. These institutions are increasingly engaged to fund infrastructure projects subject to their commercial viability against guarantee from GOI. There are many models available under which the funds can be arranged by these financial institutions with or without syndicating with other commercial banks. IIFCL e.g. fund 20% of the project cost and arrange balance through the syndication of commercial banks with a lead banker among the consortium of bankers. The loan can be given for a period of 20-30 years with interest rate ranging from 9.50% to 12% PA. IIFCL can also provide 100% funding against GOI guarantee. They arrange ECB to the extent of foreign currency requirement at very competitive rate. The funding arrangement may require the central government guarantee as well. Since the rate of interest of these financial institutions is much higher than the interest rates of soft loan provided by JICA, GOI and GOM shall have to bear the interest difference and provide subsidy suitably to the SPV to make the project financially sustainable.

Suppliers Credit: - Suppliers Credit is an established method to secure funding of imports. It is backed by EXIM banks of exporting countries and is often a much better instrument than bilateral aid. While bilateral aid ties the borrowing entity, Suppliers Credit can be used intelligently and effectively to spur competition in competitive international tendering method. In cases of Rolling Stock, where market is truly competitive (unlike S&T) an attractive rate of interest for suppliers credit is possible. However, the supplier will load the amount of interest in the cost of supply due to which the effective completion cost will be very high.

The funding pattern assumed under government owned SPV model is placed in **Table 18.11** as under:-

Table 18.11

Funding pattern under SPV model (with All Taxes & Duties)

Particulars	With Taxes & Duties	
	Amount (Rs/Crore)	% of contribution
Equity by GOI	1114.00	12.83%
Equity by GOM	1114.00	12.83%
SD by GOM for central Taxes (50%)	441.00	5.08%
SD by GOI for Central Taxes (50%)	441.00	5.08%
SD by GOM for State Taxes	259.00	2.98%
SD by GOM for Land	644.00	7.42%
Nagpur Improvement Trust Contribution	421.00	4.85%
Nagpur Municipal Corporation Contribution	421.00	4.85%
JICA Loan @ 1.40% PA/Market Borrowing @12%	3825.00	44.08%
Total	**8680.00**	**100.00%**

19.5.4 Public Private Partnership Mode

Public Private Partnership (PPP) arrangements are steadily growing in use particularly in road, power, and telecom sectors which are more of commercial nature rather than in a social sector project. PPP models are arrayed across a spectrum ranging from BOT where the private sectors have total involvement to other tailor made models where both public and private sector assume separate responsibilities. A few alternatives which can be selected in this regard are:-

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 Maharashtra 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 amount towards the project. The metro being a social sector project may not attract much private parties. Besides quite expectedly the private operator may demand assured rate of return in the range of 16% to 18% (Equity IRR) or a comfort of guaranteed ridership etc.

The funding pattern assumed under this model to ensure 16% as EIRR is placed in **Table 19.12** tabulated as under: -

Table 19.12
Funding pattern under BOT model (with all taxes)

Particulars	Amount (Rs/Crore)	% of contribution
VGF by GOI	1555.40	20.00%
VGF by GOM	524.60	6.75%
Equity by Concessionaire	1898.00	24.42%
Concessionaire's debt @12% PA	3798.00	48.83%
Total	**7777.00**	**100.00%**
Land Free by GOM	844.00	
State Taxes by GOM	253.00	
IDC	445.00	
Total including IDC	**9126.00**	

19.6. RECOMMENDATIONS

The FIRR of subject metro with all taxes is 18.00% and therefore the corridors are recommended for implementation.

The total fund contribution of GOI & GOM under various alternatives is tabulated in table 19.13.

Table 15.13

Rs. in crore

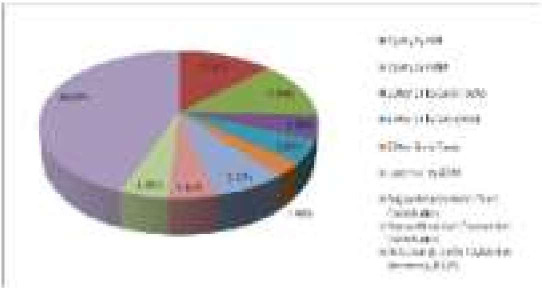
Contributor	SPV Model	BOT
Government of India	1356.00	1555.40
Government of Maharashtra	2408.00	1427.60
Total	**3764.00**	**2983.00**

Considering the fact that the innovative financing from additional FAR, Stamp Duty, development fund revenue provided by Nagpur Improvement Trust shall dues only to the government instrumentalities and not to the private operator, it is recommended to implement the project under SPV model as per the funding pattern given in Table 15.11.

The details showing cash flow under JICA Loan, Market Borrowing, BOT model to ensure 10% EIRR when the project cost is with all taxes are shown respectively in table 15.14, 15.15& 15.16.

The funding pattern assumed under SPV model is depicted in the pie chart i.e., Figure 15.2 as under: -

Figure 15.2
Funding Pattern: - SPV Model



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CHAPTER 20

ECONOMIC APPRAISAL

TABLES

FIGURES

Chapter - 20

ECONOMIC APPRAISAL

20.1 INTRODUCTION

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

20.1.1 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.

20.1.2 The sources from where economic savings occur are identified first. Although there are many kinds of primary, secondary and tertiary benefits, only the quantifiable components can be taken to measure the benefits. These components are quantified by linking with the number of passengers shifted and the passenger km saved by the trips which are shifted from road/rail based modes to metro. It may be observed that first four benefit components given in **Table 20.1** are direct benefits due to shifting of trips to metro, but other benefit components are due to decongestion effect on the road. Benefit components were first estimated applying market values then were converted into respective

Economic values by using separate economic factors which are also given in table 20.1. Depending upon methodology of estimation, economic factors are assumed. Overall economic value of benefit components is 93% of the market value. Similarly economic value of the cost components are 80% of the market cost.

Table 20.1: Benefit Components due to Metro

	Benefit Components	Economic Factors
1	Construction Cost	80%
2	Maintenance Cost	80%
3	Annual Time Cost Saved by Metro Passengers	90%
4	Annual Fuel Cost Saved by Metro Passengers	90%
5	Annual Vehicle Operating Cost Saved by Metro Passengers	90%
6	Emission Saving Cost	100%
7	Accident Cost	100%
8	Annual Time Cost Saved by Road Passengers	90%
9	Annual Fuel Cost Saved by Road Passengers	90%
10	Annual Infra Structure Maintenance Cost	90%
11	Overall economic factor for the benefit components	93%

20.3 VALUES ADOPTED FOR SOME IMPORTANT VARIABLES

Benefit components are converted (by applying appropriate unit cost) to money values (Rs.). Some of the values used for economic analysis are shown in **Table 20.2**.

Table 20.2: Values adopted for some important variables

	Values	Important variables
1	Rs. 2.791/min (2013)	Time Cost derived from passenger's journey time and fare paid (mode wise).
2	Market Rate (2013)	Fuel Cost (value of Petrol, Diesel and CNG)
3	Table 20.3	Vehicle Operating Cost (Derived from Life Cycle Cost of different passenger vehicles per km)
4	Table 20.4 (CPCB)	Emission (gm/km as per CPCB and UK Norms) Emission Saving Cost (adopted for Indian conditions in Rs/ton)
5	Table 20.5 (Accident Rate & Cost)	Accident Rate (No of fatal and all accidents per one Cr VKM). Accident costs are derived from published papers at current rate.
6	57.3%	Passenger km to Vehicle km conversion factor (derived from 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. 1.0/vehicle km	Infra Structure Maintenance Cost is derived from published values on annual expenditure on roads and traffic and

		annual vehicle km
9	13.54 min	Average Journey Time Saved for average km journey after Shifting (Derived)
10	24.05 kmph	Average Journey Speed (Speed & Delay Study)

Table 20.3: 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	0.67	0.72	2.26	2.75
Capital Cost	2.40	2.67	1.20	0.15	0.16	0.72	1.72
Total VOC	6.96	5.58	3.52	0.82	0.48	3.27	4.92

Table 20.4: Vehicle Emission 2011-2021(CPCB) and Cost in Rs.

VEHICLE	CO	HC	NOX	PM	CO	CO2
BUS	3.72	0.16	6.53	0.24	3.72	787.72
2W 2 STROKE	1.4	1.32	0.08	0.05	1.4	24.99
2W 4 STROKE	1.4	0.7	0.3	0.05	1.4	26.58
MINI BUS	2.48	0.83	6.26	0.58	2.48	368.96
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	3.58	0.17	1.24	160
3W	2.45	0.75	0.12	0.08	2.45	77.89
Cost	RS. 100000 PER TON					500

Table 20.5: Accident Rate[$] and Cost in Rs.

Accident Rate in the year 2019	Cr. Vehicle KM	Cost in Rs.
All Types	3.0	568911
Fatal Accident	0.2	1802649

$ 2011 figure of accidents in Nagpur is used

Traffic parameter values used for economic analysis are given in **Table 20.6**.

Table 20.6: Traffic parameter values

TRAFFIC INPUT	2018	2021	2026	2031	2036	2041
Trips/day NAGPUR METRO	363442	383439	419126	458800	508666	560735
Line Length (km)	38.5	38.5	38.5	38.5	38.5	38.5
Average Trip length (km)	6.42	6.46	6.49	6.53	6.52	6.52
Passenger km/km	57274	62641	[illegible]	[illegible]	[illegible]	[illegible]

Table 20.7: Average modal split in the study area

VEHICLES	% PASS	% VEHICLE
BUS	[illegible]	[illegible]
MINI BUS	[illegible]	[illegible]
CAR	[illegible]	[illegible]
TAXI	[illegible]	[illegible]
2 WH	[illegible]	[illegible]
AUTO	[illegible]	[illegible]
CYCLE	[illegible]	[illegible]

20.3 ECONOMIC BENEFIT STREAM

Benefits in terms of money value are estimated directly from the projected passenger km saved for the horizon years (2016, 2021, 2026, 2031 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 20.1) are applied. For each year values of each benefit components are obtained and thus benefit stream is estimated. Benefit Components Stream for **Nagpur Metro Rail** is shown in **Table 20.8**.

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

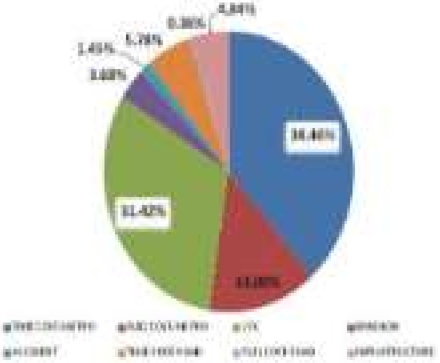

Figure 20.1 Percent of Benefits

Total Benefit between the years 2019-2043 (Component wise) are shown in figure 20.1 which shows that benefits are mainly coming from saving of travel time (metro and road) (44.25%), vehicle operation cost (VOC) (31.42%) and fuel cost (14.38%). Environmental benefit from emission reduction, accident reduction and road maintenance cost (together) is 9.97%. In this area (Nagpur City), personalized modes (cars, three and two wheelers) are dominant (87.07%) which have made vehicle by passenger ratio very high (51%). Average modal split obtained from the past study shows that about 10% passengers were using public bus within the city. Traffic volume count survey shows that 80.91% vehicle trips are by private modes as. Obviously presence of dependable mass transport system is not there.

20.4 METRO CONSTRUCTION COST

20.4.1 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. RECURRING COST includes energy cost, maintenance cost, and operation cost. Economic analysis period is taken from 2013-14 to 2042-43 out of which 6 years (2013-2018) are marked as construction period. Additional capital expenditure may be incurred in the years 2021-22 & 2026-27 (purchase of more rolling stock), 2031-32 and 2040-41. Operation is expected to start in 2018- 2019 (Year 6). This cost stream is generated with Central taxes. Detail is shown in **Table 20.8**.

Table 20.8: Estimated Capital and Recurring Cost including Central Tax

Year	Year	Capital Cost	Recurring Cost
Start	Ending	Cr. Rs.	Cr. Rs
2013	2014	447	0
2014	2015	995	0
2015	2016	1809	0
2016	2017	2334	0
2017	2018	1923	0
2018	2019	719	162
2019	2020	194	175
2020	2021	0	190
2021	2022	241	207
2022	2023	0	224
2023	2024	0	242
2024	2025	0	262
2025	2026	0	294
2026	2027	184	321
2027	2028	0	347
2028	2029	0	376
2029	2030	0	407
2030	2031	0	440
2031	2032	167	481
2032	2033	0	521
2033	2034	0	564
2034	2035	0	610
2035	2036	0	661

2036	2037	400	736
2037	2038	0	756
2038	2039	0	881
2039	2040	1702	933
2040	2041	1383	1006
2041	2042	511	1133
2042	2043	0	1226

20.5 ECONOMIC PERFORMANCE INDICATORS

After generating the cost and benefit stream table, values of economic indicators are derived and are presented in **table 20.10**. Project period is 2013-2043. EIRR (with central tax) is found to be **17.78%** and B/C ratio as 3.45 and with 12 % discount, EIRR is 5.09% and B/C ratio is 0.70. NPV without discount is Rs.51210 Cr. and with 12% discount rate, NPV is Rs.3404 Cr. which shows that the project is economically viable.

Table 20.10: Economic Indicator Values (with Central Tax)

Nagpur Metro Network	WITHOUT DISCOUNT	WITH DISCOUNT (12%)
Total cumulative cost	20914	6537
Total cumulative benefit	72126	4548
Benefit Cost Ratio	3.45	0.70
NPV	51210	3404
EIRR	17.78%	5.09%

20.6 SENSITIVITY ANALYSIS

Sensitivity analysis for EIRR and B/C ratio is performed for both with and without discount and the output is given in the **table 20.11**. 2042-43 is taken for the year of comparison. EIRR and B/C ratio after discount of 12% shows that the project is economically viable.

Table 20.11 Sensitivity of EIRR

SENSITIVITY		WITHOUT DISCOUNT			WITH DISCOUNT (12%)		
TRAFFIC	COST	EIRR	B/C	COST	EIRR	B/C	COST
0%	0%	17.78%	3.45	20914	5.09%	1.52	6537
-10%	0%	17.08%	3.32	20914	4.58%	1.46	6537
-20%	0%	16.47%	3.18	20914	3.98%	1.40	6537
0%	10%	16.35%	3.14	23008	3.88%	1.38	7191
0%	20%	15.15%	2.87	25097	2.87%	1.27	7845
-10%	10%	15.78%	3.02	23008	3.38%	1.33	7191
-20%	20%	13.98%	2.60	25097	1.78%	1.16	7845

20.7 Quantified Benefits.

Benefits which are shown in previous tables are money value of the benefits. These benefits are estimated first and the converted into money value. For brevity, only 5 year estimates are shown in table 20.8 (Reduction of Vehicle gas Emission) and in table 20.12 (Reduction of Fuel, Time of Travel, Vehicle on Road etc).

Table 20.12 Environmental Benefits Quantified

Tons/Year	2019	2020	2021	2022	2025
CO	1450.94	1484.86	1513.21	1540.73	1574.88
HC	[illegible]	746.29	760.52	775.86	791.52
NOX	235.39	238.60	241.12	245.56	250.55
PM	54.82	53.20	54.27	55.37	56.46
SO2	4.06	3.75	3.83	3.91	3.99
CO2	54621	65861	67136	68472	69854
Total Emission Saved	57789	68396	69691	71097	72531

From Table 20.12, it may be seen that in 2020, CO2 reduction will be 65.86 thousand tons and reduction of other gases will be 3.168 thousand tons.

Table 20.13 Travel Benefits Quantified

Quantified Benefits in Horizon Years	2019	2020	2021	2022	2025
Annual Time Saved by Metro Passengers in Cr. Hr.	3.21	3.32	3.44	3.56	3.69
Annual Fuel Saved by Metro Passengers in thousand Tons.	46.77	48.17	49.63	51.15	52.82
Daily vehicles reduced (off the road)	55403	57538	58834	60817	61024
Reduced No of Fatal Accidents in Year	18.38	19.61	20.24	20.72	21.18
Reduced No of Other Accidents in year	174.40	178.27	182.16	186.20	190.08
Annual Vehicle km Reduced in Thousand km.	26.344	26.846	27.362	27.914	28.477

Amount of travel in terms of vehicle reduced due to shifting of passengers to Metro Rail is equivalent to reduction of 57 thousand vehicles on the road in 2020. More than 19 fatal accidents and 182 other accidents may be avoided (approximately 4% of 2011 published figure). Hence it is expected that there will be some improvement of the overall ambiance of the city.

20.8 Transport Oriented Development (TOD) & EIRR

There will 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, increase in EIRR value will be 6.57%, and for 20% increase EIRR will increase by 9.98%, keeping other traffic inputs unchanged.

CHAPTER 21

IMPLEMENTATION STRATEGY

FIGURES

Chapter – 21

IMPLEMENTATION STRATEGY

21.1 INTRODUCTION

Nagpur city is having huge number of two wheelers and modal split towards public transport is very low. An effective public transport mode in the form of metro is expected to provide a fast, reliable, convenient and economical mode of transport to the Nagpur citizens and also the public commuting to Nagpur. It will also help in growth of the city and area as well. To ensure that the project is implemented on priority basis to, the project has to go through fast and a visible positive support from Nagpur Improvement Trust (NIT), GoM and GoI. Hence, a carefully drawn up implementation strategy is necessary for ensuring efficient execution of the metro project.

21.2 INSTITUTIONAL ARRANGEMENT

To enable Nagpur metro project to be implemented without any loss of time and cost overrun, effective institutional arrangements would need to be set up. Presently, Nagpur Improvement Trust (NIT) is dealing with this Project but there is need to have an SPV responsible entirely for this project.

21.2.1 Special Purpose Vehicle

This SPV should be on the same lines as DMRC and may be named as 'Nagpur Metro Rail Corporation Ltd.' (NMRC). Equity of NMRC will be contributed by GoM and GoI thus the Directors on its Board will be nominees of Government of Maharashtra and Government of India. In order to avoid delays usually associated with bureaucratic process of decision making, the Board of Directors (BOD) of NMRC 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.

21.2.2 Implementation models

Once the SPV is created, there are different models which can be adopted for implementing the Nagpur metro project. Three models have been analyzed below.

a) Implementation through Government

Under this model, the entire project development, implementation and operation is undertaken and financed by the government authority. Some recent examples of metro rail projects implemented directly through Government agencies are as under:

- Delhi
- Bangalore
- Chennai
- Jaipur
- Kolkata

b) Implementation through BOT model

BOT approach assumes that the metro is given to a private partner (Concessionaire) to develop and operate over the concession period. The private partner brings requisite funds and the efficiency of private sector management in the implementation as well as operation of the project. NMRC's role in this option is limited to that of a regulatory authority. Thus NMRC would monitor the implementation of the project such as laying down the passengers fares, targets for the minimum number of services to be run by the private partner, frequency, punctuality and reliability of these services, etc. There cannot be any compromise on this and penalties for not achieving these targets will be spelt out in advance. The private partner would assume substantial financial, technical and operational risk in the project and upon expiration of the concession period hand back the project to the government. There are only two projects namely Hyderabad and Mumbai being implemented through BOT model. The success of this model in India is still to be known.

c) Implementation through PPP model

It has been experienced that developing metro rail projects through PPP is a slow and time consuming process. Transferring ROW clearance, utility diversions and other site related encumbrance responsibilities to the private sector results in higher time runs. As a result, a new hybrid model has been tried in which the site development and civil construction work is managed by the government agency while the operations and management is done by the private sector.

Under this mode, the government entity undertakes all civil works and the associated station work, while all other works like rolling stock, signaling and telecom, track laying work are undertaken by the private partner along with management of the metro service over the concession period. This enables the client to monitor and adhere to quality and construction timelines for the project in a better way. Implementation of airport express line in Delhi is the only example of this model in India.

21.3 PROPOSED IMPLEMENTATION MODEL

Due to very low FIRR and uncertainties of getting the agencies for taking up this work on BOT/PPP model, it is proposed that implementation of Nagpur Metro should be done on DMRC/BMRC model.

21.4 ORGANIZATION SET-UP OF NMRC

The organizational set-up of NMRC should be such that it can undertake the execution of Metro project in efficient and effective manner. A suggestive organization structure considering various stages of implementation for Nagpur Metro Rail is as under.

Figure 21.1: Proposed NMRC Organization Structure

Note: This Organization Structure would be assisted by support staff during all phases of the project.

Therefore, NMRC should be a lean but effective organization with full mandate and total power – with accountability and responsibility – free from political and bureaucratic control. NMRC management should comprise of Managing Director with full executive powers and functional directors who would be initiated into the organization during various phases of the system. All Functional Directors will be full time 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 be assisted by the requisite support staff.

Implementing a metro project in a congested metropolis is indeed a challenge. In sheer size, magnitude and technical complexity there are few parallels to metro projects. Further, these projects are to be carried out in difficult urban environment without disturbing city life, while at the same time preserving the environment. The project involves integration of a number of complex technical systems. Some of the technologies used in these systems are new to the country.

Since NMRC may not have the required expertise and experienced manpower to check and monitor the private partner's work, it may be necessary to engage General Consultants from the very start of the metro project, who will do this job on behalf of NMRC. Generally Consultants fee is about 3-4% of the project cost. For any expert opinion on the technically difficult matters, NMRC may also need Prime Consultants whose fee is about 0.5 – 1% of project cost.

21.4 HIGH POWER COMMITTEE

During the implementation of the project, issues with regard to acquisition of land, diversion of utilities, shifting of structures falling on the project alignment 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, Govt. of Maharashtra should be set up. Other members of this Committee should be Secretaries of the concerned Departments of the State Government who will be connected in one way or the other with the implementation of the project. This Committee should meet once a month or more frequently if required and sort out all problems brought before it by NMRC.

21.5 LEGAL COVER FOR NAGPUR METRO RAIL PROJECT

Government of India has passed Legislation as "The Metro Railways (Amendment) Act 2009" for implementation of metro rail in any metropolitan area and NCR. Copy of the Act is attached as Annexure. The implementation of metro in Nagpur urban complex may be taken up under the cover of above Act.

21.7 CONCESSIONS FROM GOVERNMENT

Metro rail projects require heavy capital outlay. Loans have to be taken to fund a part of the capital cost of the project. These projects yield low financial internal rate of return though their economic internal rate of return is very high. With reasonable fare level, servicing of these loans often pose problems. Therefore, to make the project financially viable, the fares will have to be substantially increased, but this will result in their reaching socially un-acceptable levels. This will result in the ridership coming down significantly, as it is sensitive to increase in the fare levels. 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.

Taxes and duties constitute about 16 – 18% of a metro rail projects capital cost. Following are the taxes and duties, which have to be borne by a metro project:

- Custom Duty on all imported rolling stock and other equipment needed for the project.
- Excise Duty on all indigenously manufactured rolling stock and other indigenously finished goods required for the project.
- Sales Tax on all purchases made for implementation of the project whether directly by the project implementation authority or by the contractors executing the project.
- Sales Tax on works contracts to be executed for the implementation of the project.
- Tax on electricity required for operation and maintenance of the metro system.

It is recommended that GoI to pay the Central taxes to the extent of 50% in the form of Subordinate debt as being agreed for the metro projects being sanctioned by GoI and 50% of taxes to be borne by State Government.

Annexure - Metro Rail (Amendment Act) 2009

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MINISTRY OF LAW AND JUSTICE

(Legislative Department)

[illegible]

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CHAPTER 22

CONCLUSIONS

Chapter - 22

CONCLUSIONS

22.1 Nagpur Municipal Corporation (NMC) had awarded the project titled "Preparation of Master Plan/Perspective Plan for Transportation System of Nagpur City 2031" to **L&T-Ramboll Consulting Engineers Limited in June 2007**. The study aimed to update the long-term transportation strategy for NMC and identify a practicable and effective investment programme up to 2031. Consultants commenced the study in the month of June,2007 and completed in June,2008. L&T Ramboll Consulting Engineers Limited had carried out the Comprehensive Traffic and Transportation Study and prepared Transportation Master Plan for Nagpur city commissioned by NMC. In their report, L&T-Ramboll recommended the under mentioned Metro Corridors:

Alignment-1:	Pardi Naka to Dahegaon (24.34 km with 25 Stations)
Alignment-2:	Automotive Square to Dahegaon (23.84 km with 24 Stations)
Alignment-3:	Transport Plaza to Dahegaon predominantly on NH-7 (27.3 km with 26 Stations)
Alignment-4:	Transport Plaza to Dahegaon partially on NH-7 (24.2 km with 24 Stations).

DMRC however found that the corridors recommended by L&T-Ramboll were not required in totality but some portions were kept as part of earlier recommended Metro Corridors proposed in Detailed Project Report submitted in July-2013. The corridors recommended in July DPR were namely :

1) North-South Corridor(21.833 km),   2) East-West Corridor (18.288 km)

22.2 FURTHER DEVELOPMENTS

On 03.08.2013, a meeting presided by Shri S K Lohia, JS-MoUD,GoI was held at Nagpur to discuss the DPR. In that meeting, JS-MoUD,GoI expressed that the FIRR of the project should be at least 8%. Recently, MoUD has also issued advisory that FIRR of Metro Project should not be below 8%.

On 1.10.2013, a presentation on the DPR was made by M/s NIT to The Chief Minister, Government of Maharashtra. He was of the opinion to avoid underground alignment in MIHAN and also construct Maintenance Depot in the land belonging to State Govt Land. Subsequently, on 21.10.2013, a joint inspection of the NS corridor was done by VC&MD-MADC, Chairman-NIT, and Director Business Development-DMRC.

The original alignment of Corridor-I proposed was passing through Khamla Road, Airport Area after Sahakar Nagar and finally was ending at MIHAN. The alignment up to Old Airport Station was elevated, then for a length of 3.30 km, it was underground with one underground station named as New Airport Station and again elevated in MIHAN Area. Since the cost of underground section of the alignment is much more than the elevated section or the section at grade, alternative alignment was suggested for cost reduction, enhancement in PHPDT and to increase FIRR so that project becomes financially and economically viable.

The new proposed alignment suggested in the above inspection, was to pass through a 24m wide road adjacent to London Street after Sahakar Nagar Junction and was proposed to be taken to the east along 24m wide road and London Street up to Wardha Road. From the intersection at Wardha road, the elevated alignment was proposed to be on the central divider on the Wardha Road. After crossing existing intersection point of Wardha Road & Airport Road, the alignment was to be shifted to the MIHAN area. Alignment in this portion was proposed to be at grade and to run parallel to Wardha road upto ROB and abutting railway line thereafter up-to proposed Car depot.

But, while working on this modification of alignment, it was noticed that a very large number of properties were falling along the alignment due to sharp curve at the junction of Sahakar Nagar & 24 m wide road and also at the junction of 24m wide road & Wardha Road. Acquiring of these properties will be very tough and may delay the whole project.

Hence to avoid all such situation, it has been decided to take the alignment on Wardha Road only without going on Khamla Road.

Finally, NS Corridor will pass through Wardha Road after Congress Nagar Metro Station. After crossing existing intersection point of Wardha Road & Airport Road, the alignment will be shifted to the MIHAN area. Alignment in this portion will be at grade and will run parallel to Wardha road upto ROB and parallel to railway line thereafter upto proposed Car depot. 14m wide stretch of land between the railway boundary line and the road near proposed Container Depot of Container Corporation of India Ltd. will be affected by this proposed alignment of the Metro Rail as the proposed alignment passes through this stretch of land.

73 Ha land is available on the west side of railway line and south of existing flyover near Khapari station. Average width of this land is about 80m and is about 1900m long. This MADC land may be utilized for Car Depot. Similarly, Depot of EW Corridor has also been shifted to SRP Land near proposed Lokmanya Nagar Metro Station.

This has caused deletion of few earlier proposed metro stations on NS Corridor and addition of new stations on the same.

22.3 FINAL ALIGNMENT

Final alignment for both the corridors is as below.

Table 22.1 FINAL ALIGNMENT

Alignment	Detail Route
Alignment-1 North-South Corridor (19.658 km, 17 Stations)	Automotive Square, along Kamptee Road, Wardha Road, Variety Square to Abhyankar Road, along Nag River alignment will fall on Humpyard Road, Rahate Colony Road, Wardha Road, Parallel to Railway Line, Khapri Station and finally in MIHAN Area near concor depot.
Alignment-2 East – West Corridor (18.557 km, 19 Stations)	From Prajapati Nagar, along Central Avenue Road, Railway Feeder Road, Munje Chowk, Jhansi Rani Chowk, North Ambazari Road, Hingna Road, Lokmanya Nagar

22.4 From the Traffic Demand Forecast it can be seen that peak hour peak direction trips (PHPDT) on the North South Corridor is 10088, 11936, 12934 and 15726 the year of 2016, 2021, 2031 and 2041 respectively. Similarly PHPDT on East West corridor in the year of 2016, 2021, 2031 and 2041 is 7746, 8460, 9906 and 11882 respectively.

Road-based systems can optimally carry up to a maximum of 8,000 PHPDT. Since the PHPDT arrived on the above corridors exceed 8,000, there can be two options namely 1) Mono Rail and 2) Light Capacity Metro. Mono rail can carry the PHPDT projected but this technology is not a tested one. The operation and maintenance cost is much higher than that of Light metro. The capital cost of Mono rail is also almost same as that of Light Metro. Even in the other countries, the Mono rail is being adopted only for small lengths and as feeder to Metro. Hence, keeping in view the above disadvantages, it is recommended to adopt an stable, tested and reliable Metro technology. However, for Nagpur it will be Light Capacity Metro System.

22.5 After examining the various options for execution of Nagpur Metro Rail Project, it is recommended that the project be implemented through government funding through an SPV duly formed namely "NMRC". This SPV will be responsible for implementation and further operation, maintenance of Metro Network. NMRC will also examine the expansion of Metro Network further in the city and nearby urban areas.

22.6 Apart from nearby area of Khapri (MIHAN) and Nagpur Airport, Nagpur also has scope for property development as along the corridor. These areas will get boost in development once the implementation of Metro is taken up. The policy of bringing the part increased cost of the land along the corridor to metro project, to be evolved. City Authorities should also create "City Urban Transport Fund" for financing transport related Infrastructure Development.

22.7 For successful implementation of any metro project, which by its very nature is highly technical and complex and requires huge capital investment, there should be a political will and commitment. The decision making process has to be fast and the implementing agency must have the required work culture, commitment to targets, commitments to safety, quality and cost consciousness. Any time overrun will have adverse consequences by way of serious cost overruns.

22.8 To avoid delays in processing the clearance for the Project, it is suggested that immediately on receipt of the DPR, NIT should take the State Government's approval for the project.

22.9 SPV should be set up for Nagpur Metro and registered under the Companies Act, 1956. This SPV should be a PSU of GoM and GoI with its name as NMRC as suggested earlier.

22.10 After the approval of State Government, DPR to be sent to the Secretary, Ministry of Urban Development, Government of India, advising GOI of the State Government's intention to take up the Project on government funding basis and requesting for the latter's "In Principle" clearance to go ahead with the Project.

22.11 Since NMRC will not have the required expertise to take forward the project, it is recommended that NMRC may engage Interim Consultants after getting in-principle approval of Ministry of Urban Development. Interim Consultants will transfer the alignment on ground, prepare land plans with the help of local authorities and also finalise General Consultants for further implementation of project. To keep a check on the work of the General Consultants and to ensure that the Metro is being constructed to meet the appropriate specifications and safety standards, the SPV may also need to engage the services of Prime Consultants who will keep overall watch over the execution of the project.

APPENDIX-1

APPROVAL BY GOVT. OF MAHARASHTRA WITH SPV MODAL FUNDING PATTERN (WITH MODIFICATION)

Nagpur Improvement Trust,

Station Road, Sadar, Nagpur

No. [illegible] / 156 Nagpur, Dated: [illegible]

To,

[illegible],
Executive engineer,
DMRC,

Subject: Requirement of Copies of DPR of Nagpur Metro Rail Project.

This is to inform you that Nagpur Metro Rail project is approved by cabinet of Government of Maharashtra on [illegible]. The fund sharing for the project approved under SPV model by the cabinet as per Annexure enclosed. You are requested to either make the changes in the DPR or enclose this change as an Annexure with the DPR. Also as per directions of State Government a total number of 30 copies (25 copies for Government of India and 5 Copies for Government of Maharashtra) is required. You are requested to get the same printed immediately as the same is to be forwarded to Government of India within two days.

Thanking you.

Enclosure : As above

Executive Engineer (Project),
Nagpur Improvement Trust,
Nagpur.

LETTER FROM NAGPUR IMPROVEMENT TRUST ABOUT APPROVAL BY GOVT. OF MAHARASHTRA

[illegible]

Particulars	With Taxes & Duties	
	Amount (Rs/Crore)	% of contribution
Equity by GOI	[illegible]	20%
Equity by GOM	[illegible]	20%
Nagpur Improvement Trust Contribution	[illegible]	5%
Nagpur Municipal Corporation Contribution	[illegible]	5%
JICA Loan @ 1.40% P.A/Market Borrowing @12%	[illegible]	[illegible]
Total	[illegible]	100.00%

SPV MODAL FUNDING PATTERN
(WITH MODIFICATION)