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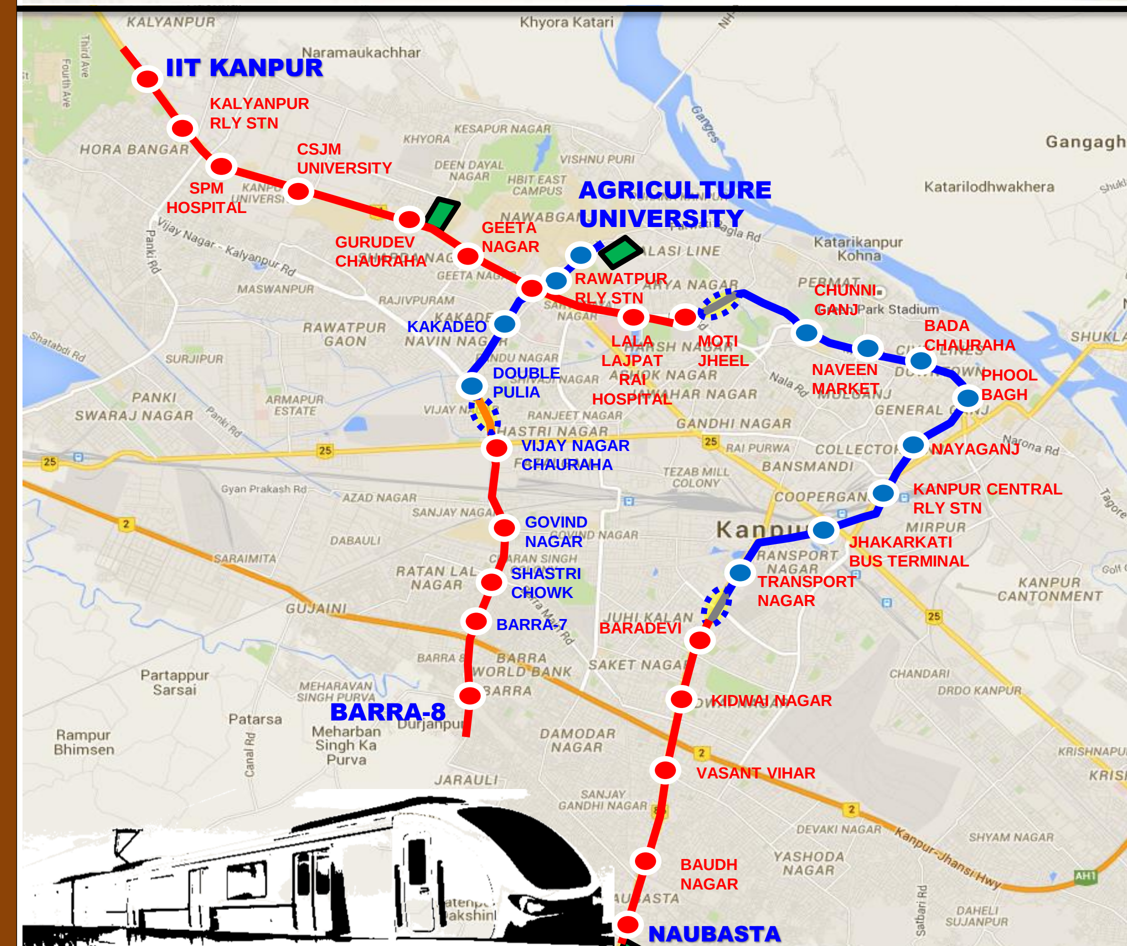
Government of Uttar Pradesh
through
Kanpur Development Authority
Coordinated by
Lucknow Metro Rail Corporation

DETAILED PROJECT REPORT FOR RAIL BASED MASS TRANSIT SYSTEM IN KANPUR



FINAL REPORT **DECEMBER 2017 (Revised)**

Consultants
RITES Ltd.
(A Government of India Enterprise)

Chapter – 1
PROFILE OF THE CITY

1. PROFILE OF THE CITY

1.1 GENERAL BACKGROUND

Kanpur is one of the most populous cities in India and the largest within the state of Uttar Pradesh. The population of Kanpur Municipal Corporation is about 27.7 Lakh as per census 2011. Kanpur has a distinct image due to its central location, linkages and being one of the oldest industrial townships of North India.

Towards the end of 19th century, Sir John Burney Allens established a group of companies such as Kanpur Textiles, Cawnpore Woolen Mills (Lal Imli), Flex Shoes Company, Elgin Mills and North Tannery having headquarters at Kanpur. Kanpur is one of the biggest producers of leather products in the world and they are exported in bulk to various destinations. Apart from the leather and textile industries, the fertilizer, chemicals, two wheelers, soaps, pan masala, hosiery and engineering industries are also operating in the City. Indian Institute of Pulse Research (an institute of ICAR) and National Sugar Institute are situated here. The stock yard of Hindustan Aeronautics Limited and Steel Authority of India Limited are also located in Kanpur. The City is an educational hub with premier institute like Indian Institute of Technology (IIT), Harcourt Butler Technical Institute (HBTI), Ganesh Shankar Vidyarthi Medical College (GSVM), Chatrapati Shahu Ji Maharaj University, Chandra Shekhar Azad University of Agriculture & Technology etc. Kanpur also has a strong cantonment base along with ordinance establishments and arms factories.

Large-scale urbanization and rapid growth of vehicles population has laid severe stress on the urban transport system in Kanpur city. The sharing of limited right of way by a variety of modes and other utility services has resulted in traffic congestion, accidents and environment deterioration. The nature of trips is also quite varied and people use private means of transport for most of these trips given the convenience of accessibility. The usage of private modes is growing tremendously mainly due to inadequate and inconvenient public transport facilities with poor level of service. The augmentation in capacity of public transport infrastructure has become necessary.

In order to alleviate the transport related problems in the City, Comprehensive Mobility Plan (CMP) has been prepared in 2017 adhering to Ministry of Housing and Urban Affairs (MoHUA), Government of India guidelines. It identifies various short, medium and long term measures of transport infrastructure in the City. CMP recommends mass transport systems along two major travel corridors.

Based on the proposals from CMP, an Alternatives Analysis has been carried out to find the most viable mass transit system along two identified corridors. Alternatives Analysis Report recommends to implement a Metro Rail system on these two corridors in Kanpur. The Government of Uttar Pradesh has engaged RITES Ltd. to prepare a 'Detailed Project Report (DPR) for Rail based Mass Transit System in Kanpur'.

1.2 LOCATION, CLIMATE, PHYSICAL SETTINGS AND REGIONAL LINKAGES

1.2.1 Location, Climate and Physical Settings

Kanpur is situated on the bank of the Ganges River and has been an important place in the history of modern India. The City is surrounded by Kanpur Dehat, Unnao and Fatehpur districts.

Kanpur's climate is characterized by hot and dry summer except during south west monsoon season. The climate in Kanpur can be divided broadly into four seasons. The period from March to the mid of June is the Summer which is followed by the south-west monsoon, which lasts till the end of September, October and first half of November from the post -monsoon or transition period. The cold season spreads from about the middle of November to February.

The district lies in area which is formed of alluvium of the early quaternary period. In the district, no hard or consolidated rock exposures are encountered. The main constituents (sand, silt and clay) of alluvium occur in variable proportions in different sections. The mineral products of the district of saline earth from which salt are derived and limestone conglomerates.

1.2.2 Regional Linkages

A number of National and State Highways criss- cross the City from many directions. Kanpur is well connected by road and rail with capital city of Uttar Pradesh, Lucknow, located about 77 Km away along NH-25 (New number NH-27). Apart from this, NH-91 (New number NH-34) connects Kanpur to other urban centers in Uttar Pradesh, NH-2 (New number NH-19) connects Kanpur to Delhi in West and Allahabad and Kolkata in East. NH-86 (New number NH-34) connects the city to neighboring state of Madhya Pradesh. Major terminals of Kanpur are highlighted in the transport map presented in **Figure 1.1**.

The Jhakarkatti Bus Terminal is largest in Kanpur catering inter-city transport demand. Fazalganj Bus Terminal caters to the intra-city travel demands. Other terminals in the City include Chunniganj, Rawatpur and Juhi.

Kanpur is served by Kanpur Central Railway Station which provides connectivity to almost every major city of India and is situated on the Howrah - Delhi broad gauge route.

At present, the nearest operational airport is Chaudhary Charan Singh International Airport at Amausi, Lucknow, which is around 75 km from Kanpur.

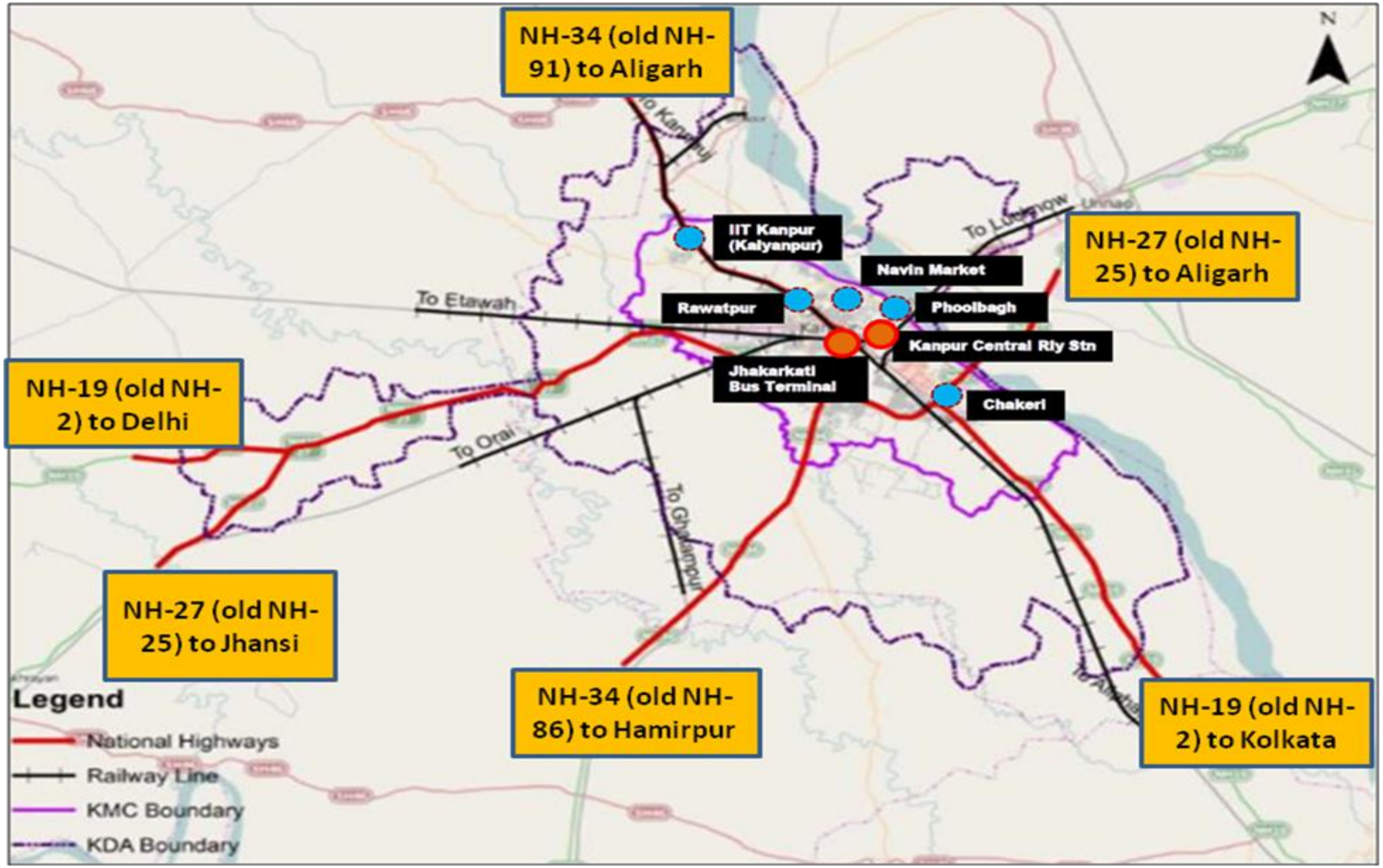
1.3 DEMOGRAPHIC & SOCIO-ECONOMIC PROFILE

Study area for the current assignment is administrative boundary of Kanpur Development Authority (KDA) which includes Kanpur Municipal Corporation (KMC), Kanpur Cantonment, Armapur Estate, two Railway Colonies and 301 surrounding villages including spillovers in districts of Unnao (29 villages) and Kanpur Dehat (45 villages). The majority of population of study area resides in the KMC area which comprise of 260 Sq km out of total study area of 1041 Sq km. **Figure 1.1** presents the KDA area which has been considered for the Study.

1.3.1 Population Growth

The population growth shows not so steep trend in the last decade with annual growth being only about 1%. The decadal population growth during the last six decades is shown in **Table 1.1.**

FIGURE 1.1: STUDY AREA - KANPUR DEVELOPMENT AUTHORITY WITH NETWORK LINKAGES



The population of study area is estimated at 41.4 Lakh for year 2017 and presented in **Table 1.2.**

TABLE 1.1: DECADAL POPULATION GROWTH IN KMC AREA

Year	Population	% Decadal Growth
1951	6,38,734	-
1961	8,83,815	38.4%
1971	11,58,321	31.1%
1981	14,81,789	27.9%
1991	18,74,409	26.5%
2001*	25,51,337	36.1%
2011*	27,65,348	8.4%

Source: CMP for Kanpur, 2011, * Census 2001& 2011 figures

TABLE 1.2: ESTIMATED POPULATION IN KDA AREA- 2017

SN	Area	Population
1	KMC	33,40,568
2	Cantonment	1,15,211
3	Armapur Estate	17,616
4	301 Surrounding Villages	6,55,627
	Total	**41,29,022**

Source: Census 2011

1.3.2 Population Density, Migration and Spatial Pattern

Population density varies from core city areas to surrounding areas. The localities forming the core city including Kanpur Central, Phoobagh, Collectorganj, Mulganj and areas along Mall Road like Bada Chauraha are densely populated with over 10,000 persons per sq km**.** Other areas in and around the Central Business District have population densities ranging from 2000-10,000 persons per sq km.

Kanpur being an industrial centre has significant migrant workers' population increase over the years. It has been observed that average annual growth in population increased to 3.5% in 1991-2001 from 2.6% during 1981-91.

The Municipal Corporation has a total of 110 wards and a population of about 27.7 lakh in 2011. The Study Area has a total estimated population of 41.4 lakh in 2017 comprising KMC, Cantonment, Armapur Estate, two Railway Colonies and 301 surrounding villages including spillovers in districts of Unnao (29 villages) and Kanpur Dehat (45 villages). Considering the Master Plan growth rate of 3% for KMC area and 2.5% for Villages (as agreed after discussions with KDA/KMC officials), the projected population in KDA area for horizon years of 2021, 2031 and 2041 are presented in **Table 1.3.**

TABLE 1.3: PROJECTED POPULATION FOR HORIZON YEARS

Year	Population (lakh)
2021	46.3
2031	56.1
2041	65.8

1.4 URBAN LANDUSE STRUCTURE

1.4.1 Landuse Characteristics as per Kanpur Master Plan 2021

From 1961 to 1998, area covered under residential and commercial land use has almost doubled from 31.8% to 62.9% and 1.9% to 3.3% respectively. The area under industries increased marginally (6.4% to 6.9%). This is due to closure of many large scale industries. It is observed that there is increase in the mixed-landuse and marginal increase in industrial and public utility land-use. The existing landuse of Kanpur presented in **Table 1.4.** Proposed landuse distribution is shown in **Figure 1.2.**

TABLE 1.4: EXISTING LANDUSE DISTRIBUTION (1961-1998)

SN	Land Use	1961		Existing (1998)	
		Area (Ha.)	%	Area (Ha.)	%
1	Residential	2815.9	31.7	8813.4	62.9
2	Commercial	164.6	1.9	460.4	3.3
3	Industrial	569.4	6.4	970.4	6.9
4	Parks and Playgrounds/ Recreational	105.1	1.2	959.1	6.8
5	Public Utilities and Services	584.0	6.6	966.5	6.9
6	Government	148.4	1.7	298.6	2.1
7	Traffic and Transportation	771.7	8.7	1452.8	10.4
8	Railway Land	817.4	9.2	-	-
9	Defense Establishments	2689.2	30.3	-	-
10	Water bodies/ River & Drains	197.8	2.2	82.6	0.6
	Total	**8863.5**	**100%**	**14003.8**	**100%**
11	Open Area	2570.8	-	-	-
12	Agricultural Green belt	18235.7	-	15679.2	-
13	Rural Area	-	-	54704.3	-
14	Non-defined Area	-	-	4743.9	5.3
	Grand Total	**29670.0**		**89131.0**	**-**

Source: Kanpur Master Plan 2021

The Master Plan 2021 has added 32,808 hectares of land for future growth of the city. The proposed landuse is presented in **Table 1.5.** Considering the growing need for transport infrastructure, Master Plan 2021 has allocated 15.2% land under Traffic and Transportation landuse as against existing 8%.

TABLE 1.5: PROPOSED LANDUSE IN MASTER PLAN 2021 FOR ADDED AREA

SN	Landuse	Area (Ha)	%
1	Residential	13575	41.37
2	Commercial	971	2.96
3	Government	1219	3.72
4	Public Utilities	1244	3.79
5	Public & Semi Public	508	1.55
6	Industrial	2949	8.99
7	Recreational	6847	20.87
8	Traffic & Transportation	5000	15.24
9	Others	495	1.51
		32,808	**100.0**

Source: Kanpur Master Plan 2021

The Development Authority takes care of the appropriateness of developments in Study Area as per proposed Master Plan 2021. The landuse plan has been formulated considering the existing landuse and the projected demand for various activities.

1.4.2 Zoning and Floor Space Index (FSI) Pattern

Further zoning regulations, planning norms and building classification for transit oriented development and mixed land use along mass rapid transit corridors have been notified by the Government of Uttar Pradesh vide letter no. 03/ Eight-3-15-198 vividh/14 dated 04.03.2015.

Uttar Pradesh Government has approved property development for Lucknow Metro vide letter no. 2624/ Eight-1-13-09 LDA/13 dated 20.08.2013 with 30% of the total area available with 5 (five) FSI to be used for commercial activity development and balance 70% for residential activity development .

FIGURE 1.2: PROPOSED LANDUSE DISTRIBUTION IN KANPUR MASTER PLAN 2021

Source: Kanpur Master Plan 2021

Mixed landuse in transit oriented development (TOD) zone along the mass transit corridors is permissible on maximum 20% of total area of the proposed developments. The landuse type in mixed use is allowed with a permissible percentage of 40-60% for Residential, 15-30% for Office/Institutional, 5-10% for each of Commercial & Industrial and 10-15% for Social/Recreation.

1.4.3 Major Activity Centers in Kanpur

The major landuse in Kanpur are industrial, institutional and mixed residential cum commercial activities. A brief of these activities along with prominent locations are presented in **Figure 1.3.**

The employment for year 2011 has been worked out from the census data figures and has been extrapolated to obtain base year 2017 employment figures. Keeping in view the economic profile of the study area, development prospects and transport intervention policies, WFPR of 25% has been assumed from Kanpur Master Plan for the Horizon years. Thus, it has been estimated that 17.4 lakh workers would comprise the workforce in the study area by 2041. **Table 1.6** shows the growth trend in employment in the study area.

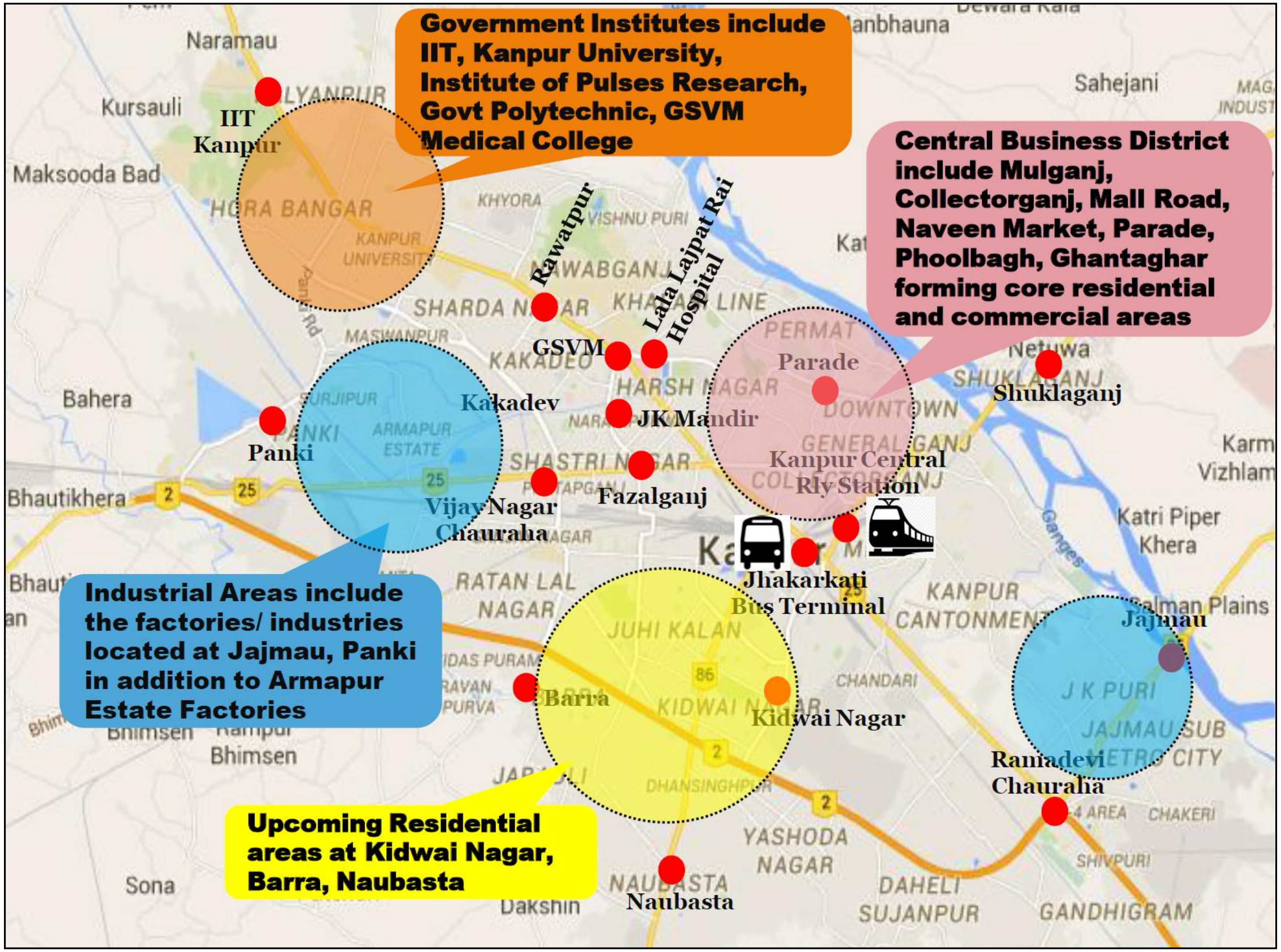
The total workers in the Study Area have been estimated at 10.8 lakh for the year 2017 with a work force participation based on master plan, economic and landuse profiles.

1.4.4 Landuse Plan (Master Plan 2021) Proposals

Kanpur Master Plan has been prepared for the population of 51 Lakh in 2021, which includes 45 Lakh urban and remaining 6 Lakh rural population with an overall population density of 300 person per hectare.

In Master Plan, about 5000 Ha land has been added under traffic and transport use which is around 15.2% of total added land. Around 251 Ha for railways and 863 Ha for widening of existing roads have been proposed. There are also proposals for bus stand / bus depots, transport nagar and truck parking terminal.

FIGURE 1.3: MAJOR AREAS AND LANDUSE ACTIVITIES



Master Plan categorizes the road network into the following hierarchy:

- **Regional Roads -** A number of National and State highways criss-cross the City from many directions such as NH-25 (New number NH-27). Apart from this, NH-91 (New number NH-34), NH-2 (New number NH-19) and NH-86 (New Number NH-34).
- **Major City Roads (Arterial & Sub-arterial)** – These are roads important for comfortable Internal traffic in the City
- **Local Roads –** These are roads additional to Regional and Major City Roads providing access to the level of local/street level areas.

Master Plan 2021 has also proposed the widening of major roads such as GT Road, Kalpi Road, Barra Bypass, Hamirpur Road Panki Road, Shivali Road, VIP Road and Mandhana Bithoor Road.

1.5 SCOPE OF WORK

DPR for Kanpur Metro has been prepared as per Metro Policy, 2017 of MoHUA, Government of India. The scope covers the following:

1.5.1 Assessment of City Profile with Existing Transport Characteristics

Task 1: A brief overview of the city in terms of its growth, economy, spatial structure and trends, perspectives on the future growth. Overview of study areas and existing plans with land use distribution, review of zoning Regulations, employment distribution by Traffic Zones, land use plan proposals should be done.

Task 2: Brief review of previous transport studies like City Master Plan, Comprehensive Mobility Plan and other urban transport proposals. A brief showing interconnection among City Master Plan, Comprehensive Mobility Plan and proposed metro rail plan should be given.

1.5.2 Existing Travel Characteristics and Demand Estimates

Task 3: Describes the components of urban transport system in terms of status, trends and gaps based on primary survey data, present travel patterns and forecast for the future travel demand.

Task 4: Based on primary survey data and various traffic and transportation studies undertaken for the city, the present travel patterns and forecast for future travel demand should be done.

Task 5: Travel demand analysis, model framework, model calibration, summary of travel demand patterns and ridership assessment for horizon year should be done.

1.5.3 System and Technology Selection

Task 6: Identification of suitable transit technology and the system specification to be adopted for the corridor including the rationale for choosing a particular technology as per the prescribed specification as issued by MoHUA from time to time. The technology chosen should not be a proprietary technology of any vendor.

1.5.4 Corridor Alignment Description

Task 7: Alignment description of approved alignment, with details about site conditions specifying road geometrics, utilities available along the corridor

Task 8: Detailed analysis of corridor options with grade selection for construction shall be carried out. Design norms for track geometry, fixed structure clearance, geotechnical details with new innovative techniques to be used for implementation in civil works, track system etc

Task 9: Identification of existing services/utilities, if any

Task 10: Detailed estimation regarding land requirement for the corridor, depots, stations, parking, multi modal stations etc. with land ownership

1.5.5 Station Planning

Task 11: Station planning with preparation of general layouts based on type of station and site specific conditions focusing on:

- Station Area planning for non-motorized vehicles and pedestrians' facilities, multi modal integration with existing modes, feeder service planning.
- Accessibility for differently abled persons including specifying parking at

stations for private and para transit facilities.

- Platform widths based on Station loadings and the minimum width to be provided.

1.5.6 Intermodal Integration

Task 12: Prepare an Intermodal Integration Plan focusing on how the Metro Rail will integrate with the existing transportation systems/proposed transit system and introduction of a feeder system, integrated with the proposed Metro Rail project for improving last mile connectivity. This will include not only preparation of an operational plan for feeder system but also infrastructure that need to be upgraded/ improved or introduced for improving the intermodal integration with other modes of public transport to improve the viability of the project. Recommendations for institutional integration, physical integration, fare integration, operational integration and technology integration would also need to be elaborated in the report.

1.5.7 Train Operation Plan

Task 13: System operation approach, station yard planning, trains operation plan including system frequency, timetabling, rolling stock requirement, stabling details.

1.5.8 Signaling and Telecommunication

Task 14: Identification of Signaling and System control, Operation Control Centre (OCC), maintenance requirement, technology selection and choice of automation

Task 15: Identification of Telecommunication System, System Traffic Control, maintenance and emergency communication and Passenger Information System (PIS)

1.5.9 Fare Collection System

Task 16: Detailing the specifications for Automatic fare collection system, Ticketing and pass system, Fare System integrated with other transport Systems including integration of fares of all available modes with the metro system planned (such as National Common Mobility Card).

1.5.10 Rolling Stock

Task 17: Technology selection, identification of rolling stock adopted as per Guidelines laid by MoHUA. Rationale for deviations, if any in choice of rolling stock parameters from the prescribed specifications and standards prevailing and rolling stock requirement for various horizon years should be specified.

1.5.11 Power Supply and Traction System

Task 18: Choice of electric traction system. Projected power demand, Source of power supply, Traction and Auxiliary Supply and supervisory control and data acquisition system. No. of tractions and their locations are also to be detailed out.

1.5.12 Ventilation and Air Conditioning System

Task 19: Need for Ventilation and Air Conditioning, design parameters and design concepts for VAC System with details on tunnel ventilation, station ventilation and air conditioning of ancillary spaces including specifications for control and monitoring facilities.

1.5.13 Depots

Task 20: Identification of Depot locations, approach to maintenance of depot facilities and workshop along with detailed designs and layout plans

1.5.14 Environmental and Social Impact Assessment

Task 21: Existing scenario, with analysis on water quality, noise level, land environment, biological environment etc.

Task 22: Environmental norms and regulations, detailed Environment Impact Assessment (EIA), Environment Management Plan (EMP), formation of an Environmental Management System (EMS) and costs estimates for Environment Impact mitigation measures.

Task 23: Detailed Social Impact Assessment (SIA) including R&R assessment, Resettlement Impacts, Resettlement Assistance Plan (RAP) and Monitoring and Evaluation Framework

1.5.15 Disaster Management and Security Measures

Task 24: Disaster Management, Disaster Management imperatives, Objectives of Disaster Management Plan, Systems to cater for disasters and Security Systems recommended for MRTS and Safety and Security Measures

1.5.16 Cost Estimation

Task 25: Detailed project cost estimates shall include

- Capital cost estimates including taxes and duties
- Innovations proposed to reduce the cost of system
- Estimation of Operations and Maintenance Cost and the assumptions made thereof

1.5.17 Transit Oriented Development Plan

Task 26: The potential for transit oriented development along the metro corridors to be developed including densification of corridor by increasing FSI and land value capture. Details of lands/areas amenable for change in near future e.g. vacant land, low rise development relocation etc.

1.5.17 Financial Analysis and Non Fare Box Revenue Assessment

Task 27: Estimations and inputs for the corridor, estimation for O & M, overheads, phasing of construction and lease of built up area (BUA), operational viability of the project

Task 28: Means of finance, revenue from different sources, fare box revenue, non-fare box revenue, like advertisement, taxes and property development etc, possible ways of funding the project using different approaches. Alternative means of funding the project using different approaches Like PPP, BOT, DBFOT, DFBOT, Developer Finance Model Etc. and need to identify the proposed funding /implementation model in line with the Metro Policy 2017

Task 29: FIRR with 30 year time horizon, Sensitivity analysis should be done based on scenario building with variation in ridership estimates scenarios, costs estimates and Time overrun. Alternative scenarios based on the different options for funding / implementation of the project should be evaluated. A project should be able to meet its financial requirement for cost recovery and under a set of plausible assumptions be able to self-finance its activities. State Governments will have to ensure the financial sustainability of the project through financial assistance.

1.5.18 Economic Analysis

Task 30: The economic analysis should include economic cost and benefit analysis of the project and estimation of the EIRR for a period of 30 years.

1.5.19 Implementation Plan

Task 31: Project implementation structure, if proposed to be implemented under various alternatives such as public or PPP model, role, responsibility and involvement (including financial stake) of the city government along with other government agencies in metro rail project, needs to be elaborated in the report.

1.5.20 Institutional Arrangement and Stakeholders Consultation

Task 32: Legal and Institutional Framework for implementation of the project based on the identified implementation plan should be included in the report. Stakeholders' consultation should be held at each major stage of the project such as the Draft DPR stage.

1.6 COMPOSITION OF THE REPORT

This 'Final Report' consists of following 21 chapters:

Chapter 1: Profile of the City covers background, demographic characteristics and urban landuse structure of the study area.

Chapter 2: The chapter gives existing transport system covering existing road network, traffic characteristics status of IPT and PT systems.

Chapter 3: Existing traffic and travel characteristics, development of base year transport demand model and future travel demand estimates have been covered in the Chapter.

Chapter 4: System and Technology Selection covering traction system etc. are part of the Chapter.

Chapter 5: This chapter gives the details about civil engineering components covering alignment planning, geometric design parameters, geotechnical investigations, utilities and land requirements.

Chapter 6: Station Planning Chapter gives the typical stations, facilities for differently-abled, parking planned for metro corridors

Chapter 7: Intermodal integration - the interchange possibilities of existing and proposed modes of transport are summarised in this Chapter.

Chapter 8: Train operation plan gives operation plan for trains and frequency of operation for the proposed corridors

Chapter 9: Signalling and Telecommunication Chapter covers the types of signaling and telecommunication systems and standards

Chapter 10: The Chapter on Fare Collection System covers the proposed ticketing system for passenger fare collection

Chapter 11: The chapter gives the requirement of rolling stock for operation

Chapter 12: This Chapter gives power supply requirements, sources of power supply, substations and related infrastructure facilities

Chapter 13: Ventilation and Air Conditioning Systems Chapter covers the need for ventilation and standards adopted

Chapter 14: Maintenance depot facilities, rolling stock maintenance and depot layouts are covered in this Chapter

Chapter 15: This Chapter details the Environmental & Social Impact Assessment characteristics covering environmental and social components

Chapter 16: Disaster Management and Security Measures Chapter covers types of disaster, preparedness and security measures

Chapter 17: Detailed Cost Estimates chapter includes details on capital and O&M cost

Chapter 18: This chapter covers the revenue potential along the corridors from Transit Oriented Development

Chapter 19: Financial Analysis and Non-Fare Box Revenue chapter covers revenue estimates and estimation financial internal rate of return

Chapter 20: Economic Analysis chapter gives economic benefits and estimation of Economic Internal Rate of Return

Chapter 21: Implementation Plan chapter provides the project implementation options

Chapter – 2

EXISTING TRANSPORTATION SYSTEM IN THE CITY

2 EXISTING TRANSPORTATION SYSTEM IN THE CITY

2.1 INTRODUCTION

Urbanization and rapid growth of vehicles population has laid severe stress on the urban transport system in Kanpur. Increase in vehicular traffic and limited augmentation road infrastructure facilities have been observed in the City. Private modes have gained more usage due to limited public transport facilities with poor level of service. This necessitates the assessment of existing transportation infrastructure in the City.

2.2 VEHICULAR GROWTH AND COMPOSITION

The registered vehicles in Kanpur have been increasing by over 7% per annum in the recent years. Kanpur city has over 11 lakh registered vehicles by 2017 and the growth of registered vehicles is presented in **Table 2.1.**

TABLE 2.1: GROWTH AND COMPOSITION OF REGISTERED VEHICLES

S No	Vehicle Type	2011	2012	2013	2014	2015	2016	2017
1	Two Wheelers	542189	600050	661553	735056	816726	856051	895377
2	Car/Jeep	112062	125137	138557	151919	166570	174733	182897
3	Three Wheeler	8493	8854	9289	9696	10121	11014	11908
4	Buses	1864	2001	2189	2312	2442	2273	2104
5	LCV Goods	10278	11335	12338	13156	14028	9319	4610
6	Trucks	21750	23633	24481	25345	26239	27552	28864
7	Tractor & Trailers	12370	12409	12432	12498	12564	13221	13878
8	Others	798	851	917	986	1060	961	862
	Total	**7,09,804**	**7,84,270**	**8,61,756**	**9,50,968**	**10,51,765**	**10,97,141**	**11,40,500**

Source: Kanpur RTO Office, 2017 Statistics

The share of two wheelers is highest at about 78%. It is significant to note that 16% of the vehicles are cars / jeeps. Close to 2 lakh cars/jeep are present in the Study Area in 2017. The sharp increase of two-wheelers and cars could be attributed to the improved economic status of people and deficient public transport supply.

2.3 ROAD NETWORK CHARACTERISTICS

2.3.1 Network Inventory

Primary traffic surveys covering road network inventory, speed and delay, traffic and travel characteristics were carried out by RITES in 2015 in the Study Area. The summary of existing road network is appraised in the subsequent sections.

About 13.0% of the road network has less than 10 m ROW, 34.5% has 10-20 m ROW and while about 13% has ROW above 30-40 m as presented in **Table 2.2.**

TABLE 2.2: DISTRIBUTION OF ROAD NETWORK AS PER RIGHT OF WAY

S No	Right of Way (m)	Length (km)	Percentage
1	< 10	81.4	13.0
2	10 – 20	214.8	34.5
3	20 – 30	165.1	26.4
4	30 – 40	81.2	13.0
5	>40	81.8	13.1
	Total	**624.3**	**100.0**

About 22% of the surveyed road network has footpath available along the sides of road. The details footpath availability is presented in **Table 2.3.**

TABLE 2.3: AVAILABILITY OF FOOTPATH

S No	Footpath	Road Length (Km)	Percentage (%)
1	Present	136.7	21.9
	One-side	23.6	17.3
	Both-sides	113.1	82.7
2	Absent	487.6	78.1
	Total	**624.3**	**100.0**

The distribution of the road network with respect to abutting land use is presented in **Table 2.4.** It is seen that the road network is abutted by residential land use up to an extent of about 47%, commercial about 15% and Industrial land-use about 4%.

TABLE 2.4: DISTRIBUTION OF ROAD NETWORK AS PER ABUTTING LANDUSE

SN	Type	Left		Right	
		Road length(Km)	Percentage	Road length (Km)	Percentage
1	Residential	296.8	47.5	303.8	48.7
2	Commercial	92.2	14.8	93.2	14.9
3	Vacant	45.9	7.4	52.3	8.4
4	Institutional	12.0	1.9	28.2	4.5
5	Industrial	26.0	4.2	23.2	3.7
6	Agricultural	151.4	24.2	123.7	19.8
	Total	**624.3**	**100.00**	**624.3**	**100.0**

2.3.2 ROBs /Flyovers

Kanpur has multiple ROBs/Flyovers in the City as the major railway main line runs parallel to GT Road in Kanpur from Kalyanpur till Chakeri and further.

Multiple ROBs in the City constructed across this railway line include Narendra Mohan Flyover at Gol Chauraha near GSVM Medical College, RuB near Afim Kothi, Ghantaghar ROB, Jhakarkatti ROB, Naya Pul from Tatmill towards Kidwai Nagar, ROB at COD Crossing.

Other ROBs in the City across railway line from/to Panki and Shuklaganj include Govindpuri, Dada Nagar, Shyam Narayan Tandon & Murray Company ROBs in Cantonment, Panki. Across Ganga from Kanpur towards Unnao / Lucknow, multiple road bridges from Nawabganj, Shuklaganj and Jajmau are in place.

In addition to above, an elevated flyover from Ramadevi till Panki for a length of about 23km serves as a major bypass to the City from Lucknow and Allahabad traffic going towards Delhi.

2.4 MAJOR TRANSPORT NODES

The Jhakarkati Bus Terminal is the largest in Kanpur catering the inter-city transport demand. Fazalganj terminal caters to the intra-city travel demands. Other terminals in the City include Chunniganj, Rawatpur and Juhi. As per bus terminal survey conducted in 2015, the daily boarding and alighting figures are observed to be 8803 (Jhakarkati), 2072 (Rawatpur), Fazalganj (1037), Juhi (807) and Chunniganj (291).

Kanpur is served by Central railway station which provides connectivity to almost every major city of India. It is a major intercity rail and commuter rail station, and is situated on the Howrah - Delhi broad gauge route passing through Uttar Pradesh. As per rail terminal survey conducted in 2015, the daily passenger figures are observed to be 62483 (Kanpur Central), 5181 (Anwarganj) and 4480 (Govindpuri).

At present, the nearest airport is Chaudhary Charan Singh International Airport at Amausi, Lucknow, which is around 75 Km from Kanpur.

2.5 PEDESTRIAN AND NON MOTORISED VEHICLE (NMV) FACILITIES

2.5.1 Pedestrian Volume

The pedestrian volume counts were carried at various locations in the city. The daily and peak hour pedestrian flows at survey locations are presented in **Table 2.5**. The maximum daily pedestrian across volume is observed at 6 Point Junction (Near Vasan Eye Care) followed by Bada Chauraha Junction.

TABLE 2.5: DAILY & PEAK HOUR TRAFFIC AT PEDESTRIAN SURVEY LOCATIONS

S.No	Name of Location	Approach	Daily Pedestrian Vol. – both side (12 Hours Counts)		Peak Hour Pedestrian Vol. (Peak Hour)	
			Across	Along	Across	Along
1	Barra (Near Anjali Hospital)	Barra-7	966	1845	74	224
		Sachan Chowk	1158	2841	175	415
		Naubasta	1152	3247	287	382
		Karrahi	1281	2954	196	352
2	Barra 7 Chowk	Naubasta	816	1359	112	177
		Gujaini	812	1648	138	149
		Vijay Nagar	946	2176	117	233
		Jarauli	671	1967	132	227
3	Vijay Nagar Chauraha	Fazalganj	1093	2076	110	189
		Rawatpur	774	2951	66	311
		Panki	737	2452	74	202
		CTI Chowk	944	2391	129	254
4	Naubasta	Bara Devi	862	3883	79	431
		Rama Devi	620	1328	64	143
		Ramaipur	1453	3240	284	357
		Gujani	1121	2017	92	201

S.No	Name of Location	Approach	Daily Pedestrian Vol. – both side (12 Hours Counts)		Peak Hour Pedestrian Vol. (Peak Hour)	
			Across	Along	Across	Along
5	Kidwai Nagar	Tat Mill	675	1942	67	250
		Gujaini	838	1555	90	162
		Yeshoda Nagar	771	2305	73	246
		Rama Devi	1199	1001	111	103
6	Gaushala Road Junction	Bara Devi	625	2047	82	221
		Saket Nagar	616	2620	68	301
		Naubasta	417	2392	36	249
		Kidwai Nagar	695	1537	99	188
7	Phoolbagh Junction	Gantaghar	1231	2357	119	252
		Bada Chowk	958	2659	103	234
		Nail road	1099	2700	207	332
		King Edward St	612	1807	49	147
8	Parade Chowk	Kachari	841	3167	135	384
		Mulganj	1312	3613	167	405
		Eidgah	2677	2037	181	171
		BadaChowk	619	993	68	94
9	Bada Churaha Junction	Phoobagh	2826	5652	356	703
		Mulganj	2177	3938	336	336
		Parade	2009	4322	209	476
		Sarasaiya Ghat	1319	3771	132	444
		Civil Court	1512	3967	119	358
10	Kanpur Mega Mall Junction	Vasan Eye Care	1486	3044	164	336
		Ghantaghar	2050	2863	173	353
		Panchakki Chowk	1916	3967	220	353
		Bada Chowk	1043	2356	113	281
11	6 Point Junction (Near Vasan Eye Care)	Panchakki Chowk	2377	4651	330	547
		Kanpur Cantonment	1753	5824	251	531
		Gantaghar (Left Side Road)	4103	3280	357	432
		Gantaghar (Mid Road)	2029	2429	241	334
		Gantaghar (Right Side Road)	1122	2557	56	302
		Phool Bagh Chowk	1486	5403	74	542
12	Fazalganj Chowk	Vijay Nagar Chowk	707	2478	60	267
		Govind Nagar	486	2290	43	280
		Jareeb Chowki	677	2327	51	292
		J.K. Temple	652	1543	65	160
13	Tat Mill Chowk	Ghantaghar	1159	2245	181	197
		Afim Kothi	1064	2995	202	344
		Kidwai Nagar	538	1749	33	263
		Rama Devi	1022	1965	149	197

2.5.2 Availability of Footpath

From primary surveys, it is observed that only about 22% of the roads have footpath available. However, high share of pedestrian and Non-Motorized Vehicles require provision of continuous, encroachment free pedestrian and NMT facilities.

The CMP has also recommended some proposals such as installation of foot paths and cycle tracks. Additionally, footpaths have been recommended to be installed in all the residential roads, wherever possible.

- A minimum usable width of 1.5 meters should be provided for footpath.
- Road Markings in the form of “zebra crossings” at all intersections for designated space for pedestrians to move across roads and other street furniture.
- Barricading of footpath near every intersection for controlled crossing from an allocated vent.

Major junctions have also been proposed for installation of pedestrian only signals with necessary road markings and footpath facility. In addition to existing facilities, new grade separated pedestrian crossing facilities were proposed at Ghantaghar, Bada Chauraha, Phoolbagh and Ramadevi.

As part of NMV proposals, cycle rickshaw management at the important congested areas have been proposed in CMP like Mulganj, Collectorganj and General Ganj etc. Cycle rickshaw management has also been proposed around major bus and rail terminals areas in the City.

2.6 TRAFFIC MANAGEMENT INCLUDING PARKING MANAGEMENT

The existing issues and concerns are as follows:

- Lack of pedestrians facilities like footpath along major roads resulting in pedestrian spill over on right of way
- Chaotic operations of shared auto services
- On-street parking causes reduction in efficient roadway width
- Absence of necessary infrastructure such as bus stop, lighting etc.

Traffic management proposals in CMP consist of improvement of some important intersections, signalizing plans, pavement marking and signages. Bakarganj Chowk, Parade Chauraha, Gumti No. 5, Jareeb Chowki, Afim Kothi, Near LIC building, Barra Bypass near Anjali Chowk, Naubasta, Ghantaghar, Tatmill Chauraha are identified in CMP for junction improvement.

CMP proposals on parking management include the parking to be developed based on parking guidelines for residential, commercial, office/educational, hospitals and medical establishments. Off street parking at 38 locations for car parking and 33 locations for two wheeler parking have been proposed in CMP.

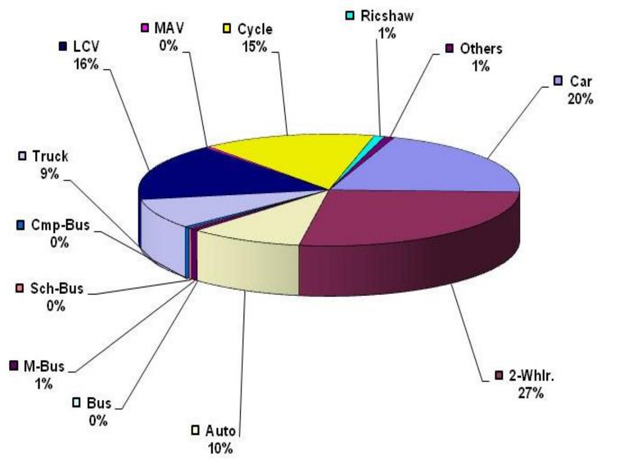
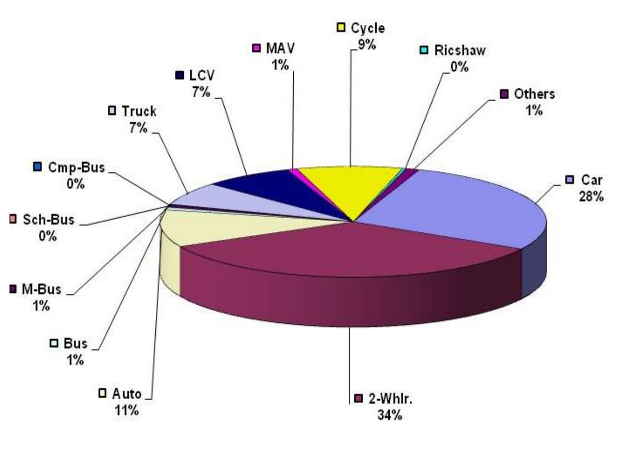
2.7 TRAFFIC CHARACTERITICS

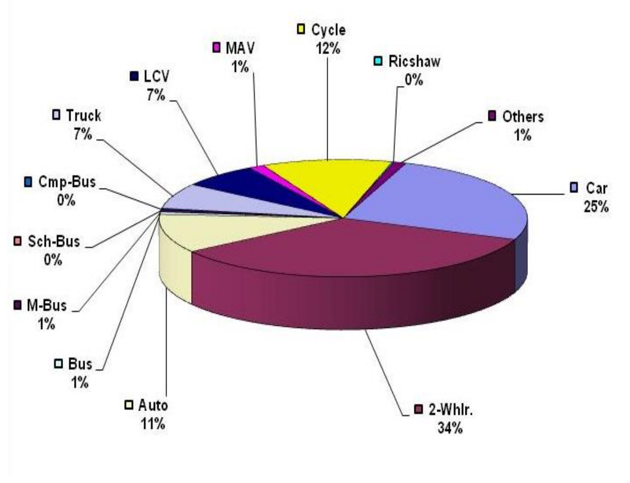
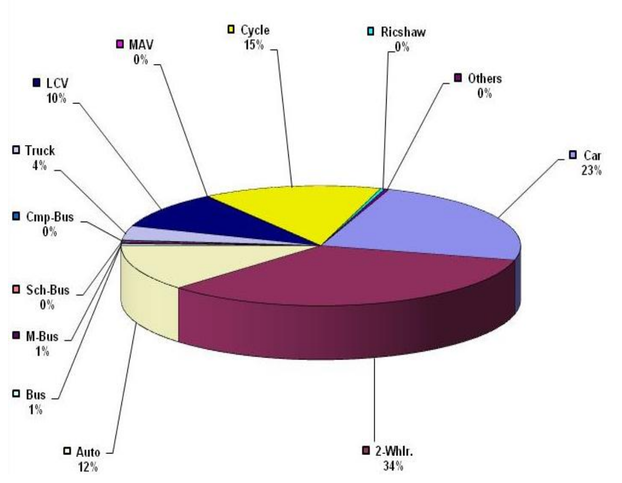
2.7.1 Traffic Volumes and Composition

The daily traffic volumes total vehicles (PCUs) at major midblock locations observed are Gujaini along NH-2 Bypass (33632 Vehicles, 37878 PCUs), Near Little Kids Valley School along NH-2-Kanpur-Fatehpur Road (31289 Vehicles, 33431 PCUs), at Sanjay Nagar Along NH-2 (30762 Vehicles, 33021 PCUs) and Near Gun Factory NH-25 Kalpi Road (34216 Vehicles, 31836 PCUs).

The daily traffic composition along these midblock locations is presented in **Figure 2.1.**

FIGURE 2.1: DAILY TRAFFIC COMPOSITION ON MAJOR MIDBLOCK LOCATIONS

Along NH-2 Bypass near Gujaini	Near Little Kids Valley School along NH-2 Kanpur Fatehpur Road (GT Road)
	

Along NH-2 at Sanjay Nagar	NH-25 Kalpi Road near Guns Factory
	

2.7.2 Speed and Delay Characteristics

It can be observed that about 16% of the road network has journey speeds less than 20 kmph during peak hours and this is observed inside the core city. About 12% has more than 40 kmph. Average Journey Speed in the network is observed to be 25.1 kmph. The distribution of network by journey speed is presented in **Table 2.6.**

TABLE 2.6: DISTRIBUTION OF ROAD LENGTH BY PEAK HOUR JOURNEY SPEED

S No	Journey Speed (Kmph)	Road Length (Km)	Percentage (%)
1	<10	26.5	4.3
2	10-20	70.8	11.3
3	21-30	240.2	38.5
4	31-40	212.6	34.1
5	>40	74.2	11.9
	Total	**624.3**	**100.0**

The running speed characteristics during peak period are presented in **Table 2.7**. It can be observed that about 75% of the road network has running speeds between 20-40 kmph during peak hours.

The distribution of causes of delays & their duration during peak hours and off-peak hours is presented in **Table 2.8**. The analysis of causes of delays reveal that the delays are caused mostly by traffic congestion which account for about 74% in the peak hour, while traffic signal with congestion account for

22.7%. As much as 33% of observed delays lasted between 60 & 120 seconds, while about 34% delays lasted more than 120 seconds during peak hours.

TABLE 2.7: DISTRIBUTION OF ROAD LENGTH BY PEAK HOUR RUNNING SPEED

S No	Running Speed (Kmph)	Road Length (Km)	Percentage (%)
1	<10	0.0	0.0
2	10-20	31.3	5.0
3	21-30	161.0	25.8
4	31-40	305.9	49.0
5	>40	126.1	20.2
	Total	**624.3**	**100.0**

TABLE 2.8: DISTRIBUTION OF CAUSES AND DELAYS IN PEAK & OFF PEAK HOURS

S No	CAUSES AND DELAYS	PEAK HOUR		OFF PEAK HOUR	
		No. of Points	%	No. of Points	%
1	Traffic Signals	6	3.2	10	11.8
2	Traffic Congestion	136	73.5	49	57.6
3	Traffic Signal +	42	22.7	24	28.2
4	Railway Crossing	1	0.5	2	2.4
Total		185	100.0	85	100.0

2.8 TRAFFIC SAFETY

Traffic safety refers to the methods and measures used to prevent road users from being killed or seriously injured. Typical road users prone to accidents include the pedestrians, cyclists, vehicle passengers and passengers of on-road public transport.

Road accidents are an outcome of various factors like vehicle population, human population and adherence/enforcement of road safety regulations etc. Road accident causes injuries, fatalities, disabilities and hospitalization with severe socio economic costs. Accident statistics are presented in **Table 2.9.**

Education, enforcement and public awareness will go a long way in maintaining safety standards in the City. Special traffic drives for making the public aware of the traffic rules include:

- Imposing ‘fines at the spot’ procedure for defaulters.

- Organizing road safety programs for:
  - informing the public of new regulations or changes to the traffic regulation system
  - influencing the attitudes towards road safety
  - persuading road users to change their behaviour in relation to identified causal factors in road accidents

TABLE 2.9: ROAD ACCIDENTS IN KANPUR

Year	Total Accidents	Killed	Injured
2013	1081	474	800
2014	1044	486	791
2015	1193	525	911
2016	1220	579	801

Source: Year-wise Statistics on Road Accidents in Kanpur, Traffic Police, 2017

2.9 INTERMEDIATE PUBLIC TRANSPORT– COMPOSITION, STATUS AND ROLE

The City is predominantly dependent upon shared auto rickshaws or tempos for the intra-city passenger travel. Battery powered E-rickshaws have also been operational in the City.

As per RTO Kanpur (in 2017), travel permits for a total of 3122 tempo taxis and 3745 auto-rickshaws have been provided.

As per CMP, IPT modes like shared autos (8 seaters) and autorickshaws have no fixed routes of operation given by any authority whereas the services are operated on routes decided by drivers. The 3 seater & 7 seater IPTs IPT have been given area permits by the RTO for a radius of 16 Km and 40 Km respectively.

The fares for both 3 seater auto rickshaw and 7 seater Vikrams are fixed by the State Transport Department and the last fare revision was done in February 2014. The IPT are metered with a starting fare of Rs 10 for the first Km. The tempos have a fare structure of Rs 5-10 as starting fare. Though fare are fixed from the State Transport Department and are metered but none follows these notifications.

2.10 PUBLIC TRANSPORTATION SYSTEM

2.10.1 Public Transportation Services

The public transport systems of the City are catered by Uttar Pradesh State Road Traffic Corporation (UPSRTC).

2.10.2 Existing Bus Routes

A total of 316 bus permits along 14 routes for private operations and a valid 103 permits along 19 routes have been issued to Kanpur City Transport Services Limited as presented in **Table 2.10.**

TABLE 2.10: BUS ROUTES IN KANPUR

SN	Route Name	Route Path via	Length (km)	No. of Permits
PRIVATELY OPERATIONAL BUS ROUTES				
1	Sarsaiyaghat to Bingava	Bada Chauraha, Mall Road, Ghantaghar, Tatmil Chauraha, Kidwai nagar, Naubasta, Machhariya	18.0	25
2	Chakori More to Bagdaodhi Kachaar	Ramadevi, PAC More, Jhakrkati, Jareeb Chowki, Medical College, Rawatpur, Kalyanpur, IIT	30.0	45
3	Jajmau to Kisan Nagar	Ramadevi, Naubasta, Bishwa Bank Chauraha, Barra, Bhauti, Sachendi	23.0	25
4	Gujaoni to Bada Chowrha	Dabouli, CTI, Vijay Nagar, Jareeb Chowki, Gumti Gurdwara, 80 feet Road, Chunniganj, Parade	18.0	9
5	Ghantaghar to Raniyan	Deputy Padaw, Jareeb Chowki, Fazalganj, Armapur Estate More, Panki, Bhauti, Sachendi	30.9	19
6	Rocket Tiraha to Bithoor	Bada Chauraha, Chunnigunj, Bakrmandi, Medical College Chauraha, Rawatpur, Kalyanpur	24	18
7	Siktiyapur to Bada Chauraha	Sarsaul, Ruma, Ramadevi Chauraha, COD, Murray Company, Phoolbagh	32	33
8	Railway Station to Naubasta	Phoolbagh, Chunniganj, Medical College, Rawatpur, Vijay Nagar, CTI, Barra Bypass	19.9	32
9	Indra Nagar to Ghantaghar	Budha Park, Awas Vikas Chauraha, Keshavpuram, Namak Factory Chauraha, Vijay Nagar	14.0	12

SN	Route Name	Route Path via	Length (km)	No. of Permits
10	Yashoda Nagar to Chidiyaghar	Kidwai Nagar, Baradevi, Juhi, Govind Nagar, Fazalganj, JK Mandir, Rawatpur, Gurudev	17.0	6
11	Rocket Tiraha to Barasirohi	Bada Chauraha, Parade, Chunnigunj, Medical College Chauraha, Rawatpur, Kalyanpur crossing	22.0	2
12	Company Bagh to Sajari	Chunnigunj, Phoolbagh, Ghasiyari Mandi, Ghantaghar, Tatmil, Ramadevi via GT Road	12.3	30
13	Jajmau to Bithoor	Defence Colony, Ompurwa, Jagipurwa, Mall Road, Nawabgunj, Chidiyaghar, Singhpur	31.1	30
14	Saraimita to Bada Chauraha	Barra Bypass, Naubasta Chauraha, Yashoda Nagar Bypass, Kidwai nagar, Tatmill Chauraha, Ghantaghar Bus Stand, Mall Road	18.0	30
KANPUR CITY TRANSPORT SERVICES LIMITED (UNDER JNNURM)				
1	Sarsaiyaghat to Saraymita	Bada Chauraha, Phoolbagh, Ghantaghar, Kidwai Nagar, Baradevi, Naubasta, Barra Bypass, Gujaini	23.0	4
2	Chakori More to IIT	Ramadevi, PAC more, Jhakarkatti, Jarib Chauki, Medical College, Rawatpur, Kalyanpur,	27.0	14
3	Jajmau to Bada Chauraha	Ramadevi, Krishna Nagar, Krishna Nagar, Ghantaghar, Phoolbagh	21.0	4
4	Parade Chauraha to Gujaini	Chunnigunj, Bajriya, 80 feet Road, Jarib Chowki, Vijay Nagar, CTI, Shastri Chowk, Dabauli	16.0	12
5	Afim Kothi to Hanspuram	Juhi Pul, Baradevi, Naubasta, Mandi Samiti, Water Park	20.0	2
6	Ghantaghar to Ghantaghar	Express Road, Phoolbagh, Parade, Motijheel, Medical College, Double Puliya, Vijay Nagar, Kidwai Nagar, Tatmil	27.0	2
7	Chidiyaghar to Gangaganj	Azad Nagar, Gurudev Palace, Rama Dental College, Indiranagar, Armanpur, Panki	15.0	5
8	Mandi Samiti to Railway Station Platform No. 1	Machhariya, Yashoda Nagar, Bada Kutiya, Tatmil	9.0	5
9	Vishwa Bank Chauraha to Tamill Chauraha	Chawla Market, Juhi Parmpurawa, Afeem Kothi, Deputy ka Padaw, Bans Mandi, Ghantaghar	9.0	11
10	Sarsaiyaghat to Ramadevi	Phoolbagh, Ghasiyari Mandi, Express Road, Ghantaghar, Tatmil, Ramadevi, via GT Road	24.0	4
11	Ramadevi to Chidiyaghar	Ramadevi bypass, Shyam Nagar, COD, Railway Platform no. 1, Bada Chowraha, Nawabganj	21.0	6
12	Shyam Nagar to Bada Chauraha	Dr. Virendr Swarup School, Shaym Nagar, PAC road, Kidwai Nagar, Ghantaghar, Mall Raod	18.0	5
13	Sarsaiyaghat to	Bada Chauraha, Ghantaghar, Tatmil, Kidwai Nagar,	48.0	4

SN	Route Name	Route Path via	Length (km)	No. of Permits
	Sarsaiyaghat	Gujauni bypass, Panki, Chidiyaghar, Nawabganj, Elgin mill		
14	Jajmau to Jajmau	Ramadevi, Railway Station, Phoolbagh, Company bagh, Kalyanpur, Panki, Vijay Nagar, Jarib chauki, Jhakarkati, Tatmil	62.0	1
15	Mehrban Singh ka Purwa to Chidiyaghar	Barra, Naubsta, Yashoda Nagar, Kidwai Nagar, Phoolbagh, Chunniganj, Nawabganj	23.0	3
16	Rawatpur to Mehrban Singh ka Purwa	Jareeb Chauki, Fajalgunj, Vijay Nagar, CTI Shastri Nagar, Cho. Ram gopal Vidhi Mahavidyalay	17.0	5
17	Jajmau to Bithoor	Circuit house, Phoolbagh, Bada Chauraha, Moti Jheel, Rawatpur, Gurudev, Kalyanpur, Singhpur	32.0	8
18	Sidharthnagar to Bithoor	Jajmau, Circuit House, Phoolbagh, Virendra Swarup Park, Nawabganj, Singhpur	30.0	7
19	Railway Station to Dabauli	Baradevi, Ghantaghar, Tatmil, Bakrganj, Kidwai Nagar, Gaushala, Naubsta Chauraha, Barra	13.0	5

Source: UPSRTC, Kanpur, 2017

2.10.3 Patronage and Financial Performance

The income, passengers and average income per km run for JNNURM buses Kanpur City Transport Services Limited (KCTSL) is presented in **Table 2.11.** An average daily income of Rs. 4,24,974/- and passengers of about 20,000 are served by KCTSL.

TABLE 2.11: OPERATIONAL CHARACTERISTICS - KCTSL

Month/Year	Monthly No. of Passengers	No. of Operational Buses	Bus Trips Performed	Income (in Rs.)	Monthly Income Per KM (in Rs.)
Apr-17	612823	3720	16265	134,03,319	19.59
May-17	639073	3576	15443	136,62,070	20.86
Jun-17	616899	3578	15247	130,93,332	20.00
Jul-17	610984	3601	15071	129,65,032	19.57
Aug-17	591413	3450	14460	124,93,380	19.74
Sep-17	618870	3502	14671	130,72,749	20.63
Oct-17	470665	2693	11067	105,54,722	22.80

Source: UPSRTC, Kanpur, 2017

2.10.4 Institutional Framework and Responsible Agency

City transport system generally has several organizations involved that look after various forms and aspects of the transport system and network. Most of these organizations have overlapping functions and areas of work. It is due to this reason that a good institutional arrangement for organizing, regulating and managing urban transport system in cities has become very essential. Public Transport requirements in the City are catered by Kanpur City Transport Services Limited (KCTSL), a venture of Uttar Pradesh State Road Transport Corporation and few private bus operators.

2.10.5 Constraints

High growth of private modes over the years has resulted in declining trend of public transport system share. The existing right of way conditions in Kanpur also need to be improved to operate public buses.

In general, the buses have less patronage due to lack in organized planning of public transport routes and thus are incurring losses. There is a need to increase the number of buses with a city wide public transport network to provide last mile connectivity.

2.11 PAST PROPOSALS FROM PREVIOUS STUDIES

Various past studies including City Development Plan, Comprehensive Mobility Plan and Master Plan for Kanpur have stressed the need for strategies to have the best transportation modes and infrastructure proposals to address the transportation related issues in the City.

2.11.1 Master Plan for Kanpur – 2021

Master Plan for KDA area was prepared in 2006 for an additional area of 32,808 hectares to accommodate a population of 45 Lakh in the KDA area. Considering the demand for transportation infrastructure, the land under traffic & transportation use was increased from 8% to 15.4%. Important proposals of Master Plan 2021 of Kanpur are as follows:

- A bypass has been proposed to join Kanpur and Delhi roads. Along this bypass new transport nagar, truck terminal and bus stand have been planned

- Proposal for a new airport to boost the city air traffic
- Ring road connecting 44 roads of the city
- Inter-State Bus Terminus (ISBT) at Ragahi Bangar and regional bus stations at other parts of city
- 44 roads proposed for constructions of shops on both sides of roads including the road coming from Ramadevi Crossing to PAC Turn, Lal Bangla Road, Hamirpur Road, Naubasta By-pass, road from Afeemkothi to Deputy Padav, around PPN Market, from Harsh Nagar Crossing to Brijendra Swarup Park, from the Ganesh Shanker Vidyarthi Memorial Medical College to Swarup Nagar Police Station etc.

2.11.2 City Development Plan (CDP) for Kanpur, 2006

In order to adopt a holistic and all round plan for development for Kanpur city, being recognized to be the one of the most important industrial cities, an integrated City Development Plan was prepared in 2006 in line with goals and objectives of JnNURM. The study area extends over 260 Sq km of Kanpur Municipal Corporation (KMC) comprising of 110 wards with a population of 25.51 Lakh in 2001.

Proposed Transport Sector Strategies:

- Introduction of CNG buses and taxies for public transport
- Restriction of trucks and slow goods vehicle on main roads
- Proper regulation of slow traffic system
- Road surface improvements to improve the traffic movement and minimize congestion
- Private sector participation for road improvement
- Discouraging private vehicles usage by imposing parking fees and declaring busy areas and old city markets as vehicle free zone
- Removing encroachments over the road
- Implement computerized signaling

- Involvement of local community for awareness generation about traffic rules, safety rules etc.
- Cycle rickshaws should be banned on main roads and highways
- Development of Parking lots on PPP basis

2.11.3 Comprehensive Mobility Plan (CMP) for Kanpur, 2017

Comprehensive Mobility Plan (CMP) has been updated in 2017 for Kanpur Development Authority (KDA) area. CMP envisions a four tier public transport management plan. At the topmost tier, the need for a mass rapid system is felt where long distance trips within the City are conveniently addressed and are complimented by safe efficient and economical services.

Comprehensive Mobility Plan has been prepared for a planning period of 20 years with a vision for transport in Kanpur to ensure that the city has a planned, best performing transport systems to address the needs and concerns of the City. The objectives of CMP is to develop specific actions in the form of short, medium and long term transportation improvement proposals that will achieve the transportation vision for the area.

a. Mass Rapid Transit Proposals:

The CMP has proposed two MRTS corridors with a total length of 97 km of rail based transit and 129 km of bus rapid transit in different phases to be developed.

b. Landuse Transport Integration Plan:

Integrated landuse and transport development promotes balanced regional growth in line with regional development strategies, with the objective of promoting balanced spatial growth, minimizing land requirements for transport, promoting transit oriented growth and reducing the need to travel.

Multimodal Transit hubs have been proposed at central railway station, central bus terminal, regional rail station, Govindpuri Junction, Panki regional rail station, Rawatpur railway station, IIT Kanpur, Ramaipur and Chakeri.

Ring and radial roads are proposed in CMP. Major rings include:

i. Mall road – Govind Nagar Road – Bara Devi Road – Naya Pul – Kanpur Raibreli Road
ii. VIP Road – Sharda Nagar Rd. – Vijaynagar – Kalyanpur Rd. – Barra 7 Road – Kidwai Nagar Avenue
iii. Ring – connecting (Sachendi – Bhimsen – Ramaipur) to Kanpur Marg (NH27), Shuklaganj Bypass, NH91 Bye pass- Indira road. Ishwari Ganj Palara road
iv. Semi New Ring – Rania to Rooma via Bidhnu Village and Majhawan Village (further extended to Bithoor and Unnao to complete the ring)

Major orbitals include:

i. NH02 Kanpur Jhansi Highway (Akbarpur to Barra 7 junction)
ii. NH86 Hamirpur Road
iii. SH17 Ramaipur Jahanabad Road
iv. Grand Trunk Road (Galatha to Kanpur city centre)
v. SH 58 Rajdhani Marg
vi. Bithoor Road
vii. Grand Trunk Road

c. Public Transport – Intra City Bus:

The CMP has proposed new bus depots and terminal locations at Bithoor, Akbarpur, Panki, Chakeri, Sarsaul and upgradation of existing Jhakarkati, Fazalganj, Chunniganj, Rawatpur and Juhi terminals.

d. Non-Motorized Transport (NMT) Plan:

In view of high share of pedestrian and NMT trips, CMP has proposed certain measures and proposals to improve non motorised transport which include footpath and cycle tracks, pedestrian phase signals at identified intersections, grade separated pedestrian crossing facilities and cycle rickshaw management. 834 km total road network has been proposed for cycle track construction and 891 km for construction of footpath.

e. Traffic Management Plan:

- A number of traffic management plans including junction improvements, area traffic control systems, traffic management measures, safety measures and parking management plan are proposed in CMP.
- Some of the junctions need improvements as per CMP are: Bakarganj, Parade Chauraha, Gumti No. 5, Jareeb Chowki, Afim Kothi, Near LIC building, Barra Bypass near Anjali Chowk, Naubasta, Ghantaghar, Tatmill Chauraha.
- Pavement Markings and Signage.
- Installation of Traffic Management Control Centre.
- Parking Management for residential, commercial, office/educational, hospitals and medical establishments etc. and off street parking facilities at 38 locations for car parking and 33 locations for two wheeler parking.

f. Other Plans:

- Grade separated pedestrian crossing facilities at 15 locations (junctions) such as Tatmill Chauraha, 6 point junction, Phoolbagh, Parade Chauraha, Bada Chauraha, Naubasta etc.
- Proposed road widening for 181 km and new roads for 210 km have been proposed.
- Education, Enforcement and Public awareness campaigns for improving traffic obedience.

2.11.4 Alternatives Analysis Report for Kanpur MRTS, 2017

Alternatives Analysis has been carried out to find the most feasible alternative transport system for Kanpur.

- Qualitative evaluation of the available alternatives namely Normal Bus System, Bus Rapid Transit, Metro Rail and Light Rail Transit have been carried out. Normal Bus and Bus Rapid Transit have been ruled out in view of limited RoW, inability to meet the passenger demand in future and significant greenhouse gas emissions.

- In preliminary screening, Metro Rail and Light Rail Transit emerged as prospective mass transport system for Kanpur for further quantitative evaluations.
- With several operational metro rail systems in India, its technology as well as various components like track gauge, civil structures and rolling stock components have been standardized and now available within the country. Efforts have also been made by the Government and Implementing Agencies towards indigenizing the various components of metro rail systems. Technical expertise has also been developed in the country over the period of time.
- Based on both qualitative and quantitative screening carried out Metro System has emerged as the most viable alternative mass transport system to meet the transport needs of Kanpur city.

2.12 INTERCONNECTIONS AMONG VARIOUS STUDIES/PROPOSALS

The past studies carried out earlier have analyzed the existing conditions in detail and have come up with possible improvement proposals in Kanpur. The City requires a mass transport system that would cater to the expected demand and provide a safe and convenient travel and alleviate the existing traffic woes. Various Non-motorized transport facilities and road improvements have also been part of proposals from Master Plan and CMP.

The land-use parameters have been estimated for horizon years considering the growth as per Master Plan 2021 for Kanpur in KMC area and surrounding villages. Traffic zone wise distribution of population and employment is largely based on the existing/proposed land-use distribution as planned in Master Plan.

CMP proposes implementation of mass transit system for two priority corridors in Kanpur. Alternatives Analysis Report recommends Metro Rail System for these two corridors.

This DPR is prepared for the proposed Metro Rail system along the two priority corridors in Kanpur.

2.13 ISSUES AND PROSPECTS

2.13.1 Existing Traffic Characteristics and Related issues

Massive urbanization and growth of personalized has been stressing the existing urban transport system in city. The sharing of limited right of way by various modes has resulted in traffic congestion, accidents, and inadequate parking area and environment deterioration. Some of the existing characteristics along major arterials with issues in parking, footpath, vehicular movements, and traffic congestion are presented in **Figure 2.2** and **Figure 2.3.**

FIGURE 2.2: EXISTING CHARACTERISTICS ALONG MAJOR ARTERIAL ROADS

 Rawatpur (NH-91) The photograph is of Rawatpur where footpath is encroached by shopkeepers and on-street parking reduces efficient roadway width.	 Tulsi Nagar The photograph is near Tulsi Nagar along Rawatpur Vijay Nagar Road. The absence of footpath and idle parking of vehicle is observed.
 Vijay Nagar (NH-25) The photograph is of Vijay Nagar intersection towards Jareeb Chowki where chaotic movement of a goods vehicle moving in the opposite direction is observed.	 Darshan Purwa (NH-25) The photograph is of Darshan Purwa along Kalpi Road from Jareeb Chowki. On street parking of cars, buses and wrong side movement of auto rickshaw are observed.

FIGURE 2.3: CONGESTION ON MAJOR ROADS

Fazalganj (NH-25)

Chunniganj (Mall Road)

Shared Auto Movement near Ghantaghar

Parade Chauraha (Mall Road)

Naubasta (NH-86)

Near Jareeb Chowki (Railway Road)

2.13.2 Air Pollution Levels

The pollution levels in the City are determined by the existing Ambient Air Quality Index (AQI). The AQI considers eight pollutants (PM_{10}, $M_{2.5}$, NO_2, SO_2, CO, O_3, NH_3, and Pb) in which one of PM10 or PM2.5 parameter is mandatory. There are six AQI categories, namely Good, Satisfactory, Moderately polluted, Poor, Very Poor, and Severe. The AQI values for identified eight pollutants are as provided in **Table 2.12.**

TABLE 2.12: AIR QUALITY INDEX PARAMETERS

AQI Category, Pollutants and Health Breakpoints								
AQI Category (Range)	PM_{10} 24-hr	$PM_{2.5}$ 24-hr	NO_2 24-hr	O_3 8-hr	CO 8-hr (mg/m^3)	SO_2 24-hr	NH_3 24-hr	Pb 24-hr
Good (0-50)	0-50	0-30	0-40	0-50	0-1.0	0-40	0-200	0-0.5
Satisfactory (51-100)	51-100	31-60	41-80	51-100	1.1-2.0	41-80	201-400	0.5 –1.0
Moderately polluted (101-200)	101-250	61-90	81-180	101-168	2.1- 10	81-380	401-800	1.1-2.0
Poor (201-300)	251-350	91-120	181-280	169-208	10-17	381-800	801-1200	2.1-3.0
Very poor (301-400)	351-430	121-250	281-400	209-748*	17-34	801-1600	1200-1800	3.1-3.5
Severe (401-500)	430 +	250+	400+	748+*	34+	1600+	1800+	3.5+

Source: NAQI Status of Indian Cities 2015-16, Central Pollution Control Board

TABLE 2.13: MEASURED POLLUTION LEVELS FOR KANPUR

MONTHS	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16
Dates	AQI Index Values	AQI Index Values	AQI Index Values	AQI Index Values	AQI Index Values
1	249	365	414	No Data	313
2	232	73	370	196	307
3	246	263	406	205	320
4	308	No Data	393	225	325
5	312	412	455	312	304
6	No Data	No Data	449	378	123
7	265	429	397	No Data	199
8	265	431	398	No Data	110
9	282	429	320	No Data	183
10	333	382	60	333	182
11	340	342	358	315	192
12	No Data	387	362	291	152
13	299	315	380	252	115
14	370	358	389	276	76
15	376	290	No Data	277	160
16	336	340	No Data	231	127
17	280	374	321	No Data	180
18	222	356	373	No Data	159
19	285	360	397	No Data	225
20	354	399	No Data	305	185
21	341	338	306	237	161
22	328	404	351	183	No Data
23	356	395	384	165	123
24	374	382	382	222	214
25	394	274	359	202	No Data
26	311	301	334	269	202
27	341	318	329	290	No Data
28	348	324	364	No Data	No Data
29	356	306	405	310	No Data
30	334	289	No Data		No Data
31		419	No Data		222
MAX	394	431	455	378	325
MIN	222	73	60	165	76
AVG	316	347	364	261	194

Good	Satisfactory	Moderate	Poor	Very Poor	Severe
(0–50)	(51–100)	(101–200)	(201–300)	(301–400)	(>401)

Source: NAQI Status of Indian Cities 2015-16, Central Pollution Control Board

As per available data of Kanpur from November 2015 to March 2016 as presented in **Table 2.13**, City has registered pollution levels ranging from 'Very Poor, 301-400' to 'Severe, 401-500'. These pollution levels are alarming considering the future growth of the City.

2.13.3 Prospects

With a view of developing efficient mass transit system to address traffic woes and pollution levels in the City, the Government of Uttar Pradesh has decided to implement Metro Rail system for Kanpur and complimenting it with intermodal integration including PT/IPT feeder systems for last mile connectivity in the City.

Chapter – 3
TRAVEL CHARACTERISTICS AND DEMAND ESTIMATES

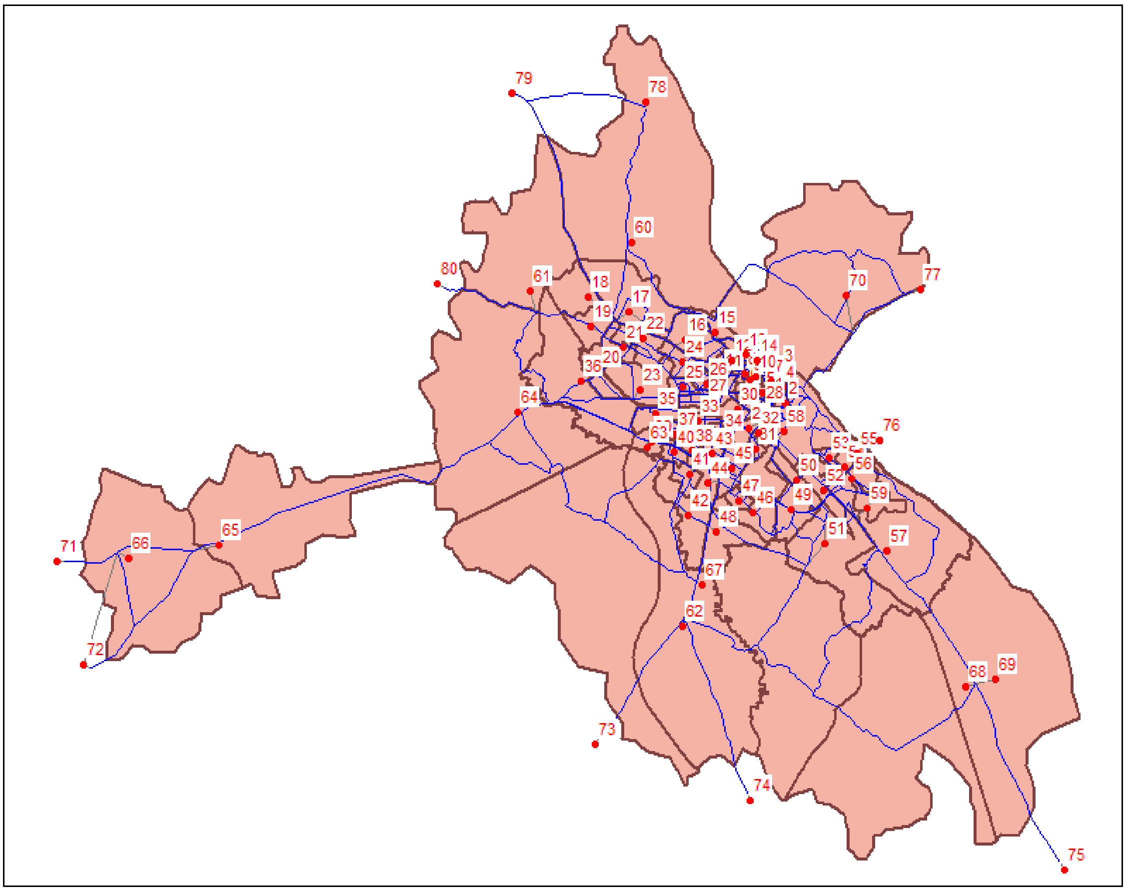
3. TRAVEL CHARACTERISTICS & DEMAND ESTIMATES

3.1 VARIOUS TRAFFIC AND TRANSPORTATION STUDIES UNDERTAKEN

3.1.1 Study Area and Traffic Zone System

Study area for the current assignment is administrative boundary of Kanpur Development Authority (KDA). To understand the travel pattern of the City, a total of 70 zones called traffic analysis zones have been identified inside the study area. Considering the ease of getting required zonal information, administrative wards were combined as zones within the Municipal Area. A total of 70 internal zones inside KDA area and 10 external zones have been considered for the Study. The traffic zone system of the Study Area is presented in **Figure 3.1**. The tentative influence area are assumed to about 6 km on both the sides of proposed Metro Corridors is shown in **Figure 3.2.**

FIGURE 3.1: TRAFFIC ZONE SYSTEM AND CODED BASE YEAR ROAD NETWORK



3.1.2 Land Use Survey

Landuse surveys have been carried out to understand the pattern along existing road network of about 625 km. The abutting land use is presented in **Table 3.1**. It is seen that the road network is abutted by residential land use upto an extent of about 48% and commercial about 15%.

TABLE 3.1: DISTRIBUTION OF ABUTTING LANDUSE ALONG MAJOR ROADS

SN	Landuse	Percentage (%)
1	Residential	48.1
2	Commercial	14.9
3	Vacant	7.9
4	Institutional	3.2
5	Industrial	3.9
6	Agricultural	22.0
Total		**100.0**

3.1.3 Traffic and Transportation Surveys

A number of traffic & travel surveys were conducted to appreciate and quantify the characteristics of commuter travel within the Study Area. This data analysis has helped us in developing the Travel Demand Model.

3.1.3.1 Classified Traffic Volume Counts

Classified traffic volume surveys were carried on average weekday to quantify the volume of traffic moving along various road sections in the study area. The counts were carried out for 16-hour at mid block/screen line and Intersection locations and for 24 hour at outer cordon locations. The survey locations were selected in a manner that would cover the entire study area and assist in understanding the traffic pattern within the study area as well as with adjacent urban settlements. These surveys help in assessing the existing traffic problems in the study area as well as to validate the transport demand models.

i. Mid-Block/Screen Line Count Survey

Locations of Midblock/Screen Line Counts are shown in **Figure 3.3** and **Table 3.2**. The quantum and temporal variation of total and daily vehicles and trips moving in the study area has been carried out in the following sections.

FIGURE 3.2: INFLUENCE AREA OF PROPOSED METRO CORRIDORS

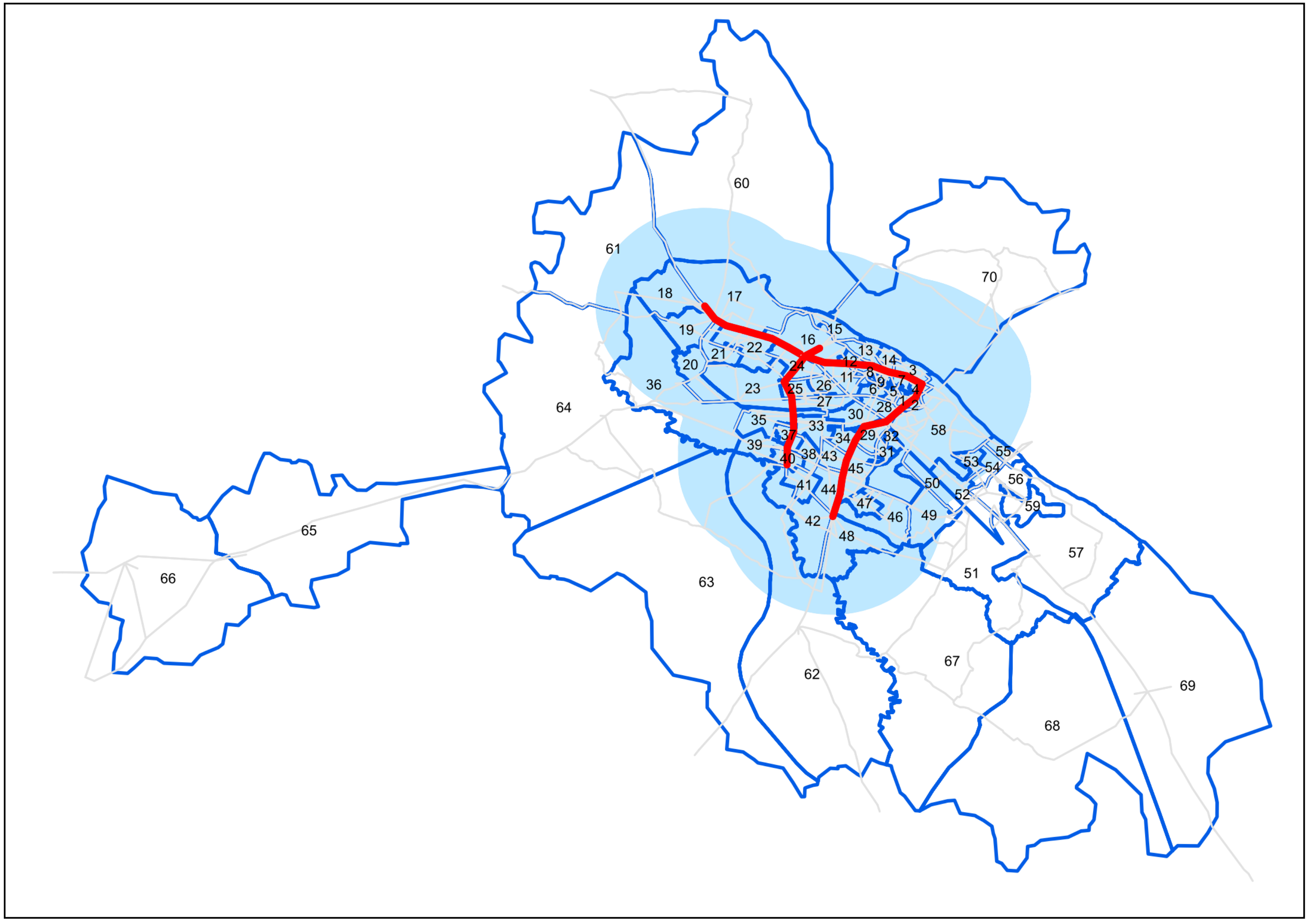


FIGURE 3.3: MID-BLOCK/SCREEN LINE & TURNING MOVEMENT COUNT SURVEY LOCATIONS

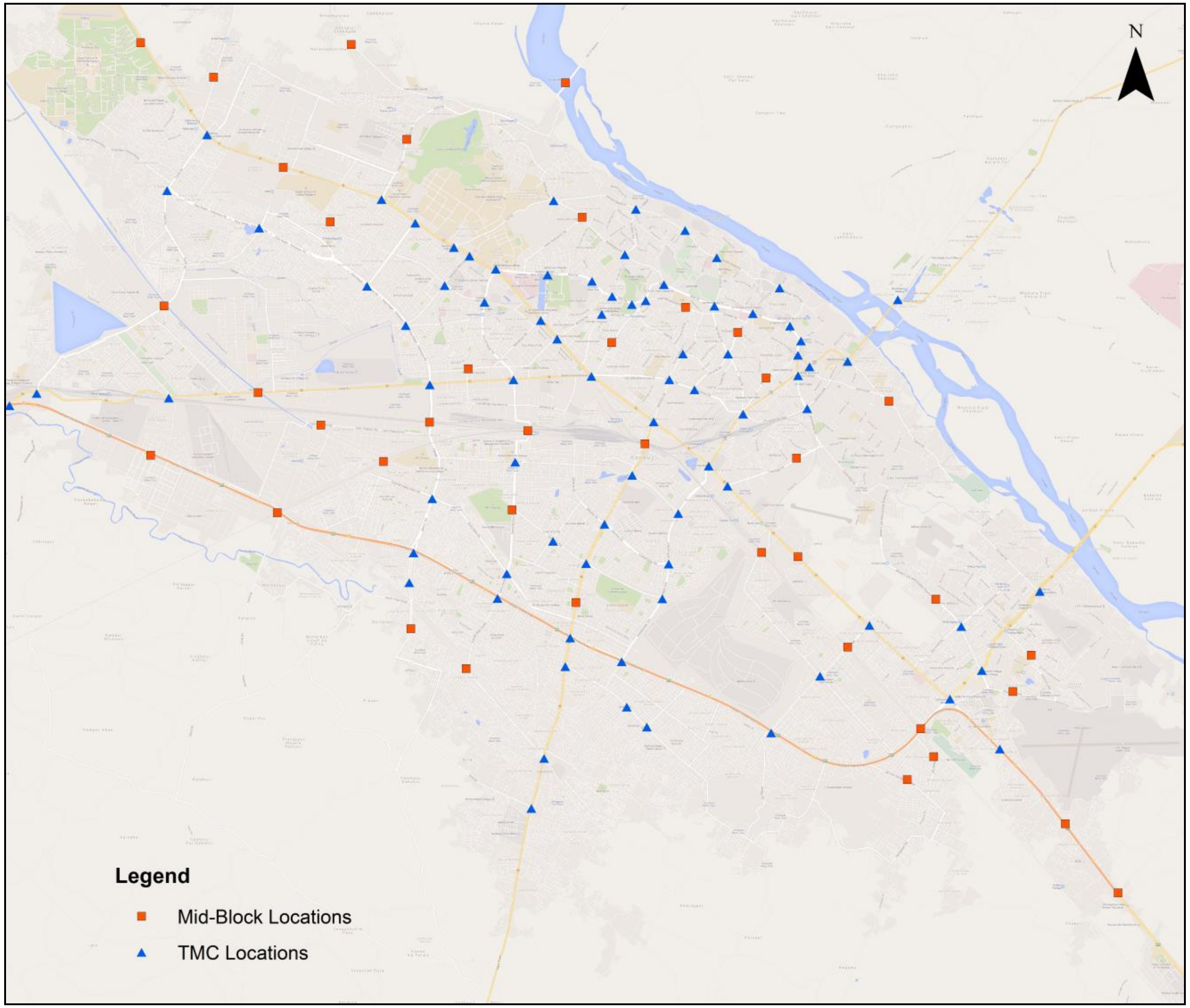


TABLE 3.2: INTENSITY AND DIRECTIONAL DISTRIBUTION OF TRAFFIC AT MID-BLOCK/SCREEN LINE LOCATIONS

SN	Name of Mid-Block Location	Total Traffic		Morning Peak				Evening Peak				Directional Distribution			
		(Veh.)	(PCUs)	(Veh.)	% of Total Traffic	(PCUs)	% of Total Traffic	(Veh.)	% of Total Traffic	(PCUs)	% of Total Traffic	Peak Direction (PCUs)	%	Off Peak Direction (PCUs)	%
1	Kalyanpur-Bithoor Road (Near Guru Nanak Modern school)	12188	9611	1397	11.46	1100	11.45	1136	9.32	884	9.19	565	51.36	536	48.64
2	NH-91-Kanpur-Kannauj Road (Near IIT Main Gate)	20331	19615	1514	7.45	1476	7.52	1864	9.17	1674	8.53	941	56.21	734	43.79
3	NH-91-Kanpur-Kannauj Road (Near CSJM University)	23429	21223	2207	9.42	1851	8.72	2274	9.71	1890	8.91	957	50.63	933	49.37
4	Nawabganj-Bithoor Road (Near Delhi Public School)	12840	9371	1086	8.46	795	8.48	1439	11.21	996	10.63	588	59.04	409	40.96
5	Chapeda Pulia-Indian Institite of Pulses Research Road (Near Panchwati)	2107	1670	224	10.63	182	10.90	185	8.78	127	7.60	112	61.54	70	38.46
6	Vikash Nagar-Ganga Barrage Road (Indra Road)(Near-Deen Dayal Nagar)	27817	22892	2383	8.57	1928	8.42	1944	6.99	1537	6.71	1101	57.11	827	42.89
7	Gyan Prakash Road (Near PNB Bank)	14463	16185	1402	9.7	1509	9.3	1432	9.9	1410	8.7	1677	54.40	1407	45.60
8	NH-2-Kanpur-Auraiya Road (Near Indian Oil Company, Gate No. 7)	19614	24426	1721	8.77	2076	8.50	1851	9.44	2118	8.67	1063	50.19	1056	49.81
9	NH-25 Kalpi Road (Near Gun Factory)	34216	31836	3228	9.43	2848	8.94	2785	8.14	2527	7.94	1390	51.19	1199	48.81
10	Panki-Kalyanpur Road (Near Panki Canal)	12012	9549	1042	8.67	825	8.63	1078	8.97	849	8.89	471	55.51	378	44.49
11	Shastri Nagar Road (Near Axis Bank ATM Shastri Nagar)	11996	8762	1240	10.34	890	10.16	1200	10.00	854	9.74	500	56.18	390	43.82
12	Fazalganj-Barra Bypass Road (Near Fazalganj Railway Colony)	27045	20234	2573	9.51	1766	8.73	2498	9.24	1849	9.14	992	53.67	857	46.33
13	Barra- Vijay Nagar Road Dada Nagar (Near Railway Crossing)	15566	10809	2005	12.88	1242	11.49	1887	12.12	1190	11.01	629	50.66	613	49.34

SN	Name of Mid-Block Location	Total Traffic		Morning Peak				Evening Peak				Directional Distribution			
		(Veh.)	(PCUs)	(Veh.)	% of Total Traffic	(PCUs)	% of Total Traffic	(Veh.)	% of Total Traffic	(PCUs)	% of Total Traffic	Peak Direction (PCUs)	%	Off Peak Direction (PCUs)	%
14	C.T.I - Dada Nagar Road (Near Prakash Vidya Mandir School)	13060	9083	1375	10.53	1017	11.19	1238	9.48	800	8.81	537	52.83	480	47.17
15	Tilak Nagar-Chunniganj Road, Tilak Nagar (Near Ratan Castle Apartment)	15057	11988	1372	9.11	1065	8.88	1524	10.12	1208	10.07	628	52.01	580	47.99
16	NH-91 Bypass Road (Near Ganga Barrage)	12911	11224	945	7.32	870	7.75	1295	10.03	1123	10.00	623	55.50	500	44.50
17	NH-86 Hamirpur Road (Near Railway Crossing)	33249	29382	3313	9.96	2752	9.36	2959	8.90	2562	8.72	1713	62.26	1039	37.74
18	Hardinge Road (Near Cantonment Hospital)	12669	10455	1110	8.76	958	9.16	1208	9.54	964	9.22	513	53.24	451	46.76
19	Tagore Road (Near Kanpur Cantt Area)	18585	14401	1611	8.67	1217	8.45	1819	9.79	1365	9.48	730	53.50	635	46.50
20	Birhana Road (Near Punjab National Bank)	6890	6063	658	9.55	610	10.06	579	8.40	459	7.56	357	58.52	253	41.48
21	Nai Sarak, Dalel Purwa (Near Ehsan Ul Madarsa)	21536	17633	1969	9.14	1583	8.97	1816	8.43	1589	9.01	800	50.36	789	49.64
22	Syed Mohd. Raja Road (Near Syed Arshad Ali Kabristan)	6622	4991	624	9.42	465	9.31	531	8.02	359	7.18	241	51.88	224	48.12
23	Kanpur Road (Near Bank of Baroda)	3770	3197	346	9.18	312	9.74	321	8.51	249	7.79	174	55.86	138	44.14
24	Barra Bypass Road (Near Jagran Institute of Management, Saket Nagar)	33453	24537	2984	8.92	2090	8.52	2937	8.78	2185	8.90	1279	58.54	907	41.46
25	Karhi Main Road (Near Water Tank Karhi)	10674	8366	777	7.28	682	8.15	957	8.97	798	9.54	447	56.02	352	43.98
26	Along NH-2 ByPass (Near Allahabad Bank ATM, Gujaini)	33631	37878	3461	10.29	3978	10.50	2754	8.19	2863	7.56	2248	56.52	1730	43.48
27	60 Feet Sanigawan Road (Near Pankaj Traders)	7089	4746	471	6.64	324	6.82	594	8.38	401	8.44	213	53.18	188	46.82

SN	Name of Mid-Block Location	Total Traffic		Morning Peak				Evening Peak				Directional Distribution			
		(Veh.)	(PCUs)	(Veh.)	% of Total Traffic	(PCUs)	% of Total Traffic	(Veh.)	% of Total Traffic	(PCUs)	% of Total Traffic	Peak Direction (PCUs)	%	Off Peak Direction (PCUs)	%
28	PAC Bridge Road (Near Mother Dairy)	17456	13630	1869	10.71	1446	10.61	1513	8.67	1237	9.07	821	56.80	625	43.20
29	Kalyanpur-Ramadevi Road (Near DMSRDE Office)	15062	11098	1876	12.46	1320	11.89	1272	8.45	960	8.65	737	55.85	583	44.15
30	COD-Defence Colony Road (Near Railway Crossing, Chandari)	21657	15692	2127	9.82	1482	9.44	2018	9.32	1351	8.61	837	56.48	645	43.52
31	Along NH-86 Hamirpur Road (Near CNG Filling Station)	35535	28575	3232	9.10	2670	9.34	2554	7.19	2034	7.12	1514	56.71	1156	43.29
32	Greater Kailash Road (Near Air Force School)	10644	7247	796	7.48	509	7.02	914	8.59	570	7.87	309	54.21	262	45.79
33	Airport Avenue Road (Near Main Gard Room)	12367	8959	1243	10.05	877	9.79	1277	10.33	863	9.63	475	54.16	403	45.84
34	NH-2 Ramadevi- Auraiya Road (Near JK Guest House)	24899	28960	2313	9.29	2580	8.91	2250	9.04	2689	9.29	1390	51.69	1299	48.31
35	Along NH-2 (Near Sanjay Nagar)	30762	33021	2927	9.51	3018	9.14	2539	8.25	2615	7.92	1616	53.55	1402	46.45
36	Along NH-2 (Near Hathipur)	23671	28819	2100	8.87	2516	8.73	1866	7.88	2214	7.68	1331	52.90	1186	47.10
37	NH-2-Kanpur-Fatehpur Road (Near Little Kids Valley School)	31289	33431	3355	10.72	3577	10.70	2970	9.49	3125	9.35	2011	56.22	1566	43.78
38	Western Sub Metropolitan Bypass Road (Near Arya Samaj Mandir)	20607	16814	2077	10.08	1562	9.29	1828	8.87	1487	8.84	890	57.00	672	43.00
39	Sanigawan Road (Near National Combard School)	7435	4340	640	8.61	389	8.96	621	8.35	362	8.34	196	50.39	194	49.61
40	Jarauli - Barra Road , Jarauli (Near Water Tank)	5170	3220	574	11.10	344	10.67	461	8.92	275	8.54	193	56.19	151	43.81

Average Daily (16 hours) and Peak Hour Traffic Characteristics

The daily and peak hour traffic counts both in terms of numbers of vehicles and Passenger Car Units (PCUs) are presented in **Table 3.2**. It is observed that the traffic at different locations varies from 2,107 Vehicle (1,670 PCU's) Chapeda Pulia-Indian Institite of Pulses Research Road to 33,631 Vehicle (37,878 PCU's) along NH-2 Bypass (Near Allahabad Bank ATM, Gujaini).

The morning peak hour volume varies from 182 PCUs (224 vehicles) on Chapeda Pulia-Indian Institite of Pulses Research Road (Near Panchwati) to 3,978 PCUs (3,461 vehicles) on Along NH-2 Bypass (Near Allahabad Bank ATM, Gujaini).

ii. Turning Movement Counts at Intersections

Direction-wise classified traffic volume surveys were carried out at 80 intersections on an average weekday in the study area to quantify the mode-wise volume of traffic moving along various road sections and intensity of traffic flow throughout the day. Locations of intersection survey are presented in **Table 3.3** and **Figure 3.3.**

Traffic Volume (Average Daily Traffic – 16 hours)

It can be seen that Tat Mill intersection handles the maximum daily traffic at 1,66,520 vehicles (1,52,593 PCUs) followed by Ghantaghar Chauraha with 109167 vehicles (99,279 PCUs) while the least daily traffic is observed at Panki-Kalyanpur Road, RK Puram intersection point with 11,398 vehicles (8,133 PCUs).

The peak hour traffic characteristics at the intersections are presented in **Table 3.3.**

TABLE 3.3: DAILY AND PEAK HOUR TRAFFIC AT INTERSECTIONS

SN	Location Name	Total Traffic		Morning Peak				Evening Peak			
		Veh.	PCUs	(Veh.)	% of Total Traffic	(PCU's)	% of Total Traffic	(Veh.)	% of Total Traffic	(PCU's)	% of Total Traffic
1	Kalyanpur Chowk	31656	26708	2800	8.8	2295	8.6	3032	9.6	2402	9.0
2	Geeta Nagar	51395	43779	4114	8.0	3508	8.0	3865	7.5	3205	7.3
3	GSVM Junction	47754	41605	3673	7.7	3281	7.9	4205	8.8	3501	8.4
4	Jareeb Chowki	72889	70987	6105	8.4	5853	8.2	6190	8.5	5869	8.3
5	Afim Kothi Chowk	78887	69592	7064	9.0	5557	8.0	7059	8.9	6083	8.7
6	Tat Mill Chauraha	166520	152593	13791	8.3	11863	7.8	14689	8.8	13148	8.6
7	Ramadevi Chowk	62346	57989	4704	7.5	4481	7.7	5001	8.0	4555	7.9
8	Gurudev Chauraha	50603	41687	4418	8.7	3553	8.5	5609	11.1	4133	9.9
9	Rawatpur Railway Station Chowk	34259	28056	2872	8.4	2286	8.1	3630	10.6	2827	10.1
10	Rawatpur Crossing	34111	24913	3348	9.8	2560	10.3	2454	7.2	1783	7.2
11	Coco-Cola Chauraha	60887	50451	5458	9.0	4607	9.1	5761	9.5	4603	9.1
12	Gumti No.5	85428	71397	6869	8.0	5720	8.0	6560	7.7	5329	7.5
13	Hardinge Road Junction	30303	24200	3030	10.0	2326	9.6	2735	9.0	2058	8.5
14	Kidwai Nagar	49874	49376	4430	8.9	4247	8.6	4782	9.6	4485	9.1
15	Naubasta	65318	70598	6340	9.7	7026	10.0	5261	8.1	5428	7.7
16	Barra Bypass Along NH-2 (Near Anjali Hospital)	73373	64539	7527	10.3	6205	9.6	6557	8.9	5507	8.5
17	Barra Bypass Along NH-2 (Near Basant Petrol Pump)	46546	45156	4742	10.2	4444	9.8	4370	9.4	3991	8.8
18	Panki Chowk	36637	43229	3250	8.9	3608	8.3	3377	9.2	3816	8.8
19	Bakarganj Junction	24397	19332	1931	7.9	1517	7.8	1842	7.6	1448	7.5
20	Baradevi Chowk	57979	49265	5807	10.0	4870	9.9	5576	9.6	4629	9.4

SN	Location Name	Total Traffic		Morning Peak				Evening Peak			
		Veh.	PCUs	(Veh.)	% of Total Traffic	(PCU's)	% of Total Traffic	(Veh.)	% of Total Traffic	(PCU's)	% of Total Traffic
21	Gaushala Chowk	52696	41837	4518	8.6	3604	8.6	4712	8.9	3555	8.5
22	Dasu Kuan	53997	41769	4960	9.2	3714	8.9	4892	9.1	3676	8.8
23	Narayanpuri	64536	60177	5436	8.4	4873	8.1	5207	8.1	4829	8.0
24	Arra Road Junction	24817	30136	2196	8.8	2820	9.4	2269	9.1	2696	8.9
25	Ramaipur	28973	30775	2272	7.8	2474	8.0	2645	9.1	2880	9.4
26	Fazalganj Chauraha	37770	29109	3588	9.5	2711.5	9.3	3894	10.3	2921.5	10.0
27	Vijay Nagar Chauraha	31147	25555	3664	11.8	2664	10.4	3602	11.6	2778	10.9
28	Bhatia Tiraha	24869	25094	2511	10.1	2371	9.4	2744	11.0	2634	10.5
29	Panki Padav Bus Stop	20279	18244	1801	8.9	1567.5	8.6	1900	9.4	1604.5	8.8
30	Bakarganj Chowk	54741	55366	5142	9.4	5138	9.3	3799	6.9	4179	7.5
31	Jawahar Road Junction	47196	41819	4344	9.2	3455	8.3	3675	7.8	2949	7.1
32	Shani Dev Mandir	26693	25686	2353	8.8	2218	8.6	2457	9.2	2404	9.4
33	Balmiki Park	16749	14376	1668	10.0	1336	9.3	1556	9.3	1364	9.5
34	Dayal Road Junction	39851	37364	3199	8.0	3099	8.3	3162	7.9	2856	7.6
35	Sir Allen Avenue Road Junction	21027	18126	2194	10.4	1786	9.9	1923	9.1	1620	8.9
36	Eidgah Junction	19565	15682	1993	10.2	1480	9.4	1597	8.2	1256	8.0
37	Mall Road & Moh. Syed Raja Road Junction	40520	42020	3613	8.9	4161	9.9	3857	9.5	3845	9.2
38	Chunniganj Junction	35648	29035	2749	7.7	2306	7.9	3547	10.0	2715	9.4
39	Parade Chauraha	79052	66037	6612	8.4	5635	8.5	6910	8.7	5685	8.6
40	Bada Chauraha	69479	49938	5869	8.4	4314	8.6	5300	7.6	3754	7.5
41	Telephone Exchange Chowk	37145	29279	3810	10.3	2896	9.9	3509	9.4	2660	9.1
42	Phoolbagh Chauraha	62067	45733	5801	9.3	4462	9.8	5773	9.3	4066	8.9

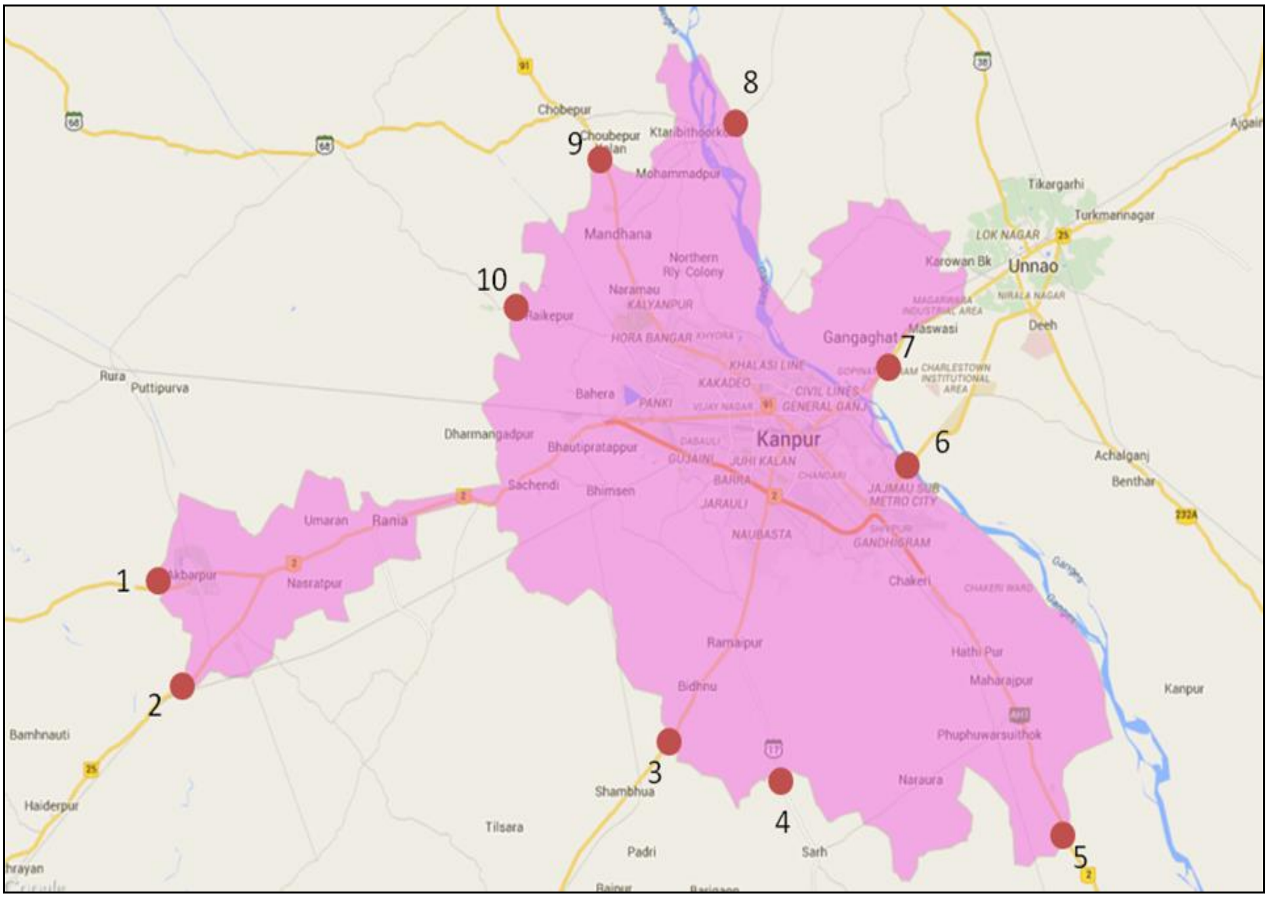
SN	Location Name	Total Traffic		Morning Peak				Evening Peak			
		Veh.	PCUs	(Veh.)	% of Total Traffic	(PCU's)	% of Total Traffic	(Veh.)	% of Total Traffic	(PCU's)	% of Total Traffic
43	Narona Chauraha	35548	28944	3197	9.0	2490	8.6	2949	8.3	2417	8.4
44	Mall Road Junction (Near LIC Building)	91025	71493	7989	8.8	6166	8.6	7716	8.5	5882	8.2
45	Company Bagh Chauraha	32015	24526	3307	10.3	2471	10.1	3561	11.1	2689	11.0
46	Elgin Mill Chowk	26907	19424	2662	9.9	1796	9.2	3024	11.2	2117	10.9
47	Tafco Chowk	25155	17662	2110	8.4	1461	8.3	2659	10.6	1900	10.8
48	Green Park	37057	29645	3321	9.0	2551	8.6	2575	6.9	2074	7.0
49	Sarsaiya Ghat Chowk	23368	18049	2443	10.5	1822	10.1	1993	8.5	1458	8.1
50	Yashoda Nagar Bus Stop	20425	14694	1899	9.3	1395	9.5	1757	8.6	1293	8.8
51	Bajarang Chauraha	18678	13816	1493	8.0	1045	7.6	1622	8.7	1265	9.2
52	PAC Bridge Road Junction	26756	19726	2831	10.6	2059	10.4	2194	8.2	1583	8.0
53	Patel Nagar Crossing (Near Pateleswar Shiv Temple)	34247	31858	2934	8.6	2627	8.2	2981	8.7	2589	8.1
54	PAC More	30252	23257	3397	11.2	2471	10.6	3123	10.3	2363	10.2
55	Shyam Nagar Bypass Chowk	41800	44415	4105	9.8	4040	9.1	3668	8.8	4090	9.2
56	Wills Hospital Chowk	17951	11487	1746	9.7	1117	9.7	1656	9.2	971	8.5
57	Jajmau Chowk	27424	31765	2964	10.8	3110	9.8	2227	8.1	2538	8.0
58	Police Chowki (Lal Bangla Road)	42498	33378	4281	10.1	3196	9.6	3226	7.6	2467	7.4
59	Harjinder Nagar Chowk	42552	43727	3552	8.3	3538	8.1	3672	8.6	3502	8.0
60	Sachan Chowk (Near Barra Bypass)	42552	43727	4520	10.6	3390	7.8	3937	9.3	2926	6.7
61	Juhi Kalan Chowk	23924	18794	2555	10.7	1780	9.5	2123	8.9	1619	8.6
62	Shastri Chowk	48047	35794	3984	8.3	2975	8.3	4457	9.3	3321	9.3
63	Panki-Kalyanpur Road (Near Rk Puram)	11398	8133	949	8.3	676	8.3	1098	9.6	790	9.7
64	Sardar Patel Chowk (Vijay Nagar – Kalyanpur Road)	24722	19863	2999	12.1	2377	12.0	1722	7.0	1314	6.6

SN	Location Name	Total Traffic		Morning Peak				Evening Peak			
		Veh.	PCUs	(Veh.)	% of Total Traffic	(PCU's)	% of Total Traffic	(Veh.)	% of Total Traffic	(PCU's)	% of Total Traffic
65	Sarvoday Nagar Chowk (Near J.K.Mandir)	57678	45316	4682	8.1	3662	8.1	4801	8.3	3701	8.2
66	Devki Nagar Chowk (Near Regional Labour Institute)	40117	33034	3543	8.8	2770	8.4	3283	8.2	2585	7.8
67	Double Pulia Chowk	30705	23299	2577	8.4	1973	8.5	2813	9.2	2023	8.7
68	Chawla Market Chowk, Govind Nagar	54478	41096	4516	8.3	3213	7.8	5444	10.0	3854	9.4
69	Maswanpur Chowk (Vijay Nagar – Kalyanpur Road)	22882	17108	1895	8.3	1385	8.1	1955	8.5	1393	8.1
70	Ganga Ghat Police Chowki	35317	24323	3194	9.0	2120	8.7	3113	8.8	2118	8.7
71	Panchakki Chowk	57364	45650	5437	9.5	4120	9.0	4544	7.9	3728	8.2
72	McRobertganj Chowk (Near K.D. Palace)	18687	13258	1778	9.5	1209	9.1	1429	7.6	995	7.5
73	Dalel Ka Purwa Chowk	32759	30981	3710	11.3	3219	10.4	2319	7.1	2481	8.0
74	Deputy Padav Chowk	49611	41801	4142	8.3	3445	8.2	4265	8.6	3416	8.2
75	Brahm Nagar Chowk	32139	24974	2995	9.3	2380	9.5	3251	10.1	2352	9.4
76	Ghantaghar Chauraha	109167	99279	9322	8.5	8422	8.5	9629	8.8	8623	8.7
77	Bans Mandi Chowk	27826	28116	2283	8.2	2272	8.1	3416	12.3	3387	12.0
78	Murray Company Chowk	34885	29804	2638	7.6	2315	7.8	3383	9.7	2906	9.8
79	Mulganj Chauraha	57120	50058	5114	9.0	4424	8.8	4819	8.4	4135	8.3
80	Shuklaganj Chowk	29656	22261	2173	7.3	1726	7.8	2489	8.4	1891	8.5

iii. Classified Traffic Volume Counts at Outer Cordon Locations

The classified traffic volume counts were carried out at 10 outer cordon locations to assess the intensity of the traffic entering and leaving the study area. Outer Cordon survey locations of are shown in **Figure 3.4.**

FIGURE 3.4: OUTER CORDON LOCATIONS



Average Daily (24 hours) and Peak Hour Traffic Characteristics

Total daily and peak hour traffic at 10 locations is presented in **Table 3.4**. It is observed that the traffic at different locations varies from 4,204 Vehicle (4,062 PCUs) at SH-17 Ramaipaur Jahanabad Road (Near Navada Village) to 22,865 Vehicle (28,922 PCU's) at NH-25 Gandhigram -Unnao Road (Near Jajmau Ganga Bridge).

The morning peak hour volume varies from 366 PCUs (489 vehicles) at Bithoor-Mandhana Road (Near Bithoor) to 2,083 PCUs (1,823 vehicles) at NH-02-Kanpur-Auraya Road (Near Akbarpur Kanpur Dehat).

TABLE 3.4: INTENSITY AND DIRECTIONAL DISTRIBUTION OF TRAFFIC AT OUTER CORDON LOCATIONS

SN	Name of Outer Cordon Location	Total Traffic		Morning Peak				Evening Peak				Directional Distribution			
		(Veh.)	(PCU's)	(Veh.)	% of Total Traffic	(PCU's)	% of Total Traffic	(Veh.)	% of Total Traffic	(PCU's)	% of Total Traffic	Peak Direction (PCUs)	%	Off Peak Direction (PCUs)	%
1	NH-2 Kanpur-Auraiya Road (Near Akbarpur Kanpur Dehat)	19588	26680	1823	9.31	2083	7.81	1284	6.56	1334	5.00	1220	58.57	860	41.43
2	NH-25 Kanpur Jhansi Road (Near Namstey Milk Dairy Kanpur Dehat)	14743	22479	1320	8.95	1727	7.68	809	5.49	1286	5.72	891	51.59	836	48.41
3	NH-86-Kanpur -Ghatampur Road (Near Bhidhnu)	17725	22980	1425	8.04	1495	6.51	1289	7.27	1424	6.20	788	52.71	707	47.29
4	SH-17 Ramaipaur Jahanabad Road (Near Navada Village)	4204	4062	446	10.61	399	9.81	389	9.25	320	7.88	221	55.46	178	44.54
5	NH-2 Kanpur-Fatehpur Road (Near Purvamir Chowki Thana Maharajpur)	10229	15200	792	7.74	967	6.36	662	6.47	966	6.35	504	52.15	463	47.85
6	NH-25 Gandhigram -Unnao Road (Near Jaajmau Ganga Bridge)	22865	28922	1706	7.46	1884	6.51	1587	6.94	1650	5.70	988	52.46	896	47.54
7	SH-58 Shuklaganj Unnao Road (Near Habatpur Shuklaganj)	18947	15600	1640	8.66	1202	7.70	1871	9.87	1471	9.43	851	57.85	620	42.15
8	Bithoor-Mandhana Road (Near Bithoor)	5706	4388	489	8.57	366	8.33	546	9.57	415	9.46	215	51.81	201	48.19
9	NH-91 Kanpur-Kannauj (Near Chaubepur)	18315	21042	1503	8.21	1387	6.59	1221	6.67	1168	5.55	747	53.88	640	46.12
10	SH-17 Shivli-Kalyanpur Road (Near Baghpur)	9308	7907	873	9.38	776	9.81	947	10.17	867	10.97	474	54.67	394	45.33

3.1.3.2 Road Side Origin and Destination Interviews at Outer Cordon Locations

Purpose wise distribution of passengers at outer cordon locations is given in **Table 3.5** and **Figure 3.5**. It is observed that the share of work purpose trips is about 48% followed by about 25% for business purposes. The educational trips contribute 4.1%.

TABLE 3.5: DISTRIBUTION OF OUTER CORDON PASSENGERS BY TRIP PURPOSE

Mode	Trip Purpose						Total
	Work	Business	Education	Social	Tourist	Others	
Car	45867	30084	4428	7525	11240	10798	109943
2-Wheeler	38735	18391	4770	5364	5040	7728	80027
Auto	32547	11772	833	1362	3693	3975	54182
Total	117148	60247	10030	14251	19973	22502	244151
Composition (%)	**48.0**	**24.7**	**4.1**	**5.8**	**8.2**	**9.2**	**100.0**

FIGURE 3.5: DISTRIBUTION OF OUTER CORDONPASSENGERS BY TRIP PURPOSE

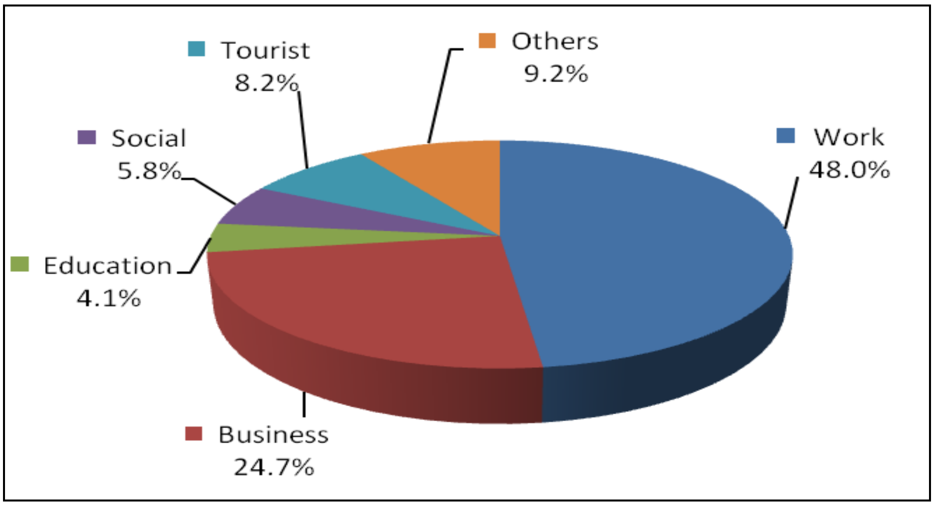
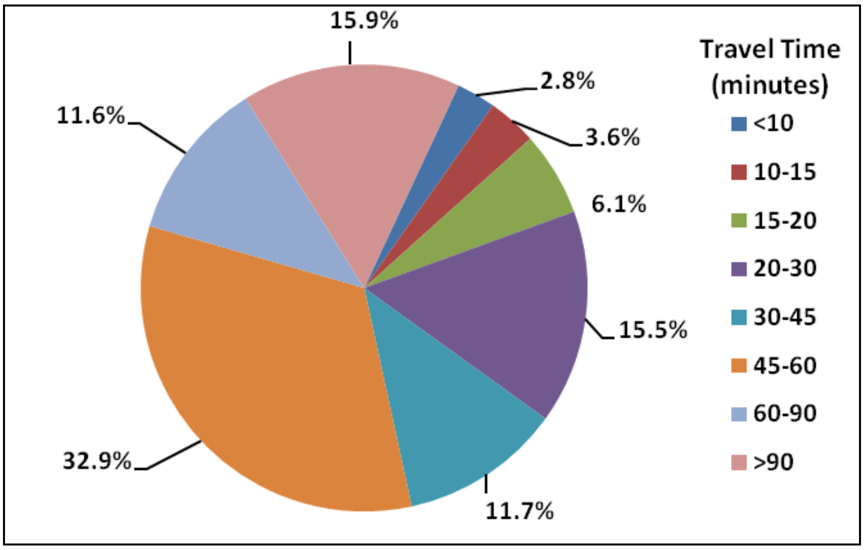


TABLE 3.6: DISTRIBUTION OF OUTER CORDON PASSENGERS BY TRAVEL TIME

Mode	Distribution of Trips by Travel Time (In minutes)								Total
	<10	10-15	15-20	20-30	30-45	45-60	60-90	>90	
Car	2274	2738	3347	11322	11825	29726	14883	33829	109943
2-Wheeler	4651	5861	6400	15022	9304	24890	9029	4870	80027
Auto	0	114	5127	11473	7335	25695	4437	0	54182
Total	6925	8713	14874	37817	28464	80311	28349	38698	244151
Composition (%)	**2.8**	**3.6**	**6.1**	**15.5**	**11.7**	**32.9**	**11.6**	**15.9**	**100.0**

FIGURE 3.6: DISTRIBUTION OF OUTER CORDON PASSENGERS BY TRAVEL TIME



It is observed from **Table 3.6** and **Figure 3.6** that about 16% of total passengers Travel Time is 20-30 minutes and about 33% travel time is 45-60 and nearly 16% travel time is more than 90 minutes at outer cordon locations.

Distribution of Passengers by trip length is presented in **Table 3.7** and it is observed that 6.5% of Passengers Trip length is less than 5 kms. About 15% trip length is 5-10 Kms. & 45% trip length more than 30 Kms.

TABLE 3.7: DISTRIBUTION OF OUTER CORDON PASSENGERS BY TRIP LENGTH

Mode	Distribution of Trips by Travel Distance (In Km)								Total
	<5	5-8	8-10	10-15	15-20	20-25	25-30	>30	
Car	4189	5366	3357	5036	5599	4927	7929	73539	109943
2-Wheeler	10072	8573	5029	7084	5981	5830	6885	30573	80027
Auto	1548	7244	7181	12520	10108	5490	4588	5504	54182
Total	15810	21183	15567	24639	21688	16247	19402	109615	244151
Composition (%)	**6.5**	**8.7**	**6.4**	**10.1**	**8.9**	**6.7**	**7.9**	**44.9**	**100.0**

3.1.3.3 Willingness to Pay/Use Surveys

This section focused on the opinion of users with respect to various characteristics of a new mass transit system in Kanpur. The respondents at various bus terminals, rail terminals and PT/IPT stops were queried with regard to preference for a good public transport system along with the quantum of extra fare they are willing to pay.

i. Willingness to Pay Survey at Bus Terminals

It is observed that 6956 (92.9%) of bus passengers have willingness to shift to MRTS which gives them comparatively superior travelling experience.

The willingness to pay extra fare for reaching bus terminal is presented in **Table 3.8**. The result indicates that about 26% respondents want the existing fare for new public transport as same as existing fare. Only 6.6% of respondents are showing their willingness to pay more than Rs.10 as extra fare for Metro system in comparison to existing fare.

TABLE 3.8: WILLINGNESS TO PAY EXTRA FARE FOR REACHING BUS TERMINAL

Parameters	Same as Existing Mode Fare	Extra as compared to Existing Mode Fare (Rs.)								Total
		2	5	10	12	15	20	25	>25	
Bus Passengers	1830	1744	2382	537	316	36	63	34	14	6956
Composition (%)	26.3	25.0	34.2	7.7	4.5	0.5	0.9	0.5	0.2	100.0

ii. Willingness to Pay Survey at Rail Terminals

It is observed that about 30,000 (75%) of rail passengers have willingness to shift to MRTS. The willingness to pay extra fare to reach rail terminal by MRTS System is presented in **Table 3.9**. The result indicates that about 28% respondents want the existing fare for new public transport as same as existing fare and only 18% are willing to pay Rs.10 or more as extra fare.

TABLE 3.9: WILLINGNESS TO PAY EXTRA FARE FOR REACHING RAIL TERMINAL

Parameters	Same as Existing Mode Fare	Extra as compared to Existing Mode Fare (Rs.)								Total
		2	5	10	12	15	20	25	>25	
Rail Passengers	8261	9423	6880	2163	1452	836	424	445	85	29969
Composition (%)	27.6	31.4	23.0	7.2	4.8	2.8	1.4	1.5	0.3	100.0

iii. Willingness to Pay Survey at PT/IPT Stops

It is observed that about 56200 (95%) of surveyed passengers have willingness to shift to MRTS System. The willingness to pay extra fare for MRTS System is presented in **Table 3.10**. The result indicates that about 26% respondents want the existing fare for new public transport as same as existing fare and 17% are willing to pay Rs.10 as extra fare. And, low share of about 6% of respondents show their willingness to pay more than Rs.10 as extra fare for Metro system in comparison to existing fare.

TABLE 3.10: WILLINGNESS TO PAY EXTRA FARE FOR MRTS

Parameters	Same as Existing PT/IPT Fare	Extra as compared to Existing PT/IPT Fare (Rs.)								Total
		2	5	10	12	15	20	25	>25	
PT/IPT Passengers	14273	19636	9479	9475	2244	548	171	161	181	56167
Composition (%)	25.4	35.0	16.9	16.9	4.0	1.0	0.3	0.3	0.3	100.0

3.1.3.4 Speed-Delay Surveys

The Speed and delay survey was conducted along the network using the running car method during peak and off-peak periods. The results of the survey with respect to the journey and running speed and delays are presented in the following paragraphs.

i. Journey Speed

The journey speed characteristics during peak period are presented in **Table 3.11.** It can be observed that about 16% of the road network has journey speeds less than 20 kmph during peak hours. About 12% of network has journey speeds more than 40 kmph. Average Journey Speed in the network is observed to be 25.1 kmph.

TABLE 3.11: DISTRIBUTION OF ROAD LENGTH BY PEAK HOUR JOURNEY SPEED

SN	Journey Speed (Kmph)	Road Length (Km)	Percentage (%)
1	<10	26.5	4.3
2	10-20	70.8	11.3
3	21-30	240.2	38.5
4	31-40	212.6	34.1
5	>40	74.2	11.9
	Total	**624.3**	**100.0**

ii. Running Speed

The running speed characteristics during peak period are presented in **Table 3.12**. It can be observed that about 75% of the road network has running speeds between 20-40 kmph during peak hours.

TABLE 3.12: DISTRIBUTION OF ROAD LENGTH BY PEAK HOUR RUNNING SPEED

SN	Running Speed (Kmph)	Road Length (Km)	Percentage (%)
1	<10	0.0	0.0
2	10-20	31.3	5.0
3	21-30	161.0	25.8
4	31-40	305.9	49.0
5	>40	126.1	20.2
	Total	**624.3**	**100.0**

iii. Delays

The distribution of causes of delays & their duration during peak hours and off-peak hours is presented in **Table 3.13**. The analysis of causes of delays reveal that the delays are caused mostly by traffic congestion which account for about 74% in the peak hour, while traffic signal with congestion account for 22.7%. Whereas in the off peak period, traffic congestion account for 57.6%.

TABLE 3.13: DISTRIBUTION OF CAUSES AND DELAYS IN PEAK & OFF PEAK HOURS

SN	Causes and Delays	Peak Hour		Off Peak Hour	
		No. of Points	%	No. of Points	%
1	Traffic Signals	6	3.2	10	11.8
2	Traffic Congestion	136	73.5	49	57.6
3	Traffic Signal + Congestion	42	22.7	24	28.2
4	Railway Crossing	1	0.5	2	2.4
Total		**185**	**100.0**	**85**	**100.0**

3.1.3.5 Parking Surveys

The Parking surveys have been conducted at 80 locations at identified on-street parking streches on major arterial and sub-arterial roads and at major existing off-street parking lots in the study area for 12 hours (8 a.m. to 8 p.m.) on fair weather working day.

i. Parking Accumulation

The observed peak parking accumulation along the surveyed locations is presented in **Table 3.14**. The total peak parking accumulation at the surveyed locations was observed to be with maximum concentration being at Kanpur Central Railway station City Side (486 E.C.S.).

TABLE 3.14: PEAK HOUR PARKING ACCUMULATION

Loc. No.	Name of Location	Time	Side	Peak Accumulation					Equivalent Car Spaces (ECS)	Parking Type
				Car	2 W	Auto	Bus	Cycle		
1	Kanpur Central Railway station (Cantt. Side)	1430-1500	Both	70	45	8	0	11	85	Off Street
2	Kanpur Central Railway station (Cantt. Side)	1030-1100	Both	18	25	24	0	6	41	Off Street
3	Kanpur Central Railway station (Cantt. Side)	1600-1630	Both	70	70	16	0	11	93	Off Street
4	Kanpur Central Railway station (Cantt. Side)	1100-1130	Both	5	590	3	0	60	158	Off Street
5	Kanpur Central Railway station (City Side)	1030-1100	Both	1	1605	2	0	500	486	Off Street
6	Kanpur Central Railway station (City Side)	1030-1100	Both	75	9	32	0	6	108	Off Street
7	Kanpur Central Railway station (City Side)	1000-1030	Both	90	6	35	0	5	121	Off Street
8	Express Road (Ganta Ghar To D.S. Trading Company)	1030-1100	Both	35	117	6	0	47	70	On Street
9	Express Road (D.S. Trading Company To Shri Sani Devi Mandir)	1230-1300	Both	96	105	6	0	17	123	On Street
10	Express Road (Shri Sani Devi Mandir To Orai Transport LTD)	1700-1730	Both	78	80	5	0	34	99	On Street
11	Express Road (Orai Transport To Reliance Mobile Showroom)	1530-1600	Both	120	130	4	0	25	146	On Street
12	Express Road (Reliance Mobile Showroom To Janta Tower)	1000-1030	Both	74	140	5	0	63	111	On Street
13	Express Road (Janta Tower To Vasan Eye Care ,Mall Road)	1200-1230	Both	78	150	3	0	50	123	On Street
14	Mall Road (Rita Hotel To LIC Building)	1500-1530	Both	100	130	3	0	30	131	On Street
15	Mall Road (PNB Bank To Bank Of Baroda)	1700-1730	Both	190	180	5	0	36	237	On Street
16	Mall Road (Bank of Baroda To Relend Tower)	1430-1500	Both	50	140	2	0	36	83	On Street
17	Mall Road (Kodak Mahindra Bank To BSNL Tower)	1730-1800	Both	50	98	3	0	24	67	On Street
18	Mall Road (BSNL Tower To Bhrat DP)	1230-1300	Both	46	101	3	0	12	69	On Street

Loc. No.	Name of Location	Time	Side	Peak Accumulation					Equivalent Car Spaces (ECS)	Parking Type
				Car	2 W	Auto	Bus	Cycle		
19	Mall Road (Bhrat DP Bada Chowk)	1030-1100	Both	45	96	2	0	35	70	On Street
20	Mall Road (Bada Chowk To Ursala Hospital)	1700-1730	Both	15	18	5	0	18	22	On Street
21	Mall Road (Ursula Hospital To Klyan Ji Bakery)	1800-1830	Both	95	380	3	0	37	182	On Street
22	Mall Road (Klyan Ji Bakery To Parade Chowk)	1100-1130	Both	153	278	2	0	32	211	On Street
23	Mall Road (Parade Chowk To Volkswagan Car Showroom)	1030-1100	Both	68	150	3	0	41	111	On Street
24	Mall Road (Volkswagan Car Showroom To Bijli Ghar)	1430-1500	Both	74	125	3	0	98	109	On Street
25	Mall Road (Bijli Ghar To Lal imli Chowk)	1700-1730	Both	15	15	3	0	15	20	On Street
26	Mall Road (HP Petrol Pump To Chunni Ganj)	1200-1230	Both	35	111	3	0	27	60	On Street
27	Mall Road (Chunniganj To Bakarganj Mandi)	1700-1730	Both	45	85	3	0	78	70	On Street
28	Mall Road (Bakarganj Mandi To Eidgah)	1100-1130	Both	25	78	2	4	89	65	On Street
29	Mall Road (Eidgah To Indian Oil Petrol Pump)	1700-1730	Both	110	253	3	0	45	173	On Street
30	Mall Road (Oil Petrol Pump To Arya Nagar Chowk)	1700-1730	Both	45	53	3	0	42	66	On Street
31	Mall Road (Arya Nagar Chowk To HP Service Center)	1730-1800	Both	24	60	2	0	8	38	On Street
32	Mall Road (HP Service Center To Sahu Ji Maharaj dwar)	1600-1630	Both	28	95	2	0	26	48	On Street
33	Mall Road (Sahu Ji Maharaj dwar To Kali Mathiya Mandir)	1600-1630	Both	36	135	2	0	29	71	On Street
34	Mall Road (Kali Mathiya Mandir To Kotwali Swaroop Nagar)	1030-1100	Both	95	35	3	0	5	103	On Street
35	Mall Road (Kotwali Swaroop Nagar To Sarvodya Nagar)	1100-1130	Both	8	145	3	0	42	47	On Street
36	NH-91 Jareeb Chowki To Renault Car Showroom)	1030-1100	Both	74	150	8	0	20	111	On Street
37	NH-91 (Renault Car Showroom To Space Style Furniture)	1100-1130	Both	30	78	6	0	20	46	On Street

Loc. No.	Name of Location	Time	Side	Peak Accumulation					Equivalent Car Spaces (ECS)	Parking Type
				Car	2 W	Auto	Bus	Cycle		
38	NH-91 (Space Style Furniture To Gurdwara Sahib Kritan Ghad)	1600-1630	Both	36	138	5	0	21	70	On Street
39	NH-91 (Gurdwara Sahib Kritan Ghad To Hotel Khana Glaxy)	1600-1630	Both	86	168	15	0	23	139	On Street
40	NH-91 (Hotel Khana Glaxy To vishal Mega Mall)	1000-1030	Both	160	260	2	0	35	218	On Street
41	Gumti No.05 Market Road (NH-91 Gurdwara Sahib Kritan Ghad To Muthoot Finance)	1100-1130	Both	150	300	15	0	35	227	On Street
42	Gumti No.05 Market Road (Muthoot Finance To Bank of Baroda)	1730-1800	Both	180	350	22	0	65	295	On Street
43	Gumti No.05 Market Road (Bank of Baroda To Sant Nagar Chowk)	1800-1830	Both	45	300	9	0	50	126	On Street
44	Gumti No.05 Market Road (Sant Nagar Chowk To Fazal Ganj)	1030-1100	Both	65	300	6	0	47	143	On Street
45	Halsi Road (Ganta Ghar To Vijya Bank)	1130-1200	Both	25	210	9	0	25	79	On Street
46	Halsi Road (Vijya Bank To UCO Bank)	1130-1200	Both	75	207	3	0	36	132	On Street
47	Halsi Road (UCO Bank To PNB Bank)	1200-1230	Both	250	270	8	0	63	323	On Street
48	Halsi Road (PNB Bank To Mulganj Chowk)	1200-1230	Both	300	500	8	0	65	431	On Street
49	Halsi Road (Mulganj Chowk To Kuraan Masjid)	1230-1300	Both	64	352	15	0	65	163	On Street
50	Halsi Road (Kuraan Masjid To Sunahri Masjid)	1100-1130	Both	73	250	5	0	35	138	On Street
51	Halsi Road (Sunahri Masjid To Daya Ram Sweets house)	1500-1530	Both	90	220	4	0	35	146	On Street
52	Railway Road (Ganta Ghar To Central Mall Godown)	1030-1100	Both	47	195	8	0	55	110	On Street
53	Railway Road (Central Mall Godown To Bans Mandi)	1700-1730	Both	135	260	9	0	50	212	On Street
54	Railway Road (Bans Mandi To Deputy Padav Chowk)	1230-1300	Both	142	202	8	0	66	208	On Street

Loc. No.	Name of Location	Time	Side	Peak Accumulation					Equivalent Car Spaces (ECS)	Parking Type
				Car	2 W	Auto	Bus	Cycle		
55	Railway Road (Sleep well shoppe To Jareeb Chowki)	1800-1830	Both	60	145	8	0	15	102	On Street
56	NH-25 Kalpi Road (Jareeb Chowki To Hotel Sheela)	1200-1230	Both	25	80	5	0	11	44	On Street
57	NH-25 Kalpi Road (Hotel Sheela To Shri Lagan Sharee)	1300-1330	Both	24	85	6	0	25	47	On Street
58	NH-25 Kalpi Road (Shri Lagan Sharee To Rza Jama Masjid)	1400-1430	Both	47	85	11	0	27	75	On Street
59	NH-25 Kalpi Road (Raza Jama Masjid To Fazal Ganj)	1730-1800	Both	32	149	5	3	45	82	On Street
60	NH-25 Kalpi Road (Fazal Ganj To RSPL)	1530-1600	Both	120	280	3	0	15	186	On Street
61	NH-25 Kalpi Road (RSPL To Tata Motor)	1700-1730	Both	75	185	2	0	45	117	On Street
62	NH-25 Kalpi Road (Tata Moter To Hotel Namaskar)	1530-1600	Both	50	145	2	0	40	87	On Street
63	NH-25 Kalpi Road (Hotel Namaskar To Vijay Nagar)	1630-1700	Both	47	185	11	2	35	102	On Street
64	NH-86 Hamirpur Road (NH-02 To Morang Mandi Chowk)	1530-1600	Both	41	150	47	2	23	116	On Street
65	NH-86 Hamirpur Road (Morang Mandi Chowk to HP Petrol Pump)	1600-1630	Both	64	140	16	0	12	106	On Street
66	NH-86 Hamirpur Road (HP Petrol Pump to Indian Oil Petrol Pump)	1530-1600	Both	31	168	2	0	24	69	On Street
67	NH-86 Hamirpur Road (Indian Oil Petrol Pump To Shiv Mandir)	1630-1700	Both	35	65	1	0	50	56	On Street
68	NH-86 Hamirpur Road (Shiv Mandir To Gaushala Chowk)	1630-1700	Both	28	77	6	0	21	48	On Street
69	NH-86 Hamirpur Road (Gaushala Chowk To Cera Interprises)	1530-1600	Both	33	165	1	0	150	100	On Street
70	NH-86 Hamirpur Road (Cera Interprises Thana Juhi)	1730-1800	Both	46	140	52	9	45	143	On Street
71	NH-86 Hamirpur Road (Thana Juhi To Baradevi)	1530-1600	Both	30	150	15	0	48	81	On Street
72	NH-86 Hamirpur Road (Baradevi To Jai Motor)	1730-1800	Both	16	165	30	0	50	110	On Street

Loc. No.	Name of Location	Time	Side	Peak Accumulation					Equivalent Car Spaces (ECS)	Parking Type
				Car	2 W	Auto	Bus	Cycle		
73	NH-86 Hamirpur Road (Jai Motor To Swadesi Cotton Mill)	1130-1200	Both	16	54	9	0	21	38	On Street
74	NH-86 Hamirpur Road (Swadesi Cotton Mill To Police Chowki Military Camp)	1700-1730	Both	35	98	11	0	37	67	On Street
75	NH-86 Hamir Pur Road (Police Chowki Maletry Camp To Shiv Mandir)	1500-1530	Both	25	120	5	0	31	55	On Street
76	NH-86 Hamirpur Road (Shiv Mandir To Railway Crossing)	1700-1730	Both	16	140	5	0	25	55	On Street
77	NH-86 Hamir Pur Road (Railway Crossing To Afim Khothi)	1500-1530	Both	15	60	0	0	45	32	On Street
78	NH-86 Hamirpur Road (Afim Kothi To Eldeco Garden Apartment)	1600-1630	Both	25	142	1	0	76	70	On Street
79	NH-86 Hamir Pur Road (Eldeco Garden Apartment To Bajrang Bali Baba Mandir)	1630-1700	Both	11	99	0	0	85	50	On Street
80	NH-86 Hamirpur Road (Bajrang Bali Baba Mandir To Deputy Padav)	1330-1400	Both	15	85	15	0	21	47	On Street
Grand Total				**5151**	**13900**	**646**	**20**	**3473**	**9217**	

ii. Parking Demand

The total parking demand at the surveyed locations is presented below in Error! Not a valid bookmark self-reference.. The total parking demand over the day at the main parking stretches was observed to be about 4320 E.C.S. with maximum demand being observed at Halsi Road (PNB Bank to Mulganj Chowk).

TABLE 3.15: PARKING DEMAND

Loc. No	Name of Location	Car	2-Whlr	Parking Demand (ECS)
1	Kanpur Central Railway station (Cantt. Side)	451	218	506
2	Kanpur Central Railway station (Cantt. Side)	57	80	77
3	Kanpur Central Railway station (Cantt. Side)	370	228	427
4	Kanpur Central Railway station (Cantt. Side)	12	2016	516
5	Kanpur Central Railway station (City Side)	4	7252	1817
6	Kanpur Central Railway station (City Side)	1072	18	1077
7	Kanpur Central Railway station (City Side)	329	24	335
8	Express Road (Ganta Ghar To D.S. Trading Company)	193	940	428
9	Express Road (D.S. Trading Company To Shri Sani Devi Mandir)	761	772	954
10	Express Road (Shri Sani Devi Mandir To Orai Transport LTD)	494	589	641
11	Express Road (Orai Transport LTD To Reliance Mobile Showroom)	947	951	1185
12	Express Road (Reliance Mobile Showroom To Janta Tower)	498	1162	789
13	Express Road (Janta Tower To Vasan Eye Care ,Mall Road)	592	1068	859
14	Mall Road (Rita Hotel To LIC Building)	867	813	1070
15	Mall Road (PNB Bank To Bank Of Baroda)	1375	1275	1694
16	Mall Road (Bank of Baroda To Relend Tower)	280	846	492
17	Mall Road (Kodak Mahindra Bank To BSNL Tower)	366	526	498
18	Mall Road (BSNL Tower To Bhrat DP)	322	1084	593
19	Mall Road (Bhrat DP Bada Chowk)	320	776	514
20	Mall Road (Bada Chowk To Ursala Hospital)	111	97	135
21	Mall Road (Ursula Hospital To Klyan Ji Bakery)	612	2973	1355
22	Mall Road (Klyan Ji Bakery To Parade Chowk)	1428	2300	2003
23	Mall Road (Parade Chowk To Volkswagan Car Showroom)	577	1352	915
24	Mall Road (Volkswagan Car Showroom To Bijli Ghar)	570	1337	904
25	Mall Road (Bijli Ghar To Lal imli Chowk)	116	108	143
26	Mall Road (HP Petrol Pump To Chunni Ganj)	204	962	445
27	Mall Road (Chunniganj To Bakarganj Mandi)	268	633	426
28	Mall Road (Bakarganj Mandi To Eidgah)	182	394	281

Loc. No	Name of Location	Car	2-Whlr	Parking Demand (ECS)
29	Mall Road (Eidgah To Indian Oil Petrol Pump)	979	2749	1666
30	Mall Road (Oil Petrol Pump To Arya Nagar Chowk)	313	437	422
31	Mall Road (Arya Nagar Chowk To HP Service Center)	110	437	219
32	Mall Road (HP Service Center To Chatra Pati Sahu Ji Maharaj dwar)	255	484	376
33	Mall Road (Chatra Pati Sahu Ji Maharaj dwar To Kali Mathiya Mandir)	300	1521	680
34	Mall Road (Kali Mathiya Mandir To Kotwali Swaroop Nagar)	466	103	492
35	Mall Road (Kotwali Swaroop Nagar To Sarvodya Nagar)	30	31	38
36	NH-91 Jareeb Chowki To Renault Car Showroom)	455	1466	822
37	NH-91 (Renault Car Showroom To Space Furniture Showroom)	8	408	110
38	NH-91 (Space Furniture Showroom To Gurdwara Sahib Kritan Ghad)	187	1004	438
39	NH-91 (Gurdwara Sahib Kritan Ghad To Hotel Khana Glaxy)	762	1812	1215
40	NH-91 (Hotel Khana Glaxy To vishal Mega Mall)	1559	2383	2155
41	Gumti No.05 Market Road (NH-91 Gurdwara Sahib Kritan Ghad To Muthoot Finance)	1458	2754	2147
42	Gumti No.05 Market Road (Muthoot Finance To Bank Of Baroda)	1466	3031	2224
43	Gumti No.05 Market Road (Bank Of Baroda To Sant Nagar Chowk)	236	2664	902
44	Gumti No.05 Market Road (Sant Nagar Chowk To Fazal Ganj)	549	2629	1206
45	Halsi Road (Ganta Ghar To Vijya Bank)	128	1904	604
46	Halsi Road (Vijya Bank To UCO Bank)	630	1688	1052
47	Halsi Road (UCO Bank To PNB Bank)	2336	2347	2923
48	Halsi Road (PNB Bank To Mulganj Chowk)	3105	4858	4320
49	Halsi Road (Mulganj Chowk To Kuraan Masjid)	743	3083	1514
50	Halsi Road (Kuraan Masjid To Sunahri Masjid)	658	2679	1328
51	Halsi Road (Sunahri Masjid To Daya Ram Sweets house)	758	2097	1282
52	Railway Road (Ganta Ghar To Central Mall Godown)	439	1982	935
53	Railway Road (Central Mall Godown To Bans Mandi)	1718	2707	2395
54	Railway Road (Bans Mandi To Deputy Padav Chowk)	1660	2224	2216
55	Railway Road (Sleep well shoppe To Jareeb Chowki)	403	1364	744
56	NH-25 Kalpi Road (Jareeb Chowki To Hotel Sheela)	181	429	288
57	NH-25 Kalpi Road (Hotel Sheela To Shri Lagan Sharee)	172	610	325
58	NH-25 Kalpi Road (Shri Lagan Sharee To Rza Jama Masjid)	341	724	522
59	NH-25 Kalpi Road (Raza Jama Masjid To Fazal Ganj)	258	1498	633
60	NH-25 Kalpi Road (Fazal Ganj To RSPL)	933	2758	1623
61	NH-25 Kalpi Road (RSPL To Tata Motor)	605	1553	993
62	NH-25 Kalpi Road (Tata Moter To Hotel Namaskar)	351	1544	737

Loc. No	Name of Location	Car	2-Whlr	Parking Demand (ECS)
63	NH-25 Kalpi Road (Hotel Namaskar To Vijay Nagar)	291	1811	744
64	NH-86 Hamirpur Road (NH-02 To Morang Mandi Chowk)	267	1649	679
65	NH-86 Hamirpur Road (Morang Mandi Chowk To HP Petrol Pump)	536	1563	927
66	NH-86 Hamirpur Road (HP Petrol Pump To Indian Oil Petrol Pump)	262	1542	648
67	NH-86 Hamirpur Road (Indian Oil Petrol Pump To Dana Dan Shiv Mandir)	254	473	372
68	NH-86 Hamirpur Road (Dana Dan Shiv Mandir To Gaushala Chowk)	234	727	416
69	NH-86 Hamirpur Road (Gaushala Chowk To Cera Interprises)	235	1849	697
70	NH-86 Hamirpur Road (Cera Interprises Thana Juhi)	409	1537	793
71	NH-86 Hamirpur Road (Thana Juhi To Baradevi)	263	1493	636
72	NH-86 Hamirpur Road (Baradevi To Jai Motor)	354	1695	778
73	NH-86 Hamirpur Road (Jai Motor To Swadesi Cotton Mill)	86	440	196
74	NH-86 Hamirpur Road (Swadesi Cotton Mill To Police Chowki Military Camp)	292	959	532
75	NH-86 Hamir Pur Road (Police Chowki Maletry Camp To Shiv Mandir)	238	1258	553
76	NH-86 Hamirpur Road (Shiv Mandir To Railway Crossing)	102	1305	428
77	NH-86 Hamir Pur Road (Railway Crossing To Afim Khothi)	74	444	185
78	NH-86 Hamirpur Road (Afim Kothi To Eldeco Garden Apartment)	160	1551	548
79	NH-86 Hamir Pur Road (Eldeco Garden Apartment To Bajrangbali Mandir)	50	638	210
80	NH-86 Hamirpur Road (Bajrang Bali Baba Mandir To Deputy Padav)	117	546	254

3.1.3.6 Public Transport & IPT Surveys

The following public transport surveys were conducted as part of the study:

- Bus Terminal Surveys
- Rail Terminal Surveys
- Bus/Tempo Stop Surveys

i. Bus Terminal Surveys

A total of 5 Bus terminals were selected to conduct in and out, Origin-Destination, Opinion and Willingness to Pay Surveys within study area. It is observed from **Table 3.16** that Jhakarkati Bus Terminal caters to the maximum number of passengers with 4,843 Boarding & 3,960 Alighting.

TABLE 3.16: DISTRIBUTION OF PASSENGERS AT BUS TERMINALS

SN	Name of Location	Total Boarding	Total Alighting	Total	Peak Time	Peak Hour Boarding	Peak Hour Alighting	Peak Hour
1	Jhakarkati	4843	3960	8803	18:45-19:45	348	313	661
2	Fazalganj	789	248	1037	17:15-18:15	56	26	82
3	Chunniganj	219	72	291	10.00-11.00	31	9	40
4	Rawatpur	1198	874	2072	10.00-11.00	130	156	286
5	Juhi	437	370	807	17:45-18:45	34	49	83

3.1.4 Origin – Destination, Opinion & Willingness to Pay Survey at Bus Terminals

It is observed from **Table 3.17** that the share of service purpose trips is about 24%, followed by business trips which contribute to 18%. The educational trips and social trips contribute about 14% & 9% respectively. Distribution of passenger trips by purpose is presented in **Figure 3.7.**

TABLE 3.17: DISTRIBUTION OF BUS PASSENGERS BY TRIP PURPOSE

Trip Purpose	Service	Business	Education	Social	Others	Total
Bus Passengers	1797	1370	1076	664	2578	7486
Composition (%)	24.0	18.3	14.4	8.9	34.4	100.0

FIGURE 3.7: DISTRIBUTION OF BUS PASSENGERS BY TRIP PURPOSE

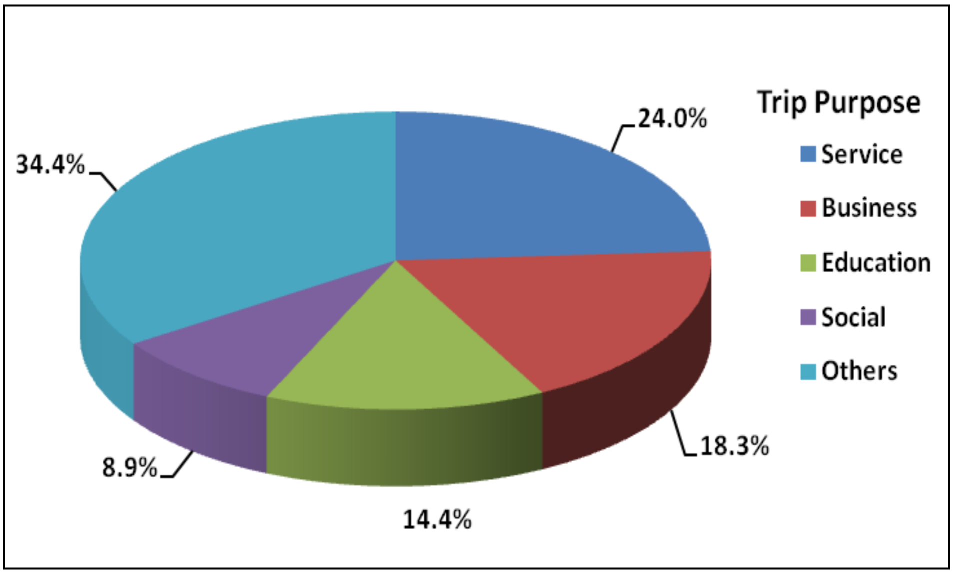


Table 3.18 shows that about 66% of passengers use auto to reach bus terminal. Bus contributes about 24% share while walk trips are only around 4%.

TABLE 3.18: DISTRIBUTION OF BUS PASSENGERS BY MODE TO REACH TERMINAL

Mode	Car	2-Whlr.	Auto	Bus	Mini Bus	Pvt. Bus	Cycle	Rickshaw	Train	Walk	Total
Bus Passengers	96	256	4928	1814	10	0	4	87	0	291	7486
Composition (%)	1.3	3.4	65.8	24.2	0.1	0.0	0.1	1.2	0.0	3.9	100.0

ii. Rail Terminal Surveys

A total of 5 Rail terminals were selected to conduct in and out survey spread over the entire study area. It is observed from **Table 3.19** that Kanpur Central Railway Station caters to the maximum number of passengers with 32,283 Boarding & 30,200 Alighting.

TABLE 3.19: DISTRIBUTION OF PASSENGERS AT RAIL TERMINALS

SN	Name of Location	Total Boarding	Total Alighting	Total	Peak Time	Peak Hour Boarding	Peak Hour Alighting	Peak Hour
1	Kanpur Central	32283	30200	62483	10.00-11.00	2863	3317	6180
2	Rawatpur	1767	1620	3387	9.00-10.00	172	310	482
3	Chakeri	571	409	980	17:30-18:30	75	110	185
4	Govindpuri	2350	2130	4480	9.30-10.30	168	380	548
5	Anwar Ganj	2875	2306	5181	9.00-10.00	306	255	561

3.1.5 Origin – Destination Survey at Rail Terminals

It is observed from **Table 3.20** that the share of educational purpose trips is about 27%, followed by social trips which contribute to 18.3%. Distribution of passenger trips by purpose is presented in **Figure 3.8.**

TABLE 3.20: DISTRIBUTION OF RAIL PASSENGERS BY TRIP PURPOSE

Trip Purpose	Service	Business	Education	Social	Others	Total
Rail Passengers	5029	7828	10863	7285	8848	39853
Composition (%)	12.6	19.6	27.3	18.3	22.2	100.0

FIGURE 3.8: DISTRIBUTION OF RAIL PASSENGERS BY TRIP PURPOSE

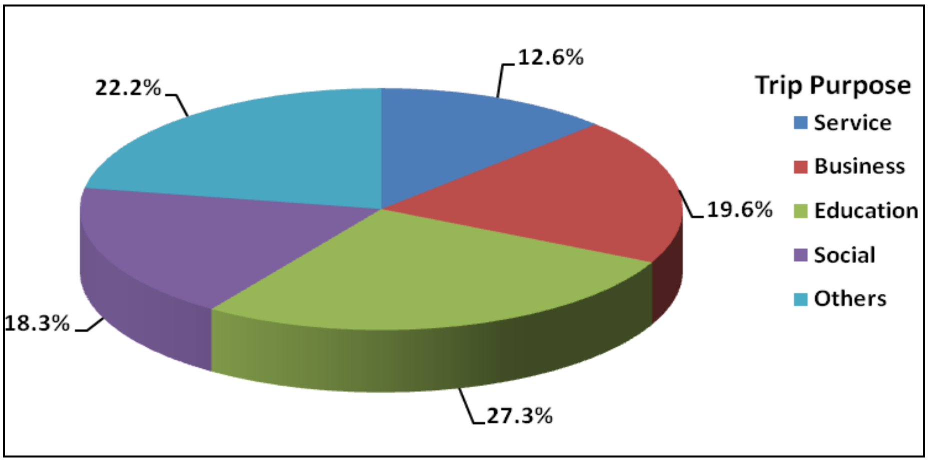


Table 3.21 shows that about 74% of passengers use auto to reach rail terminal. Bus contributes about 12% share while walk trips are only around 4%.

TABLE 3.21: DISTRIBUTION OF RAIL PASSENGERS BY MODE TO REACH TERMINAL

Mode	Car	2W	Auto	Bus	Mini Bus	Cycle	Rickshaw	Train	Walk	Total
Rail Passengers	982	1631	29430	4594	624	9	478	574	1532	39853
Composition (%)	2.5	4.1	73.8	11.5	1.6	0.0	1.2	1.4	3.8	100.0

iii. Bus Stop/Auto Stand/ IPT Surveys

The PT/IPT Stop survey was carried out at various locations to assess the maximum boarding and alighting of passengers at different stops. A total of 100 stops were selected in the entire study area. It is observed from **Table 3.22** that PT/IPT stop at Naubasta caters to the maximum number of passengers/other user viz. 2,664 Boarding & 994 Alighting.

3.1.6 Origin – Destination Survey at PT/IPT Stops

It is observed from **Table 3.23** that the share of service purpose trips is about 29%, followed by educational trips which contribute to 14.5%. Distribution of passenger trips by purpose is presented in **Figure 3.9**.

TABLE 3.22: DISTRIBUTION OF PASSENGERS AT PT/IPT STOPS

SN	Mode	Name of Location	Direction	Total Boarding	Total Alighting	Total (B+A)	Peak Time	Peak Hour Boarding	Peak Hour Alighting	Peak Hour (B+A)
1	Bus/Auto	Ghantaghar	Ghantaghar to Sarvodaya Nagar	1025	729	1754	1130 - 1230	99	72	171
2	Bus/Auto	Ghantaghar	Sarvodaya Nagar to Ghantaghar	925	627	1552	1730 - 1830	92	53	145
3	Bus/Auto	Naronah Choraha Mall Road	Ghantaghar to Sarvodaya Nagar	1014	309	1323	1830 - 1930	122	28	150
4	Bus/Auto	Naronah Choraha Mall Road	Sarvodaya Nagar to Ghantaghar	216	318	534	0945 - 1045	32	32	64
5	Bus/Auto	Mall Road PNB (Opp LIC)	Ghantaghar to Sarvodaya Nagar	376	130	506	1000 - 1100	29	25	54
6	Bus/Auto	Bada Choraha	Ghantaghar to Sarvodaya Nagar	834	541	1375	0945 - 1045	110	85	195
7	Bus/Auto	Bada Choraha	Sarvodaya Nagar to Ghantaghar	534	811	1345	0945 - 1045	74	97	171
8	Bus/Auto	Parade	Ghantaghar to Sarvodaya Nagar	610	338	948	1545 - 1645	67	16	83
9	Bus/Auto	Parade	Sarvodaya Nagar to Ghantaghar	395	714	1109	0930 - 1030	51	98	149
10	Bus/Auto	Lal Imli	Ghantaghar to Sarvodaya Nagar	224	275	499	1745 - 1845	20	39	59
11	Bus/Auto	Lal Imli	Sarvodaya Nagar to Ghantaghar	260	208	468	0930 - 1030	40	31	71
12	Bus/Auto	Chunni Ganj	Ghantaghar to Sarvodaya Nagar	249	397	646	0900 - 1000	37	42	79
13	Bus/Auto	Chunni Ganj	Sarvodaya Nagar to Ghantaghar	349	124	473	0930 - 1030	37	11	48
14	Bus/Auto	Thana Bajaria	Ghantaghar to Sarvodaya Nagar	347	370	717	0900 - 1000	43	41	84
15	Bus/Auto	Thana Bajaria	Sarvodaya Nagar to Ghantaghar	411	285	696	1630 - 1730	36	40	76
16	Bus/Auto	Eidgah	Ghantaghar to Sarvodaya Nagar	194	137	331	0915 - 1015	36	11	47
17	Bus/Auto	Eidgah	Sarvodaya Nagar to Ghantaghar	178	208	386	0915 - 1015	29	20	49
18	Bus/Auto	Harsh Nagar	Ghantaghar to Sarvodaya Nagar	238	190	428	1715 - 1815	41	22	63
19	Bus/Auto	Harsh Nagar	Sarvodaya Nagar to Ghantaghar	306	279	585	1715 - 1815	47	34	81
20	Bus/Auto	Sachendi	Sachendi to Ramadevi	579	62	641	1030 - 1130	73	3	76
21	Bus/Auto	Sachendi	Ramadevi to Sachendi	214	575	789	1715 - 1815	12	98	110
22	Bus/Auto	Chakkar Bus Mandi	Sachendi to Ramadevi	581	357	938	1745 - 1845	81	36	117
23	Bus/Auto	Chakkar Bus Mandi	Ramadevi to Sachendi	465	551	1016	1700 - 1800	70	74	144
24	Bus/Auto	Bhotigaon	Sachendi to Ramadevi	325	257	582	1630 - 1730	29	38	67

SN	Mode	Name of Location	Direction	Total Boarding	Total Alighting	Total (B+A)	Peak Time	Peak Hour Boarding	Peak Hour Alighting	Peak Hour (B+A)
25	Bus/Auto	Bhotigaon	Ramadevi to Sachendi	482	403	885	0930 - 1030	53	41	94
26	Bus/Auto	Bhoti Bypass	Sachendi to Ramadevi	435	284	719	1745 - 1845	52	30	82
27	Bus/Auto	Bhoti Bypass	Ramadevi to Sachendi	529	389	918	0900 - 1000	55	44	99
28	Bus/Auto	Panki Padav	Sachendi to Ramadevi	230	168	398	1800 - 1900	28	24	52
29	Bus/Auto	Lohia Chauraha	Sachendi to Ramadevi	450	344	794	1645 - 1745	75	29	104
30	Bus/Auto	Lohia Chauraha	Ramadevi to Sachendi	366	429	795	0915 - 1015	33	66	99
31	Bus/Auto	Gujani Choraha	Sachendi to Ramadevi	360	341	701	1800 - 1900	41	34	75
32	Bus/Auto	Gujani Choraha	Ramadevi to Sachendi	347	295	642	0900 - 1000	56	30	86
33	Bus/Auto	Barra -7	Sachendi to Ramadevi	309	221	530	1715 - 1815	31	35	66
34	Bus/Auto	Barra -7	Ramadevi to Sachendi	328	295	623	0900 - 1000	36	30	66
35	Bus/Auto	Barra Bypass NH-2	Sachendi to Ramadevi	458	518	976	1530 - 1630	30	86	116
36	Bus/Auto	Barra Bypass NH-2	Ramadevi to Sachendi	533	414	947	0945 - 1045	62	36	98
37	Bus/Auto	Naubasta	Sachendi to Ramadevi	536	615	1151	0930 - 1030	74	66	140
38	Bus/Auto	Naubasta	Ramadevi to Sachendi	815	567	1382	0915 - 1015	88	65	153
39	Bus/Auto	Yashoda Nagar	Sachendi to Rama Devi	364	435	799	0900 - 1000	45	46	91
40	Bus/Auto	Yasoda Nagar	Rama Devi to Sachendi	444	376	820	1630 - 1730	49	50	99
41	Bus/Auto	IIT	Ramadevi to IIT Chaubepur	286	227	513	0930 - 1030	30	32	62
42	Bus/Auto	Kalyanpur	Ramadevi to IIT Chaubepur	131	160	291	1000 - 1100	15	19	34
43	Bus/Auto	Kanpur University	IIT Chaubepur to Ramadevi	299	224	523	1015 - 1115	28	36	64
44	Bus/Auto	Kanpur University	Ramadevi to IIT Chaubepur	303	249	552	0945 - 1045	39	35	74
45	Bus/Auto	Gurudev Place	Ramadevi to IIT Chaubepur	268	191	459	0915 - 1015	35	17	52
46	Bus/Auto	Rawatpur Railway Station	Ramadevi to IIT Chaubepur	519	382	901	1700 - 1800	80	68	148
47	Bus/Auto	Gol Chauraha	Ramadevi to IIT Chaubepur	310	343	653	1815 - 1915	42	38	80
48	Bus/Auto	Coco Cola Chowk	IIT Chaubepur to Ramadevi	308	122	430	1745 - 1845	29	22	51
49	Bus/Auto	Coco Cola Chowk	Ramadevi to IIT Chaubepur	154	121	275	1645 - 1745	15	18	33
50	Bus/Auto	Gumti No.5	Ramadevi to IIT Chaubepur	331	192	523	1000 - 1100	31	19	50

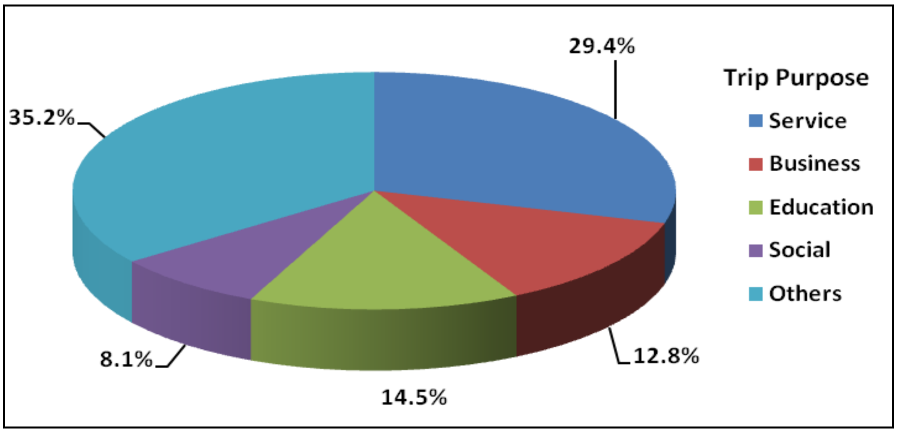
SN	Mode	Name of Location	Direction	Total Boarding	Total Alighting	Total (B+A)	Peak Time	Peak Hour Boarding	Peak Hour Alighting	Peak Hour (B+A)
51	Bus/Auto	Jareeb Chowki	IIT Chaubepur to Ramadevi	508	486	994	1630 - 1730	67	43	110
52	Bus/Auto	Jareeb Chowki	Ramadevi to IIT Chaubepur	422	713	1135	1000 - 1100	59	85	144
53	Bus/Auto	Anwarganj	Ramadevi to IIT Chaubepur	202	146	348	1700 - 1800	30	15	45
54	Bus/Auto	Jhakarkati	Ramadevi to IIT Chaubepur	309	311	620	1745 - 1845	38	30	68
55	Bus/Auto	Jhakarkati	Ramadevi to IIT Chaubepur	176	132	308	0930 - 1030	26	19	45
56	Bus/Auto	PAC More	IIT Chaubepur to Ramadevi	363	446	809	1000 - 1100	42	34	76
57	Bus/Auto	PAC More	Ramadevi to IIT Chaubepur	484	209	693	0945 - 1045	66	30	96
58	Bus/Auto	Ramadevi	Ramadevi to IIT Chaubepur	1456	229	1685	0945 - 1045	156	24	180
59	Bus/Auto	Baker Ganj	Naubasta to Tat Mill	346	430	776	0915 - 1015	37	33	70
60	Bus/Auto	Baker Ganj	Tat Mill to Naubasta	473	300	773	1030 - 1130	61	29	90
61	Bus/Auto	Kidwai Nagar	Naubasta to Tat Mill	452	450	902	1630 - 1730	40	41	81
62	Bus/Auto	Kidwai Nagar	Tat Mill to Naubasta	752	409	1161	0945 - 1045	136	13	149
63	Bus/Auto	Baradevi	Tat Mill to Naubasta	441	337	778	0930 - 1030	40	32	72
64	Bus/Auto	Baradevi	Naubasta to Tat Mill	455	325	780	1745 - 1845	47	39	86
65	Bus/Auto	Naubasta	Naubasta to Tat Mill	1460	685	2145	1615 - 1715	165	45	210
66	Bus/Auto	Tat Mill	Tat Mill to Naubasta	403	274	677	1615 - 1715	46	37	83
67	Auto	Ramgopal Chowk	Barra-7 to Namak Factory	315	214	529	1730 - 1830	34	21	55
68	Auto	Ramgopal Chowk	Namak Factory to Barra-7	229	401	630	1845 - 1945	16	44	60
69	Auto	Barra 7	Barra-7 to Namak Factory	659	514	1173	1815 - 1915	75	43	118
70	Auto	Barra 7	Namak Factory to Barra 7	453	579	1032	0845 - 0945	46	61	107
71	Auto	Satya Trama Center	Barra-7 to Namak Factory	633	587	1302	0815 - 0915	115	16	131
72	Auto	Satya Trama Center	Namak Factory to Barra-7	689	605	1294	0945 - 1045	85	75	160
73	Auto	Sastri Chowk	Barra-7 to Namak Factory	357	367	724	1730 - 1830	41	39	80
74	Auto	Sastri Chowk	Namak Factory to Barra 7	341	279	620	1000 - 1100	39	40	79
75	Auto	CTI	Barra-7 to Namak Factory	975	829	1804	1515 - 1615	129	82	211
76	Auto	CTI	Namak Factory to Barra 7	862	707	1569	1730 - 1830	95	80	175

SN	Mode	Name of Location	Direction	Total Boarding	Total Alighting	Total (B+A)	Peak Time	Peak Hour Boarding	Peak Hour Alighting	Peak Hour (B+A)
77	Auto	Dada Nagar	Barra-7 to Namak Factory	546	482	1028	1715 - 1815	42	53	95
78	Auto	Dada Nagar	Namak Factory to Barra-7	536	560	1096	1000 - 1100	61	44	105
79	Auto	Vijay Nagar	Barra-7 to Namak Factory	1084	1108	2192	0900 - 1000	115	116	231
80	Auto	Vijay Nagar	Namak Factory to Barra-7	1191	1320	2511	1700 - 1800	136	146	282
81	Auto	Double Pulia	Namak Factory to Barra-7	649	638	1287	1700 - 1800	99	86	185
82	Auto	Double Pulia	Barra-7 to Namak Factory	886	418	1304	0915 - 1015	149	36	185
83	Auto	Namak Factory	Barra-7 to Namak Factory	374	659	1033	1030 - 1130	24	92	116
84	Auto	Namak Factory	Namak Factory to Barra-7	801	491	1292	1800 - 1900	109	73	182
85	Auto	Rawatpur	Barra-7 to Rawatpur	970	1257	2227	0930 - 1030	157	141	298
86	Auto	Rawatpur	Rawatpur to Barra-7	1644	1617	3261	0930 - 1030	189	186	375
87	Auto	Kidwai Nagar	Tat Mill to Nobasta	869	553	1422	0900 - 1000	117	37	154
88	Auto	Kidwai Nagar	Naubasta to Tat Mill	832	652	1484	1730 - 1830	100	46	146
89	Auto	Naubasta	Nobasta to Tat Mill	2030	564	2594	0945 - 1045	221	55	276
90	Auto	Naubasta	Naubasta to Tat Mill	332	826	1158	1745 - 1845	32	90	122
91	Auto	Baradevi	Tat Mill to Naubasta	844	327	1171	0845 - 0945	89	32	121
92	Auto	Tatmill	Tatmill to Naubasta	977	320	1297	1715 - 1815	109	41	150
93	Auto	Baradevi	Baradevi to Rawatpur	1821	476	2297	0900 - 1000	189	42	231
94	Auto	Baradevi	Baradevi to Mulganj	1978	495	2473	0930 - 1030	213	31	244
95	Auto	Jakarkatti	Jakarkatti	633	511	1144	0915 - 1015	137	54	191
96	Auto	Tatmill	Ramadevi to Chaubepur	1446	450	1896	1715 - 1815	168	41	209
97	Auto	Naubasta	Naubasta to Ramadevi	2664	994	3658	0815 - 0915	292	70	362
98	Auto	PAC More NH-02	Sachendi to Ramadevi	442	460	902	0730 - 0830	34	41	75
99	Auto	PAC More NH-02	Ramadevi to Sachendi	470	467	937	1000 - 1100	38	56	94
100	Auto	Afim Kothi	Ramadevi to Chaubepur	318	102	420	1100 - 1200	42	15	57

TABLE 3.23: DISTRIBUTION OF PT/IPT PASSENGERS BY TRIP PURPOSE

Trip Purpose	Service	Business	Education	Social	Others	Total
PT/IPT Passengers	17441	7582	8597	4814	20861	59295
Composition (%)	29.4	12.8	14.5	8.1	35.2	100.0

FIGURE 3.9: DISTRIBUTION OF PT/IPT PASSENGERS BY TRIP PURPOSE



3.2 SOCIO-ECONOMIC CHARACTERISTICS

The household travel survey has been conducted to bring out socio-economic and travel characteristics of the study area like household size, income, and vehicle ownership, per capita trip rates for various purposes viz. Work, education and other trips, expenditure on transport and modal split.

A total of 10,741 households (i.e. about 1.5% sample size) were interviewed in the study area representing 70 internal traffic zones. A random sampling technique was used to identify the sample. Further, care was taken that the representative households of all socio-economic strata i.e. High Income Groups (HIG), Middle Income Groups (MIG) and Lower Income Groups (LIG) were covered in the sample.

The data was collected through trained enumerators. The survey was initiated with a pilot survey in the field and amendments in the method of recording the observations were made wherever necessary before starting the actual survey.

A daily programme for the households to be surveyed was prepared and the data was collected back from the enumerators on daily basis. The checked data set was compiled and coded in the office.

3.2.1 Household Socio Economic Characteristics

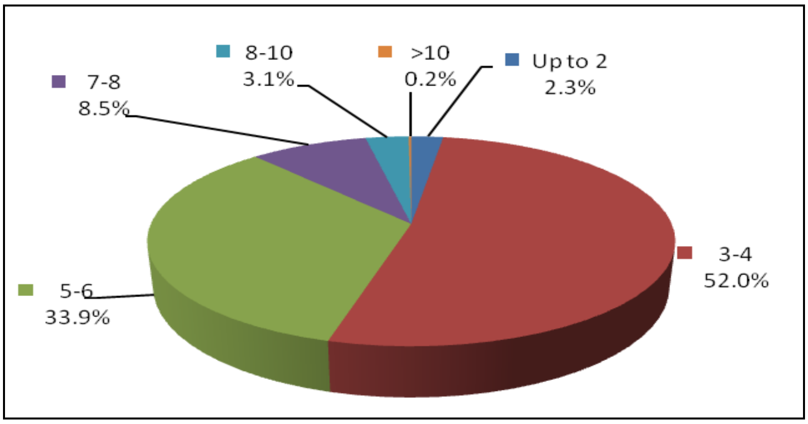
i. Household Size

The average household size in the study area is 4.71 persons per household. The distribution of households by size is presented in **Table 3.24** and **Figure 3.10**. It can be observed that majorly 52% of the households fall under the category of 3-4 persons per household and 33% of household's falls under category of 5-6 persons group.

TABLE 3.24: DISTRIBUTION OF HOUSEHOLDS BY SIZE

SN	Household by Size	Number of Households	Percentage
1	Upto 2	246	2.3
2	3-4	5589	52.0
3	5-6	3645	34.0
4	7-8	909	8.5
5	9-10	332	3.0
6	>10	20	0.2
Total		**10741**	**100.0**

FIGURE 3.10: DISTRIBUTION OF HOUSEHOLDS BY SIZE



ii. Age Wise Distribution

The distribution of individuals by age is presented in **Table 3.25**. It is observed that about 46% of individuals are up to age of 14 to 35 years. About 5% of the surveyed individuals are senior citizen.

TABLE 3.25: DISTRIBUTION OF HOUSEHOLD MEMBERS BY AGE

SN	Age (in years)	%
1	0-14	20.1%
2	14-28	32.5%

SN	Age (in years)	%
3	28-35	13.3%
4	35-45	15.1%
5	45-60	13.8%
6	60+	5.1%
Total		100.0

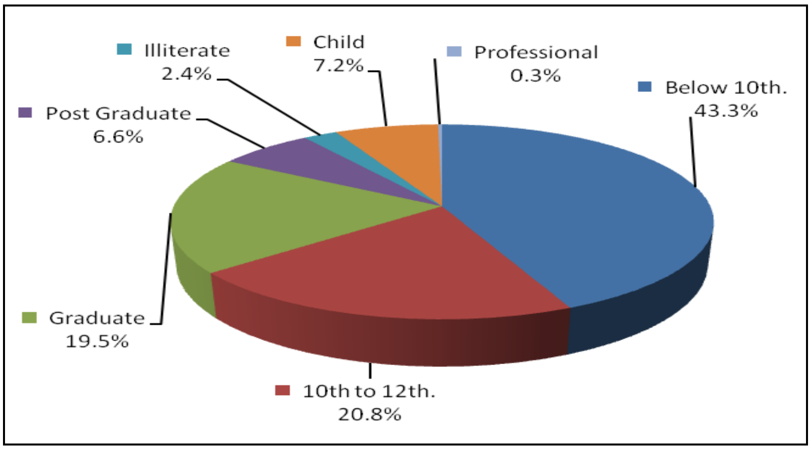
iii. Education Level

The distribution of household members by educational qualifications is presented in **Table 3.26** and **Figure 3.11**. The members of household with age below four years have been considered as children. About 43% have studied below 10th level, 21% have studied up to 10th-12th level. Only 2% of the surveyed sample is illiterate.

TABLE 3.26: DISTRIBUTION OF HOUSEHOLD MEMBERS BY EDUCATION LEVEL

SN	Education	No. of Sampled Household Members	Percentage
1	Below 10th	21911	43.3
2	10th to 12th	10522	20.8
3	Graduate	9852	19.5
4	Post Graduate	3342	6.6
5	Illiterate	1195	2.4
6	Child	3636	7.2
7	Professional	139	0.3
Total		50597	100.0

FIGURE 3.11: DISTRIBUTION OF HOUSEHOLD MEMBERS BY EDUCATION LEVEL



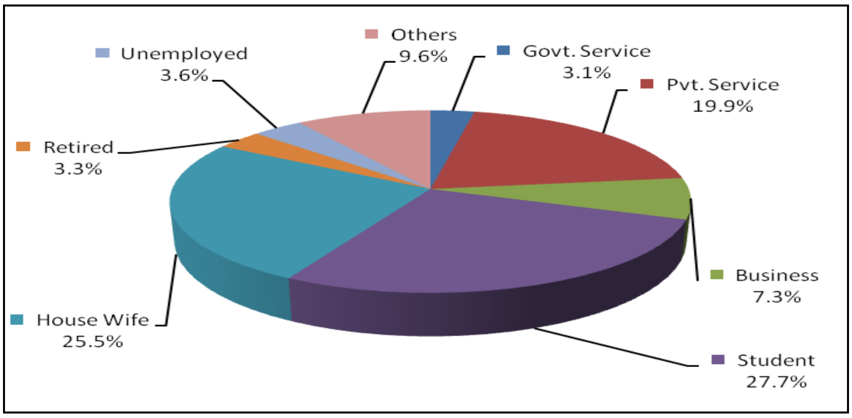
iv. Activity Status/Occupation

The activity status/occupational structure of the surveyed household members is presented in **Table 3.27** and **Figure 3.12**. It is observed that about 60% samples are non-workers comprising of students, housewives, retired and unemployed people. Among the service class, majorly about 20% are in private sector and about 3% in government services.

TABLE 3.27: DISTRIBUTION OF HOUSEHOLD MEMBERS BY ACTIVITY STATUS /OCCUPATION

SN	Occupation	No. of Sampled Household Members	Percentage
1	Govt. Service	1574	3.1
2	Pvt. Service	10066	19.9
3	Business	3688	7.3
4	Student	14021	27.7
5	House Wife	12898	25.5
6	Retired	1684	3.3
7	Unemployed	1824	3.6
8	Others	4842	9.6
Total		**50597**	**100.0**

FIGURE 3.12: DISTRIBUTION OF HOUSEHOLD MEMBERS BY ACTIVITY STATUS/OCCUPATION



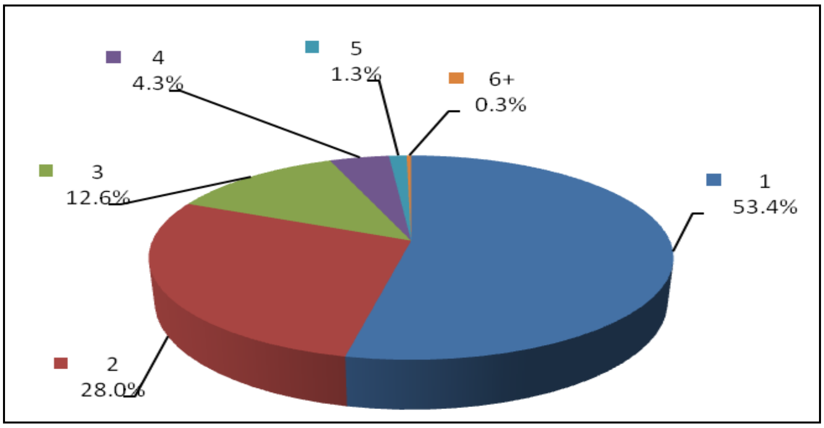
v. Number of Earning Members per Household

The distribution of earning members per household in the study area is presented in **Table 3.28**. It is seen that about 53% of the households have only 1 earning member, 28% have 2 earning members, while nearly 13% have 3 earning members. Household distribution by number of worker per household is presented in **Figure 3.13.**

TABLE 3.28: DISTRIBUTION OF HOUSEHOLDS BY NUMBER OF EARNING MEMBERS

SN	No. Workers	No. of Households	Percentage
1	1	5738	53.4
2	2	3011	28.0
3	3	1358	12.6
4	4	463	4.3
5	5	137	1.3
6	6+	34	0.3
Total		**10741**	**100.0**

FIGURE 3.13: DISTRIBUTION OF HOUSEHOLDS BY NUMBER OF EARNING MEMBERS



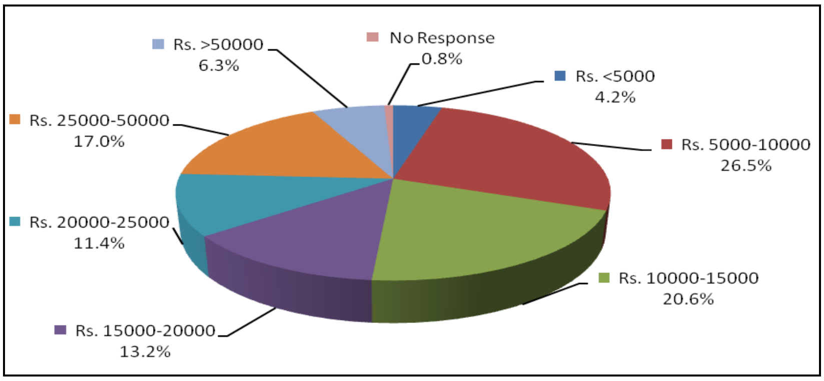
vi. Income Distribution

The average monthly household income in the study area is Rs.11,986. **Table 3.29 & Figure 3.14** indicates that 26% of the households earn Rs.5000 to Rs.10,000. Only, about 6% of the households has monthly income more than Rs.50,000.

TABLE 3.29: DISTRIBUTION OF HOUSEHOLDS BY MONTHLY INCOME

SN	Income Group (Rs.)	No. of Households	Percentage
1	<5000	456	4.2
2	5000-10000	2844	26.5
3	10000-15000	2214	20.6
4	15000-20000	1420	13.2
5	20000-25000	1220	11.4
6	25000-50000	1824	17.0
7	>50000	680	6.3
8	No Response	83	0.8
	Total	**10741**	**100.00**

FIGURE 3.14: DISTRIBUTION OF HOUSEHOLDS BY MONTHLY INCOME



vii. Vehicle ownership per Household

Distribution of households owning vehicles is presented in **Table 3.30.** It is observed that about 10.3% of households have no vehicle.

TABLE 3.30: DISTRIBUTION OF HOUSEHOLDS BY VEHICLE OWNERSHIP

SN	Type of Vehicle	Number of Households	Percentage
1	No Vehicle	1105	10.3
2	Only Car	120	1.1
3	Only 2-Wheeler	2419	22.5
4	Only Cycle	2507	23.3
5	Only Auto Rickshaw	13	0.1
6	Car & 2-Wheeler	874	8.1
7	Car & Cycle	35	0.3
8	2-Wheeler & Cycle	3133	29.2
9	2-Wheeler & Auto Rickshaw	14	0.1
10	Cycle & Auto Rickshaw	20	0.2
11	Car, 2-Wheeler & Cycle	460	4.3
12	2-Wheeler, Cycle & Auto Rickshaw	28	0.3
13	Car & Auto Rickshaw	4	0.0
14	Car, 2-Wheeler & Auto Rickshaw	5	0.0
15	Car, 2-Wheeler, Cycle & Auto Rickshaw	4	0.0
Total		**10741**	**100.0**

3.2.2 Travel Characteristics

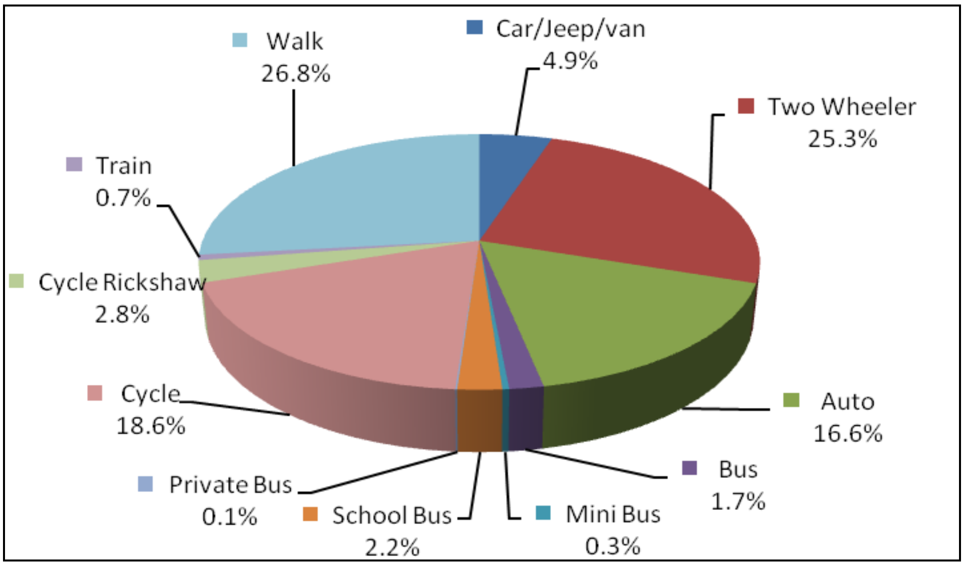
i. Trip Rate

The total daily trips, as derived from the household survey, in the study area is about 48.26 lakh. Distribution of daily trips by modes is presented in **Table 3.31 & Figure 3.15**. About 73% of these are vehicular trips while 27% are walk trips. The per capita trip rate (including walk) is found to be 1.24 in the study area, whereas, per capita trip rate is 0.9 for the trips excluding walk trips.

TABLE 3.31: DISTRIBUTION OF DAILY PASSENGER TRIPS BY MODE

Mode		No. of Trips	Percentage
Vehicular Trips	Car/Jeep/van	237264	4.9
	Two Wheeler	1223127	25.3
	Auto + Share Auto	801515	16.6
	Bus	81403	1.7
	Mini Bus	15988	0.3
	School Bus	104895	2.2
	Private Bus	4563	0.1
	Cycle	899324	18.6
	Rickshaw	133090	2.8
	Train	33233	0.7
Walk Trips	Walk	1291196	26.8
Total Trips		**4825598**	**100.0**
PCTR Including Walk		**1.24**	
Total Trip without walk		**3534402**	
PCTR Excluding Walk		**0.91**	

FIGURE 3.15: DISTRIBUTION OF DAILY PASSENGER TRIPS BY MODE



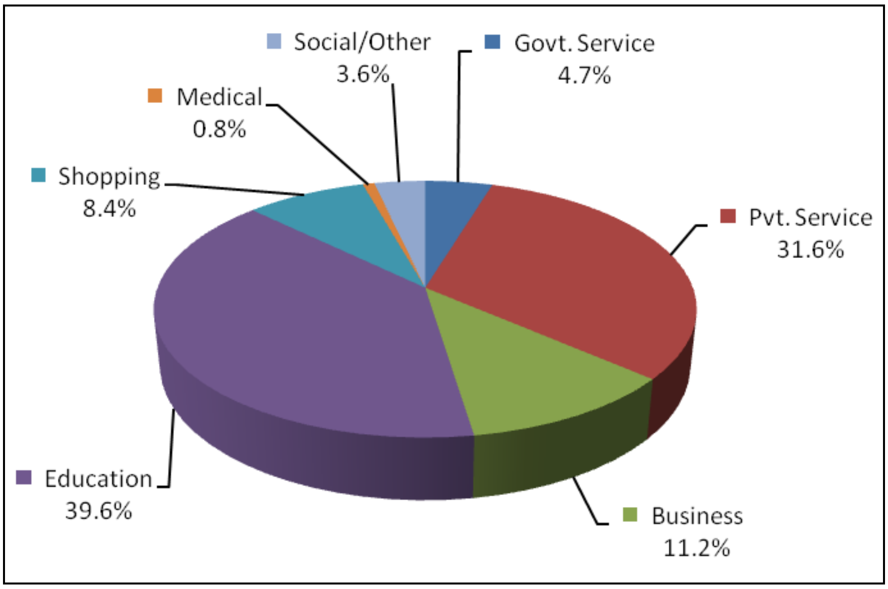
ii. Trip Purpose

Distribution of daily vehicular and walk trips is presented in **Table 3.32** and **Figure 3.16.** It is observed that among the total trips, government and private work trips account for about 36%, education about 40%, and business trips for about 11%.

TABLE 3.32: DISTRIBUTION OF PASSENGER TRIPS BY PURPOSE

SN	Trip Purpose	Total Trips	%
1	Govt. Service	227006	4.7
2	Pvt. Service	1526558	31.6
3	Business	541415	11.2
4	Education	1912680	39.6
5	Shopping	407054	8.4
6	Medical	39248	0.8
7	Social/Other	171637	3.6
Total		**4825598**	**100.0**

FIGURE 3.16: DISTRIBUTION OF PASSENGER TRIPS BY PURPOSE



iii. Trip Length

Average trip length of 6.4 km (including walk) and 8.3 km (excluding walk) is observed in the study area as presented in **Table 3.33.** It is observed that an average trip length of 1.2 km is being covered up by walk and cars travel an average trip length of 10.9 km.

TABLE 3.33: DISTRIBUTION OF AVERAGE TRIP LENGTH BY MODE

SN	Mode	Total Trips	Average Trip Length (km)
1	Car/Jeep/van	237264	10.9
2	Two Wheeler	1223127	7.0
3	Auto	801515	6.0
4	Bus	81403	21.5
5	Mini Bus	15988	10.5

SN	Mode	Total Trips	Average Trip Length (km)
6	School Bus	104895	5.6
7	Chartered Bus	4563	35.0
8	Cycle	899324	5.0
9	Cycle Rickshaw	133090	1.9
10	Train	33233	44.1
11	Walk	1291196	1.2
Total including Walk		**4825598**	
Total excluding Walk		**3534402**	

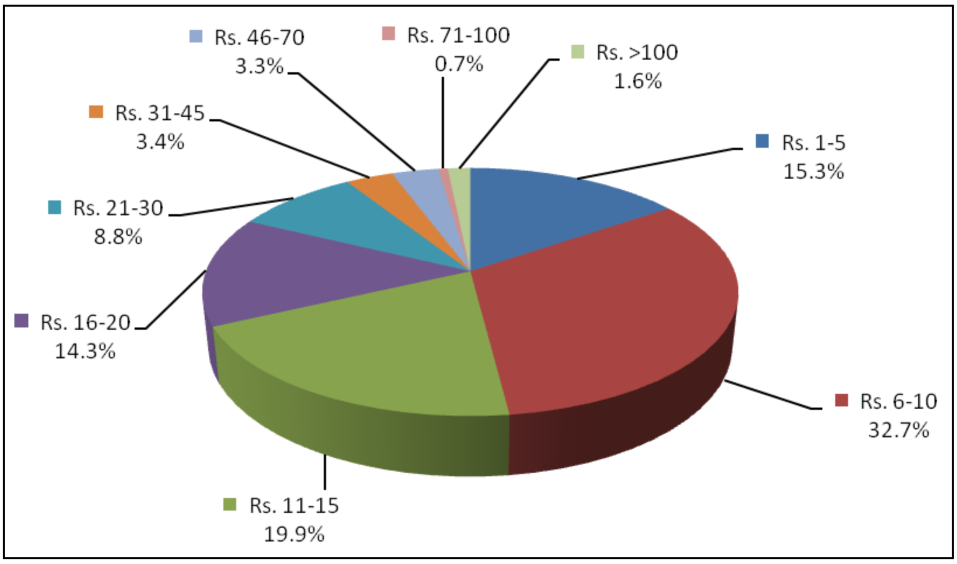
iv. Expenditure on Travel

The distribution of passenger trips (excluding walk and cycle) by travel cost in the study area is presented in **Table 3.34** and **Figure 3.17.** It is seen that 15% of the trips cost upto Rs.5 for travelling and about 33% of the trips cost between Rs 6 to 10. Only about 9% of the trips have travel cost between Rs.21 to Rs.30.

TABLE 3.34: DISTRIBUTION OF PASSENGER TRIPS BY TRAVEL COST (EXCLUDING WALK AND CYCLE)

Travel Cost (Rs)	1-5	6-10	11-15	16-20	21-30	31-45	46-70	71-100	>100	Total
Number of Trips	403768	859902	524850	376504	231251	88317	87420	17484	41901	2631397
Percentage	15.3	32.7	20.0	14.3	8.8	3.4	3.3	0.7	1.6	100.0

FIGURE 3.17: DISTRIBUTION OF PASSENGER TRIPS BY TRAVEL COST (EXCLUDING WALK AND CYCLE)



v. Mobility Patterns and Needs of Women

The purpose wise distribution of women trips in the study area is presented in **Table 3.35**. Among the total trips, education trips account for 59% and Shopping/Recreation trips is about 27%.

TABLE 3.35: DISTRIBUTION OF WOMEN TRIPS BY PURPOSE

SN	Trip Purpose	%
1	Govt. Service	1.8
2	Pvt. Service	8.5
3	Business	1.6
4	Education	59.4
5	Shopping/Recreation	26.6
6	Medical	0.7
7	Social/Others	1.4
Total		**100.0**

3.3 TRAVEL DEMAND ANALYSIS

3.3.1 Approach For Demand Modeling

The travel demand assessment in urban environment is a complex exercise involving a large number of parameters and warrants the development of a transport model at the City level.

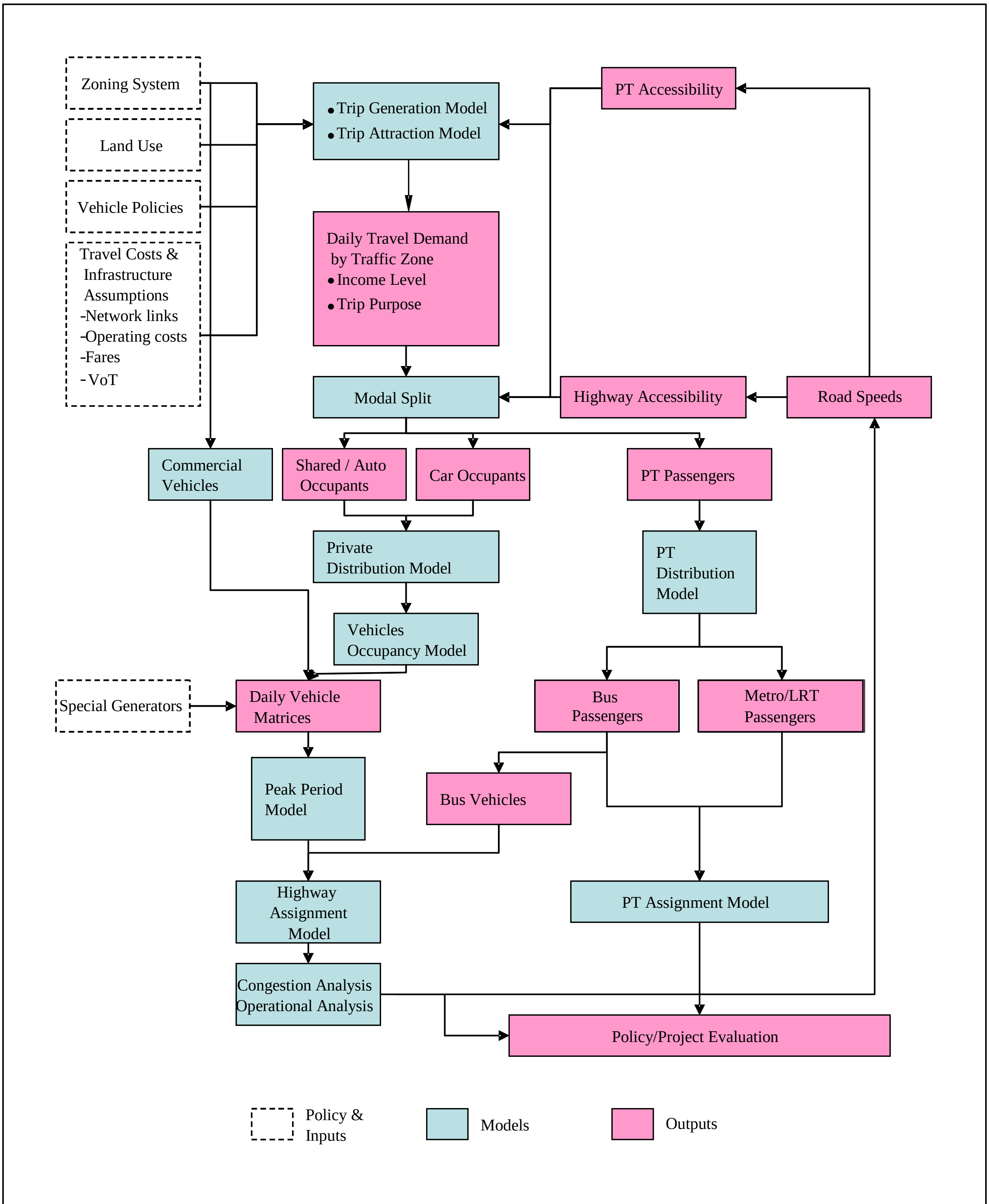
Detailed traffic and travel studies have been carried out as part of the assignment to establish the existing and future transport demand in the study area. An operational travel demand model is required to enable estimation of future travel demand that will help towards identifying transport requirements for the study area. The said model is also a pre-requisite to the fact that the consultants are able to validate the actual travel patterns (as observed) within an acceptable error range (+-15%).

The standard 4 stage Urban Transport Planning System model has been adopted that inter-alia consists of:

- Trip Generation and Attraction Sub Model
- Trip Distribution Sub Model
- Modal Split Sub Model
- Assignment Sub Model

The sequence of activities involved in the model is depicted in **Figure 3.18**.

FIGURE 3.18: FOUR STAGE TRAVEL DEMAND MODEL



3.3.2 Model Structure

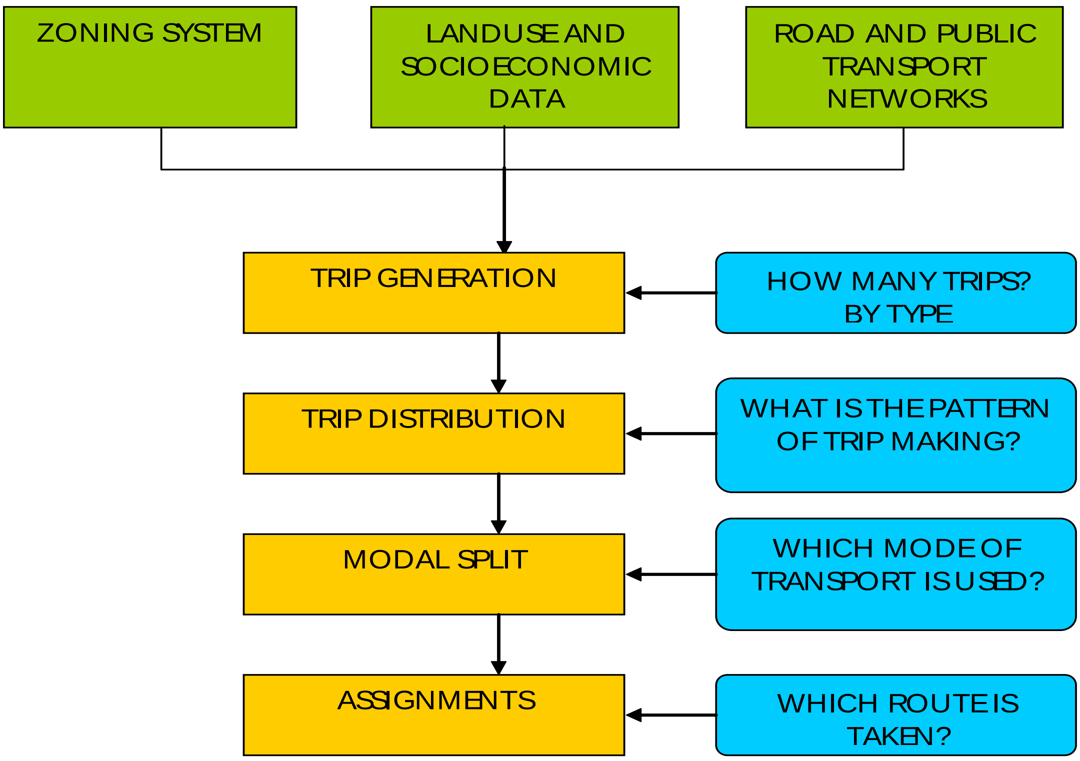
The model (**Figure 3.19**) is based on motorised trip productions / attractions and internal trips of Kanpur Development Authority area residents. The various modes of travel (i.e. Car, Two wheelers, Auto-rickshaw and Public Transport including Shared Auto, Bus & Mini bus) comprise about 24.13 Lakh daily trips. The remaining trips are those relating to non-mechanized trips (walk, cycle and cycle rickshaw).

Four sub models are developed viz. Generation, Attraction, Distribution, Modal Choice and Assignment models.

The model development is largely based on the Households Interview Survey (HIS) and other traffic surveys after expansion from survey sample to total population. This is calculated at a zonal level.

The next step was to build the base year road matrices necessary to obtain costs for the model development (distribution and modal choice). The base year HIS person matrices converted to vehicles using occupancy factors, trip matrices, external zones matrices from road side interview at Outer Cordon locations and special generators (bus and railway station) matrices to get total traffic across the Study Area.

FIGURE 3.19: FOUR STAGE MODEL STRUCTURE



3.3.3 Trip Generation & Attraction

The two components of trip generation modeling are:

Trip Production: This is defined as the home end of a home based trip or as the origin of a non-home based trip. It thus gives the total trips produced by a zone.

Trip Attraction: This is defined as the non-home end of a home-based trip or as the destination of a non-home based trip. It thus, gives the total trips attracted to a zone.

3.3.4 Factors Affecting Trip Generation

The factors that affect Trip Generation include:

- Land Use Factors: Population, Indicators of Intensity of Residential Activity, Intensity of Employment Opportunities, Land Values etc.
- Household Factors: Household Income, Vehicle Ownership, Family Size, Family Structure etc.
- Urbanization Factors: Degree of Urbanization, Distance from CBD, Accessibility etc.

3.3.5 Trip Purposes

The purpose of the trip can be broadly categorized in home based trips & non-home based trips. Home based trips are those in which one of the either trip ends is at the home while the non-home based are those in which neither end is at home. Different transportation studies have adapted different classification systems for trip purpose depending upon the planning issues involved and the size of the city. The trip generation model has been developed for home based trips in aggregation while the trip attraction model incorporates the 4 trip purposes of home base work (HBW), home base business (HBB), home base education (HBE) and home base other (HBO) trips for the study.

3.3.6 Mathematical Forms

- **Trip Production Equations**

The general form of the work trip production equation developed is

$$Ti = a + b*(IVi)$$

Where,

Ti = Trips produced from zone i
a = constant (unexplained part of the relationship)
b=parameter explaining the dependency on the independent variable and

representing the Trip Rate

IVi = Independent Variable in zone i

- **Trip Attraction Equations**

The general form of the trip attraction equation developed is

$$\mathbf{Tj = a + b^*(IVj)}$$

Where,

Tj = Trips attracted to zone j

a = constant (unexplained part of the relationship)

b = parameter explaining the dependency on the independent variable

IVi = Independent Variable in zone j

3.3.7 Trip Generation Model

The linear regression analysis was used to develop the trip production and trip attraction equations. A zonal regression model was used in which each traffic zone is treated as one observation. The aggregated analysis has been applied for developing the model which is based on the assumption that contiguous households exhibit a certain amount of similarity in travel characteristics. This assumption allows the data in a zone to be grouped and the mean value of the independent variable used in further calculations. The trip production and attraction output in terms of the correlation coefficients are given in **Table 3.36.**

TABLE 3.36: TRIP GENERATION SUBMODELS - 2015

Dependent Variable	Independent Variable	Regression Coefficient (Trip Rate)	(R^2) Co-efficient of Determination
(Y)	(X)	(b)	
Trip Production			
All Modes	Population	0.7301	0.75

- **Independent Variable: Zonal Population**

Figure 3.20 shows the scatter plotting between population and production. **Table 3.37** details the summary of the output for Trip Production Model. The trip production model developed for Kanpur is stated below:

Trips Produced = 0.73013551 X (Population), **R^2 = 0.75**

Where,

P = Population

R^2 = Coefficient of Determination

FIGURE 3.20: SCATTER PLOT: POPULATION VS TRIP PRODUCTION

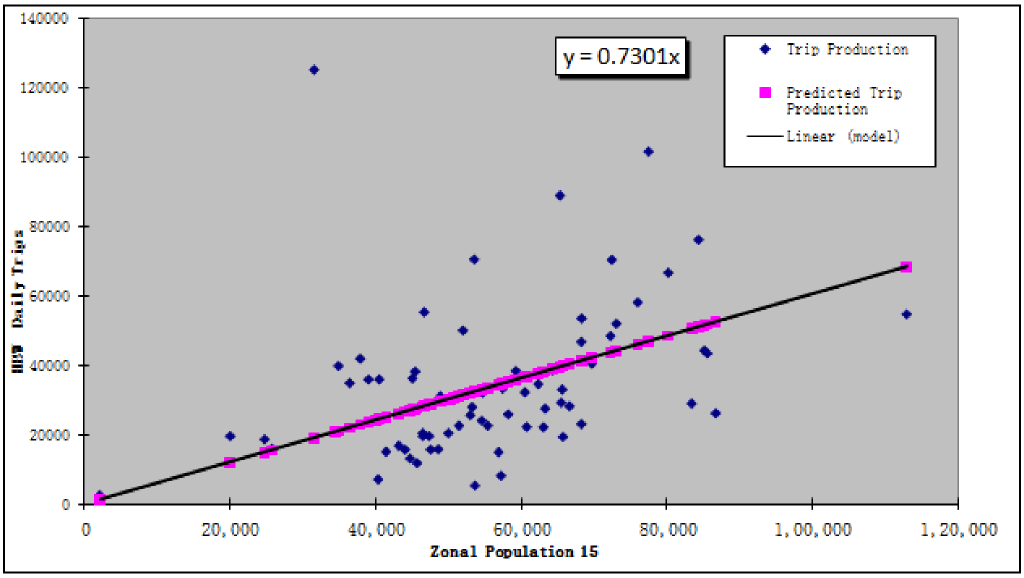


TABLE 3.37: SUMMARY OF OUTPUT OF TRIP PRODUCTION MODEL

SUMMARY OUTPUT								
Regression Statistics								
Multiple R	0.8641							
R Square	0.7467							
Adjusted R Square	0.7322							
Standard Error	20711.3232							
Observations	70							
ANOVA								
	df	***SS***	***MS***	***F***	***Significance F***			
Regression	1			203.4596	4.01769E-22			
Residual	69							
Total	70							
	Coefficients	***Standard Error***	***t Stat***	***P-value***	***Lower 95%***	***Upper 95%***	***Lower 95.0%***	***Upper 95.0%***
Intercept	0							
X Variable 1	0.7301	0.04241	14.2639	2.91522E-22	0.5203	0.6895	0.5203	0.6895

3.3.8 Trip Attraction Model

The Generation model produces daily person trips (all purpose combined) generated by zone, whilst the attraction model estimates daily person trips attracted by zone. For each of the 4 purpose groups, a linear regression was estimated, explaining the number of trips attracted by the socio-economic data, total employment for HBW, HBB, and HBO, and school enrolments for HBE. To be consistent with the generation model, the attraction model is based on PA.

The coefficient of Determination R^2 is the deciding factor for linear regression analysis. The more R^2 is near to 1, more the linear regression is reliable. For instance,

Figure 3.21 presents the linear regression of HBW trips with R-square value equal to 0.91 showing a good match between the data from HIS and the estimated values from the linear regression. **Table 3.38** details the summary of the output for Trip Production Model.

FIGURE 3.21: ATTRACTION MODEL (HBW – LINEAR REGRESSION)

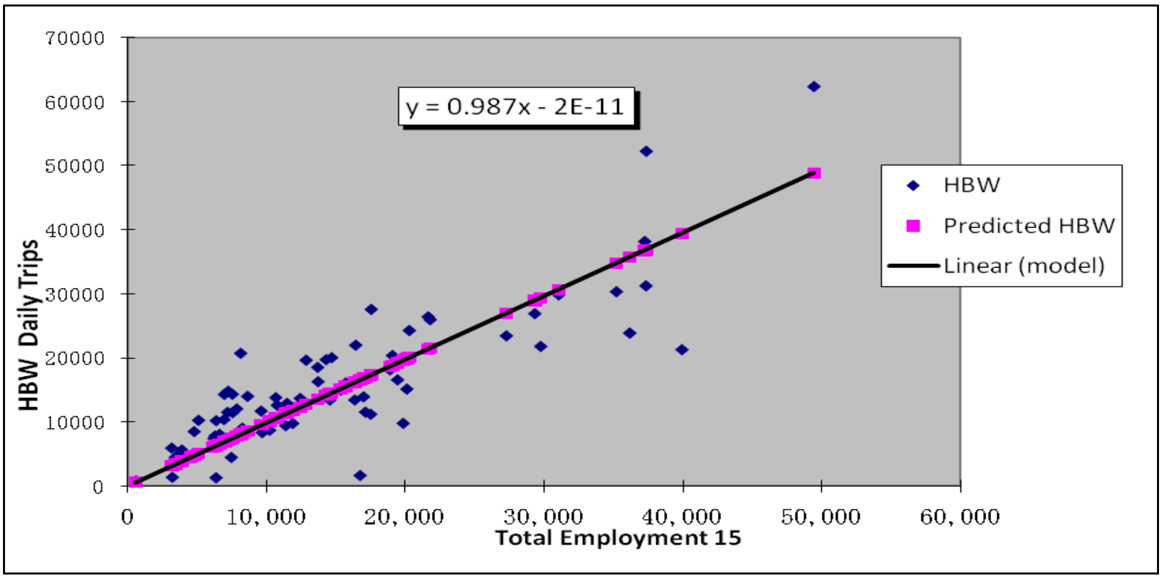


TABLE 3.38: SUMMARY OF OUTPUT OF TRIP ATTRACTION FOR HBW TRIPS

SUMMARY OUTPUT								
Regression Statistics								
Multiple R	0.9516							
R Square	0.9055							
Adjusted R Square	0.8910							
Standard Error	5852.2502							
Observations	70							
ANOVA								
	df	***SS***	***MS***	***F***	***Significance F***			
Regression	1	22655188234	2.2655E+10	661.48789	9.27662E-37			
Residual	69	2363169471	34248832.9					
Total	70	25018357705						
	Coefficients	***Standard Error***	***t Stat***	***P-value***	***Lower 95%***	***Upper 95%***	***Lower 95.0%***	***Upper 95.0%***
Intercept	0							
X Variable 1	0.9872	0.0384	25.7194	0.0000	0.9106	1.0637	0.9106	1.0637

The Attraction Model calibration is summarized in **Table 3.39**, by purpose; HIS and model figures are very similar, showing a very close correspondence between modeled and observed values.

TABLE 3.39: ATTRACTION MODEL CALIBRATION RESULTS

Group	HIS	Model	Difference
HBW	10,91,946	10,91,501	0.04%
HBB	6,52,329	6,49,727	0.40%
HBE	3,62,253	3,61,618	0.18%
HBO	3,06,749	3,07,644	-0.29%
Total	**24,13,277**	**24,10,490**	**0.12%**

3.3.9 Trip Distribution Model

After determining the trip productions (T_i) and trip attraction (T_j), the next stage is to link the productions with attractions in order to quantify how the trips are produced in a zone and are distributed among or attracted to all other zones (T_{ij}).

A number of methods are available which explains and predicts the distribution of trips. These are:

- Growth Factor Models
- Gravity Models
- Opportunity Models
- Stochastic Behavioral Models

3.3.10 Gravity Model Development and Calibration

For the practical purpose of gravity model application in the study area and distribution of the observed Tij for other zone pairs where zero trips were observed in sample matrix, fully constrained gravity model has been chosen for the base year of 2015. The models were developed based on the HIS database and the generalized costs (GC) produced from the highway and public transport cost models implemented in Cube Voyager software.

FIGURE 3.22: GRAVITY MODEL FORMULATION

$$T_{ij} = a_i b_j P_i A_j F(C_{ij})$$

Where

T_{ij} = trips estimated from zone i to zone j

P_i = productions from zone i

A_j = attractions to zone j

a_i, b_j = row/column balancing factors

$F(C_{ij})$ = cost deterrence from zone i to zone j

$$F(C_{ij}) = C_{ij}^{X_1} \exp(X_2 C_{ij})$$

Where

$F(C_{ij})$ = cost deterrence for zone i to zone j

C_{ij} = generalised cost for zone i to zone

X_1, X_2 = coefficients to be calibrated.

The main features of the models are as follows:

- **Unit:** person (productions / attractions – PA);
- **Period:** daily;
- **Model formulation:** gravity model, based on composite GC presented in

The composite GC is the average of the GC for individual modes weighted by modal split proportions (produced by modal split models) by origin / destination movements.

The measure of deterrence is the perceived inter-zonal generalized cost (this is what the traveler unconsciously thinks it costs him to travel from one place to another). For each pair of zones, generalized cost by different modes is determined. For any inter-zonal trip, the cost between each of the two zone centroids and between them and the appropriate actual network nodes is added to establish the least cost journey through the whole network between the zones. For example, for a trip including one or more public transport links and walk links thereto, the public transport generalized cost is made up of:

- Walking time to bus stop (from notional centroids link)
- Waiting time at bus stop
- Travelling time on bus
- Interchange waiting time – where appropriate
- Walking time from bus stop to destination (to notional centroids link)

For individual modes, the **GC** represents perceived costs, where the unit is minute equivalent, implying the use of values of time (VOT, 2015 prices, Rupees / hour) by mode to convert monetary costs (fare, vehicle operating cost - VOC) into minutes. Occupancy factors (OCC) are also used for car, 2w, and auto to obtain person based GC. The GC by mode is described below:

- **Car GC** = Time + [((VOC) / OCC) / VOT] x 60;

- **2W GC** = Time + [((VOC) / OCC) / VOT] x 60;

- **Auto GC** = Time + 1.5 x Wait Time + [(Fare / OCC) / VOT] x 60;

- **PT GC** = IVT + 1.5 x Walk Time + 2 x Wait Time + (Fare / VOT) x 60 + Transfer Time;

3.3.11 Gravity Model – Calibration Results

This section provides the distribution models calibration results by the segments: X1 and X2 parameters, average GC (in minutes), and trip GC distribution. As illustrated by **Table 3.40** the overall models results are almost similar to the HIS database.

TABLE 3.40: DISTRIBUTION MODELS CALIBRATION RESULTS

Trip	HIS	Model				Difference in Trips
	Daily Trips	X1	X2	GC	Trips	
Total Trips	**24,13,277**	-1.07218	0.03534	19.59	24,10,490	0.10%

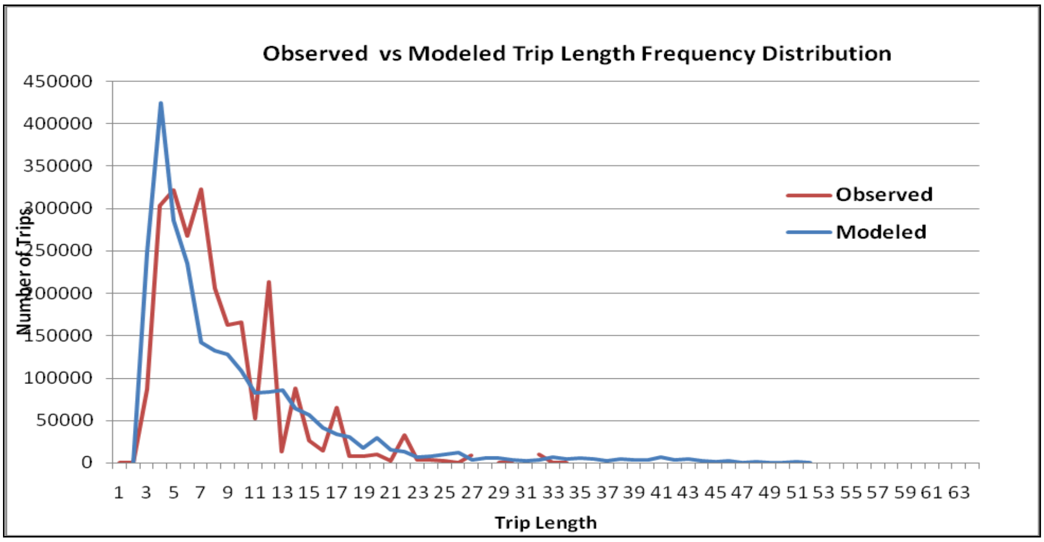
Calibration process included comparison of observed and simulated mean trip time (minutes) as well as shapes of the trip time frequency distribution. The observed trip time frequency distributions were obtained from the Household Travel Survey data. A comparison of observed and modeled trip length frequency for total trips is presented in **Figure 3.23**.

For developing speed flow relationship, data from Road User Cost Study was adopted and used to calculate calibration factors of Curve. The form of equation (power curve) used for the study is as under;

t(v) = t0 + (tc – t0) (v/c)n

Where, tc = t0 + acn is the travel time at capacity. This form is sometimes easier for user manipulation since it uses only basic variables and removes the necessity to calculate the value of the coefficient 'a'.

FIGURE 3.23: OBSERVED & MODELED TRIP LENGTH FREQUENCY DISTRIBUTION



3.3.12 Modal Split Model

The modal split model is developed based on the HIS database and the Generalised Costs (GC) produced from the highway and public transport cost models implemented in Cube Voyager software.

The total trips are split into two major group of private and public mode of travel. Then private modes are further divided into Car, 2W, and Auto. PT trips are separated between bus, shared auto and metro services during the assignment stage. It should be noted that the PT matrix produced by the modal split model contains trips using school, chartered, and public buses, but only the last category is retained for the PT assignment, the other two groups (school and chartered buses) not using the public network. However, these are taken into account in the highway assignment.

The main features of the modal split model are as follows:

- **4 modes:** Car, two wheelers, auto, and PT (including shared auto);
- **Unit:** person (productions / attractions – PA);
- **Period:** daily;
- **Model formulation:** Combined Split, Multi-Logit Formulas (equations provided in **Figure 3.24**, where P means Probability and C is the Generalised Cost);

FIGURE 3.24: MULTI-LOGIT FORMULAS (COMBINED SPLIT)

$$P_{Car+taxi} = \frac{e^{(-\lambda C_{Car})}}{e^{(-\lambda C_{Car})} + e^{(-\lambda C_{2W})} + e^{(-\lambda C_{Auto})} + e^{(-\lambda C_{PT})}}$$

$$P_{2W} = \frac{e^{(-\lambda C_{2W})}}{e^{(-\lambda C_{Car})} + e^{(-\lambda C_{2W})} + e^{(-\lambda C_{Auto})} + e^{(-\lambda C_{PT})}}$$

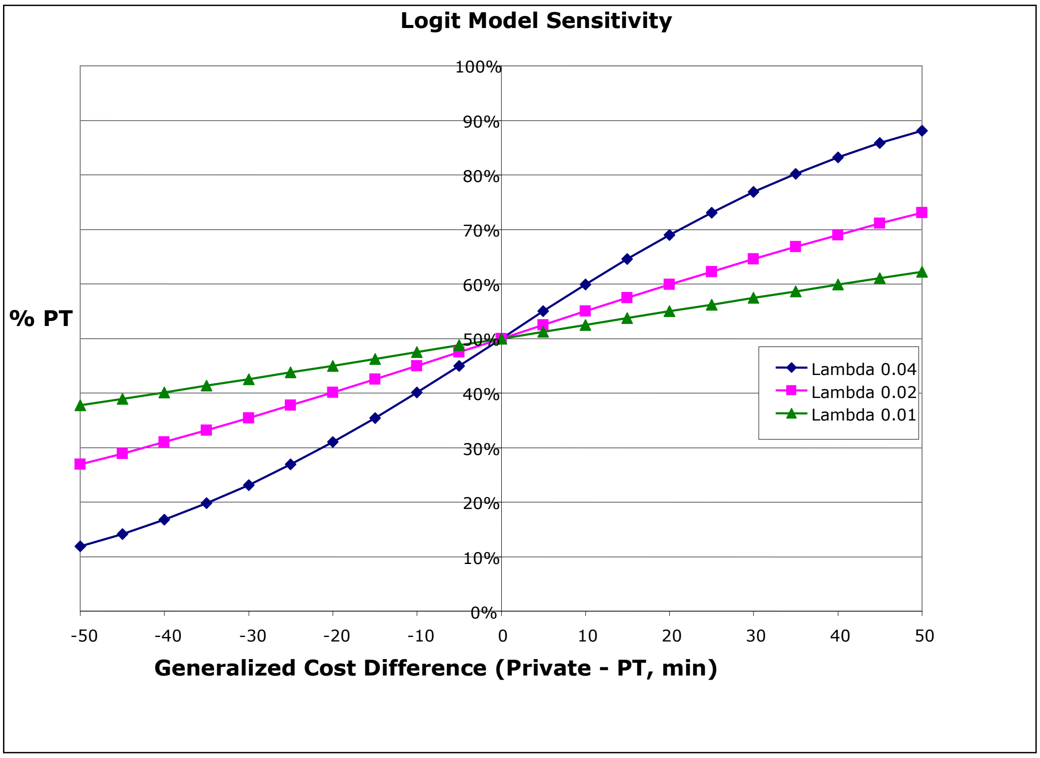
$$P_{Auto} = \frac{e^{(-\lambda C_{Auto})}}{e^{(-\lambda C_{Car})} + e^{(-\lambda C_{2W})} + e^{(-\lambda C_{Auto})} + e^{(-\lambda C_{PT})}}$$

$$P_{PT} = \frac{e^{(-\lambda C_{PT})}}{e^{(-\lambda C_{Car})} + e^{(-\lambda C_{2W})} + e^{(-\lambda C_{Auto})} + e^{(-\lambda C_{PT})}}$$

- **Logit Parameters Estimation:** The mode choice sensitivity revealed by the model is mainly determined by the parameterλ. This model parameter was developed based on statistical regression analysis, which also provided some initial estimates on the mode biases between private and public modes of travel. **Figure 3.25** shows logit model sensitivity for illustrative purpose (example with Private versus Public Travel modes), when λ increases, the model becomes more responsive to the difference in cost.

The GC represents perceived costs, where the unit is minute equivalent, implying the use of Values of Time (VOT, 2015 prices, Rupees / hour) by mode to convert monetary costs (fare and vehicle operating cost - VOC) into minutes.

FIGURE 3.25: LOGIT MODEL SENSITIVITY



Occupancy factors (OCC) are also used for car, 2w, and auto to obtain person based GC. Below are described the GC by mode:

- **Car GC** = Time + [(VOC/OCC) / VOT] x 60;
- **2W GC** = Time + [(VOC/OCC) / VOT] x 60;
- **Auto GC** = Time + 1.5 x Wait Time (4) + [(Fare / OCC) / VOT] x 60;
- **PT GC** = IVT + 1.5 x Walk Time + 2 x Wait Time + (Fare / VOT) x 60 + Transfer Time

3.3.13 Modal Split Calibration Results

Table 3.41 demonstrates that there is close correspondence between the synthesized and observed values from the HIS. The following observations can be made:

In theory, for any multi-logit model with two possible choices, there is one bias factor available. Calibrated Modal Choice Model has been developed with the Lambda parameters between private & public as - 0.34263 and further between buses and shared autos as - 0.11112.

TABLE 3.41: MODAL SPLIT MODEL CALIBRATION RESULTS

Modes	HIS	Model
Car	228138	228302
2W	1199224	1200364
Auto	79676	79372
PT including Shared Auto	906239	902452
Total	**2413277**	**2410490**

3.3.14 Trip Assignment Models

The trip assignment procedure determines the route choice of trip maker to whole or a part of a network and is the last part of travel demand modeling process where the inter-zonal modal trips are assigned to the various links of the network. There are at least four factors that lead people to choose one route over another. They are travel time, generalized travel cost, Travel distance and level of service. Taking a single parameter to determine the shortest path between each zone pair assumes that there is only one preferred path between each origin and destination.

The road assignment is a multiple user class assignment using equilibrium algorithm and capacity constraint. In this method of assignment, trip matrices are loaded onto the network, using an incremental assignment method. The trip matrices are assigned to the shortest paths generated successively after assignment of small lots each of 15-20% increment of the trips matrices. The incremental assignment proceeds by updating the transport networks using the speed flow relationships of the links. The assignment is largely controlled by alternative paths, which are built by the shortest path algorithm through the network. The output of the assignment is a loaded highway network with volumes (PCU unit) by link and vehicle type, and network speeds.

For the public transport assignment, the person trips unit is retained. The public transport network is developed from the highway network following the highway assignment, a process which produces a loaded road network representing congested travel times on the road network.

The public transport assignment considers multiple routes at an origin / destination level, and includes the modeling of fares for different modes. The selection of public transport route choice is based on the travel costs, including walk access time to bus or metro stops, wait time, in vehicle time and fare, transfer or interchange walk times and subsequent wait times, and the time to reach the final destination. The output of the assignment is a loaded public transport network with patronage by service.

The PT assignment is based on the PT lines file built in Cube Voyager software, which contains a total of existing 150 "real" lines of buses and shared auto (considering the directionality) in the study area.

The 4-stage model produces daily matrices therefore a standard average hour factor of 7% is applied to the matrices for both the daily road and public transport assignments. Peak hour model assignment is done separately to exhibit the constrained level of services during the peak hour.

3.3.15 Peak Hour Model Validation

The 4-stage model finally provides Daily & Peak Hour person matrices by mode at the end of the process including the peak hour external and special generators matrices.

3.3.16 Peak Hour Assignments Validation Result

The travel demand model needs to be validated to determine whether it is reproducing existing traffic conditions. Model validation has been undertaken by comparing the observed data collected from the traffic volume count surveys with their equivalent synthesized results as produced by the Cube model. The discrepancies observed at most of the survey locations are within 0-15% of the actual counts. The assigned peak hour traffic volume on network for the base year 2015 is presented in **Figure 3.26.**

Table 3.42 shows comparison of observed and assigned flows across the identified Midblock locations. The validation results are quantified thorough GEH Statistics using the 'Validation' option in Cube. The GEH Statistic is a formula used in traffic modeling to compare two sets of traffic volumes. Although its mathematical form is similar to a chi-square test, is not a true statistical test. Rather, it is an empirical formula that has proven useful for a variety of traffic analysis purposes.

FIGURE 3.26: ASSIGNED PEAK HOUR TRAFFIC VOLUME ON NETWORK IN PCU - 2015

The formula for the "GEH Statistic" is:

$$GEH = \sqrt{\frac{2(M-C)^2}{M+C}}$$

Where, M is the hourly traffic volume from the traffic model (or new count) and C is the real-world hourly traffic count (or the old count).

Using the GEH Statistic avoids some pitfalls that occur when using simple percentages to compare two sets of volumes. This is because the traffic volumes in real-world transportation systems vary over a wide range. For traffic modeling work in the "baseline" scenario, a GEH of less than 7.0 is considered a good match between the modeled and observed GEHs in the range of 7.0 to 10.0 may warrant investigation. GEH greater than 10.0 is not acceptable.

For the present study the traffic flows at identified midblock locations are within the acceptable error range.

TABLE 3.42: COMPARISON OF OBSERVED AND MODELED FLOWS AT SCREENLINE LOCATIONS

S.No.	Location	Observed Peak Hour PCUs	Modeled Peak Hour PCUs	% Difference	GEH Value
	Mid-Block / Screenline				
1	Geeta Nagar Crossing (Geeta Nagar Main Road)	904	1030	12.3%	4.1
2	Rawatpur Crossing (Rawatpur Main Road)	969	1121	13.6%	4.7
3	Coca Cola Chauraha (Mariampur Road)	1464	1508	3.0%	1.2
4	Jareeb Chowki (Vijay Nagar Road)	2096	2312	9.3%	4.6
5	Afim Kothi (Hamirpur Road - NH86)	1945	1885	-3.2%	1.4
6	PAC Mor (PAC Bridge Road)	1061	1243	14.6%	5.4
7	Govindpuri (Fazalganj - Barra Road)	2718	2459	-10.5%	5.1
8	Afim Kothi RuB (Hamirpur Road - NH86)	1671	1885	11.4%	5.1
9	Ganga Ghat Police Chowki (Phoolbagh - Moti Nagar Road)	236	279	15.4%	2.7

S.No.	Location	Observed Peak Hour PCUs	Modeled Peak Hour PCUs	% Difference	GEH Value
	Outer Cordon				
10	NH-02 - Kanpur-Auraya Road (Near Akbarpur Kanpur Dehat)	1334	1384	3.6%	1.4
11	NH-25 - Kanpur Jhansi Road (Near Namastey Milk Dairy Kanpur Dehat)	1286	1275	-0.9%	0.3
12	NH-86- Kanpur - Ghatampur Road (Near Bhidhnu)	1424	1298	-9.7%	3.4
13	SH-17 - Ramaipaur Jahanabad Road (Near Navada Village)	320	312	-2.6%	0.5
14	NH-2 - Kanpur-Fatehpur Road (Near Purvamir Chowki Thana Maharajpur)	966	853	-13.2%	3.7
15	NH-25 Gandhigram -Unnao Road (Near Jaajmau Ganga Bridge)	1650	1850	10.8%	4.8
16	SH-58 - Shuklaganj Unnao Road (Near Habatpur Shuklaganj)	1471	1391	-5.8%	2.1
17	Bithoor - Mandhana Road (Near Bithoor)	415	387	-7.2%	1.4
18	NH-91 - Kanpur-Kannauj (Near Chaubepur)	1168	1167	-0.1%	0.1
19	SH-17 Shivli-Kalyanpur Road (Near Baghpur)	867	820	-5.7%	1.6

The model validation results as presented above show that the model accurately replicates the existing travel situation in the study area (base year 2015) since the model figures are close to the observed data, HIS database and traffic counts. Therefore, the step following the model development, calibration, and validation, is to provide travel demand forecasts for the future years.

3.4 FUTURE TRAVEL DEMAND SCENARIOS

3.4.1 Forecast of Planning Parameters

Future Growth Scenario

Master Plan for Kanpur 2021 gives the likely growth within the various areas of study area. The Master Plan also gives locations of various land uses such as residential, commercial, industrial uses etc.

The population of surrounding towns of Kanpur is also expected to grow rapidly due to its close proximity to Kanpur. This will result in higher traffic interaction between the city and these towns. It is expected that the inter-city traffic to/from Kanpur will grow at growth rate of 3% per annum upto the horizon year of 2041 in various adjoining towns.

It has been proposed that Uttar Pradesh State Industrial Development Corporation (UPSIDC) will develop Trans-Ganga project covering 1,156 acres near Ganga Barrage in Kanpur City. It has been conceptualised for spurring investment, job creation, education, health and industrial development in the region. Post development, an attractive investment to the tune of Rs 10,000 core is expected to flow in the mega project, which would create about 1,00,000 direct and indirect jobs.

Transit Oriented Development (TOD) aims to develop planned sustainable urban growth centers, having walkable and livable communes with high density mixed land-use within the walking distance of (500 m) along the metro corridors. The population and employment in the traffic zones along the corridors have been estimated considering impact of TOD.

The horizon year planning parameters were finalised in consultation with KDA and a technical note on 'Land-use Parameters Estimation and Traffic Zone wise Distribution of Population, Employment and School Enrolment' was submitted on 13th May, 2015.

3.4.2 Population and Employment – Trends and Forecast

RITES has also forecasted the population based on the growth trends taken separately for Core, Middle, Outer and special areas collectively forming the study area in addition to existing growth pattern from Census Data. The population in the study area in the base year 2015 is 38.9 lakhs.

The employment for year 2011 has been worked out from the census data figures and has been extrapolated to obtain base year employment figures. WFPR as observed in the base year 2015 is 26.8% (total 9.3 lakh employment). Keeping in view the economic profile of the study area, development prospects and transport intervention policies, WFPR of 25% has been assumed from Kanpur Master Plan for the Horizon years. Thus, it has been estimated that 17.4 lakh workers would comprise the workforce in the study area by 2041.

Accordingly, the population and employment in the study area for the horizon years including TOD and other growth parameters for 2021, 2031 and 2041 is presented in **Table 3.43.**

The distribution of population and employment in horizon years amongst various traffic zones would be based on land use and population density for core, middle and outer areas as derived from Master Plan and presented in **Table 3.44.** The major activity centres generating employment in the study area include Mulganj, Collectorganj, Navin Market, Parade, Phoolbagh etc. have been considered.

TABLE 3.43: FORECASTED POPULATION & EMPLOYMENT IN THE STUDY AREA

Year	Forecasted Population (lakh)	Workers (Lakh)	WFPR (%)
2021	46.3	11.7*	25.3
2031	56.1	14.4*	25.7
2041	65.8	17.4*	25.5

** Estimated Figures based on 25% WFPR as per Master Plan, Economic & Landuse Profiles*

TABLE 3.44: ZONEWISE FORECASTED POPULATION AND EMPLOYMENT FOR HORIZON YEARS

Zone No.	2021		2031		2041	
	Population	Employment	Population	Employment	Population	Employment
1	40313	42365	44092	46798	46347	49191
2	49410	18166	54041	20066	56805	21093
3	38680	55658	47150	67847	54720	84341
4	50559	7011	55298	7745	58126	8141
5	46817	21056	51206	23259	53824	24449
6	96398	21264	106484	23489	111929	24690
7	92937	40715	113290	49632	131477	61698
8	57122	30704	69631	37428	80810	46527
9	47553	6481	52010	7159	54670	7525
10	88602	42033	108005	51238	125345	63694
11	49578	16092	60435	19616	70137	24384
12	80284	19122	97866	23310	113577	28977
13	24586	12811	29970	15617	34782	19413
14	66792	10817	81418	13186	94489	16391
15	81961	12119	104916	15665	127893	19473
16	30541	11511	39095	14879	47656	18496
17	65909	33012	84369	42673	102845	53047
18	65549	16390	83908	21186	102283	26337

Zone No.	2021		2031		2041	
	Population	Employment	Population	Employment	Population	Employment
19	79131	15400	101294	19907	123477	24746
20	42992	22833	55033	29515	67085	36690
21	62404	15435	79883	19952	97377	24802
22	55162	22635	67242	27592	78037	34299
23	64764	12911	71540	14262	75199	14992
24	103128	39633	125713	48312	145895	60058
25	73645	42055	81350	46455	85511	48831
26	89860	24529	115028	31707	140219	39415
27	60177	7804	77032	10088	93901	12541
28	77105	13379	93991	16309	109080	20273
29	65212	7170	83477	9269	101758	11522
30	42419	7064	54300	9132	66192	11352
31	95302	41930	121994	54200	148710	67377
32	88871	21468	113763	27750	138676	34496
33	63329	5386	81066	6963	98819	8655
34	53175	5105	68069	6599	82975	8203
35	71629	5738	91691	7417	111771	9220
36	68179	6996	87275	9043	106388	11241
37	63995	24366	81919	31496	99859	39153
38	74006	17270	90213	21052	104696	26170
39	80874	9293	103525	12013	126197	14933
40	31774	3866	40673	4997	49580	6212
41	119889	18610	131127	20556	137833	21608
42	2352	639	2573	706	2704	742
43	53996	4450	58493	5808	71303	7363
44	80899	17024	92931	22222	113282	28169
45	46862	3720	49360	4856	60170	6156
46	96773	18199	148660	23755	183749	30113
47	51662	3354	56505	3705	59394	3895
48	55947	21879	71617	28282	87301	35157
49	58277	8830	74599	11414	90936	14189
50	98634	34954	126260	45182	153910	56166
51	76970	33493	85023	36997	89371	38889
52	104120	9149	126921	11153	147297	13864
53	77414	8500	94368	10362	109518	12881
54	66943	9712	81603	11839	94704	14717

Zone No.	2021		2031		2041	
	Population	Employment	Population	Employment	Population	Employment
55	53138	6986	58118	7717	61091	8111
56	76256	14463	92955	17631	107879	21917
57	72488	8478	88362	10334	102548	12847
58	49020	8089	59755	9861	69349	12258
59	83495	13987	101779	17050	118119	21195
60	83484	18487	101766	22536	118104	28014
61	80107	19697	97650	24010	113327	29847
62	47788	7835	58254	9550	67606	11872
63	44623	8141	54395	9924	63128	12336
64	48145	8648	51002	11288	62171	14309
65	66046	11228	73917	14656	90105	18579
66	100623	18960	118179	24748	144060	31372
67	70526	12359	79652	16132	97095	20449
68	53061	4512	57295	5890	69842	7466
69	62285	7370	69103	9620	84236	12194
70	66435	19401	74416	25323	90713	32101
Total	**3892171**	**1043101**	**5605895**	**1437924**	**6579959**	**1741824**

3.4.3 Assumptions for Transport Demand Forecasting

The following assumptions have been made for forecasting transport demand by the model for years 2021, 2031 and 2041.

i. Calibrated and validated travel demand model has been used.
ii. Land use parameters (population, employment and student enrolment) have been distributed in various traffic zones for 2021, 2031 and 2041.
iii. Impact of the development due to the metro corridors (TOD) have been considered while distributing it in traffic zones.
iv. Fare levels of buses and vehicle operating costs of different vehicles have been taken as same as in the year 2015. The fare levels of metro have been considered same as that of the Lucknow Metro network.
v. Inter-city passenger to/from the study area will grow at the growth rate of 3% per annum in various adjoining towns.
vi. The special generator passenger traffic of bus terminals and railway stations in Kanpur is expected to grow at 6 % per annum respectively.
vii. Inter and Intra-city goods traffic is expected to grow at 5% per annum up to 2041.

Since the metro operation in Kanpur is proposed to be started by 2024, the demand for 2024 is estimated based on the growth between 2021 and 2031.

3.4.4 Transport Demand Forecast for Business As Usual (BAU) Scenario, 2041

Considering the above assumptions and calibrated / validated traffic demand model, forecasting of transport demand has been carried out for 'Business as Usual' (BAU) scenario in the year 2041.

Overall modal split for various modes in this scenario for the year 2041 is given in **Table 3.45**. The inter and intra city motorized trips modal split (% of trips by public transport to total motorized trips) in favor of public transport in 2041 is expected to be 39% slightly more than existing modal share of 38%. The total no. of PT trips will increase from 9.1 Lakh to about 26.2 Lakh indicating a high capacity mass transport network will be needed to address the travel demand requirements in the study area in the horizon years.

TABLE 3.45: DAILY MOTORISED INTER + INTRA CITY TRIPS IN BAU SCENARIO, 2041

SN	Mode	2015		2041 BAU	
		Trips	Modal Share	Trips	Modal Share
1	Car	228138	9.5%	681473	10.3%
2	Two Wheeler	1199225	49.7%	3092657	46.8%
3	Private Auto	79676	3.3%	226620	3.4%
4	PT + Shared Auto	906239	37.6%	2616741	39.4%
	Total	**2413278**	**100.0%**	**6617491**	**100.0%**

Desire line diagram for total peak hour traffic (in PCUs) for BAU Scenario 2041 is given in **Figure 3.27**. The figure indicates the zone to zone traffic interaction on the overloaded roads in 2041 in business as usual scenario. Trip assignments on the road network in terms of peak hour PCUs for this BAU scenario 2041 is given in **Figure 3.28**.

3.5 RIDERSHIP ASSESSMENT FOR HORIZON YEARS

3.5.1 Transport Demand Forecast for Recommended Scenario

The trips made between two adjacent stations of proposed mass transit corridors have been worked out for the years 2024, 2031 and 2041. The maximum peak hour peak direction trips for proposed metro corridors are given in **Table 3.47**. Total proposed Metro length in Phase-I is about 33 Km.

FIGURE 3.27: DESIRE LINE DIAGRAM FOR PEAK HOUR TRAFFIC (IN PCU'S) ON ROAD NETWORK IN BAU SCENARIO 2041

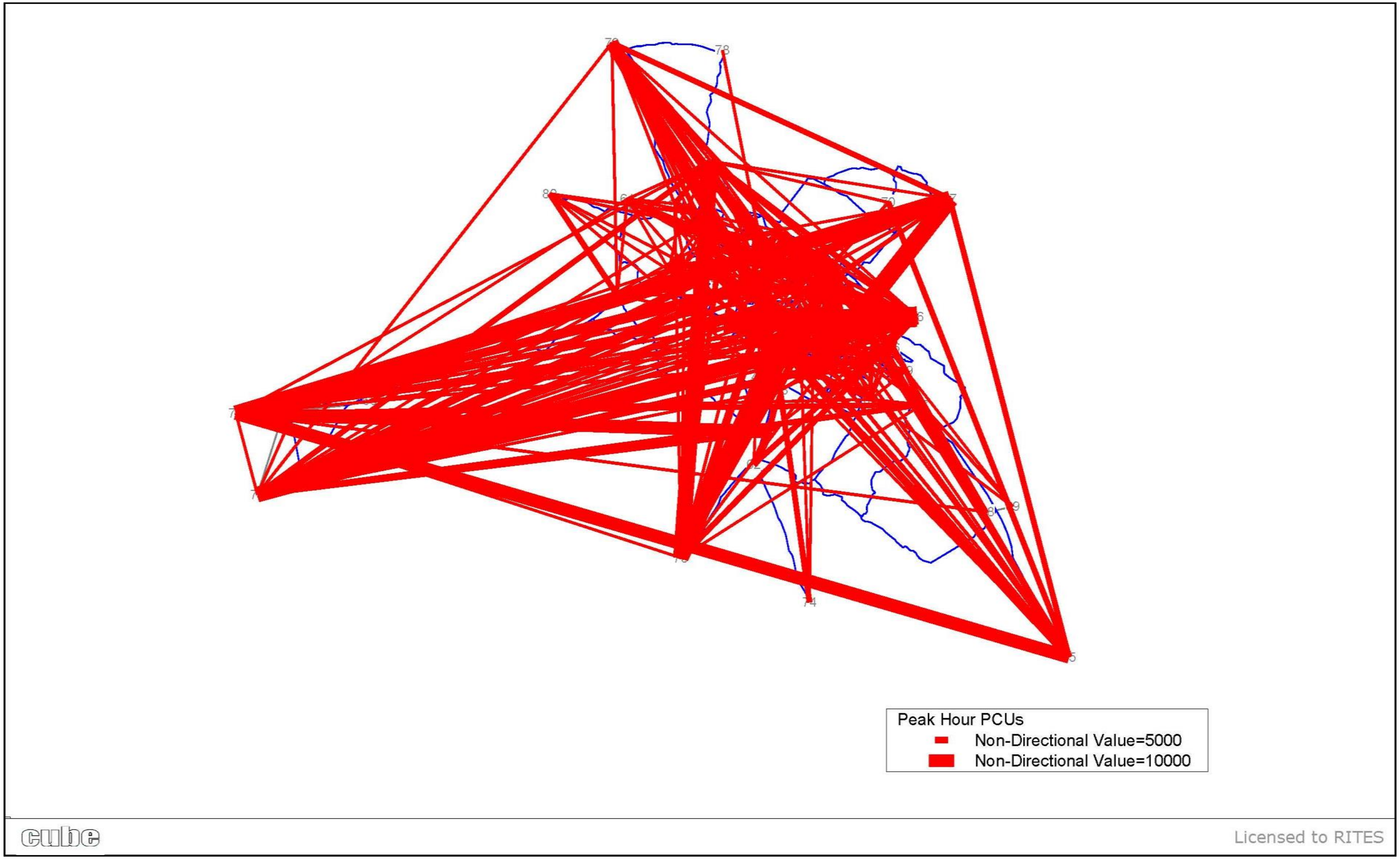


FIGURE 3.28: TRAFFIC ASSIGNMENT FOR PEAK HOUR TRAFFIC (IN PCU'S) ON ROAD NETWORK IN BAU SCENARIO 2041

TABLE 3.46: MAXIMUM PEAK HOUR SECTION LOADING ON PHASE I METRO CORRIDORS

Corridor No.	Corridor details	Maximum PHPDT			Length (Km)
		2024	2031	2041	
1	IIT Kanpur to Naubasta	18040	21300	27900	24.0
2	Agriculture University to Barra-8	12540	17800	20800	9.0
	Total Length of Phase I				**33.0**

3.5.2 Horizon Year Peak Hour Traffic Assignment

Figure 3.28 shows the horizon year trip assignments on the road network in terms of peak hour PCUs for 2041 in recommended scenario.

3.5.3 Ridership on Phase-I Metro Corridors for 2024, 2031 & 2041

Daily ridership on the Phase-I metro corridors for the years 2024, 2031 and 2041 is expected to be 9.4 Lakh, 10.8 Lakh and 13.5 Lakh passengers respectively. Line wise daily passenger boardings (including the interchanges between metro stations) and trips for 2024, 2031 and 2041 are shown in **Table 3.47.** The sectional loads of the proposed Phase-I metro corridors for 2024 is presented in **Figure 3.30.**

TABLE 3.47: DAILY RIDESHIP ON METRO PHASE I CORRIDORS IN YEAR 2024, 2031 & 2041

S No.	Corridor Name	Daily Boardings (Lakh)			Daily Trips (Lakh)		
		2024	2031	2041	2024	2031	2041
1	IIT Kanpur to Naubasta	7.63	8.55	11.06	6.77	7.22	9.33
2	Agriculture University to Barra-8	2.97	4.22	4.94	2.65	3.57	4.17
Total Daily Boardings / Trips		**10.60**	**12.77**	**16.00**	**9.42**	**10.79**	**13.50**

3.5.4 Peak Hour Section Loads and Station Boarding & Alighting on Phase-I Metro Corridors

The trips made between two adjacent stations of proposed metro corridors have been worked out for the horizon years of 2024, 2031 and 2041. The section loads for the horizon years are presented in **Table 3.48.**

Peak hour station loads (two way boarding & alighting) on Phase-I metro corridors for various horizon years of 2024, 2031 and 2041 are given in **Table 3.49**.

FIGURE 3.29: ASSIGNED PEAK HOUR TRAFFIC ON NETWORK IN PCUS - 2041

TABLE 3.48: PEAK HOUR SECTION LOADS ON PHASE-I METRO CORRIDORS

From	To	2024		2031		2041	
		Dir1	Dir2	Dir1	Dir2	Dir1	Dir2
Corridor 1: IIT Kanpur to Naubasta							
IIT Kanpur	Kalyanpur Railway Station	2100	1900	3100	2800	4500	4100
Kalyanpur Railway Station	SPM Hospital	6900	6500	8700	9200	15900	12800
SPM Hospital	Kanpur University	7400	8600	9500	12300	16900	16500
Kanpur University	Gurudev Chauraha	8900	12500	11300	16900	18700	17900
Gurudev Chauraha	Geeta Nagar	9000	12700	11600	17200	13300	18000
Geeta Nagar	Rawatpur Railway Station	8600	12700	11300	16900	13300	17000
Rawatpur Railway Station	Lala Lajpat Rai Hospital	12500	13500	12900	14300	17900	17200
Lala Lajpat Rai Hospital	Moti Jheel	12900	13800	13800	14900	19300	18100
Moti Jheel	Chunniganj	13000	14100	14700	15700	20300	19200
Chunniganj	Naveen Market	12600	15300	14000	17500	19400	21700
Naveen Market	Bada Chauraha	12500	15700	14200	18000	19000	22800
Bada Chauraha	Phoolbagh	9400	**18000**	9500	**21300**	12000	**27900**
Phoolbagh	Nayaganj	9300	17000	9500	20000	11700	26200
Nayaganj	Kanpur Central Rly. Station	10100	16700	10200	20800	11900	27500
Kanpur Central Rly.Station	Jhakarkati Bus Terminal	8300	15100	8400	15300	9100	21000
Jhakarkati Bus Terminal	Transport Nagar	6100	12400	7700	12600	9200	17900
Transport Nagar	Baradevi	5800	10800	7300	11600	8800	16500
Baradevi	Kidwai Nagar	5800	10800	6700	12400	8100	16800
Kidwai Nagar	Vasant Vihar	5500	9800	6400	10800	7800	15700
Vasant Vihar	Baudh Nagar	5700	7100	6400	7500	7700	9200
Baudh Nagar	Naubasta	4400	4400	5400	5100	7100	6500
Corridor 2: Agriculture University to Barra-8							
Agriculture University	Rawatpur Rly. Station	4200	5000	5400	6200	6500	7400
Rawatpur Rly. Station	Kakadeo	8000	12300	11100	17200	12000	19700
Kakadeo	Double Pulia	7500	**12500**	10300	**17800**	10800	**20800**
Double Pulia	Vijay Nagar Chauraha	7200	11800	10100	17200	10500	20000
Vijay Nagar Chauraha	Govind Nagar	3200	7500	8000	13400	8400	18000
Govind Nagar	Shastri Chowk	3100	6300	8200	12100	9200	16500
Shastri Chowk	Barra-7	2500	5400	7800	11200	9700	15300
Barra-7	Barra-8	1600	2600	4000	4800	4200	5200

TABLE 3.49: PEAK HOUR STATION LOADS ON PHASE-I METRO CORRIDORS

Station	Peak Hour 2024*		Peak Hour 2031*		Peak Hour 2041*	
	Boarding	Alighting	Boarding	Alighting	Boarding	Alighting
Corridor 1: IIT Kanpur to Naubasta						
IIT Kanpur	2100	1900	3100	2800	4500	4100
Kalyanpur Railway Station	5700	5600	6700	7500	14700	11900
SPM Hospital	1100	2700	1900	4300	2700	5400
Kanpur University	2600	5100	3600	6400	7400	7000
Gurudev Chauraha	3400	3400	4100	4100	8000	12400
Geeta Nagar	1800	2200	2300	2300	3100	3100
Rawatpur Railway Station	12900	9700	17400	13300	19400	15000
Lala Lajpat Rai Hospital	1600	1600	2100	1700	3100	2500
Moti Jheel	2300	2600	2700	2700	3900	4000
Chunniganj	2400	3900	3500	5900	5100	8500
Naveen Market	3900	4500	7000	7400	9500	11000
Bada Chauraha	2500	7800	3600	11400	4900	17000
Phoolbagh	2900	2000	3200	2100	3800	2400
Nayaganj	4700	3900	4800	5600	5100	6200
Kanpur Central Railway Station	6900	7900	15800	11100	16300	12600
Jhakarkati Bus Terminal	5100	4600	6700	4700	7900	4800
Transport Nagar	1000	700	1700	1200	2700	1800
Baradevi	2600	1900	3800	3100	5300	6200
Kidwai Nagar	1400	700	1500	900	2100	1300
Vasant Vihar	5300	1600	5400	3400	9900	3500
Baudh Nagar	3500	2000	3800	2300	4700	2700
Naubasta	4400	4400	5400	5100	7100	6500
Corridor 2: Agriculture University to Barra-8						
Agriculture University	1800	1700	1900	2200	2000	2500
Rawatpur Railway Station	8200	12500	10900	16700	11500	18300
Kakadeo	1000	1800	1800	3200	2600	4900
Double Pulia	1300	1000	1400	1100	1900	1400
Vijay Nagar Chauraha	6700	6100	7900	6300	9200	9300
Govind Nagar	2000	900	2700	1100	4100	1800
Shastri Chowk	2600	2200	4600	4100	5800	4200
Barra-7	3300	1400	5500	3900	9500	5900
Barra-8	2600	1600	4800	4000	5200	4200

* Two way boardings/alightings on platforms

FIGURE 3.30: SECTIONAL LOADS IN PROPOSED METRO CORRIDORS IN 2024

3.5.5 Design Ridership

The metro corridor from IIT Kanpur to Naubasta is being designed for 18000 PHPDT in 2024, 21300 in 2031, 27900 in 2041 where as Agriculture University to Barra-8 Corridor is being designed for 12500 PHPDT in 2024, 17800 in 2031, 20800 in 2041 respectively. These PHPDT figures will rely on proposed developments as envisaged in Master Plan of Kanpur, realization of other planned transport infrastructure projects and a number of unforeseen issues that could appear during next 20-40 years.

MRTS system however, will serve the city much beyond 2041. The design ridership for the two corridors in Phase-I have been taken as PHPDT of 40000 (IIT Kanpur to Naubasta) and PHPDT of 30000 (Agriculture University to Barra-8) respectively to take care of traffic growth beyond 2041. These two Phase I metro corridors have been prioritized for implementation by KDA. The system will start operating with initial ridership estimated and the capacity will be increased depending on the ridership growth.

Chapter – 4
SYSTEM & TECHNOLOGY SELECTION

4. SYSTEM & TECHNOLOGY SELECTION

4.1 TECHNOLOGY

Selection of a particular mass transit system largely depends on the characteristics of the city and its metropolitan area, the projection of traffic demand for transit travel and the availability of suitable right-of-way (ROW). Mass Transit System is selected and planned to provide comfortable, safe, reliable and fast/high frequency connectivity across the cityscapes.

The urban transport requirements of Kanpur City have been evaluated based on projected traffic demand. Considering the city specific characteristics, traffic demand and availability of right of way, a medium capacity Metro rail system, which can cater to design capacity of 40000 PHPDT is proposed for Kanpur.

Metro Rail system is most prevalent mass transit system adopted worldwide. In India, MRTS is operational in various cities viz. Delhi, Chennai, Kolkata, Mumbai, Bangalore, Kochi, Jaipur etc. Metro rail technology offers the advantage of latest technology being available off the shelf with standardization, indigenization and has already stabilized for reliability, acceptance and availability of manufacturing infrastructure (for spare parts etc.) around the world and also in India. It is a grade separated system with exclusive right of way characterized by short distances of stations spaced at about 1 km and modern state of the art rolling stock having high acceleration and deceleration with maximum speed of 80-120 kmph. Sharpest curve of 120m radius is permitted for MRTS. The system can be designed to meet the peak hour peak direction traffic (PHPDT) carrying capacity from 10,000 to up to 80,000 depending upon the type of systems and infrastructure adopted such as rolling stock, train set configurations, signaling system, stations platform length etc. Considering the city specific characteristics, traffic demand, availability of right of way, **Medium capacity Metro rail system with 6 car train composition can be adopted for the proposed corridors of Kanpur**. The capacities indicated for 6 car trains have been calculated by considering 1.5 minutes (90 seconds) headway which is achievable with advanced signalling system i.e. CBTC technology. However, because of the track geometry, radius of curvatures and gradients etc. along the track alignment, headway of 90 seconds may not be practically achievable for metro systems.

4.2 SYSTEM SPECIFICATIONS ADOPTED FOR THE CORRIDOR

Following system specification parameters are considered for the Kanpur Metro corridors. The rationale for choosing the particular technological parameter has been discussed in detail in the respective chapters.

TABLE 4.1: SYSTEM SPECIFICATION PARAMETERS

Parameters		**System Specification**
Traffic Handling capacity (PHPDT)		10000-80000
Alignment and Gauge	**Minimum radius of curvature**	Min. for elevated = 120m Min. for UG = 200m
	Gradient	4%
	Gauge	Standard gauge (1435 mm)
Traction System		25 kV AC Overhead Catenary
Signaling System		Communication Based Train Control (CBTC) System as per IEEE 1474.1
Telecommunication System		IP GE based
Rolling Stock	**Coach Width**	2.9 m wide coaches
	Basic Unit	One motor car and one trailer car
	Train Composition	3- Car: DMC-TC-DMC 6 –Car: DMC-TC-MC-MC-TC-DMC Capable of GoA4 operation Every coach should be fully interchangeable with any other coach of same type.
	Coach construction	Light weight stainless steel/Aluminum body
	Axle load	≤16 T
	Braking System	Regenerative Braking
	Propulsion system	3 phase drive system with VVVF control
	Performance Characteristics	Max. Design speed : **90 kmph** Max. Acceleration :**0.8 m/s^2** Max. Deceleration : **1.0 m/s^2 (Normal brake)** More than **1.3 m/s^2 (Emergency brake**

Chapter – 5

CIVIL ENGINEERING, ALIGNMENT DETAILS

5. CIVIL ENGINEERING, ALIGNMENT DETAILS

5.1 ALIGNMENT DESCRIPTION OF APPROVED ALIGNMENT, AVAILABILITY OF ROAD

5.1.1 ENGINEERING SURVEY

5.1.1.1 Survey Methodology

- Before starting the detailed topographical survey work, a team of expert in the field of alignment design and survey has conducted reconnaissance survey to familiarize with the area and selection of control points along the proposed Metro Route.

- Topographical survey of the Corridor 1- (IIT Kanpur to Naubasta) and Coridor-2 (Agriculture University to Barra-8) have been carried out to collect all manmade and natural features like roads, building, drain, railway line telephone/electric pole etc., falling in the proposed metro corridor for better and accurate planning of the metro alignment.

- Topographical survey was carried out in detail covering all the activities which are mentioned in Terms of Reference of the Contract using modern surveying instrument like GPS, Total Station and Auto/Digital Level. Survey Drawings were prepared in AutoCAD format.

- Topographical survey has been carried out in following six steps:

  1. Establishment of Horizontal Control Points using DGPS
  2. Densification of Horizontal Control Points using Total station
  3. Establishment of Vertical Control Points
  4. Detailed survey of corridor
  5. Preparation of drawings.
  6. Site verification of features.

5.1.1.2 Horizontal Control Points Establishment using DGPS

Before starting the GPS work, network has been planned and a pair of concrete pillars of 300x300x400mm size of M15 grade concrete has been fixed at every one Km in both corridors. A mild steel rod of 20mm diameter and 350mm long

has been provided at the centre of pillar to mark location of GPS point. Location of these pillars has been selected such that these are obstruction free towards sky at an angle of 15 degree with Horizontal plane to achieve required degree of accuracy in GPS observation.

For carrying out network adjustment, one control point (base point) in the centre of the project area in Vijay Nagar has been selected. At this point, 24hrs GPS observation was done to achieve higher degree of accuracy and for other points, 4hrs common period observation have been done. Common period observation at three points have been carried out to form the triangle and find out accuracy of the loop with the help of loop closer reports by solving these triangle with the help of data processing software.

In this survey, ***Sokkia GRX-2*** GPS has been used for collecting GPS Data. Data was downloaded and processed with ***Spectrum office*** software. In this processing UTM Projection system and WGS84 Datum has been used for horizontal controls whereas for vertical control Earth Gravitation Model 2008 (EGM 08) has been used. Grid Co-ordinates have been converted in Ground Co-ordinate by using combined scale factor. These Ground Co-ordinates are used in total station during the traversing and topographical survey. Details of GPS Control points established are provided given in **Table 5.1**

TABLE 5.1: LIST OF GPS CONTROL POINTS

S. No.	Point ID	Ground Coordinate		MSL Level (m)	Description
		Northing	Easting		
1	GPS 1	2933614.899	424212.116	126.028	LHS OF GT ROAD NEAR RLY PILLAR NO 13/5
2	GPS 1A	2933528.978	424260.665	126.199	LHS OF GT ROAD NEAR RLY PILLAR 13/4, NEWLY CONSTRUCTED L.C.
3	GPS 2	2932954.014	424593.548	126.594	RHS OF THE GT ROAD ,NEAR RLY PILLAR 12/10
4	GPS 2A	2932781.848	424697.375	126.749	RHS OF THE GT ROAD RLY PILLAR 12/8

S. No.	Point ID	Ground Coordinate		MSL Level (m)	Description
		Northing	Easting		
5	GPS 3	2932224.877	425166.439	127.766	LHS OF THE GT ROAD , NEAR RAVI DAS UDYAN NEAR WELDING SHOP
6	GPS 3A	2932110.560	425197.954	128.368	RHS OF THE GT ROAD CEMENT STORE JANTA TRADERS
7	GPS 4	2931209.557	425921.141	126.966	RHS OF GT ROAD, CLOSER TO RLY LINE AND INFRONT OF KALYANPUR INDIAN OIL PETROL PUMP
8	GPS 4A	2931159.400	425998.228	126.784	RHS OF THE GT ROAD AND CLOSER TO LEVEL CROOSING AND RLY PILLAR NO 10/5
9	GPS 5	2930798.805	427245.680	126.944	RLY PILLAR 8/15 NR MANDIKHEDA ROAD
10	GPS 5A	2930766.148	427345.439	126.839	RLY PILLAR 8/13 BEFORE IIPR MAIN GATE
11	GPS 6	2930477.453	428164.655	128.296	RHS OF GT ROAD RLY PILLAR 7/17 INFORNT OF HANUMAN TEMPLE
12	GPS 6A	2930452.841	428316.559	127.862	LHS OF GT RLY PILLAR 7/14 IN BESIDE THE CADD CENTER
13	GPS 7	2929772.072	429483.926	126.561	RHS OF GT ROAD AND RLY PILLAR 6/10 AND INFRONT OF BRITISH PAINT
14	GPS 7A	2929720.395	429528.769	126.429	RLY PILLAR 6/8 AND INFRONT OF ANKUR INDAND UP LAMINATOR LTD
15	GPS 8	2929478.588	430286.036	126.794	NEAR CENTRAL REPAIRING HOUSE UPSRTC & LHS VIP ROAD
16	GPS 8A	2929520.213	430382.819	126.604	INFRONT OF UPSRTC BUS CANTEEN RHS SIDE OF VIP ROAD
17	GPS 9	2929259.362	431118.699	126.935	INSIDE GSVM COLLEGE PLAY GR SE CORNER
18	GPS 9A	2929387.151	431062.882	126.444	INSIDE GSVM COLLEGE PLAY GR NE CORNER
19	GPS 10	2928705.762	431735.919	127.217	MOTI JHEEL ON OPEN AREA, LHS OF THE ROAD

S. No.	Point ID	Ground Coordinate		MSL Level (m)	Description
		Northing	Easting		
20	GPS 10A	2928615.009	431788.530	126.899	MOTI JHEEL ON OPEN AREA LHS OF INFRONT OF PARK ROAD
21	GPS 11	2928812.100	432585.958	125.063	BESIDES SCOUT OFFFICE AND CANTEEN SCOUT OFFICE
22	GPS 11A	2928729.061	432673.404	124.853	NEAR GATE OF THE PRIVATE COMPANY
23	GPS 12	2928884.074	433820.129	125.701	NEAR CHUNNIGANJ BUS DEPOT SECURITY OFFICE
24	GPS 12A	2928858.927	433914.597	126.245	CHUNNIGANJ BUS DEPOT CORNER
25	GPS 13	2928301.477	434770.557	125.948	PARED MARKET GR GATE, RHS OF ROAD AND OPPOSITE TO LANDMARK
26	GPS 13A	2928248.368	434821.182	125.643	PARED MARKET GR TRANSFORMER, RHS OF ROAD AND OPPOSITE TO LANDMARK MARKET COMPLEX
27	GPS 14	2928207.471	435471.634	122.778	BOUNDRY SIDE OF Z SQUARE SHOPPING MALL, LHS ROAD
28	GPS 14A	2928187.197	435527.891	122.268	AT EXIT GATE OF Z SQUARE SHOPPING MALL, LHS OF ROAD
29	GPS 15	2927698.950	436265.670	125.551	NEAR THE MAHATMA GANDHI STATUE INSIDE KANPUR MUNICIPALTY PARK, LHS ROAD
30	GPS 15A	2927623.128	436242.062	125.950	NEAR THE WATER TANK INSIDE KANPUR MUNICIPALTY PARK, LHS ROAD
31	GPS 16	2926748.334	435647.703	126.366	OPPOSITE SIDE OF JALA SANSTHAN
32	GPS 16A	2926721.878	435587.620	126.559	LHS OF CANAL ROAD
33	GPS 17	2926092.579	434893.668	128.134	NEAR OVERHEAD TANK BY THE SIDE OF ROB, WEST END OF THE KANPUR CENTRAL RAILWAY STATION

S. No.	Point ID	Ground Coordinate		MSL Level (m)	Description
		Northing	Easting		
34	GPS 17A	2925985.727	434836.170	125.717	IN FRONT OF A RLY QUATER SIDE OF THE ROB CONNECTING GHANTAGHRA TO TATA MILL , WEST END OF KANPUR CENRTAL RAILWAY STATION
35	GPS 18	2925695.791	433959.820	126.578	NEAR LEVEL CROSSING POLE
36	GPS 18A	2925614.056	434008.873	126.007	BESIDE THE RLY TRACK
37	GPS 19	2925166.645	433063.300	126.901	INFRONT OF SHYAM THEATER AND RHS OF ROAD
38	GPS 19A	2925012.913	433008.762	126.607	INFRONT OF PNB STORE AND LHS OF ROAD
39	GPS 20	2924092.051	432532.510	126.168	BACKSIDE OF MANDIR AND LHS OF ROAD NEAR GOSAL JUNCTION
40	GPS 20A	2923974.346	432433.614	125.268	SIDHARTH EYE HOSPITAL AND RHS OF ROAD GOSAL JUNCTION
41	GPS 21	2923053.200	432213.353	125.255	MANDIR AND SAND STORAGE
42	GPS 21A	2922866.160	432144.306	124.906	MADHUBAN GARDEN, RHS OF NAUBASTA ROAD
43	GPS 22	2921939.675	431984.821	125.706	GURU MOTOR DRIVING RHS OF NAUBASTA ROAD
44	GPS 22A	2921811.960	431986.320	126.002	MARKED IN MEDIAN OF NAUBASTA NEAR SBI ATM
45	GPS 23	2920466.046	431647.303	126.648	MARKED IN MEDIAN OF NAUBASTA IN VEGITABLE MARKET
46	GPS 23A	2920297.970	431606.573	126.285	MEDIAN OF NAUBASTA INFRONT OF CEMENT STORE
47	GPS 24	2919572.741	431429.530	125.074	MANAYTA HOSPITAL INFRONT, LHS OF ROAD
48	GPS 24A	2919391.728	431370.448	124.902	GAYATRI HOSPITAL NEAR MARKED POINT ON LHS OF ROAD
49	GPS 25	2930047.451	431297.643	126.118	AGRI RESERCH INSTITUTE FILED AND RHS OF VIP ROAD
50	GPS 25A	2929976.045	431098.322	125.512	INFRONT OF AGRI RESERCH INST. AND LHS OF VIP ROAD
51	GPS 26	2928858.709	429965.630	126.024	INFRONT OF REGIONAL LABOUR INSTITUTE, RHS OF ROAD

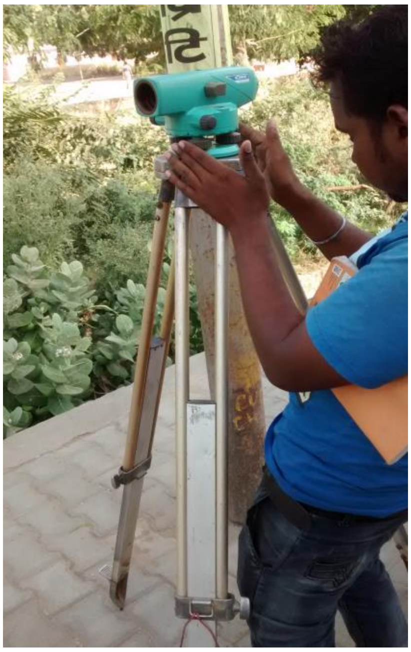
S. No.	Point ID	Ground Coordinate		MSL Level (m)	Description
		Northing	Easting		
52	GPS 26A	2928732.166	429883.124	126.336	NEAR THEATER CLOSED & AKAYA SHOP FRONT, LHS OF ROAD
53	GPS 27	2928100.518	429317.902	126.092	NEAR THE BASTI AT DOUBLE PULLIA & INDANE GAS DEPOT, LHS OF ROAD
54	GPS 27A	2928085.813	429259.034	126.133	JAIPURIA ENGLISH MEDIUM PRE SCHOOL, RHS OF ROAD
55	GPS 28	2927160.523	429638.529	124.757	INFRONT OF FRUIT SHOP VIJAYANAGAR, LHS OF ROAD
56	GPS 28A	2927057.108	429631.602	125.477	MARKED IN MEDIAN NEAR VIJAYNAGAR CHAURAHA
57	GPS 29	2926016.043	429662.056	128.382	LHS OF THE VIJAY NAGAR-JARAULI ROAD AT DADA NAGAR AREA BY THE SIDE OF A RAILWAY OVER BRIDGE BEFORE THE RAILWAY CROSSING
58	GPS 29A	2925895.854	429712.896	127.525	LHS OF THE VIJAY NAGAR-JARAULI ROAD AT DADA NAGAR AREA BY THE SIDE OF A RAILWAY OVER BRIDGE AFTER THE RAILWAY CROSSING
59	GPS 30	2924802.581	429648.758	122.758	NEAR THE PUMP HOUSE JANATA NAGAR FIELD
60	GPS 30A	2924748.103	429615.771	122.694	LHS OF VIJAYNAGAR- JARAULI ROAD, CORNER OF PARK, JANATA NAGAR
61	GPS 31	2923995.111	429307.178	124.030	NEAR KARGIL PETROL PUMP BEHIND THE SAUCHALAYA NEAR HIGH WAY CROSSING
62	GPS 31A	2923905.536	429443.614	123.795	100 LEFT OF THE JARAULI VIJAYNAGAR ROAD INSIDE A OPEN FIELD CLOSE TO A NEEM TREEAND THE SHIV TEMPLE
63	GPS 32	2923031.506	429255.864	124.047	RHS OF THE ROAD, CORNER OF THE FIELD INSIDE JARAULI RESISENTIAL AREA
64	GPS 32A	2922964.007	429266.763	123.884	ON THE MEDIAN OF ROAD CLOSER TO THE MEDIAN END

S. No.	Point ID	Ground Coordinate		MSL Level (m)	Description
		Northing	Easting		
65	GPS 33	2922405.243	429133.908	123.262	RHS 21 M FROM THE JARAULI EXISTINF ROAD, CLOSER TO THE BOUNDARY WALL
66	GPS 33A	2922314.595	429072.692	123.367	RHS , 20 M FROM EXISTING ROAD 100 M BEDORE THE ANANDA SOUTH CITY GATE

5.1.1.3 Densification of Horizontal Control Points using Total Station

AS per project requirement, five to six additional pillars of same size on traverse points have been fixed between GPS control points which is used during the detailed topographical survey of the corridors.

Densification of horizontal points involves fixing of additional pillars between GPS Pillars along the corridors. In this activity traversing has been carried out by Leica Total Station of 1"(one second) accuracy between GPS points which co-ordinates are already determined with help of GPS observation. Co-ordinates of intermediate points established with the help of total station have been determined by solving the traverse network between GPS control Points. Closing error of traverse network was calculated and errors which were within permissible limits, were adjusted by transit rule method after adjusting the angular error of the traverse. As per TOR, total linear error in traverse after angular adjustment was permitted 1 in 50,000 where as angular error of traverse was permitted 15"√n where n is the number of angle measured in the traverse network.



5.1.1.4 Establishment of Vertical Control

Establishment of vertical control was started from a known benchmark situated on wall of CETA building near Kanpur Railway station. The value of this benchmark is 418.38ft (127.522m) which was collected from AEN Works, Kanpur, North Western Railway. From this location bench mark was transferred along the both corridor using three stadia method of leveling with Auto levels. Every loops of level has been closed and closing error of leveling loops has been worked with the formula given below:

$\sum$ BS - $\sum$ FS = $\sum$ RISE - $\sum$Fall = Last R.L – First R.L.

Closing error within permissible limit has been adjusted. Permissible error in leveling is 6√K mm where K is length of the loop in Km. The Leveling was carried out by a precision auto level with accuracy of ±6√K. Reduced levels of all traverse stations and permanent control points were taken by Double territory method. Bench mark has been established at interval of 500m along the corridor or as per instruction of site in- charge. Details of benchmarks are given in **TABLE 5.2**

TABLE 5.2: LIST OF TEMPORARY BENCHMARKS

S. No.	TBM No	Easting	Northing	RL	Description
1	TBM 1G	424243.181	2933584.287	125.311	ON PARAPET OF CULVERT AT GATE (LHS) OF BHARATIYA ANUSANDHAN SANSTHAN, NEAR MAST 13/5 -4.
2	TBM 2G	424566.667	2933007.306	126.907	ON PARAPET OF RLY CVT NO. 19 RHS B/W MAST 12/6-7 IN GPS 2 TO GPS 2A
3	TBM 3G	425141.061	2932200.651	128.565	ON BASE OF HAND PUMP NEAR SAT GUNA RABI DAS UDYAN AT GPS 3A. (RHS)
4	TBM 3/5G	425695.125	2931401.848	128.136	ON PLINTH OF LC NO. 13-B IN B/W MAST 10/14-15.
5	TBM 4/2G	426341.257	2931104.028	126.074	ON PARAPET OF FUTURE PEDDY SCHOOL. LHS IN B/W GCP 4/2 TO 4/3 NEAR RLY MAST 9/14.

S. No.	TBM No	Easting	Northing	RL	Description
6	TBM4/6G	426880.98	2930916.482	127.194	ON PLINTH OF PARK BOUNDARY AT CHHATRAPATI SAHU (LHS) IN B/W GCP 4/6 NEAR RLY STATION 9/6 .
7	TBM 5/4G	428058.307	2930543.606	128.229	ON MEDIAN UPSIDC RD IN FRONT OF ELECTRONICS CLASSES GATE, NEAR GCP 5/4, RLY MAST 5/1 .
8	TBM 6G	428348.851	2930457.503	127.945	ON BASE OF PETROL PUMP BOARD NEAR RLY STATION MAST (LHS) IN FRONT OF CADD CENTER.
9	TBM G7	430117.771	2929368.501	127.942	AT RAWATPUR STN UNDER THE NAME BOARD
10	TBM G8	430820.752	2928997.521	128.588	FS ON TBM G8 UNDER THE FLY OVER AT GOAL CHAURAHA
11	TBM TA23	431361.131	2928939.156	127.710	ON THE PLINTH OF BUS STOP, INFRONT OF KOTTWALI SWARUP NAGAR POLIC STATION
14	TBM TA22	431990.438	2928910.859	127.678	UNDER STATUE OF CHHATRAPATI SIBAJI, IN FRONT OF CHHATRAPATI SHVAJI
15	TBM TA21	432456.487	2928868.664	127.456	ON THE VERRANDA OF L.G, SHOPH, NAMRATA ELECTRONICS
16	TBM TA20	432738.561	2928611.047	127.191	ON PLINTH OF IOC PETROL PUMP UNDER THE NAME BOARD
17	TBM TA19	433063.512	2928488.117	126.230	ON BASE OF HANDPUMP INFRONT OF MASJID
18	TBM TA18	433464.865	2928480.483	126.208	ON TOP OF MEDIAN AT BAKER MANDI
19	TBM TA17	433636.781	2928763.528	126.033	ON PLINTH OF TEMPLE NEAR KABARSTAN
20	TBM TA16	433815.696	2928770.485	126.295	AT CHUNNIGANJ ON THE 2ND STEP OF DAKHINESWAR MAHADEV TEMPLE NEAR KHETRIYA KARYALAYA

S. No.	TBM No	Easting	Northing	RL	Description
21	TBM TA15	434184.568	2928569.805	125.580	ON TRAFIC POST (NEW) NEAR RAJAKIYA INTER COLLEGE
22	TBM TA14	434604.497	2928406.646	124.472	ON PLINTH, AT PARADE INDIAN OIL PETROL PUMP OPPOSITE SITE OF TANISHQ
23	TBM TA13	434923.129	2928345.881	124.626	ON PLINTH OF NEW PLASTIC CORNER SHOP NABIN MARKET, NEAR KALYANA-G BAKERY
24	TBM TA12	435448.57	2928187.243	124.273	ON PLINTH OF HANUMAN TEMPLE UNDER FOOTOVER BRIDGE
25	TBM TA10	436020.739	2928020.729	125.133	ON OPPOSITE SIDE OF KOTAK MAHINDRA BANK UNDER KALIN LIGHTS POLE
26	TBM TA9	436170.453	2927484.955	125.049	FS ON TBM TA9 AT THE CHARLIS COWK
27	TBM TA8	436197.524	2927193.546	126.089	ON PLATFORM OF VASAN EYE CARE
28	TBM TA7	436023.333	2927029.56	126.599	ON PLINTH OF SOUCHALAYA, NEAR HANUMAN TEMPLE
29	TBM TA6	435720.114	2926797.013	126.386	FS ON TBM TA6 ON 2ND STEP OF P.N.B. ATM NAYAGANJ
30	TBM TA5	435543.959	2926697.734	126.508	FS ON TBM TA5 ON THE PLINTH OF MAHAKALI MANDIR BHUSHA TILL CHORAYRA
31	TBM TA4	435384.622	2926584.294	127.471	FS ON TBM TA4 ON THE 3RD STEP OF SIVA TEMPLE INFRONT O SARADA TRADERS, NEAR SRI ADISHAKTI DURGA MANDIR
32	TBM TA3	435237.52	2926497.629	127.640	FS ON TBM TA3 AT GHANTAGHAR NEAR POLICE CHHOWKI NAYAGANJ UNDER THE BHARAT MATA STATUE
33	TBM TA2	434866.966	2925998.063	127.137	FS ON TBM TA2 ON THE PLINTH OF MUMBAI OPTICAL CENTER UNDER THE SHALIMAR PAINTS BOARD
34	TBM TA1	434576.089	2925508.59	126.683	FS ON TBM TA1 AT TATA MILL MEDIAN

S. No.	TBM No	Easting	Northing	RL	Description
35	TBM TG1	433953.952	2925707.672	127.198	FS ON TBM TG1 AT TRANSPORT NAGAR ON THE PLINTH OF GANESH TEMPLE
36	TBM PG	433919.717	2925675.083	126.463	TBM PG IN TRANSPORT NAGAR VILLAGE
37	TBM TG3	432810.899	2924657.398	127.019	TBM TG3 ON TOP OF JSA JAIMOTERS PLINTH
38	TBM 21/2G	432114.302	2922534.683	126.173	FS ON TBN 21/2G ON PARAPET OF HIGHWAY OVER BRIDGE NAUBASTA (RHS)
39	TBM 22G	431975.784	2921937.21	126.708	FS ON TBM 22G ON 4TH STEP OF WORLDSUN GROUP OF COMPANIES NEAR GURU MOTOR DRIVING TRAINING SCHOOL (RHS) IN B/W GPS 22 AND GPS 22A
40	TBM 22/2G	431909.25	2921319.193	126.060	FS ON TBM 22/2G ON BASE OF HAND PUMP INFRONT OF BABA PARMESWAR MANOKAMANA SIDHYA DHAM MANDIR
41	TBM 23/4G	431824.624	2920945.199	126.042	FS ON TBM 23/4G ON PARAPEET OF CVT NEAR KM STONE 9, RAJRANG AUTO PARTS SHOP (RHS) IN B/W 22/4 TO 22/5
42	TBM 23/1G	431582.847	2920283.132	125.643	FS ON TBM 23/1G ON PLINTHS OF SHIVA TEMPLE NEAR GURU ETA BIKRI KENDRA IN B/W GPS 23A TO GCP 24/1 (RHS)
43	TBM G24	431392.58	2919564.963	125.610	FS ON TBM G 24 ON THE STEP AS SRINATH ELECTRONICS, OPP. MANNAT HOSPITAL
44	TBM G25	430073.52	2928962.699	126.923	TBM G25 ON PARAPET OF REGIONAL LABOUR INSTITUTE GATE
45	TBM TA26	429532.131	2928287.028	125.827	TBM TA26 ON THE PLINTH OF BHARAT PETROL PUMP

S. No.	TBM No	Easting	Northing	RL	Description
46	TBM 27G	429286.137	2928107.002	126.346	FS ON TBM 27G ON PARAPEET OF JAIPURIA PRE SCHOOL , GATE (RHS) IN B/W GPS 27 TO GPS 27A
47	TBM 27/4G	429468.099	2927578.483	124.509	FS ON TBM 27/4 G ON TOP OF GATE. NEAR SINHA DOWNLOADING POINT SHOP RHS IN B/W GCP 27/4 TO 27/5 OPPOSITE OF SHEESH MAHAL HOMEO STORE
48	TBM 28/2G	429613.622	2926785.208	125.028	FS ON TBM 28/2G INFRONT OF 11A GATE SADASYA INDIAN INDUSTRIES AUSTRIATION KASI SALES WORKS (LHS) AT GCP 28/2
49	TBM 28/4G	429623.418	2926297.957	134.707	FS ON TBM 28/4G ON ABUTMENT OF ROB RHS MAST NO. 1023/7 TO 1023/5
50	TBM 29G	429661.935	2925943.41	128.429	FS ON TBM 29G ON PARAPET OF BRIDGE NO. J. 4 AT DADA NAGAR LC (240-A) IN B/W MAST 1241/27-29
51	TBM 29/4G	429774.9	2925302.272	126.785	FS ON TBM 29/4G ON 3RD STEP PF SHIVA TEMPLE , NEAR SRI SAI HOMEOPATHIC CLINIC (LHS) IN B/W GCP 29/4 TO 29/5 GCP
52	TBM 30G	429636.115	2924744.297	123.261	FS ON TBM 30G ON STEP OF MANDAP ON KDA PARK NEAR GPS 30A , DURGA PARK (LHS) JANATA NAGAR PARK
53	TBM 30/4G	429400.956	2924198.05	124.686	FS ON TBM 30/4G ON PARAPEET OF KENDRIYA AKBARPUR LOKSABHA KHETRA LHS IN B/W GCP 30/4 TO GPS 31. NEAR JSA AUTO PALA MOTORS
54	TBM 31/2G	429285.93	2923756.777	124.497	FS ON TBM 31/2G ON THE STEP OF BRAMHAWART BANK ATM (LHS) IN B/W GCP 31/2 TO 31/3

S. No.	TBM No	Easting	Northing	RL	Description
55	TBM 31/6G	429237.397	2923504.669	124.800	FS ON TBM 31/6G ON THE BOUNDARY WALL & MULAYAM SINGH YADAV STATUE (RHS) IN B/W GCP 31/6 TO 31/7 RAMGOPAL YADAV
56	TBM 32/3G	429285.313	2922631.132	123.881	FS ON TBM 32/3G ON PLINTH OF KANPUR VIKAS PRADHIKAM, SAMUDAIK KENDRA.

5.1.1.5 Detailed Survey of the Corridor

Based on Easting & Northing co-ordinates arrived by the traversing and Elevation by Precise Leveling, Detail survey was carried out along the proposed metro route for 100m wide corridor (50m either side of the centre line of the road) or upto Built line in charge using total stations of desired accuracy. At some places instrument having reflector-less facilities has been used for collecting details of features due to inaccessibility of the area.

Survey covered road/rail track showing important structures all the bye lanes, footpaths, dividers/central verges, roads, railway tracks, trees, manholes and other structures, drains, Storm water drains, H.T., L.T., Transmission lines, bridges, ROBs / RUBs / FOBs with type and spans, ponds, HFL and bed level of streams/drains, level crossing with their type, traction masts, signal posts, etc. Spot/ Ground levels were taken at 25 m intervals in longitudinal as well as traverse direction and at sudden change of levels.

Location of approach roads, main roads, lanes showing road/lane name, carriageway, footpaths, central verge, drains and the widths of all the main and approach roads and at locations where there is a sudden change in widths of roads were measured physically and marked on the drawings.

Details of Railway tracks along the proposed alignment including take off points, FOBs, transitions, crossings, switches and other details including electrical structures with their distances were taken.

Details of Religious structures such as temples, Gurudwaras, Mosques, Churches, monuments, tombs etc., clearly marking the Metro boundary all along the corridor and giving cross reference of these structures with reference to Metro boundary were taken.

5.1.1.6 Preparation of Drawings

Drawings were prepared in Auto CAD format in 1: 1000 scale as per project requirement showing all the manmade and natural features. Different features are shown in different layers. Attributes of all the features like name of the road its width, name of railway line, name of the building and its number of stories, width of drains and its HFL, Type of overhead crossings (Electric and Telephone lines) and its rating have been provided in this drawings.

Details of all the religious structure such as Temple Gurudwara, Church, Monuments, Tomb, etc have been shown in the drawing as per standard legend.

Spot levels have been shown in drawing to access the terrain of the area along with trees falling in said survey corridor of 100m. Control points, established during conducting the survey work, have been also shown in the drawings.

5.1.1.7 Site Verification of Features

Details of features shown in the drawings were verified at site and additional details were collected and incorporated in the drawing wherever needed.

5.1.2 ALIGNMENT DESCRIPTION

5.1.2.1 Corridor – 1: IIT Kanpur to Naubasta

Considering centre line of IIT Kanpur Station as 0.00m, this corridor is 23785m long starting from -450m and running upto 23335m. This corridor starts as elevated stretch followed by Switch Over Ramp (SOR), Underground stretch, Switch Over Ramp (SOR), and finally again as elevated stretch. The corridor is summarised as under in **Table 5.3**. **Figure 5.1** shows the proposed corridor.

TABLE 5.3: ALIGNMENT DESCRIPTION OF CORRIDOR-1

Alignment Type	From (m)	To (m)	Length (m)
Elevated	-450	8522	8972
Switch over Ramp (+)7.5m to (-)8.0m	8522	9150	628
Underground	9150	17235	8085
Switch over Ramp (-)8.0m to (+)7.5m	17235	17624	389
Elevated	17624	23335	5711

The Alignment of Corridor -1 is described in detail in following sub sections:-

I) IIT Kanpur - Moti Jheel Section
II) Switch Over Ramp from Elevated to Underground
III) Chunniganj to Tranport Nagar
IV) Switch Over Ramp from Underground to Elevated
V) Baradevi Chauraha to Naubasta

I) IIT Kanpur - Moti Jheel Section

- The proposed alignment of Corridor-1 starts from IIT Kanpur along Aligarh - Kanpur Road (NH-91) as elevated and heads in East direction.
- Total length of the section is about 9.0 Km and is completely elevated.
- Following 9 elevated stations have been proposed in this section:-
  - IIT Kanpur
  - Kalyanpur
  - SPM Hospital
  - CSJM University
  - Gurudev Chauraha
  - Geeta Nagar
  - Rawatpur
  - Lala Lajpat Rai
  - Moti Jheel
- Alignment/station locations along NH-91 have been designed considering the future widening plan of NH Division of Kanpur PWD. Presently, road

widening has been planned with 1.2 m wide median, which will not be sufficient to accommodate the elevated substructure for Metro Corridor. PWD - NH Division (Kanpur) has been informed to keep the provision for 3.0 m wide median.

- Depot land for corridor-1 was identified by KDA in the Govt. Polytechnic College campus with the planning that Polytechnic College shall be relocated at some other suitable location. With this objective, entire 21.9 Ha land of Polytechnic College campus is proposed to be acquired for construction of depot, parking & property development. Connectivity for maintenance cum stabling Depot at Polytechnic College has been examined from Gurudev Chauraha as well as from Geeta Nagar Stations. In all, three options with details as under have been explored from alignment, traffic, Depot layout and train operation point of view.

A) Option-1: Connectivity from Gurudev Chauraha by crossing road with rail level at (+) 7.50 m

- Gurudev Chauraha station has been located near the junction to serve the converging traffic thus ensuring easy transfers between G.T. Road and Indira Nagar Road traffic. The entry/exits have been planned in such a way that it caters to the traffic movement pattern. The existing Bus and IPT Stops will supplement and complement the metro.

- An entry across the railway tracks will give direct accessibility to the dense residential areas of Vinayakpur, Sharda Nagar, Keshavpuram, Uttaripura etc in the South. Whereas, the other two entries, one in the north and one along the G.T. Road will help easy transfer of riders from existing modes.

- To further improve the ridership, feeder bus routes from Gurudev Chauraha towards North and South have been proposed to provide the last mile connectivity.

- To cross the road at Gurudev Chauraha at (+) 7.5m, the station is to be shifted by minimum 175m towards IIT-K side (with the provision of limiting grade of 4%). It will adversely affect the locational advantage as well as the passenger interchange.

Hence this option is not suitable from Traffic considerations and is ruled out.

FIGURE 5.1: PROPOSED KANPUR METRO CORRIDOR-1

B) Option-2: Connectivity from Gurudev Chauraha by crossing road with rail level at (+) 12.0 m

This option will make location of Gurudev Chauraha metro station near road crossing and will be better option from point of view of traffic integration. Gurudev Chauraha Station is located near road crossing and the proposed land of Polytechnic college is located adjacent to road, leaving very little margin for providing connectivity to depot. With maximum possible gradient, zero level of the track connection is landing approx. 250 m inside and at extreme corner of area marked for depot. Further 400 m will be required for stabling lines and its ladder. In order to fit the depot in identified land plot, automatic wash plant is proposed on ramp area and compact depot layout similar to Transport Nagar depot of Lucknow Metro has been proposed with option of having workshop and inspection facilities at start of depot. Proposed layout and connectivity to depot is shown in **Figure 5.2.**

This option will have following bearings over train operation:-

- After washing/servicing at depot, the morning services can be initiated from Gurudev Chauraha Station towards IIT Kanpur directly and towards Naubasta with reversal.
- At the end of services, rakes from IIT Kanpur end can enter the depot directly but passengers boarding the train from IIT Kanpur end will have to be deboarded at CSJM University Station and thereafter, empty rake will be placed to depot via Gurudev Chauraha Station. However, being short distance, it is advisable to run empty rake from IIT Kanpur for entry to Depot.
- Also, trains coming from Naubasta end cannot be placed directly to depot via Gurudev Chauraha, hence, it is required to run the passenger services from Naubasta to IIT Kanpur, terminate the services at IIT Kanpur Station and run empty rake upto depot.
- However, this option will have constraint that all movement to workshop and inspection lines will require reverse shunting.

Hence this option is not recommended.

C) Option-3: Connectivity from Geeta Nagar

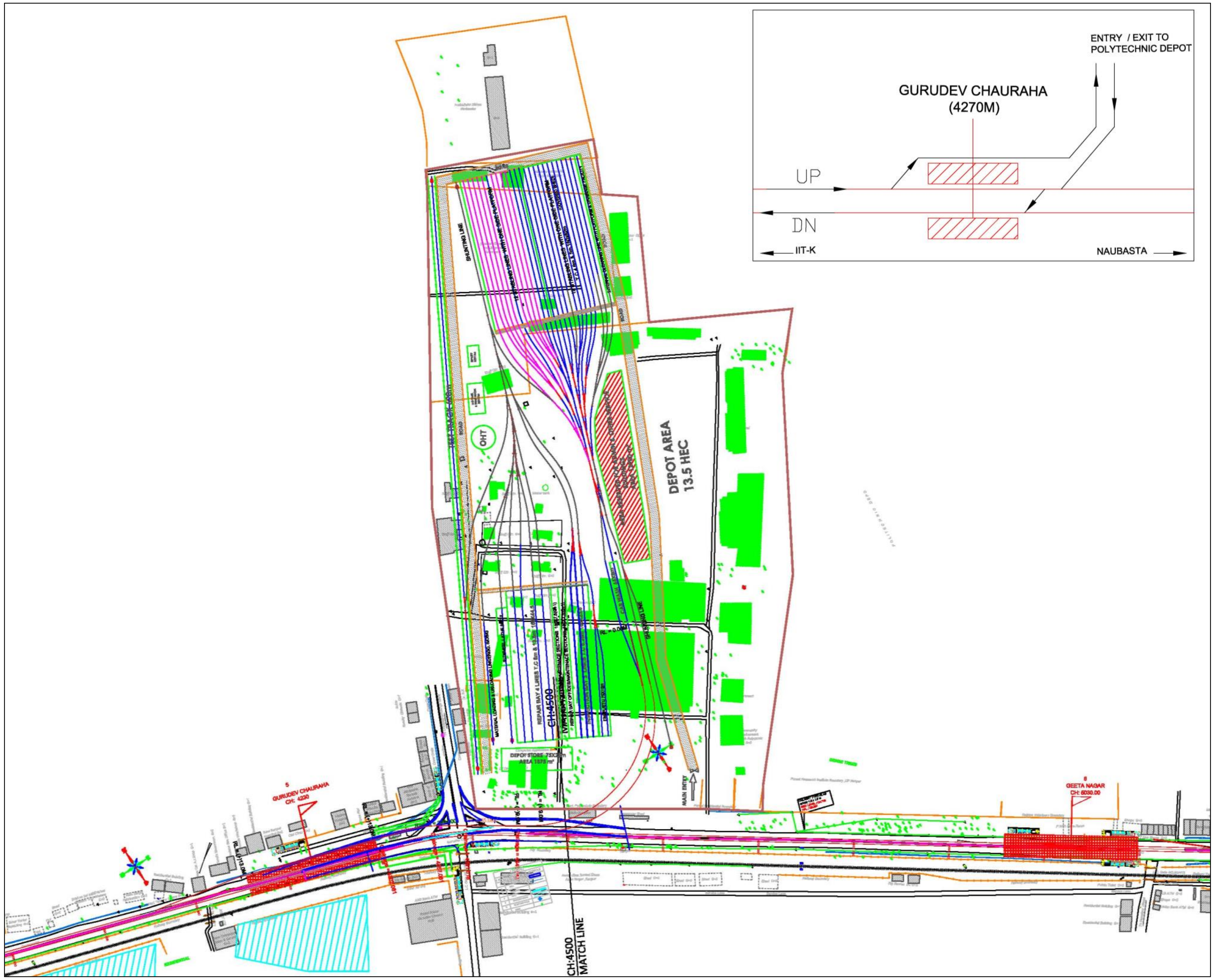
Geeta Nagar is 6th station from IIT Kanpur. Distance of Depot boundary from Geeta Nagar is sufficient for bringing track to depot level near entry point. Geeta Nagar Station with one additional line has been proposed facilitating simultaneous entry and exit of trains to depot. Proposed layout and connectivity to depot is shown in **Figure 5.3.**

This option will have following bearings over train operation:-

- Morning train services can be initiated from IIT-K to Naubasta by utilizing four + two nos. rakes stabled at stabling line beyond IIT-K station and at IIT-K Station respectively. These six rakes will be sufficient to initiate the morning services at off-peak frequency of 10 mins. During this period, the rakes from Naubasta mini depot will reach IIT-K and regular flow of train operation will be maintained.
- After washing/servicing at depot, the morning services can be initiated from Geeta Nagar station towards Naubasta directly.
- Passenger services can be run from Naubasta to IIT Kanpur, and after termination of services at IIT Kanpur Station, empty rakes can be placed into depot after reversal at Geeta Nagar Station. Since, placement to depot is to be done in the off-peak night period, reversal will not be a problem.
- However, this option will have more flexibility and easy internal movement of rakes within depot layout. Besides this, the layout can be efficiently fitted within identified plot of Polytechnic College land.

In view of above, Consultants recommends option-3 i.e. connection of Polytechnic depot from Geeta Nagar.

FIGURE 5.2: CONNECTIVITY TO DEPOT LOCATION FROM GURUDEV CHAURAHA (OPTION-2)



- Rawatpur station is proposed as an interchange station of Corridor - 1 & 2. The station building for Corridor - 1 has been proposed as elevated and for Corridor-2 as underground. Most likely, elevated stretch will be constructed prior to underground stretch and hence, special span configuration of 34m + 45m + 34m by Cantilever construction method is proposed to accommodate future construction of underground station by cut & cover method without causing any disruption to elevated structures of Corridor-1 and train operations. Alternatively, Steel span of 45m may also be provided.
- The alignment follows median of NH-91 upto Gol chowk, henceforth, due to existing ROB and constrained ROW, the alignment enters into GSVM Medical College premises. After the end of the ROB, the alignment comes back along the median of Mall Road and runs along it upto Moti Jheel.
- From point of construction and operational phasing, Moti Jheel Station will be priority stretch for corridor-1 and accordingly, Moti Jheel station has been planned as Mid-Terminal Station with facilities for reversal. Moti Jheel station is proposed at Ch: 8003 m which is about 750 m from Lala Lajpat Rai Hospital station (towards IIT Kanpur) and about 1850 m from Chunniganj Station (towards Naubasta). Moti Jheel station is proposed near Moti Jheel Park entrance as well as entrance to KDA/KMC office. The said station is about 450 m away from Harsh Nagar Road crossing and further shifting of station towards Harsh Nagar Road crossing has been avoided on account of traffic and alignment considerations as under:-

  - The proposed station location serves the multiple high end land uses. It will provide direct accessibility of about 300 meters to the work centers like KDA and KMC. Also, will create an opportunity to make Moti Jheel Park an attractive city level recreational spot, which at present is underutilized.
  - It will also, provide direct connectivity to high end residential cum commercial areas of Keshav Nagar, Swaroop Nagar.
  - The development and its intensity in the catchment as per present location is much better as compared to the areas towards Harsh Nagar,
  - Shifting the station towards Harsh Nagar will increase the walking distance thereby causing discomfort to the users. This may also lead to fall in ridership.

FIGURE 5.3: CONNECTIVITY TO DEPOT FROM GEETA NAGAR (OPTION-3 - RECOMMENDED)

- From Harsh Nagar Road crossing, the alignment takes a left turn and enters into Brijendra Swaroop Park. Ramp has been proposed in Brijendra Swaroop Park to facilitate switching over alignment from elevated to underground. The restricted length of about 290 m of the above park warrants crossing of Harsh Nagar Road at minimum rail level from road surface, which has been proposed at (+)7.50 m. This will be possible by using Double U-Girders at this location.

- In case, rail level from station to (+) 7.50 m is provided in 450 m length, it will result into 1.11% gradient, which is beyond the permitted gradient of 1 in 1000 for station limit.
- About 140m length will be required to bring down the rail level from station height to (+)7.50 m at limiting grade of 1 in 28.

- Being Mid-terminal station, reversal arrangements are required to be provided at this station. The 1 in 9 cross-over will require length of about 75 m.

- Around 90 m length will be required for shunting of 4-car Rake envisaged during initial period of operation.

- Accordingly, a lot of space will be consumed for bringing down the rail level from station height to mid section height, for providing cross overs/turnouts for shunting and for providing shunting neck and hence, it is not possible to provide the station at Harsh Nagar road crossing.

In view of above, it is recommended to provide Moti Jheel Station at Ch: 8003 m.

In this stretch, at five locations i.e. at Gurudev Chauraha, Rawatpur Station, Gol Chowk near GSVM & Lala lajpat Rai Hospital, alignment is proposed on portal for deviating from median of the road to off road locations.

II) Switch Over Ramp From Elevated to Underground

- Switch over Ramp (SWR) is required to take alignment in vertical plane from elevated to underground position and vice-versa. In this stretch, SOR is required to provide transition from elevated to underground alignment after Moti Jheel. Horizontal and vertical alignment in this stretch has been designed in such fashion so that minimum land is required.

- The ramp ((+)7.5m to (-) 8.0m) has been proposed at limiting gradient of 4% (compensated) from Ch: 8522 m to Ch: 9150 m to become underground from elevated. About 6900 sqm land for locating the ramp (from elevated to underground) will be required permanently in Brijendra Swaroop Park. The road connecting Brijendra Swaroop Park and Nayapurva area will be obstructed by the ramp, as Rail level of ramp at the said road location is (-)2.0m. The said road will be permanently diverted along the perimeter of the ramp.

III) Chunniganj to Transport Nagar Section

This section is Underground consisting of total 8 nos. underground stations namely, Chunniganj, Naveen Market, Bada Chauraha, Phoolbagh, Nayaganj, Kanpur Central, Jhakarkati and Transport Nagar Station. All the stations has been proposed by Cut & Cover station except Nayaganj station which has been proposed by NATM.

Two options have been examined for Chunniganj station i.e. at location of existing bus depot and along Parade Road.

A) Option 1: Inside existing Chunniganj Bus Depot

In this option, Metro station is proposed on existing Chunniganj bus depot. The station location also passes through cluster of residential quarters and will result into dismantling of large number of quarters for construction of station by cut & cover method. Besides this, shifting of Chunniganj bus station will also be required during construction phase. Though, said location of station will provide better traffic integration with bus terminal being used by inter-state passengers, it will be away from adjoining roads and will not serve the larger public.

B) Option 2: Along Parade Road

In this option, Metro station is proposed on Govt. land along Parade Road and will require acquisition of few Govt. buildings like Police station, fire station, Rain basera etc. This option serves the better catchment of intra city passengers and hence this option is recommended.

- Due to ground constraints and heavily built-up area, Nayaganj Station has been proposed by NATM. It will require acquisition of properties for locating shafts at both ends for TBM retrieval and launching of construction machinery for NATM. This station is discussed in detail in subsequent para no.4.5.2.2

- Kanpur Central station has been proposed inside the parking area of Kanpur Central Railway Station (Ghanta Ghar side) for better integration with existing Railway station. It will require 1200 sqm land on permanent basis for construction of Entry/exits in the circulatory area of Railway station. Besides this, around 8000 sqm of Railway land will be required on temporary basis for about 2 years period for construction of station by Cut & Cover method. Moreover, one no. G+0 structure, approx. 54 sqm, accommodating Co-operative bank of NCR staff shall be acquired and new structure will be constructed at suitable location in the vicinity in consultation with N.C. Railway.

- Jhakarkati station has been proposed inside existing Jhakarkati Bus Terminal for better integration. Traffic diversion/alternate entry to Bus terminal will be required during the construction phase. The proposed station cuts the existing road which will be required to be restored by provision of decking slab so as to minimize disruption of road traffic.

- Transport Nagar station has been proposed inside Transport Nagar on existing road. It will also require acquisition of large number of squatters occupying warehouses/shops (mostly G+0). The affected properties are not the legal construction and State Govt. shall provide encumbrance free land for construction of this station by cut & cover. Accordingly, cost of land has been taken into account as Govt. land. Moreover, as per norms of International funding agencies, squatters are also required to be rehabilitated and hence, cost of structures has been taken into account.

IV) Switchover Ramp From Underground to Elevated

Further, the alignment after transport Nagar station turns left and heads in South direction along Hamirpur road and terminates at Naubasta.

To become elevated from underground, ramp has been provided along Hamirpur Road after Transport Nagar station. The switch over ramp has been proposed from Ch: 17235 m to Ch: 17624 m at limiting gradient of 4% (compensated). About 4280 sqm PWD land will be required permanently for locating the ramp. Since the ramp is proposed at the middle of the wide road having ROW of more than 36m, there will not be any adverse affect to road traffic during construction phase as well as on permanent basis. The existing road shall be widened by 6m on either side of the ramp area so as to restore the original width of the carriageway. Sufficient shoulder width is available for the required widening.

V) Baradevi Chauraha to Naubasta

- The proposed section is elevated consisting of total 5 elevated stations namely, Baradevi Chauraha, Kidwai Nagar, Vasant Vihar, Baudh Nagar and Naubasta.
- The alignment crosses four lane elevated bypass of NH-25 (Jhansi - Allahabad Road) as double elevated. To cross the elevated bypass of NH-25 including its service roads, central span of 45m will be required for metro alignment at RL of 16.6 m above existing ground level and about 9.8m above elevated road. This can be done by either 34m +45m + 34m span configuration by Cantilever construction method or 45m span steel span.
- Naubasta elevated station is the terminal station of Corridor-1 and reversal facilities has been planned at this station.
- Separate entry to the stabling yard has been proposed from Naubasta station. An area of 6.75 Ha of Govt. land has been proposed for stabling facilities. A portion of road falling in proposed depot area will required to be diverted along the outer perimeter of depot land.

5.1.2.1.1 Nayaganj Station

Site Description: Nayaganj station is located in between Phoolbagh metro station on IITK side and Kanpur Central metro station towards Naubasta side. The alignment passes through heavily congested commercial establishments on both sides of various roads having ROW about 10m. Nayaganj station is proposed at Ch: 13825 m having interstation distance of 895 m from Phoolbagh metro station and 922 m from Kanpur Central metro station. In order to appreciate the congestion at site, bird eye view of site may be referred in **Figure 5.4**

FIGURE 5.4: BIRD EYE VIEW OF NAYAGANJ SITE LOCATION

Soil Characteristics: For underground stretches, preliminary Geological Investigations were carried out at approximately 500m to 700m distances along the corridor to have a general idea of soil characteristics. The bore holes were drilled upto depth of 30m and following three type of soil layers were met with :-

LAYER TYPE – I, Brownish Clayey Silt Low to Medium Plasticity (CL/CI,CL-CI)
LAYER TYPE – II, Sandy Silts – Low plasticity to Non Plastic (ML)
LAYER TYPE - III, Silty Sand- Low plasticity to Non Plastic (SM)

Bore Hole No. BH-20 was drilled at proposed site of Nayaganj station and soil characteristics are detailed in **Table 5.4**

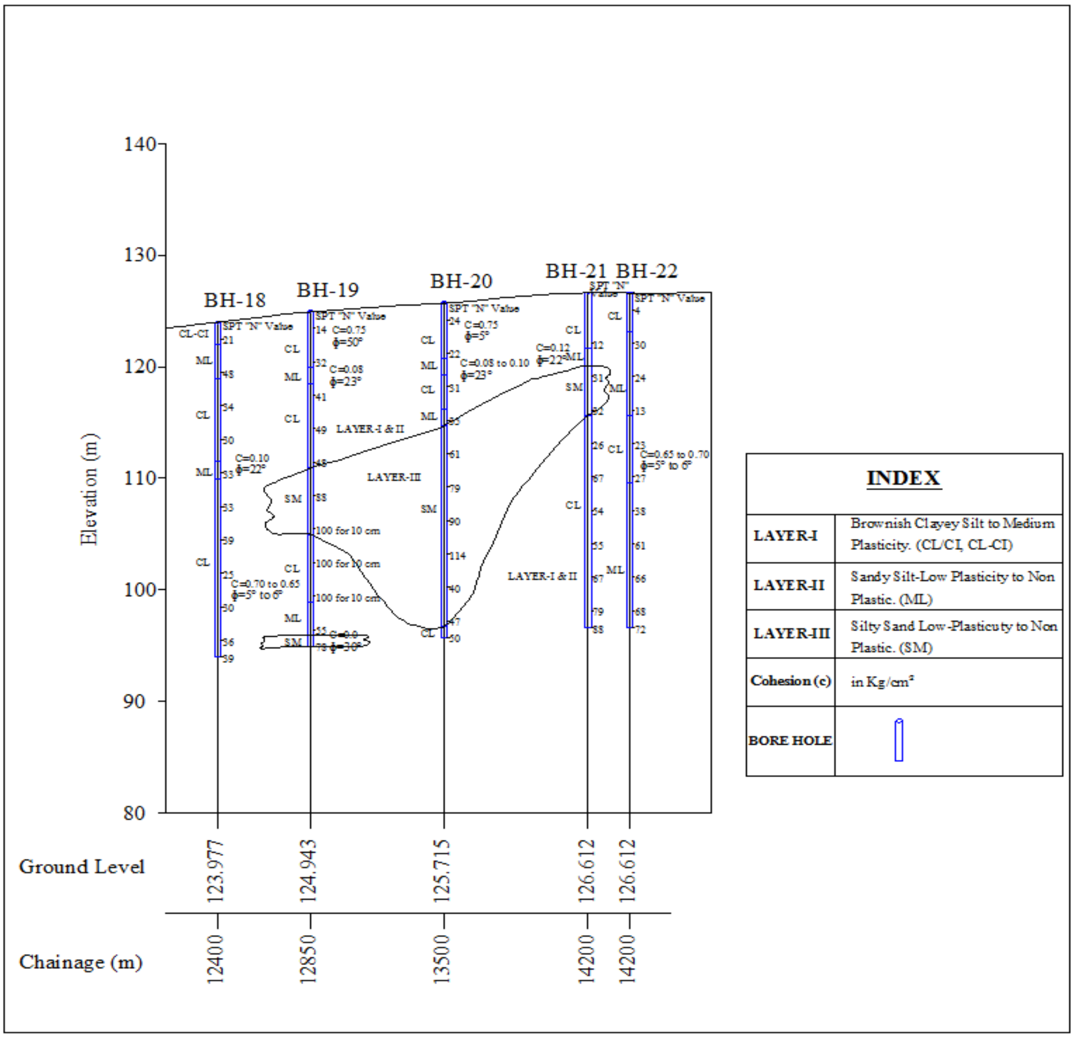
TABLE 5.4 : SOIL CHARACTERISTICS (BH-20)

Bore Hole No. and depth	**Bore hole location**	**Layer Depth Range (m)**	**Layer Type**	**SPT Value**	**Shear Parameter 'C' (Kg/cm^2) & 'Ø'**		**Water Table (m)**
BH-20, Depth of bore hole 30m	Chainage: 13500, near Nayaganj metro station	0.00 - 5.00	CL/CI, CL - CI	22 - 24	0.75	5	Not met with
		5.00 - 6.50	ML	35	0.10	23	
		6.50 - 9.50	CL/CI, CL - CI	31	0.75	5	
		9.50 - 11.00	ML	35	0.10	23	
		11.00-29.00	SM	31-65	0.08	23	
		29.00-30.00	CL/CI, CL - CI	51	0.75	5	

Parameters relevant for selecting construction methodology:

- Due to less width of roads and busy traffic, cut & cover method for construction of underground station is ruled out.
- Due to adjoining alignment passing beneath residential / commercial buildings, the RL of this station is proposed (-) 20.00m below ground level.
- The preliminary geotechnical investigation conducted at DPR stage are only indicative and need to be supplemented by detailed geological investigations to map the soil profile more accurately and to decide the appropriate construction methodology and scheme.
- The track tunnels are proposed to be bored through TBMs and NATM may be carried out to accommodate the additional width required for Platforms. The support system for enlargement of tunnels needs to be decided based upon detailed geological investigations at DDC stage.
- The traffic load at Nayaganj station may be referred at Traffic chapter. Though the traffic load at this station is moderate, in terms of para 5.3.3.7 of NFPA 130 - 2014, "Alternate egress: at least two means of egress remote from each other shall be provided from each station platform".
- For providing entry / exits and station buildings, one shaft at each end i.e shaft 1 and shaft 2 are proposed. Towards Kanpur Central side, it is proposed to acquire Rain Basera, KESCO office and substation and use adjoining open space to construct the shaft (shaft 1) by open cut method. The road in between the building lines may also be used to be part of shaft and by decking, road traffic may be continued. Approximately 3040 sqm plan area may be obtained with above scheme and multi-storied construction may be planned to provide required space to accommodate entry /exits, concourse, commercial space and various types of service rooms and ancillary buildings etc.

FIGURE 5.5: LITHOLOGICAL PROFILE OF NAYAGANJ & ADJOINING STRETCHES



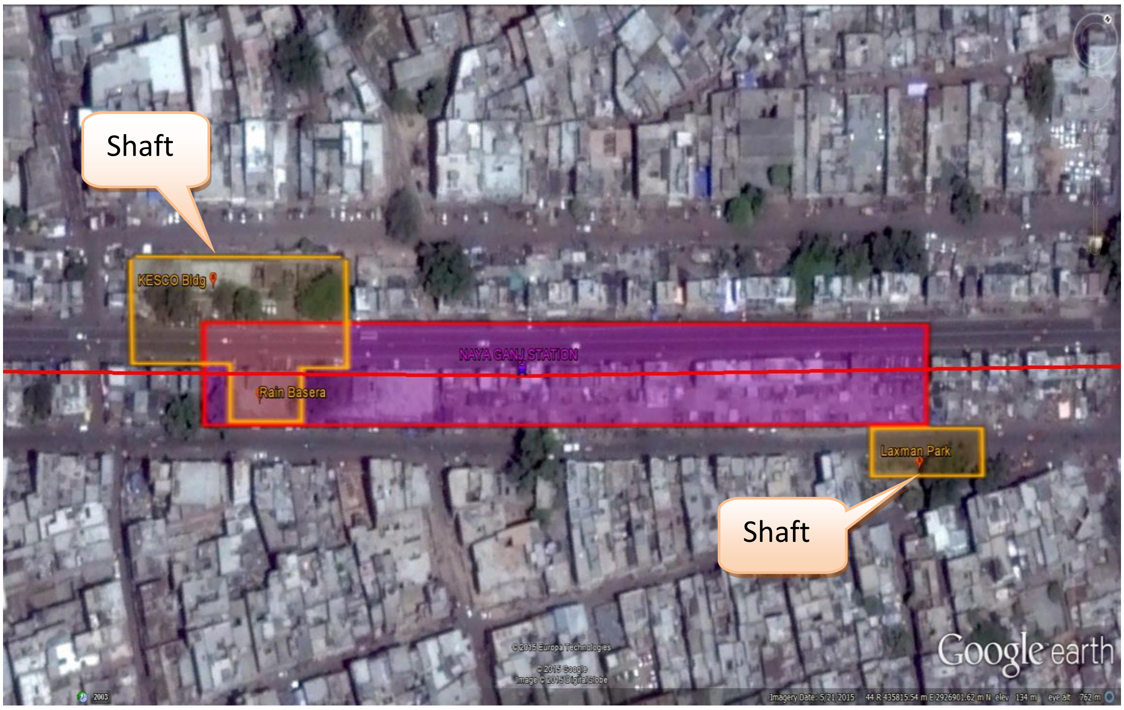
➢ Towards Phoolbagh metro station side, there is a small land plot available in Laxman park, which is proposed to be used to provide second egress. To create more space, it is proposed to acquire one temple and pump room located in the said park. The adjoining road area may also be used to be part of shaft and by decking, road traffic may be continued. Approximately 800 sqm plan area may be obtained with above scheme.

➢ The two shafts will also serve as means of de-mucking the excavated soil.

➢ In case soil characteristics do not favour for adoption of NATM method, Shield tunneling with manual digging may be adopted.

➢ The general layout proposed for this station is summarized in **Figure 5.6.**

FIGURE 5.6: PROPOSED LAYOUT OF NAYAGANJ STATION



5.1.2.1.2 Reference Point

For the planning convenience, the zero point of the Corridor is considered at the centre line of the proposed IIT Kanpur station. The chainage along the alignment increases in Eastern and Southern direction. All elevations are from Mean Sea Level (MSL).

5.1.2.1.3 Terminal stations of Corridor-1

i. IIT Kanpur Metro Station (North side terminal station)

The North side station on the Metro corridor is IIT Kanpur Metro Station. The station is proposed elevated and rail level has been kept 12.00 m (minimum) above the ground level. Proposed metro station will provide connectivity to IIT Kanpur as well as residential area of Kalyanpur at south side of station. Under construction multi-storied buildings on the southern side will also be catered.

Reversal facilities have also been planned beyond IIT Kanpur Metro station. Two nos. elevated stabling lines for two rakes each has also been proposed beyond IIT Kanpur station along NH-91 to provide stabling space for total four rakes. In addition, two rakes can be stabled at IIT-K station.

ii. Naubasta Metro Station (South side terminal station)

South side Terminal of the corridor will be Naubasta Metro Station. The station is proposed elevated and rail level has been kept 12.00 m (minimum) above the ground level. It will serve the nearby localities of Rajendra Nagar, KDA Colony and Naubasta.

Reversal/stabling facility has also been planned beyond Naubasta Metro station. The entry to minor depot in Housing board land (6.75 Ha) has also been planned after the station by providing the ramp.

iii. Interchange Stations

Efforts have been made to select station locations in such a fashion so as to provide convenient and efficient passenger interchange with other modes of transport such as other Railway system and Bus system. Interchange stations provided along the Corridor are shown in **Table 5.5.**

TABLE 5.5: INTERCHANGE STATIONS OF CORRIDOR-1

S. No.	Name of Metro station	Mode	Interchange with
1	Kalyanpur Metro Station	IR Broad Gauge Railway network	Kalyanpur Railway Station of Mathura – Kanpur Railway line
2	Rawatpur Metro Station	IR Broad Gauge Railway network	Rawatpur Railway Station of Mathura – Kanpur Railway line
3	Chunniganj	Bus System	Chunniganj Inter-State Bus Stand
4	Kanpur Central Metro Station	IR Broad Gauge Railway network	Kanpur Railway station of North Central Railway on Delhi - Howrah route.
5	Jhakarkati Bus Terminal	Bus System	Jhakarkati Inter-state Bus Terminal

5.1.2.1.4 Major Roads along Corridor-1

The major roads along and across the alignment are given in **Table 5.6** and **Table 5.7** respectively.

TABLE 5.6: MAJOR ROADS ALONG CORRIDOR-1

S. No.	Name of the Road	Chainage	
		From (m)	To (m)
1	NH-91	(-) 450	6800
2	Mall Road	6800	8500

S. No.	Name of the Road	Chainage	
		From (m)	To (m)
3	Mall Road	10030	13100
4	Canal Road	13400	14100
5	Hamirpur Road	17000	23335

TABLE 5.7: MAJOR ROADS ACROSS CORRIDOR-1

S. No.	Description	Chainage
1	To IIT-K through L.C No. 14A SPL /3T	-220
2	Towards Kalyanpur through L.C No. 14C /2T	240
3	Towards Vijay Nagar through L.C No.13B/2T	1061
4	Towards Awas vikas colony through L.C. No. 12A-B/2T	1500
5	To I.I.P.R. through L.C. Gate NO. 12B/2E	2940
6	Towards Lakhanpur through L.C NO. 11 B/2E	4107
7	Towards Sharda Nagar through L.C. Gate NO.10A/2E	4388
8	Sharda Nagar road through L.C. No. 9 SPL/T-3	5117
9	Towards Geeta Nagar through L.C. No. 8 SPL/T3	5520
10	Rawatpur Main road through L.C. No. 7 SPL/T3	6251
11	Bithur Road	830
12	Yabatpuri Road	3600
13	Chidiyaghar/Ganga bairaj Road	4387
14	VIP Road	5940
15	Gol Chauraha	6808
16	Swaroop Nagar Road	7286
17	Gwaltoli (Near N.S.I.C Build.) Road	8465
18	Bajariya Thana Road	10033
19	CESCO (Sub Station Near Chunniganj) Road	10024
20	Road to Lal Imli	10455
21	Parade Chauraha	11000
22	Bada Chauraha	11700
23	Jail Road	12380
24	Road to Company Bagh	12800
25	Road to Canal Road	13070
26	NayaGanj Chauraha	13400
27	Taat Mill Flyover	14970
28	Flyover near Jhakkarkatti Bus Terminal	15775
29	Transport Nagar road	17000
30	Baradevi Chauraha	17980

S. No.	Description	Chainage
31	Gosala Chauraha	18750
32	Kidwai Nagar road	19180
33	Elevated NH-25 Bypass	20015
34	Road to Vasant Vihar	20390
35	Road to Anand Vihar	20610
36	Road to Govind Nagar	21685
37	Road to Baudh Nagar Nagar	21830

5.1.2.2 Corridor-2: Agriculture University to Barra - 8

Considering centre line of Agriculture University Station as 0.00m, this corridor is 8600m long starting from -750m and running upto 7850m. This corridor starts as Underground stretch followed by Switch Over Ramp (SOR) and finally terminates as elevated stretch. The corridor is summarised in **Table 5.8**.

TABLE 5.8: ALIGNMENT DESCRIPTION OF CORRIDOR - II

Alignment Type	From (m)	To (m)	Length (m)
Underground	-750	3460	4210
Switch over Ramp (-)8.0m to (+)7.5m	3460	3873	413
Elevated	3873	7850	3977

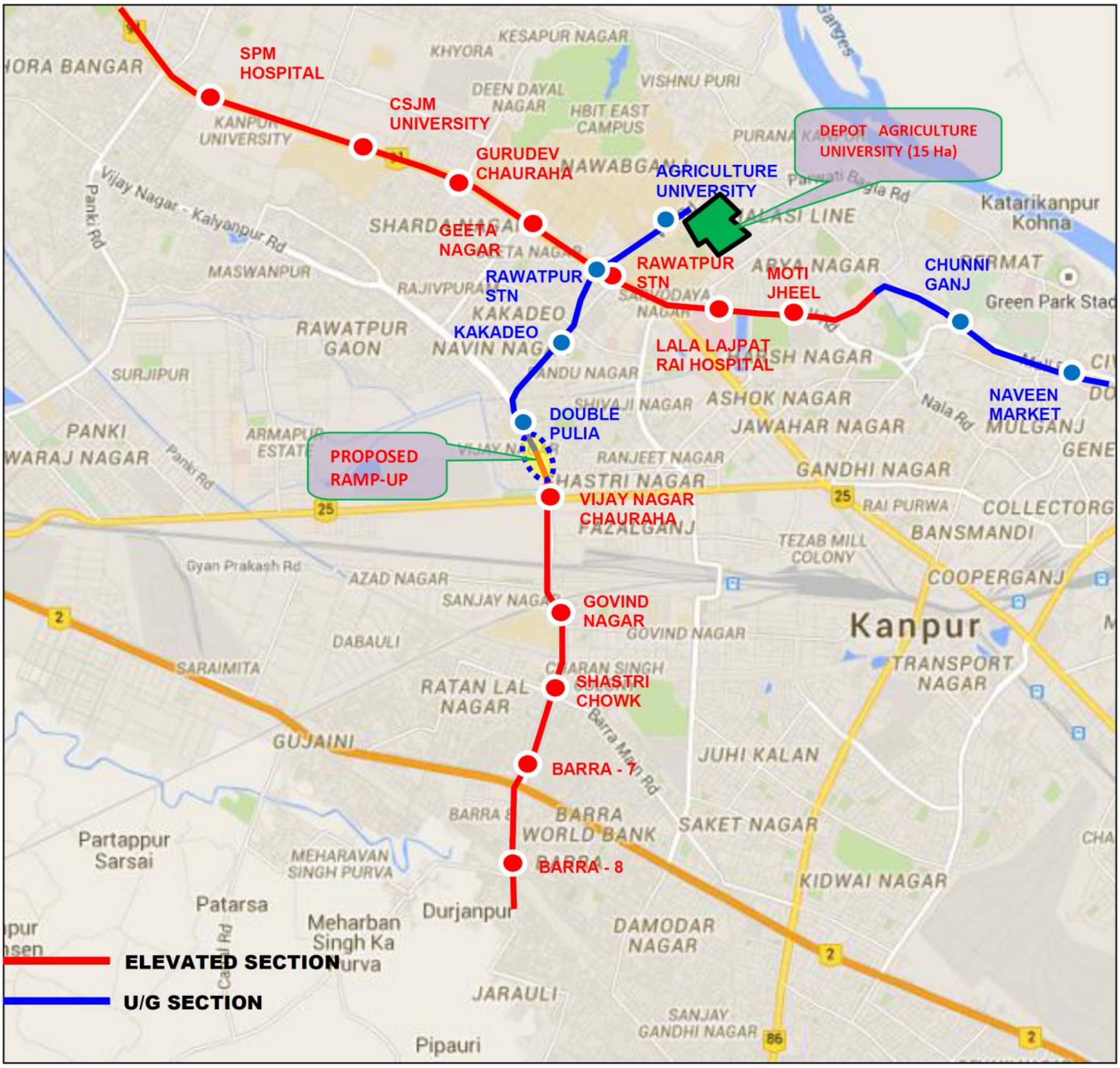
- The proposed MRTS alignment of Corridor-2 starts from Agriculture University along VIP Road. The alignment heads in South direction passing through UPSRTC workshop, Mathura - Kanpur Railway tracks at Rawatpur Railway station and private properties of R.S. Puram. To integrate with Corridor-1 and with a view to provide scope for future Northward extension of Corridor-2, Rawatpur has become an obligatory point for Corridor-2. **Figure 5.7** shows the proposed corridor-2.
- After touching Rawatpur, alignment negotiates reverse curve and aligns along Rawatpur Main Road upto Double Pulia and thereafter, it runs along Vijay Nagar - Kalyanpur Road. Further, the alignment of Corridor-2 runs along Barra-7 Road and crosses elevated Jhansi Kanpur Highway. Further, the alignment runs along the green belt and terminates at Barra-8. The alignment passes through Barra-3, Barra-7 and Barra-8 areas.

- The total length of Corridor-2 is about 8.6 Km having 3.977 Km as elevated, Switch Over Ramp in a length of 413m from (-) 8.0m to (+) 7.5m for Underground to Elevated portion followed by 4.210 Km as Elevated.
- Total of 9 stations have been proposed for the corridor which includes 4 as underground namely, Agriculture University, Rawatpur, Kakadeo and Double Pulia and 5 as elevated namely, Vijay Nagar Chauraha, Govind Nagar, Barra Road, Barra - 7 and Barra - 8.
- Location of Agriculture University station is towards Ganga bank from Rawatpur station. It will facilitate the future extension of this corridor to cover the upcoming development across the Ganga River. As the area beyond Agriculture University and upto Ganga Bank is heavily built-up and is served by narrow roads, elevated alignment is not possible and extension is possible only through underground alignment. Hence, Agriculture University station is proposed as Underground station at (-) 15.0m below ground level. It is proposed to construct this station by Cut & Cover method by taking half the width at a time. First, Station half width falling in open land in front of Agriculture University buildings / structures may be taken up and restored after the construction. Thereafter, road may be diverted longitudinally to the restored land in front of Agriculture University buildings / structures and construction below the road area may be taken up. Road will be restored to its original location after the construction of Station.

The second station of Corridor-2 is Rawatpur station which is also an Underground station. At Rawatpur Interchange of Metro Corrido-1, Metro Corridor-2 & Rawatpur station of N.E. Railway has been planned. For elevated corridor, special span of 34m+45m+34m has been proposed so as to accommodate Construction of Underground Rawatpur station of Corridor at a later stage. Due to major interchange point, there will be inescapable requirement of sufficient parking area. For Underground station, parking cum property development, Workshop of UPSRTC department is proposed to be acquired, dismantled and relocated to a suitable location decided by State Govt.

- The third station of this corridor is Kakadeo station. The available ROW at the proposed location is 25m - 28m. Hence, the 3-tier station is proposed

FIGURE 5.7: PROPOSED KANPUR METRO CORRIDOR-2



with lesser width of about 19.5m with Rail level of about 18m below ground level.There are commercial development on both side of the road and hence the station construction will be undertaken in two stages i.e. half the width at a time so that access to shops remains available. There are alternate parallel road available through which traffic diversion may be planned to reduce the traffic load on affected road.

- The fourth station is Double Pulia station, which is also the last Underground station of this corridor. The available ROW at the proposed location is sufficient and the station width proposed is typical 24m. The existing road has 3m wide median. During the construction period, the road shall be widened on available road shoulders and traffic shall be diverted away from the reserved construction area.

- **Switchover Ramp From Underground to Elevated**
  To become elevated from underground, switch over ramp from Underground to Elevated has been provided on the centre of the Kalyanpur - Vijay Nagar Road after Double Pulia station. The ramp runs from Ch: 3460 m to Ch: 3873 m at limiting gradient of 4% (compensated). About 4540 sqm PWD land will be required permanently for locating the ramp. Since the ramp is proposed at the middle of the wide road with 3m wide median and having ROW of more than 36m, there will not be any adverse affect to road traffic during construction phase as well as on permanent basis.

FIGURE 5.8: RAILWAY TRACKS AT DADA NAGAR

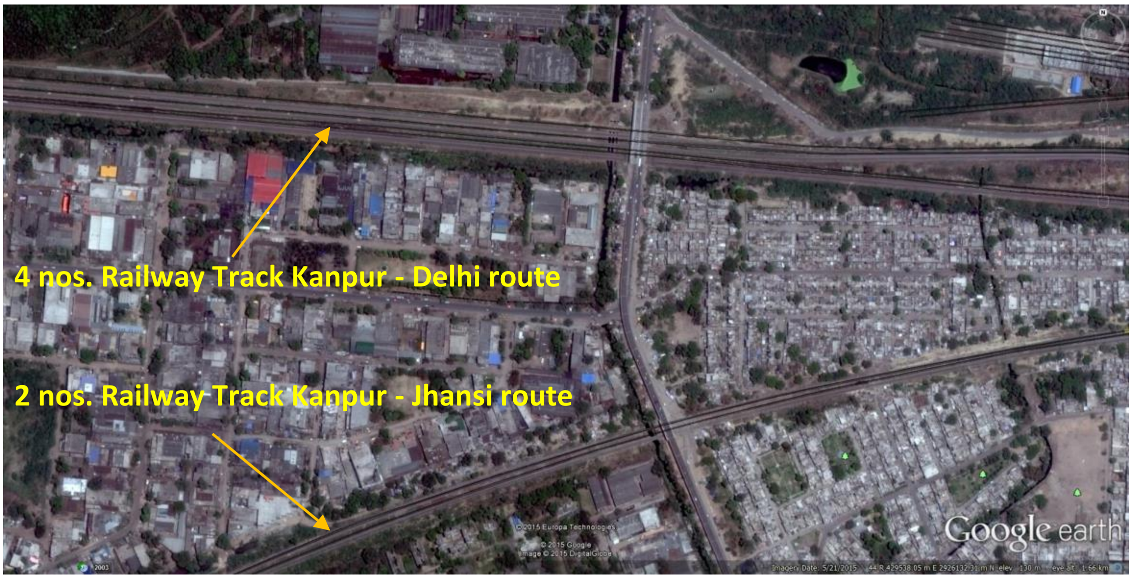
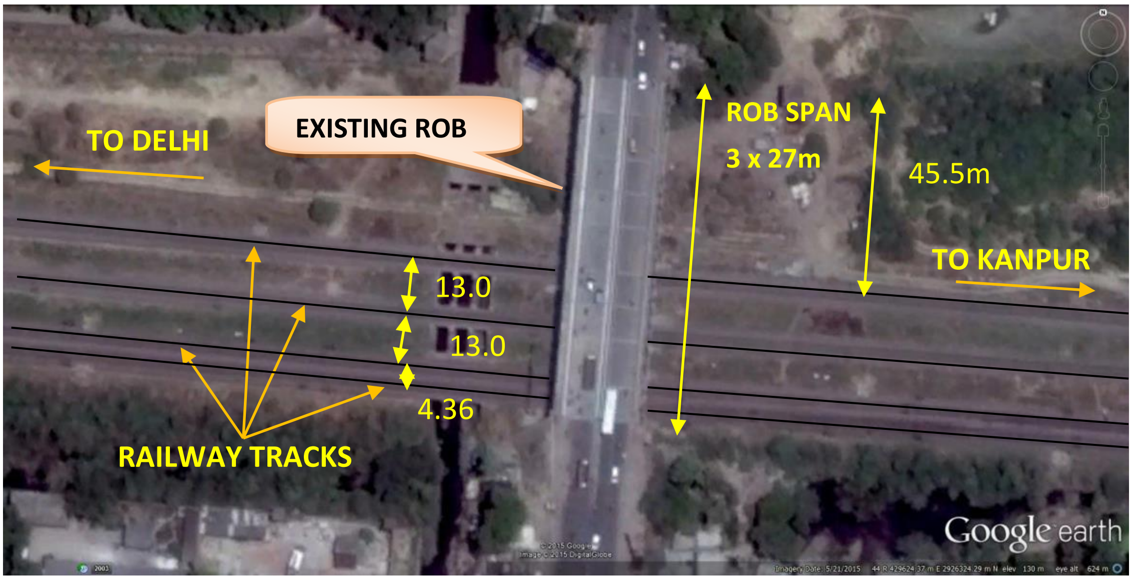


FIGURE 5.9: ROB ON DELHI – KANPUR 4 NO.RAILWAY TRACKS



The existing road shall be widened by 4.5m on either side of the ramp area so as to restore the original width of the carriageway. Sufficient shoulder width is available for the required widening.

- At Ch: 4554m, the elevated alignment crosses 4 railway tracks of Delhi - Kanpur Railway Network. On west of the existing ROB, new road over bridge is under construction and about 7 m wide Nallah is running along it. Accordingly, the alignment has been proposed on the east of the existing ROB. To minimize, interface with Railways and to avoid foundations of abutments of existing Road Over Bridge, special span configuration of 75m + 105m + 75m by Cantilever construction method is proposed at a lateral clear distance of 12m from adjacent edge of ROB residential houses located on the low lying land. Encumbrance free land will be provided by State Govt. at this location for viaduct. Cost of providing structures for rehabilitating the squatters is accounted for in the estimate.

FIGURE 5.10: ROB ON KANPUR - JHANSI 2 NO.RAILWAY TRACKS

- From Ch: 4929 m to Ch: 4955 m, the alignment crosses 2 railway tracks of Kanpur - Jhansi Railway Network. The crossing is possible with the regular span of 28 m similar to existing ROB. The alignment is proposed on the east of the existing ROB. considering the existing level crossing and future construction of new ROB, clear distance of 20 m has been kept between edge of existing ROB and edge of Viaduct of said Metro corridor.

- Govind Nagar elevated station is proposed after crossing 2 railway tracks of Kanpur - Jhansi Railway Network. The station is proposed off the road in the available park area. The ground level of proposed Govind Nagar station is down by 5-6m in comparision to level of adjacent road. As the station is proposed in open land, no traffic diversion is required.

- The next elevated stations are Shastri Chowk, Barra-7 & Barra-8. The road section between Shastri Chowk to Barra-8 is having width of more than 30m with 18m wide median in between the two carriageways. Sufficient shoulder width is also available on either side of road edges. Elevated stations are proposed on the centre of the median with Entry/exits on the shoulders.

- Barra-8 is the terminal station. The viaduct of the elevated section is extended beyond the terminal station so as to accommodate one rakes on each line. Besides this, two rakes shall be stabled at Barra-8 station. Further extension of viaduct will require shifting of 3 nos. HT OH lines. Being short corridor of 8.6 km with journey time of approx. 16 minutes, four stabled rakes will be sufficient to start the morning services from Barra-8 end.

- **Major Depot at Agriculture University open land**

Separate depot with an area of 12.5 Ha at Agriculture University open land has been proposed for Corridor-2. Overall three options have been considered for this depot and are discussed as under:-

Option 1- Connection of Depot from Rawatpur station

In this option, Rawatpur as well as Agriculture University stations are proposed to be underground with rail level at (-) 15.00 m and entry to Agriculture University Depot has been proposed from Rawatpur underground Station as shown in **Figure 5.11.**

For smooth operation and placement/withdrawl of rakes to/from depot, double line connectivity from Rawatpur station is proposed through two underground lines of about 500 m. These lines are proposed to be constructed by cut & cover method. The depot connecting lines are planned through available open land for ease of construction and to avoid acquisition of properties.

Along VIP road, there is one row of residential buildings (G+0, G+1) of State Govt. having entry from VIP road itself. There are other residential buildings behind the front row buildings. There is one connecting road which takes off from VIP road and then runs at the back side of the front row buildings. The said connecting road can be used during construction phase for construction of ramp for depot connectivity from R.L. (-)15.00 to surface level. As other road alternatives are also available, there will be no obstruction to internal traffic flow of residential colony. After construction of ramp from R.L. (-)15.00 to R.L. (-)8.00, substantial portion of road will be restored and only 175m of road will require lateral diversion due to ramp portion from R.L. (-)8.00 to R.L. 0.00. Only one G+0 residential building of Medical College, numbered as R-9 along with its garage with total floor area of 324 sqm is to be acquired. Moreover, the depot layout has been planned in a way that only two pump houses of Agriculture University with total floor area of 211 sqm are required for depot.

This option will have following bearings over train operation:-

- After washing/servicing at depot, the morning services can be initiated from Rawatpur Station towards Barra-8 directly and towards Agriculture University with reversal. As frequency of trains during off-peak period is less, reversal can be done without any operational restraints.
- During night, terminating rakes coming from Barra-8 may be terminated at Agriculture University station and empty rakes can be placed inside the depot with reversal via Rawatpur station. As frequency of trains during off-peak period is less, reversal can be done without any operational restraints.

Option 2- Connection of Depot from Agriculture University Station

In this option, connectivity of depot is proposed from Agricultural University station instead of Rawatpur. This will avoid construction of additional tunnel and ramp for depot connectivity from Rawatpur station. The level of Agricultural University station is proposed as (-) 6.00 m considering the future extension of the corridor. Also, to avoid hindrance to road traffic, Agricultural University station has been proposed off the road, and will require acquisition of residential and official buildings of Agriculture University on the front row along VIP road. About 24 residential buildings of Agriculture University with total floor area of 14508 sqm and 18 residential buildings of Medical College with Total floor area of 14717 sqm will need to be acquired permanently for depot entry and depot. The entry to Agriculture University Depot is proposed with U-curve after Agriculture University station as shown in **Figure 5.12.**

This option will have following bearings over train operation:-

- After washing/servicing at depot, the morning services can be initiated from Agriculture University Station towards Barra-8 directly.
- At the end of services, empty rakes can enter the depot directly from Agriculture University Station.
- The entry to depot is longer as compared to Option-I.

Option 3- Connection of Depot from Agriculture University Station with Reverse Shunting

In this option, connectivity of depot is proposed from Agricultural University station. The level of Agricultural University station is proposed as (-) 6.00 m considering the future extension of the corridor. Also, to avoid hindrance to road traffic, Agricultural University station has been proposed off the road, and will require acquisition of residential and official buildings of Agriculture University on the front row along VIP road. 21 residential buildings of Agriculture University with total floor area of 8989 sqm and 23 residential buildings of Medical College with total floor area of 7328 sqm will need to be acquired permanently for depot entry and depot. The single track connectivity from Agriculture University to Depot is proposed with reverse shunting as shown in Figure 5.13.

This option will have following bearings over train operation:-

- After washing/servicing at depot, the morning services can be initiated from Agriculture University Station towards Barra-8 directly.
- At the end of services, empty rakes can enter the depot directly from Agriculture University Station.
- The entry/exit to/from depot will involve longer duration due to longer length and involvement of reverse shunting process.
- The single track connectivity will result into placement / withdrawl of one rake at a time and is not a preferred option from operational view point.

A comparison of all three depot options has been tabulated in **Table 5.9, Table** 5.10 **& Table 5.11.**

FIGURE 5.11: CONNECTIVITY TO DEPOT FROM RAWATPUR STATION (OPTION-1 - RECOMMENDED)

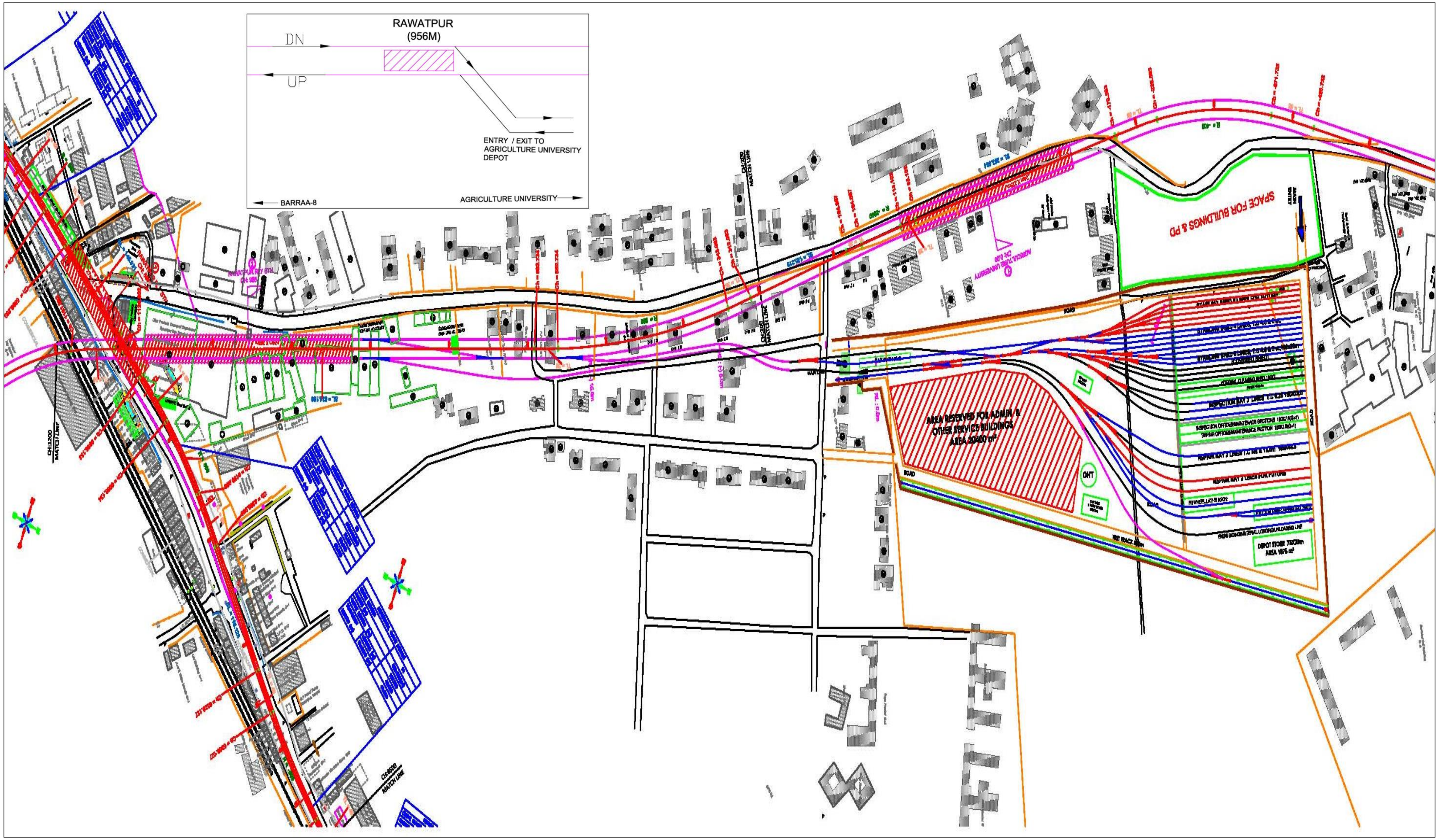


FIGURE 5.12: CONNECTIVITY OF DEPOT FROM AGRICULTURE UNIVERSITY (OPTION-2)

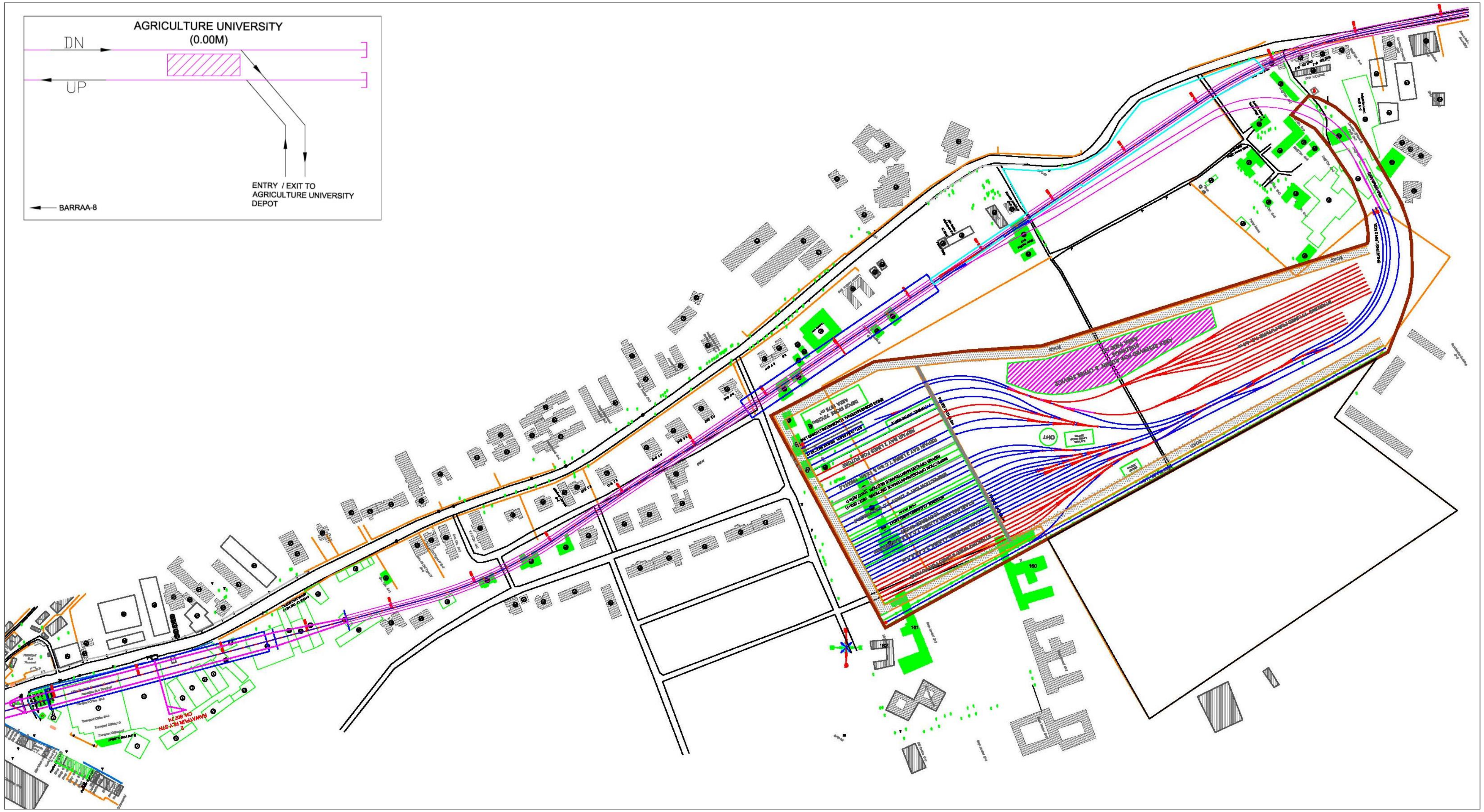


FIGURE 5.13: CONNECTIVITY OF DEPOT FROM AGRICULTURE UNIVERSITY WITH REVERSE SHUNTING (OPTION-3)

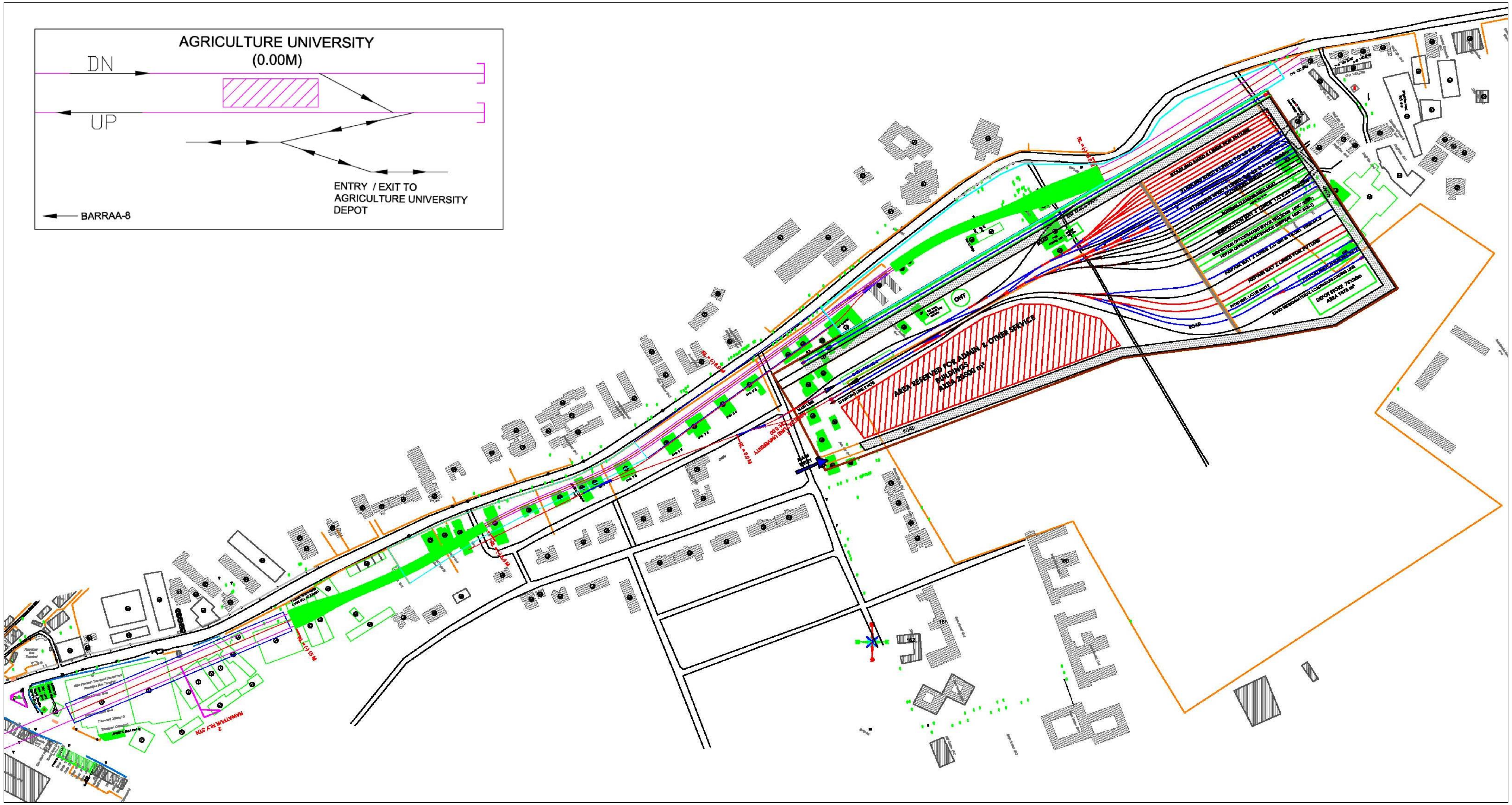


TABLE 5.9: DETAILS OF LAND AND STRUCTUE REQUIREMENT FOR DEPOT OPTIONS

Building No.	Ownership	Type of Structure	Area (Sqm)	Floor Area (Sqm)	From Agriculture Univ. Direct	From Rawatpur	From Agriculture Univ. with Reverse Shunting
23	Medical College	Old Type IV No. 49 G+0	296	296	No	No	Yes
24	Medical College	Old Type IV G+0	253	253	No	No	Yes
25	Medical College	Govt Quarters G+1	407	814	No	No	Yes
26	Medical College	PPS Govt Quarters G+1	582	1164	No	No	Yes
27	Medical College	Govt Quarters G+0	195	195	No	No	Yes
28	Medical College	Govt Quarters G+0	258	258	No	No	Yes
29	Medical College	Govt. Resi. Quarter R-1	193	193	No	No	Yes
29A	Medical College	Medical Campus G+1	269	538	No	No	Yes
30	Medical College	Govt. Resi. Quarter R-2	319	319	No	No	Yes
31	Medical College	Govt. Resi. Quarter R-3	319	319	No	No	Yes
32	Medical College	Govt. Resi. Quarter R-4	445	445	No	No	Yes
33	Medical College	Govt. Resi. Quarter R-5	294	294	No	No	Yes
34	Medical College	Govt. Resi. Quarter R-6	285	285	No	No	Yes
35	Medical College	Govt. Resi. Quarter R-7	183	183	No	No	Yes
36	Medical College	Govt. Resi. Quarter R-8	239	239	No	No	Yes
37	Agriculture University	Sasya Dehiki Vibhag G+1	1052	2104	Yes	No	Yes
38	Agriculture University	Legume Section G+0	494	494	No	No	Yes
39	Agriculture University	Building G+0	91	91	No	No	Yes
40	Agriculture University	Building G+0	73	73	No	No	Yes
41	Agriculture University	Building G+0	104	104	No	No	Yes
42	Agriculture University	Alsi Resha Shed	288	288	No	No	Yes

Building No.	Ownership	Type of Structure	Area (Sqm)	Floor Area (Sqm)	From Agriculture Univ. Direct	From Rawatpur	From Agriculture Univ. with Reverse Shunting
43	Agriculture University	Building G+0	292	292	No	No	Yes
44	Agriculture University	Kapas Anubhag G+0	150	150	No	No	Yes
45	Agriculture University	Tilhan Section G+0	717	717	Yes	No	Yes
46	Agriculture University	Building G+0	132	132	Yes	No	Yes
49	Medical College	Shed	176	176	Yes	No	No
50	Medical College	Building G+0	187	187	Yes	No	No
51	Medical College	Govt Resi. Bldg G+0	317	317	Yes	No	No
52	Medical College	Govt Resi. Bldg G+0	229	229	Yes	No	No
58	Medical College	Building G+0	302	302	Yes	No	Yes
59	Medical College	Building G+0	215	215	Yes	No	Yes
59A	Medical College	Building G+0	106	106	Yes	No	Yes
59B	Agriculture University	Building G+0	79	79	Yes	No	Yes
59C	Agriculture University	Building G+0	30	30	No	No	Yes
60	Agriculture University	Dalhan Anubhag G+1	129	258	Yes	No	Yes
61	Agriculture University	Govt Resi. Bldg G+0	193	193	Yes	No	Yes
62	Medical College	Govt Resi. Bldg No.R-9 G+0	212	212	Yes	**Yes**	Yes
63	Medical College	Garage of R-9 & R-10	112	112	Yes	**Yes**	Yes
64	Medical College	Govt Resi. Bldg G+0	262	262	Yes	No	Yes
65	Medical College	Govt Resi. Bldg G+0	242	242	Yes	No	Yes
66	Medical College	Govt Resi. Bldg G+0	82	82	Yes	No	Yes
67	Medical College	Guest House G+0	355	355	Yes	No	No
68	Medical College	Club G+0	343	343	Yes	No	No
69	Medical College	Building G+0	219	219	Yes	No	No

Building No.	Ownership	Type of Structure	Area (Sqm)	Floor Area (Sqm)	From Agriculture Univ. Direct	From Rawatpur	From Agriculture Univ. with Reverse Shunting
70	Medical College	Building G+0	477	477	Yes	No	No
81	Agriculture University	Staff Quarter G+1	238	476	Yes	No	No
82	Agriculture University	Staff Quarter G+2	212	636	Yes	No	No
87	Agriculture University	Staff Quarter G+1	270	540	Yes	No	No
89	Agriculture University	Seed & Science Technology G+1	214	428	Yes	No	No
90	Agriculture University	Staff Quarter G+0	578	578	Yes	No	No
91	Agriculture University	Staff Quarter G+0	114	114	Yes	No	No
92	Agriculture University	Staff Quarter G+0	122	122	Yes	No	No
93	Agriculture University	Rabi Sasya Office G+0	448	448	Yes	No	Yes
94	Agriculture University	Pump House	67	67	Yes	**Yes**	Yes
95	Agriculture University	Pump House	144	144	Yes	**Yes**	Yes
96	Agriculture University	Staff Quarter G+0	72	72	Yes	No	Yes
97	Agriculture University	Staff Quarter G+0	447	447	Yes	No	Yes
98	Agriculture University	Cluster of Houses	2531	2531	Yes	No	Yes
99	Agriculture University	Building G+0	275	275	Yes	No	Yes
100	Agriculture University	Cluster of Houses	1202	1202	Yes	No	No
102	Agriculture University	Building G+0	554	554	Yes	No	No
107	Agriculture University	Irrigation W/S Shed G+0	2025	2025	Yes	No	No
108	Agriculture University	Director of Seed & Feed	366	366	Yes	No	No
160	Medical College	hostel G+2	2134	6402	Yes	No	No
161	Medical College	hostel G+2	1493	4479	Yes	No	No

Note: AutoCad drawing may please be referred for location of buildings.

TABLE 5.10: COMAPRISON OF LAND REQUIREMENT OF DEPOT OPTIONS

Ownership	From Rawatpur (Option-1)		From Agriculture University Direct (Option-2)		From Agriculture University with Reverse Shunting (Option-3)	
	No. of Structures	Floor Area	No. of Structures	Floor Area	No. of Structures	Floor Area
Agriculture University	2	211	24	14508	21	8989
Medical College	2	324	18	14717	23	7328
Total	**4**	**535**	**42**	**29225**	**44**	**16317**

TABLE 5.11: DETAILED COMAPRISON OF DEPOT OPTIONS

Depot Entry Station	Main Line			Depot				
	Alignment	Station Depth (m)	Land Area (Ha)	Length of Depot Connectivity (m)	Operation Depot Entry	Operation Internal Depot	Land Area (Ha)	Remaining Useful Land (Ha)
Rawatpur	By TBM	(-) 15.0	0	500	Direct by means of double line.	Smooth	12.5*	15.80
Agriculture Direct	By Cut & Cover (-)15.0 to (-)6.0 to (-)15.0	(-) 6.0	1.67	780	Direct by means of double line.	Smooth but length of depot is more	25.2	8.70
Agriculture with Reverse Shunting	By Cut & Cover (-)15.0 to (-)6.0 to (-)15.0	(-) 6.0	3.37	830	Reverse Shunting with single line.	Smooth	13.8	17.50

* Including ramp area required for depot connectivity

Considering operational issues (longer length of depot entry, reverse shunting etc.) & to avoid acquisition of large number of residential buildings of Agriculture University and Medical College, Option 2 & 3 are ruled out and **Option-1 is recommended for Corridor-2.**

5.1.2.2.1 Reference Point for Corridor-2

For the planning convenience, the zero point of the Corridor is considered at the centre line of the proposed Agriculture University Metro station. The chainage along the alignment increases in Southern direction. All elevations are from Mean Sea Level (MSL).

5.1.2.2.2 **Terminals of Corridor-2**

i. **Agriculture University Metro Station (North terminal station)**

The Northernmost station on the Metro corridor - 2 is Agriculture University Station. The station is proposed underground and rail level has been kept (-) 15.00m (minimum) below the ground level. Proposed metro station will cater the areas along VIP road in north and Agriculture University. Provision for future extension across the Yamuna River has also been kept. Reversal facilities have also been planned at Agriculture University station. Entry to the proposed depot has also been planned after the station.

ii. **Barra-8 Metro Station (South terminal station)**

Southern Terminal of the corridor will be Barra-8 Metro Station. The station is proposed elevated and rail level has been kept 12.00 m (minimum) above the ground level. It will serve the nearby localities of Varun Vihar Colony, various blocks of Barra, and World Bank Colony.

Reversal/stabling facility has also been planned beyond Barra-8 Station. Two elevated stabling lines for one Rake each has also been proposed beyond Barra-8 station.

iii. **Interchange Stations**

Efforts have been made to select station locations in such a fashion so as to provide convenient and efficient passenger interchange with other modes of transport such as other Railway system and Bus system. Interchange stations provided along the Corridor are shown in **Table 5.12.**

TABLE 5.12: INTERCHANGE STATIONS OF CORRIDOR-2

S. No.	Name of station	Mode	Interchange with
1	Rawatpur Metro Station	Metro	Proposed elevated Rawatpur Station of Corridor-1
2	Rawatpur Metro Station	Railway	Rawatpur Railway Station of Mathura – Kanpur Railway line

5.1.2.2.3 Major Roads along Corridor-2

The major roads along and across the alignment are given in **Table 5.13 & Table 5.14** respectively.

TABLE 5.13: MAJOR ROADS ALONG CORRIDOR-2

S. No.	Name of the Road	Chainage	
		From (m)	To (m)
1	VIP Road	(-) 750	1100

S. No.	Name of the Road	Chainage	
		From (m)	To (m)
2	Rawatpur Main Road	1825	2623
3	Vijay Nagar - Kalyanpur Road	2950	3900
4	Dada Nagar ROB over Kanpur - Delhi NC Railway lines	4514	4594
5	Dada Nagar ROB over Kanpur - Jhansi NC Railway lines	4925	4953
6	Barra 7 Road	3900	6900
7	Jarauli Road	6900	7850

TABLE 5.14: MAJOR ROADS ACROSS CORRIDOR-2

SN	Description	Chainage
1	NH-91	1125
2	Devki Chauraha - JK Temple road/Kalyanpur road	1842
3	Kakadeo Chauraha	2220
4	Santnagar Road	3685
5	Vijay Nagar Chauraha - Kalpi road/Fajalgang Road	3890
7	Dada Nagar Colony Road/ Lohiya Road	4775
8	Dada Nagar Chauraha Road	5230
9	Shastri Chowk - Barra Main road	5935
10	Barra-6 road	6400
11	Elevated NH-25 Bypass	6940
12	Barra-8 road	7500
13	Varun Vihar road	7850

5.2 ANALYSIS OF CORRIDORS TO BE ELEVATED, UNDERGROUND OR AT-GRADE

5.2.1 Comprehensive Mobility Plan (CMP)

The Comprehensive Mobility Plan (CMP) was prepared in 2011 for the Kanpur Development Authority (KDA) area. Total 70 km length of rail based MRTS network has been proposed in CMP for two corridors as under:-

- Corridor-1: Mandhana to Sarsaul via NH 91 and NH 25 (47 km)
- Corridor-2: Jajmau to Kalyanpur via Panki (23 km)

5.2.2 Site Reconnaissance

To select the high-density corridor in 2015 as well as major industrial areas and upcoming developments, a site reconnaissance survey was carried out by RITES along with KDA and LMRC officials to finalise the priority MRTS corridors. Based on site reconnaissance, two corridors were agreed as priority corridors which are as under:

- Corridor 1: IIT Kanpur to Naubasta (Approx. 24 Kms)
- Corridor 2: Agriculture University to Barra-8 (Approx. 9 Kms)

5.2.3 Alignment Options Parameters

The consultant studied the various alignment options for the priority MRTS corridors based on the planning parameters shown in **Figure 5.14**

MRTS corridors as recommended in Inception cum Options Report are presented in **Figure 5.15** and are briefly discussed as under.

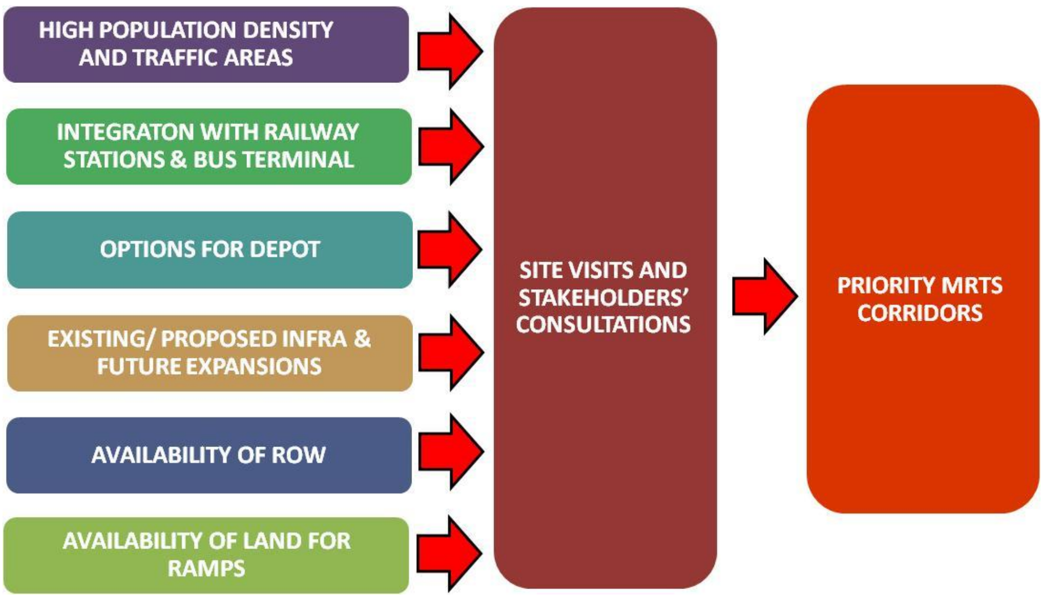
5.2.4 Alignment Options for Corridor -1

The consultant studied the following alignment options for Corridor-1:

A. IIT Kanpur to GSVM Medical College Section

The corridor-1 starts from IIT Kanpur and runs along NH-91 and heads in East direction.

FIGURE 5.14: ALIGNMENT OPTIONS PARAMETERS



Following three options were presented in Inception cum options report:

- **Option - I**: IIT Kanpur to GSVM Medical College as partially elevated/ underground with ramp down near Kanpur University.
- **Option - II**: IIT Kanpur to GSVM Medical College as partially elevated/ underground with ramp down near Polytechnic College.

- **Option - III**: IIT Kanpur to GSVM Medical College as partially elevated/ underground with ramp down along GSVM Medical College boundary.

Two options for Major Depot for corridor-1 were proposed as under:

- **Option - I**: About 20 ha Central Govt. open land was identified at Kalyanpur opposite IIT Kanpur.
- **Option - II**: About 22 ha Polytechnic College land (State Govt. land) was identified at near Gurudev Chauraha.

B. GSVM Medical College to Kanpur Central Railway Station Section

Due to constrained ROW, traffic congestion and acquisition of private property at sharp curves along Mall Road and Canal Road, the section was proposed completely underground. However, two options were studied between Moti Jheel and Chunniganj which are as follows:

- **Option - I**: Moti Jheel to Chunniganj as underground along Mall Road.
- **Option - II**: Moti Jheel to Chunniganj as underground along Mall Road and Nawabganj Road.

C. Kanpur Central Railway Station to Naubasta

The section from Kanpur Central to Naubasta was proposed partially underground/elevated with ramp up along Hamirpur Road near Baradevi. Minor Depot with an area of 5 Ha open land (State Govt. land) had been proposed at Naubasta.

5.2.5 Alignment Options for Corridor -2

The consultant studied the following alignment options for Corridor-2:

A. Agriculture University to Vijay Nagar Chauraha Section

Three options were presented in Inception cum options report for Rawatpur to Vijay Nagar Chauraha Section which is as under:

- **Option-2A**: Agriculture University to Vijay Nagar Chauraha as partially underground/elevated with ramp up along Vijay Nagar–Kalyanpur Road.
- **Option-2B**: GSVM Medical College to Vijay Nagar Chauraha as elevated.
- **Option-2C**: Geeta Nagar to Vijay Nagar Chauraha as elevated.

Major Depot for Corridor-2 has been proposed in open land of Agriculture University with an area of 20 Ha.

B. Vijay Nagar Chauraha to Barra-8 Section

The section from Vijay Nagar Chauraha to Barra-8 had been proposed as completely elevated.

5.2.6 Selection of Corridors

- During the meeting chaired by Commissioner, Kanpur on 07.04.2015, the proposed Corridor-1 was approved with partially elevated/underground alignment with ramp down at GSVM Medical College and ramp up along Hamirpur Road near Baradevi. The major depot at Polytechnic College (22 Ha land) and minor depot at Naubasta (7 Ha land) was also approved.

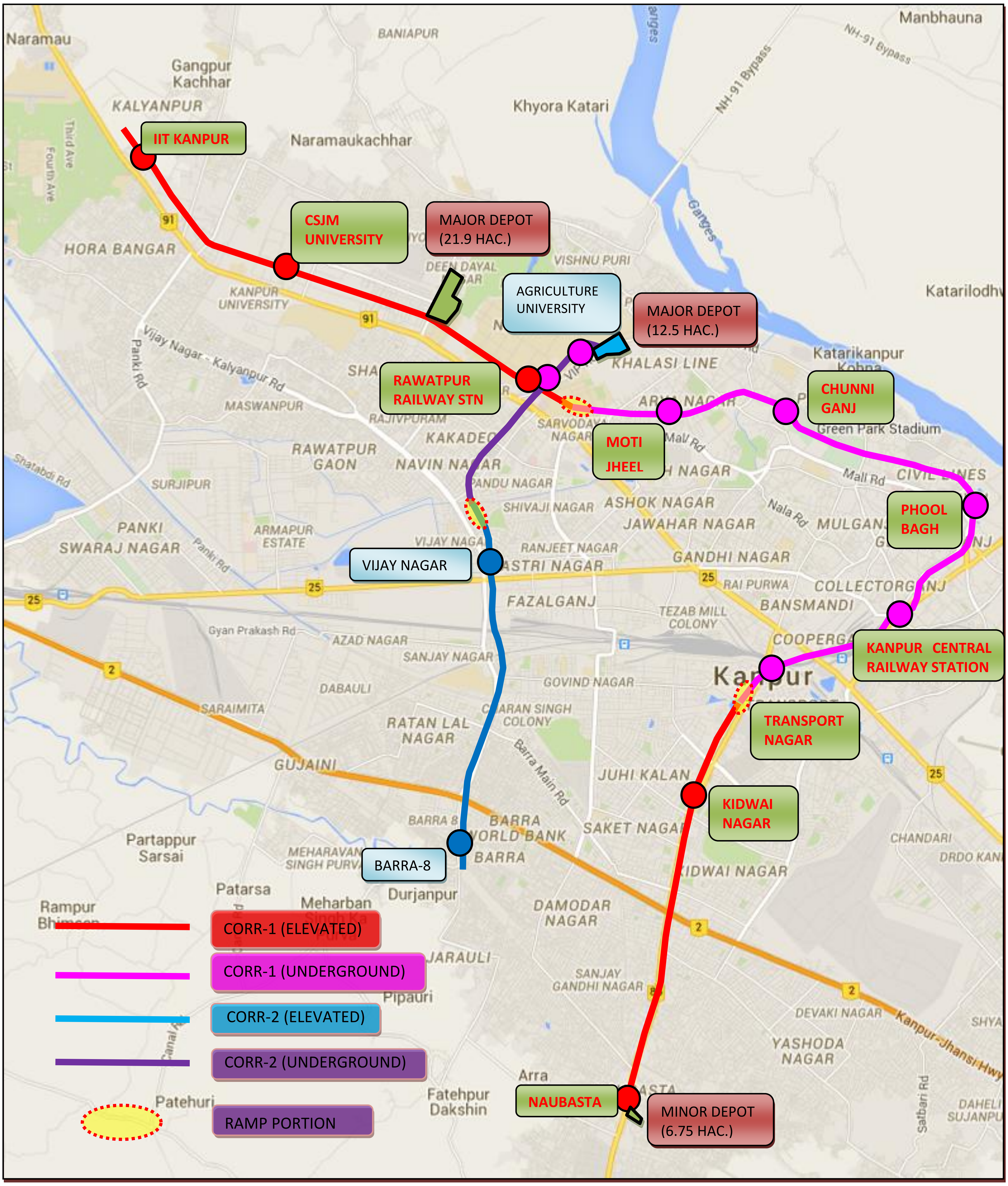
  Also, considering the future development along VIP Road and across Ganga River, the proposed Corridor - 2 was approved with start of alignment from Agriculture University and terminating at Jarauli with ramp up along Vijay Nagar – Kalyanpur Road and major depot in open land of Agriculture University with an area of 20 Ha. It will be possible to extend the alignment from Agricultural University and upto/across the Ganga as underground alignment.

- During site visit of RITES team with KDA and LMRC officials on 09.05.2015 for Corridor-1, it was decided that the alignment from IIT Kanpur to Harsh Nagar will be planned elevated and ramp down will be in Brijendra Swaroop Park. Further, it was also communicated by KDA and LMRC officials that underground Rawatpur Metro station of Corridor-2 has to be planned in the UPSRTC workshop/depot. For this purpose, the Corridor-2 shall be realigned accordingly.

- During site visit of RITES team with KDA and LMRC officials on 09.06.2015 for Corridor-2, it was decided that as depot has already been approved at Agriculture University and in view of low ridership in the catchment Jarauli, Jarauli station shall be dropped. Barra-8 will be the terminal station, hence reversal facilities shall be planned at Barra-8 station.

- During meeting of RITES team with LMRC officials on 25.07.2015 at Lucknow, it was advised that from view point of construction and operational phasing, Moti Jheel Station will be priority stretch for Corridor-1 and accordingly, Moti Jheel station is to be planned as Mid-Terminal Station with facilities for reversal.

FIGURE 5.15: RECOMMENDED METRO ALIGNMENT IN INCEPTION CUM OPTIONS REPORT



5.3 DESIGN NORMS

The geometric design norms have been worked out based on detailed evaluation of passenger comfort, safety, experience and internationally accepted practices being followed in currently operating rapid transit and rail systems.

5.3.1 Principles for Metro Corridors

While fixing the alternatives on proposed corridor, following requirements/ constraints have been kept in view:

i) To remain on the CL of the existing road or Government premises/land to the extent feasible.

ii) To utilize the existing road Right of Way (ROW) to the maximum extent in order to minimise the land acquisition and also length of diversions.

iii) To avoid dismantling of existing structures/Buildings etc. to the extent feasible.

iv) To avoid private built up areas, villages, habitation and religious structures etc. to the extent feasible.

v) To provide adequate clearance from existing Railway/ Highway structures.

vi) To satisfy the requirements of sound economic engineering practices

vii) To rationalise the location of proposed stations and underground ramps

5.3.2 Geometric Design Parameters

5.3.2.1 Alignment Considerations: As far as possible-

- Tangent alignment has been maximized.
- Flattest possible curves have been proposed.
- Number of curves has been minimized.
- Maximum possible transition lengths, commensurate to operating speed have been proposed.
- Elevated alignment has been maximized.
- Number of gradients has been minimized.
- Flattest possible vertical curve have been proposed.

- Cants of appropriate values, commensurate to operating speed at specific locations have been proposed to counter the effect of centrifugal force.
- Vertical curves & transition curves of horizontal alignment do not overlap.

5.3.2.2 General Criteria

General Criteria used for the design purpose are given below in **Table 5.15.**

TABLE 5.15: DESIGN CRITERIA

S. NO.	CRITERIA	DIMENSION
1	Gauge	1435 mm
2	Design Speed	90 Kmph
3	Maximum Axle Load	16T
4	Electric Power Collection	25 KV AC (OHE)

5.3.2.3 Horizontal Alignment

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

A) Circular Curves

Circular curves shall be defined by their radii in meters. Larger radii shall be used whenever possible to improve the riding quality. The minimum radius of curvature for mainline track shall be governed by the design speeds and by the limits for cant but shall not be less than 120m. The horizontal curve parameters are tabulated below in **Table 5.16**

TABLE 5.16: HORIZONTAL CURVE PARAMETERS

Description	U/G Section	Elevated Section
Desirable Minimum Radius	300 m	200 m
Absolute minimum Radius	200 m	120 m
Minimum curve radius at stations	1000 m	
Maximum permissible cant (Ca)	110 mm*	
Maximum cant deficiency (Cd)	85 mm	
* The applied cant will be decided in relation to normal operating speeds at specific locations like stations/vicinity to stations.		

B) Reverse Curves

The use of reverse curves is discouraged but where necessary, the two curves have been separated by minimum 25 m. If provision of 25 m straight length is restricted by physical constraints, the two curves have provided without any straight in between.

C) Transition Curves

It is necessary to provide transition curves at both ends of the circular curves for smooth transition from straight section to curved section and vice-versa. **Table 5.17** shows required Length of transitions for Horizontal curves.

TABLE 5.17: LENGTH OF TRANSITIONS OF HORIZONTAL CURVES

Minimum Length	0.44 *actual cant (in mm) 0.44 * cant deficiency (in mm) whichever is higher
Desirable Length	0.72 *actual cant (in mm) 0.72 * cant deficiency (in mm) whichever is higher
Minimum Straight between two transition curves	25 m or NIL
Minimum horizontal curve length between two transition curves	25 m
No Overlap is allowed between transition curves and vertical curves	

5.3.2.4 Vertical Alignment

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

A) Elevated Section

As per para 2.12.2 of IRC: SP-73, "*Minimum 5.50 m vertical clearance shall be provided from all points of the carriageway of project Highways to the nearest surface of the overpass structure*". However, it is recommended to keep suitable margin for future raising of road by resurfacing etc. Rail level will also depend upon the type and detailed design of pier cap and super-structure elements.

Rail levels at elevated station locations have been proposed by providing minimum vertical clearance and con-course of 3.50 m. Structural design of con-course floor slabs and viaduct will also govern the final rail level. **Table 5.18** shows required Track centres and height for elevated station.

TABLE 5.18: TRACK CENTRE AND HEIGHT IN ELEVATED SECTION

Parameter	Minimum Track Centre	Minimum Rail Level above Ground Level
Mid-Section	4.00 m*	7.50 m**
Station w/o Scissor Cross-over	4.00 m	12.00 m
Station with Scissor Cross-over	4.50 m	12.00 m

Note:

* Track centre in elevated section can be modified as per the choice of girder/superstructure. For Double U-girder minimum 4.60 m track centre will be provided.

** For I-girder and Box-girder, Minimum Rail Level above Ground Level shall be 8.50 m

B) Underground Section

Rail level at mid-section tunnels has been proposed with a view to provide minimum cover of tunnel diameter 'D' to the foundation of structures located above. At stations, depth of rail below the ground level shall accommodate station concourse also. **Table 5.19** shows required Track centres and depth for underground station.

TABLE 5.19: TRACK CENTRE AND DEPTH IN UNDERGROUND SECTION

Description	Minimum Track Centre	General Depth below Ground Level
Running section by TBM	15.00 m	15.0 m
Running section by cut & cover except ramp	4.60 m	12.60 m
Stations by cut & cover and island platform of 13 m	16.03 m	15.0 m
Stations by cut & cover and side platform	4.60 m	15.0 m
Stations by NATM	22.00 m	18.0 m

5.3.2.5 Gradients

A) Mid-Section

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

- Switch over ramp between underground and elevated sections where a grade of up to 4% (compensated) may be adopted to minimise the length of ramp.
- Where the existing road gradient is more than 2% as the elevated section is kept parallel to the road surface to minimise the rail level (to reduce the pier height).

Suitable longitudinal grades with drains at the low point are proposed for assuring proper drainage.

B) Stations

Preferably, the stations shall be on level stretch with suitable provision for drainage by way of cross slope and slope of longitudinal drains. However, maximum grade shall not exceed 1 in 400. There shall be no change of grade on turnouts on ballastless track.

C) Depot

For connectivity to track depot, maximum 4% (compensated) gradient is proposed. For other portions of depot, gradient as flat as possible with adequate track drainage shall be designed to suit the actual ground slope. All shop tracks shall be at level. Sidings shall be level or shall fall away from the main line connection at a gradient not exceeding 0.25%. There shall be no change of grade within 30 m of any points and crossing on ballasted track. **Table 5.20** shows gradient parameters.

TABLE 5.20: GRADIENT PARAMETERS

Description	Desirable	Absolute Minimum
Gradient at Mid-Section	Upto 2%	Upto 4% (compensated)
Gradient at Stations	Level	Upto 0.25%

5.3.2.6 Vertical Curves

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

It is proposed that vertical curves and transition curves of horizontal alignment do not overlap. Minimum radius and length of vertical curves are shown in **Table 5.21.**

TABLE 5.21: VERTICAL CURVE PARAMETERS

Parameter	Vertical Curve
Desirable Radius on Main line	2500 m
Absolute Minimum Radius on Main line	1500 m
Minimum Length of Vertical Curve	20 m

5.3.3 Design Speed

The maximum sectional speed will be 90 km/h, subject to further restriction by radius of horizontal curves, cant and cant deficiency. The parameters of radius of horizontal curve, cant and permitted speed are summarized below. **Table 5.22** shows Radius, Cant and Permitted Speed.

TABLE 5.22: RADIUS, CANT AND PERMITTED SPEED

Radius	Actual Cant (Ca)	Permitted Speed
(m)	(mm)	(km/h)
5000	15	90
4000	15	90
3500	15	90
3000	15	90
2800	15	90
2400	20	90
2000	20	90
1600	25	90
1500	30	90
1200	35	90

Radius	Actual Cant (Ca)	Permitted Speed
(m)	(mm)	(km/h)
1000	45	90
800	55	90
600	70	90
500	90	90
450	110	85
400	110	80
350	110	75
300	110	70
200	110	55
175	110	50
150	110	45
120	110	40

5.3.3 GEOTECHNICAL INVESTIGTION

5.3.3.1 Coverage

Geotechnical investigation was carried out by RITES with the objective of determining subsurface profile of the underlying strata and required strength characteristics of the underlying soil / rock strata in order to propose the suitable substructure for elevated section, stations buildings, other buildings and underground alignment.

Geotechnical report includes field investigation, laboratory test results of the soil samples to evaluate the soil parameters and recommendations with regard to suitable sub-structure which may be adopted for various elevated and underground structures.

5.3.3.2 Physiography & Climate

Kanpur Metropolis, the largest city of Uttar Pradesh and the 8th largest city of India, is located on western bank of river Ganga. Kanpur city occupies a geographical area in the central part of U.P., lying between latitude 26° 20’ and 26° 35’ North and longitude 80° 10’ and 80° 30’ East (Survey of India Toposheet No. 63 B) and a mean altitude of 125 meters above mea sea level. Kanpur City lies on the right bank of the river Ganges, which is elevated very high from the river, which is the reason that the city never floods. Though, some of the rural outskirts of the city lie on the flood-prone areas of the Ganges, and it often floods the villages on its banks during the monsoon season

Kanpur metropolis forms a part of Ganga sub -basin in the Central Indo-Gangetic Plain. It exhibits more or less a flat topography with the master slope from north-west to south-east. The area is drained by the river Ganges and its tributary Pandu. The area of city has been geomorphologically divided into two units. (i) Low lands or Younger Alluvial Plain & (ii) Up lands or Older Alluvial Plain. The Low land or Younger Alluvial Plain has been identified as flat to gently sloping and slightly undulating terrain of large areal extent, formed by river deposition, and is limited along river Ganga with the breadth not exceeding 5 km. The sediments comprise of recent unconsolidated alluvial material of varying lithology. The fluvial land-forms such as palaeo channel meander scar and oxbow lakes are common features. Further west of Younger Alluvial Plain is the area of stable upland which has been produced by extensive deposition of older alluvium comprising of coarse to fine sand, silt and clay. The patches of salt encrustations have been reported in the area around Panki and Chakeri.

Kanpur features an atypical version of a humid subtropical climate. It is has one of the lowest temperatures in northern plains during the winter season and is one of the warmest during the summer season. Unlike many other cities with a humid subtropical climate, Kanpur features long and very hot summers, mild and relatively short winters, dust storms and a monsoon season. Kanpur lies in northern plains of India, which witness extremes of temperature. It can drop to a minimum of 0.0 °C in the winters while it goes up to 48 °C in summers. Kanpur experiences severe fog in December and January, resulting in massive traffic and travel delays. In summer excessive dry heat is accompanied by dust storms and Loo, traits more commonly seen in desert climates. Rains appear between July and September almost at the end of regular monsoon season. Some rainfall is recorded during the harvest season of March-April. Wind speed exceeding 100 km/h have been experienced in the outer areas of the city. The average rainfall recorded in the city is 885 mm.

5.3.3.3 General Geology & Related Characteristics

Kanpur is situated on the banks of river Ganga and also on most important national highways no. 2 & 25 and state highway. It is also situated on the main

Delhi-Howrah railway trunk line. It has an area of over 1000 km² and it is about 125 meters above the sea level. Kanpur has benefited from its fertile agricultural hinterland of the Upper Ganga Valley and Bundelkhand plateau & the available developed links of transportation. In this city, in spite of a low percentage of irrigated area, the density is high and that is obviously due to great industrial concentration.

The Kanpur Nagar district is part of Indo Gangetic Plain. The clay, silt, gravel and sands of different grades are main sedimentary constituents. The generalized geological succession is as shown in **Table 5.23.**

TABLE 5.23: GEOLOGICAL SUCCESSION IN KANPUR

Period	Age	Land Form (Geomorphology)	Rock Type
QUATERNARY	Upper Pleistocene to Recent	Newer Alluvium	Fine Sand and Clays
	Lower Pleistocene to Upper Pleistocene	Older Alluvium	Sand of different grades and clay mixed with Kankar
--UNCONFORMITY--			
Bundelkhand Granite (Archean), Vindhyan Sandstone (Proterozoic)			

The older alluvium, alluvial deposit mostly occurring in the central part were deposited during lower to Upper Pleistocene period. The newer alluviums were deposited during Upper Pleistocene to Recent period mostly occurring along the course of rivers. The soil of the district exhibits a great variety of composition and appearance. The major part of the district consists of ordinary soils known locally as Bhur and Sand on ridges, Matiyar or clay in depressions and Domat or Loam in the Plains. The 'Reh' prevails in the clay dominant areas.

5.3.3.3 Seismicity

The district lies in the Ganga basin which is formed of alluvium of the early quaternary period. In the district, no hard or consolidated rock exposures are encountered. The main constituents (sand, silt and clay) of alluvium occur in variable proportions in different sections. The mineral products of the district of saline earth from which salt petre and salt are derived and limestone conglomerates (U.P. District Gazetteers Kanpur).

According to the Vulnerability Atlas of India, Kanpur (Urban) district lies in moderate earthquake risk zone. It may experience damage of MSK VII category. The level of vulnerability of houses is of different categories to the earthquake risk. According to Seismic Zonation map of India, Kanpur city falls in Zone – III.

Though the earthquake risk for the district is moderate, most of the houses in Kanpur have not incorporated building by-laws, and may not have adequate structural strength to withstand even moderate earthquake. The Kanpur urban centre which lies within 350 km from the central seismic gap has been considered for detailed assessment of seismic hazard. The city of Kanpur also lies close to Lucknow-Faizabad fault having a seismic gap of 350 years. Considering the possible seismic gap in the Himalayan region and also the seismic gap in Lucknow-Faizabad fault, it is assessed that northern and western parts of Kanpur are found to have a Peak Ground Acceleration (PGA) of 0.11g-0.13g, which is 1.6- to 2.0 fold higher than the seismic hazard compared to the other parts of Kanpur. Seismic Zones in India and Earthquake Hazard map are shown in **Figure 5.16 & Figure 5.17.**

5.3.3.4 Scope of Investigations

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

a) Drilling of 150mm diameter boreholes in all kind of soil including gravels and cobbles and Nx size boreholes in boulders and rocky strata. All boreholes have been drilled upto 30 m depth below the ground level. These bore holes have been drilled at an interval of about one kilometer for elevated part of alignment and at about 500m c/c distance for underground part of alignment or at change of strata.

b) Conducting Standard Penetration test (SPT) at every 3.0 m interval upto BH termination depth.

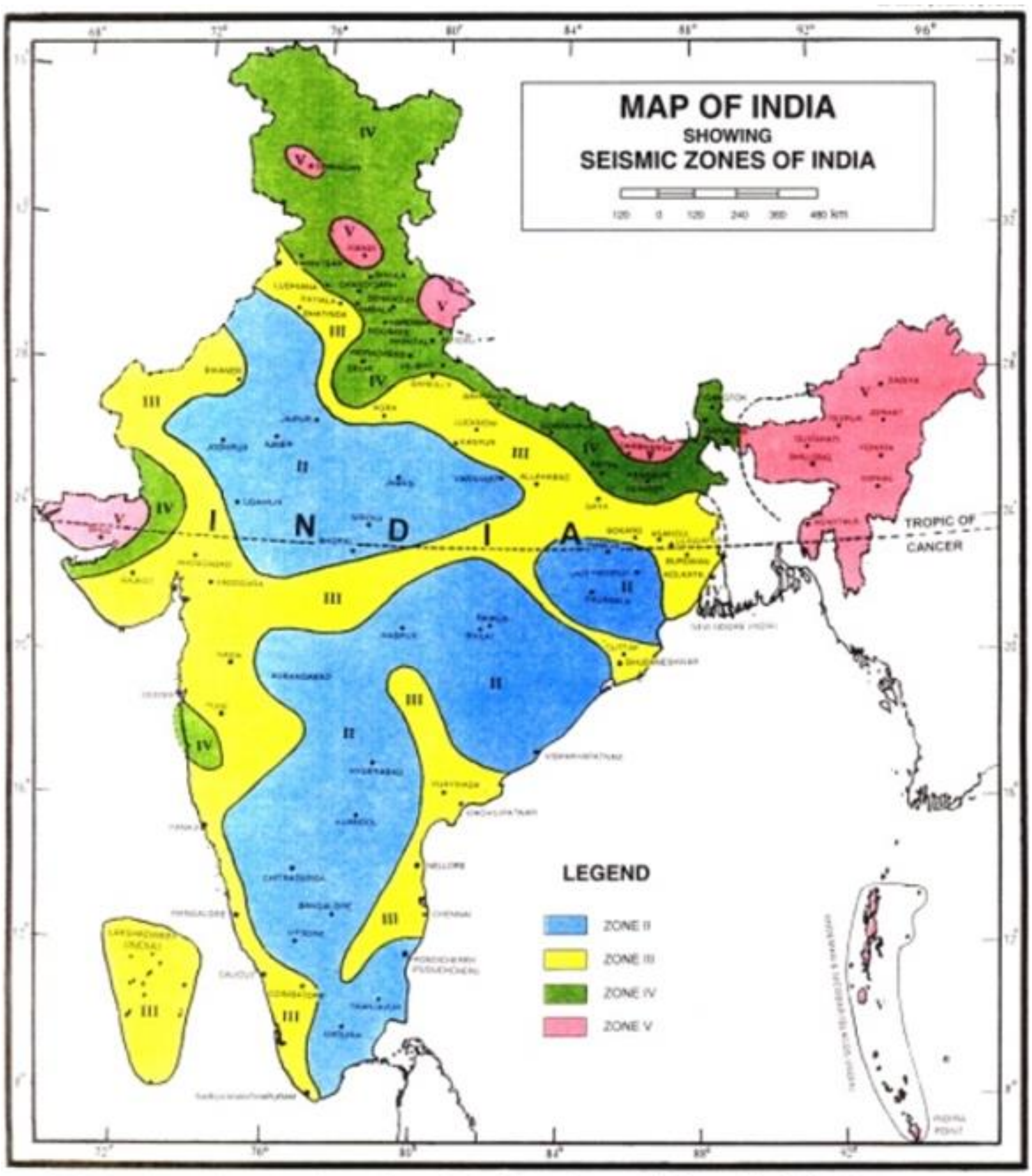
c) Collection of disturbed & undisturbed soil samples as per IS:2132, IS:1892.

Following laboratory tests were conducted on collected soil samples:

TABLE 5.24: GEOLOGICAL SUCCESSION IN KANPUR

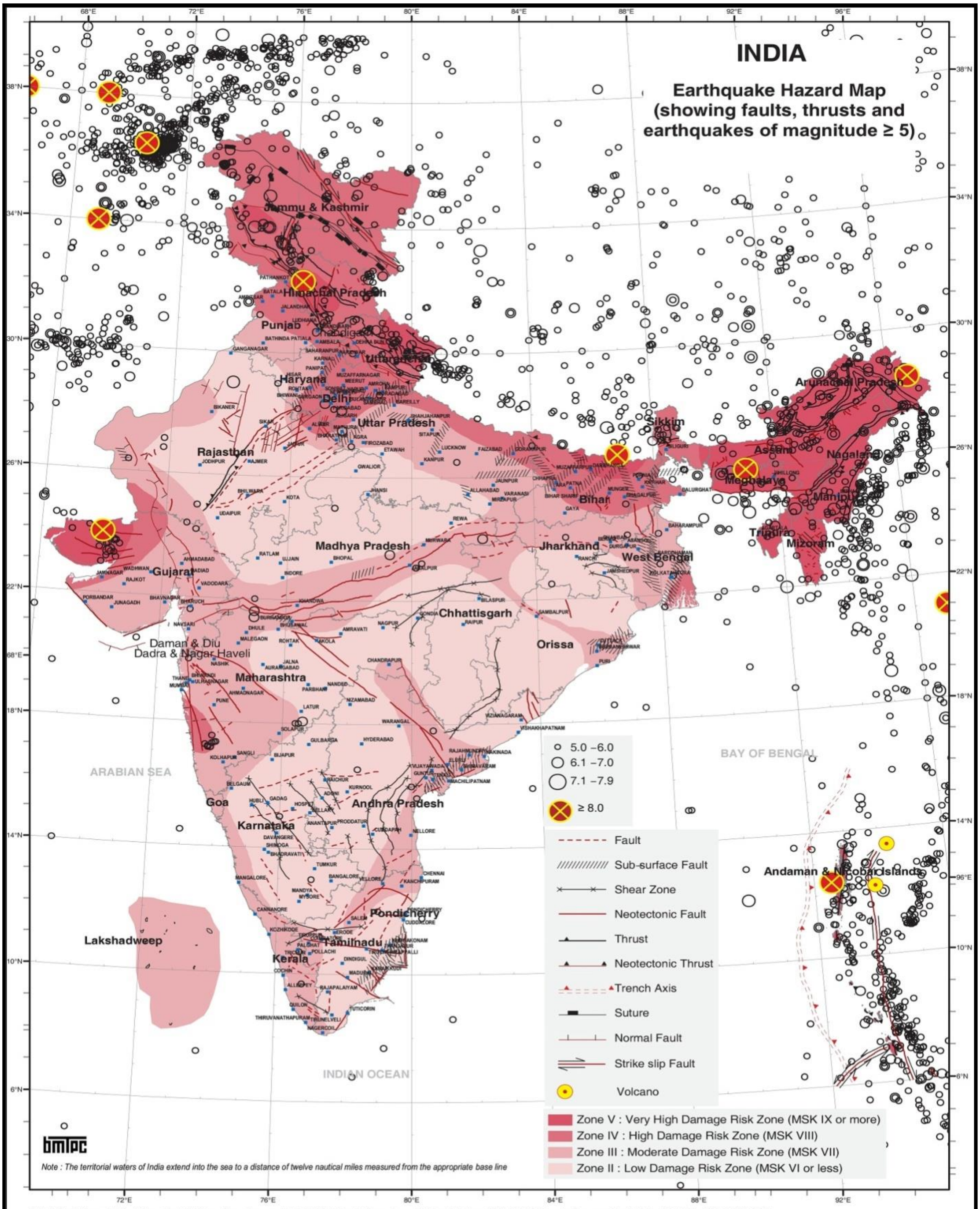
S. NO.	PARTICULARS OF PROPERTIES	RELEVANT IS CODE	DISTURBED SAMPLES	UNDISTURBED SAMPLES
1.	Sieve Analysis	IS 2720 (part IV)	✓	✓
2.	Natural Moisture Content	IS 2720 (part II)		✓
3.	Bulk/Dry Density	IS 2720 (part II)		✓
4.	Specific Gravity	IS 2720 (part III)		✓
5.	Atterberg's Limit	IS 2720 (part V)	✓	✓
6.	Direct Shear test	IS 2720 (part XIII)		✓
7.	Triaxial Shear Test	IS 2720 (part XI)		✓

FIGURE 5.16: SEISMIC ZONES OF INDIA



NOTE : Towns falling at the boundary of zones demarcation line between two zones shall be considered in High Zone.

FIGURE 5.17: EARTHQAUKE HAZARD MAP



BMTPC : Vulnerability Atlas –2nd Edition; Peer Group, MoH&UPA; Map is Based on digitised data of SOI, GOI; Seismic Zones of India Map IS:1893 –2002, BIS, GOI, Seismotectonic Atlas of India and its Environs, GSI, GOI

5.3.3.5 Details of Geotechnical Investigation

5.3.3.5.1 General

In total, 50 Bore Holes (BHs) have been drilled for 30 m depth each, all along the length of proposed Metro alignment. 34 BHs have been drilled in Corridor-I (IIT to Naubasta), 13 BHs have been drilled in Corridor-II (Agriculture University to Barra 8) & 3 BHs have been drilled for depots.

Standard Penetration Test (SPT) was conducted in the boreholes at every 3.0 m interval and change of strata as per specifications. Standard split spoon sampler attached to lower end of drill rods was driven in the boreholes 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 and number of blows required for each 15 cm penetration was recorded. The number of blows for the first 15 cm penetration was not taken into account as it is considered seating drive. The number of blows for next 30 cm penetration was 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 were collected in polythene bags of suitable size. These samples were properly sealed, labeled, recorded and carefully transported to laboratory for testing.

Undisturbed Soil Samples (UDS) were collected from the boreholes at every 3.0 m interval & change of strata as per sampling specifications, in thin walled sampling tubes of 100 mm dia. and 450 mm length. These sampling tubes after retrieval from the boreholes were properly waxed and sealed at both ends. These were carefully labeled and transported to the laboratory for testing. UDS wherever slipped during lifting, were duly marked in the bore logs as well in the soil profile.

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.

5.3.3.5.2 Details for Corridor-I

A total of 34 BHs having 30.0 m depth each have been drilled in the soil for corridor between IIT Kanpur to Naubasta. Summary of the boreholes drilled in the corridor is given in **Table 5.25.**

TABLE 5.25: SUMMARY OF BORE HOLES OF CORRIDOR-I

S. No.	BH No.	Location	Chainage (km.)	Ground Level (m)	Water Table (m B.G.L)	Remarks
1	1	Near IIT Kanpur Metro Station	0.200	127.817	Not met with	Viaduct
2	2	Near Kalyanpur Railway Station Metro Station	0.800	127.607	19.00	Viaduct
3	3	Near SPM Hospital Metro station	1.600	128.024	Not met with	Viaduct
4	4	Near CSJM University	2.300	126.857	16.00	Viaduct
5	5	Near CSJM University	2.800	127.817	17.00	Viaduct
6	6	Near Gurudev Chauraha Metro Station	4.500	126.870	19.00	Viaduct
7	7	Near Geeta Nagar Metro Station	5.500	127.414	Not met with	Viaduct
8	8	Near Rawatpur Railway Metro Station	5.900	126.608	Not met with	Viaduct
9	9	Near GSVM Medical College Bus Stop	6.750	127.305	Not met with	Viaduct
10	10	Near Moti Jheel	7.730	127.168	Not met with	Viaduct
11	11	Near B.N.S.D. Shiksha Niketan Inter College	8.600	126.689	Not met with	Viaduct
12	12	Near Gwai Bus Stop	9.300	122.042	Not met with	Underground
13	13	Near Chunniganj Metro Station	9.900	125.731	Not met with	Underground
14	14	Near John Forbes Lane Bus Stop	10.500	124.456	Not met with	Underground
15	15	Near Navin Market Metro Station	11.050	125.325	Not met with	Underground
16	16	Near Head Post Office, Kanpur	11.600	123.537	Not met with	Underground
17	17	Near BadaChauraha Metro Station	11.800	123.177	Not met with	Underground

S. No.	BH No.	Location	Chainage (km.)	Ground Level (m)	Water Table (m B.G.L)	Remarks
18	18	Near Telephone Bhawan	12.400	123.977	Not met with	Underground
19	19	Near Phoolbagh Metro Station	12.850	124.943	Not met with	Underground
20	20	Near Nayaganj Metro Station	13.500	125.715	Not met with	Underground
21	21	Near Shyam Hotel	14.200	126.612	Not met with	Underground
22	22	Near Dana Khori	14.400	126.70	Not met with	Underground
23	23	Near Kanpur Central Railway Metro Station	14.650	126.788	Not met with	Underground
24	24	Near Kanpur Central Railway Metro Station	14.850	127.266	Not met with	Underground
25	25	Near Jhakarkati Bus Terminal Metro Station	15.700	126.399	Not met with	Underground
26	26	Near Dhakna Purwa	16.400	126.882	Not met with	Underground
27	27	Near Transport Nagar Metro Station	17.200	127.701	Not met with	Underground
28	28	Near Transport Nagar Metro Station	17.400	127.415	Not met with	Underground
29	29	Near Bara Devi Metro Station	18.200	126.641	Not met with	Viaduct
30	30	Near Kidwai Nagar Metro Station	19.150	126.168	Not met with	Viaduct
31	31	Near Kendranchal Colony	19.800	125.730	Not met with	Viaduct
32	32	Near Vasant Vihar Metro Station	20.400	125.566	20.00	Viaduct
33	33	Near Baudh Nagar Metro Station	21.700	125.712	Not met with	Viaduct
34	34	Near Naubasta Metro Station	22.650	125.597	20.00	Viaduct

5.3.3.5.3 **Details for Corridor-II**

A total of 13 BHs having 30.0 m depth each have been drilled in soil for the corridor between Agriculture University to Barra 8. Summary of the boreholes drilled in the corridor is given in **Table 5.26**

TABLE 5.26: SUMMARY OF BORE HOLES IN CORRIDOR-II

S. No.	BH No.	Location	Chainage (km.)	Ground Level (m)	Water Table (m B.G.L)	Remarks
1	35	Near Agriculture University Metro Station	-0.150	126.376	Not met with	Underground
2	36	Near Agriculture University Bus Stop	0.580	127.229	Not met with	Underground
3	37	Near Rawatpur Railway Metro Station	0.750	127.513	Not met with	Underground
4	38	Near Moti Vihar Society	1.540	126.827	Not met with	Underground
5	39	Near Kakadeo Metro Station	1.800	127.136	Not met with	Underground
6	40	Near Kakadeo Metro Station	2.350	125.596	Not met with	Underground
7	41	Near Double Pulia Metro Station	2.700	126.920	Not met with	Underground
8	42	Near Double Pulia Metro Station	3.050	125.406	Not met with	Underground
9	43	Near Vijaynagar Chauraha Metro Station	4.050	125.196	25.00	Viaduct
10	44	Near Govind Nagar Metro Station	5.000	125.152	Not met with	Viaduct
11	45	Near Shashtri Chauraha Metro Station	5.550	126.475	Not met with	Viaduct
12	46	Near Barra 7 Road Metro Station	6.900	124.901	21.00	Viaduct
13	47	Near Barra 8 Metro Station	7.650	124.067	Not met with	Viaduct

5.3.3.5.4 **Details for Depots**

A total of 3 BHs having 30.0 m depth each has been drilled in soil for the 3 proposed depots. Summary of the boreholes drilled is given below in **Table 5.27.**

TABLE 5.27: SUMMARY OF BORE HOLES FOR DEPOTS

S. No.	BH No.	Location	Chainage (km.)	Ground Level (m)	Water Table (m B.G.L)	Remarks
1	D-1	Near Polytechnic College Depot	4.600	126.870	13.00	At Ground Level
2	D-2	Near Agriculture University Depot	0.500	126.980	Not met with	
3	D-3	Near Naubasta Depot	23.785	125.728	13.00	

5.3.3.6 DISCUSSION OF FIELD & LAB TEST RESULTS

5.3.3.6.1 Corridor-I (IIT Kanpur to Naubasta)

The proposed corridor-I has been explored by drilling of 34 nos. bore holes. The strata met along this corridor have been described in following three layers:

LAYER TYPE – I, Brownish Clayey Silt Low to Medium Plasticity (CL/CI,CL-CI)
LAYER TYPE – II, Sandy Silts – Low plasticity to Non Plastic (ML)
LAYER TYPE - III, Silty Sand- Low plasticity to Non Plastic (SM)

The top stratum generally comprises 2.00m to 6.50m thick layer-I with SPT 'N' values ranging from 23 to71. Cohesion and Angle of Repose has been calculated from lab tests are ranging 0.60 kg/cm^2 to 1.00 kg/cm^2 and 5 to 7 degrees respectively. At few locations this layer has been replaced by layer II, of thickness ranging from 6.50m to 17.00m, with SPT 'N' values from 7 to 43. Cohesion and Angle of repose has been calculated from lab tests are 0.10 kg/cm^2 to 0.13 kg/cm^2 and 20 to 24 degrees. The layer –III has also met in few bore holes at depth ranging from 3.5m to 26.00m till the depth of exploration. SPT 'N' values are recorded from 20 to 100. Cohesion and Angle of repose has been calculated from lab tests are 0.0 to 0.10 kg/cm^2 and 22 to 26 degrees respectively. Ground water table met in few bore holes at depth ranging from 17m to 20m below ground level.

The lithological sections of the strata met along the corridor-I are enclosed at **Figure 5.18 to Figure 5.21.**

5.3.3.6.2 **Corridor-II (Agriculture University to Barra 8)**

The proposed corridor-II has been explored by drilling of 13 nos. bore holes. The strata met along this corridor has been described in following three layers:

LAYER TYPE – I, Brownish Clayey Silt Low to Medium Plasticity (CL/CI,CL-CI)
LAYER TYPE – II, Sandy Silts – Low plasticity to Non Plastic (ML)
LAYER TYPE - III, Silty Sand- Low plasticity to Non Plastic (SM)

The top stratum generally comprises 2.00m to 12.50m thick layer-I with SPT 'N' values ranging from 14 to 63. Cohesion and Angle of Repose has been calculated from lab tests are ranging 0.70 kg/cm^2 to 1.00 kg/cm^2 and 4 to 7 degrees respectively. This layer is followed by 1.5m to 16m thick Layer –II having SPT 'N' values from 21 to 100. Cohesion and Angle of repose has been calculated from lab tests are 0.10 kg/cm^2 to 0.12kg/cm^2 and20 to 24 degrees. The layer –III has also met in few bore holes at depth ranging from 2.00m to 17.00m till the depth of exploration. SPT 'N' values are recorded from 14 to 105. Cohesion and Angle of repose has been calculated from lab tests are 0.06kg/cm^2 to 0.12kg/cm^2 and 21 to 23 degrees respectively. Ground water table met in few bore holes at depth ranging from 21m to 25m below ground level.
The litho logical sections of the strata met along the corridor-II are enclosed at **Figure 5.21**

5.3.3.6.3 **Depot Area**

The proposed three depot at locations has been explored by drilling of one bore hole at each depot site. The strata met along the depot sites has been described in following three layers :

LAYER TYPE – I, Brownish Clayey Silt Low to Medium Plasticity (CL/CI,CL-CI)
LAYER TYPE – II, Sandy Silts – Low plasticity to Non Plastic (ML)
LAYER TYPE - III, Silty Sand- Low plasticity to Non Plastic (SM)

BH-D-1 (Near Polytechnic College Depot)

The top stratum comprises 12.5m thick layer-I with SPT 'N' values ranging from 23 to 47. Cohesion and Angle of Repose has been calculated from lab tests are 0.75kg/cm^2 and 5 degrees respectively. This layer is followed by 1.5m thick Layer–II and again 6m thick Layer-I met at 17m depth. SPT 'N' values are recorded from 42 to 46. Cohesion and Angle of repose has been calculated from lab tests are 0.75 kg/cm^2 and 4 degrees respectively. The layer –II met at 23m depth is continued till depth of exploration. SPT 'N' values are recorded from 53 to 83. Water table has been recorded at 13m below ground level.

BH-D-2 (Near Agriculture University Depot)

The top stratum comprises 2m thick layer-I with SPT 'N' values as 16. Cohesion and Angle of Repose has been calculated from lab tests are 1.4kg/cm^2 and 6 degrees respectively. This layer is followed by 6m thick Layer–II and again 3m thick Layer-I met at 8m depth with SPT 'N' values as 30. Cohesion and Angle of repose has been calculated from lab tests are 1.4 kg/cm^2 and 6 degrees respectively. The 3m thick layer –II with SPT N value as 101 met at 11m depth is followed by Layer-I and continued till depth of exploration. SPT 'N' values of Layer – I are recorded from 77 to 100. Cohesion and Angle of Repose has been calculated from lab tests are 1.4kg/cm^2 and 6 degrees respectively. Ground water table has not met with.

BH-D-3 (Near Naubasta Depot)

The top stratum comprises 2m thick layer-III with SPT 'N' values as 19. This layer is followed by 13.5m thick Layer–I having SPT N values from 24 to 44. Cohesion and Angle of Repose has been calculated from lab tests are 1.4kg/cm^{2}and 5 degrees respectively. A 4.5 m thick Layer-III met at 15.5m depth with SPT 'N' values as 44. The layer -I met at 20m depth is continued till depth of exploration. SPT 'N' values of this Layer are recorded from 35 to 58. Cohesion and Angle of Repose has been calculated from lab tests are 0.94kg/cm^2 and 6 degrees respectively. Ground water table has been recorded at 13m below ground level.

5.3.3.7 Engineering Parameters of Each Layer

Sub Soil Profile

The sub-soil strata at proposed alignment are generally homogeneous and comprises of mainly three types of layers (based on field tests & laboratory test result data). Description of engineering parameters of each layer met along the corridors and Depot areas is as under;

LAYER TYPE – I, Brownish Clayey Silt Low to Medium Plasticity (CL/CI,CL-CI)
LAYER TYPE– II, Sandy Silts – Low plasticity to Non Plastic. (ML)
LAYER TYPE - III, Silty Sand- Low plasticity to Non Plastic.(SM)

TABLE 5.28: ENGINEERING PARAMETERS OF EACH LAYER MET ALONG CORRIDOR I

BH NO.	LAYER-I (CL/CI,CL-CI)				LAYER-II (ML)				LAYER-III (SM)			
	Depth (m) from - to	SPT N VALUES	Shear Parameters C (Kg/cm²)	φ	Depth (m) from - to	SPT N VALUES	Shear Parameters C (Kg/cm²)	φ	Depth (m) from - to	SPT N VALUES	Shear Parameters C (Kg/cm²)	φ
1.	0.0 – 3.50	23	0.60	7	3.50 – 8.00	16 – 21	0.10	24	-	-	-	-
	8.00 – 9.50	-	-	-	9.50 – 12.50	28	0.10	22	-	-	-	-
	12.50 – 14.00	51	0.60	7	14.00 – 30.00	30 - 69	0.10	22	-	-	-	-
2.	17.00 – 18.50	42	-	-	0.00 – 17.00	7 – 51	0.10	20	-	-	-	-
	-	-	-	-	18.50 – 30.00	45 - 90	0.10	24	-	-	-	-
3.	0.00 - 21.50	21-70	0.60	5	21.00 – 30.00	53 - 77	0.09	25	-	-	-	-
	-	-	0.60	7	-	-	-	-	-	-	-	-
4.	0.00 – 5.00	27-31	0.60	7	5.00 – 8.00	40	0.12	21	18.50 – 20.00	72	0.08	25
	8.00 – 11.00	47	0.60	6	11.00 –12.50	-	0.08	25	-	-	-	-
	12.50 – 17.00	54-75	0.60	8	17.00 – 18.50	-	0.08	25	-	-	-	-
	20.00 – 26.00	65-87	0.60	5	26.00 – 30.00	78-95	0.08	25	-	-	-	-
5.	0.00 – 3.50	8-10	0.60	7	3.50 – 5.00	15	0.11	19	-	-	-	-
	5.00 – 9.50	18	0.70	5	9.50 –11.00	20	0.09	23	-	-	-	-
	11.00 – 26.00	33-51	0.70	6	26.00 – 30.00	77-84	0.11	19	-	-	-	-
6.	5.00 – 6.50	25	0.63	5	0.00 – 3.50	15	0.13	19	3.50 – 5.00	20	0.02	31
	15.50 – 20.00	37-52	0.63	5	12.50 – 15.50	18	0.08	24	6.50 – 12.50	36-67	0.00	32
	21.50 – 30.00	64-74	0.63	5	-	-	-	-	20.00 – 21.50	58	-	-

BH NO.	LAYER-I (CL/CI,CL-CI)				LAYER-II (ML)				LAYER-III (SM)			
	Depth (m) from - to	SPT N VALUES	Shear Parameters C (Kg/cm^2)	φ	Depth (m) from - to	SPT N VALUES	Shear Parameters C (Kg/cm^2)	φ	Depth (m) from - to	SPT N VALUES	Shear Parameters C (Kg/cm^2)	φ
	-	-	-	-	0.00 – 6.50	13-43	0.10	22	6.50 – 8.00	51-63	0.00	26
7.	-	-	-	-	8.00 – 17.00	46-102	0.00	26	17.00 – 21.50	-	0.00	26
	-	-	-	-	21.50 – 30.00	27-71	0.00	26	-	-	-	-
	0.00 – 2.00	12		-	-	-	-	-	-	-	-	-
8.	5.00 – 14.00	24-30	0.70	6	2.00 – 5.00	27	0.06	22	14.00 – 17.00	85	-	-
	17.00 – 30.00	26-44	0.80	5	-	-	-	-	-	-	-	-
9.	0.00 - 5.00	9-20	0.95	6	5.00 – 6.50	-	-	-	6.50 – 12.50	30-53	-	-
	12.50 – 26.00	54-66	1.06	5	-	-	-	-	26.00 – 30.00	71-76	-	-
	0.00 – 2.00	-	-	-	-	-	-	-	-	-	-	-
10.	11.00 – 12.50	12	-	-	-	-	-	-	-	-	-	-
	14.00 – 15.50	-	0.684	-	2.00 - 3.50	-	0.10	23	3.50 – 11.00	18-42	0.10	22
	23.00 -30.00	26-100	0.80	5	12.50 – 14.00	56	-	-	15.50 - 23.00	60-100	-	-
11.	6.50 – 12.50	29-41	0.65	5	0.00 – 3.50	29	0.08	21	3.50 – 6.50	34	0.10	22
	20.00 – 30.00	40-79	0.65	5	12.50 – 15.50	81	0.10	23	15.50 – 20.00	88-100	0.10	23
12.	5.00 – 11.00	23-59	0.75	6	11.00 – 12.00	-	0.08	24	0.00 – 5.00	16-25	-	-
	12.50 – 30.00	36-54	-	-	-	-	-	-	-	-	-	-
	4.00 – 5.50	21	-	-	0.00- 4.00	22	0.08	22	26.00 – 30.00	61-66	-	-
13.	6.50 – 8.00	29	0.80	4	5.50 – 6.50	-		-	-	-	-	-
	11.00 – 26.00	33-57	0.65	6	8.00 – 11.00	28	0.08	22	-	-	-	-

BH NO.	LAYER-I (CL/CI,CL-CI)				LAYER-II (ML)				LAYER-III (SM)			
	Depth (m) from - to	SPT N VALUES	Shear Parameters C (Kg/cm²)	φ	Depth (m) from - to	SPT N VALUES	Shear Parameters C (Kg/cm²)	φ	Depth (m) from - to	SPT N VALUES	Shear Parameters C (Kg/cm²)	φ
14.	0.00 – 2.00	42	-	-	2.00 – 3.50	-	0.12	23	3.50 – 5.00	30	0.12	22
	8.00 – 21.50	29-62	0.80	5	5.00 – 8.00	36	-	-	21.50 – 30.00	90-100	-	-
15.	0.00 – 5.00	8-15	0.70	6	5.00 – 6.50	-	0.08	22	14.00 – 15.00	82	-	-
	6.50 – 14.00	24-41	0.75	5	-	-	-	-	19.50 – 30.00	46-100	0.08	23
	15.00 – 19.50	33-90	-	-	-	-	-	-	-	-	-	-
16.	2.00 – 5.00	19	-	-	0.00 – 2.00	15	-	-	-	-	-	-
	6.50 – 14.00	23-64	0.85	5	5.00 – 6.50	-	-	-	14.00 – 2.00	45-69	-	-
	23.00 – 29.00	62-98	-	-	20.00 – 23.00	51	0.10	21	29.00 – 30.00	100	-	-
17.	0.00 – 8.00	18-43	0.75	5	8.00 - 9.50	-	-	-	12.50 – 15.50	63	-	-
	9.50 – 12.50	51	-	-	-	-	-	-	20.00 – 30.00	100	-	-
	15.50 -20.00	36-40	0.70	5	-	-	-	-	-	-	-	-
18.	0.00 – 2.00	21	-	-	2.00 – 5.00	48	0.10	22	-	-	-	-
	5.00 – 12.50	30-34	0.70	5	12.50- 14.00	33	-	-	-	-	-	-
	14.00 – 30.00	25-39	0.65	6	5	-	-	-	-	-	-	-
19.	0.00 – 5.00	14-32	0.75	5	5.00 – 6.00	-	-	-	14.00 – 20.00	52-58	0.00	30
	6.50 – 14.00	41-49	-	-	26.00 – 29.00	55	0.08	23	29.00 – 30.00	78	-	-
	20.00 – 26.00	100	-	-	-	-	-	-	-	-	-	-

BH NO.	LAYER-I (CL/CI,CL-CI)				LAYER-II (ML)				LAYER-III (SM)			
	Depth (m) from - to	SPT N VALUES	Shear Parameters C (Kg/cm^2)	φ	Depth (m) from - to	SPT N VALUES	Shear Parameters C (Kg/cm^2)	φ	Depth (m) from - to	SPT N VALUES	Shear Parameters C (Kg/cm^2)	φ
20.	0.00 – 5.00	22-24	-	-	5.00- 6.50	-	0.10	23	11.00 – 29.00	31-65	0.08	23
	6.50 – 9.50	31	0.75	5	9.50 – 11.00	35	-	-	-	-	-	-
	29.00 – 30.00	51	-	-	-	-	-	-	-	-	-	-
21.	0.00 – 5.00	12	-	-	5.00 – 6.50	-	0.12	22	6.50 – 11.00	31-32	-	-
	11.00 – 30.00	-	-	-	-	-	-	-	-	-	-	-
22.	0.00 – 3.50	4	-	-	3.50 - 7.00	23	-	-	-	-	-	-
	11-.00 – 20.00	23-38	-	-	20.00 – 30.00	38-43	-	-	7.00 – 11.00	13-19	-	-
23.	0.00 - 3.50	-	1.20	6	3.50 – 9.50	18-23	0.08	23	-	-	-	-
	9.50 – 11.00	32	-	-	11.00 – 20.00	45-56	0.08	23	-	-	-	-
	20.00 – 30.00	42-76	1.20	4	-	-	-	-	-	-	-	-
24.	-	-	-	-	0.00 – 9.50	23-27	0.10	22	-	-	-	-
	9.50 – 20.00	26-107	1.15	6	20.00 – 30.00	51-100	-	-	-	-	-	-
25.	0.00 – 6.50	17-23	0.95	5	12.00 20.00	55-74	-	-	6.50 – 11.00	45	-	-
	20.00 - 30.00	40-82	0.80	5	-	-	-	-	-	-	-	-
26.	0.00 – 14.00	18-21	0.75	5	-	-	-	-	14.00 – 26.00	34-56	0.00	20
	26.00 – 30.00	38-42	-	-	-	-	-	-	-	-	-	-
27.	6.50 – 8.00	47	-	-	0.00 - 6.50	18-31	0.10	22	-	-	-	-
	12.50 – 20.00	61-83	-	-	8.00 – 12.50	51	0.08	23	-	-	-	-
	23.00 – 30.00	50-72	-	-	20.00 - 23.00	100	0.08	23	-	-	-	-

BH NO.	LAYER-I (CL/CI,CL-CI)				LAYER-II (ML)				LAYER-III (SM)			
	Depth (m) from - to	SPT N VALUES	Shear Parameters C (Kg/cm²)	φ	Depth (m) from - to	SPT N VALUES	Shear Parameters C (Kg/cm²)	φ	Depth (m) from - to	SPT N VALUES	Shear Parameters C (Kg/cm²)	φ
28.	0.00 – 2.00 10.50 – 12.00	27 -	0.65 -	5 -	2.00 – 10.50 -	29-31 -	0.10 -	23 -	12.00 – 30.00 -	34-64 -	0.08 -	27 -
29.	0.00 – 5.00 8.00 – 14.00	13-28 36-43	1.14 0.8	6 5	5.00 – 8.00 -	16 -	0.08 -	22 -	14.00 – 30.0 -	91-100 -	- -	- -
30.	0.00 – 3.50 8.00 - 18.50 23.00 – 30.00	12 23-46 68-89	0.9 - 1.24	4 - 5	- - -	- - -	- - -	- - -	3.50 – 5.0 18.50 – 23.00 -	21 76-83 -	- - -	- - -
31.	0.00 – 14.00 26.00 – 30.00	10-52 45-55	1.14 0.85	6 5	14.00 – 17.00 18.50 – 26.00	56 32-60	0.85 -	21 -	- -	- -	- -	- -
32.	0.00 – 11.00 -	13-21 -	1.30 -	6 -	12.50 – 17.00 -	48 -	- -	- -	11.00 – 12.50 17.00 – 30.00	56-78	0.10 0.10	23 21
33.	0.00 – 5.00 11.00 – 14.00	17-30 36-44	- -	- -	8.00 – 11.00 -	36-70 -	0.06 -	24 -	5.00 – 8.00 14.00 – 30.00	57 63 - 100	0.06 0.06	24 24
34.	0.00 - 2.00 5.00 - 6.00 9.50 - 14.00	19 40-61 -	- - -	- - -	2.0 – 5.00 - -	28 - -	0.08 - -	23 - -	6.00 – 8.00 14.00 – 30.00 -	40 76 - 100 -	- - -	- - -

TABLE 5.29: ENGINEERING PARAMETERS OF EACH LAYER MET ALONG CORRIDOR II

BH NO.	LAYER-I (CL/CI,CL-CI)				LAYER-II (ML)				LAYER-III (SM)			
	Depth (m) from - to	SPT N VALUES	Shear Parameters C (Kg/cm^2)	φ	Depth (m) from - to	SPT N VALUES	Shear Parameters C (Kg/cm^2)	φ	Depth (m) from - to	SPT N VALUES	Shear Parameters C (Kg/cm^2)	φ
35.	0.00 – 2.00 6.50 – 14.00 17.00 – 30.00	22 22-36 29-50	0.60 - 0.70	4 - 5	2.00 – 6.50 14.00 – 17.00 -	23 36 -	0.10 0.12 -	22 23 -	- - -	- - -	- - -	- - -
36.	0.00 – 2.00 11.00 – 30.00	15 47-98	0.78	6	2.00 – 8.00 9.50 – 11.00	23-34 21	0.12 0.12	22 22	8.00 – 9.50	33	0.12	22
37.	0.00 – 5.00 8.00 – 15.50 29.00 – 30.00	15-23 21-47 38	0.76 0.75 -	6 5 -	5.00 – 6.50 - -	- - -	0.08 - -	22 - -	6.50 – 8.00 15.00 – 29.00 -	34 44-100 -	- 0.04 -	- 28 -
38.	3.50 – 5.00 8.00 – 18.50 21.50 – 30.00	21 42-100 32-60	0.70 - 0.75	5 - 5	0.00 – 3.50 5.00 – 8.00 -	19 29 -	0.08 - -	22 - -	18.50 – 21.00 - -	100 - -	- - -	- - -
39.	0.0 – 2.00 15.50 - 17.00	26 46	0.70 -	5 -	2.00 – 15.50 -	25-31 -	0.06 -	22 -	17.00 – 30.00 -	100 -	- -	- -
40.	0.00 – 2.00 5.00 – 6.50 22.00 – 30.00	10 - 44-86	0.75 - -	4 - -	2.00 – 5.00 6.50 – 22.00 -	17 20-49 -	0.08 0.0 -	22 23 -	- - -	- - -	- - -	- - -
41.	0.00 – 5.00 -	29-30 -	- -	- -	5.00 – 8.00 14.00 – 30.00	32 43-100	0.10 0.10	23 23	8.00 – 14.00 -	56-60 -	0.10 -	23 -
42.	0.00- 2.00	14	-	-	-	-	-		2.00 – 30.00	21-92	-	-
43.	2.00 - 9.50 29.00 – 30.00 -	20-27 45 -	1.00 0.84 -	5 4 -	0.00 - 2.00 9.50 -11.00 26.00 -29.00	39 - 28	0.10 - -	23 - -	14.00 -26.00 - -	100 - -	- - -	- - -

BH NO.	LAYER-I (CL/CI,CL-CI)				LAYER-II (ML)				LAYER-III (SM)			
	Depth (m) from - to	SPT N VALUES	Shear Parameters C (Kg/cm^2)	φ	Depth (m) from - to	SPT N VALUES	Shear Parameters C (Kg/cm^2)	φ	Depth (m) from - to	SPT N VALUES	Shear Parameters C (Kg/cm^2)	φ
44.	2.00 – 3.50	-	1.45	6	3.50 – 6.50	21	0.10	22	0.00 – 2.00	14		
	-	-	-	-	9.50 – 15.50	28-70			6.50 – 9.50	24-29	0.10	22
	-	-	-	-	23.00 – 30.00	50-78			15.50 - 23.00	71-82		
45.	0.00 – 12.50	19-100	0.70	4	-	-	-	-	12.50 – 14.00	71	-	-
	14.00 – 17.00	56-71	1.20	4	-	-	-	-	17.00 – 20.00	105	-	-
	20.00 – 29.00	64-75	1.20	4	-	-	-	-	29.00 – 30.00	88	-	-
46.	0.00 – 5.00	10-24	0.96	6	5.00 – 11.00	39-52	-	-	17.00 – 21.50	46-86	-	-
	11.00 – 15.00	40	-	-	-	-	-	-	-	-	-	-
	21.50 – 30.00	34-73	0.90	5	-	-	-	-	-	-	-	-
47.	0.00 -11.00	19-63	0.86	4	11.00 – 15.50	65-71	0.06	21	15.50 – 20.00	62-75	0.06	21
	20.00 – 30.00	22-33	-	-	-	-	-	-	-	-	-	-

TABLE 5.30: ENGINEERING PARAMETERS OF EACH LAYER MET ALONG CORRIDOR II

BH NO.	LAYER-I (CL/CI,CL-CI)				LAYER-II (ML)				LAYER-III (SM)			
	Depth (m) from - to	SPT N VALUES	Shear Parameters C (Kg/cm^2)	φ	Depth (m) from - to	SPT N VALUES	Shear Parameters C (Kg/cm^2)	φ	Depth (m) from - to	SPT N VALUES	Shear Parameters C (Kg/cm^2)	φ
D-1	0.00 – 12.50	23-47	0.75	5	12.50 – 14.00	88	-	-	14.00 – 17.00	89	-	-
	17.00 – 23.00	42-46	0.75	4	23.00 – 30.00	53-83	-	-	-	-	-	-
D-2	0.00 – 2.00	16	1.4	6	2.00 – 8.00	23-25	-	-	-	-	-	-
	8.00 – 11.00	30	1.4	6	11.00 – 14.00	101	-	-	-	-	-	-
	14.00 – 30.00	77-100	1.4	6	-	-	-	-	-	-	-	-
D-3	2.00 – 15.50	24-44	1.40	5	-	-	-	-	0.00 – 2.00	19	-	-
	20.00 – 30.00	35-58	0.94	6	-	-	-	-	15.50 – 20.00	44	-	-

FIGURE 5.18: LITHOLOGICAL SECTION ALONG CORRIDOR - I (A)

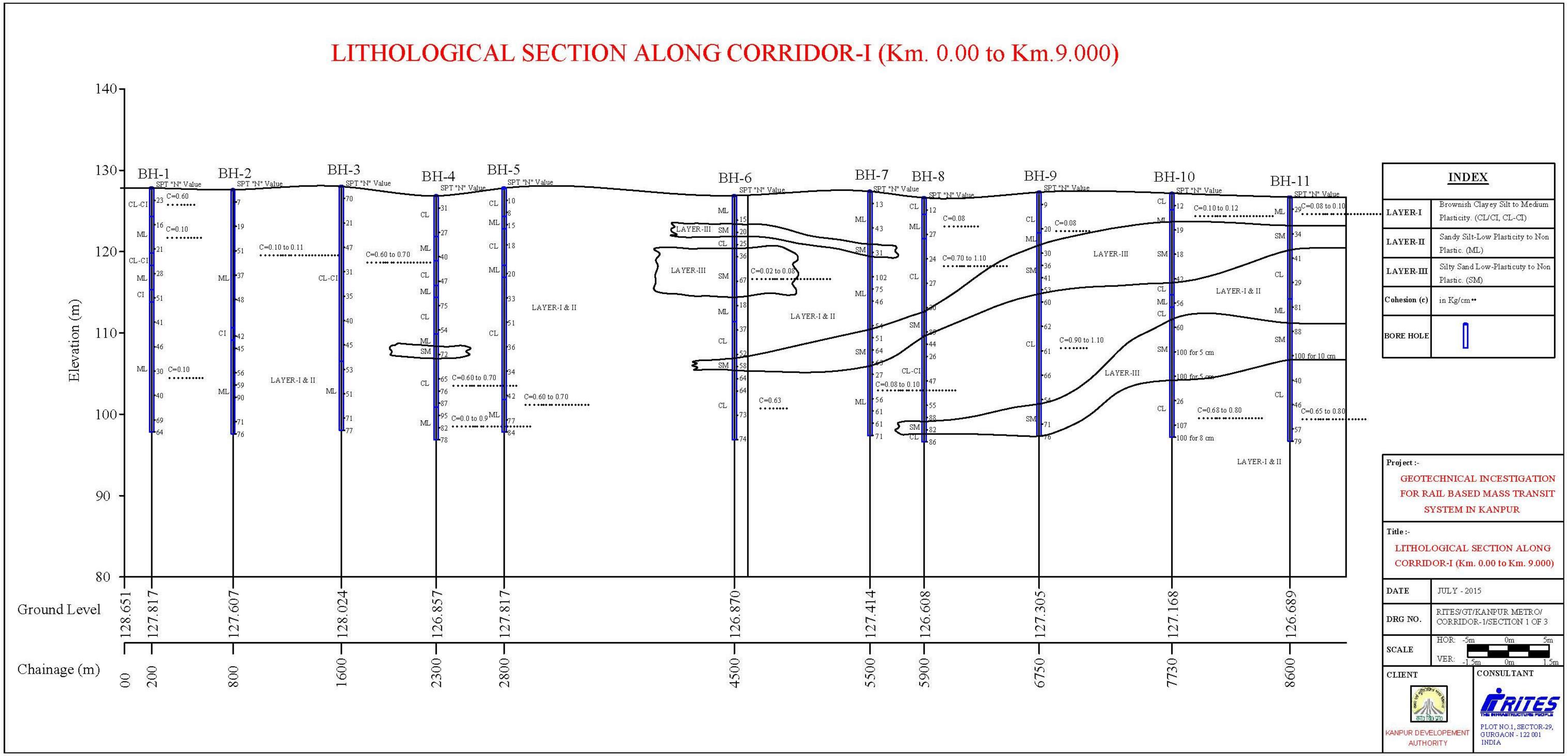


FIGURE 5.19: LITHOLOGICAL SECTION ALONG CORRIDOR - I (B)

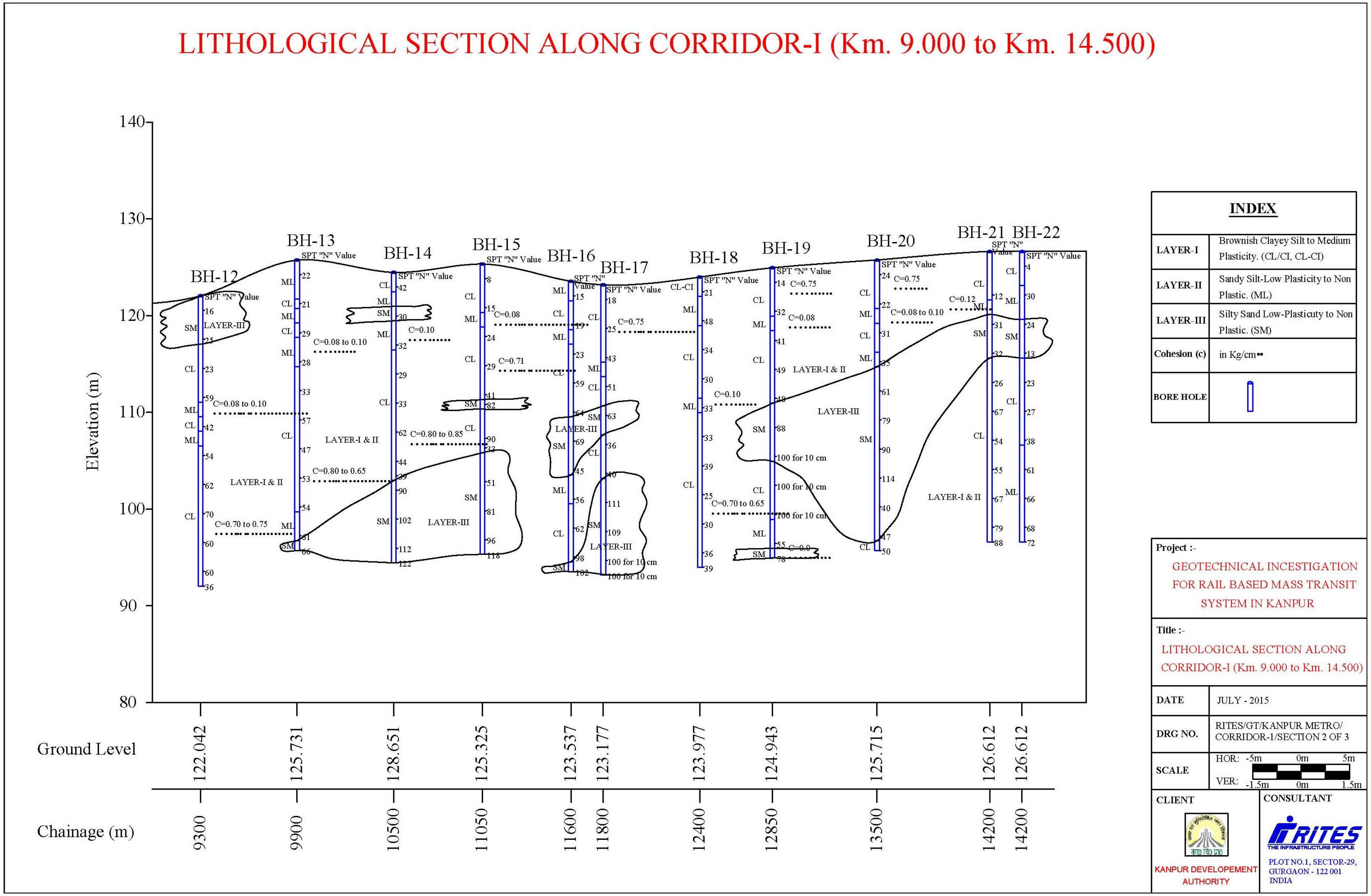


FIGURE 5.20: LITHOLOGICAL SECTION ALONG CORRIDOR - I (C)

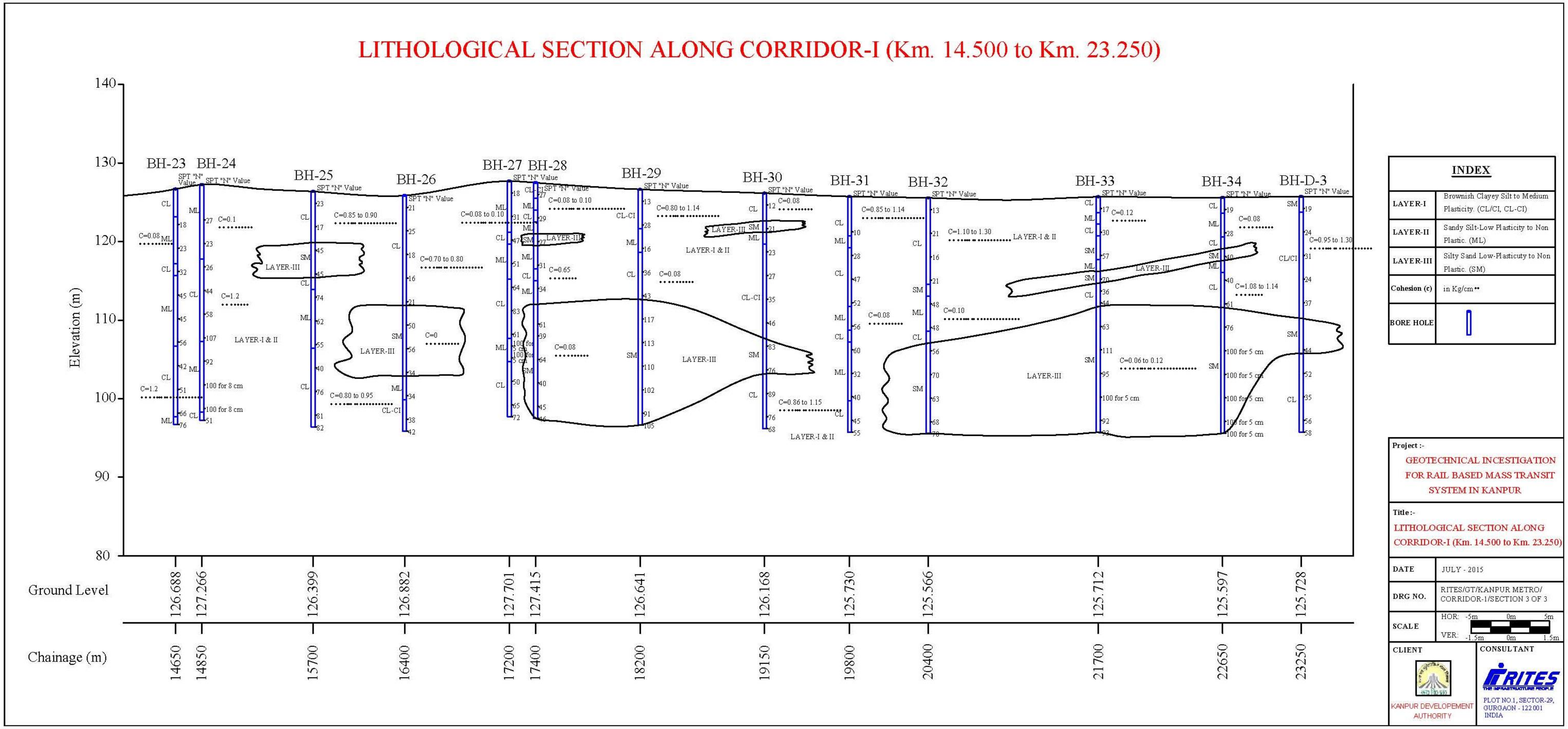
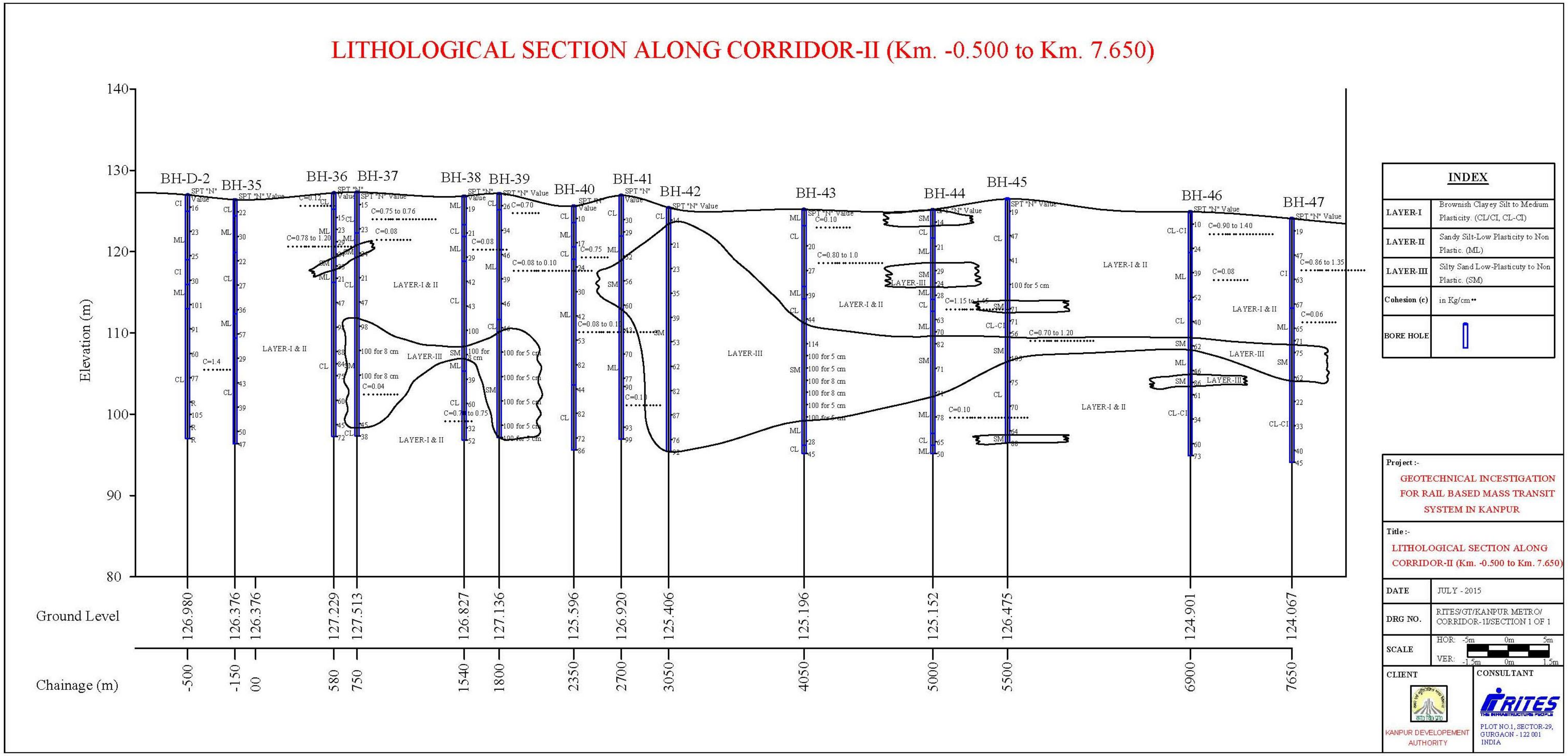


FIGURE 5.21: LITHOLOGICAL SECTION ALONG CORRIDOR - II



5.3.3.8 Type of Foundation

The proposed alignment has been explored by drilling of fifty boreholes down to depth of 30m below ground level. Since heavy loads are expected, shallow foundations are ruled out except for depot locations where Open foundation may be provided for light weight structures. For all viaduct locations, either driven or bored cast in-situ piles preferably (bored ones) are recommended.

5.3.3.8.1 Safe Load Carrying Capacity of Open Foundation

Considering the nature of soil, type of proposed structures, expected loads on foundations, Continuous strip footing is recommended;

For satisfactory performance of a foundation, the following criteria must be satisfied;

i) The foundation must not fail in shear.
ii) The foundation must not settle by an amount more than the permissible settlement.

5.3.3.8.2 Depth of Foundation in Soil

A foundation must have an adequate depth from considerations of adverse environmental influences. It must also be economically feasible in terms of overall structure. Depth of foundations in soil shall be decided as per clause 7 of IS: 1904 for special cases like; where volume change is expected / scour is expected / foundations on sloping ground / foundation on made up or filled up ground / frost action is expected etc.

Allowable Bearing Capacity of Open Foundations in Soil

It will be taken, as the net intensity of loading which the foundation will carry without undergoing settlement in excess of the permissible value for the structure under consideration but not exceeding net safe bearing capacity.

Safe Bearing Capacity, Safe Load Carrying Capacity and Safe Uplift Capacity

A) Safe Bearing Capacity of Soil for Shallow Foundations

Net Safe bearing Capacity of Continuous strip foundation has been worked out as per IS: 6403 and tabulated below in **Table 5.31.**

TABLE 5.31: SBC OF CONTINUOUS STRIP FOUNDATION (DEPOT LOCATIONS)

Location	Depth (m)	Width (m)	Safe Bearing Capacity (T/m^2)		Recommended Bearing Capacity (T/m2)
			Based on settlement	Based on shear failure	
Near Polytechnic College Depot	2	1	20	29	20
		2	12	25	12
		3	9	23	9
	3	1	21	33	21
		2	13	27	13
		3	10	25	10
Near Agriculture University Depot	2	1	18	33	18
		2	14	33	14
		3	12	35	12
	3	1	22	54	22
		2	18	49	18
		3	16	50	16
Near Naubasta Depot	2	1	22	49	22
		2	13	42	13
		3	10	40	10
	3	1	23	57	23
		2	14	46	14
		3	10	43	10

B) Safe Load Carrying Capacity and Safe Uplift Capacity

The safe pile load carrying capacity and safe uplift capacity for various lengths and diameters of piles has been worked out as per IS 2911 (Part 1/Sec 2): 2010- Design and Construction of Pile Foundations equation and tabulated below in **Table 5.32, Table 5.33 & Table 5.34.**

TABLE 5.32: SAFE LOAD CARRYING CAPACITY & SAFE UPLIFT CAPACITY CORRIDOR-I

Location	Pile Stem Dia. D (m)	Length of pile below cut-off (m)	Safe Load Capacity of Pile (T)	Safe Uplift Capacity of Pile (T)
BH-1	1.0	17.0	184.61	124.98
	1.2	17.0	243.77	151.47
BH-2	1.0	16.0	202.16	139.59
	1.2	16.0	264.60	168.92
BH-3	1.0	17.0	154.53	120.17
	1.2	17.0	189.72	145.69

Location	Pile Stem Dia. D (m)	Length of pile below cut-off (m)	Safe Load Capacity of Pile (T)	Safe Uplift Capacity of Pile (T)
BH-4	1.0	17.0	164.87	99.39
	1.2	17.0	230.47	124.59
BH-5	1.0	17.0	147.33	112.98
	1.2	17.0	181.41	137.07
BH-6	1.0	17.0	165.89	129.63
	1.2	17.0	203.29	157.01
BH-7	1.0	17.0	238.42	161.57
	1.2	17.0	313.58	195.37
BH-8	1.0	17.0	157.82	111.83
	1.2	17.0	196.85	135.69
BH-9	1.0	17.0	157.00	112.09
	1.2	17.0	195.59	136.00
BH-10	1.0	17.0	176.03	117.83
	1.2	17.0	233.48	142.89
BH-11	1.0	17.0	170.89	113.46
	1.2	17.0	227.19	137.65
BH-29	1.0	17.0	168.93	109.33
	1.2	17.0	226.58	132.69
BH-30	1.0	17.0	178.61	127.98
	1.2	17.0	210.56	145.42
BH-31	1.0	17.0	172.50	129.95
	1.2	17.0	212.76	157.43
BH-32	1.0	17.0	157.00	118.21
	1.2	17.0	193.83	143.35
BH-33	1.0	17.0	134.51	82.79
	1.2	17.0	183.92	100.84
BH-34	1.0	17.0	168.21	102.74
	1.2	17.0	229.52	124.78

TABLE 5.33: SAFE LOAD CARRYING CAPACITY & SAFE UPLIFT CAPACITY CORRIDOR-II

Location	Pile Stem Dia. D (m)	Length of pile below cut-off(m)	Safe Load Capacity of Pile, (T)	Safe Uplift Capacity of Pile (T)
BH-43	1.0	17.0	179.67	109.95
	1.2	17.0	244.75	133.44
BH-44	1.0	17.0	226.89	153.78
	1.2	17.0	298.58	186.03
BH-45	1.0	17.0	192.73	115.93
	1.2	17.0	263.54	140.61
BH-46	1.0	17.0	195.82	125.52
	1.2	17.0	262.80	152.12
BH-47	1.0	17.0	155.10	107.71
	1.2	17.0	203.72	130.75

TABLE 5.34: SAFE LOAD CARRYING CAPACITY & SAFE UPLIFT CAPACITY OF DEPOT

Location	Pile Stem Dia. D (m)	Length of pile below cut-off(m)	Safe Load Capacity of Pile (T)	Safe Uplift Capacity of Pile (T)
BH-D-1	1.0	16.0	171.99	118.96
	1.2	16.0	225.54	144.16
BH-D-2	1.0	17.0	184.40	138.69
	1.2	17.0	227.38	167.92
BH-D-3	1.0	17.0	219.77	143.97
	1.2	17.0	292.49	174.26

5.3.3.9 Conclusions

- Fifty boreholes have been drilled down to maximum depth of 30 m below ground level for sub soil exploration. Following is recommended for different type of foundations:
- Considering field and lab test results, **pile foundations** have been recommended for the proposed viaduct at locations of BH-1 to BH-11, BH-29 to BH-34, BH-43 to BH-47 & BH-D-1, D-2, D-3. Open foundation is recommended for light weight structures at location of BH-D-1, BH-D-2 and BH-D-3. Since portion between BH-12 to BH-28 & BH- 35 to BH-42 is proposed as underground section, engineering parameters of sub soil may be used for tunnel design and construction.
- The load carrying capacities of piles are based on empirical correlation's and to be confirmed by conducting **pile load test as per IS: 2911 (Part 4)** on test piles before execution of working piles.
- Since the proposed site is situated in seismic **Zone III** of the seismic zone map of India, suitable seismic coefficient commensurate to seismic Zone III (IS: 1893) should be adopted in the design of the structures.

5.3.4 CONSTRUCTION METHODOLOGY

Construction of elevated, underground alignment involves following type of constructions:-

- Sub-structure - Columns on Open/Pile foundations with pier cap at top of columns. Alternatively, Portal arrangement is provided at certain locations.

- Superstructure by segmental construction of whole unit construction. Box segments are most common type of segmental construction. I-Girder and U-girder are most common type of non-segmental construction methods where the structural element for whole span length is pre casted and launched in position.
- Underground alignment by means of tunnels made through Tunnel Boring Machine / open cut and cover method/ NATM method.
- Underground stations by means of cut and cover method or NATM method.
- Earth retaining structures like diaphragm walls, sheet piles, secant piles etc.

5.3.4.1 Cast in-situ and Pre-Cast Construction

A) Cast in-situ construction

In cast in-situ construction method, structure is cast at its final location of use. This involves erection of temporary shuttering, scaffolding and support system for casting the structure. The temporary supports and shuttering is removed when the concrete is set and structure attains the strength to bear its dead weight and other loads. This method involves longer construction time and interference to road users for longer period. This method is restricted to casting of substructure - open foundation, pile, pile caps, columns; station structure; earth retaining structures.

B) Pre - cast construction

In this method, structural segments are pre-casted in casting yards, pre-stressed and then transported to the location of use and launched by means of suitable launching arrangement. The structural elements for superstructure i.e. box segments, I-Girders, U-girders and sometimes pile caps are casted by pre-cast technique. Pre cast construction may be segmental or non-segmental type.

Casting yard is required for casting of precast structural segments and other precast units like U-girder, I-Girder etc. The construction depot has arrangement 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 Ha is required for each construction depot.

Pre-cast construction has 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. For other type of construction i.e. I-Girder, U Girder etc. longer trailer and straighter roads are required but erection can be done by using road cranes in comparatively less time.
- As the pre-cast elements are cast on production line in a construction depot, better and uniform quality control can be exercised.
- This method reduces the interference to road users to minimum.

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 segmental construction has 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.
- It is easy to incorporate last minute changes in span configuration if the site situation so warrants.
- Segmental construction permits a reduction of construction time as segments are manufactured in a casting yard while substructure work is in progress, and erected rapidly thereafter.
- Better quality control is possible in the casting yard.
- It is easier to transport smaller segments by road trailers on city roads.
- Interference to the traffic during construction is significantly reduced.

5.3.4.2 Structural System of Viaduct

5.3.4.2.1 Sub-structure

Two broad categories of sub-structure i.e Pile Foundation and Open foundation are considered for Metro Systems. For heavy/medium loads and loose/soft/filled up upper strata, Pile foundation systems are proposed. This requires lesser space and time for excavation. Pile load bearing capacity is calculated as per IS 2911 Part 2 & IRC- 78. At locations where hard strata/rock is available close to ground level, open foundations may be adopted.

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. Circular pier of dia in the range of 1-5-1.7 m are commonly used as it occupies the minimum space at ground/road 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 1.0m height above existing road level has been proposed all around the pier. A gap of 25mm has been also provided in between the crash barrier and outer face of pier. The shape of upper part of pier has been so dimensioned that the required minimum clearance of 5.5m 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 8.5m. The longitudinal center to center spacing of elastomeric/pot bearing over a pier would be about 1.8m.

The space between the elastomeric bearings will be utilized for placing the lifting jack required for the replacement of elastomeric bearing. An outward slope of 1:200 will be provided at pier top for the drainage due to spilling of rainwater, if any. The transverse spacing between bearings would be about 3.0m. The orientation and dimensions of the piers for the continuous units or steel girder (simply supported span) have to be selected to ensure minimum footprint at ground/road 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.

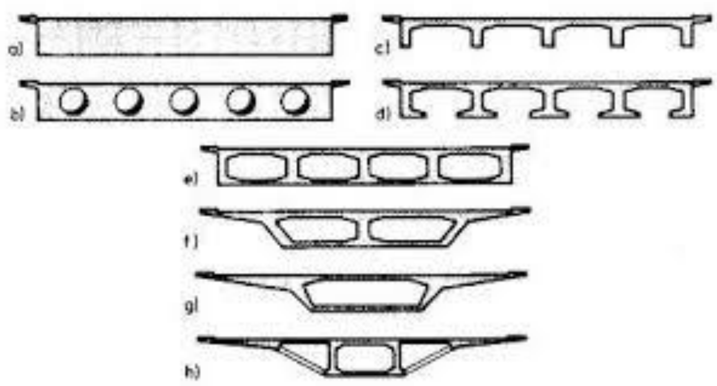
Pile caps are casted over the columns to support the superstructure. Soffit width of superstructure governs the width of pile cap. While box girder requires less width of pile, I-girder and U-girders require larger width of pile caps to support the full width of soffit of such superstructures. At locations where elevated alignment moves from central verge of the road to side of the road and vice versa, Portal arrangement is made instead of column and pile cap. Also at locations where elevated alignment takes a perpendicular left or right turn, portal type arrangement is provided to provide support to superstructure.

5.3.4.2.2 **Superstructure**

The choice of superstructure has to be made keeping in view the ease of constructability, maximum safety, least disturbance and inconvenience to road users and maximum standardization of the form-work for wide span ranges. Following types of superstructure may be considered.

i) Precast segmental box girder using external unbonded tendon.
ii) Precast U-Channel superstructure with internal pre-stressing.
iii) Precast U-Channel segmental superstructure using external unbonded tendon.
iv) I-Girder with internal pre-stressing.
v) Special spans

FIGURE 5.22: TYPES OF SUPERSTRUCTURE



Three types of superstructures are further deliberated as under:-

A) Precast Segmental Box Girder using External Unbonded Tendon

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

For Box girder segmental construction, normally span of 31m is kept by providing 9 segments of 3m length and two end segments of 2m length each. The other standard spans (c/c of pier) comprises of 25m, 28 m, 22m, 19m & 16m, which shall be made by removing/adding standard segments of 3.0m each from the center of the span.

The number of "breaks" in the stretch can be identified by number of continuous units. The suggested method of erection will be detailed in the construction drawings. 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 55 M.T. The launching girder is slightly greater than two span lengths. It must be able to negotiate sharp curves in conjunction with temporary brackets.

Transportation of segments from casting yard to the sites 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.

FIGURE 5.23: LAUNCHING OF BOX GIRDER SEGMENTS

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.

The main advantages of externally pre-stressed pre-cast 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.
- Replacement of tendons in case of distress is possible and can be done in a safe and convenient manner.
- Facilitates inspection and monitoring of tendons during the entire service life of the structure.

However, higher depth and higher construction-transportation- erection cycle time are disadvantages of Box Girder.

B) Precast U-Channel Superstructure with Internal Pre-stressing

The single/Double U type of viaduct structure is also a pre-cast construction with internal pre-stressing. Double U-Girders are provided for 25-28m span. For shorter spans, Single U girders may be provided.

FIGURE 5.24: PRECAST U-CHANNEL SUPERSTRUCTURE

The main advantages for this type of structural configuration of superstructure are:-

- Possibility to lower the longitudinal profile by approximately 1m compared to conventional design.
- Saving in construction and erection cycle time.
- Built in structural elements capable to maintain the coaches on the bridge in case of derailment (a standard barrier design allows this).
- Built in cable support and system function.
- Built in maintenance and evacuation path on either side of the track.
- Built in sound barrier.

However, Single U- girder has weight in the range of 300 MT per unit and it is difficult to transport girder of such length and weight. To reduce the weight per girder, double U- girder may be used, but it results into wider track center of 4.6 m to accommodate the two inside walls of the two girders.

FIGURE 5.25: LAUNCHING OF U-CHANNEL GIRDER

C) Precast U-Channel segmental Superstructure with Internal Pre-stressing

In this arrangement, superstructure consists of U-shape segments. These are to be launched in a similar way as box segments. This type of superstructure results in shallow depth of superstructure in comparison to box type segments.

D) Precast I-Girder Superstructure with Internal Pre-stressing

Pre cast I-Girders for various span ranges 20-34 m can be designed. At locations with restricted head room, I-Girder with span range of 20m may be used. Precast, pre-stressed I-Girders are casted in casting yard, transported to site and erected as 3/4 I-girders per span (depending upon Detailed design) by using road cranes, connected together at site by casting diaphragm wall and thereafter top slab is casted at site. The depth of I-girder is comparable to Box girder. Since unit length of I-Girder is for full span, their transportation is not possible for all locations. However, the unit weight of I-Girder is approximately in the range of 70 MT, which is almost half when compared to Double U-girder and hence can be launched with lower capacity road cranes. Deck Slab of I-Girder can easily be planned to accommodate curved alignment. I-Girders are most suitable for station locations, where Box and 'U' Girders are not continued.

FIGURE 5.26: LAUNCHING OF I-GIRDER

E) Special span configuration

Regular spans upto 31m span are not suitable for crossing large openings like road over bridges, wide surface road crossings, railway tracks, wide canals etc. Cantilever construction Method using PSC spans are used in such situation. Some of common span arrangements are suggested as under:-

- 34m + 45m + 34m
- 34m + 60m + 34m
- 75m + 105m + 75m

Other span configurations may also be designed as per specific site requirement. Other alternatives is to use steel span. Steel span of upto 60m have been used in Metro systems in India.

FIGURE 5.27: CLC SPAN 75M + 105M + 75M AND STEEL SPAN 60M

Recommendation

The Design and Build Contractor may choose any type of super structure keeping in view site conditions, availability of construction time and other resources i.e. road cranes/launching girders/shuttering etc. Combination of above type of superstructure may also be chosen. Appropriate special spans may be provided for specific locations.

5.3.4.3 Construction of Elevated Stations

Elevated stations with elevated concourse over the road are proposed for elevated stretch of alignment. To keep the rail level low, it is proposed not to take viaduct through the stations. Thus a separate structural configuration is required, with shorter spans and lower depth of superstructure, 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. Two configurations as under are available for elevated station super-structure:-

a) Three legged portal structure supporting concourse and platform level decks through series of Precast I girders resting on the Portal beam ledge.

b) Cantilever structure with single centre pier with the arms extending in transverse direction at concourse level and platform level.- Concourse and Platform decks are supported by I girders resting on extended pier arms.

Comparative analysis of above two types of structural arrangements is shown in **Table 5.35.**

TABLE 5.35: COMPARATIVE ANALYSIS OF TYPES OF STRUCTURAL ARRANGEMENTS

Item	Three legged portal structure	Cantilever Structure
General	Three legged portal structure is best suited for stations having high traffic load requiring more width. Central median of 3.0 m can be created to position the Central leg of the portal. This median can also divide the road traffic into two carriageways on either side of the median. Entry structures can be built beyond the carriageway on either side.	Cantilever station is more suitable for densely populated downtown areas having narrow ROW. The main elevated superstructure is already supported on cantilever pier caps. To accommodate the platform width (approx. 4m each), total 8m additional width of cantilever is required. The station rooms, entry/exit staircases etc. may be planned by providing more width at these locations only and such wider width can be supported on portal.
Merit	• Three legged portal is a better structural arrangement with respect to vibration induced by the train loads, long term deflections of the concrete members etc., • The concentrated loads coming from escalators and stair cases connecting concourse level to platform level are effectively transferred to the ground through portal legs in the shortest path. • Need for Bus bays, drop/pick up points is avoided as the outmost lane can be used for this purpose.	• Station structure will be compact and economical. • No need to provide Service road to access adjoining properties. • The concentrated loads coming from escalators and stair cases connecting concourse level to platform level are to be transferred to the ground through portal arrangement.
Demerit	• Cost of the station structure will be more due to large built up area. Wherever there is scope of property development, same	• There is need for Bus bays, drop/pick up points.

Item	Three legged portal structure	Cantilever Structure
	may be planned at Concourse level to use the available space.. • Service lane need to be provided to ensure access to adjoining properties.	

Typical Elevated Station

The elevated station is generally located on the road median 140 m long and 24 m wide and is a three level structure. Passenger area on concourse is spread throughout the length of the station, with staircases leading from either side of the road. Passenger facilities 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. The public zone is further divided into paid and unpaid areas. Area left over in the unpaid zone, after accommodating the passenger movement and other station facilities is earmarked for commercial utilization.

Since the stations are planned generally in the middle of the road, minimum vertical clearance of 5.50 m has been provided under the concourse. Concourse floor level is about 7.0 m above the road. Consequently, platforms are at a level of about 13.0 m from the road. To reduce physical and visual impact of the elevated station, stations have been made transparent with minimum walls on the sides. **Figure 5.29** shows a typical cross section of elevated station.

5.3.4.4 Construction of Tunnels for Underground Alignment

For underground alignment, tunneling arrangements are decided based upon following objectives:-

- Minimization of the surface settlement to maintain all metropolitan activities without adverse effect.
- Expeditious tunnel execution to minimize duration and space of the surface effects due to tunnelling.
- Economy in tunnelling costs.

To achieve above objectives, use of Tunnel Boring Machine (TBM) is the prime method of tunneling. Locations where deployment of TBM is not possible (tunneling of short length, cross passages, underground stations which are not possible by cut and cover method etc.) are tackled by NATM method.

FIGURE 5.28: TYPICAL BOX GIRDER VIADUCT SECTION

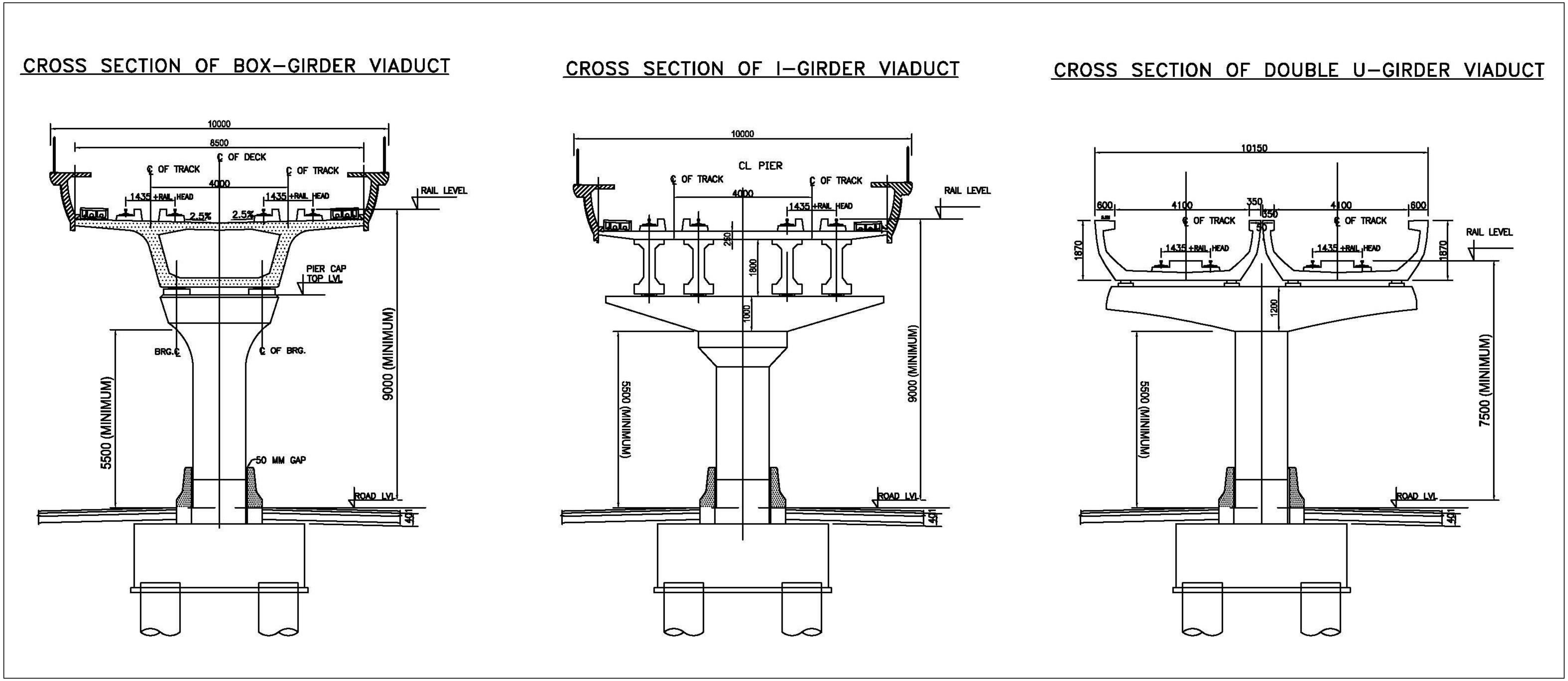
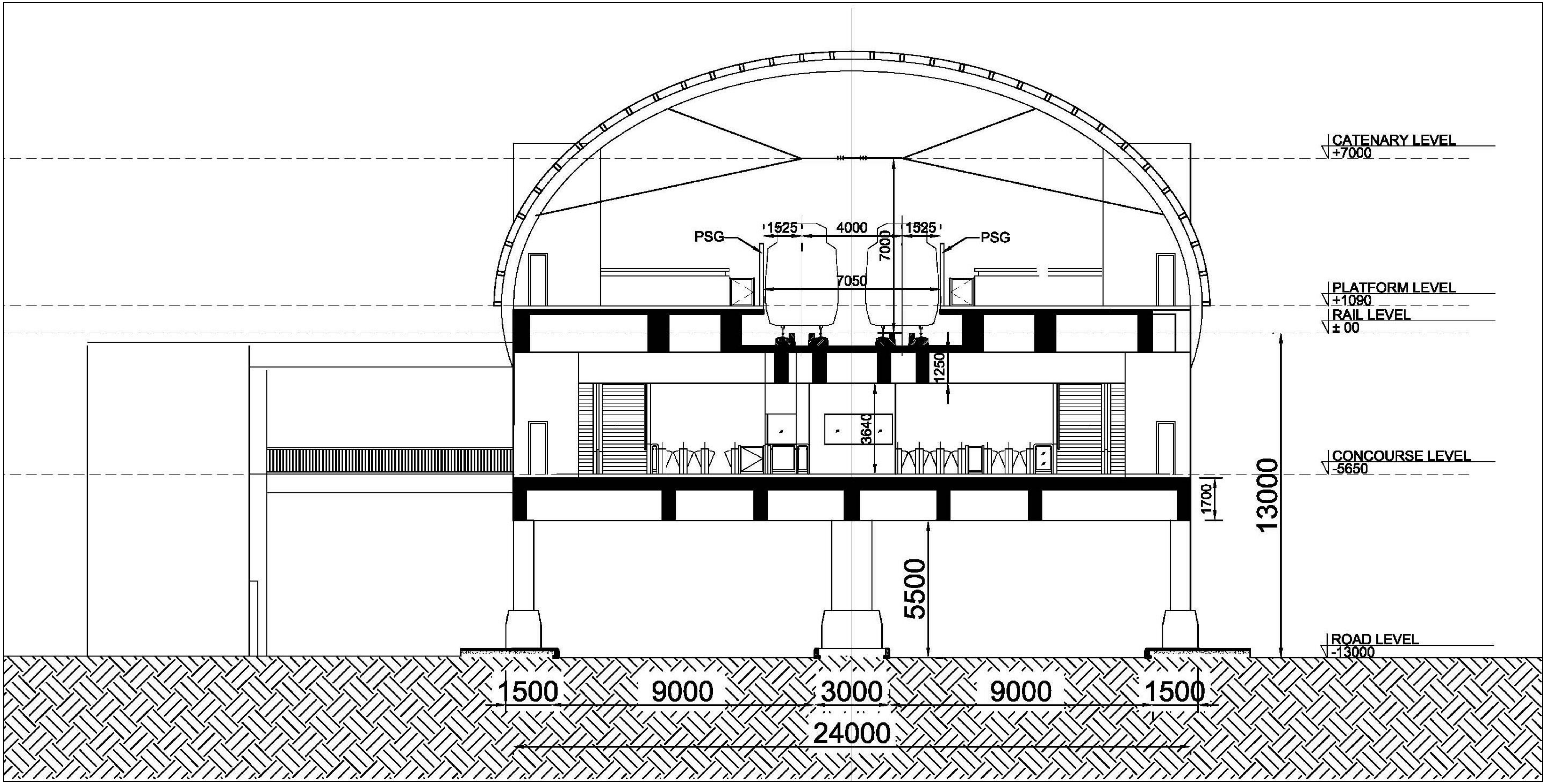


FIGURE 5.29: TYPICAL ELEVATED STATION



5.3.4.4.1 **Selection of TBM**

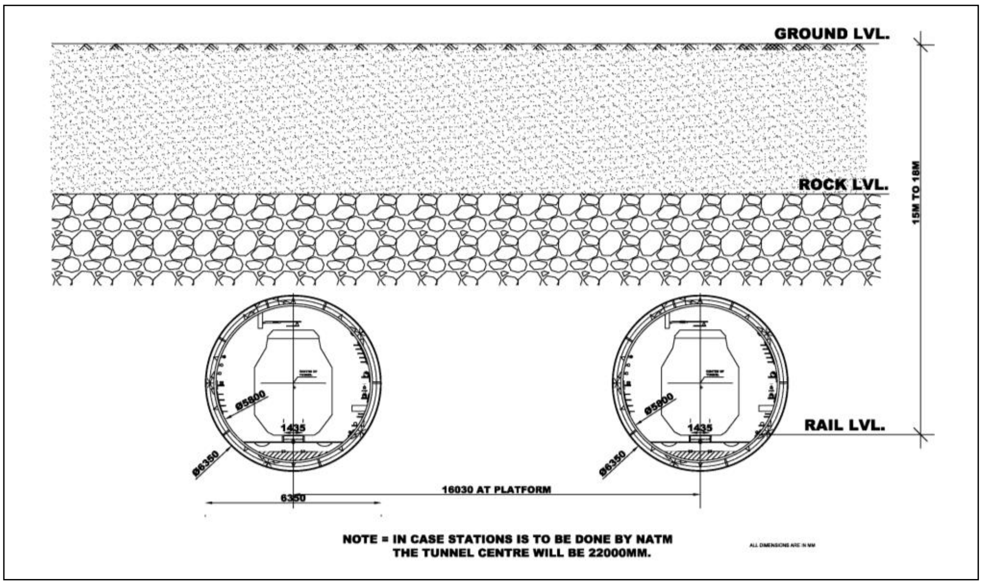
Choice of appropriate TMB depends upon the detailed geological studies and soil conditions. In the rocky strata, heavy disc cutters are required in the cutter head, whereas for excavating soft soils, scrappers are provided in the cutter head. In mixed soil conditions, the TBM should be capable of excavating soils and rocks both, hence combination of scrappers and disc cutters is used under such situations.

The most important issues to be addressed in selecting a Shield tunnelling method is face stability and minimum displacement/settlement of ground and structures confronting suitable TBM in this project will be the closed type. The Closed type TBM is further categorized as Earth- Pressure Balanced (EPB) TBM and Slurry type TBM. EPB is further categorized into Earth-pressure type TBM and Mud-pressure type TBM.

- **Earth-pressure type TBM**
  The Earth-pressure type TBM is suitable for certain types of soil that can be directly fluidized. Fluidized soil fills the cutter chamber and the screw conveyor is used for discharge of muck, thereby keeping the cut face stable. The shield machine is able to simultaneously excavate soil during shield advance, so not only is the face well stabilized, but also the effects on the surrounding ground are minimized.

FIGURE 5.30: EARTH PRESSURE BALANCE TBM

FIGURE 5.31: TYPICAL TWIN TUNNEL ARRANGEMENT



- **Mud-pressure type TBM**

  The Mud-pressure type TBM is that soil pressure at the face is transferred efficiently to ground that is high in sand content and low in fluidity through the addition of water, mud, and additives. It is applicable to a large range of soils, including soft ground with low solidity such as alluvial sand/gravel, sand, silt and clay, alluvial deposits, and alternating hard and soft soil layers. The only limitation is that the soil discharge screw conveyor is unable to operate when the ground has high hydrostatic pressure. For this reason, it is necessary to closely study the soil properties before implementation.

- **Slurry type TBM**

  Slurry type TBM (Air tunnel-boring machine) is used for tunnel-boring in highly permeable unstable terrain, or under civilian structures sensitive to ground disturbances.

  When digging in highly unstable or liquid terrain, the pressure exerted by the terrain is directly governed by the depth at which digging is performed. It is therefore necessary to balance the pressure exerted by the terrain: the front shield of the Slurry TBM is filled with excavated material, with the exception of one air-filled part. The pressure within this air bubble is subject to fine control. Bentonite injection waterproofs the working face and improves its resistance.

5.3.4.4.2 Proposed Dimensions

TABLE 5.36: DIMENSIONS OF TBM

Parameter	Proposed dimension
Tunnel internal diameter	5800 mm
Tunnel external diameter	6350 mm
Tunnel excavation diameter	6700 mm
TBM cutter head diameter	6770
Number of segments/rings	5 + 1 Key
Width of segments	1.2m/1.4m/1.5m
Thickness of segments	275 mm
Weight to segments	Normal segments Approx 3.0 T each Key segment 1 T
Weight of complete ring	16 T
Grade of concrete	M - 45

5.3.4.4.3 Sequence of Tunnelling by TBM

Between two stations tunnel is constructed by TBM. It will be launched from launching shaft. It is dragged in station area and continues from other side of station. Ground settlement analysis and monitoring is required during tunneling by TBM. Two separate tunnels are constructed by two different TBM. Depending upon the soil/rock strata, suitable type of TBM shall be used for tunneling.

A) Pre-Assembly Activities

The following construction sequence is necessary before Assembly of TBM can be taken up:

1) Construction of Head Wall & Installation of rubber seal ring

This is a concrete structure designed to hold the main frame of the Entrance ring of TBM and prevent water and slurry flowing into the shaft during the assembly and operation of the TBM. Rubber Seal (25 mm thick) and seal retainers keep full contact with the shield TBM. Three air ventilation tubes are installed near the tunnel crown and one at the invert, to release the air, when the void is being filled with grout while launching the TBM. These can also be used for grouting.

2) **Construction of Cradle**

This is a Pre-fabricated steel structure over which the TBM is assembled in–situ. This also acts as guide to help TBM oriented in the required direction, while in operation. After the TBM becomes operational, the cradle will be carefully dismantled so that the same material can be used at different shaft.

3) **Construction of Reaction Frame**

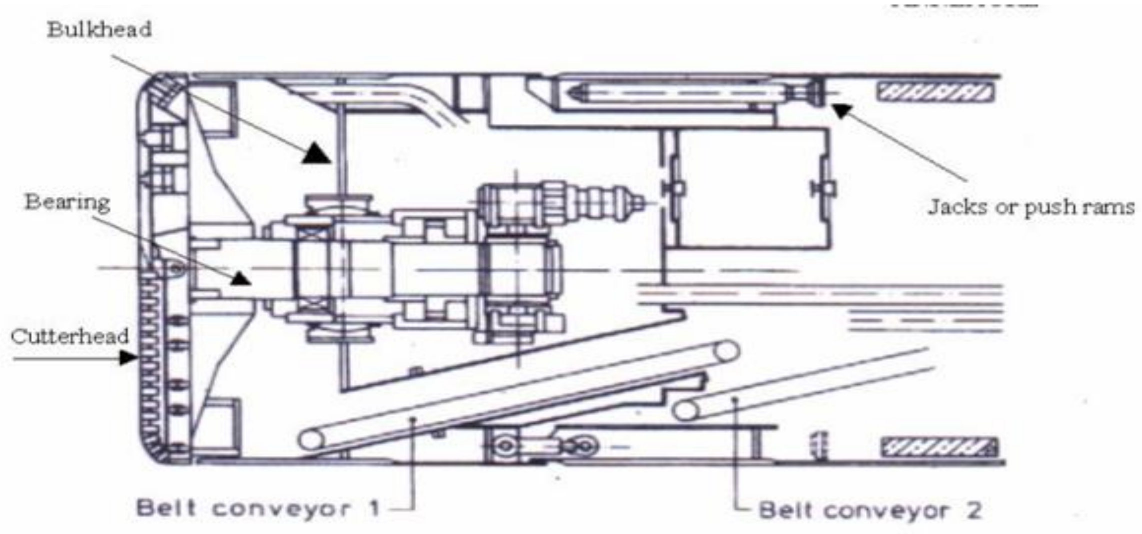
This is a steel Structure consisting of the Frame and supports which is fixed to the shaft floor and is designed to safely bear the thrust [a force of App. 1200 ton (30% of total thrust)] applied by the TBM during its working (force required by the cutting edge to cut the rock). The machine is to be assembled in- situ on a platform called Cradle and a Reaction frame is to be constructed in advance to bear the reaction of the force exerted by the main drive of the TBM for cutting the rock. Once the TBM becomes operational, the steel work in the Reaction Frame will be carefully dismantled as the same material is to be used repeatedly at subsequent assemblies at different sites.

B) Assembly of TBM

After the Head Wall, Entrance ring, Cradle, Reaction Frames are constructed and other preparatory works are completed, the TBM can be assembled in-situ in a launching chamber on the cradle and launched for tunneling. Metro underground station being constructed by cut and cover method can be used as launching shaft for TBM.

FIGURE 5.32: LAUNCHING CHAMBER

FIGURE 5.33: TYPICAL ASSEMBLY OF TUNNEL BORING MACHINE



Following steps are involved in the assembly of TBM:

1) Lowering of the shield,
2) Lowering of Cutter Head and fixing the same to the shield,
3) Fixing Segment erector and screw conveyor erection,
4) Lowering and Assembly of back up gantries.

FIGURE 5.34: MAIN SHIELD ERECTION

It takes about three-four weeks each for completing the preparatory work and actual assembly of TBM in position, before it could be launched. The cradle and the Reaction Frames are specially designed for every situation depending upon the machine characteristics and the rock characteristics. A 35 ton crane with a traveling gantry (or a suitable road mobile crane) is required for assembling the TBM. A 50 ton mobile crane will be required at the receiving end for dismantling TBM before shifting the same to another location.

FIGURE 5.35: ERECTOR, SCREW CONVEYOR & BACKUP SYSTEM

C) Excavation

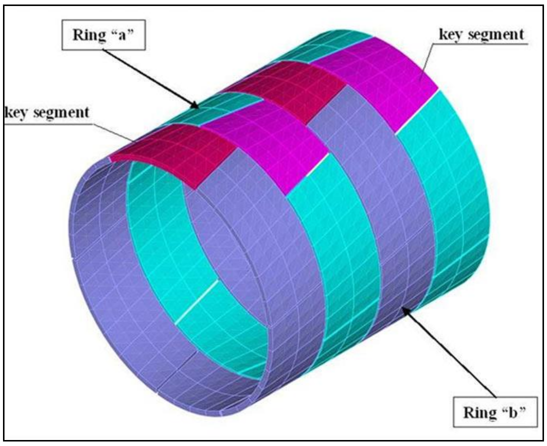
The TBM will operate at all times in enclosed mode. The pressure being maintained by balancing excavated material and foam introduced against material removed via the screw. A belt weighing device will be included on conveyor belt. This will measure the weight of the excavated material as it is transported on the conveyor belt.

FIGURE 5.36: EXCAVATION

D) Ring Erection

As the machine advances, the construction of the permanent lining takes place behind the excavation face of the machine and typically consists of 6 segments which make one ring.

FIGURE 5.37: RING SEGMENT



E) Settlement Control

Settlement is primary caused by over excavation by TBM and the failure to fill annular voids behind the segments. To prevent over excavation during the TBM drives the following actions will be carried out:-

- Surface monitoring scheme to be agreed and installed prior to TBM launch.
- Provision of belt weighing device to measure excavated material weight.
- Ground treatment of launch area & receiving area (if required)
- Display in TBM drivers cabin to show actual excavated volume vs. theoretical excavated volume in real time. Data to be recorded by TBM data logger.

To ensure settlement do not occur due to the annulus ring not being filled by grout the following actions will be carried out.

- Grouting system based on pressure control.
- Recording of grout volumes & pressure by TBM data logger.
- Tabulation of grout volumes to be done weekly showing running 10 ring averages. Grout pressure will be adjusted as necessary.

The above actions should ensure all annular voids are filled during the initial drive thereby controlling settlement caused by poor grouting practices.

F) Grouting and Waterproofing

After ring installation, theoretical void distance between the excavated radius and the external radius of the precast ring need to be filled up. Grouting fill the voids and it also controls the ground settlement. Grouting pressure is calculated on the basis of overburden pressure. Structures shall be watertight if the leakage does not exceed 5 ml/m2/hour. Inside surface above spring line of the tunnel shall be always kept dry condition.

Cavity grouting of segmental lining

Cavity grout shall be executed during the tunnelling in order to:

- Secure the waterproofing of the tunnel
- Maintain the tunnel ring shape
- Limit the surface settlement
- Distribute ground pressures evenly onto the lining

The grouting can be distinguished into two types. These are single compound type and the other is the two compounds type. The hardening time of the one compound type is relatively slow and its strength is also low. On the other hand it is relatively easy for the two compounds type to adjust the hardening time and strength. Hence it is recommended to use the two compounds type for the cavity grout.

The two compounds type is also distinguished into two types - liquid type and plastic type. The liquid type can be sometime diluted by the underground water and segregated. However, the plastic type is changed instantly into gel and kept very stable until it gets its own strength. Thus plastic type grout is recommended. The major materials of the liquid-A for the plastic type are mainly cement, fly-ash and bentonite. And the major material of the liquid-B for the plastic type is sodium silicate.

Primary grouting is the initial cavity grouting which is applied simultaneously or immediately after a unit of lining has been built. Where primary grouting does not completely fill all cavities, secondary grouting shal1 be carried out. Primary grouting shall be undertaken at a pressure sufficient to place the grout properly but not greater than 1 bar above the prevailing hydrostatic pressure at the location of grouting. Primary grouting shall be timed so as to minimize ground movement and be injected through grout holes provided in the linings or via shield tail skin injection pipes.

Secondary grouting shall be undertaken in selected rings by means of removing grout plugs from the tunnel lining and drilling a hole to the back of the existing grout. Secondary grouting is the re-grouting of lining and shall be completed as soon as practicable but within 14 days of the primary grouting or when the face has advanced 50 m from the location of primary grouting whichever first occurs. Secondary grouting shall be at a pressure consistent with filling all voids. Automatic grouting system as TBM advances shall be equipped.

Segment Gasket

It is recommended to apply the three layers of gasket to the perimeter of the segment. The materials for the gasket are mainly distinguished into chloroprene rubber type and natural rubber type. It should be tested for durability and water swelling ratio before using. The natural rubber type is suitable for the tunnel under high water pressure and the chloroprene rubber type is suitable for the tunnel under low water pressure.

- Gaskets shall be fitted into the grooves provided in the edges of the segment to be sealed in the manner recommended by the gasket manufacturer. The gasket dimensions shall match the groove width, subject to the specified tolerance.
- Sealing strips of the hydrophilic or gasket type, or a combination of the two, shall be provided at all faces between segments to provide a seal against ingress of ground water. Gaskets must be capable of withstanding the anticipated water pressure when in use in the tunnel. Test certificates or other information shall be provided to demonstrate this capability.
- Elastomeric gasket materials shall comply with the requirements of BS 2494, including resistance to chemical attack and microbiological degradation.
- Immediately prior to the erection of a gasketed segment, the gasket shall be checked for cleanliness and position. The gasket shall be lubricated as recommended by the gasket manufacturer.

G) TBM in Station Area

Cradle will be installed to drag the TBM in station area and again drive to other end of station by cutting D-wall. One end of station is receiving chamber and other end is launching chamber.

FIGURE 5.38: TBM THROUGH THE DIAPHRAGM WALL

FIGURE 5.39: TBM PUSHED TO THE OTHER END OF THE STATION

5.3.4.5 New Austrian Tunnelling Method (NATM)

The term New Austrian Tunnelling Method Popularly Known as NATM, was first used by Mr. Rabcewicz in 1962. This method has been evolved as a result of experience gained in Austrian Alpine tunnelling condition. The first use of NATM in soft ground tunnelling is done in Frankfurt metro in 1969. The basic aim of NATM is for getting stable and economic tunnel support systems. Providing flexible primary lining in shape of shotcrete, wire mesh, rock bolts, lattice girder. In case of weaker rock mass the use of pipe forepole/pipe roofing is also resorted for crown support which in turn leads to less over-break as well as ensure safety during the execution. The main aspect of the approach is dynamic design based on rock mass classification as well as the in situ deformation observed. This method has been very useful in complex diversified geological condition where forecasting of the rock mass is difficult due to rapidly changing geology.

Generally, two separate tunnels each accommodating a track and platform are constructed for two tracks and these two platform tunnels are interconnected by cross passages at regular interval so that both the platforms are accessed through a common set of stair cases and escalators provided at two shafts. In fact, these two platforms interconnected with number of cross passages act as an island platform.

FIGURE 5.40: CONSTRUCTION OF TUNNEL BY NATM

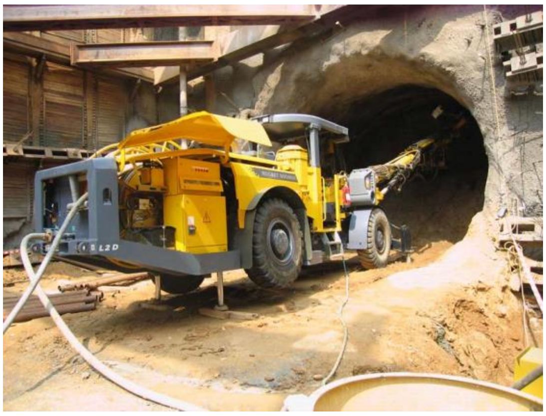
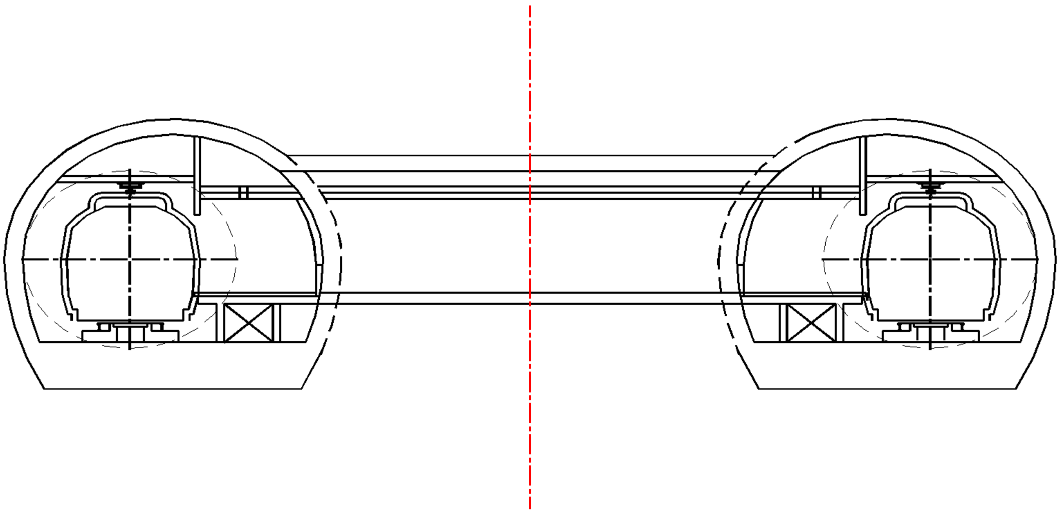


FIGURE 5.41: TYPICAL CROSS SECTION OF TWIN TUNNELS OF U/G STATION BY NATM



5.3.4.5.1 **Broad Principles of NATM**

NATM broadly based on the following principles:

i) **Dynamic Design** – The design is dynamic during the tunnel construction. Every face opening classification of rock is done and the supports are selected accordingly. Also the design is further reinforced based on the deformation as noticed during the monitoring.

ii) **Mobilization of the strength of rock mass**: The method relies on the inherent strength of the rock mass being conserved as the main component of tunnel support. Primary support is directed to enable the rock to support itself.

iii) **Shotcrete Protection**: Loosening and excessive rock mass deformation should be minimised by applying a layer 25-50mm of sealing shotcrete immediately after opening of the face.

iv) **Measurements:** Every deformation of the excavation must be measured. NATM requires installation of sophisticated measurement instrumentation. It is embedded in lining, ground such as load cells, extensometers and reflectors.

v) **Primary Lining:** The primary lining is thin. It is active support and the tunnel is strengthened not by a thicker concrete lining but by a flexible combination of rock bolts, wire mesh and Lattice girders.

vi) **Closing of invert**: Early as far as possible closing the invert so as to complete the arch action and creating a load-bearing ring is important. It is crucial in soft ground tunnels.

vii) **Rock mass classification:** The participation of expert geologist is very important as the primary support as well as the further designing of supports etc. during the excavation of rock requires the classification of the rock mass.

5.3.4.5.2 **Construction of Shafts**

Generally the shafts meant for entry / exits are constructed by Cut and Cover method. Due to presence of buildings very close to excavation area rigid support system in the form of Diaphragm Walls and Secant Pile Walls is proposed to be adopted for the braced excavation in the soil. However, the excavation in rock is usually done by stabilizing the rock face by means of shotcrete and rock dowels. A combination of two may be necessary where diaphragm wall / secant pile is provided in the over burden soil and rock excavation is done below.

It is proposed to construct permanent diaphragm wall duly socketed into the rock and excavation below the diaphragm wall level be done by supporting rock face by shotcrete / rock bolting depending on the rock conditions. Once the excavation proceeds in rock diaphragm wall can be extended below by jacketing. For this it is proposed to use couplers in the diaphragm wall reinforcement. In some cases, however, where it is considered risky to do trenching for diaphragm wall panel on account of poor soil conditions and proximity to the building temporary secant pile or diaphragm wall with shorter panels may be adopted.

5.3.4.5.3 **Cross Passage**

It is recommended to follow NFPA 130 which is an international standard for the underground structures. Cross passageways shall not be further than 244m (800ft) apart according to the NFPA 130. At least one cross passage is required in each underground section between the stations. Construction method of cross passage is briefly explained below:

- The SGI segment is sometimes used at the location of the cross passage in order to strengthen the segment lining because some parts of the segment lining must be dismantled during the construction of the cross passage.
- Ground treatment is carried out from the ground surface. Usually the jet grout is applied. The jet grout is much more effective than other methods for the ground treatment because the original soil is totally replaced by the improved soil.
- Ground treatment is also carried out from the tunnel after the jet grouting above ground. The purpose of the grouting from the tunnel is supplementary grouting for the jet grouting above ground.
- Dismantling of the piece of the segments is commenced one piece by one piece together with carefully confirming of the soil condition. Additional grouting should be done if necessary.
- Excavation to the other tunnel with lagging or shotcreting.
- Structural work

5.3.4.5.4 **Support Measures**

Support measures prescribed for these NATM tunnels generally included shotcrete, wire mesh, lattice girders, forepiling etc. M25 grade of shotcrete is generally adopted for these tunnels. Standard shotcrete thickness is 25-30 cm for such sizes of platform tunnels, cross adits and service tunnels. However, in special areas such as intersections and transitions and areas of weak ground a higher shotcrete thickness of approximately 30-40 cm is applied. To avoid the buildup of water pressure on the shotcrete lining weep holes are drilled through the shotcrete lining. These weep holes are equipped with slotted PVC pipes wrapped in geo-textile.

Lattice girders are installed to provide immediate support for the exposed rock mass during excavation and to serve as template for the excavation geometry. They also serve as guidance and support for forepiling and are considered as reinforcement of the shotcrete lining. Different types of lattice girders are installed depending on the applied shotcrete thickness.

For the tunnels wire mesh 150/150/6 mm are applied as standard. Wire mesh is applied after application of a shotcrete sealing layer. Proper overlap of 300 mm (2 mesh Openings) is provided in both directions i.e. circumferential and in longitudinal direction.

FIGURE 5.42: LATTICE GIRDER

In some cases, forepling is installed in the crown area of the top heading to avoid development of loosening rock zones. Forepiling is installed after each round from the current top heading face to provide safety for the following top heading excavation round. It is installed from the top of the last lattice girder installed.

5.3.4.6 Construction of Underground Stations

Construction of underground station is mostly done by **Cut and Cover Method** where adequate ROW is available to support the excavation width to cover the width of station including protection work. Margin for road traffic also need to be available beyond the excavation line. Where ROW is restricted, only half width of station will be tackled at a time. In cases where ROW is extremely restricted and cut & Cover method is not possible, excavation will be done by **New Austrian Tunneling Method (NATM).**

5.3.4.6.1 Cut and Cover Method

In this method, entire volume required to accommodate structure is first excavated, structures are casted followed by backfilling. The open cut excavation with slope but without support is not suited due to large depths of excavation involved. Hence support of excavated sides by way of diaphragm wall/sheet pile/soldier piles/secant piles is essentially done in cut and cover method. The support walls are often braced to effectively resist the huge earth pressure. The braced cut and cover method involves following steps:-

- Identification and diversion of utilities
- Construction of support walls
- Excavation between support walls along with bracing, ties or anchors
- Concrete construction
- Removal of temporary supports
- Backfilling and restoration of surface/utilities

There are two methods for cut and cover construction:-

i) **Bottom Up Construction**: This is the conventional construction method in which excavation is carried out through to the design depth and then construction starts from bottom most floor slab and proceeds upwards. In this method the restoration of top surface is possible only after all the structures are constructed upto top level and hence it involves longer restoration time.

ii) **Top Down Construction:** In this method, after excavation of first stage, floor slabs are constructed. These floor slabs are permanent structures which replace temporary steel struts in the braced excavation method to counteract the earth pressure from back of retaining wall. In this way, the underground structure construction is finished with the completion of excavation process. The floor slabs used in this method are heavier than steel struts used in conventional excavation method. In addition, superstructure being constructed simultaneously during excavation puts more weight on the column. Hence, bearing capacity of column is to be considered. Typical construction procedure of top down construction method is as under:-

1) Construct the retaining wall.
2) Construct piles. Place the steel columns where piles are constructed.
3) Proceed to the first stage excavation.
4) Cast the floor slab.
5) Begin to construct superstructure.
6) Proceed deeper to second stage of excavation. Cast the floor slab.

7) Repeat the same procedure till designed depth is achieved.
8) Cast bottom most slab.

The merits and de-merits of this method are shown in **Table 5.37.**

TABLE 5.37: MERITS AND DEMERITS OF TOP-DOWN METHOD

Merit	De-merit
• Shortened construction period due to simultaneous construction of underground structure and superstructure. • Faster restoration of ground surface and utilities as topmost slab of underground construction is casted first. • Higher stiffness of floor slabs compared to steel struts improves the safety of excavation.	• Higher cost. • Possibility of lateral displacement of retaining wall or ground settlement is more due to longer construction period of bottommost slab. • Natural ventilation and illumination is affected due to construction of first slab.

5.3.4.6.2 **New Austrian Tunneling Method (NATM)**

Where ROW is extremely restricted and it is not possible to adopt cut and cover method, stations are constructed by NATM. In this method, two separate tunnels consisting of one track and one platform are constructed by NATM method and are connected by means of cross passages. This method requires overburden of about 2-2.5 times dia of tunnel. In this method, progress is slow. This method is described in detail in tunnelling sub-section.

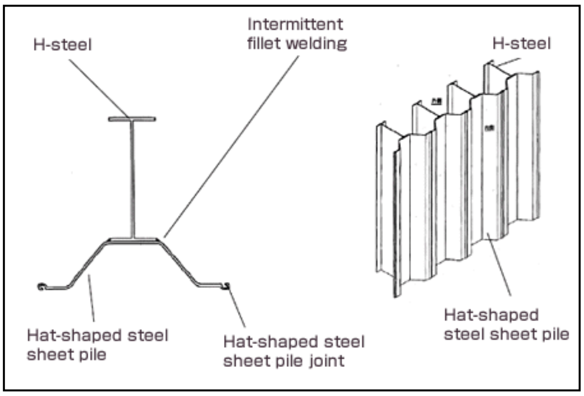
5.3.4.6.3 **Earth retaining structures for underground stations**

Following earth-retaining structures are used to support excavation for construction of underground stations:-

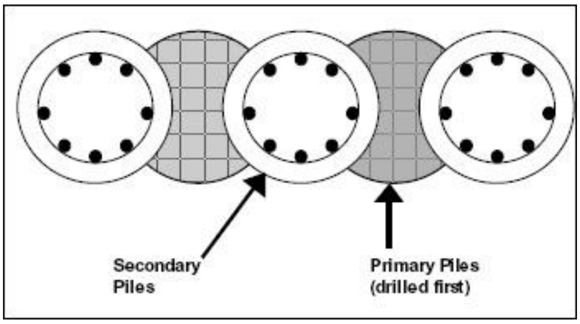
A) Soldier Piles: H/I section steel piles are driven in the ground at an interval of 1-1.5 m and the gap between the two piles is filled by using laggings of timber planks/steel sheets/GI sheets. These piles are reusable, can be easily

pulled out and results into less ground disturbance while driving and pulling out. However, these piles are not watertight and dewatering measures are required. Void between soldier piles and surrounding soil need filling.

B) **Sheet Piles:** Sheet piles of 'Z' or 'U' shape are driven into soil by striking or static vibrating. The sheet pile is interconnected with adjoining piles to achieve interlocking and water sealing. Sheet piles can be used again and again and hence becomes economical. Driving of sheet piles require considerable efforts and cause vibrations to ground and adjoining structures. Sheet piles have higher stiffness than soldier piles.

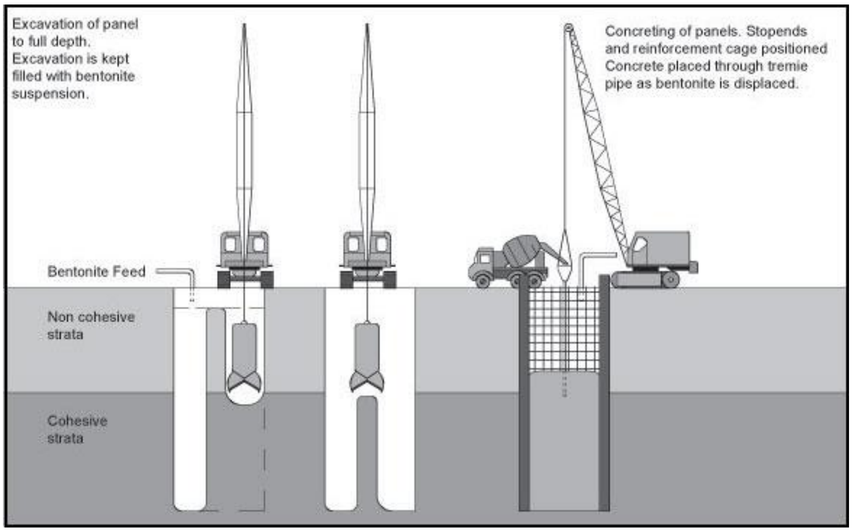


C) **Secant Piles:** It is series of piles cutting into adjoining piles to achieve water tight retaining structure. In this method, alternate soft piles, called female piles, of dia (D) 800 to 1000 mm (without reinforcement) are cast at an inter-distance of less than D and when these piles are still green, hard piles (containing reinforcement) are bored by cutting female piles. Thus, a series of alternate and interconnected hard and soft pile is achieved which acts as rigid earth retaining structure. It has all the advantages of diaphragm wall, except that it cannot be used as part of permanent structure.



D) **Diaphragm Wall**: It is a rigid support system ensuring maximum safety against settlement/lateral displacement. Typically diaphragm wall of 1 m thickness is sufficient to retain the earth pressure in a cut cover construction. The diaphragm wall can be used as part of permanent structure. With diaphragm wall, it is possible to adopt top down construction method.

FIGURE 5.43: DIAPHRAGM WALL



5.3.4.6.4 Typical Underground Station

A typical underground station is three level station with entrances and ventilation shafts at the ground level, a concourse with ticketing and AFCs at the mezzanine level and finally platforms at the lowest level. 140 m long island platform is proposed on the stations. Platform is 12 m wide with 2 sets of staircase/ Escalator planned leading to either end of the station. A lift is planned in the centre. **Figure 5.44** shows a typical cross section of underground station.

Two end concourses have been proposed, one at each end. The concourse is divided into paid and unpaid area by the AFC gates. Paid area is limited to access to the stair / escalator and corridors connecting the two concourses, also lead to the lift which is centrally provided.

Since, very limited space is available on the ground at stations, all the over-ground structures are therefore, planned as and where space is available and are therefore, not necessarily grouped at ground level.

5.3.4.6.5 Flexible Joint at the Junction of the Tunnel and Station/Shaft

Following three models are considered for the connection.

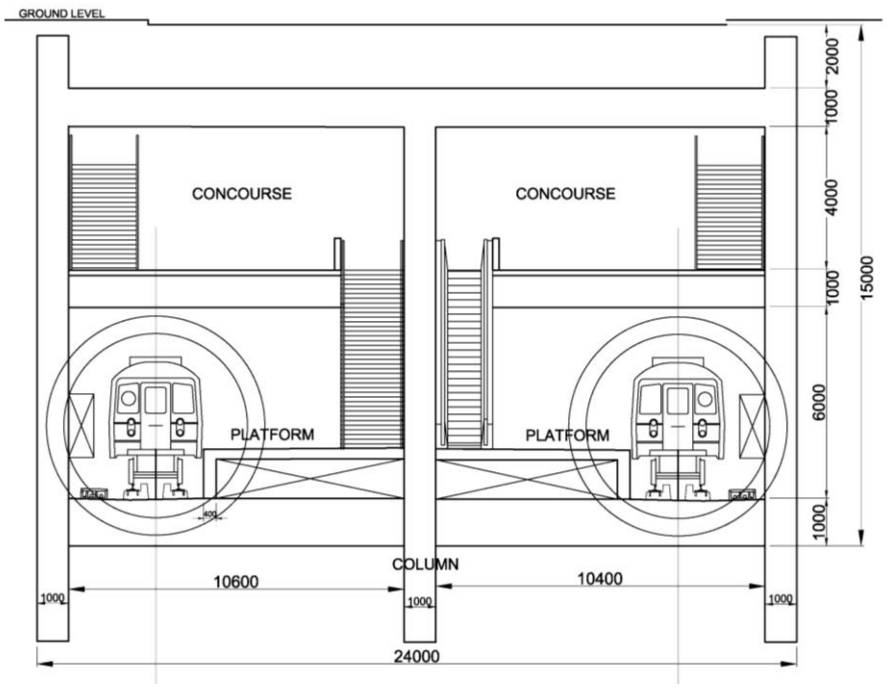
- Rigid connection
- Pin connection
- Free connection

The Rigid connection is recommended. There are some measures for such joint between the tunnel and station which are as follows.

- RC segment only
- RC segment with elastic washers for 7 meters (1D long)
- SGI segment for 7 meters (1D long)
- SGI segment with elastic washers for 7 meters (1D long)
- Flexible joint

Considering safety and cost for the construction it is recommended to apply the rigid joint at the connection between tunnel and station. Detailed analysis such as FEM analysis should be done for the earthquake to estimate the displacement of the joint**.**

FIGURE 5.44: TYPICAL UNDERGROUND STATION



5.3.4.6.6 **Protection of Stray Current**

The corrosion control system shall be designed to mitigate the potential effects of stray currents. The consultant team recommends the following measures.

- Connections shall be provided to enable electrical bonding of the inner reinforcement across isolation joints.
- Facilities for jointing any or all of the connections shall be provided.

- Reinforcement for segmental concrete lining shall be designed such that no electrical continuity will exist across the circle joint.
- SGI segments shall be bonded to mitigate potential stray current effects.
- Cathodic protection should be applied to all the pipes inside the tunnel.
- Bracket for the pipes or cable should be taken care of its insulation.

5.3.4.6.7 **Ventilation**

A mechanical emergency ventilation system is required in a fixed guide way transit underground or enclosed train way that is longer than 304.8 m (1000 ft) according to the NFPA 130, 2003 edition. RITES recommends for adopting the Saccardo ventilation system in the project. This system is widely used in Japan, USA and Singapore.

Saccardo ventilation system is such a longitudinal ventilation operational system as high velocity air jet produces high volume airflow into the tunnel. This system is especially effective to the twin tunnels with a single track because the section area of the tunnel is relatively small and the direction of the traffic is always same. Moreover the innovation of the ventilation fan is so fast that this system is getting more effective to the ventilation of the even longer tunnels in these days.

The analysis of the ventilation for the normal and emergency condition can be made by the Subway Environment Simulation (SES) computer program, which was developed by the Department of Transportation of USA. However, the air velocity of 2 m/s is applied for designing the capacity of the ventilation fan in the Japanese latest metro system. This figure complies with the NFPA 130 and a reference for the system in the project.

5.3.4.7 Grade of Concrete

It is proposed to carry out construction work with design mix concrete. Computerized Automatic Batching Plants will be installed. Following grades of concrete are proposed 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/M-50
iv) All pre-cast elements for viaduct and stations: M-45
v) Tunnel segments : M-45

vi) Cantilever piers and portals: M-45 /M-50/M-60

vii) Other miscellaneous structures: M-30

For all main structures, permeability test of concrete is recommended to ensure impermeable concrete.

5.3.4.8 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 T 13 and or 19 K 15 is recommended (confirming to IS:14268).

5.3.5 TRAFFIC MANAGEMENT PLAN DURING CONSTRUCTION

The aim of the traffic management measures is to relieve, wherever possible, or minimize the (short term) disruption to normal traffic likely to be caused by the construction of the metro works. The traffic management measures would need to cope, in safety, with all aspects of traffic, including those generated from

- Goods vehicles
- Public transport
- Essential services
- Pedestrian movement
- Local and through private traffic

The organization of traffic during construction activities is proposed to be phased into and coordinated with the long term strategic traffic plans under CMP.

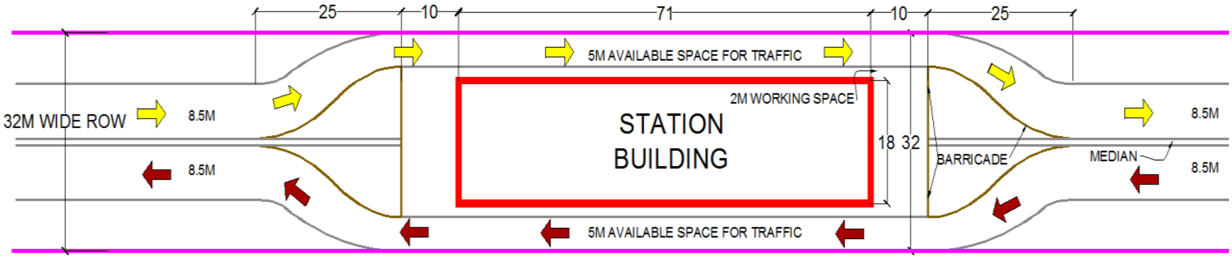
5.3.5.1 Typical Traffic Diversion Plan

The typical traffic diversion plans has been prepared based on two scenarios as under:
Scenario 1:- At stations where ROW> 32m
Scenario 2:- At stations where ROW< 32m

At stations where ROW> 32m

At stations where existing ROW is more than 32m, traffic will be diverted on both sides of the proposed station built up area during construction. The typical traffic diversion plan for such stations is shown in **Figure 5.45**. To increase the available space width for traffic, the option of construction of station in two sequences (half by half method) can be adopted.

FIGURE 5.45: TYPICAL TRAFFIC DIVERSION PLAN (ROW> 32M)



At stations where ROW< 32m

At some of the stations existing ROW is between 22m to 32m, so the traffic will be diverted on such locations one side of the proposed station during construction and construction of station will be done half by half method in sequence. The typical traffic diversion plans for such stations are shown in **Figure 5.46 &**

FIGURE 5.47

FIGURE 5.46: TYPICAL TRAFFIC DIVERSION PLAN (ROW< 32M)

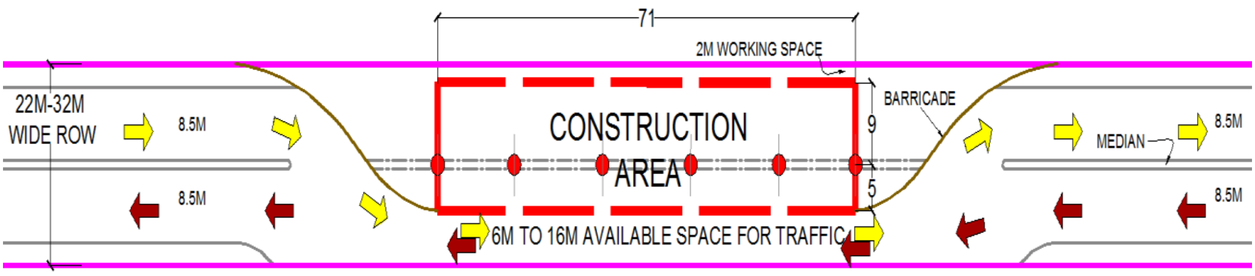
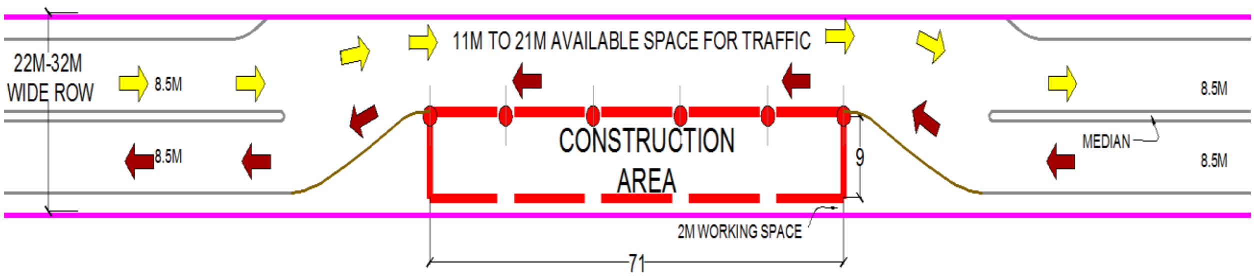


FIGURE 5.47: TYPICAL TRAFFIC DIVERSION PLAN



5.4 GEOMETRIC DESIGN OF CORRIDORS INCLUDING PLAN / PROFILE

5.4.1 Alignment Design Considerations

Following considerations have been kept in view, while designing the alignment.

a) The alignment has been proposed to cover the high-density traffic corridors and origination/destination centers.

b) The elevated alignment has been generally proposed along the median of the road.

c) Track Centre of 4.6 m has been proposed for elevated section so as to provide flexibility of adopting Double U-shaped Girders for superstructure.

d) Underground alignment has been designed with a view to avoid high rise buildings having deep foundations.

e) To minimise the construction cost, underground stations have been proposed to be constructed by Cut and Cover method. However, exception has been made for Nayaganj U/G station, which has been proposed by NATM method due to heavily built up location.

f) Traffic diversion will be required where Switch Over Ramps and underground station are proposed along the road by cut & cover method.

g) Effort has been made to minimize disruption to road traffic during construction phase.

h) Effort has been made to position the ramps and depots on Government land.

5.4.2 Alignment Design of Corridor -1

5.4.2.1 Horizontal Curvature

Although the topology of Kanpur is not very undulating and the terrain type is plain, yet the existing road has frequent horizontal curves to negotiate the densely built up areas. The proposed alignment also negotiates frequent horizontal curves to follow the existing road median. At some places there are sharp turns and curves along the road and this necessitates provision of sharp curves on metro alignment also.

Total 51 nos. horizontal curves have been provided on the entire length of the alignment. The minimum radius of curves is 250 m in underground section and 200 m in elevated section. About 54% alignment is on straight & about 46% of alignment is on curves. The abstract and details of curves are indicated in **Table 5.38 & 40** respectively.

TABLE 5.38: ABSTRACT OF HORIZONTAL CURVES OF CORRIDOR-1

S. No.	Curve Radius	No. of Occurrences	Length	Percentage
1	<120	0	0.00	0.00
2	200	1	277.68	2.52
3	>200 < 300	4	1349.19	12.24
4	≥300 ≤ 500	7	1532.65	13.91
5	>500 ≤ 800	14	3552.41	32.23
6	>800 ≤ 1000	9	1757.79	15.95
7	>1000	16	2550.78	23.15
	Total	**51**	**11020.49**	**100.00**

5.4.2.2 Gradient

While designing vertical alignment, efforts have been made to avoid frequent gradients. The number of gradients has been kept to minimum, however, due to ground profile, difference in rail level of viaduct over mid section and station location, horizontal alignment and switch over ramps, gradients are inevitable. Efforts have been made to provide the gradients as flat as possible, subject to ground profile.

A total 68 number of change of gradients has been provided in the entire Corridor. Flattest gradient is level provided for 46% of the alignment. Steepest gradient is 4% (compensated) provided for two no. Switch Over Ramps near Moti Jheel & Transport Nagar. The abstract and details of gradients are given in **Table 5.39 & Table 5.41** respectively.

TABLE 5.39: ABSTRACT OF GRADIENTS OF CORRIDOR-1

S. No.	Description	Nos. of Occurrences	Length (m)	% Length
1	Level (0%)	27	10963	46.26
2	>0% ≤ 1%	14	5869	24.76
3	>1% ≤ 2%	23	5276	22.26
4	>2% ≤ 3%	0	0	0.00
5	>3%	4	1592	6.72
	TOTAL	**68**	**23700**	**100.00**

TABLE 5.40: DETAILS OF HORIZONTAL CURVES OF CORRIDOR-1

Curve No	Chainage		Direction	Radius	Intersection Angle			Transition Length		Tangent Length	Curve Length	Total Curve Length	Straight Between
	Transition Starts	Transition Ends			D	M	S	In	Out				
1	-259.83	322.08	Right	4000	8	1	31.80	20	20	291.42	541.90	581.90	135.50
2	457.57	727.54	Left	-2000	6	21	6.12	40	40	135.11	189.97	269.97	334.09
3	1061.63	1558.58	Left	-750	33	13	29.64	60	60	254.93	376.95	496.95	1344.19
4	2902.76	2938.97	Right	10000	0	6	15.84	5	5	18.11	26.21	36.21	480.26
5	3419.24	3496.02	Right	3000	1	3	1.44	20	20	38.39	36.79	76.79	30.20
6	3526.23	3602.45	Left	-3000	1	2	33.36	20	20	38.11	36.22	76.22	416.60
7	4019.05	4106.05	Left	-1050	3	3	48.96	30	30	43.51	27.00	87.00	63.45
8	4169.50	4623.45	Right	1000	24	10	21.36	30	30	230.22	393.95	453.95	34.80
9	4658.25	4757.82	Left	-800	4	9	36.36	40	40	49.81	19.58	99.58	668.31
10	5426.13	5513.18	Left	-2100	1	19	56.64	30	30	43.53	27.05	87.05	141.39
11	5654.57	5784.77	Left	-400	12	7	17.04	45	45	65.28	40.20	130.20	Nil
12	5784.83	5890.20	Right	848	4	15	0.36	40	40	52.71	25.37	105.37	145.93
13	6036.13	6210.00	Right	500	14	6	49.68	50	50	87.28	73.86	173.86	118.13
14	6328.13	6515.29	Left	-800	10	19	19.92	40	40	93.80	107.16	187.16	29.15
15	6544.44	6728.80	Left	-300	23	27	2.52	60	60	93.18	64.37	184.37	32.36
16	6761.16	6875.50	Right	800	5	11	33.72	40	40	57.20	34.34	114.34	29.69
17	6905.19	7025.88	Right	1000	4	22	20.64	40	40	60.37	40.69	120.69	Nil
18	7026.27	7173.91	Left	-1640	4	16	24.24	20	20	73.85	107.64	147.64	82.75
19	7256.66	7533.81	Left	-1500	9	15	45.00	30	30	138.86	217.15	277.15	85.73
20	7619.53	7737.99	Left	-1000	5	2	25.80	30	30	59.26	58.45	118.45	67.84
21	7805.82	7927.63	Right	1000	5	9	12.96	30	30	60.94	61.80	121.80	145.59

Curve No	Chainage		Direction	Radius	Intersection Angle			Transition Length		Tangent Length	Curve Length	Total Curve Length	Straight Between
	Transition Starts	Transition Ends			D	M	S	In	Out				
22	8073.21	8465.68	Right	1000	21	12	9.72	20	20	198.42	352.47	392.47	Nil
23	8465.70	8743.38	Left	-200	63	28	23.16	55	55	152.34	167.68	277.68	153.80
24	8897.18	9496.65	Right	600	52	16	53.40	50	50	320.78	499.47	599.47	Nil
25	9496.66	9746.16	Right	300	37	5	6.36	55	55	128.44	139.50	249.50	234.11
26	9980.27	10357.12	Left	-600	31	7	27.12	50	50	192.64	276.85	376.85	132.51
27	10489.63	10622.29	Right	800	6	22	51.60	40	40	66.38	52.66	132.66	217.98
28	10840.27	11034.71	Left	-600	13	28	24.24	50	50	97.59	94.44	194.44	481.58
29	11516.29	11713.32	Right	1000	8	35	42.00	40	40	98.68	117.03	197.03	274.18
30	11987.50	12206.31	Left	-700	13	29	24.36	50	50	109.83	118.81	218.81	136.78
31	12343.09	12859.93	Right	260	101	27	48.24	55	55	347.88	406.85	516.85	174.96
32	13034.90	13199.23	Left	-300	20	31	29.64	55	55	82.85	54.33	164.33	35.67
33	13234.90	13592.60	Right	300	57	29	4.20	55	55	193.38	247.71	357.71	433.29
34	14025.90	14287.45	Left	-250	47	12	5.76	55	55	137.29	151.55	261.55	Nil
35	14287.64	14630.11	Right	250	65	31	48.00	55	55	189.81	232.47	342.47	290.34
36	14920.45	15290.73	Left	-550	33	12	55.08	50	50	189.88	270.28	370.28	183.16
37	15473.89	15746.57	Right	400	30	16	30.00	60	60	139.01	152.68	272.68	246.70
38	15993.26	16204.38	Right	800	12	9	6.84	40	40	105.90	131.12	211.12	129.03
39	16333.41	16562.88	Left	-800	13	20	28.32	40	40	115.19	149.47	229.47	345.26
40	16908.14	17136.48	Left	-250	39	25	59.16	55	55	117.99	118.33	228.33	686.62
41	17823.10	17910.53	Left	-1300	2	18	55.08	30	30	43.72	27.44	87.44	427.77
42	18338.30	18413.70	Left	-2400	1	11	31.92	20	20	37.70	35.40	75.40	148.65
43	18562.36	18668.59	Left	-2000	2	6	36.72	30	30	53.12	46.23	106.23	98.03

Curve No	Chainage		Direction	Radius	Intersection Angle			Transition Length		Tangent Length	Curve Length	Total Curve Length	Straight Between
	Transition Starts	Transition Ends			D	M	S	In	Out				
44	18766.62	18948.25	Left	-700	10	27	45.36	50	50	91.02	81.63	181.63	457.52
45	19405.76	19479.80	Left	-2400	1	10	20.64	20	20	37.02	34.04	74.04	521.78
46	20001.59	20070.90	Left	-2800	1	0	11.88	20	20	34.66	29.31	69.31	495.11
47	20566.01	20749.05	Left	-2000	4	3	18.72	40	40	91.55	103.04	183.04	391.36
48	21140.40	21269.15	Right	1000	5	3	2.16	40	40	64.41	48.75	128.75	147.92
49	21417.07	21556.74	Right	600	9	18	37.08	40	40	69.96	59.67	139.67	434.25
50	21990.99	22306.38	Left	-2000	7	31	55.56	40	40	157.91	235.39	315.39	476.50
51	22782.88	22902.15	Right	1000	5	3	55.08	30	30	59.67	59.27	119.27	347.85

TABLE 5.41: DETAILS OF GRADIENTS OF CORRIDOR-1

S. No.	Chainage		Length	Rail Level		Gradient (%)	Remarks
	From	To		From	To		
1	-450	100	550	141.70	141.70	0.00	Level
2	100	347	247	141.70	137.60	-1.66	Fall
3	347	640	293	137.60	137.60	0.00	Level
4	640	840	200	137.60	141.50	1.95	Rise
5	840	1040	200	141.50	141.50	0.00	Level
6	1040	1245	205	141.50	137.50	-1.95	Fall
7	1245	1320	75	137.50	137.50	0.00	Level
8	1320	1475	155	137.50	140.50	1.94	Rise
9	1475	1745	270	140.50	140.50	0.00	Level
10	1745	1945	200	140.50	136.50	-2.00	Fall
11	1945	2200	255	136.50	136.10	-0.16	Fall
12	2200	2400	200	136.10	140.00	1.95	Rise
13	2400	2600	200	140.00	140.00	0.00	Level
14	2600	2800	200	140.00	136.00	-2.00	Fall
15	2800	3935	1135	136.00	137.50	0.13	Rise
16	3935	4135	200	137.50	141.20	1.85	Rise
17	4135	4370	235	141.20	141.20	0.00	Level
18	4370	4570	200	141.20	139.30	-0.95	Fall
19	4570	5330	760	139.30	139.30	0.00	Level
20	5330	5720	390	139.30	142.10	0.72	Rise
21	5720	6120	400	142.10	142.10	0.00	Level
22	6120	6400	280	142.10	137.00	-1.82	Fall
23	6400	7230	830	137.00	140.50	0.42	Rise
24	7230	7455	225	140.50	140.50	0.00	Level
25	7455	7560	105	140.50	138.40	-2.00	Fall
26	7560	7675	115	138.40	137.40	-0.87	Fall
27	7675	7865	190	137.40	139.80	1.26	Rise
28	7865	8370	505	139.80	139.80	0.00	Level
29	8370	8760	390	139.80	125.62	-3.64	Fall
30	8760	9175	415	125.62	109.00	-4.00	Fall
31	9175	9660	485	109.00	109.50	0.10	Rise
32	9660	10060	400	109.50	109.50	0.00	Level
33	10060	10555	495	109.50	109.00	-0.10	Fall
34	10555	10810	255	109.00	106.60	-0.94	Fall
35	10810	11330	520	106.60	106.60	0.00	Level
36	11330	11490	160	106.60	109.00	1.50	Rise
37	11490	11693	203	109.00	107.00	-0.99	Fall
38	11693	12026	333	107.00	107.00	0.00	Level
39	12026	12495	469	107.00	109.40	0.51	Rise
40	12495	12825	330	109.40	109.00	-0.12	Fall

S. No.	Chainage		Length	Rail Level		Gradient (%)	Remarks
	From	To		From	To		
41	12825	13140	315	109.00	109.00	0.00	Level
42	13140	13345	205	109.00	106.00	-1.46	Fall
43	13345	15000	1655	106.00	106.00	0.00	Level
44	15000	15390	390	106.00	111.90	1.51	Rise
45	15390	15660	270	111.90	110.90	-0.37	Fall
46	15660	16063	403	110.90	110.90	0.00	Level
47	16063	16500	437	110.90	110.00	-0.21	Fall
48	16500	16995	495	110.00	110.00	0.00	Level
49	16995	17182	186	110.00	116.66	3.57	Rise
50	17182	17782	600	116.66	140.60	3.99	Rise
51	17782	18082	300	140.60	140.60	0.00	Level
52	18082	18282	200	140.60	136.60	-2.00	Fall
53	18282	18738	456	136.60	136.60	0.00	Level
54	18738	19092	354	136.60	141.30	1.33	Rise
55	19092	19322	230	141.30	141.30	0.00	Level
56	19322	19647	325	141.30	136.00	-1.63	Fall
57	19647	19972	325	136.00	142.50	2.00	Rise
58	19972	20142	170	142.50	142.50	0.00	Level
59	20142	20387	245	142.50	139.11	-1.38	Fall
60	20387	20632	245	139.11	139.11	0.00	Level
61	20632	20832	200	139.11	135.50	-1.81	Fall
62	20832	21392	560	135.50	135.50	0.00	Level
63	21392	21652	260	135.50	139.31	1.47	Rise
64	21652	21852	200	139.31	139.31	0.00	Level
65	21852	22052	200	139.31	135.50	-1.91	Fall
66	22052	22372	320	135.50	135.50	0.00	Level
67	22372	22602	230	135.50	140.00	1.96	Rise
68	22602	23250	648	140.00	140.00	0.00	Level

* Note : All the change points are provided with Vertical curves

5.4.2.3 Special Span & Portals

Details of locations having special spans and portal arrangement are given in **Table 5.42 & Table 5.43** respectively.

TABLE 5.42: LOCATION OF SPECIAL SPANS CORRIDOR - 1

S. No	Location	Chainage		Special span Configuration	Type of Structure
		From	To		
1	Rawatpur Station	5948	6061	34m + 45m + 34m	PSC by Cantilever construction method
2	Elevated Road NH-25	20035	20148	34m + 45m + 34m	

* Note : Alternatively, Single Steel span of 45m may also be provided.

TABLE 5.43: LOCATION OF PORTALS CORRIDOR - 1

S. No.	Location	Chainage		Length (m)	Purpose
		From	To		
1	Gurudev Chauraha	4150	4200	50	Due to difference in Metro Alignment & road geometry. Metro alignment diverted from road median to off-road & vice versa for off road Gurudev Chauraha station.
		4440	4700	300	
3	Rawatpur	5750	5890	140	Due to difference in Metro Alignment & road geometry. Alignment diverted from road median to off-road & vice versa for off road Rawatpur station.
		6040	6300	260	
4	Gol Chowk near GSVM	6700	6800	100	Crossing of Road junction
5	Lala Lajpat Rai Hospital	7050	7150	100	Alignment crosses road diagonally from GSVM to Lala Lajpat Rai hospital metro station

5.4.2.4 Break-up of Alignment Length

Break-up of alignment length for Corridor-1 is given in **Table 5.44.**

TABLE 5.44: BREAK-UP OF ALIGNMENT LENGTH FOR CORRIDOR-1

S. No.	Description	Chainage (m)		Length (m)	Method of Construction/ Structure Type
		From	To		
1	Elevated	-450	8522	8972	Box/I/U- Shape Girder
2	Underground	9150	17235	8085	TBM/ Cut & cover/NATM
3	Elevated	17624	23335	5711	Box/I/U- Shape Girder

5.4.3 Alignment Design of Corridor -2

5.4.3.1 Horizontal Curvature

A total of 23 curves have been provided on the entire length of the alignment. The minimum radius of curves is 280 m in underground section and 220 m in elevated section. About 52.5% of the length of the alignment is on curves. The abstract and details of curves are indicated in **Table 5.45**.

5.4.3.2 Gradients

A total 21 number of change of gradients has been provided in the entire Corridor. Flattest gradient is level provided on 56.26% of alignment including the stations and steepest gradient is 4.00% (compensated) provided for a length of 738 m for ramp. The abstract and details of gradients are given in **Table 5.46 & Table 5.47** respectively.

TABLE 5.45: ABSTRACT OF HORIZONTAL CURVES OF CORRIDOR-2

SN	Curve Radius	No. of Occurrences	Length	Percentage
1	<120	0	0.00	0.00
2	>120 ≤ 200	0	0.00	0.00
3	>200 < 300	3	941.96	20.88
4	≥300 ≤ 500	4	1140.56	25.28
5	>500 ≤ 800	4	764.75	16.95
6	>800 ≤ 1000	5	959.33	21.26
7	>1000	7	705.24	15.63
	Total	**23**	**4511.84**	**100.00**

TABLE 5.46: ABSTRACT OF GRADIENTS OF CORRIDOR-2

S. No.	Description	No's of Occurrences	Length (m)	% Length
1	Level (0%)	9	4838	56.26
2	>0% to 1%	3	1540	17.91
3	>1% to 2%	6	863	10.03
4	>2% to 3%	3	621	7.22
5	>3%	1	738	8.58
	TOTAL	**22**	**8600**	**100.00**

TABLE 5.47: DETAILS OF GRADIENTS OF CORRIDOR-2

S. No.	Chainage		Length	Rail Level		Gradient	Remarks
	From	To		From	To		
1	-750	225	975	111.30	111.30	0.00	Level
2	225	300	75	111.30	112.80	2.00	Rise
3	300	1040	740	112.80	112.80	0.00	Level
4	1040	1220	180	112.80	109.10	-2.06	Fall
5	1220	2000	780	109.10	107.00	-0.27	Fall
6	2000	2720	720	107.00	107.00	0.00	Level
7	2720	2960	240	107.00	109.50	1.04	Rise

S. No.	Chainage		Length	Rail Level		Gradient	Remarks
	From	To		From	To		
8	2960	3290	330	109.50	109.50	0.00	Level
9	3290	4028	738	109.50	139.00	4.00	Rise
10	4028	4271	243	139.00	139.00	0.00	Level
11	4271	4367	96	139.00	141.20	2.28	Rise
12	4367	5197	830	141.20	141.20	0.00	Level
13	5197	5427	230	141.20	136.70	-1.96	Fall
14	5427	5542	115	136.70	135.40	-1.13	Fall
15	5542	5777	235	135.40	137.30	0.81	Rise
16	5777	6065	288	137.30	137.30	0.00	Level
17	6065	6267	203	137.30	133.60	-1.83	Fall
18	6267	6612	345	133.60	141.00	2.14	Rise
19	6612	7017	405	141.00	141.00	0.00	Level
20	7017	7542	525	141.00	136.60	-0.84	Fall
21	7542	7850	308	136.60	136.60	0.00	Level

5.4.3.3 Special Span & Portals

Details of locations having special spans and portal arrangement are given in **Table 5.48 & Table 5.49** respectively.

TABLE 5.48: LOCATION OF SPECIAL SPANS CORRIDOR - 2

S. No	Location	Chainage		Configuration Special span
		From	To	
1	Dada Nagar Railway Crossing	4426	4681	75m + 105m + 75m
2	Elevated Road NH-25	6884	6997	34m + 45m + 34m

TABLE 5.49: LOCATION OF PORTALS CORRIDOR - 2

S. No.	Location	Chainage		Length	Purpose
		From	To		
1	Dada Nagar Flyover	5400	5500	100	Alignment runs from one side of flyover to road median

TABLE 5.50: DETAILS OF HORIZONTAL CURVES OF CORRIDOR-2

Curve No	Chainage		Direction	Radius	Intersection Angle			Transition Length		Tangent Length	Curve Length	Total Curve	Straight Between
	Transition	Transition			D	M	S	In	Out				
1	-426.73	-170.58	Left	-400	28	29	4.20	55	55	130.33	146.15	256.15	263.68
2	93.10	184.87	Left	-2000	2	1	55.56	20	20	45.89	51.77	91.77	128.22
3	313.08	592.73	Right	800	17	31	29.28	30	30	140.86	219.65	279.65	534.17
4	1126.90	1578.66	Left	-290	78	13	54.84	55	55	264.32	341.76	451.76	Nil
5	1579.30	1881.93	Right	280	50	24	6.84	55	55	160.28	192.63	302.63	395.67
6	2277.60	2381.86	Right	2000	2	4	25.68	30	30	52.13	44.26	104.26	241.46
7	2623.32	3039.32	Left	-300	68	33	51.84	55	55	233.76	306.00	416.00	253.66
8	3292.98	3404.15	Right	1500	3	3	36.36	30	30	55.60	51.17	111.17	69.14
9	3473.29	3634.47	Right	300	19	11	33.72	60	60	81.15	41.18	161.18	88.26
10	3722.73	3856.46	Right	2000	2	34	54.48	30	30	66.88	73.73	133.73	354.62
11	4211.08	4318.79	Left	-1500	2	34	50.16	30	30	53.87	47.71	107.71	39.54
12	4358.33	4541.75	Right	700	10	33	4.68	50	50	91.92	83.42	183.42	27.83
13	4569.58	4687.80	Right	750	5	34	59.16	40	40	59.15	38.22	118.22	Nil
14	4687.90	4875.47	Left	-220	34	18	48.96	55	55	96.03	77.57	187.57	210.71
15	5086.18	5393.41	Right	500	28	11	41.64	60	60	156.27	187.23	307.23	48.75
16	5442.16	5625.63	Right	600	11	28	21.00	60	60	91.98	63.47	183.47	165.12
17	5790.75	5849.79	Left	-3000	0	30	10.08	15	15	29.52	29.04	59.04	156.40
18	6006.19	6103.76	Right	1200	3	8	0.24	30	30	48.79	37.57	97.57	426.13
19	6529.89	6668.48	Right	1000	5	23	7.80	40	40	69.34	58.59	138.59	135.45
20	6803.93	7178.38	Left	-1000	19	5	40.20	40	40	188.81	294.45	374.45	87.49
21	7265.87	7400.52	Left	-1000	5	15	8.64	40	40	67.37	54.66	134.66	769.48
22	7461.25	7600.69	Left	-1000	5	24	54.72	40	40	69.77	59.44	139.44	569.31
23	7681.27	7853.46	Right	1000	7	20	33.72	40	40	86.20	92.19	172.19	316.54

5.4.3.4 Break-up of Alignment Length

Break-up of alignment length for Corridor-2 is given in **Table 5.51.**

TABLE 5.51: BREAK-UP OF ALIGNMENT LENGTH FOR CORRIDOR-2

S. No.	Description	Chainage (KM)		Length (m)	Method of Construction/ Structure Type
		From	To		
1	Underground	- 750	3460	4210	TBM/Cut & cover/NATM
2	Switch over Ramp	3460	3873	413	Cut & cover
3	Elevated	3873	7850	3977	Box/I/U- Shape Girder
Total Length				**8600**	

5.4.4 STATIONS

- Stations have been located so as to serve major passenger catchment areas and to enable convenient integration with other modes of transport.
- Stations vary in complexity along the route and have been located by an interactive process influenced by ridership forecasts, availability of open land, interchange requirements with other modes of transport, construction feasibility, inter station distance, alignment, utilities, road and pedestrian requirements, future infrastructural developments and joint site visits & consultations with KDA & LMRC.
- Possibility of Parking space at all the stations has also been explored.
- List of stations along with their chainage and interstation distances (ISD) for Corridor-1 and Corridor-2 are given in **Table 5.52 & Table 5.53** respectively**.**

TABLE 5.52: LIST OF STATIONS FOR CORRIDOR-1

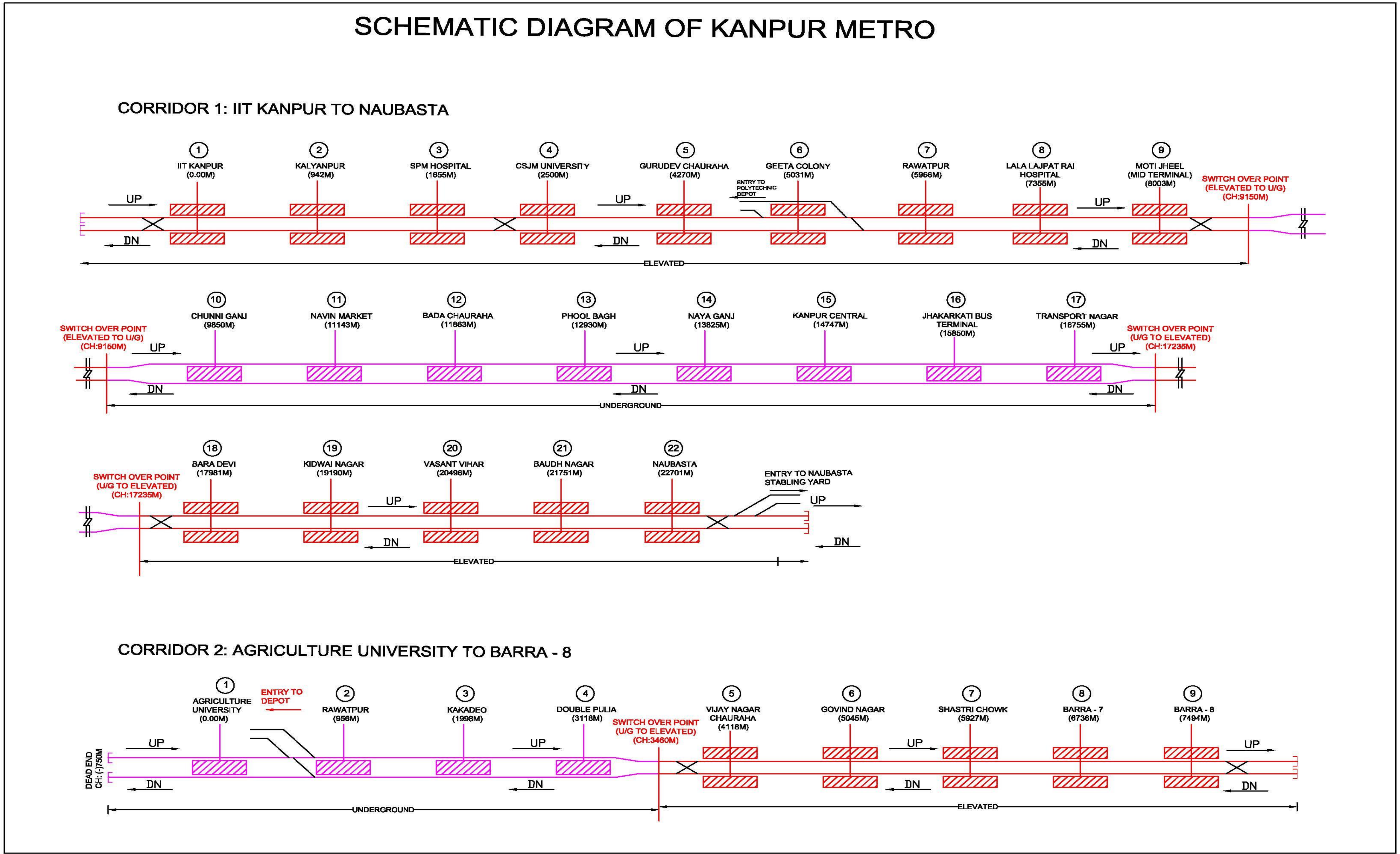
Station Name	Chainage (m)	Inter Station Distance (m)	Existing Ground Level (m)	Proposed Rail Level (m)	Level Difference (m)	Elevated/ Underground	Construction Methodology	Type of Platform
IIT Kanpur	0	-	128.47	141.70	13.23	Elevated	Portal	2- Side Platforms
Kalyanpur Rly Stn	942	942	128.16	141.50	13.34	Elevated	Portal	2- Side Platforms
SPM Hospital	1655	713	127.23	140.50	13.28	Elevated	Portal	2- Side Platforms
CSJM University	2500	845	126.83	140.00	13.17	Elevated	Portal	2- Side Platforms
Gurudev Chauraha	4270	1770	127.99	141.20	13.21	Elevated	Portal	2- Side Platforms
Geeta Nagar	5031	761	127.18	139.30	12.12	Elevated	Portal	1- Side & 1-Island Platform
Rawatpur Rly Stn	5966	935	127.22	142.10	14.89	Elevated	Portal	2- Side Platforms
Lala Lajpat Rai Hospital	7355	1389	126.90	140.50	13.60	Elevated	Portal	2- Side Platforms
Moti Jheel	8003	648	127.00	139.80	12.80	Elevated	Portal	2- Side Platforms
Chunniganj	9850	1847	125.96	109.50	-16.46	Underground	Cut & Cover	Island Platform
Navin Market	11143	1293	124.56	106.60	-17.96	Underground	Cut & Cover	Island Platform
Bada Chauraha	11863	720	123.35	107.00	-16.35	Underground	Cut & Cover	Island Platform
PhoolBagh	12930	1067	125.39	109.00	-16.39	Underground	Cut & Cover	Island Platform
Nayaganj	13825	895	126.04	106.00	-20.04	Underground	NATM	Island Platform
Kanpur Central Rly Stn	14747	922	126.34	106.00	-20.34	Underground	Cut & Cover	Island Platform
Jhakkarkati Bus Terminal	15850	1103	125.99	110.90	-15.09	Underground	Cut & Cover	Island Platform
Transport Nagar	16755	905	126.38	110.00	-16.38	Underground	Cut & Cover	Island Platform

Station Name	Chainage (m)	Inter Station Distance (m)	Existing Ground Level (m)	Proposed Rail Level (m)	Level Difference (m)	Elevated/ Underground	Construction Methodology	Type of Platform
Bara Devi	17981	1226	127.13	140.60	13.47	Elevated	Portal	2- Side Platforms
Kidwai Nagar	19190	1209	127.54	141.30	13.76	Elevated	Portal	2- Side Platforms
Vasant Vihar	20496	1306	126.59	139.11	12.52	Elevated	Portal	2- Side Platforms
Baudh nagar	21751	1255	125.98	139.31	13.33	Elevated	Portal	2- Side Platforms
Naubasta	22701	950	126.09	140.00	13.92	Elevated	Portal	2- Side Platforms

TABLE 5.53: LIST OF STATIONS FOR CORRIDOR-2

Station Name	Chainage (m)	Inter Station Distance (m)	Existing Ground Level (m)	Proposed Rail Level (m)	Level Difference (m)	Elevated/ Underground	Construction Methodology	Type of Platform
Agriculture Universuity	0	-	126.91	112.80	-15.00	Underground	Cut & Cover	Island Platform
Rawatpur Rly Stn	956	956	128.56	112.80	-15.76	Underground	Cut & Cover	Island Platform
Kakadeo	1998	1042	125.82	107.00	-18.82	Underground	Cut & Cover	Island Platform
Double Pulia	3118	1120	125.00	109.50	-15.50	Underground	Cut & Cover	Island Platform
Vijay Nagar Chauraha	4118	1000	125.51	139.00	13.49	Elevated	Portal	2- Side Platforms
Govind Nagar	5045	927	125.56	141.20	15.64	Elevated	Portal	2- Side Platforms
Shastri Chowk	5927	882	123.13	137.30	14.17	Elevated	Portal	2- Side Platforms
Barra-7	6736	809	124.20	141.00	16.80	Elevated	Portal	2- Side Platforms
Barra-8	7494	758	123.76	136.60	12.84	Elevated	Portal	2- Side Platforms

FIGURE 5.48: SCHEMATIC DIAGRAM OF KANPUR METRO



5.5 IDENTIFICATION OF EXISTING SERVICE / UTILITIES

5.5.1 Introduction

- Large number of sub-surface, surface and overhead utility services viz. sewers, water mains, storm water drains, gas pipe lines, telephone/ communication cables, Overhead power transmission lines, power cables, traffic signals, etc. exists all 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 and relocation or by supporting in position. Any interruption to these will have serious repercussions on the most sensitive suburban services and direct impact on the public besides set back in construction and project implementation schedule & costs. Therefore, meticulous detailed survey and planning will be required to protect/divert the utility services.

- Accordingly, overhead utiliites were identified during physical survey of corridor. Moreover, liaison with concernd utitlity owners was made for identificaton and mapping of various underground utilities. No trenching / GPR survey etc. was conducted for underground utilities.

5.5.2 Agencies for Utility Services

For identification of likely utilities in the proposed metro corridor -1 (IIT Kanpur to Naubasta) and Corridor -2 (Agriculture University to Barra -8), liaison was made with following Organizations/Departments presented in **Table 5.54.**

TABLE 5.54: UTILITY RESPONSIBILITY DEPARTMENTS

SN	Organization/ Department	Utility Services
1	NH Division of PWD Kanpur	Road Construction and maintenance of National Highways
2	PWD	City Road and Highways
3	Indian Railways	Railway crossings, subways, signals, railway bridges etc.
4	Kanpur MC-Jal Nigam	Water pipe lines.
5	Jal Kal Vibhag	Sewer lines and Water lines
6	Kanpur Electricity Supply Company Ltd. (KESCo)	HT/other overhead Power lines.
7	Kanpur MC-Sewerage	Sewerage pipe lines.
8	Kanpur MC-Storm Water Drains	Storm water drainage.

SN	Organization/ Department	Utility Services
9	Irrigation Dept.	Canal
10	Gas Authority of India (GAIL).	Gas Pipelines
11	IOCL/Central U.P. Gas Limited	Gas pipe lines
12	BSNL (OFC)	Telecommunications cables, junction boxes, telephone posts, O.H lines.
13	BSNL (Cables)	Telecommunications cables, junction boxes, telephone posts, O.H. Lines.
14	Airtel	Telecommunications cables, junction boxes, telephone posts, etc.
15	Aircel	Telecommunications cables, junction boxes, telephone posts, etc.
16	Vodafone	Telecommunications cables, junction boxes, telephone posts, etc.
17	Idea	Telecommunications cables, junction boxes, telephone posts, etc.
18	Reliance	Telecommunications cables, junction boxes, telephone posts, etc.
19	Uninor	Tele cables, junction boxes, telephone posts, etc.

5.5.3 Guidelines for Diversion of Underground Utilities

While planning for diversion of underground utility services viz. sewer lines, water pipelines, cables, etc., during construction of MRTS, 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. The utility service can also be encased within the foundation piles.

5.5.4 Sewer Lines, Storm Water Drains and Water Lines

The storm water drains and water pipe lines generally exists either side of under main carriageway or at some places on the central verge, as a result of subsequent road widening. However, majority of sewer lines are running in the centre of the road. The major sewer, storm water drains and water pipe lines 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 the 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. Summary of sewer lines & storm water drains and water pipe lines affected are indicated in **Table 5.55 to Table 5.57**.

TABLE 5.55: SUMMARY OF SEWER LINES OF JAL KAL VIBHAG

Dia. (M)	Diversion Length (M) Corridor I	Diversion Length (M) Corridor II	Diversion Length (M) Corridor I & II
0.3	1850	300	**2150**
0.35	380	0	**380**
0.45	1335	350	**1685**
0.6	2050	0	**2050**
0.9	2450	400	**2850**
1.2	965	0	**965**
1.8	2964	0	**10080**
	11994	**1050**	**20160**

TABLE 5.56: SUMMARY OF SEWER LINES OF JAL NIGAM

Dia. (M)	Diversion Length (M) Corridor I	Diversion Length (M) Corridor II	Diversion Length (M) Corridor I & II
0.6	790	1250	**2040**
0.8	1860	0	**1860**
1	3650	0	**3650**

Dia. (M)	Diversion Length (M) Corridor I	Diversion Length (M) Corridor II	Diversion Length (M) Corridor I & II
1.2	2580	0	**2580**
1.4	3030	1250	**4280**
2	870	0	**870**
	12780	**2500**	**15280**

TABLE 5.57: SUMMARY OF WATER PIPE LINES OF JAL KAL VIBHAG

Dia. (M)	Diversion Length (M) Corridor I	Diversion Length (M) Corridor II	Diversion Length (M) Corridor I & II
0.1	500	0	**500**
0.3	3325	2150	**5475**
0.4	1650	0	**1650**
0.5	0	0	**0**
0.6	0	2150	**2150**
0.7	50	0	**50**
0.15	1100	200	**1300**
0.25	660	0	**660**
1.1	1015	0	**1015**
1.2	50	0	**50**
1.4	50	0	**50**
1.5	0	0	**0**
2.1	186	3340	**3526**
Total	**8586**	**4500**	**11785**

5.5.5 Canal Crossing

The details of canals have been collected from the irrigation department. Most of the canals are of British period and are presently abandoned/filled with soil. As such, such abandoned/filled canals need not to be diverted for construction of Metro corridors, but care should be taken to place the founding level of piers/columns of elevated viaduct/station buildings and another structures below the filled up depth. The details of canals are as shown in **Table 5.58.**

5.5.6 Telecom Cables, OFC, Ducts and Trench

At several places, telecom cables, OFC, ducts and trenches of Vodafone, Idea, Aircel, Airtel and BSNL are also running along and across the proposed corridors and few of them are likely to be affected.

5.5.7 Gas Pipe Lines

Few gas pipe lines with varying diameters belonging to Central UP Gas Ltd. are running along and across the roads along which the metro alignment is proposed. Though, the alignment is planned almost along the road, en-route few pipelines running across and along the alignment likely to be affected by the alignment are summarised in **Table 5.59.**

5.5.8 Above Ground Utilities

Above ground utilities namely Power transmission lines, transformers are running along and across the proposed corridors and few of them are likely to be affected. Detail of transformers and HT Lines are presented in **Table 5.60 & 61** respectively.

TABLE 5.58: DETAILS OF CANALS

S. No	From Ch. (m)	To Ch. (m)	LHS/ RHS	Position of Alignment	Remarks
Corridor-1					
1	7900	7900	FROM RHS	PERPENDICULAR	very old canal of british time, now filled with soil and pipe line is under the canal
2	13000	13000	FROM RHS	PARALLEL	very old canal of british time, now abonded and filled. now known as canal road.
Corridor-2					
1	1800	1800	ACROSS	PERPENDICULAR	very old canal of british time, now filled with soil and pipe line is under the canal.
2	5580	5580	ACROSS	PERPENDICULAR	8 m wide canal coming from kanpur branch and goes towards sarsouli - halwa khanda distributory canal

TABLE 5.59: SUMMARY OF GAS PIPE LINES OF CENTRAL UP

Type	Diversion Length (M) Corridor I	Diversion Length (M) Corridor II	Diversion Length (M) Corridor I & II
Carbon Steel	2595	935	**3530**
MDPE	1420	650	**2070**
Total	**4015**	**1585**	**5600**

TABLE 5.60: DETAILS OF TRANSFORMERS

S. No.	Utility	From Ch. (m)	LHS/Rhs	Remarks
CORRIDOR-1: IIT KANPUR - NAUBASTA				
1	TRANSFORMER	100	RHS	250 KVA
2	TRANSFORMER	850	LHS	250 KVA
3	TRANSFORMER	1122	LHS	250 KVA
4	TRANSFORMER	1800	RHS	250 KVA
5	TRANSFORMER	2800		250 KVA
6	TRANSFORMER	4200	LHS	250 KVA
7	TRANSFORMER	4250	LHS	250 KVA
8	TRANSFORMER	6368	LHS	250 KVA
9	TRANSFORMER	6515	LHS	250 KVA
10	TRANSFORMER	6761	LHS	400 KVA
11	TRANSFORMER	10000	LHS	400 KVA
12	TRANSFORMER	10000	LHS	400 KVA
13	TRANSFORMER	11000	LHS	900 KVA
14	TRANSFORMER	11000	LHS	900 KVA
15	TRANSFORMER	11000	LHS	900 KVA
16	TRANSFORMER	11380	RHS	900 KVA
17	TRANSFORMER	12700	RHS	400 KVA
18	TRANSFORMER	14600	RHS	400 KVA
19	TRANSFORMER	14600	LHS	400 KVA
CORRIDOR-2: AGRICULTURE UNIVERSITY - BARRA-8				
1	TRANSFORMER	-700	RHS	5 MVA
2	TRANSFORMER	1500	LHS	400 KVA
3	TRANSFORMER	52050	LHS	400 KVA

TABLE 5.61: DETAILS OF HT-LINES

S. No	Utility	From Ch. (m)	To Ch. (m)	LHS/ RHS	Position of Alignment	Remarks
CORRIDOR-1: IIT KANPUR - NAUBASTA						
1	HT LINE	-450	-450	LHS	PERPENDICULAR	3X70 SQMM CABLE (250 KV), DOG CONDUCTOR, 325A
2	HT LINE	-450	4400	LHS	PARALLEL	CABLE (250 KV), DOG CONDUCTOR, 325A
3	LT LINE	620	1121	LHS	PARALLEL	CABLE (11 KV), 128A
4	LT LINE	2500	2800	LHS	PARALLEL	CABLE (11 KV), 128A
5	OVER HEAD LINE	3600	3600	RHS	PERPENDICULAR	33 KV LINE, 4 NO.S (UG) 3X300 SQM

S. No	Utility	From Ch. (m)	To Ch. (m)	LHS/ RHS	Position of Alignment	Remarks
6	OVERHEAD LINE	3600	3600	LHS	PERPENDICULAR	33KV LINE, 425A, DOUBLE CIRCUIT, DC LINE, 2 NOS.
7	LT LINE	3600	4200	LHS	PARALLEL	CABLE (11 KV), 128A
8	DOUBLE CIRCUIT LINE	4400	4400	LHS	PERPENDICULAR	CABLE (33KVA), 325A, 2 NOS DOUBLE CIRCUIT
9	HT LINE	4400	4400	LHS	PERPENDICULAR	CABLE (250 KV), DOG CONDUCTOR, 325A
10	HT LINE	4400	6761	RHS	PARALLEL	CABLE (33KVA), 325A, DOG CONDUCTOR
11	HT LINE	4400	4450	LHS	PARALLEL	CABLE (33KVA), 325A, DOG CONDUCTOR, UG
12	HT LINE	4450	8900	LHS	PARALLEL	CABLE (33KVA), 325A, DOG CONDUCTOR
13	HT LINE	6368	6761	LHS	PARALLEL	CABLE (11KV), 325A, DOG CONDUCTOR
14	HT LINE	6761		ALONG	LONGITUDINAL	UG CABLE (33KVA), 325A, DOG CONDUCTOR
15	HT LINE	7200	7200	ACROSS	PERPENDICULAR	BOTH HT LINE MEET EACH OTHER
16	HT LINE	7200		RHS	PARALLEL	CABLE (11KV), 325A, DOG CONDUCTOR
17	LT LINE	9490	9886	LHS	PARALLEL	CABLE (6.6KV), 250A, WEISEL CONDUCTOR
18	LT LINE	9490	9886	RHS	PARALLEL	CABLE (6.6KV), 250A, WEISEL CONDUCTOR
19	LT LINE	10100		RHS	PERPENDICULAR	CABLE 110A, AIR BUNCH CONDUCTOR
20	LT LINE	9900	9900	ACROSS	PERPENDICULAR	BOTH LT LINE MEET EACH OTHER
21	LT LINE	9490	10130	LHS	PARALLEL	CABLE (6.6KV), 250A, WEISEL CONDUCTOR
22	HT LINE	10130	10710	LHS	PARALLEL	CABLE (33KV), 325A, DOG CONDUCTOR
23	HT LINE	10710	11000	LHS	PARALLEL	CABLE (11KV), 325A, DOG CONDUCTOR
24	LT LINE	10130	10710	RHS	PARALLEL	CABLE 110A, AIR BUNCH CONDUCTOR 3X95 SQMM
25	LT LINE	10710	10710	ACROSS	PERPENDICULAR	BOTH LT LINE MEET EACH OTHER
26	HT LINE	10710	11000	RHS	PARALLEL	CABLE (11KV), 325A, DOG CONDUCTOR
27	LT LINE	11380	11702	RHS	PARALLEL	CABLE (6.6KV) 250A, WEISEL CONDUCTOR
28	LT LINE	11702	12300	LHS	PARALLEL	CABLE (6.6KV) 128A, WEISEL CONDUCTOR

S. No	Utility	From Ch. (m)	To Ch. (m)	LHS/ RHS	Position of Alignment	Remarks
29	HT LINE	11702		LHS	PERPENDICULAR	CABLE (11KV), 325A, DOG CONDUCTOR
30	HT LINE	12339		LHS	PERPENDICULAR	CABLE (33KV), 325A, DOG CONDUCTOR
31	HT LINE	12500	12827	RHS	PARALLEL	CABLE (11KV), 325A, DOG CONDUCTOR
32	HT LINE	12600	13000	LHS	CURVE	CABLE (11KV), 325A, DOG CONDUCTOR
33	HT LINE	12773	14500	LHS	PARALLEL	CABLE (33KV), 325A, DOG CONDUCTOR
34	LT LINE	14600		RHS	LONGITUDINAL	CABLE (11KV), 128A, WEISEL CONDUCTOR
35	HT LINE	16251	17500	LHS	PARALLEL	CABLE (33KV), 325A, DOG CONDUCTOR
36	HT LINE	16251	17500	RHS	PARALLEL	CABLE (33KV), 325A, DOG CONDUCTOR
37	HT LINE	17500	17900	LHS	PARALLEL	CABLE (33KV), 325A, DOG CONDUCTOR
38	HT LINE	17500	18683	RHS	PARALLEL	CABLE (11KV), 325A, DOG CONDUCTOR
39	HT LINE	17900	21000	LHS	PARALLEL	CABLE (11KV), 325A, DOG CONDUCTOR
40	HT LINE	18683	20100	RHS	PARALLEL	CABLE (33KV), 325A, DOG CONDUCTOR
41	LT LINE	20080	20080	ACROS S	PERPENDICULAR	BOTH LT LINE MEET EACH OTHER
42	HT LINE	20100	23252	RHS	PARALLEL	CABLE (33KV), 325A, DOG CONDUCTOR
43	HT LINE	21000	23252	LHS	PARALLEL	CABLE (33KV), 325A, DOG CONDUCTOR
44	HT LINE	21000	23252	LHS	PARALLEL	CABLE (33KV), 325A, DOG CONDUCTOR
45	HT LINE	21000	23252	LHS	PARALLEL	CABLE (33KV), 325A, DOG CONDUCTOR
CORRIDOR- 2: AGRICULTURE TO BARRA- 8						
1	LT LINE	-700	0.000	LHS	PARALLEL	CABLE (6.6KV) 128A, AIR BUNCH CONDUCTOR
3	LT LINE	1250		RHS	PERPENDICULAR	CABLE (11KV) 325A, DOG CONDUCTOR
4	LT LINE	1250	1900	LHS	PARALLEL	CABLE (11KV) 325A, DOG CONDUCTOR
5	LT LINE	1727	2000	LHS	PARALLEL	CABLE (440V) 125A, WEISEL CONDUCTOR
6	LT LINE	2039	2220	LHS	PARALLEL	CABLE (440V) 125A, WEISEL CONDUCTOR
10	LT LINE	2200	2500	LHS	PARALLEL	CABLE (440V) 125A, WEISEL CONDUCTOR

S. No	Utility	From Ch. (m)	To Ch. (m)	LHS/ RHS	Position of Alignment	Remarks
11	HT LINE	2800	3700	LHS	PARALLEL	CABLE (33KV),325A, DOG CONDUCTOR
12	HT LINE	2800	4399	RHS	PARALLEL	CABLE (33KV), 325A, DOG CONDUCTOR
13	LT LINE	4928	4928	ACROSS	PERPENDICULAR	CABLE (11KV) ,125A, WEISEL CONDUCTOR
14	LT LINE	5205	5580	LHS	PARALLEL	CABLE (11KV) ,125A, WEISEL CONDUCTOR
16	HT LINE	6000	6900	LHS	PARALLEL	CABLE (33KV), 325A, DOG CONDUCTOR
17	HT LINE	6000	6900	CENTRE	PARALLEL	CABLE (33KV), 325A, DOG CONDUCTOR
18	HT LINE	6000	6900	RHS	PARALLEL	CABLE (33KV), 325A, DOG CONDUCTOR
19	HT LINE	6900	7000	LHS	PARALLEL	CABLE (33KV), 325A, DOG CONDUCTOR
20	HT LINE	6900	7000	CENTRE	PARALLEL	CABLE (33KV), 325A, DOG CONDUCTOR
21	HT LINE	6900	7000	RHS	PARALLEL	CABLE (33KV), 325A, DOG CONDUCTOR
22	HT LINE	7000	7800	LHS	PARALLEL	CABLE (33KV), 325A, DOG CONDUCTOR
23	HT LINE	7000	7800	CENTRE	PARALLEL	CABLE (33KV), 325A, DOG CONDUCTOR
24	HT LINE	7000	7800	CENTRE	PARALLEL	CABLE (33KV), 325A, DOG CONDUCTOR
25	HT LINE	7000	7800	CENTRE	PARALLEL	CABLE (33KV), 325A, DOG CONDUCTOR
26	HT LINE	7000	7800	RHS	PARALLEL	CABLE (33KV), 325A, DOG CONDUCTOR

5.6 LAND REQUIREMENT

5.6.1 Main Component

Land will be required for the following main 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.

5.6.2 Land for Underground stretches

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

5.6.3 Land for Switch-over Ramps

Switchover ramps are required for transition from the elevated to underground section and vice versa. The ramp covers a stretch at ground for the whole width of structure for two tracks. 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.

For Corridor-1 an area of 4575 sqm and 3892 sqm has been proposed in B.S. Park and along Hamirpur Road for locating ramps. For Corridor-2 an area of 4134 sqm has been proposed for ramp along Kalyanpur – Vijay Nagar Road.

5.6.4 Land for Traffic integration

Govt. land has been proposed for integration with Rail system, Metro corridors and Bus system.

5.6.5 Land for Maintenance Depot

About 21.90 Hectares of Govt. Polytechnic College land for major Depot and about 6.75 Hectares of Housing Board land for minor depot has been proposed for corridor-1. About 12.50 Hectares of Govt. Agriculture University land for major Depot has been proposed for corridor-2. List of Structures to be relocated at Polytechnic College and UPSRTC Workshop at Rawatpur are given in **Table 5.62 & Table 5.63** respectively.

TABLE 5.62: LIST OF POLYTECHNIC COLLEGE STRUCTURES TO BE RELOCATED

S.No.	Building	Floor Area of Structures (Sqm)
1	Polytechnic Main Bldg(G+1)	20188
2	01 Girls Hostel (G+2)	1788
3	Boys Hostel (G+1)	6948

S.No.	Building	Floor Area of Structures (Sqm)
4	Boys Hostel (G+0)	1705
5	Boys Hostel (G+1)	1058
6	Vishveshariya Boys Hostel (G+1)	1522
7	U/C Building (G+2)	1209
8	Staff Qtrs 12 locations (G+0),	3702
9	IT Deptt (G+1)	894
10	Comp. Application & C.R.(G+1)	1128
11	Textile Technology (G+0).	1289
12	Textile Chem. W/S + one Bldg (G+0)	4914
13	Civil Deptt (G+1)	1058
14	Computer Development (G+0)	718
15	AICTE Building (G+1)	874
16	Training Institute AICTE (G+2)	1122
17	Miscellaneous Structures	1883
	Total	**52000**

TABLE 5.63 : LIST OF UPSRTC WORKSHOR STRUCTRES AT RAWATPUR TO BE RELOCATED FOR STATION/PARKING/PD

Building No.	Ownership	Type of Structure	Area (Sqm)	Floor Area (Sqm)
1	UPSRTC	W/S Shed	138	138
2	UPSRTC	W/S Shed	4239	4239
3	UPSRTC	W/S Shed	3604	3604
4	UPSRTC	W/S Shed	478	478
5	UPSRTC	W/S Shed	518	518
6	UPSRTC	W/S Shed	608	608
7	UPSRTC	W/S Shed	901	901
8	UPSRTC	W/S Shed	400	400
9	UPSRTC	W/S Shed	502	502
10	UPSRTC	W/S Shed	628	628
11	UPSRTC	W/S Shed	135	135
12	UPSRTC	W/S Shed	442	442
13	UPSRTC	W/S Shed	271	271
14	UPSRTC	W/S Shed	1791	1791
15	UPSRTC	W/S Shed	434	434
16	UPSRTC	W/S Shed	554	554
17	UPSRTC	W/S Shed	598	598
18	UPSRTC	W/S Shed	337	337
19	UPSRTC	W/S Shed	116	116

Building No.	Ownership	Type of Structure	Area (Sqm)	Floor Area (Sqm)
20	UPSRTC	W/S Shed	576	576
21	UPSRTC	Cluster of Houses	432	432
22	UPSRTC	Govt Quarters G+1	114	228
Total			**17816**	**17930***

* Out of 17930 sqm floor area, 10000 sqm is required for parking/PD.

5.6.6 Land for TSS, RSS, ASS and DG Sets

Total of two TSS have been proposed on the corridor-I at Phoolbagh and Naubasta and one in Corridor-II at Barra-8. An area of 3500 sqm has been proposed for each TSS**.** ASS and DG Sets are required at all stations.

5.6.7 Temporary Construction Depot

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.

Also, large numbers of pre-cast tunnel segments are required for construction of tunnels for which a large Open area is required for setting up of casting yard. As far as possible, this area will be in temporary construction depot.

Since the area of land being acquired permanently at most of the stations is bare minimum, the land required for construction depots purpose is identified throughout the corridor, in the vicinity of the stations on temporary acquisition basis. 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.

About **20.2 Hac** land for Corridor-I and **9.0 Hac** for Corridor-II is proposed for construction depots along the corridor. At the time of construction, depending upon the need, area requirements, the location and size can be reassessed and temporary land acquisitions can be made accordingly.

TABLE 5.64: LAND TEMPORARILY REQUIRED FOR CONSTRUCTION DEPOT

S. No.	Station Name	Land Details	Govt. / Pvt.	Area (Sqm)
Corridor - 1: IIT Kanpur to Naubasta				
1	SPM Hospital	Awas Vikas	State Govt.	60000

S. No.	Station Name	Land Details	Govt. / Pvt.	Area (Sqm)
2	Moti Jheel	Brijendra Swaroop Park	State Govt.	45000
3	Phoolbagh	Phoolbagh	State Govt.	37000
4	Transport Nagar	Swadeshi Mill	Central Govt. (NTC)	60000
Corridor -2: Agriculture University to Barra 8				
5	Double Pulia	Central Park	State Govt.	30000
6	Shastri Chowk	PAC Land	State Govt.	60000
			Total Land	**292000**

5.6.8 Summary of Land Requirement

Abstract of land requirements for different components of corridors are given in **Table 5.65 & Table 5.66.** However, the land requirement is summarized below:

TABLE 5.65: CORRIDOR-1- LAND & STRUCTURES REQUIREMENT (IN HA)

Ownership	Purpose	Permanent Land (Ha)	Temporary Land (Ha)	Structures (Floor area)
Central Govt	Alignment / Stations etc	0.12 (NC Railway at Kanpur Central Railway Station Entry / Exit	0.92, For UG stns (NC Railway land - 0.8 Ha at Kanpur Central station for Kanpur Metro Station + 0.12 Ha near Jhakkarkati bus terminal)	0.0054
	Casting Yard	0	6.0 (Swadeshi Cotton Mill, NTC)	0
	Total	**0.12**	**6.92**	**0.0054**
State Govt	Alignment / Stations etc	3.50 (including 1 Ha State Gvt land occupied by Squatters at Transport Nagar)	4.64	1.22
	Depot	28.65 (including 1.92 Ha land for PD, parking)	0	5.21
	Parking cum PD	57.995 (including 40 Ha Samaj Kalyan Land)	0	0
	Casting Yard	0	14.20	0
	RSS	0.60	0	0
	Ancillary buildings & Misc.	0.20	0.10	0.10
	Total	**90.945**	**18.94**	**6.53**
Private	Alignment / Stations etc	0.54	0	0.95

Ownership	Purpose	Permanent Land (Ha)	Temporary Land (Ha)	Structures (Floor area)
	Parking cum PD	1.7	0	0
	Ancillary buildings & Misc.	0.1	0	0.1
	Total	**2.34**	**0**	**1.05**
Squatters	Transport Nagar UG Station	**0**	**0**	**0.7**
Grand Total		**93.405**	**25.86**	**8.29**

TABLE 5.66: CORRIDOR-2 - LAND & STRUCTURES REQUIREMENT (IN HA)

Ownership	Purpose	Permanent Land (Ha)	Temporary Land	Structures (Floor area)
Central Govt	Alignment / Stations	0	0	0
	Casting Yard	0	0	0
	Total	**0**	**0**	**0**
State Govt	Alignment / Stations	0.77 (including 0.3 Ha State Gvt land occupied by Squatters at Dada Nagar)	2.4	0.8
	Depot	12.5 (including 2 Ha land for PD / parking)	0	0.0535
	Parking cum PD	5.19 (including 2.67 Ha UPSRTC Land)		1.0
	Casting Yard	0	9.0	0
	RSS	0.3	0	0
	Ancillary buildings & Misc.	0.1	0.1	0.1
	Total	**18.86**	**11.5**	**1.95**
Private	Entry Exit at Shastri Chowk, Ancillary buildings, Temples & Misc.	0.12	0	0.12
	Total	**0.12**	**0**	**0.12**
Squatters	After CNB-DLI railway tracks at Dada Nagar UG Station	**0**	**0**	**0.3**
Grand Total		**18.98**	**11.50**	**2.38**

* Inclusive of land area required for depot connectivity.

5.7 OWNERSHIP DETAILS OF THE LAND REQUIRED FOR THE CORRIDORS

5.7.1 Details of Land Required for Corridor-1

TABLE 5.67: DETAILS OF PERMANENT LAND REQUIRED FOR CORRIDOR-1

Area in SQM

S.N.	Location	Chainage from (m)	Chainage to (m)	Owner	Purpose	Details of Properties	Land Area	Floor Area
1	CSJM University	2455	2461	State Govt	Station Elevated	Passenger Shed	0	14
2	Gurudev Chauraha Station.	4315	4327	State Govt	Station Elevated	Traffic Police Chowki	0	59
3	Mid Section	4556	4587	State Govt	Depot Connectivity from Geeta Nagar	Bus Shed	0	52
4	Geeta Nagar Station	5022	5079	State Govt	Station Elevated	Part of PWD Store & G.I. Sheet Str. (G+0)	418	418
5	Geeta Nagar Station	5085	5140	Private	Station Elevated & Depot Connectivity	15 Shops G.I sheets (G+0), Vehicle Repair Shop to Divya telecom	584	584
6	Mid Section	5811	5893	Private	Alignment Viaduct	40 Shops (G+0 / G+1)	670	900
7	Rawatpur Station	5896	5925	Private	Station Elevated	Mahoba Pan Shop + 2 Shops, G+0	203	203
8	Rawatpur Station	5988	5994	Private	Station Elevated	Temple Bldg	0	24
9	Rawatpur Station	6005	6012	State Govt	Station Elevated	Bus Shed	0	10
10	Rawatpur Station	6027	6075	Private	Station Entry/Exit	07 shops (G+0) from Prabhukripa to Gurudev Garments	560	560
11	Rawatpur Station	6059	6086	State Govt	Alignment Viaduct	Building (G+3), UPSRTC	195	780
12	Mid Section	6790	7060	State Govt	Alignment Viaduct	GSVM Med College land	1935	0
13	Mid Section	6846	6851	State Govt	Alignment Viaduct	Ghumti GSVM	0	26
14	Mid Section	6958	6972	State Govt	Alignment Viaduct	02 Sheds (G+0), GSVM	0	14

S.N.	Location	Chainage from (m)	Chainage to (m)	Owner	Purpose	Details of Properties	Land Area	Floor Area
15	Lala Lajpat Rai Hospital Stn	7160	7500	State Govt	Alignment Viaduct & Elevated Station	Hospital Land	5442	0
16	Lala Lajpat Rai Hospital Stn	7346	7351	State Govt	Station Elevated	statue	0	13
17	Mid Section	7517	7530	State Govt	Alignment Viaduct	Open Shed (G+0)	0	71
18	Mid Section	7522	7533	State Govt	Alignment Viaduct	Govt Build (G+0)	83	83
19	Mid Section	7540	7546	State Govt	Alignment Viaduct	01 Shelter Home(G+0)	0	89
20	Mid Section	7546	7551	State Govt	Alignment Viaduct	Govt. Structure (G+0)	0	59
21	Mid Section	7551	7554	State Govt	Alignment Viaduct	SBI ATM (G+0)	0	32
22	Mid Section	7660	7685	State Govt	Alignment Viaduct	2 Statues	0	6
23	Mid Section	7737	7745	State Govt	Alignment Viaduct	01 Resi Builg (G+0), CE, KDA Bunglow	200	200
24	Mid Section	7844	7848	State Govt	Alignment Viaduct	01 abandoned Toilet (G+0)	0	41
25	Mid Section	8005	8023	State Govt	Station Elevated	02 Bus Shed	0	14
26	Mid Section	8071	8108	State Govt	Station Entry/Exit	Part of Primary School, Benajhawar, Land	284	0
27	Mid Section	8105	8118	State Govt	Alignment Viaduct	Resi. Bldg. A-1, Sanyukt Sachiv	200	200
28	Mid Section	8160	8184	State Govt	Alignment Viaduct	UP Sachiv/KDA (G+1) & Financial Controller KDA(G+1)	345	690
29	Mid Section	8194	8205	State Govt	Alignment Viaduct	Jal Kal (G+1)	0	260
30	Mid Section	8205	8217	State Govt	Alignment Viaduct	Shed (G+0)	0	45
31	Mid Section	8314	8377	State Govt	Alignment Viaduct	05 Govt Resi Bldg. (G+1)	0	1102
32	Mid Section	8347	8354	State Govt	Alignment Viaduct	Hut Cluster	0	42

S.N.	Location	Chainage from (m)	Chainage to (m)	Owner	Purpose	Details of Properties	Land Area	Floor Area
33	Mid Section	8402	8412	State Govt	Alignment Viaduct	01 Govt Resi for staff(G+1)	0	142
34	Mid Section	8441	8452	State Govt	Alignment Viaduct	01 Govt Resi for staff(G+1)	87	174
35	Moti Jheel Station	7510	8500	State Govt	Alignment Viaduct & Elevated Station	Moti Jheel Land	10093	0
36	Mid Section	8527	8531	Private	Alignment Viaduct	Isha Car Bazar (G+0)	40	40
37	Mid Section	8531	8536	Private	Alignment Viaduct	Uth Collection(G+0)	40	40
38	B.S. Park	8564	8582	State Govt	Alignment Viaduct	Scout Bhawan (G+0)	0	176
39	B.S. Park & Palika Stadium Rd	8520	9029	State Govt	Alignment Elevated & Ramp	Land	4575	0
40	Naya Purva upto Nala	8912	9150	Private	Alignment Elevated & Ramp	Land	1000	0
41	Naya Purva	9096	9128	Private	Alignment Ramp	Resi (G+0/G+1)	0	2000
42	Lal Imli	9190	9254	Private	Alignment Ramp & U/G	02 Nos. (G+0) Old Abandoned Shed G.I. Sheets	0	1126
43	Chuni Ganj Stn	9765	9776	State Govt	Station	02 Public Toilet (G+0)	113	133
44	Chuni Ganj Stn	9802	9856	State Govt	Station	Balika Inter College	3400	3744
45	Chuniganj Stn	9909	9931	State Govt	Station	01 Govt. Resi (G+2)	0	1000
46	Chuniganj Stn	9930	9962	State Govt	Station	01 Fire Stn (G+1)	0	1000
47	Bada Chauraha Stn	11743	11762	State Govt	Station	FOB	0	130
48	Bada Chauraha Stn	11743	11791	Private	Station Entry/Exit	Land C.C College	238	0
49	Bada Chauraha Stn	11786	11789	Private	Station	Temple Bldg	0	7

S.N.	Location	Chainage from (m)	Chainage to (m)	Owner	Purpose	Details of Properties	Land Area	Floor Area
50	Bada Chauraha Stn	11916	11920	Private	Station	Temple Bldg	0	13
51	Bada Chauraha Stn	11942	11960	Private	Station Entry/Exit	Sweekriti Restaurant Bldg. & Shed	134	134
52	Bada Chauraha Stn	11928	11975	Private	Station Entry/Exit	Land C.C College	335	0
53	Bada Chauraha Stn	11731	11996	Private	Road Diversion during const. later permanently for PD	Land C.C College	0	500
54	Bada Chauraha Stn	11900	11930	Private	Road Diversion during const. later permanently for PD	HPCL Petrol Pump	500	500
55	PhoolBagh Stn	12823	12954	State Govt	Station Entry/Exit	Phoolbagh Land	530	0
56	Phoolbagh Station	12812	12815	State Govt	Station	Statue	0	15
57	Phoolbagh Station	12969	12973	State Govt	Station	Statue	0	15
58	Nayaganj Stn	13890	13950	State Govt	Station	Ran Basera, KESCO bldg, Laxman park	3625	1300
59	Nayaganj Stn	13890	13950	Private	Station	Ancillary Buidings & Misc.	1000	2500
60	Corridor I	-450	23250	Private	PD cum Parking	Various locations	17000	0
61	Corridor I	-450	23250	State Govt	PD cum Parking	Various locations incl. Samaj Kalyan Land (40 Ha)	579950	0
62	Kanpur Central Stn.	14616	14621	Central Govt	Station	Cooperative Bank- (G+0)	0	54
63	Kanpur Central Stn.	14577	14777	Central Govt	Station Entry/Exit	North Central Railway Land	1200	0
64	Jhakarkatti Bus Terminal	15900	15909	State Govt	Station	Shed (G+0)	0	48
65	Mid Section	16995	17001	Private	Alignment Ramp & U/G	Rajat Sweet & Bakery (G+1)	31	62
67	Transport Nagar stn	16552	16817	Squatters warehouse etc.	Station	Continuous Tin Sheds Commercial Bldgs (G+0)	0	7000

S.N.	Location	Chainage from (m)	Chainage to (m)	Owner	Purpose	Details of Properties	Land Area	Floor Area
68	Mid Section	17235	17624	State Govt	Alignment Ramp & U/G	Road Centre	3892	0
69	Bara devi Chauraha Stn	17844	1787	Private	Station Entry/Exit	05 Nos. Resi. Pucca Huts-200 sqm, Ashok Handloom + 01 Shop-148 sqm	0	347
70	Corridor I	-450	23250	State Govt	Misc.	Ancillary Buidings & Misc.	2000	1000
71	Corridor I	-450	23250	Private	Misc	Ancillary Buidings & Misc.	1000	1000
72	Corridor I	-450	23250	State Govt	Depot	Polytechnic College	219000	52000
73	Corridor I	-450	23250	State Govt	Depot	Naubasta Depot	67500	100
74	Corridor I	-450	23250	State Govt	RSS	Phoolbagh & Naubasta	6000	0

TABLE 5.68: DETAILS OF TEMPORARY LAND REQUIRED FOR CORRIDOR-1

S.N.	Location	Chainage From (m)	Chainage To (m)	Owner	Purpose	Detailes of Properties	Land Area	Floor Area
1	Naya Purva upto Nala	8912	9150	State Govt	Alignment Elevated & Ramp	Land at road	600	0
2	Chuni Ganj	9737	9962	State Govt	Station	State Govt Land	7000	0
3	Naveen Market	11010	11275	State Govt	Station	PWD Land	8000	0
4	Bada Chauraha	11730	11995	State Govt	Station	PWD Land	8000	0
5	PhoolBagh	12780	13045	State Govt	Station	State Govt Land	7000	0
6	Kanpur Central	14543	14809	Central Govt	Station	North Central Railway Land	8000	0
7	Jhakarkatti	15646	15700	Central Govt	Station	North Central Railway Land	1200	0
8	Jhakarkatti	15712	15911	State Govt	Station	Jhakarkatti Bus Terminal Land	5800	0
9	Transport Nagar	16552	16817	State Govt	Station	State Govt Land at road (3000) & Encroached by shops (7000)	10000	0
10	Corridor I	-450	23250	State Govt	Misc.	Ancillary Buidings & Misc.	1000	

S.N.	Location	Chainage From (m)	Chainage To (m)	Owner	Purpose	Detailes of Properties	Land Area	Floor Area
11	Corridor I	-450	23250	State Govt	Casting Yard	Land	142000	0
12	Corridor I	-450	23250	Central Govt	Casting Yard	Land	60000	0

5.7.2 Details of Land Required for Corridor-2

TABLE 5.69: DETAILS OF PERMANENT LAND REQUIRED FOR CORRIDOR-2

AREA IN SQM

S.n.	Location	Chainage From (m)	Chainage To (m)	Owner	Purpose	Detailes of Properties	Land Area	Floor Area
1	Agriculture Depot	-750	800	State Govt	Depot	R9+Garage+2 pump houses	125000	535
2	Rawatpur Stn	700	1000	State Govt	Parking cum PD	Land of UPSTRC Workshop (G+0)	26700	10000
3	Other than Rawatpur Stn	700	1000	State Govt	Parking cum PD	Various Locations	25200	0
4	Rawatpur Stn	700	1000	State Govt	Station by Cut & Cover	Land of UPSTRC Workshop (G+0)	0	8000
5	Rawatpur Stn	1008	1026	State Govt	Entry/ Exit	UPSRTC Bus Depot Land	110	0
6	Kakadeo Station	2208	2219	State Govt	Entry/ Exit	Land Green Belt	398	0
7	Double Pulia station	3243	3251	Private	Station by Cut & Cover	Temple Building	0	22
8	Mid Section	3459	3873	State Govt	Alignment Ramp	Road Centre	4134	0
9	Vijay Nagar Chauraha	4278	4282	Private	Viaduct	Temple Building	0	8
10	Dada Nagar Area b/w ROB & LC	4643	4924	State Govt	Viaduct	Pucca Houses (G+0) / G+1)/ G+2)	3000	0
11	Dada Nagar Area b/w ROB & LC	4643	4924	Squatters	Viaduct	Pucca Houses (G+0) / G+1)/ G+2)	0	3000
12	Govind Nagar	5083	5089	State Govt	Station by Cut & Cover	Bus Stand	0	14
13	Mid Section	5204	5207	Private	Viaduct	Temple Building	0	7
14	Shashtri Chauraha	5917	5920	Private	Entry/ Exit	Part of Build.	200	200

S.n.	Location	Chainage From (m)	Chainage To (m)	Owner	Purpose	Detailes of Properties	Land Area	Floor Area
15	Mid Section	7005	7015	State Govt	Viaduct	Govt. Str.(G+0)	0	65
16	Mid Section	7270	7274	Private	Viaduct	Temple Building	0	10
17	Corridor II	-750	7850	State Govt	Misc	Ancilliary Bldg & Misc	1000	1000
18	Corridor II	-750	7850	Private	Misc	Ancilliary Bldg & Misc	1000	1000
19	Corridor II	-750	7850	State Govt	RSS	RSS	3000	0

TABLE 5.70: DETAILS OF TEMPORARY LAND REQUIRED FOR CORRIDOR-2

S. n.	Location	Chainage From (m)	Chainage To (m)	Owner	Purpose	Detailes of Properties	Land Area	Floor Area
1	Agriculture University	-113	113	State Govt	Station	Cut & Cover	8000	0
2	Kakadeo	-750	7850	State Govt	Station	Cut & Cover	8000	0
3	Double Pulia	-750	7850	State Govt	Station	Cut & Cover	8000	0
4	Corridor II	-750	7850	State Govt	Misc	Ancilliary Bldg & Misc	1000	0
5	Corridor II	-750	7850	State Govt	Casting Yard	Casting yard	90000	0

Chapter – 6
STATION PLANNING

6. STATION PLANNING

6.1 STATION PLANNING BASED ON SITE CONDITIONS

6.1.1 Kanpur Metro System has been planned to serve major passenger catchment areas/ destinations and to enable convenient integration with other modes of transport. Stations vary in complexity along the route and have been located by an interactive process influenced by ridership forecasts, interchange requirements with other modes of transport, station spacing, alignment, utilities, road and pedestrian requirements, etc.

Station locations along the priority metro corridors in phase-I from 'IIT Kanpur to Naubasta' and 'Agriculture University to Barra-8' have been finalized after having detailed joint site visits with Kanpur Development (KDA) and Lucknow Metro Rail Corporation (LMRC) officials.

The stations attributes are presented in **Table 6.1** and **Figure 6.1**.

TABLE 6.1: INTER-STATION DISTANCE AND TYPE OF PROPOSED STATIONS

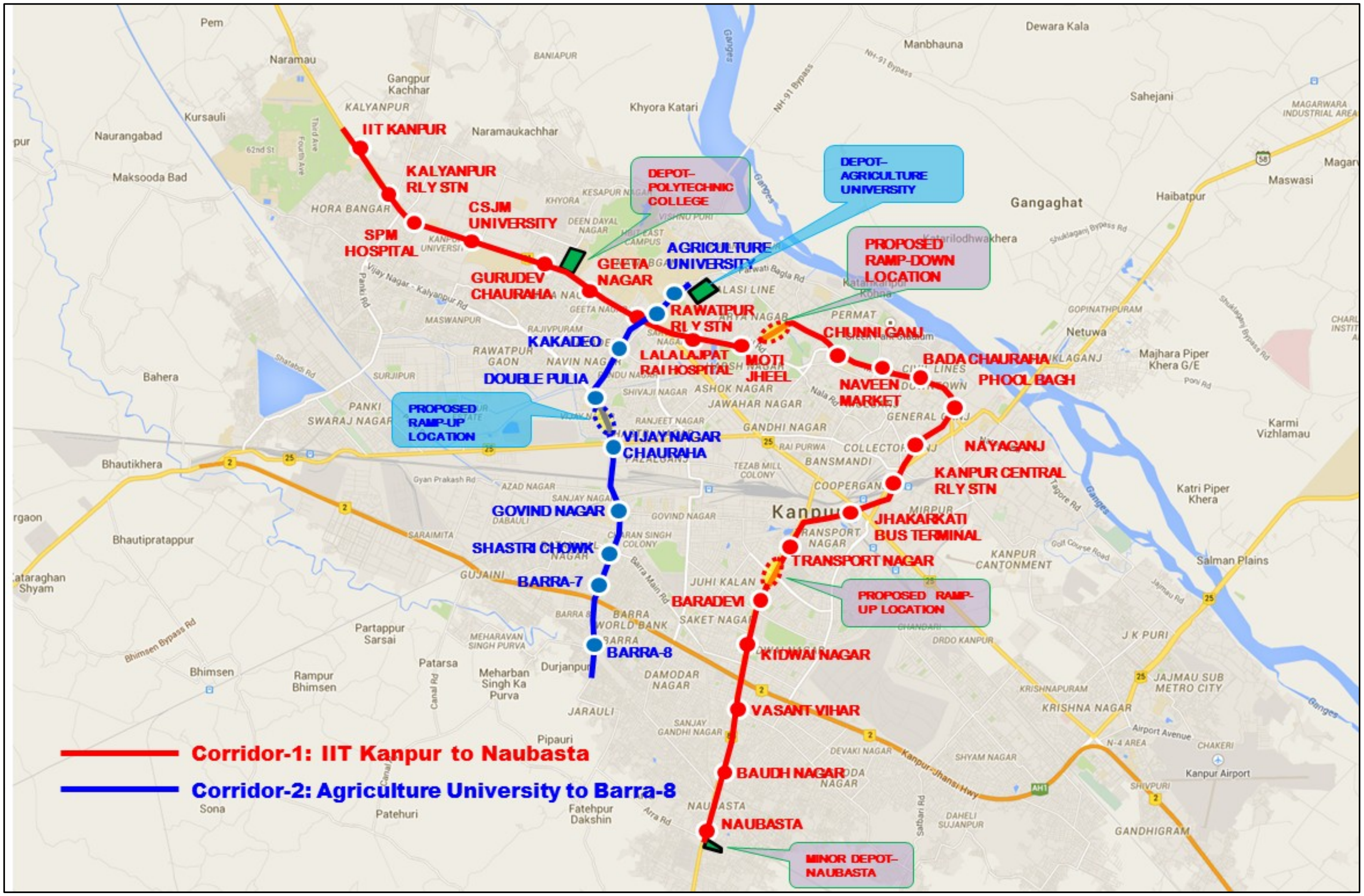
SN	Station Name	Inter-station Distance (m)	Cumulative Distance (m)	Elevated/ Underground
	Corridor 1: IIT Kanpur to Naubasta			
1	IIT Kanpur	0.00	0.00	Elevated
2	Kalyanpur Railway Station	942.36	942.36	Elevated
3	SPM Hospital	712.64	1655.00	Elevated
4	CSJM University	845.00	2500.00	Elevated
5	Gurudev Chauraha	1769.56	4269.56	Elevated
6	Geeta Nagar	761.18	5030.74	Elevated
7	Rawatpur Railway Station	935.39	5966.13	Elevated
8	Lala Lajpat Rai Hospital	1388.40	7354.53	Elevated
9	Moti Jheel	648.68	8003.21	Elevated
10	Chunniganj	1847.17	9850.38	Underground
11	Naveen Market	1293.09	11143.47	Underground
12	Bada Chauraha	719.63	11863.10	Underground

SN	Station Name	Inter-station Distance (m)	Cumulative Distance (m)	Elevated/ Underground
13	Phoolbagh	1050.10	12913.20	Underground
14	Nayaganj	733.91	13647.11	Underground
15	Kanpur Central Railway Station	1029.41	14676.52	Underground
16	Jhakarkati Bus Terminal	1103.00	15779.52	Underground
17	Transport Nagar	905.15	16684.67	Underground
18	Baradevi	1225.12	17909.79	Elevated
19	Kidwai Nagar	1208.69	19118.48	Elevated
20	Vasant Vihar	1294.18	20412.66	Elevated
21	Baudh Nagar	1267.18	21679.84	Elevated
22	Naubasta	949.71	22629.55	Elevated
	Corridor 2: Agriculture University to Barra-8			
1	Agriculture University	877.31	0.00	Underground
2	Rawatpur Railway Station	1303.47	877.31	Underground
3	Kakadeo	946.72	2180.78	Underground
4	Double Pulia	1000.50	3127.50	Underground
5	Vijay Nagar Chauraha	919.19	4128.00	Elevated
6	Govind Nagar	882.77	5047.19	Elevated
7	Shastri Chowk	808.85	5929.96	Elevated
8	Barra-7	910.64	6738.81	Elevated
9	Barra-8	877.31	7649.45	Elevated

6.1.2 Station Area Characteristics

The catchment areas for all stations, issues and concerns, potential improvements along two metro corridors are summarized below.

FIGURE 6.1: KANPUR METRO PHASE - I CORRIDORS WITH STATION LOCATIONS



1. Corridor 1: IIT Kanpur to Naubasta

i. IIT Kanpur

IIT Kanpur is the first station of the proposed metro Corridor 1. It is an elevated station proposed on the G.T. Road near IIT Kanpur. This station provides dispersal connectivity to IIT Kanpur and to Kalyanpur residential and commercial areas, CPWD Staff Colony, Rajkiya Unnyan Basti through Gooba Garden road and other nearby cross roads.

Issues & Concerns	Potential for Improvements
• Lack of pedestrians facilities like footpath along GT Road results in pedestrian spill over on road • Chaotic operations of tempo services • On-street parking causes reduction in efficient roadway width • Absence of seating arrangements in bus stop opposite IIT main gate • Pedestrian Safety is a concern	• Parking areas and dedicated bays for pick up/ drop facilities for IPT • Dedicated pedestrian friendly facilities like footpath and cycle tracks on GT Road. • Seating arrangements and proper roofing system at bus stop.

1. IIT Kanpur Entrance Gate

2. Unorganized Tempo Operations

3. Bus Stop in front of IIT Gate with insufficient commuter facilities

4. Road side encroachments and on-street parking

ii. Kalyanpur Railway Station

It is an elevated station located on the G.T. Road. The major roads connecting the station are Bithoor Road in the North and Panki Road in the South. The station caters the residential Imperial apartments, Railway Quarters and commercial areas in Kalyanpur in North and South. The station is proposed to have direct integration with existing Kalyanpur Railway Station.

Issues & Concerns	Potential for Improvements
• Lack of pedestrians facilities like footpath and cycle tracks • Lack of pedestrian facilities results in pedestrian spillover on road • On-street parking on both raods causes efficient roadway width on GT Road • Chaotic operations of Tempo services • Pedestrian Safety is a concern	• Integration with Interstate Bus Terminal • Parking areas and dedicated bays for pick up/ drop facilities as metro will induce more usage of Bus Terminal. • Planning of dispersal activities through feeder modes will cater to a larger catchment. • Dedicated pedestrian facilities like footpath and cycle tracks on GT Road.

1. Traffic charatersitics on G.T. Road

2. Absence of footpath

3. On-street parking on both sides of the road reducing the effective carriageway width.

4. New multi-storied residential development along G.T. Road

iii. SPM Hospital

SPM Hospital Station is an elevated station proposed along GT Road near Kanpur University. Catchment area of the station comprises mainly residential areas of Avas Vikas-1, Indra Nagar and Kanpur University along with Commercial areas in Kalyanpur North and South.

Issues & Concerns	Potential for Improvements
• Lack of pedestrians facilities like footpath and cycle tracks • Turning traffic at the level crossing into awas vikas areas is a concern • Pedestrian Safety is a concern	• Dedicated pedestrian friendly facilities like footpath and cycle tracks on GT Road. • Exclusive lanes for turning traffic which cross the railway level crossing

1. Railway Level Crossing

2. Right Turn at level Crossing

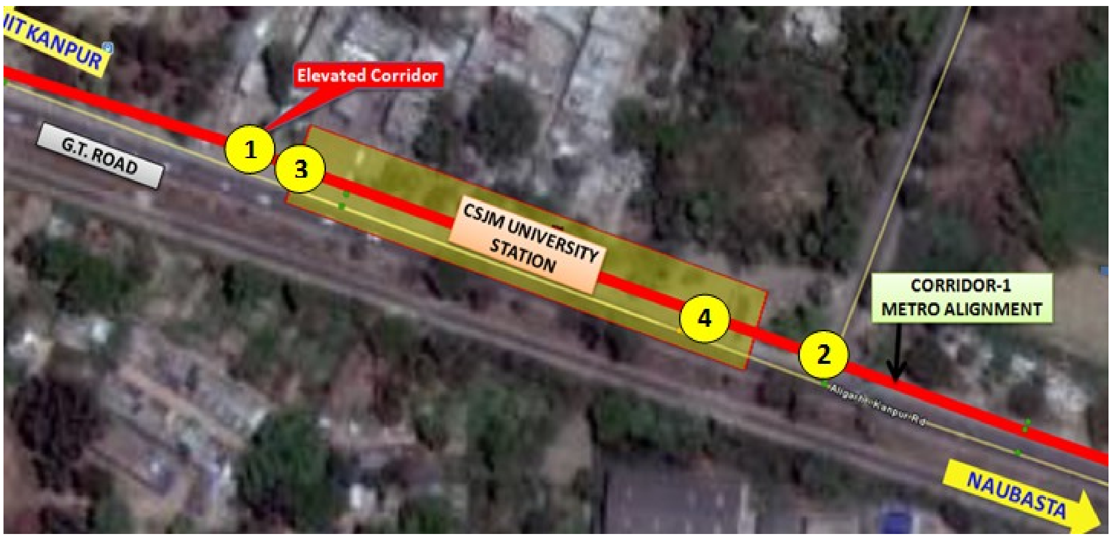
3. Woodbenie School Campus

4. Passenger Traffic at level Crossing

iv. CSJM University

It is an elevated station proposed on GT Road near Chatrapati Sahuji Maharaj University. The major road connecting the station is Makri Kheora in the North. Catchment area of the station comprises mainly of institutional area such as Chatrapati Shahuji Maharaj University, Indian Institute of Pulses Research and Rama Dental College.

Issues & Concerns	Potential for Improvements
• Lack of pedestrians facilities like footpath and cycle tracks • PT/IPT stops at University entrance do not have dedicated bays which causes congestion at carriageway • Pedestrian Safety is a concern	• Dedicated pedestrian friendly facilities like footpath and cycle tracks on GT Road and cross roads. • Exclusive lanes for turning traffic which cross the railway line



1. Absence of bays for PT/IPT stops


2. Lack of pedestrian facilities


3. Absence of footbath along GT Road

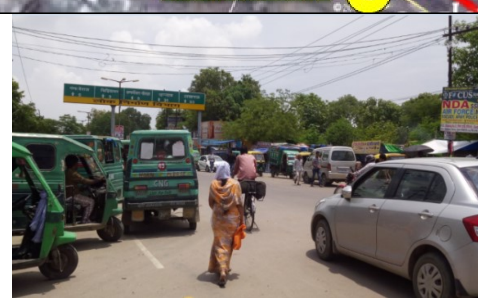

4. Landuse near Staiton Area along GT Road

v. Gurudev Chauraha

It is an elevated station proposed on GT Road near Gurudev Chauraha. The station is accessible by Indra Road in the North and Cross Roads in the South. Catchment area of the station comprises of institutional areas of Government Polytechnic College, HBTI west Campus in the North, Residential cum Commercial areas of Vikas Nagar & Lakhanpur in the North and Sharda Nagar and Vinayakpur in the South.

Issues & Concerns	Potential for Improvements
• Lack of pedestrians facilities like footpath along GT Road results in pedestrian spill over on road • Chaotic operations of tempo services • Encroachments and On-street parking causes reduction in efficient roadway width • Congestion because of existing railway level crossing and associated turning traffic • Pedestrian Safety is a concern	• Dedicated bays for pick up/ drop facilities for IPT • Dedicated pedestrian friendly facilities like footpath and cycle tracks on GT Road and Indra Road. • Seating arrangements and proper roofing system for commuters

1. Encroachment of road space



2. Lack of pedestrian facilities – pedestrians walk on road

3. Chaotic Traffic Movement

4. Hawkers occupy shoulder areas on GT Road

vi. Geeta Nagar

It is an elevated station proposed along GT Road near Forest Research Institute. The major roads connecting the station are Sharda Nagar Road, Rawatpur Village Road. Catchment area of the station comprises mainly of residential and commercial areas in Geeta Nagar and Tulsi Nagar.

Issues & Concerns	Potential for Improvements
• Lack of pedestrians facilities like footpath along GT Road which results in pedestrian spill over on road • No dedicated lanes for turning traffic at level crossing	• Dedicated pedestrian friendly facilities like footpath and cycle tracks on GT Road and Indra Road. • Dedicated lanes for turning traffic at level crossing

1. Railway Level Crossing near Geeta Nagar

2. Lack of pedestrian facilities and bays for PT / IPT

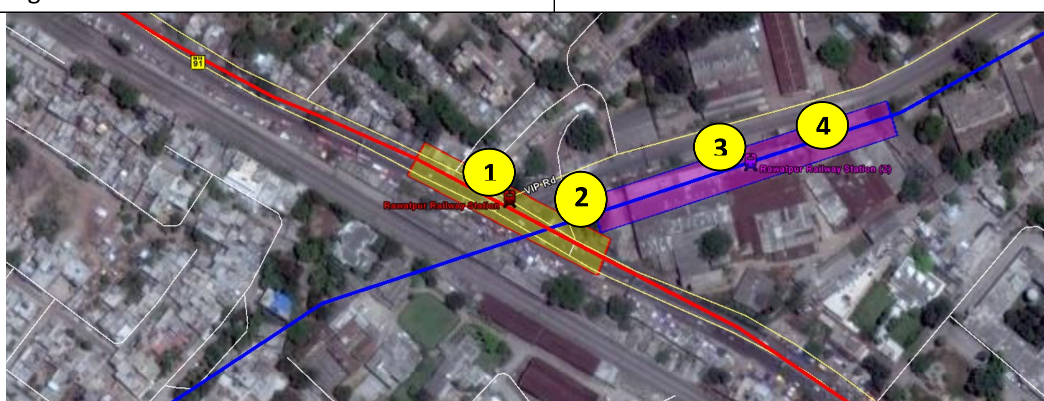
3. Carriageway Configuration near Station

4. Wide RoW along Geeta Nagar Road

vii. Rawatpur Railway Station – Interchange Station

It is an elevated station (underground in Corridor-2) proposed on G.T.Road near Rawatpur Railway Station. The major roads connecting the station are VIP Road in North and Rawatpur Main Road in South. This important interchange station connects existing Rawatpur Railway Station, proposed metro station of Corridor-2 and Rawatpur Bus Terminal. The catchment comprises of Agriculture University, JK Cancer institute in the North, GSVM Medical College, areas of Geeta Nagar, Moti Vihar, Kakadeo, Ambedkar Nagar in the South.

Issues & Concerns	Potential for Improvements
• Undefined Bus stop area, resulting in passenger spillover on road. • Unorganized areas for operation of Intermediate Public Transport. Tempos operate on GT Road & VIP Road without having designated parking areas reducing the carriageway width. • Absence of footpath, lack of pedestrian facilities results in pedestrian spillover on road. • On-street parking on both roads causes efficient roadway width and increases congestion.	• Dedicated pedestrian friendly facilities like footpath and cycle tracks. • Integration with proposed Rawatpur metro station of Corridor-2, existing Rawatpur Railway Station and Rawatpur Bus Terminal. • Planning of dispersal activities through feeder modes will cater to a larger catchment. • Being located in prominent area, it will generate ridership from surrounding areas.



1. Lack of Pedestrian Facilities

2. Undefined Bus stop area

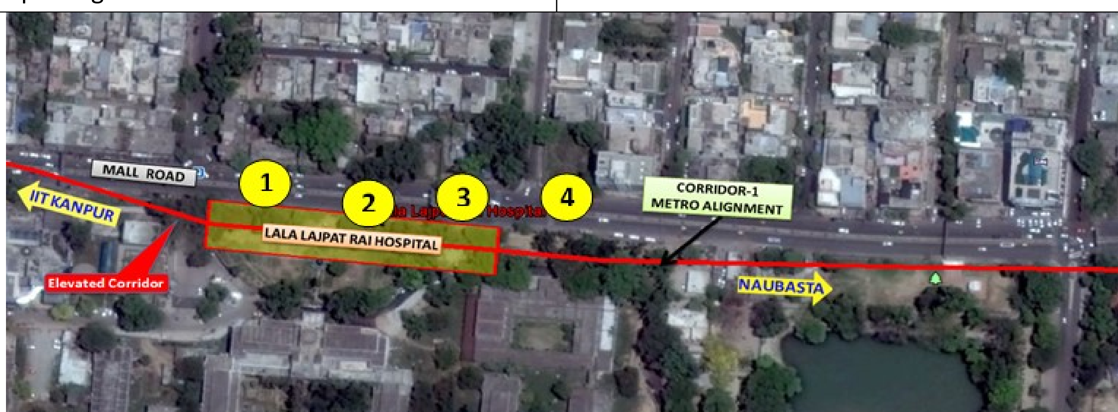
3. On-street parking on both sides of the VIP

4. Absence of footpath

viii. Lala Lajpat Rai Hospital

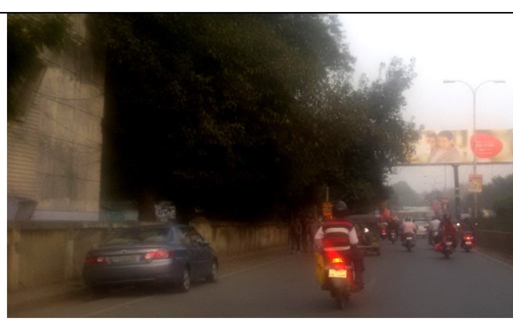
It is an elevated station proposed over open area of Lala Lajpat Hospital along Mall Road. The major roads connecting the station are Mata Swarnapuri Road in the north, Indrajit Jain Marg and Akal Desh Marg. Catchment area of the station comprises mainly of public -semi public and residential areas of Swaroop Nagar, Kesav Nagar and Sarvodaya Nagar.

Issues & Concerns	Potential for Improvements
• Undefined Bus stop area, resulting in passenger spillover on road. • Absence of footpath, lack of pedestrian facilities results in pedestrian spillover on road. • On-street parking on both roads causes efficient roadway width • Pedestrian Safety is a concern with truncated road widths because of on-street parking	• Dedicated pedestrian friendly footpath and FOB to ensure pedestrian safety • Bays for PT/IPT stops at designated locations to prevent traffic chaos



1. On-street parking of Two-wheelers and Cars

2. Vulnerable Pedestrians – No pedestrian facilities like FOB existent



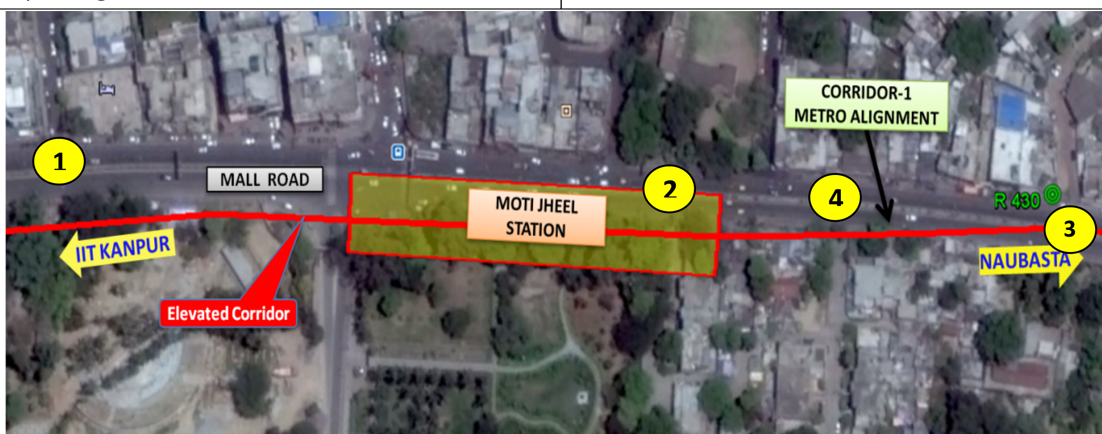
3. Absence of footpath causes pedestrian spillover on road

4. Absence of dedicated bays for PT/IPT stops causes congestion

ix. Moti Jheel

It is an elevated station proposed on Mall Road near Moti Jheel Park. The major road connecting the station is Moti Jheel Avenue leading to Coca-cola Chauraha at GT Road and other cross roads. The station catchment area comprises of Residential cum Commercial areas of Arya Nagar & Swaroop Nagar in the North, KDA, KMC offices & Hallet hospital in the South.

Issues & Concerns	Potential for Improvements
• Undefined Bus stop area, resulting in passenger spillover on road. • Absence of footpath • On-street parking and encroachment reduce efficient roadway width and increases congestion in the station area. • Pedestrian Safety is a concern with truncated road widths because of on-street parking	• Dedicated pedestrian friendly footpath and FOB to ensure pedestrian safety • Bays for PT/IPT stops at designated locations to prevent traffic chaos



1. Temple inside ROW of Mall Road

2. On-street parking and absence of dedicated bays for PT/IPT stops near Moti Jheel Station

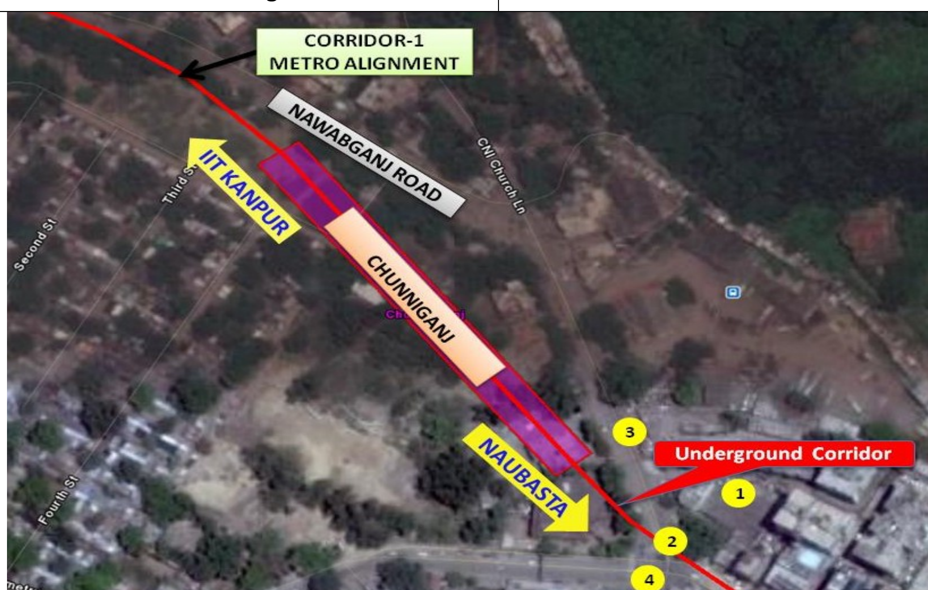
3. Absence of pedestrian facilities causes pedestrian spillover on road

4. Encroachment of road shoulder

x. Chunniganj

It is the first underground station in IIT Kanpur to Naubasta direction and is proposed below Chunniganj Bus Terminal at Nawabganj Road and Mall Road intersection. The major roads connecting this station are Nawabganj Road, CN Church Lane and Rahmani Avenue Road. It would be an interchange station, with the passenger interchange with the existing Chunniganj Bus Terminal. The station would serve BNSD & GIC Colleges in the South

Issues & Concerns	Potential for Improvements
• Unorganized areas for operation of Intermediate Public Transport. Tempos are operated on Mall Road & Nawabganj Road without having designated terminal parking areas • Absence/discontinuity of footpath, lack of pedestrian facilities results in pedestrian spillover on road. The traffic signals are not obeyed causing chaotic situations near Chunniganj Signal • On-street parking on both roads causes efficient roadway width and increases congestion	• Dedicated pedestrian friendly facilities like footpath and cycle tracks. • Integration with proposed Chunniganj metro station with existing Chunniganj Bus Terminal will integrate bus and metro commuters. • Dispersal activities through feeder modes will cater to a larger catchment. • Enforcement and education for adherence to traffic rules



1. Chunniganj Bus Terminal

2. Unorganized movement of IPT services

3. Absence /discontinuous/ encroached footpath

4. Traffic rules not followed

xi. Naveen Market

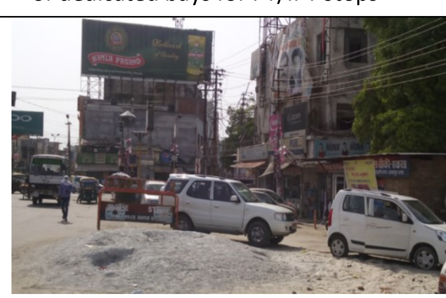
It is an underground station proposed near Parade Chauraha. The major roads connecting this station are Navin Market lane, Empire Lane in the North and Halsi Road (to Ghantaghar) in the South. Catchment area of the station comprises mainly of commercial areas of Naveen Market, Green Park Cricket Stadium in the North, Mulganj in the South.

Issues & Concerns	Potential for Improvements
• Undefined PT/IPT stops resulting in passenger spillover on road. • Absence of footpath, lack of pedestrian facilities results in pedestrian spillover on road. • On-street parking and encroachment reduce efficient roadway width and increases congestion in the station area. • Insufficient parking in Naveen Market lane	• Dedicated pedestrian friendly footpath and FOB to ensure pedestrian safety • Provision of bays for PT/IPT stops at designated locations to prevent traffic chaos

1. Traffic signals are not obeyed

2. Pedestrian spill over on road due to absence of dedicated bays for PT/IPT stops

3. Insufficient parking facilities



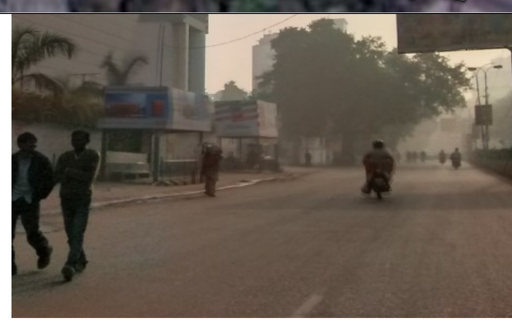
4. Encroachment of road shoulder

xii. Bada Chauraha

It is an underground station proposed below the central median of Mall Road near Z-Square Mall. The major roads connecting this station are Post Office Lane, Moore Street, Sirsaya Ghat Road in the North and Meston Road, H. Imran Street in the South. The station will cater Christchurch Intercollege in the South, Commercial areas of Z-Square Mall in the North.

Issues & Concerns	Potential for Improvements
• Undefined PT/IPT stops resulting in passenger spillover on road. • Absence of footpath, lack of pedestrian facilities results in pedestrian spillover on road. • On-street parking and encroachment reduce efficient roadway width and increases congestion in the station area. • Pedestrian Safety is a concern with chaotic movement of tempo/ mini bus services	• Dedicated pedestrian friendly footpath to ensure pedestrian safety • Bays for PT/IPT stops at designated locations to prevent traffic chaos

1. Absence of pedestrian facilities



2. No dedicated bays for PT/IPT stops

3. Road surface conditions are poor

4. Chaotic auto rickshaw / tempo operations

xiii. Phoolbagh

It is an underground station proposed along Mall Road below Phoolbagh four and six point junctions. The major roads connecting this station are Nazrat Umar Khattab Avenue, Neil Road, Canal Road and Birhana Road. Catchment area of the station comprises mainly of commercial and residential areas of the Central Business District.

Issues & Concerns	Potential for Improvements
• Undefined PT/IPT stops resulting in passenger spillover on road. • Absence of footpath, lack of pedestrian facilities results in pedestrian spillover on road. • On-street parking and encroachment reduce efficient roadway width and increases congestion in the station area. • Pedestrian Safety is a concern with chaotic movement of tempo/ mini bus services	• Dedicated pedestrian friendly footpath to ensure pedestrian safety • Bays for PT/IPT stops at designated locations to prevent traffic chaos • Commuter facilities at PT/IPT stops • Removal of encroachments and junction improvement measures

1. Absence of seating facilities in PT/IPT stops

2. Encroachment at Phoolbagh Entrance

3. Traffic Characteristics near Phoolbagh

4. Neil Road Intersection-Improper geometrics

xiv. Nayaganj

It is an underground station proposed below the Canal/Express Road near Mega Mall. There are cross roads connecting the station to the nearby dense commercial areas. This will cater Residential and Commercial activities of Nayaganj areas along Canal/Express Road.

Issues & Concerns	Potential for Improvements
• Private shops encroachment of footpath results in pedestrian spillover on road. • On-street parking and vehicular encroachment reduce efficient roadway width and increases congestion in the station area. • Pedestrian Safety is a concern with chaotic movement of tempo/ mini bus services	• Removal of encroachments to widen carriageway • Bays for PT/IPT stops at designated locations to prevent traffic chaos

1. On-street parking at proposed Nayaganj Station location

2. Dense commercial activities along Canal Road

3. Tempo & LCV parking along Canal Road

4. Pedestrian spillover on road

xv. Kanpur Central Railway Station

This underground station is proposed near Kanpur Central Railway Station towards Ghantaghar. This station connects existing railway station with proposed metro station. The major connecting roads are Halsi Road (to Parade), Birhana Road (to Phoolbagh), Canal Road (to Phoolbagh), Railway Road (to Jareeb Chowki), Rajdhani Marg (to Tat Mill) and Elliot Road (to Cantonment). Catchment area of the station comprises of Residential cum Commercial areas of Collectorganj, Ghantaghar, Dhana Khori in the North, Cantonment, Triveni Nagar and railway colonies in the South.

Issues & Concerns	Potential for Improvements
• Lack of pedestrians facilities like footpath and refugee islands along Ghantaghar to Tat Mill Road in the entrance area of Ghantaghar side. • Lack of pedestrian facilities • On-street parking causes reduction in carriageway • Chaotic operations of Tempo services	• Integration of metro with Kanpur Central Railway Station • Dedicated footpath and cycle tracks on all legs at Ghantaghar Chauraha. • Better Management of Tempo Operations

1. Pedestrian – Vehicular conflicts

2. Heavy pedestrian traffic & encroachment

3. On-street parking on both sides of the road narrowing the effective carriageway width

4. Traffic at Ghantaghar Chauraha

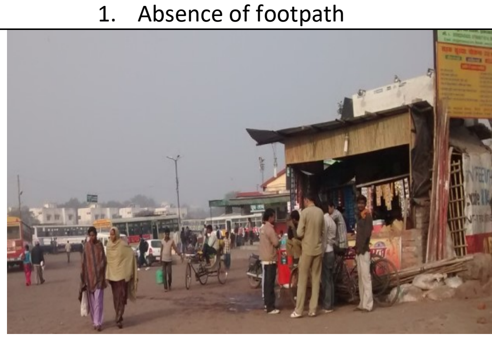
xvi. Jhakarkati Bus Terminal

It is an underground station proposed inside the Jhakarkati bus terminal. The station is proposed to have direct integration with the existing Jhakarkati bus terminal. GT Road is major road connecting to this station through which dispersal will be effected. Catchment area of the station comprises of Railway Colonies, Commercial areas of Afim Kothi and Tat Mill.

Issues & Concerns	Potential for Improvements
• Lack of pedestrians facilities like footpath along GT Road and near the bus terminal. • Lack of pedestrian facilities results in pedestrian spillover on road. • Absence of IPT pick up/ drop bays inside Terminal. • On-street parking on both raods causes efficient roadway width in front of Bus Terminal • Improper parking facilities inside Bus Terminal	• Integration of metro with Interstate Bus Terminal • Provision of parking areas and dedicated bays for pick up/ drop facilities • Dispersal activities through feeder modes will cater to a larger catchment. • Dedicated pedestrian facilities like footpath and cycle tracks on GT Road.

1. Absence of footpath

2. Lack of pedestrian facilities



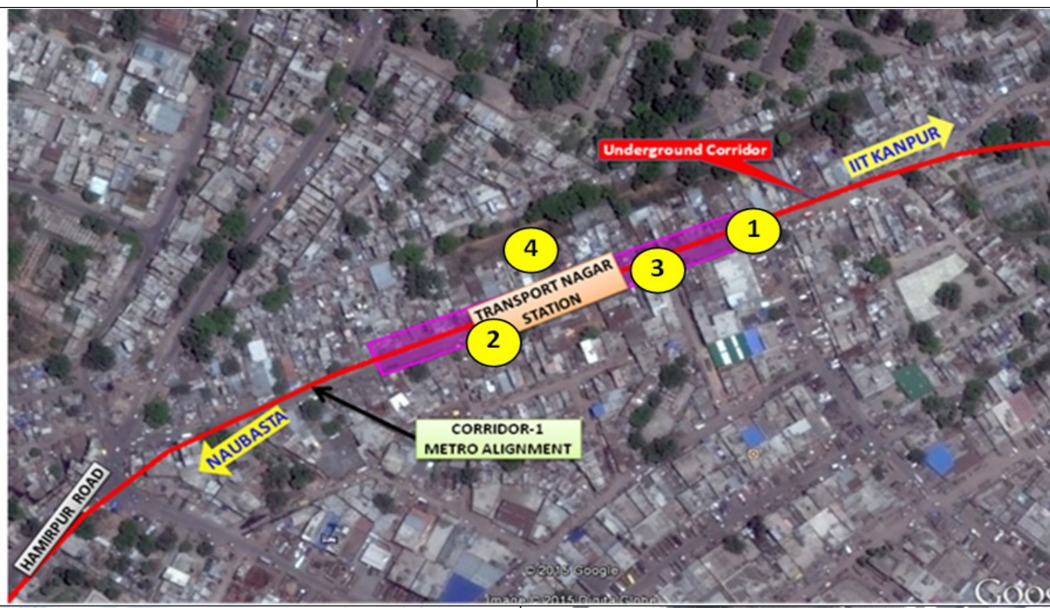
3.Jhakarkati Bus Terminal

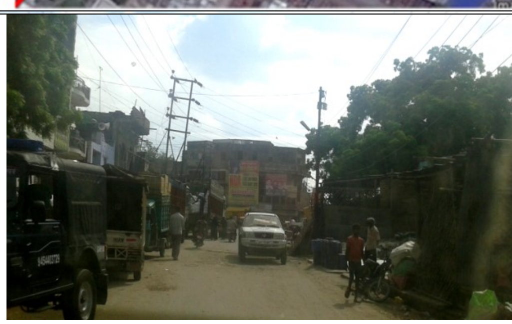
4. Traffic at ROB - Jhakarkati Bus Terminal

xvii. Transport Nagar

It is an underground station proposed below the central verge of Hamirpur Road (NH-86) near Swadeshi Cotton Mill. Major connecting roads are Hamirpur Road and Bakerganj Road. This will cater residential cum commercial areas of Juhi in the west and Transport Nagar, Bakarganj in the east.

Issues & Concerns	Potential for Improvements
• Lack of pedestrians facilities like footpath and pedestrian crossing • On-street parking causes reduction in efficient roadway width • Huge encroachment of the road space	• Dedicated pedestrian friendly facilities like footpath and cycle tracks • Removal of encroachments and optimal usage of ROW





1. Congested Transport Nagar Road

2. Encroachment by Religious Structures and Commcercial Shops

3. On-street parking – Transport Nagar Station Area

4. Baradevi Junction

xviii. Baradevi

It is an elevated station proposed near Baradevi Chauraha on Hamirpur Road (NH-86). Major connecting roads are Jawahar Road connecting Kidwai Nagar with Juhi and Govind Nagar. Catchment area of the station comprises of residential cum commercial areas of Juhi and Govind Nagar in the west and Ajitganj, Anandpuri in the east.

Issues & Concerns	Potential for Improvements
• Lack of pedestrians facilities like footpath and zebra crossings at Baradevi Junction • On-street parking causes reduction in efficient roadway width • Encroachments by vehicles and private commercial reduces effective width of carriageway	• Integration of metro with existing Baradevi tempo operations • Dedicated pedestrian friendly facilities like footpath and cycle tracks on Hamirpur Road and Govind Nagar Road • Better Management of Tempo Operations

1. Traffic Characteristics near Baradevi Station

2. Pedestrian crossings are not marked

3. Traffic Congestion at Baradevi Junction

4. Chaotic Tempo Movement at Baradevi

xix. Kidwai Nagar

It is an elevated station located on the central verge of Hamirpur Road (NH-86) near Gosala chowk. Major connecting roads are Keshav Nagar-Kidwai Nagar Road and service roads of NH-2 bypass. Catchment area of the station comprises of residential cum commercial area of Ashok Nagar, Kanjar Purwa, Saket Nagar, Usmanpur, Keshav Nagar and Kendranchal Colony in the west and RBI colony, SBI colony, Kidwai Nagar in the east.

Issues & Concerns	Potential for Improvements
• Lack of pedestrian facilities results in pedestrian spillover on road and safety issues • On-street and encroachments parking causes reduction in efficient roadway width • Chaotic operations of Tempo services	• Dedicated footpath and cycle tracks at Station area and Gaushala Road which forms a major access for pedestrian dispersal • Better Management of Tempo Operations

1. Carriageway near Kidwai Nagar Station

2. Gaushala Road Intersection

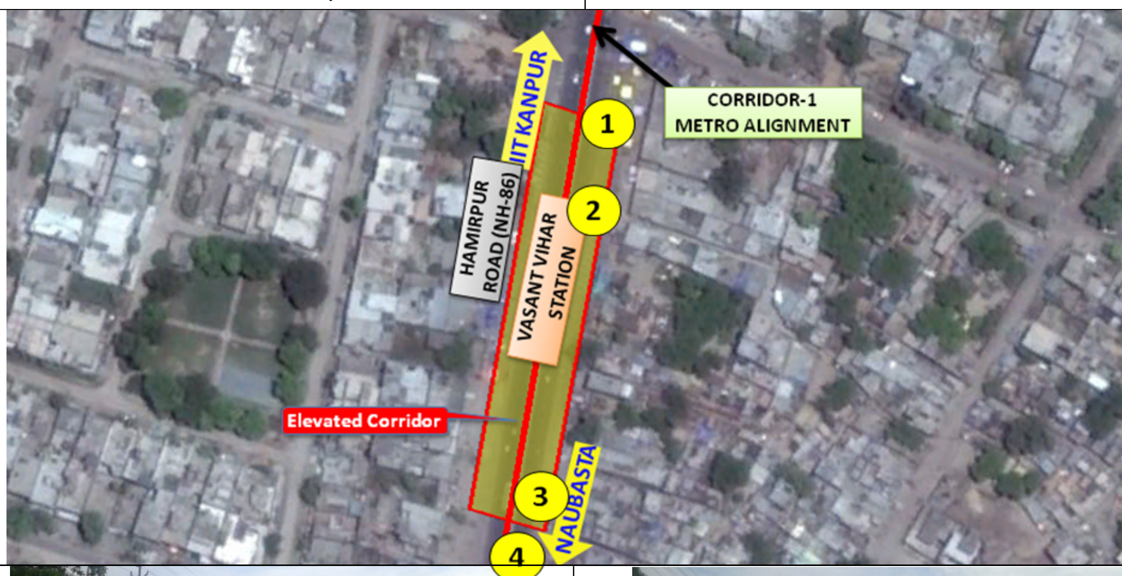
3. On-street parking and Encroachments

4. Wide RoW near Gaushala Road Intersection

xx. Vasant Vihar

It is an elevated station proposed on the central verge of Hamirpur Road (NH-86) near Dassu Kunwa Churaha. Major connecting roads are Pipeline Road and Mohamad Ali Marg. Catchment area of the station comprises of residential cum commercial areas of Vasant Vihar, Sanjay Gandhi Nagar in the west and Dhansingpur, Yashodha Nagar, Pashupathi Nagar in the east.

Issues & Concerns	Potential for Improvements
• Lack of pedestrians facilities like footpath in Hamirpur Road and cross roads • Lack of pedestrian facilities results in pedestrian spillover on road and safety issues • On-street parking and encroachment causes reduction in efficient roadway width	• Dedicated footpath and cycle tracks on Hamirpur Road and cross roads




1. Wide RoW at Station Area


2. On-street Parking at Station Location

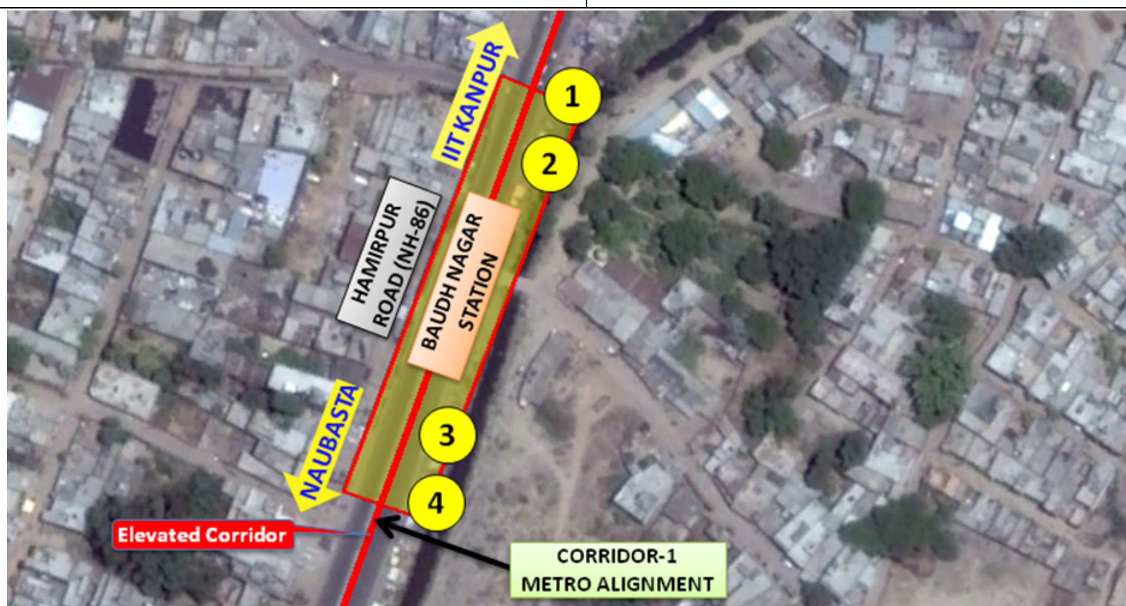

3. Roadside Encroachments


4. Absence of pedestrian facilities

xxi. Baudh Nagar

It is an elevated station proposed on the central verge of Hamirpur Road (NH-86) near Dhubin Pulia Churaha. Major connecting roads are Khandepur Road and Nala Road. This will cater residential cum commercial areas of Hanumanth Vihar, Baudh Nagar & Narayanpuri in the west and Naubasta in the east.

Issues & Concerns	Potential for Improvements
• Lack of pedestrians facilities like footpath along Hamirpur Road and cross roads • Lack of pedestrian facilities results in pedestrian spillover on road and safety issues • On-street parking and encroachment causes reduction in efficient roadway width	• Dedicated pedestrian footpath and cycle tracks on Hamirpur Road and cross roads



1. Encroachment by shops

2. Temporary Residential/Commercial Structures

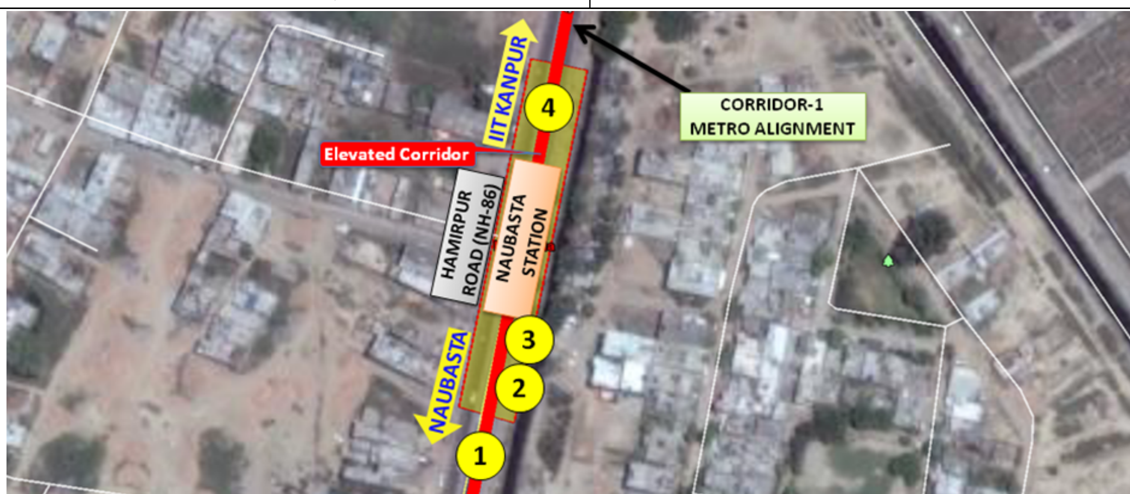
3. Canal along Hamirpur Road near Station

4. Access controlled stretch along Hamirpur Road

xxii. Naubasta

It is the last station on IIT Kanpur to Naubasta corridor, proposed on the central verge of Hamirpur Road (NH-86) near Bambaa chowk. It is an elevated station. The major roads connecting the station are cross roads to the nearby residential areas. Catchment area of the station comprise of residential cum commercial areas of Rajendra Nagar & KDA Colony in the west and Naubasta in the east.

Issues & Concerns	Potential for Improvements
• Lack of pedestrians facilities like footpath in Hamirpur Road and cross roads • Lack of pedestrian facilities results in pedestrian spillover on road and safety issues • On-street parking and encroachment causes reduction in efficient roadway width	• Dedicated footpath and cycle tracks on Hamirpur Road and cross roads



1. Wide RoW at Naubasta Station Location

2. Temporary Structures along Station Location

3. Absence of pedestrian facilities in Hamirpur Road/ Dispersal Roads

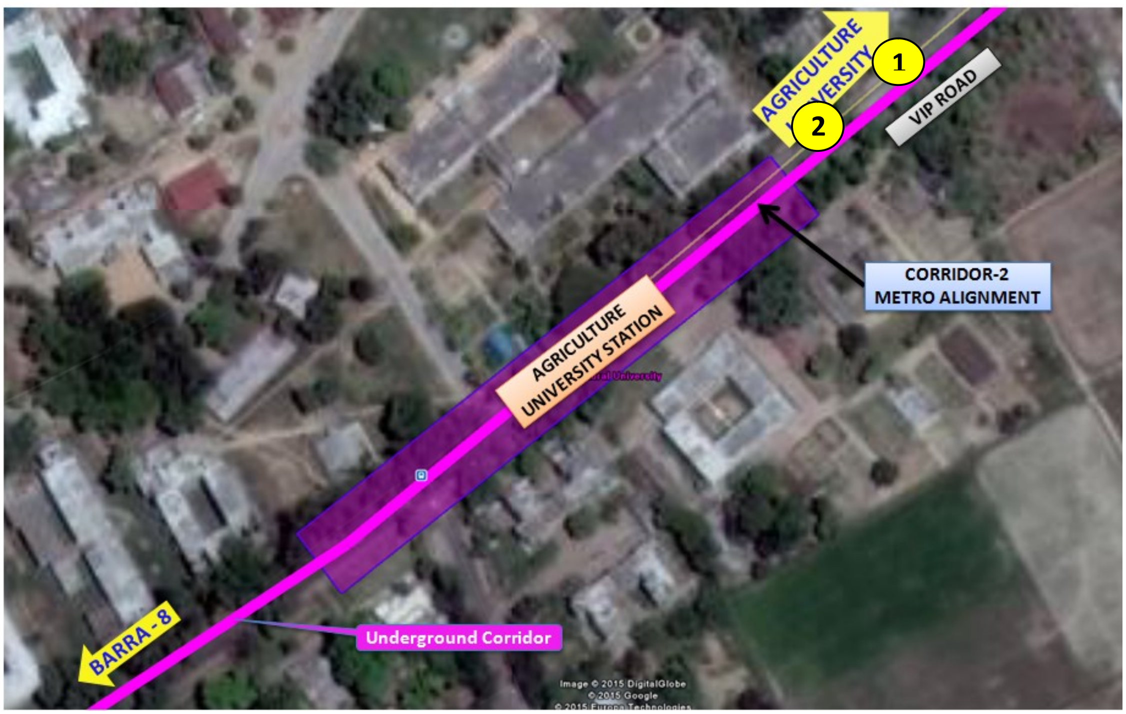
4. View of Hamirpur Road with wide median

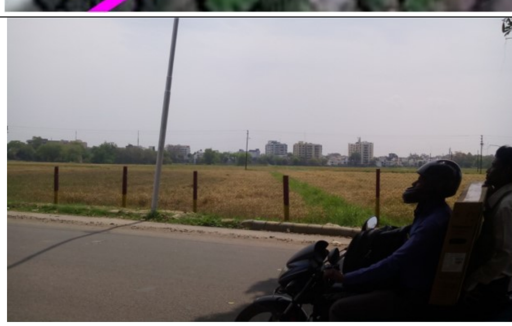
5.2.2 Corridor 2: Agriculture University to Barra-8

i. Agriculture University

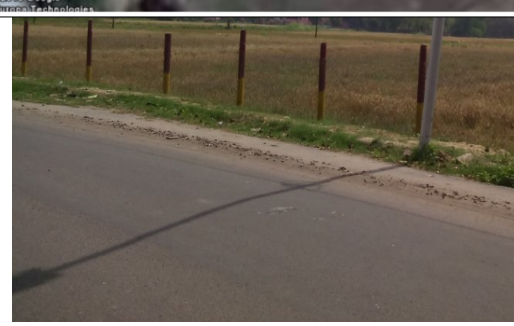
It is the first station of Corridor-2 from Agriculture University to Barra-8 proposed beneath VIP Road near Agriculture University. The station catchment comprises of Institutional area (Agriculture University) and a residential area which includes staff quarters on east and west sides.

Issues & Concerns	Potential for Improvements
• Lack of pedestrian facilities results in pedestrian spillover on road and safety issues • Limited RoW along VIP Road • Lack of sign boards	• Dedicated pedestrian friendly facilities • Installation of speed restriction sign boards as there are curves along VIP road from Rawatpur to Company Bagh Chauraha





1. Limited RoW at Station Location (VIP Road)



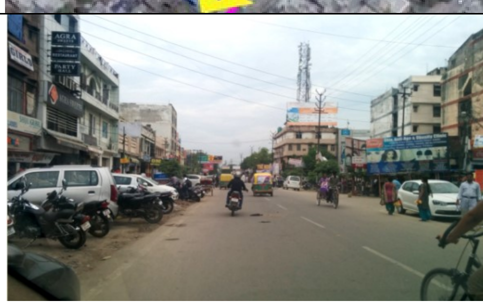
2. Absence of pedestrian facilities

ii. Rawatpur Railway Station (interchange station discussed as part of 6.1.2 vii)

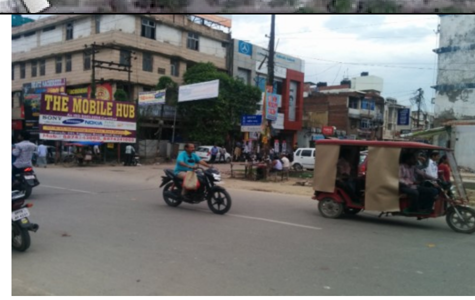
iii. Kakadeo

It is an underground station proposed below the central verge of Vijay Nagar Road near Kakadeo Chauraha. It is accessible by Esplande Road on East & West. Catchment area of the station comprises of Residential cum commercial areas of Kakadeo in the West and Pandu Nagar in the East.

Issues & Concerns	Potential for Improvements
• Lack of pedestrian facilities results in pedestrian spillover on road and safety issues • On-street parking and encroachments causes reduction in efficient roadway width	• Dedicated footpath and cycle tracks at Station area and cross roads for pedestrian dispersal



1. On-street Parking at Kakadeo Station Location



2. Absence of pedestrian facilities on cross ro ads

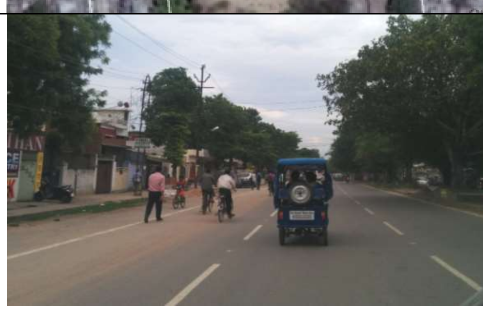
3. Traffic Characteristics at Rawatpur Main Road

4. Encroachment of shoulder

iv. Double Pulia

It is an underground station proposed below the central verge of Vijay Nagar Road near Double Pulia Chauraha. The major roads connecting to the Station are Rawatpur Main Road in the North, Curson Road (East) and cross roads in the West. Catchment area of the station comprises of Residential cum commercial areas of Navin Nagar, MG College & Vijay Nagar in the West, Pandu Nagar and Sindhi Colony in the East.

Issues & Concerns	Potential for Improvements
• On-street and encroachments parking causes reduction in efficient roadway width	• Better enforcement would reduce encroachment activities



1. 6-lane Divided Carriageway – Double Pulia Station Location

2. Encroachment of shoulder and footpath by vehicles

3. Intersection to Mahatma Gandhi College

4. Space availability inside RoW

v. Vijay Nagar Chauraha

It is the first elevated station along Corridor-2 proposed on the central verge of Vijay Nagar Road near Vijay Nagar. Kalpi Road is the major connecting road to the station. Catchment area of the station comprises of Industrial area of Panki & Armapur Estate in the West and Fasalganj & Shastri Nagar industries in East, Residential cum commercial areas of Vijay Nagar, Pratapganj in the East.

Issues & Concerns	Potential for Improvements
• Lack of pedestrian facilities results in pedestrian spillover on road and safety issues • On-street and encroachments parking causes reduction in efficient roadway width • Chaotic operations of Tempo services	• Dedicated footpath and cycle tracks • Pedestrian crossing facilities as there is more vehicles pedestrians interference observed • Better Management of Tempo Operations

1. Pedestrian spillover at Vijay Nagar Station

2. Pedestrians – Vehicle Interference

3. Traffic Charactristics at Vijay Nagar Chauraha

4. Existing Canal near Station Locaiton

vi. Govind Nagar

It is an elevated station proposed along Barra -7 Road near CTI Chauraha. The dispersal activities will be effected through Gyan Prakash Road. Catchment area of the station comprises of Industrial area of Sanjay Nagar, Advanced Training Institute (ATI) for Labour in the West and residential cum commercial areas of Govind Nagar & Labour Colony in the East.

Issues & Concerns	Potential for Improvements
• Lack of pedestrian facilities results in pedestrian spillover on road • On-street parking and encroachments reduces efficient road width • Chaotic operations of Tempo services • Long delays at level crossing	• Dedicated footpath and cycle tracks at Station area and Govind Nagar Road which forms a major access for pedestrian dispersal • Removal of encroachments • Better Management of Tempo Operations

1. Absence of pedestrian facilities

2. IPT Stand under Flyover near Station

3. Dada Nagar Level Crossing

4. Ending of Flyover near Station Location

vii. Shastri Chowk

<table>
<tr><td colspan="2">It is an elevated station proposed at Shastri chowk. The major roads connecting the station are Nala Road, Ratanlal Nagar Main Road in the West and Barra Main Road in the East. The station catchment includes residential cum commercial areas of Ratanlal Nagar in the West and Malikpuram & Charan Singh Colony in the East.</td></tr>
<tr><th>Issues & Concerns</th><th>Potential for Improvements</th></tr>
<tr><td>• Lack of pedestrian facilities results in pedestrian spillover on road
• On-street parking and encroachments reduces efficient road width
• Chaotic operations of Tempo services</td><td>• Dedicated footpath and cycle tracks at Station area and Ratanlal Nagar Main which forms a major access for pedestrian dispersal
• Removal of encroachment near Shastri Chowk Junction and cross roads
• Better Management of Tempo Operations</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td>
1. Absence of pedestrian facilities</td><td>
2. Traffic Characteristics at Shastri Chowk</td></tr>
<tr><td>
3. Poor Road Surface Characteristics</td><td>
4. On-street parking and encroachment</td></tr>
</table>

viii. Barra-7

It is an elevated station proposed the central verge of green belt along Barra -8 Road near Barra bypass intersection. The approaching road access to the station are Barra -7 Road, Barra -6 Road and other cross roads on either sides to Barra. The station catchment area includes Residential cum commercial areas of Barra.

Issues & Concerns	Potential for Improvements
• Lack of pedestrian facilities results in pedestrian spillover on road and safety issues • On-street parking and encroachments reduces efficient road width • Chaotic operations of Tempo services	• Dedicated footpath and cycle tracks at Station area and cross roads for pedestrian dispersal • Better Management of Tempo Operations

1. On Street Parking of Vehicles reduces effective carriageway width

2. Wide RoW at proposed Station Location

3. Wide Median at Barra-7

4. Encroachment by shops

ix. Barra-8

It is the last station proposed on the central verge of green belt along Barra -8 Road near Ram Gopal Churaha. The major roads connecting to the Station are Varun Vihar Road and Cross roads on either side to Barra 8. The station catchment area includes Varun Vihar, southern blocks of Barra and Jarauli.

Issues & Concerns	Potential Improvements
• Lack of pedestrian facilities results in pedestrian spillover on road • On-street parking and encroachments reduces efficient road width	• Dedicated footpath and cycle tracks at Station area and cross roads for effective pedestrian dispersal

1. On Street Parking of Vehicles

2. Vasant Vihar – Barra8 Intersection

3. Wide Maneuvering Area at Intersection

4. Green belt with wide median at Barra-8

6.1.3 Station Planning Norms & Standards

a. General

- The design year maximum PHPDT of about 40000 between IIT Kanpur to Naubasta and 30000 between Agricultural University to Barra-8 is considered for planning the passenger facilities at stations.
- The platform length is planned for 6 cars train.
- The total evacuation time for the movement of all passengers in an emergency from platform level to the landing at the next level does not exceed 4.0 minutes (as per "NFPA 130" Guidelines) in underground stations. However this is 5.5 minutes in elevated stations considering that these stations are open and risk is much less.
- The station planning is also in compliance to the "Guidelines and Space Standards for Barrier Free Built Environment for Disabled and Elderly persons" published by the Ministry of Urban Affairs and Employment India in 1998.

The egress requirement (Platform to Concourse) & platform width calculations, evacuation time calculations and passenger related facilities for the design year are presented in **Annexure 6.1, Annexure 6.2** and **Annexure6.3** respectively

b. Entry/Exit

The position of entrances is determined by the juxtaposition of building location of roadway footpath width, space availability and flow directions of passenger traffic. The width of entrances takes into account the predicted passenger flow and available space.All entrances extending to street level are proposed to be protected against flooding. This protection is done by the provision of a minimum of 3 steps up to a landing (+450 mm minimum)

c. Walkways / Ramps

Walkways / ramps are planned based on established principles of pedestrian flow and arranged to minimize unnecessary walking distances and cross-flows between incoming and outgoing passengers. Cross flow and changes in direction are minimized or eliminated.

d. Concourse Planning Standards

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

ii. Concourse consists of “Non Public Areas” and “Public Areas”. The “Non Public Areas” comprise of the Back of House (BOH) areas. The BOH areas consists of Power Supply & Traction (PST), System Rooms, Operations, Staff Facilities, Tunnel Ventilation System, Station ventilation System, Water Supply and Drainage System and Miscellaneous requirements. A list of BOH areas is given below in **Table 6.2**. The description of such areas is also detailed in the subsequent paragraphs.

iii. The “Public Area” is further subdivided into “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.

iv. Passenger handling facilities comprise of stairs/escalators, lifts, ticketing counters/automatic ticket vending machines and ticket gates required to process the peak traffic from street to platform and vice-versa. These facilities are provided in the concourse and they also act as a medium to transfer between Paid and Unpaid areas (these facilities also enable evacuation of the station under emergency conditions, within a set safe time limit).

v. Uniform number of these facilities has been provided for system wide uniformity, although the requirement of the facilities actually varies from station to station based on the peak hour passenger load.

The accommodation of station facilities is presented in **Table 6.2.**

TABLE 6.2: STATION FACILITIES ACCOMMODATION

PST (POWER SUPPLY & TRACTION)	STAFF FACILITIES
Auxiliary substation Track disconnection switch DG set Fuel tank	Staff toilets/ locker (male) Staff toilets/ locker (female) First aid Staff mess room Train crew room
SYSTEM ROOMS	**TUNNEL VENTILATION SYSTEM**
SIGNALLING Signalling Equipment Room (SER) UPS room (signaling) TELECOMMUNICATION TER Mobile phone equipment room UPS Room (telecom)	Tunnel ventilation plant room-1 Tunnel ventilation plant room-2 ECS plant room-1 ECS plant room-2
OPERATIONS	**STATION VENTILATION SYSTEM**
Station Control Room (SCR) Station Manager Ticket Office/Ticketing Ticket Office Supervisor Audit and Cash Storage TVM/ BOMS Security/ Police Room Excess Fare Office (EFO)	Chiller Plant Cooling Tower Staircase Pressurization
MISCELLANEOUS	**WATER SUPPLY & DRAINAGE SYSTEM**
Emergency Equipment Room Cleaners Room-1 Cleaners Room-2 Refuse Store Permanent Way Store	Sewage Pump Room Seepage Pump Room-1 Seepage Pump Room-2 Smoke Extraction Fan Room

e. Operational Rooms for Public Use

i. Ticketing Gates

- The requirement of the number of gates is based on the peak hour passenger traffic at the station.
- Ticketing gates' requirement has been calculated taking the gate capacity as 28 persons per minute per gate (80% of the Maximum Practical Capacity which is assumed as 35 persons per minute per gate). At least two ticketing gates will be provided at any station even if the design requirement is satisfied with only one gate. Uniform space has been provided at all stations where gates can be installed as and when

required. In the design year output capacity of 35 passengers is assumed because of passenger's familiarity with the system.

- The total number of gates also includes one more gate in case of breakdown or maintenance. Special gates are designed for Disabled persons access, Customers with luggage, Customers with strollers.

ii. Ticket Counters and Ticket Vending Machines (TVMs)

- It is proposed to deploy manual ticket issuing counters in the beginning of the operation of the line. At a later stage, automatic TVMs would be used, for which space provision will be made at the concourse. Capacity of manual ticket vending counters is assumed as 5 passengers per minute per window and it is assumed that only 20% of the commuters would purchase tickets at the stations while performing the journey. The rest are expected to buy prepaid tickets, prepaid card, smart card etc. About 10% of the Smart card users will use the Ticket window for renewal/recharging etc. Accordingly, the requirement of ticket counters has been calculated and the same provided for in the plans.
- The number of TVMs required is governed by the peak hour passenger traffic, the fare policy and the ticketing. Depending on the composition of monthly pass/smart card users and single ticket users, the number of TVMs could change. As a general thumb rule, it is proposed to provide 7 to 10 TVMs for stations with high traffic and 2 to 5 TVMs for other stations. The ticket vending machines at stations is presented in **Figure 6.2.**

FIGURE 6.2: TICKET VENDING MACHINES AT STATIONS

MTR Wall mounted TVM with maintenance corridor in the back – Paris

Shinjuku Station Tokyo

iii. Ticket Office

The number of Ticket Offices is determined by the passenger traffic and the operation policy. A minimum of 2 ticket office per station in the stations with high traffic, and 1 ticket office per station in the stations with low traffic have been planned **(Figure 6.3).**

FIGURE 6.3: TICKET OFFICE AT STATIONS

iv. First Aid Room

First aid room is not a specific operation room but is proposed to be located in every station in accordance with the technical provisions of the project. This room could also be used as a detention room if it is needed.

v. Passenger Amenities

Toilets for disabled are not specific operation rooms are proposed to be provided at all stations in accordance with the technical provisions of the project.

f. Operation Rooms for Staff Use Only

i. Safe Deposit

In each station, a safe deposit room located next to the main ticket office is provided. This room has to be near the Ticket Office and TVM back-store, with restricted and monitored access, and shall be directly connected with it in the operation area, in order to avoid money transfer to be visible to the public. It should also be close to the Station Master's Control Room for management reasons.

ii. **Male and Female Locker and Rest Rooms**

These rooms are proposed close to the staff operation areas in the non-public operation area. The area of these rooms is dependent on the number of employees in each station.

iii. Male and Female Staff Toilet

It is recommended to fit the stations with specific toilets for the employees. Separate male and female toilets are proposed for each station.

g. Operation Rooms in Terminal Stations or Intermediate Terminal Station

i. Train Driver Rooms

In case of start and shut down operation directly in terminals with stabled trains during the night, train driver rooms are required. These rooms are preferably located at the platform level and include:

- Train drivers dispatch office,
- Training room / emergency room,
- Operation storage room,
- Male and female locker rooms separated,
- Restrooms

The train drivers dispatch office is a specific room allowing conductors to sign on/sign off and to be informed of new instructions and special orders.

ii. Lost and Found Room

Management of Lost and Found items will be centralized in a specific station for the entire network. The lost and found room is proposed to be located into the public area at a Terminal / Mid Terminal Stations (IIT Kanpur, Rawatpur Railway Station, Naubasta and Barra-8 in this case). The lost and found location will require a public zone and a restricted room dedicated to lost objects.

h. Passenger Handling Facilities

The regulations and standards shall form the basis for the design of escalator elevator system and Stairs are American National Standard Institute (ANSI), American Society of testing Materials (ASTM), International Electro technical Commissions (IEC), Indian Standard (IS), European Norm (EN), National Electrical manufacturers Association (NEMA), National Fire Protection Association (NFPA), Underwriter's Laboratories, Inc. (UL)

- **Design Criteria - Escalator**

The escalators will be heavy duty "public" service escalators capable of operating safely, smoothly and continuously in either direction, for a period of not less than 16 hours per day, seven days per week, (except special holiday which may be operated 24 hours a day) within the environmental conditions prevailing within the well way and at locations where the escalators are installed. The maximum allowable passenger load of each step should not be less than load equivalent of three 65 Kg person per step. The escalators will be equipped with energy saving system. Speed of escalators will be in the range of 0.60 -0.75 m/s for normal operation. The energy saving system will reduce speed of escalators to standby speed mode of 0.20 m/s during low traffic hour.

The number of flat steps at the upper landing should be in proportion to the vertical rise of the escalator. For 6.1 m to 18.3 m rise, minimum four flat steps should be provided and for a rise up to 6.1 m manufacturers' standards should be used (2-3 flat steps).

The planning of escalators which act as emergency stairways should meet all the criteria requirements in NFPA 130 Standards. The planning of escalators will be such that they can be used as fixed staircases under a condition of power failure, activation of stop button or activation by safety/protection devices. When the escalators are stationed, no slipping, jerking, sliding and vibration should occur. Escalators will be equipped with protective barriers, where necessary.

- **Design Criteria- Elevator Requirements**

Lifts will be of the goods/passenger public service type and rated at minimum 180 starts per hour. Lifts will be of proven technology and designed to have low energy consumption, low operational costs and will provide environment friendly passenger service. Lifts will be rope traction type capable of operating safely and smoothly without jerking under all loading conditions, for a period of not less than 20 hours per day (except special holiday which may be operated 24 hours a day), seven days per week within the environmental conditions prevailing within the hoist-way and at the location where the elevators are installed.

Lift will be capable of carrying minimum loading of 750 kg, and may be sized for comfortably taking an injured person on a stretcher with room for the stretcher bearers to place the stretcher in the lift without difficulty.

Lifts have a minimum internal size of 1,400 mm x 2,300 mm wide, the door width will be minimum 1,100 mm clear and 2,200 mm high. The drive machine, its associated machinery and all necessary control equipment of lifts at stations will be installed within the lift shaft without any lift machine room. Intercom will be provided inside the lift car to communicate with the Station Operation Room of the station where lifts are installed.

The leveling accuracy at the landing served, under no load and full load condition in either up and down direction, will be made within + 5 mm.

The speed of lift will be capable of reaching the uppermost discharge point in not more than one minute. The time will be calculated from the time the doors are fully closed at the lowest discharge point to the time that they begin to open at the uppermost discharge point. The minimum speed will be not less than 1.0 m/s irrespective of the travel distance. Lifts will be equipped with facilities for physically challenged people, in accordance with the relevant standards.

- **Design Criteria- Stairs Requirements**
  - A central handrail is provided where stair width is 4.5 m or more
  - Risers per flight: 3 minimum, 12 maximum
  - All Steps in a flight of Stairs have the same dimensions
  - Tread width of steps will be 300mm
  - Riser will be 150mm
  - Length of intermediate landing: lesser of 2m or width of stairs
  - Handrail: 0.9m high, 50mm diameter, 45mm clearance to wall.
  - Step noses will be rounded and color contrasted
  - Minimum Stair width for public use: 2400mm
  - Minimum Stair width for emergency evacuation: 1100mm

i. Platform Design Standards

- The length of Platform will be 140m. This allows for the length of 6 car train and a stopping tolerance.

- The nominal platform width measured from platform edge to any continuous (longer than 2000mm) fixed structure shall be a minimum of 3000 mm. The minimum distance from platform edge to any isolated obstruction e.g. columns, shall be 2500mm (an isolated obstruction shall not be longer than

2000 mm). This clearance shall be maintained for safety reasons, irrespective of passenger flow. The platform width greater than the minimum may be required at stations with large passenger flow.

The platform edge shall have a safety margin of 600 mm wide with a non-slip surface and a yellow warning strip of 100 mm wide of contrasting texture. The platform ends shall be provided with 1200 mm wide security gate and be installed with a Pressure Mat Alarm system.

- Platform widths shall be determined to cater to the following scenarios:
  - Normal service: The platform width shall be determined by multiplying the peak minute flow by 0.5 Sqm/person and headway, then dividing by the platform length.
  - Delayed / Emergency service: The platform width shall be determined by the peak minute flow, allowing for two missed headways. The crush load is assumed as sectional load between two stations. For an island platform, the area between the boundaries of the two platforms can be included in the calculation.
- Markings on the platform to assist and control the flow of passengers for boarding and alighting the trains shall be provided.Space occupied by stairs, escalators, structure, seating, platform supervisor’s accommodation etc. is not to be included as part of the platform area.

j. Emergency Evacuation Standards

i. The Requirement is to evaluate people from a station platform to another location, initially the next level below or above and then on to street level without hindrance.

ii. The principles to be followed are :-
- The maximum distance to an exit route on the platform shall be 50 meter.
- The time required walking from the farthest point on a platform to the escalator or stair landing must be considered. Walking speed is assumed to be 1 meter/sec.
- A Check shall be made to ensure that sufficient capacity exists at the level to which passengers are evacuated as being a place of ultimate safety so that people can move freely away from stairs and escalators as they arrive.

- The emergency is assumed to be occurring in one direction of travel only at any given point of time.

iii. For ensuring adequacy of platform area, stair widths and requirement of additional 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 (or full train load if the section load exceeds a full train load) expected to be evacuated at the station in case of an emergency.

k. Commercial Programs

i. A high level of passenger traffic using the stations presents a great potential for high commercial value for advertising.The conditions of success to attract announcers and advertising in transit systems include

- A high level of passenger traffic:
- Maximum of space and maximum of repetitions: minimum space for posters is around 96 positions to be efficient on the entire network (that means a minimum of 6 positions per station)
- Importance of light and the treatment of light to see the posters
- Advertising sales agency to manage the advertising space.

ii. The different possibilities of advertising spaces include

- On the platforms (20% of the spaces on the platform could be used for advertising).
- On the walls beside the escalators
- On the walls of the first level of the stations
- Inside the Rolling Stock (specific dedicated areas)

The provision of advertisements at stations is presented in **Figure 6.4.**

- On the Rolling Stock: train wearing advertisement campaign (train is used as an advertising medium for one campaign). Advertisement on Rolling Stock is presented in **Figure 6.5.**

FIGURE 6.4: ADVERTISEMENTS AT STATIONS

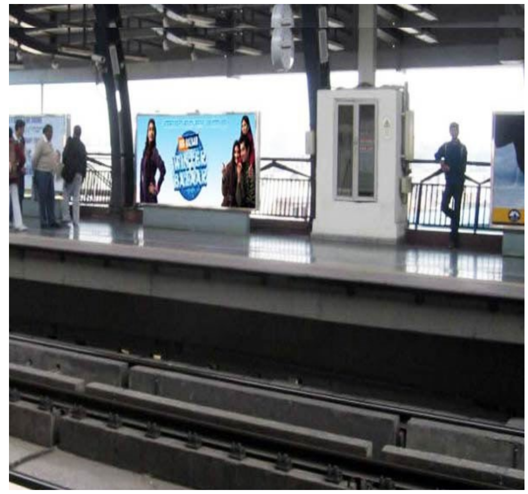


FIGURE 6.5: ADVERTISEMENTS ON ROLLING STOCK

- The entire station can be used as an advertising medium for one campaign.
- New technologies can be used especially on the platforms: LCS screens (about 8m²) with projection. It implies cables have to be set up in the stations and on the platforms. The screens include sensors to calculate the number of passengers who pass and see the poster. The screen can also communicate with mobile phones.

iii. General Principles about the advertising space:

- Advertising spaces must be seen by the customers on the platforms and on the platforms, a symmetry position can be set up as illustrated in **Figure 6.6.**

Commercial Areas for Retail Shops

a. Like Advertising, retail shops in the stations could provide additional financial income. The expected level of passenger traffic in the stations provides great potential for a high commercial value for the retail shops. An agency will preferably be appointed for management of these retail shops at all stations on the proposed Corridor.

b. The different area possibilities for location of retail shops;
   - Inside the stations (paid as well as unpaid areas)
   - Minimum space: 3.5 m of depth all the way across the station; 50m² (3.5 x 14 m) for the smallest stations

c. On the platforms
   - Space: 15 m² per platform for automatic vending machines (for drinks, eatables, etc.) or small convenience stores

d. Inside the stations (before the tool zone)
   - Space for automatic vending machines could be dedicated (for example: for cash, photos)
   - In the covered zone: space for a shopping mall could be created depending on the market potential.

e. Outside the stations (in front of the cars parks or the bus stops)
   - Small corners or kiosks; licenses could be created and negotiated for such shops.
   - Commercial areas and designs will be guided by the market characteristics and local habits.

6.1.4 Planning of Metro Stations

The typical planning of other stations on the corridor is adaptations of the typical stations. Since land is at a premium throughout the corridor, the process of reconciling the land that is actually required for the station development has had a major influence upon the design process and important elements of the stations such as entry/exits, concourse, platforms, ancillary buildings etc. have been designed and marked for each station to overcome land acquisition problems. But, wherever the vacant land parcels have not been found available, land acquisition has been proposed for placing the necessary utilities/facilities.

The most important design consideration is to provide a safe and comfortable environment to passengers during both normal and emergency operation. The space planning requirement for each of the stations with respect to the number of AFC gates, ticket windows, stair width, number of escalators, platform width etc. in normal and emergency conditions are based on peak hour passenger traffic which is detailed in **Annexures 6.1** to **6.3**. These calculations not only accommodate the normal and delayed operation but also satisfy NFPA 130 guidelines.

The stations have been provided with an internal environment suitable for a world class metro railway system by incorporating the experience of international best practices. The stations have been planned in such a way that they are easily operated, maintained and can be upgraded in future. Accommodation for staff and plant rooms is provided at both platform and concourse levels within areas that are entirely separate from the public access. The main plant systems accommodated within the station are the auxiliary sub-stations at the concourse level at each end, ECS plant rooms at concourse level at each end and adjacent to the station box and TVS plant rooms at platform level at each end, between the two tracks. The S&T equipment rooms are provided between the subway and ECS plant room.

The internal arrangement for the stations is evolved in such a way that Back of House accommodation is organized, so that the rooms of a similar operational use are placed along a common corridor and plant accommodation is clearly distinct from habitable rooms.

Seven standardized station typologies have been worked out, namely

- IA Elevated 27 m X 140 m
- IB Elevated 24 m X 140 m
- IIA and IIB Underground 24 m X 265 m
- II C Underground 24 m X 225 m
- IID Underground by NATM
- II E Underground 19.5 m X 275 m (3 levels)
- III Interchange Station

These will be further developed for specific conditions at detailed design stage.

i. Elevated Station

a. Type IA Stations

The stations are generally located on the road median. Total length of the station is 140 m. All the stations are three-level stations. The passenger areas on concourse level is concentrated in a length of about 90 m in the middle of the station, with 2-4 staircases, escalators & elevators leading from either side of the road. The total width of the station is restricted to 27 m allowing for 10.5 m wide carriageway below the concourse with 3 m wide central median. 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.

Since the station is generally in the middle of the road, minimum vertical clearance of 5.5-m has been provided under the concourse. Concourse floor level is about 7.2-m above the road. Consequently, platforms are at a level of about 13.5-m from the road. To reduce physical and visual impact of the elevated station, stations have been made narrow towards the ends.

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 aluminium cladding to achieve a light look. Platforms would be protected from the elements by providing an overhang of the roof and sidewalls would be avoided, thereby enhancing the transparent character of the station building. In order to allow unhindered traffic movement below the stations, portals across the road have been proposed in the concourse part, over which the station structure would rest. The rest of the station structure is supported on a single column, which lies unobtrusively on the central verge. The room schedule for Type IA and elevated station are presented in **Table 6.3, Figure 6.6** and **Figure 6.7** respectively.

TABLE 6.3: ROOM SCHEDULE FOR STATION TYPE IA

ROOM NO.	ROOM NAME	SIZE OF ROOM(M)		AREA PROVIDED (SQ.M)
1	Staff/Mess Room	4.87	9.17	41.49
2	Changing Room	4.5	1.65	2.5
3	Women's Toilet	5.28	4.22	25.32
4	Men's Toilet	3.36	4.2	14.13
5	Handicapped Toilet	1.57	2.15	3.36
6	Refuge Room	2.25	3.53	7.42
7	Cleaner Room	2.25	5.03	11.35
8	UPS	7.41	7.49	63.07
9	Retail-1	7.41	5.51	38.98
10	TER	8.18	6.7	57.76
11	SER	5.38	2.95	15.86
12	T.O.M. 1	2.45	7.77	19.26
13	T.O.M. 2	2.5	7.96	21.57
14	Security Room 1	3.52	2.61	9.19
15	Security Room 2	3	2.6	7.8
16	SCR	10.43	3.18	31.54
17	First Aid Room	3.01	2.35	7.09
19	Store Room	2.5	4.7	11.76
20	UPS Room	3.99	7.49	30.73
21	ASS	25.36	14.08	348.94
22	EFO	4.57	4.42	16.15
23	Retail - 2	21.35	9.23	206.71
24	Corridor (Part - 1) or (Part -2)	5.61 & 5.62	2.45/5.62	28.22

b. Type I B Stations

The 140 m long stations are located on the road median and are three level structures. Passenger areas on concourse are spread throughout the length of the station, with staircases leading from either side of the road. A full length concourse has been proposed due to road below is reduced to 9 m from 10.5 m on either side due the site constraints. The total width of the station is restricted to 24 m. Passenger facilities like ticketing, information, etc. as well as operational areas are provided at the concourse level. The room schedule for Type IB is presented in **Table 6.4.** The sections and plans for Type IB stations are presented in **Figures 6.8** and **6.9.**

TABLE 6.4: ROOM SCHEDULE FOR STATION TYPE IB

ROOM NO.	ROOM NAME	SIZE OF ROOM(M)		AREA PROVIDED (SQ.M)
1	Staff/Mess Room	5.78	8.16	44.38
2	Changing Room	1.50	1.66	2.50
3	Women's Toilet	5.04	2.70	18.25
4	Men's Toilet	3.32	4.69	15.61
5	Handicapped Toilet	2.12	2.98	5.79
6	Refuge Room	3.50	2.70	9.44
7	Cleaner Room	3.50	2.21	7.05
8	UPS	8.64	4.88	41.66
9	TER	5.52	7.46	38.31
10	SER	5.30	4.83	22.32
11	T.O.M. 1	2.97	12.98	38.56
12	T.O.M. 2	2.97	12.98	38.56
13	Security Room 1	3.52	2.60	9.19
14	Security Room 2	3.00	2.60	7.80
15	SCR	10.70	3.44	36.90
16	First Aid Room	3.01	2.35	7.09
17	Ups Room	9.07	3.38	30.15
18	ASS	10.64	20.04	207.34
19	EFO	4.44	3.22	12.41

FIGURE 6.6 CROSS SECTION OF ELEVATED TYPE IA STATION

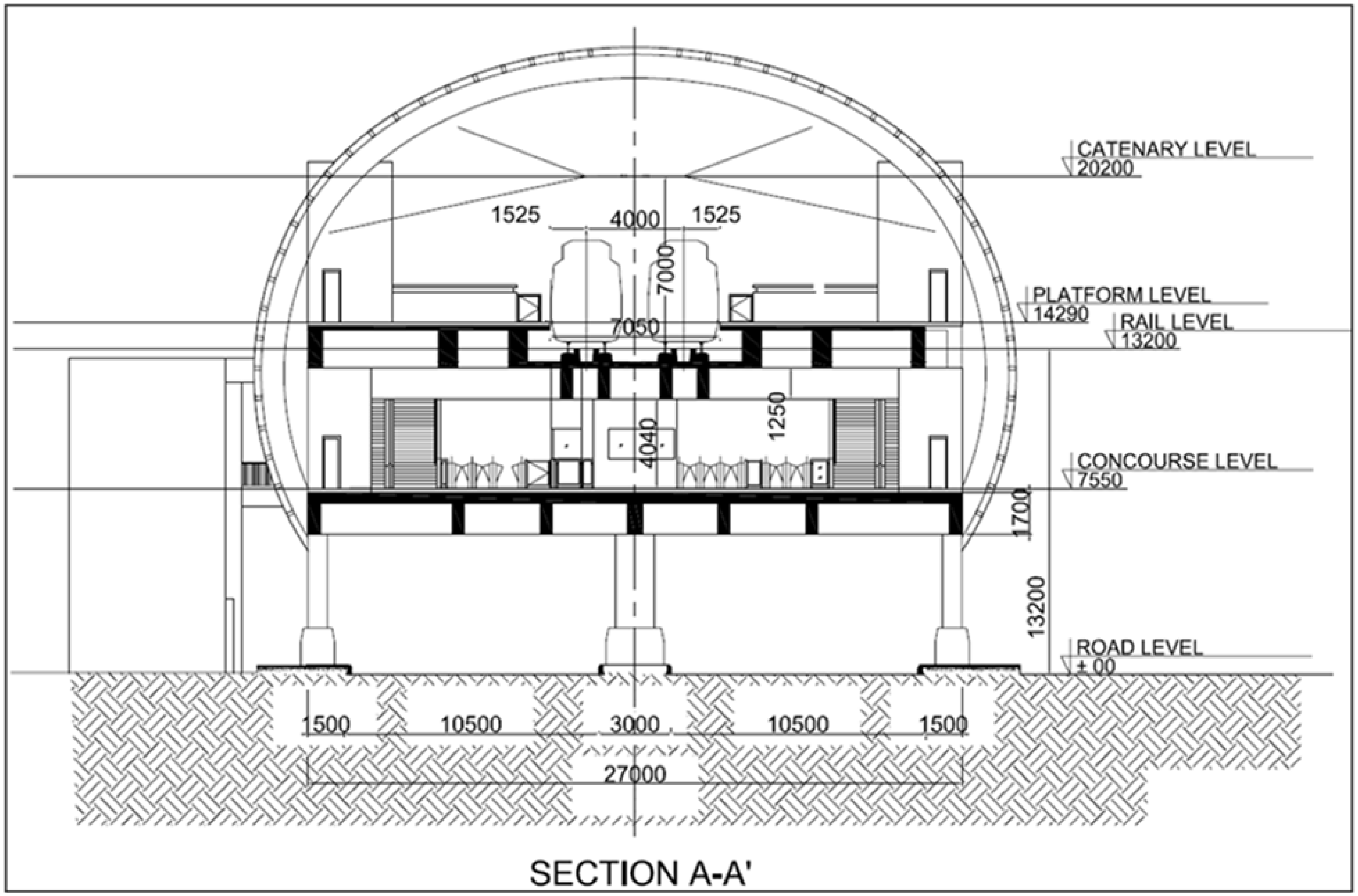


FIGURE 6.7: ELEVATED STATION: TYPE IA

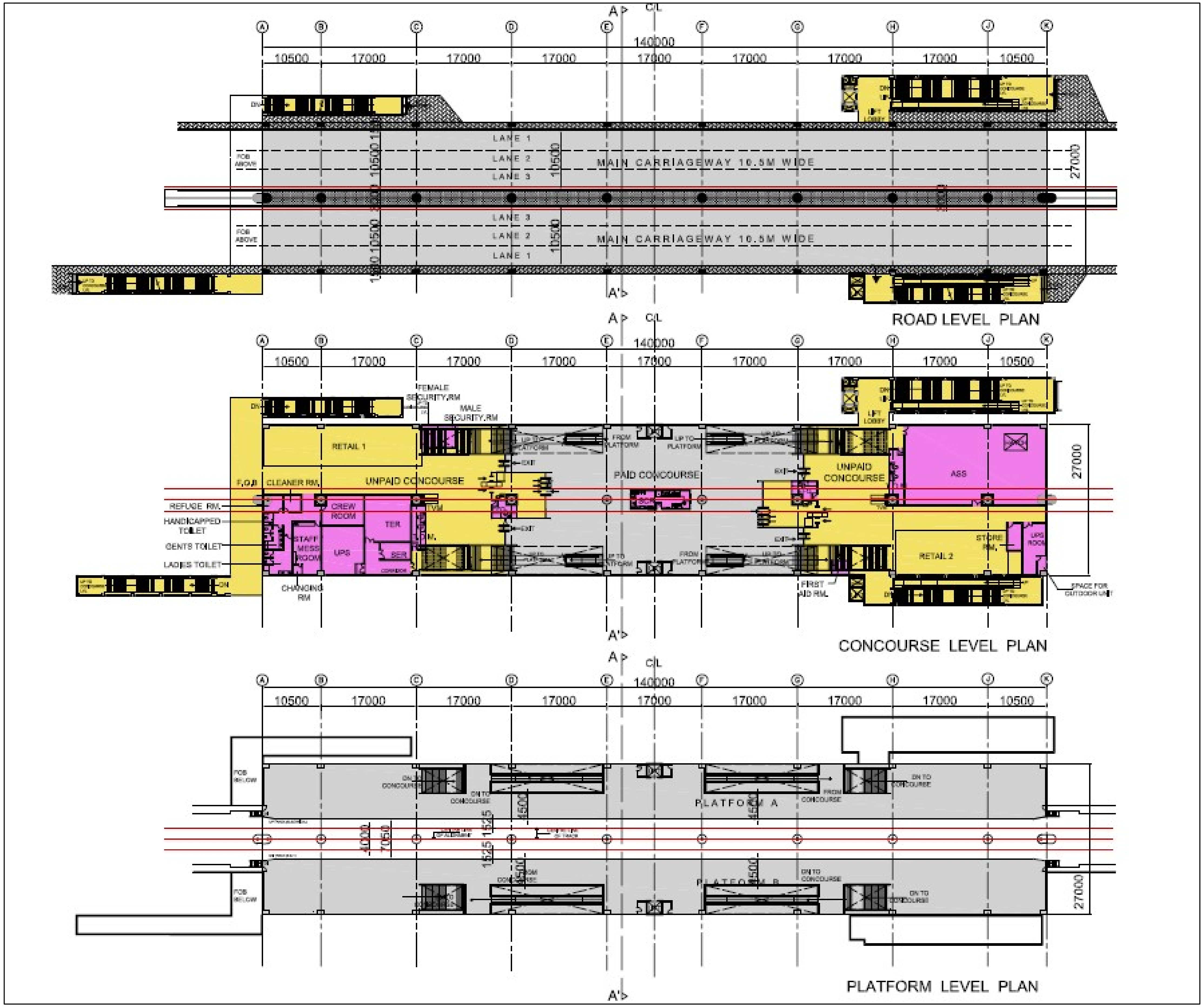


FIGURE 6.8: CROSS SECTION OF ELEVATED STATION - TYPE IB

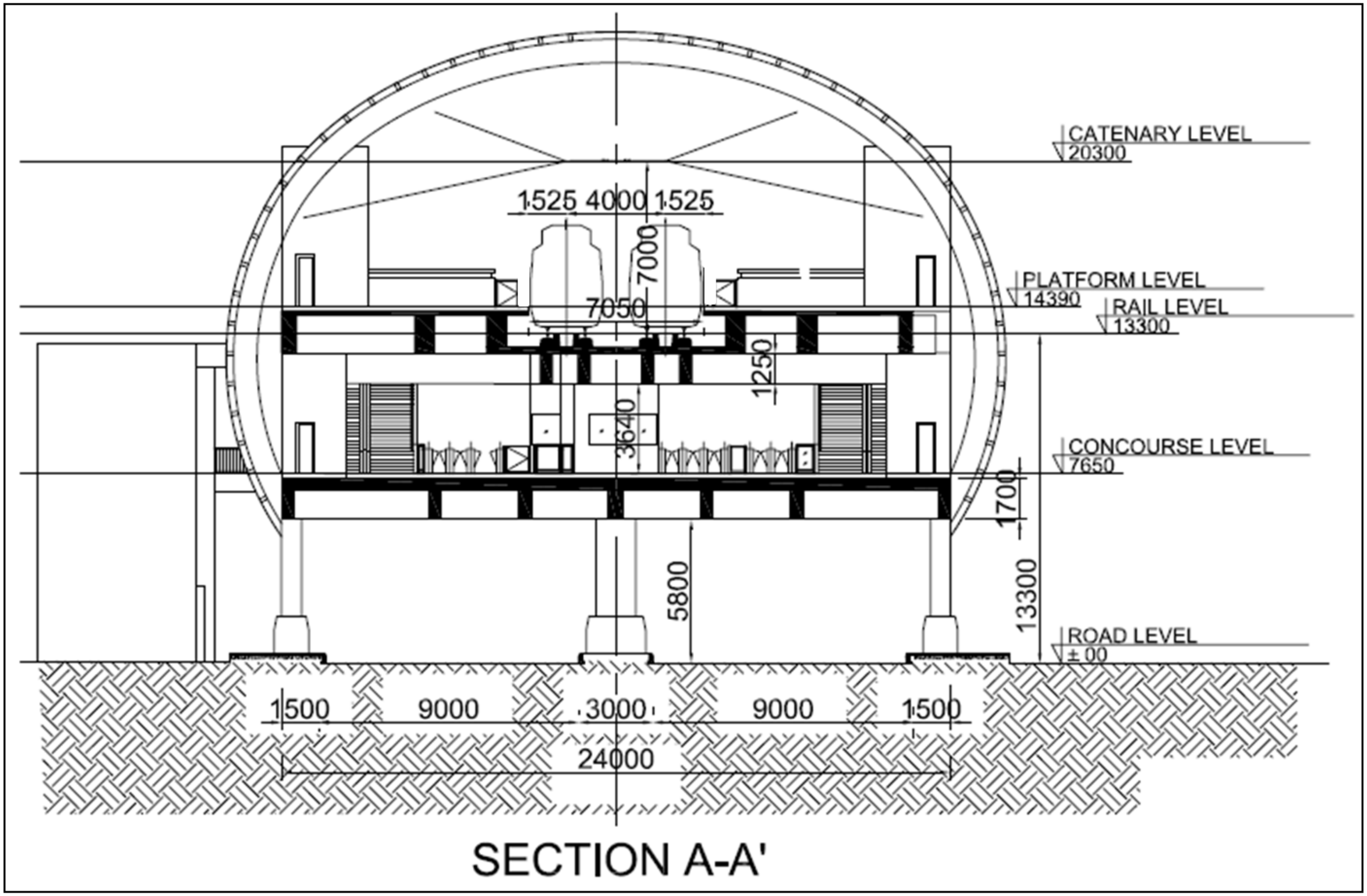
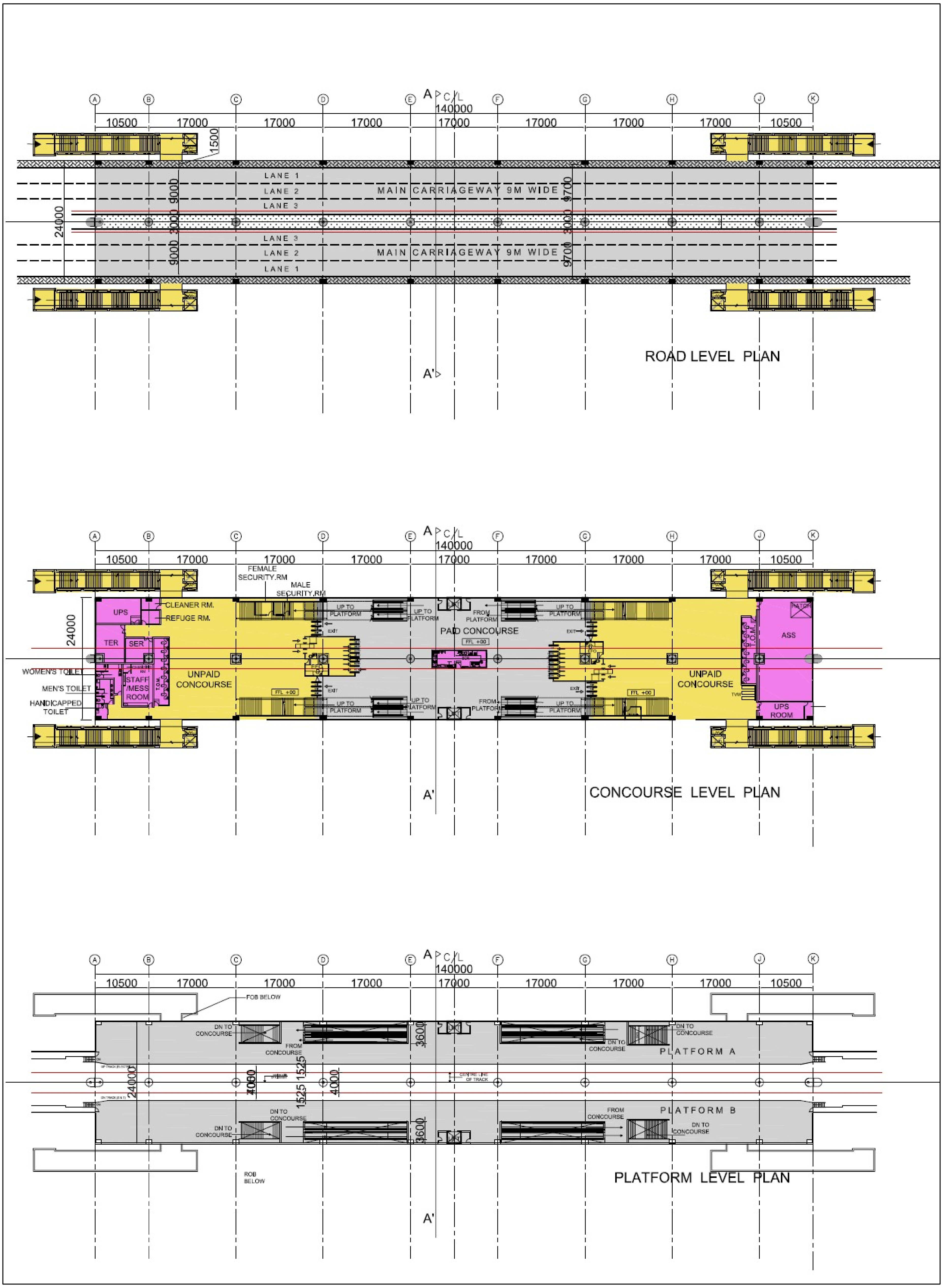


FIGURE 6.9: ELEVATED STATION: TYPE IB



ii. Underground Station

a. Type II A & II B

The underground station is a 2-level station with platforms at the lower level and concourse on upper level. The upper level has all the passenger amenities, ECS plant rooms, electrical and S&T equipment rooms, station operation areas such as Station Control Room, Station Master's Office, Waiting Room, Meeting Room, UPS & Battery Room, Signalling & Train Crew Room, Train Crew Supervisor's Office, Security & Station Store Room, Staff Toilets, etc. Lower level has platforms, tracks, seepage sump, pump room Tunnel ventilation room and similar ancillary spaces beyond the platforms on either side. Two / Three banks of 2.4 m of staircase and 2 escalators have been planned from concourse to platform to meet the traffic demands. Ventilation shafts, equipment hatch, entrances and chiller plants for ECS plant are above ground structures associated with the underground station and are provided on the open spaces by the road side. Four entrances are provided to the station, two at each end (one each from either side of road). Structure of the station is essentially a concrete box about 22 m wide, 14m high and 266 m long with an intermediate slab. Sides of the box are made of 0.8-1.2 m thick RCC walls.

The station Type IIB is similar to Type IIA except that the concourse has three banks of staircases and escalators from concourse to ground to cater to the projected no. of passengers in the horizon years. The room schedule for underground stations is presented in **Tables 6.5 and 6.6.** The section and plans of Type IIA & IIB are presented in **Figures 6.10 and 6.11**.

TABLE 6.5: ROOM SCHEDULE FOR UNDERGROUND STATION TYPE II-A & B

ROOM	ROOM NAME	ROOM SIZE (m)		AREA PROVIDED (SQ.M)
U01	Station Entrance Unpaid Area	27.85	17.83	393.85
U02	Concourse Paid Area	96.79	17.83	1733.43
U03	Station Control Room (SCR)	12.9	3.31	42.70
U04	Station Manager Room (SMR)	4.74	4.8	21.67
U05A	Ticket office machine (TOM)	9.62	2.3	22.13
U05B	Ticket office machine (TOM)	3	18.16	54.48
U07A	EFO	2.5	2.5	6.25
U07B	EFO	2.5	2.5	6.25
U09	Security Room	3.27	4.8	15.69
U12	Cleaners Room	4.17	2.4	10.01
U13	Refuse Store Room	4.97	2.4	11.93
U15L	Publice Toilets (L)	4.37	3.31	14.46
U15G	Publice Toilets (G)	2.47	5.01	12.37

ROOM	ROOM NAME	ROOM SIZE (m)		AREA PROVIDED (SQ.M)
U16	Mess Room	5.29	3.31	17.51
U19A	ECS Plant Room (ECS)	42.85	22.63	766.45
U18A	DB Room	2.24	6.60	13.77
U18B	DB Room	2.24	6.50	13.77
U20A	Tunnel Ventilation Plant Room	13.85	10.40	143.28
U20B	Tunnel Ventilation Plant Room	13.85	10.40	143.32
U21	Platform Public Area	118.80	12.60	1701.72
U25A	Auxiliary Sub-Station	21.68	10.40	227.29
U25B	Auxiliary Sub-station	21.20	10.40	222.18
U27A	Electrical UPS Room	6.80	4.85	27.52
U27B	Electrical UPS Room	6.80	4.37	31.14
U31A	Seepage Room	4.60	6.60	30.36
U31B	Seepage Room	6.22	2.40	14.93
U32	Sewage Room	4.59	2.30	10.55
U39A &U39B	Emergency Escape Staircase	7.17	1.50	11.55
U40	Fireman Access Staircase	1.20 3.60	4.37 1.37	10.19
U48	Chiller Plant Room	16.70	25.20	420.82
U19B	ECS Plant Room	44.25	22.63	830.10
U22	Signaling Equipment Room (SER)	4.90	5.31	26.02
U23	Telecom Equipment Room (TER)	7.92	5.31	42.06
U24	UPS Room for S & T	11.65	5.31	61.86
U28	CDMA Room	4.69	5.31	24.90
U29	GSM Room	4.45	5.31	23.63
U43	Pump Room	16.70	25.20	420.83
U46	Public Toilets (H)	1.80	2.00	3.60
U51	Emergency Equipment Room	2.95	6.25	18.44
U63 & U64	E &M Staff and Store Room	6.80	6.70	45.56
U10	Store Room	5.49	2.10	11.10

TABLE 6.6: ROOM SCHEDULE FOR U/G STATION TYPE II-A & B - SEWAGE SUMP

ROOM	DESCRIPTION	SIZE	CAPACITY (Cu.m)
1	Sewage Sump -1	10.2	60.18
2	Sewage Sump -2	-	60.68
3	Sewage Sump	-	15.54

b. Type II C

This station typology has a design having constraint length. The length has been kept as 223 m as against 265 m in typical underground stations. However, the station configuration is similar to Type II A. The only difference is that the utility areas on both the ends have been expanded in width, **Figure 6.12.**

Apart from these, another three typologies have been worked out which are area specific, i.e. Tunnel Bored Station **(IIC)**, 3 levels underground station **(IID)** and Interchange station **(III)**. These are explained in subsequent paragraph**.**

iii. Types of Metro Stations on Phase-I Corridors

All Phase –I corridor's stations with their types are presented in **Table 6.7.**

TABLE 6.7: DETAILS OF STATION TYPE

SN	Name of Station	Description	Station Type
Corridor 1 IIT Kanpur to Naubasta			
1	IIT Kanpur	Elevated	I A
2	Kalyanpur Railway Station	Elevated	I B
3	SPM Hospital	Elevated	I B
4	CSJM University	Elevated	I B
5	Gurudev Chauraha	Elevated	I A
6	Geeta Nagar	Elevated	I B
7	Rawatpur Railway station	Interchange	III
8	Lala Lajpat Rai Hospital	Elevated	I B
9	Moti Jheel	Elevated	I B
10	Chunniganj	UG	II C
11	Naveen Market	UG	II B
12	Bada Chauraha	UG	II B
13	Phoolbagh	UG	II C
14	Nayaganj	UG	II D
15	Kanpur Central Railway station	UG	II B
16	Jhakarkati Bus terminal	UG	II A
17	Transport Nagar	UG	II A
18	Baradevi	Elevated	I B
19	Kidwai Nagar	Elevated	I B
20	Vasant Vihar	Elevated	I A
21	Baudh Nagar	Elevated	I B
22	Naubasta	Elevated	I A

SN	Name of Station	Description	Station Type
Corridor 2: Agricultural University to Barra-8			
1	Agricultural University	UG	II C
2	Rawatpur Railway Station	Interchange	III
3	Kakadeo	UG	II E
4	Double Pulia	UG	II A
5	Vijay Nagar Chauraha	Elevated	I A
6	Govind Nagar	Elevated	I B
7	Shastri Chowk	Elevated	I A
8	Barra-7	Elevated	I A
9	Barra-8	Elevated	I A

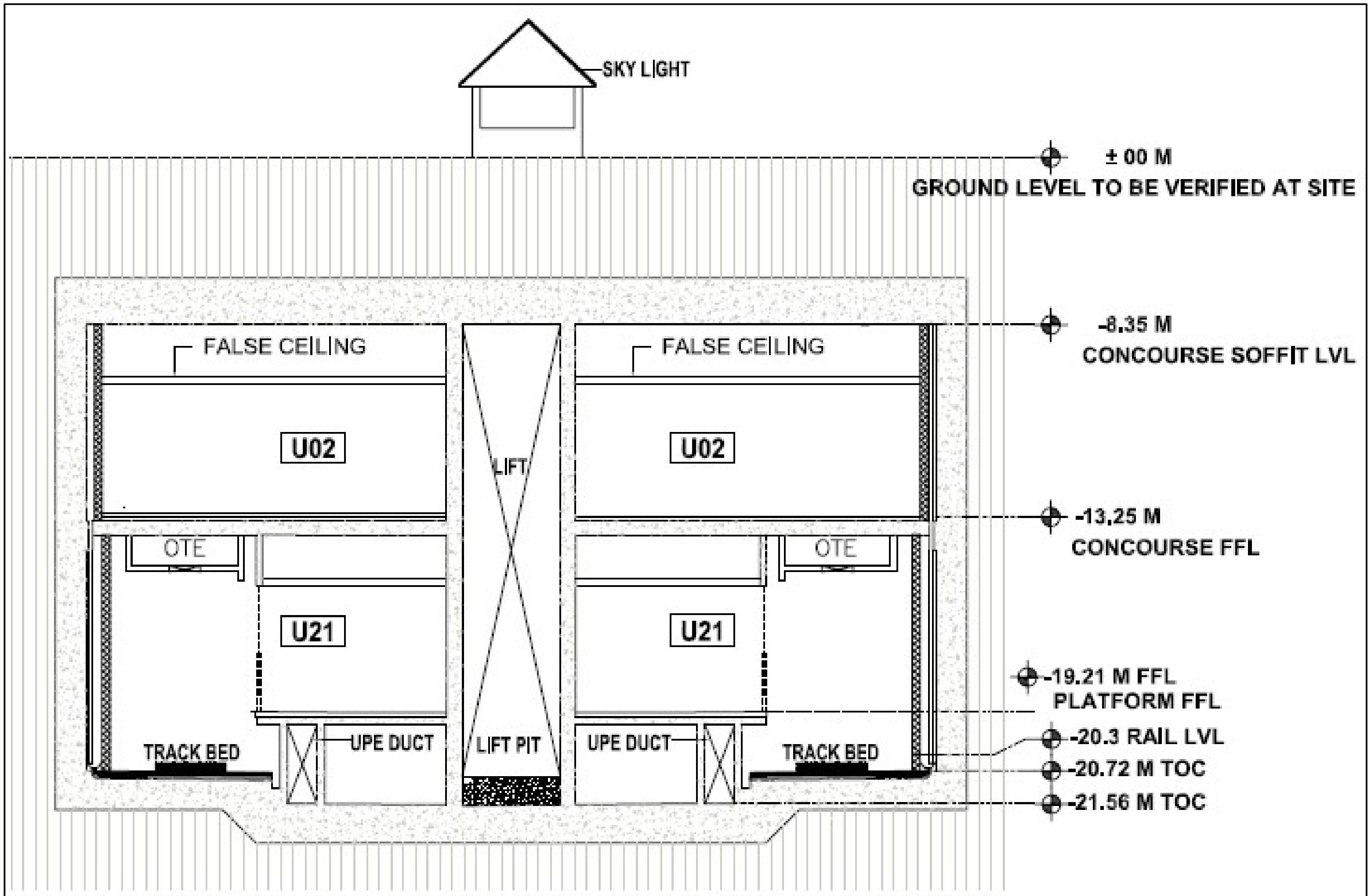
6.1.5 Typical Metro Station Planning

Planning of 10 identified typical stations (5 underground, 4 elevated stations & 1 Interchange station) for Phase-I metro corridors is discussed in subsequent paragraphs.

These stations have been selected judiciously on the basis of following and will form the basis for planning of other remaining stations along the corridors.

1. **IIT Kanpur** - This station is terminal Station of Corridor-1 from IIT Kanpur to Naubasta.
2. **Kalyanpur Railway Station** - This is an important location, this station provides intermodal connectivity with the existing Kalyanpur Railway Station.
3. **Gurudev Chauraha** - An important junction effecting passenger transfer between GT Road and Vikas Nagar Road.
4. **Rawatpur Railway Station (Interchange Station)**- One of the important locations in the city, this is an interchange metro station along with Bus Terminal, Railway Station and Terminal point for shared autos making it a passenger transfer hub.
5. **Chunniganj** - This station has an existing Bus Terminal for intercity buses and the first underground station from IIT Kanpur to Naubasta Corridor.
6. **Nayaganj** - This underground station is planned in the congested area on Canal Road. This is the only station in Kanpur metro which has been proposed to be constructed using NATM (New Austrian Tunneling Method).

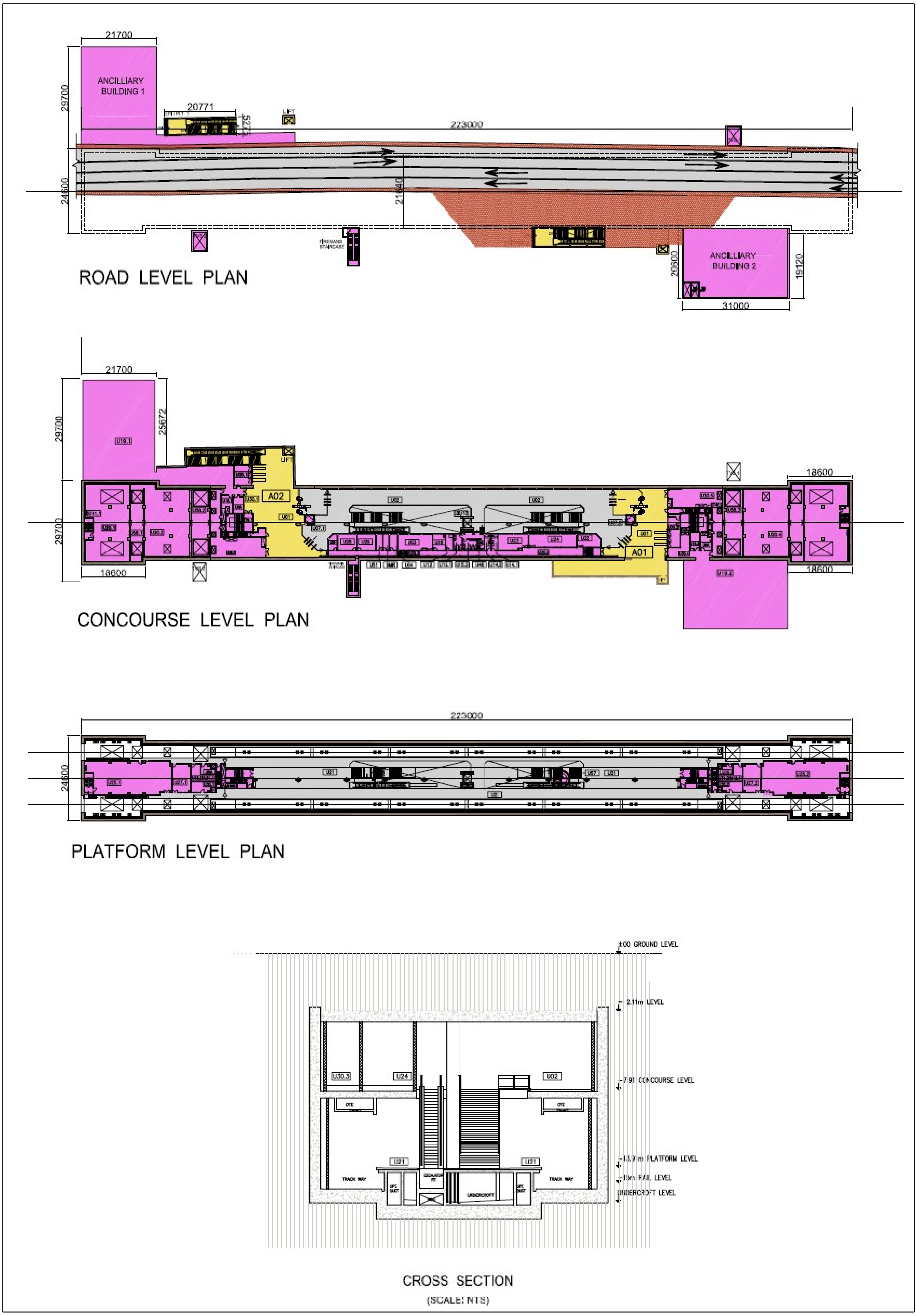
FIGURE 6.10: CROSS SECTION OF UNDERGROUND STATION - TYPE II A & II B



(SCALE: NTS)

FIGURE 6.11: UNDERGROUND STATION: TYPE II-A&B

FIGURE 6.12: UNDERGROUND STATION: TYPE IIC



7. **Kanpur Central Railway Station** – This underground metro station integrates the existing Kanpur Central Railway Station. The railway station experiences thousands of passengers arriving/ departing to various parts of study area every day. In addition, Ghantaghar side is an important centre for IPT and PT interchange.
8. **Naubasta** - This is the terminal station of Phase-I of Corridor-1.
9. **Agriculture University** – This underground station is terminal station on Corridor-2 of Phase-I.
10. **Kakadeo** - This station on Corridor-2 from Agriculture University to Barra-8 has been reduced in width (19.45 m) in comparison to typical underground station due to its location on a narrow road with buildings on either sides.

1. IIT Kanpur

This is a terminal station located on the road median. Total length of the station is 140m. The station is a two-level elevated station. The concourse is concentrated along the whole length of the station, with staircases leading from either side of the road on both end of the concourse. The total width of the station is restricted to 27 m allowing for 10.5 m wide carriageway below the concourse with 3 m wide central median. Passenger facilities like ticketing, information, etc. as well as operational areas are provided at the concourse level. DG Room, Pump Room and firefighting water tanks are located below one of the entry structure to avoid acquisition of additional land. The Ground Level Plan, Concourse Level Plan, Platform Level Plan and Cross Section for IIT Kanpur Station are presented in **Annexure 6.4.**

2. Kalyanpur Railway Station

This type B station is located adjacent to Kalyanpur railway station on the south side. The width of the station is reduced to 24 m due to constrained urban environment. A carriageway of 7.5 m has been planned to address the local site problems. There is heavy development beyond the Kalyanpur Railway Station which is proposed to be connected to the metro station by skywalks across the railway lines to provide easy and convenient access. The skywalks shall bring passengers to the concourse level directly. The escalators and staircases have planned to meet the design standards described in the previous pages. The Ground Level Plan, Concourse Level Plan, Platform Level Plan and Cross Section for Kalyanpur Railway Station are presented in **Annexure 6.5.**

3. Gurudev Chauraha

The station is located close to Gurudev Chauraha traffic intersection. The station is similar to IIT Kanpur 27 m wide spanning over the road. The station is integrated with the surroundings with set of proposed skywalks to provide unhindered access to station even from across the rail level crossing. The entry-exit staircases have been strategically located to facilitate passengers coming from all directions at the cross road junction and across the railway line to reach the station with ease. The Ground Level Plan, Concourse Level Plan, Platform Level Plan and Cross Section for Gurudev Chauraha Station are presented in **Annexure 6.6** and **6.7.**

4. Rawatpur Railway Station (Interchange Station)

Rawatpur Railway Station is the interchange station between Phase I Corridors of Kanpur Metro. To enable seamless transfer of passengers between one line and another, it is proposed to connect the paid area of proposed underground station with paid area of elevated station through a set of staircases and escalator to negotiate the height of 17.5m between the two concourses of elevated and underground stations.

This station is likely to be one of the busiest stations owing to its proximity to the Rawatpur Railway Station and Bus Terminal. There will be a large no. of passengers interchanging between the two metro corridors. The station has been sized accordingly. The structural arrangement of columns of elevated station (27 m X 140 m) is proposed to allow the construction of two underground tunnels of Corridor 2 passing under the elevated station of Corridor 1.

The platform level of underground station is contained within a two storied cut and cover structural box of 266 m x 22 m. The platforms are 14.7 m below the ground level. The size of island platform is 140 m x 13 m. Vertical circulation, in the form of two sets of adequately sized stairs and escalators have been provided in the center of island platform, to cater to normal and emergency passenger movement for the design station load. Separate firemen access stairs and passenger escape stairs have also been provided at each end of station.

There are 2 side platforms of the elevated station at 16 m above ground level with a full length concourse between platforms and ground. A common entry at ground level has been planned at ground level with ticket counters. A passenger can go to the elevated or underground from this entrance. There are three entry/exit structures which are located to address the catchment areas and local site constraints. The station is also integrated with adjacent bus terminal. In addition, elevators have been provided for the use of physically challenged passengers. The Ground Level Plan, Concourse Level Plan, Platform Level Plan and Cross Section for Rawatpur Station are presented in **Annexure 6.8** to **6.10.**

5. **Chunniganj**

Chunniganj station is an underground station of Type IID. The station is located in the vicinity of bus terminal and college under the Mall Road. The station box of 22m x 223m consists of station operational, functional, public and non-public areas with two ancillary structures planned to accommodate the ECS Plant Rooms, Chiller rooms, UG Tanks and DG Sets. Two banks of staircase and escalators are proposed to meet the emergency scenario. Two set of entrances have been planned to bring the passengers to the station and suitably located to address the local area requirements. The station shall be constructed by cut and cover method. The station is approached by station entrances located suitably considering the catchment areas and surroundings. The Ground, Concourse & Platform Level Plans and Cross Section for Chunniganj Station are presented in **Annexure 6.11.**

6. **Nayaganj**

The station is located within the thickly built up area having surrounding commercial land use. There is no area available for the construction of station box by cut and cover method. To avoid the large scale displacement or relocation of people and land acquisition, a bored tunnel station is proposed. The station will be of Type IIC as described earlier. The tunnels are proposed to be constructed by NATM method. Each tunnel is wide enough to accommodate a platform and a rail track. The approach to platforms is designed through two vertical shafts where the staircase and escalators are placed. The station operational areas are also planned in these shafts. The Ground Level Plan, Concourse Level Plan, Platform Level Plan and Cross Section for Nayaganj Station are presented in **Annexures 6.12 & 6.13.**

7. **Kanpur Central Railway Station**

The metro station is located in front of Kanpur Central Railway station and shall provide interchange for the passengers using the railway station. The station box of 22mx266 m accommodates all station operational, functional and public & non-public areas. Due to heavy patronage three banks of staircases and escalators are proposed to meet the emergency scenario. Three sets of entrances have been planned to bring passengers to the metro station. An underground ancillary building is planned where the chiller, pump room, firefighting water tanks and DG room are accommodated. The station shall be constructed by cut and cover method. The Ground Level Plan, Concourse Level Plan, Platform Level Plan and Cross Section for Kanpur Central Railway Station are presented in **Annexure 6.14.**

8. Naubasta

Naubasta station is a terminal station of Corridor 1 and is of Type IA. There is a canal which is proposed to be covered to make available space for entry/exit structure and parking. The Ground Level Plan, Concourse Level Plan, Platform Level Plan and Cross Section for Naubasta Station are presented in **Annexures 6.15** to **6.16.**

9. Agriculture University

Agriculture University is the terminal station of Corridor 2 from Agriculture University to Barra-8. This underground station is of Type II D. The station box of 22m x 223m consists of station operational, functional, public and non-public areas with two ancillary structures planned to accommodate the ECS Plant Rooms, Chiller rooms, UG Tanks and DG Sets. Two banks of staircase and escalators are proposed to meet the emergency scenario. Two sets of entrances have been planned to bring the passengers to station. The station shall be constructed by cut and cover method. The Ground Level Plan, Concourse Level Plan, Platform Level Plan and Cross Section for Agriculture University Station are presented in **Annexure 6.17.**

10. Kakadeo

The underground Kakadeo station of Corridor 2 is of Type II E. The station box of 19.5m x 275m consists of station operational, functional, public and non-public areas with one large ancillary structure planned to accommodate the ECS Plant Room, Chiller rooms, UG Tanks and DG Sets. Two banks of staircase and escalators are proposed to meet the emergency scenario. Two sets of entrances have been planned to bring the passengers to the station. Due to narrow road width available at its location, the width of the station has been reduced to ease construction and avoid hindrance to neighbouring buildings. The station shall be constructed by cut and cover method. The Ground Level Plan, Concourse Level Plan, Platform Level Plan and Cross Section are presented in **Annexure 6.18.**

6.2 STATION AREA PLANNING FOR NON-MOTORIZED VEHICLE AND PEDESTRIANS FACILITIES

The following pedestrian and non motorized vehicles facilities have been planned near the station influence area.

- The circulating area adjoining the station building is proposed to be properly designed to ensure rapid/efficient dispersal of passengers, avoiding conflict between pedestrians and vehicular traffic.

- The station entry/exit have been planned keeping in view the major growth centers/activity areas. The entry/exit has been designed to integrate the station with existing/ proposed bus stops/bus bays, pick-drop zones and IPT services within walking distance.

- Pick and drop zones and bays for feeder modes like buses, IPT have been proposed near the station.

- Dedicated linkages have been proposed like subways, skywalks, covered walkways etc. at interchange stations which reduces the passenger travel time and pedestrian load on the roads.

- All the footpaths in the metro station influence zone have been planned to be upgraded to desired level of comfort and also proposed new within the stations vicinity areas. The existing road shoulder areas and service lanes also have been augmented/ strengthened in the design wherever possible to utilize the complete RoW to cater to the future traffic volume

- 2 m wide footpath has been proposed on the local roads whereas a continuous footpath of 3 m width on the major roads, subject to site conditions, to provide accessibility to people on wheel chairs as per Code of Practice for Urban Roads (Part-1),2012 of MoUD.

- The vendors if any on the footpaths shall be removed and desired accessibility to metro stations will be provided.

- Junctions and intersections have been proposed with proper pedestrian crossings. In the design, table top crossings has been proposed wherever possible, otherwise ramps with gentle slope ranging from 1:5-1:7 have been designed for pedestrians

FIGURE 6.13: PEDESTRIAN FACILITIES PROVIDED NEAR PROPOSED STATIONS

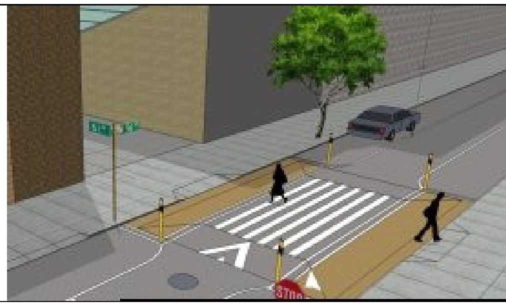


Table top crossing for pedestrians	Ramp from footpath to carriageway for easy movement
	
Footpath and Cycle Track Facilities	Footpath For Pedestrian Movement

- For non motorized vehicles like bicycle, rickshaw etc, separated NMV lane have been planed within the station influence area for smooth circulation on the basis of the availability of land.
- The design has been incorporated with a 2 m continuous strip of cycle track on both sides of the road around stations in accordance to available RoW.
- The cycle track will be differentiated by colour, markings and material for uninterrupted movement.

FIGURE 6.14: NMT FACILITIES AT STATION AREA

	
Cyclist friendly junction design	Lane Marking for Cyclists

6.3 ACCESSIBILITY FOR DIFFERENTLY ABLED

'Space Standards for Barrier Free Built Environment for Disabled and Elderly Persons-1998' and revised in 2013 and other international best practices have been considered.

User-friendly mass transport system can ensure accessibility to persons with differently abled, people travelling with small children or carrying luggage and the elderly persons. The following measures will be considered while planning of metro stations for such persons:

- A metro route map in Braille/raised numbers shall be maintained at the enquiry/ticketing window. In each car, there shall be an announcement and provision of a visual display of the names of stations en route.

- Tactile Guiding Paver (Line-Type) and Tactile Warning Paver (Dot-Type) shall be installed from station entry upto the platform boarding/alighting place for visual impaired persons wherever is needed.
- At least one of the ticket gates shall allow a wheelchair user through and have a continuous line of guiding paver for people with visual impairments.

- Public dealing counters (Information or help desks) shall be close to the terminal entrance, and highly visible. They shall be clearly identified and accessible to both those who use wheelchairs and those who stand.

- Staircase, lift and ramp shall be planned for persons with learning differently abled, intellectual differently abled, and elderly persons. Location shall be clearly visible from the pedestrian route. Lifts shall have both visual and audible floor level indicators.

- In emergency situations, audible alarms with 'voice instructions' 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).

Figure 6.15 shows various features for differently abled person as proposed in a metro station.

FIGURE 6.15: DIFFERENTLY ABLED FEATURES IN/AROUND METRO STATIONS

Tactile Guiding Tiles for Wayfinding

Station Entry symbols for all users

Signage for accessible washroom

Way finding signage

6.4 PARKING AT STATIONS

Dedicated parking provision for metro commuters is one of the key factors determining success of the metro system. Parking provisions along with priority to pedestrians through foot over bridges and feeder bus services would encourage more commuters to use the metro system. Passengers can safely park their vehicles at the nearest station, walk to the station or rely on feeder connectivity. The station wise parking facility area for personal vehicles and public bicycle sharing as planned along both the metro corridors is presented in **Table 6.8.**

TABLE 6.8: DETAILS OF PARKING FOR PHASE-I CORRIDORS

SN	Metro Station	Parking Area (Sqm)
Corridor-1: IIT Kanpur to Naubasta		
1	IIT Kanpur	5000
2	Kalyanpur	800
3	SPM Hospital	10000
4	CSJM University	36500
5	Gurudev Chauraha	6500
6	Geeta Nagar	2700
7	Rawatpur Rly Stn. (Interchange Station)	13350
8	Lala Lajpat Rai Hospital	2300

SN	Metro Station	Parking Area (Sqm)
9	Moti Jheel	1500
10	Chunniganj Bus Terminal	13050
11	Navin Market	2000
12	Bada Chauraha	2750
13	Phoolbagh	2300
14	Nayaganj	1000
15	Kanpur Central Rly Stn.	8300
16	Jhakarkati Bus Terminal	1750
17	Transport Nagar	1000
18	Baradevi	2400
19	Kidwai Nagar	5800
20	Vasant Vihar	1400
21	Baudh Nagar	2000
22	Naubasta	6000
Corridor-2: Agriculture University to Barra-8		
23	Kakadeo	3800
24	Double Pulia	4100
25	VIjay Nagar	5400
26	Govind Nagar	3500
27	Shastri Chowk	2050
28	Barra 7	2600
29	Barra 8	2900
Depots & Samaj Kalyan Vibhag Land		
31	Agriculture Univ Depot	9200
	Total	**161950**

Various modes of transportation like feeder buses, auto rickshaw/taxi and bicycles can provide first mile as well as last mile connectivity other than walking to the metro station. For catchment area of about 0.5-1 km from the proposed network, commuter can easily access it by walk. People residing in the next 1 km can reach the station by cycles, 2-Wheeler and auto-rickshaws. Areas beyond the 2-km catchment will require regular feeder bus services to reach the metro station. Adequate arrangements have been provided for receiving and dispatch of PT/ IPT at all metro stations. Parking provisions have been made at all stations. Parking provisions are made specifically on the available Govt. land in order to minimize cost of land acquisition. However parking provisions at 5 stations are also provided on private land.

ANNEXURE 6.1

EGRESS REQUIREMENT (PLATFORM TO CONCOURSE) AND PLATFORM CALCULATIONS – DESIGN YEAR

S No.	Station Name	Direction 1					Evacuation time	Direction 2					Platform width			Egress capacity in Mts (P-C)		
		Peak Hour Boarding	Peak Minute Boarding	Sectional load Hourly	Sectional Load (per train)	Occupant Load		Peak Hour Boarding	Peak Minute Boarding	Sectional load Hourly	Sectional Load (per train)	Occupant Load	Required Direction1	Required Direction 2	Provided	Direction 1	Direction 2	Provided
1	IIT Kanpur	5500	110	0	0	1089	5.50	0	0	5000	275	275	1.56	0.39	3.5	3.14	0.79	7
2	Kalyanpur Railway Station	12530	251	5500	303	2787	5.50	5370	107	15600	858	1921	3.98	2.74	3.5	8.04	5.54	11.7
3	SPM Hospital	2310	47	19400	1067	1532	5.50	990	20	20100	1106	1302	2.19	1.86	3.5	4.42	3.76	6.15
4	CSJM University	6300	126	20600	1133	2380	5.50	2700	54	21800	1199	1734	3.40	2.48	3.5	6.87	5.00	8.4
5	GurudevChauraha	6860	138	22800	1254	2620	5.50	2940	59	20700	1139	1721	3.74	2.46	4.5	7.56	4.97	9.4
6	Geeta Nagar	2660	54	16300	897	1431	5.50	1140	23	20700	1139	1364	2.04	1.95	3.5	4.13	3.94	7
7	Rawatpur Railway Station	16520	331	16300	897	4173	5.50	7080	142	21000	1155	2557	5.96	3.65	4.5	12.04	7.38	12.5
8	LalalajpatRai Hospital	2660	54	21900	1205	1739	5.50	1140	23	22000	1210	1436	2.48	2.05	3.5	5.02	4.14	7
9	MotiJheel	3290	66	23500	1293	1946	5.50	1410	28	23500	1293	1572	2.78	2.25	3.5	5.62	4.54	7.6
10	Chunniganj	4340	87	24800	1364	2348	4.00	1860	37	26500	1458	2113	3.35	3.02	12	10.48	8.38	12
11	Naveen Market	8120	163	23600	1298	3141	4.00	3480	70	27700	1524	2750	4.49	3.93	13	14.02	10.91	15.8
12	BadaChauraha	4200	84	23100	1271	2221	4.00	1800	36	33900	1865	2498	3.17	3.57	13	9.91	9.91	15.8
13	PhoolBagh	3290	66	14600	803	1549	4.00	1410	28	31900	1755	2251	2.21	3.22	13	6.92	8.93	12.3
14	Nayaganj	4340	87	14200	781	1765	4.00	1860	37	33500	1843	2498	2.52	3.57	13	7.88	9.91	13.5
15	Kanpur Central Railway Station	13860	278	14500	798	3942	4.00	5940	119	25600	1408	3502	5.63	5.00	13	17.60	13.89	18.2
16	Jhakarkati Bus Terminal	6790	136	11100	611	2149	4.00	2910	58	21800	1199	2224	3.07	3.18	13	9.59	8.83	12.3
17	Transport Nagar	2310	47	11200	616	1147	4.00	990	20	20100	1106	1457	1.64	2.08	13	5.12	5.78	12.3
18	Baradevi	4480	90	10700	589	1480	5.50	1920	38	20500	1128	1508	2.11	2.15	3.5	4.27	4.35	7.6
19	Kidwai Nagar	1750	35	9900	545	891	5.50	750	15	19200	1056	1205	1.27	1.72	3.5	2.57	3.48	7
20	VasantVihar	8470	170	9500	523	2206	5.50	3630	73	11200	616	1335	3.15	1.91	3.5	6.37	3.85	7
21	Baudh Nagar	4060	82	9400	517	1329	5.50	1740	35	8000	440	785	1.90	1.12	3.5	3.83	2.26	7
22	Naubasta	0	-	8600	473	473	5.50	5500	110	0	0	1089	0.68	1.56	3.5	1.37	3.14	7
1	Agricultural University	2200	44	0	0	462	4.00	0	0	20000	1167	1321	0.66	1.89	12	2.06	5.90	12
2	Rawatpur Railway Station	9800	196	18900	1103	3455	4.00	4200	84	24000	1400	2968	4.94	4.24	13	15.42	13.25	18.20
3	Kakadeo	2240	45	14600	852	1391	4.00	960	19	25300	1476	1835	1.99	2.62	9.6	6.21	8.19	8.6
4	Double Pulia	1610	33	13100	764	1159	4.00	690	14	24400	1423	1684	1.66	2.41	13	5.17	7.52	12.3
5	Vijay Nagar Chauraha	7840	157	12900	753	2401	5.50	3360	67	21900	1278	1983	3.43	2.83	3.5	6.93	5.72	8
6	Govind Nagar	3500	70	10200	595	1330	5.50	1500	30	20100	1173	1488	1.90	2.13	3.5	3.84	4.29	7
7	ShastriChauraha	4970	100	11200	653	1703	5.50	2130	43	18600	1085	1532	2.43	2.19	3.5	4.92	4.42	7
8	Barra-7	8120	163	11800	688	2400	5.50	3480	70	9900	578	1308	3.43	1.87	3.5	6.93	3.78	7
9	Barra-8	0	-	7500	438	438	5.50	3400	68	0	0	714	0.63	1.02	3.5	1.26	2.06	7

ANNEXURE 6.2

EVACUATION TIME CALCULATIONS (CONCOURSE TO GROUND LEVEL) – DESIGN YEAR

S No.	Station Name	Peak Hour Boarding	Peak Hour Alighting	Peak Minute Boarding	Peak Minute Alighting	Concourse Occupant load under normal conditions	Concourse Occupant load under abnormal conditions		Concourse Occupant load per minute under abnormal conditions			Staircase width required in mts		Egress Capacity in Mts (Staircase Width) *Ground lvl - Concourse lvl*			
							Direction 1	Direction 2	Direction 1	Direction 2	Total	Normal conditions	Abnormal conditions	Staircase	Escalator	Total Width Provided	Lifts
Corridor 1 IIT Kanpur to Naubasta																	
1	IIT Kanpur	5500	5000	110	100	210	1089	330	218	66	284	3.33	4.50	9.6	2	11.6	2
2	Kalyanpur Railway Station	17900	14500	358	290	648	2787	354	557	71	628	10.29	9.97	8.4	1	9.4	2
3	SPM Hospital	3300	6600	66	132	198	1532	65	306	13	320	3.14	5.07	7.8	1	8.8	2
4	Kanpur University	9000	8600	180	172	352	2380	178	476	36	512	5.59	8.12	7.8	1	8.8	1
5	GurudevChauraha	9800	15200	196	304	500	2620	194	524	39	563	7.94	8.93	13.2	4	17.2	1
6	Geeta Nagar	3800	3800	76	76	152	1431	75	286	15	301	2.41	4.78	8.4	2	10.4	2
7	Rawatpur Railway Station	23600	18300	472	366	838	4173	467	835	93	928	13.30	14.73	6	4	10	1
8	LalalajpatRai Hospital	3800	3100	76	62	138	1739	75	348	15	363	2.19	5.76	7.8	1	8.8	1
9	MotiJheel	4700	4900	94	98	192	1946	93	389	19	408	3.05	6.47	6	2	8	2
10	Chunniganj	6200	10400	124	208	332	2348	123	671	35	706	5.93	12.61	8.4	3	11.4	1
11	Naveen Market	11600	13400	232	268	500	3141	230	898	66	963	8.93	17.20	13.8	3	16.8	4
12	BadaChauraha	6000	20800	120	416	536	2221	119	635	34	668	9.57	11.94	11.4	3	14.4	3
13	Phoolbagh	4700	3000	94	60	154	1549	93	443	27	469	2.75	8.38	7.2	2	9.2	1
14	Nayaganj	6200	7500	124	150	274	1765	123	504	35	539	4.89	9.63	4.8	4	8.8	0
15	Kanpur Central Railway Station	19800	15400	396	308	704	3942	392	1126	112	1238	12.57	22.11	4.8	4	8.8	1
16	Jhakarkati Bus Terminal	9700	5700	194	114	308	2149	192	614	55	669	5.50	11.94	6	2	8	2
17	Transport Nagar	3300	2200	66	44	110	1147	65	328	19	346	1.96	6.18	8.4	2	10.4	2
18	Baradevi	6400	7600	128	152	280	1480	127	296	25	321	4.44	5.10	10.2	1	11.2	4
19	Kidwai Nagar	2500	1600	50	32	82	891	50	178	10	188	1.30	2.99	8.4	2	10.4	2
20	VasantVihar	12100	4100	242	82	324	2206	240	441	48	489	5.14	7.76	10.2	1	11.2	3
21	Baudh Nagar	5800	3300	116	66	182	1329	115	266	23	289	2.89	4.58	7.8	1	8.8	3
22	Naubasta	5500	5400	110	108	218	356	109	71	22	93	3.46	1.48	4.8	2	6.8	2
Corridor 2 Agricultural University to Barra-8																	
1	Agricultural University	2200	3000	44	60	104	462	210	132	60	192	1.86	3.43	4.8	2	6.8	2.0
2	Rawatpurrailway Station	14000	22300	280	446	726	3455	294	987	84	1071	12.96	19.13	6	3.0	9	2.0
3	Kakadeo	3200	5900	64	118	182	1391	67	398	19	417	3.25	7.44	7	2	9.2	2
4	Double Pulia	2300	1700	46	34	80	1159	48	331	14	345	1.43	6.16	8.4	2	10.4	2
5	Vijay Nagar Chauraha	11200	11400	224	228	452	2401	235	686	47	733	7.17	11.64	9.0	3	12	3
6	Govind Nagar	5000	2200	100	44	144	1330	105	380	21	401	2.29	6.37	5	1	6.4	1
7	Shastri Park	7100	5100	142	102	244	1703	149	487	30	516	3.87	8.20	11.4	2	13.4	3
8	Barra-7	11600	7200	232	144	376	2400	244	686	49	734	5.97	11.66	7.8	2	9.8	2
9	Barra-8	3400	2200	68	44	112	154	71	44	14	58	1.78	0.93	8	2	10.4	2

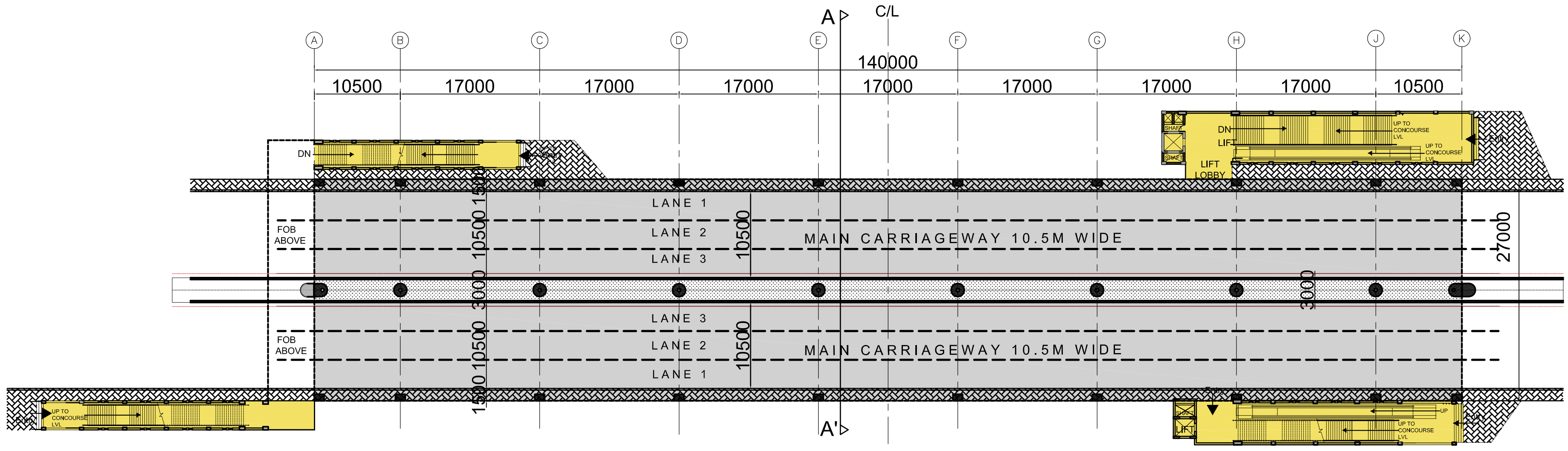
ANNEXURE 6.3

PROPOSED PASSENGER RELATED FACILITIES – DESIGN YEAR

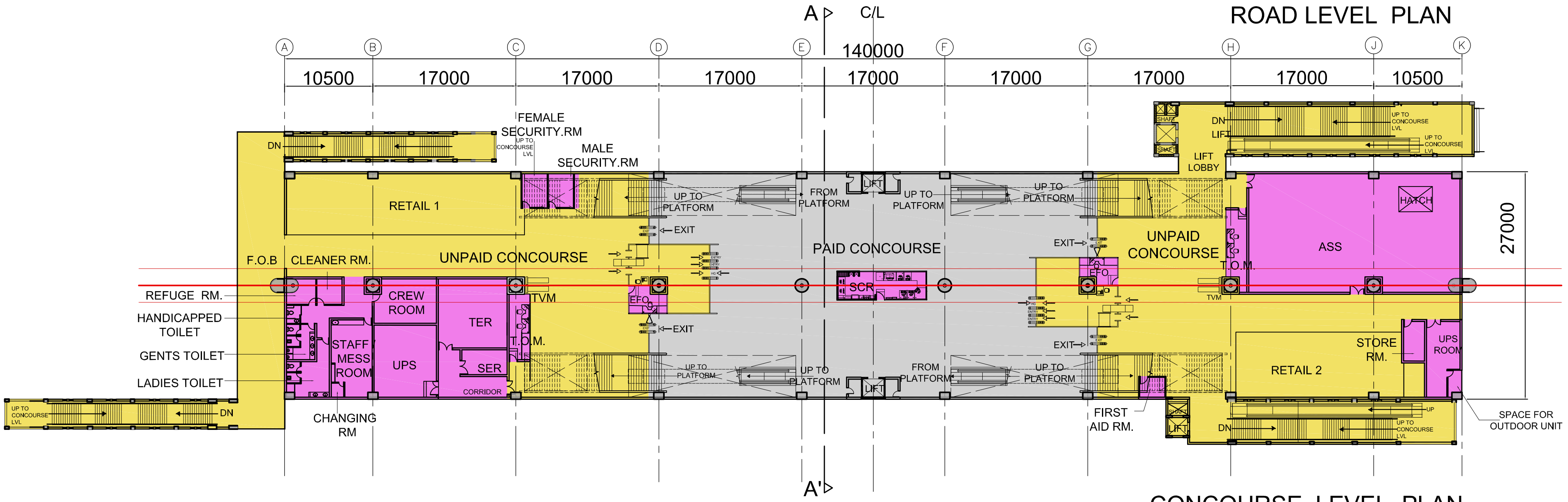
S No.	Station name	Peak Hour Boarding			Peak Minute Boarding	90% will buy smart cards	10% will buy tickets	10% of smart card will upgrade	Peak Hour Alighting			Peak Minute Alighting	TOM	AFC IN Gates @ 35 persons/minute	AFC OUT Gates @ 35 persons/ minute	Emer-gency Gates	Provided		Gates for Disabled	Total no. of Gates
		Direction 1	Direction 2	Total					Direction 1	Direction 2	Total						IN Gates	OUT Gates		
Corridor 1 IIT Kanpur to Naubasta																				
1	IIT Kanpur	5500	0	5500	110	99	11	10	0	5000	5000	100	4	4	3	2	4	4	2	12
2	Kalyanpur Railway Station	12530	5370	17900	358	322	36	32	10150	4350	14500	290	14	11	9	2	12	12	2	28
3	SPM Hospital	2310	990	3300	66	59	7	6	4620	1980	6600	132	3	2	4	2	4	4	2	12
4	Kanpur University	6300	2700	9000	180	162	18	16	6020	2580	8600	172	7	6	5	2	6	6	2	16
5	GurudevChauraha	6860	2940	9800	196	176	20	18	10640	4560	15200	304	7	6	9	2	10	10	2	24
6	Geeta Nagar	2660	1140	3800	76	68	8	7	2660	1140	3800	76	3	3	3	2	4	4	2	12
7	Rawatpur Railway Station	16520	7080	23600	472	425	47	42	12810	5490	18300	366	18	14	11	2	14	14	2	32
8	LalaLajpatRai Hospital	2660	1140	3800	76	68	8	7	2170	930	3100	62	3	3	2	2	4	4	2	12
9	MotiJheel	3290	1410	4700	94	85	9	8	3430	1470	4900	98	4	3	3	2	4	4	2	12
10	Chunniganj	4340	1860	6200	124	112	12	11	7280	3120	10400	208	5	4	6	2	6	6	2	16
11	Naveen Market	8120	3480	11600	232	209	23	21	9380	4020	13400	268	9	7	8	2	8	8	2	20
12	BadaChauraha	4200	1800	6000	120	108	12	11	14560	6240	20800	416	5	4	12	2	12	12	2	28
13	PhoolBagh	3290	1410	4700	94	85	9	8	2100	900	3000	60	4	3	2	2	4	4	2	12
14	NayaGanj	4340	1860	6200	124	112	12	11	5250	2250	7500	150	5	4	5	2	4	4	2	12
15	Kanpur Central Railway Station	13860	5940	19800	396	356	40	36	10780	4620	15400	308	15	12	9	2	12	12	2	28
16	Jhakarkati Bus Terminal	6790	2910	9700	194	175	19	17	3990	1710	5700	114	7	6	4	2	6	6	2	16
17	Transport Nagar	2310	990	3300	66	59	7	6	1540	660	2200	44	3	2	2	2	4	4	2	12
18	Baradevi	4480	1920	6400	128	115	13	12	5320	2280	7600	152	5	4	5	2	6	6	2	16
19	Kidwai Nagar	1750	750	2500	50	45	5	5	1120	480	1600	32	2	2	1	2	4	4	2	12
20	VasantVihar	8470	3630	12100	242	218	24	22	2870	1230	4100	82	9	7	3	2	8	8	2	20
21	Baudh Nagar	4060	1740	5800	116	104	12	10	2310	990	3300	66	4	4	2	2	4	4	2	12
22	Naubasta	0	5500	5500	110	99	11	10	5400	0	5400	108	4	4	4	2	4	4	2	12
												Total	**138**	**115**	**112**	**44**	**144**	**144**	**44**	**376**
Corridor 2 Agricultural University to Barra-8																				
1	Agricultural University	2200	0	2200	44	40	4	4	0	3000	3000	60	2	2	2	2	4	4	2	12
2	Rawatpur Railway Station	9800	4200	14000	280	252	28	25	15610	6690	22300	446	11	8	13	2	14	14	2	32
3	Kakadeo	2240	960	3200	64	58	6	6	4130	1770	5900	118	3	2	4	2	4	4	2	12
4	Double Pulia	1610	690	2300	46	41	5	4	1190	510	1700	34	2	2	1	2	4	4	2	12
5	Vijay Nagar Chauraha	7840	3360	11200	224	202	22	20	7980	3420	11400	228	9	7	7	2	8	8	2	20
6	Govind Nagar	3500	1500	5000	100	90	10	9	1540	660	2200	44	4	3	2	2	4	4	2	12
7	Shastri Park	4970	2130	7100	142	128	14	13	3570	1530	5100	102	6	5	3	2	6	6	2	16
8	Barra-7	8120	3480	11600	232	209	23	21	5040	2160	7200	144	9	7	5	2	8	8	2	20
9	Barra-8	0	3400	3400	68	61	7	6	2200	0	2200	44	3	2	2	2	4	4	2	12
												Total	**49**	**38**	**39**	**18**	**56**	**56**	**18**	**148**

ANNEXURE 6.4

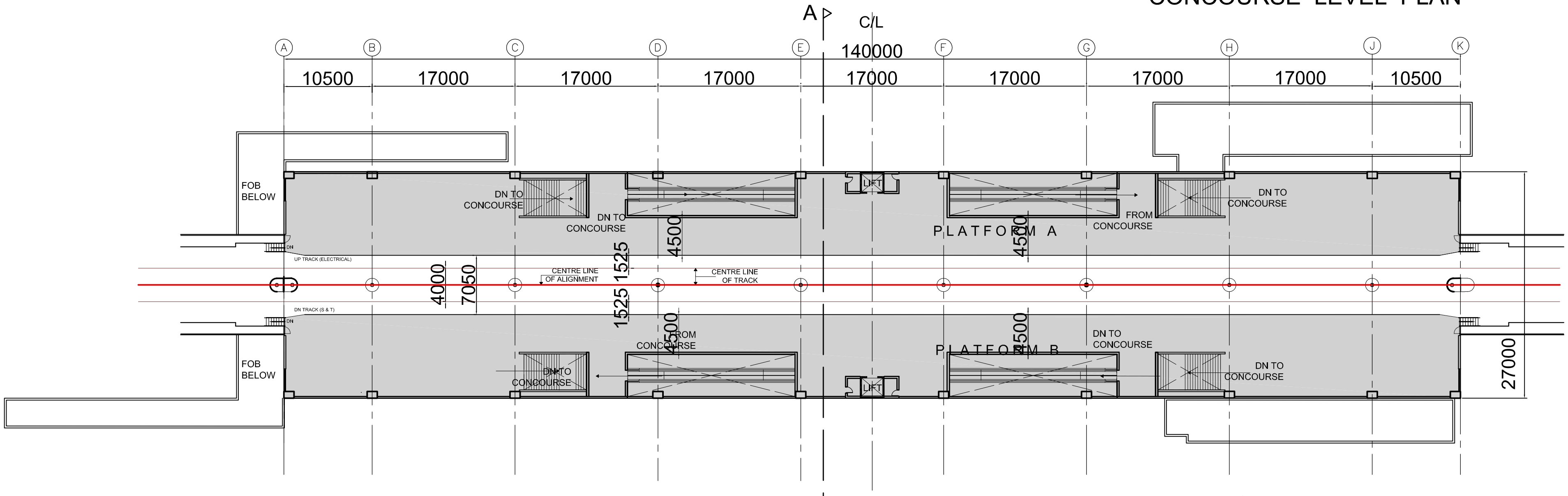
STATION DESIGN OF IIT KANPUR METRO STATION



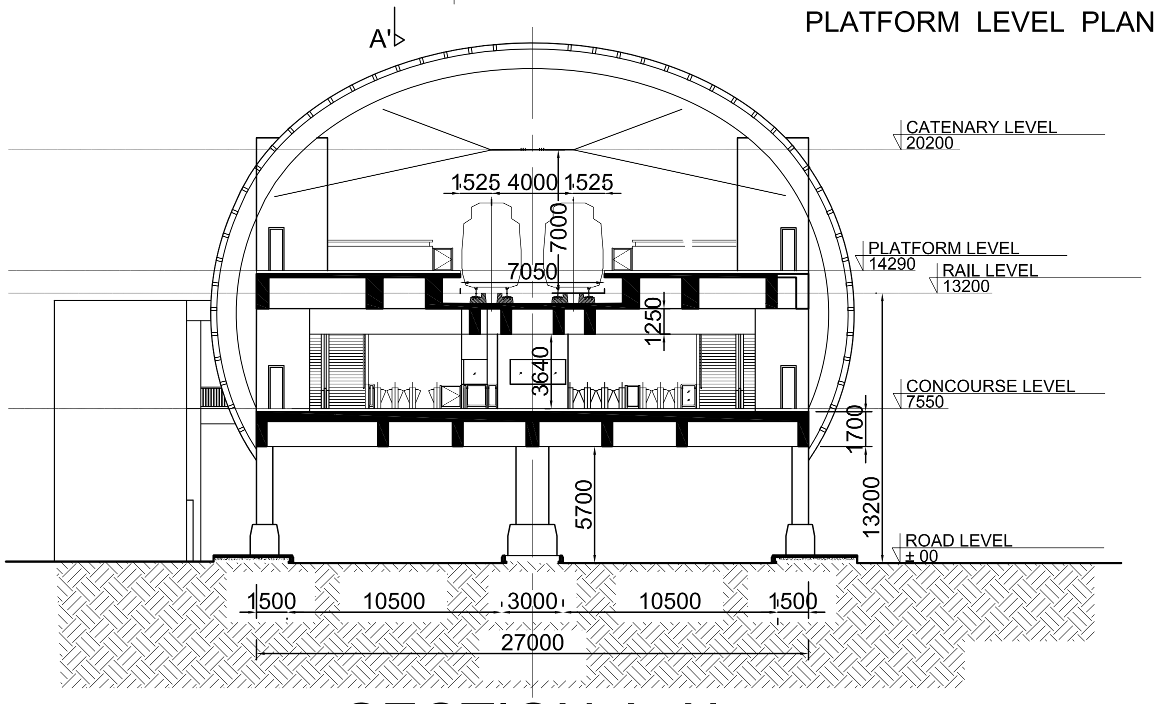
ROAD LEVEL PLAN



CONCOURSE LEVEL PLAN



PLATFORM LEVEL PLAN



SECTION A-A'

(SCALE: NTS)

ROOM SCHEDULE

ROOM. NO.	ROOM NAME	SIZE OF ROOM (M)		AREA PROVIDED (SQ.M)
01	STAFF/MESS ROOM	4.87	9.17	41.49
02	CHANGING ROOM	1.50	1.65	2.50
03	WOMEN'S TOILET	5.08	4.22	25.32
04	MEN'S TOILET	3.36	4.20	14.13
05	HANDICAPPED TOILET	1.55	2.15	3.36
06	REFUGE ROOM	3.48	3.03	8.65
07	CLEANER ROOM	3.00	3.03	9.09
08	UPS	7.40	8.55	63.07
09	RETAIL-1	28.3	7.25	205.17
10	TER	8.18	6.70	57.76
11	SER	5.38	2.95	15.86
12	T.O.M 1	2.50	7.77	19.26
13	T.O.M 2	2.50	7.96	21.57
14	SECURITY ROOM 1	3.00	4.00	12.00
15	SECURITY ROOM 2	3.00	4.00	12.00
16	SCR	10.69	3.47	37.13
17	FIRST AID ROOM	3.01	2.35	7.09
19	STORE ROOM	2.50	4.70	11.76
20	UPS ROOM	3.99	8.99	30.73
21	ASS	25.13	14.08	348.94
22	EFO	9.78	3.44	13.77
23	RETAIL-2	21.35	7.72	174.63
24	CORRIDOR (PART-1) (PART-2)	5.61 2.57	2.45 5.62	28.22

IIT KANPUR STATION

DPR FOR KANPUR MRTS

STATION LAYOUT PLANS : TYPE IA ELEVATED - 27M X 140M

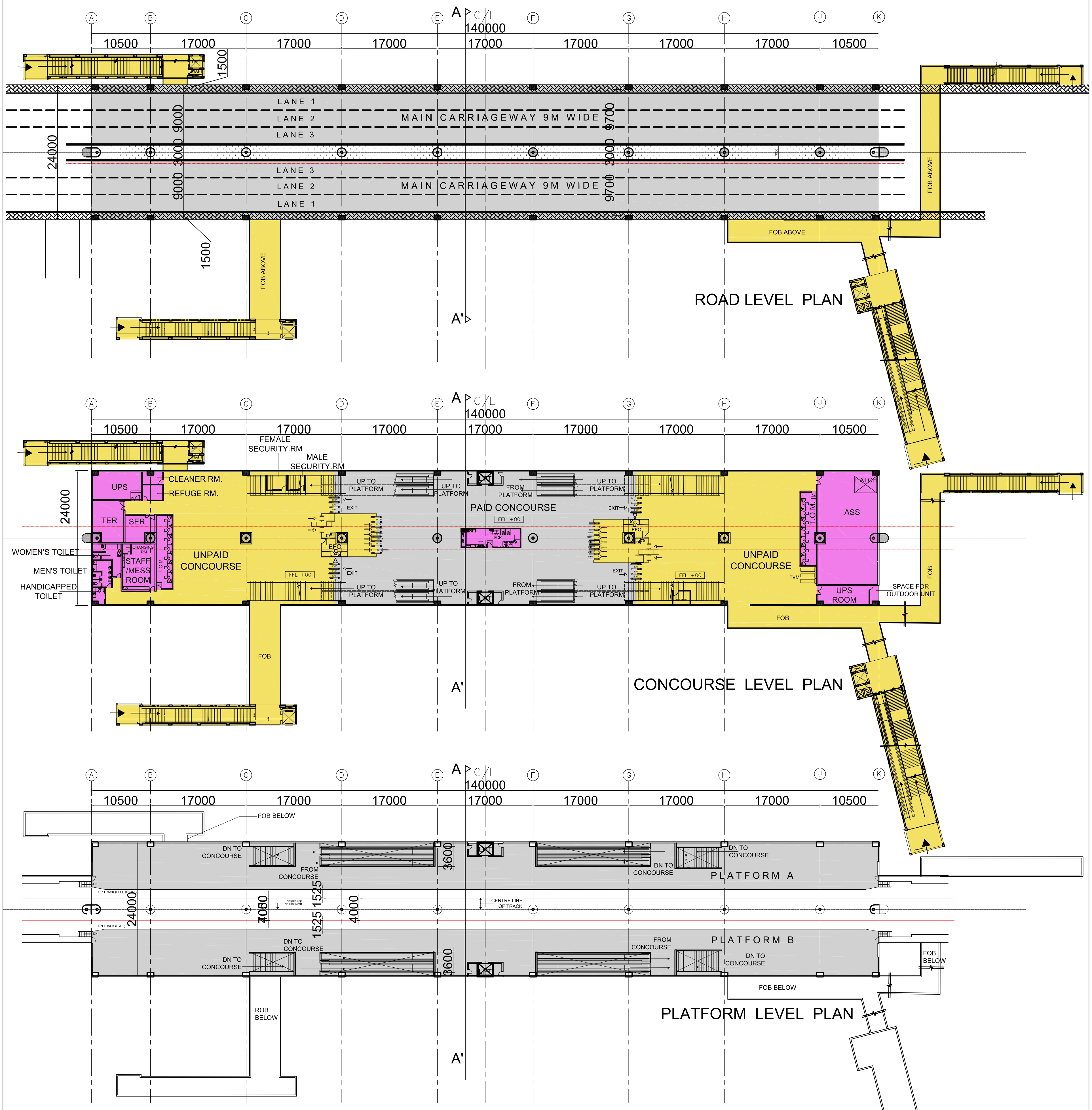
IIT KANPUR - NAUBASTA CORRIDOR

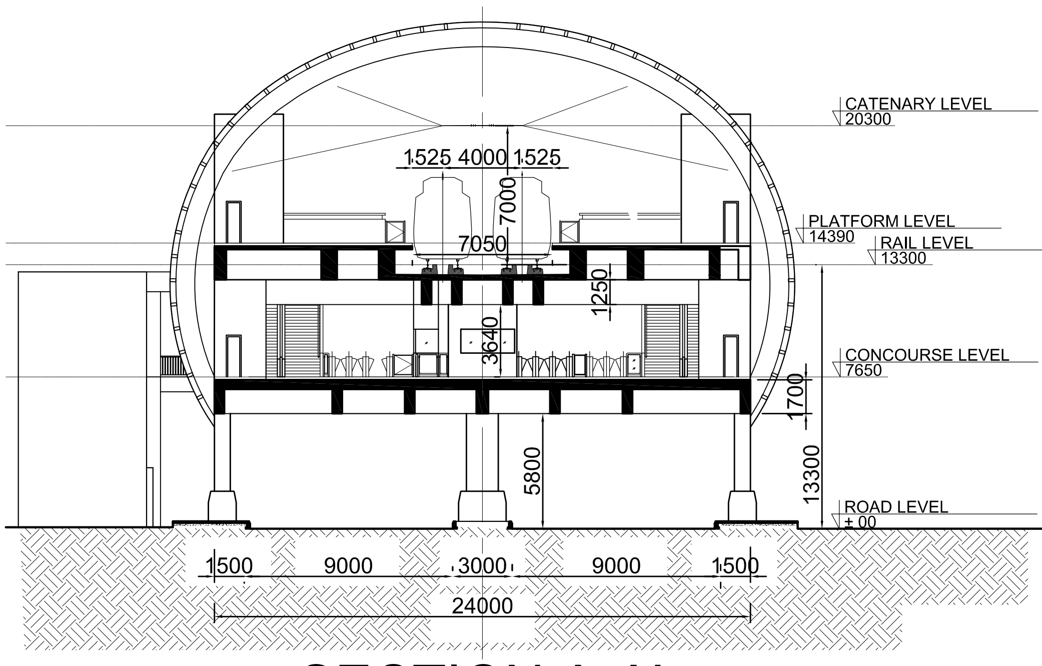
ARCHITECTURAL

DRG. NO.	REV.	SCALE	STATUS
KM-TYPIA-01b	R1	1:650	CONCEPT DESIGN

ANNEXURE 6.5

STATION DESIGN OF KALYANPUR RAILWAY STATION





SECTION A-A'

(SCALE: NTS)

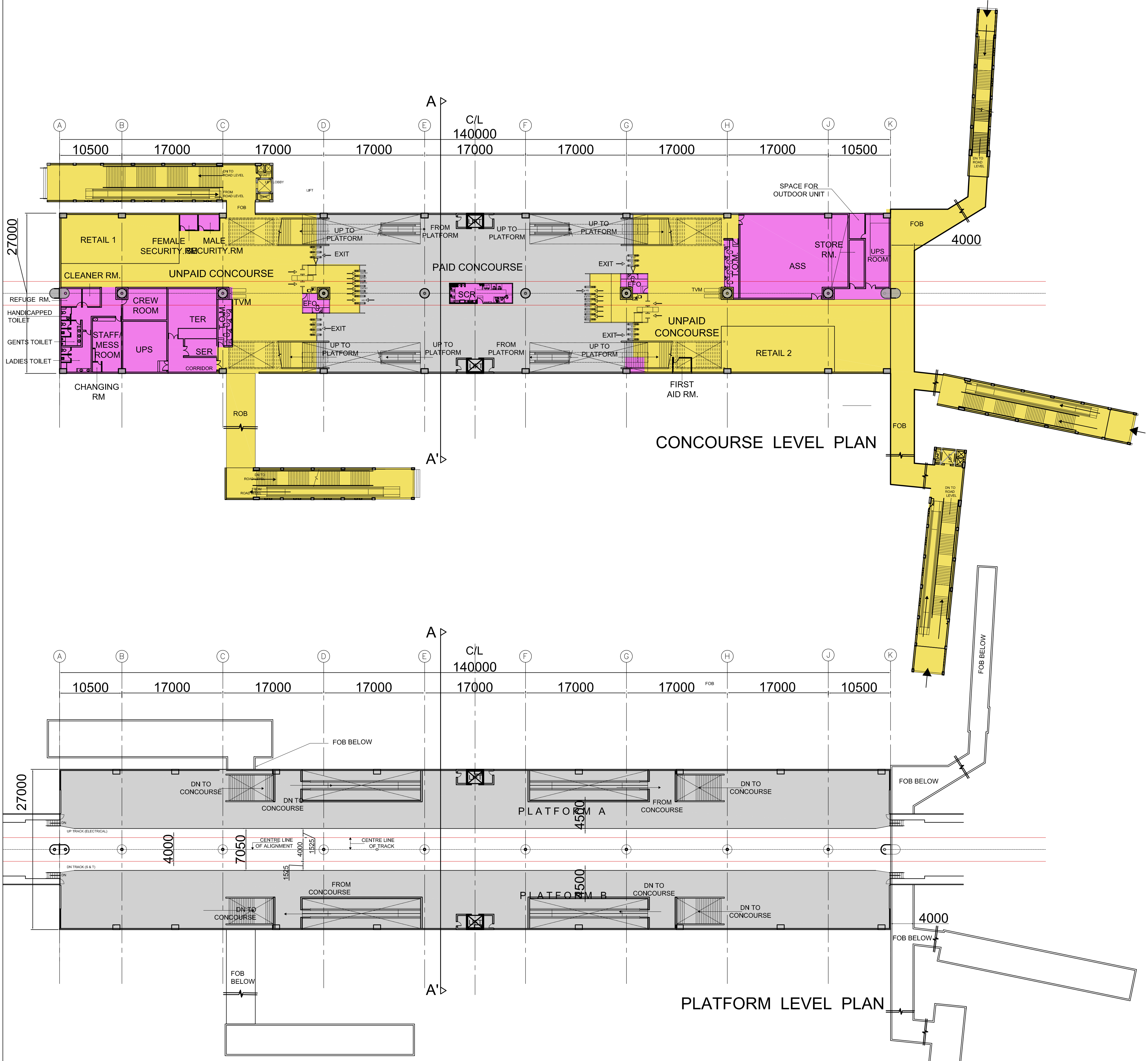
ROOM SCHEDULE

ROOM. NO.	ROOM NAME	SIZE OF ROOM (M)		AREA PROVIDED (SQ.M)
01	STAFF/MESS ROOM	5.78	8.16	44.38
02	CHANGING ROOM	1.50	1.66	2.50
03	WOMEN'S TOILET	5.04	2.70	18.25
04	MEN'S TOILET	3.32	4.69	15.61
05	HANDICAPPED TOILET	2.12	2.98	5.79
06	REFUGE ROOM	3.50	2.70	9.44
07	CLEANER ROOM	3.50	2.21	7.05
08	UPS	8.64	4.88	41.66
09	TER	5.52	7.46	38.31
10	SER	5.30	4.83	22.32
11	T.O.M 1	2.97	12.98	38.56
12	T.O.M 2	2.97	12.98	38.56
13	SECURITY ROOM 1	3.52	2.60	9.19
14	SECURITY ROOM 2	3.00	2.60	7.80
15	SCR	10.70	3.44	36.90
16	FIRST AID ROOM	3.01	2.35	7.09
17	UPS ROOM	9.07	3.38	30.15
18	ASS	10.64	20.04	207.34
19	EFO	4.44	3.22	12.41

KALYANPUR RLY STN			
DPR FOR KANPUR MRTS			ARCHITECTURAL
STATION LAYOUT PLANS : TYPE IB ELEVATED - 24m x 140M			
IIT KANPUR - NAUBASTA CORRIDOR			
DRG. NO. KP/TYP1B/02b	REV. R1	SCALE 1:650	STATUS CONCEPT DESIGN

ANNEXURE 6.6

STATION DESIGN OF GURUDEV CHAURAHA - 1



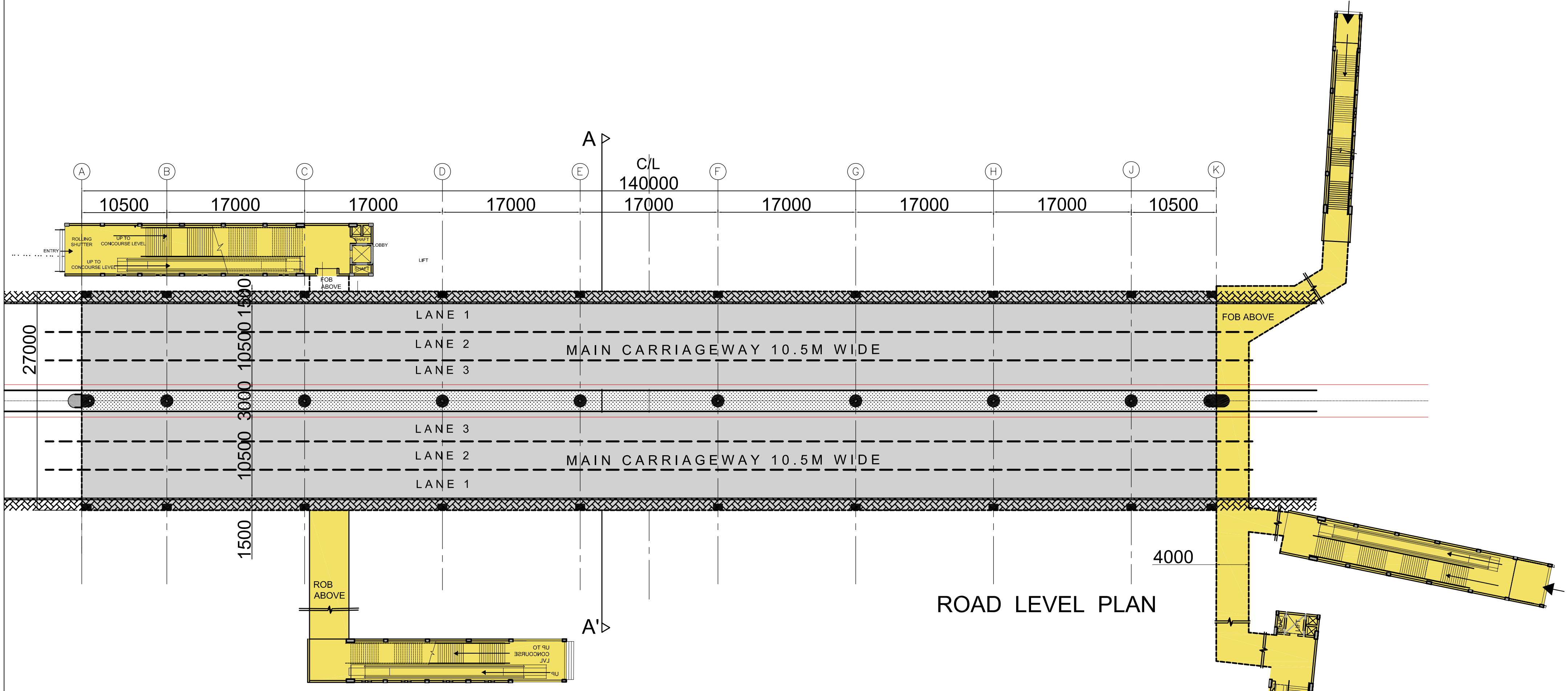
ROOM SCHEDULE

ROOM. NO.	ROOM NAME	SIZE OF ROOM (M)		AREA PROVIDED (SQ.M)
01	STAFF/MESS ROOM	4.87	9.18	41.53
02	CHANGING ROOM	1.50	1.66	2.50
03	WOMEN'S TOILET	5.08	4.22	24.77
04	MEN'S TOILET	3.36	4.20	14.14
05	HANDICAPPED TOILET	1.57	2.14	3.37
06	REFUGE ROOM	3.48	3.03	8.65
07	CLEANER ROOM	3.00	3.03	9.09
08	UPS	7.40	8.54	63.07
09	RETAIL-1	28.29	8.25	212.88
10	TER	8.18	6.70	57.76
11	SER	5.38	2.95	15.86
12	T.O.M 1	2.45	7.77	19.07
13	T.O.M 2	2.50	7.96	21.57
14	SECURITY ROOM 1	3.00	2.60	7.80
15	SECURITY ROOM 2	3.52	2.60	9.16
16	SCR	10.69	3.47	37.13
17	FIRST AID ROOM	3.01	2.35	7.09
18	STORE ROOM	2.50	7.96	19.90
19	UPS ROOM	3.98	12.24	48.32
20	ASS	18.18	14.08	247.34
21	EFO	4.66	3.44	13.81
22	RETAIL-2	19.08	7.72	146.01
23	CORRIDOR (PART-1)	5.61	2.45	
	(PART-2)	2.57	5.62	28.21

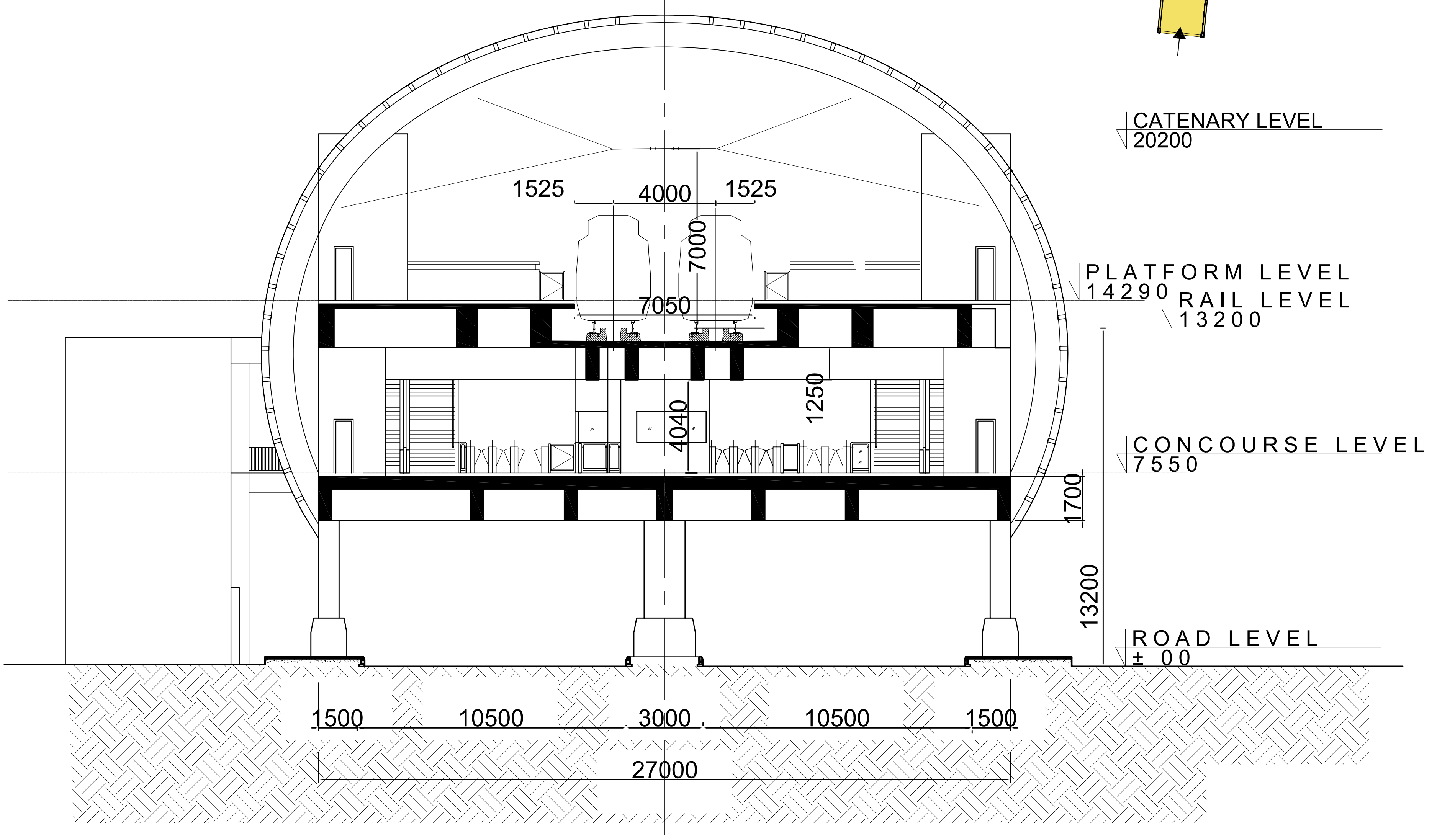
GURUDEV CHAURAHA			
DPR FOR KANPUR MRTS			ARCHITECTURAL
STATION LAYOUT PLANS : TYPE IA ELEVATED - 27M X 140M			
IIT KANPUR - NAUBASTA CORRIDOR			
DRG. NO. KP/TYP1A/03b	REV. R1	SCALE 1:650	STATUS CONCEPT DESIGN

ANNEXURE 6.7

STATION DESIGN OF GURUDEV CHAURAHA - 2



ROAD LEVEL PLAN



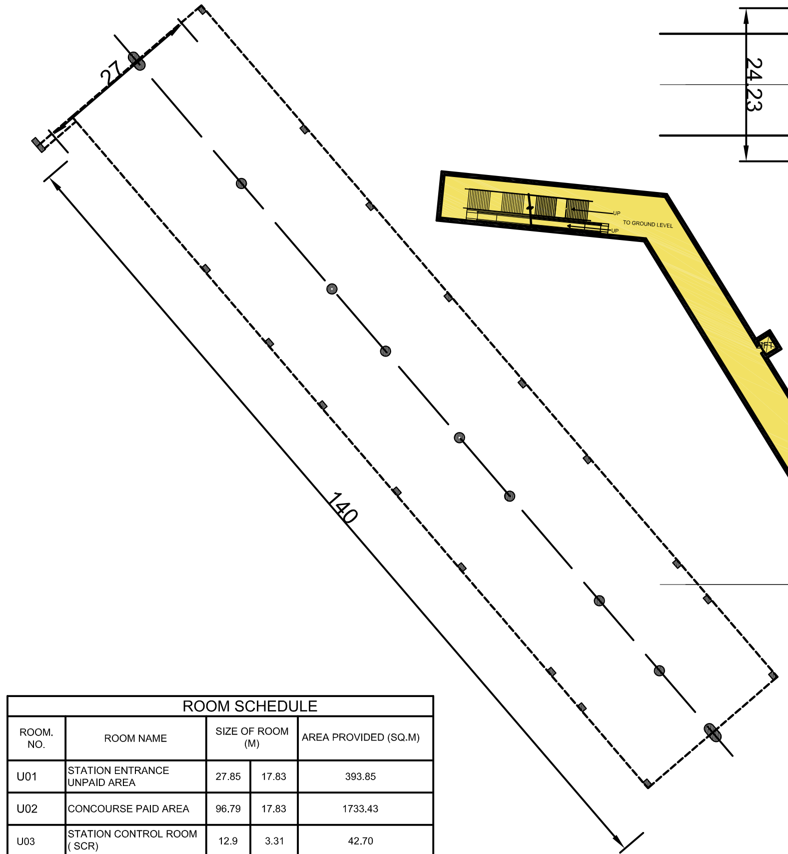
SECTION A-A'

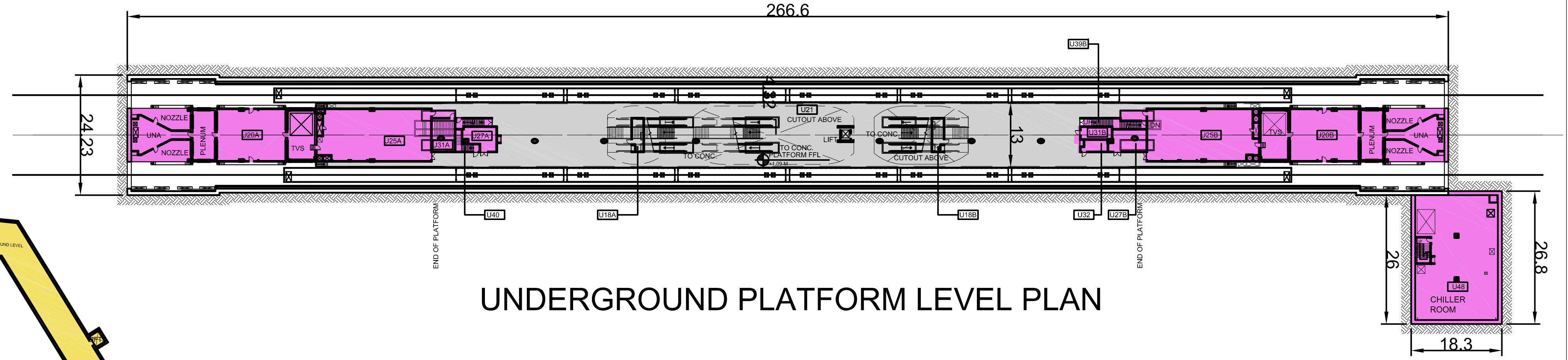
(SCALE: NTS)

GURUDEV CHAURAHA			
DPR FOR KANPUR MRTS			ARCHITECTURAL
STATION LAYOUT PLANS : TYPE IA ELEVATED - 27M X 140M			
IIT KANPUR - NAUBASTA CORRIDOR			
DRG. NO. KP/TYP1A/03c	REV. R1	SCALE 1:650	STATUS CONCEPT DESIGN

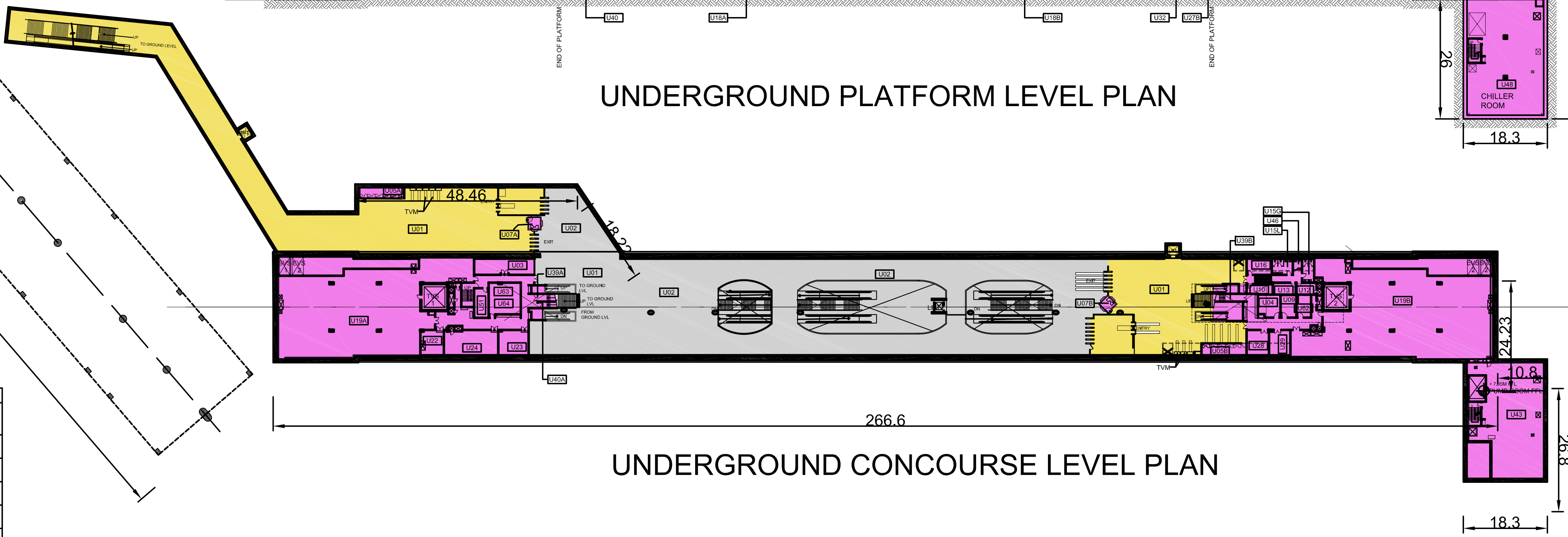
ANNEXURE 6.8

STATION DESIGN OF RAWATPUR RAILWAY STATION - 1





UNDERGROUND PLATFORM LEVEL PLAN

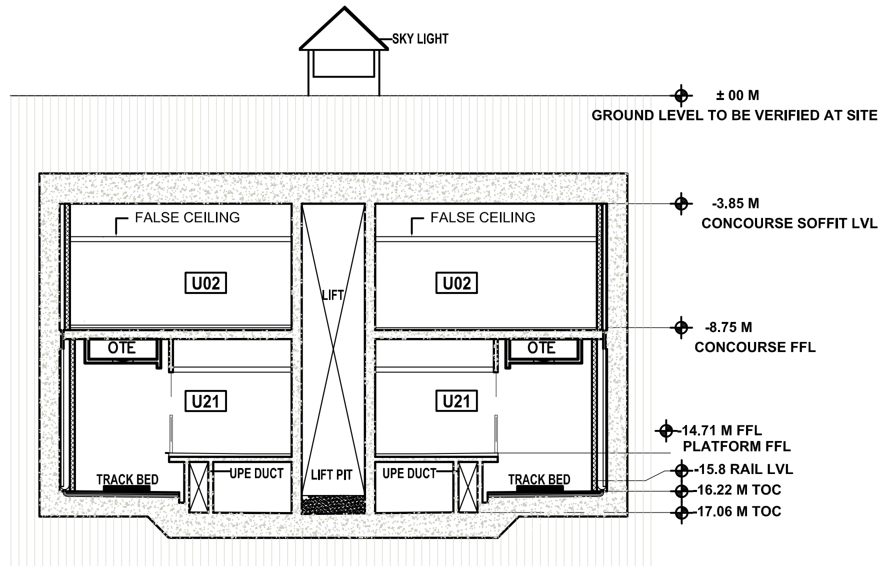


UNDERGROUND CONCOURSE LEVEL PLAN

ROOM SCHEDULE				
ROOM. NO.	ROOM NAME	SIZE OF ROOM (M)		AREA PROVIDED (SQ.M)
U01	STATION ENTRANCE UNPAID AREA	27.85	17.83	393.85
U02	CONCOURSE PAID AREA	96.79	17.83	1733.43
U03	STATION CONTROL ROOM (SCR)	12.9	3.31	42.70
U04	STATION MANAGER ROOM (SMR)	4.74	4.80	21.67
U05A	TICKET OFFICE MACHINE (TOM)	9.62	2.30	22.13
U05B	TICKET OFFICE MACHINE (TOM)	3.0	18.16	54.48
U07A	EXCESS FARE OFFICE & CUSTOMER CARE (EFO)	2.50	2.50	6.25
U07B	EXCESS FARE OFFICE & CUSTOMER CARE (EFO)	2.50	2.50	6.25
U09	SECURITY ROOM	3.27	4.80	15.69
U12	CLEANERS ROOM	4.17	2.40	10.01
U13	REFUSE STORE ROOM	4.97	2.40	11.93
U15L	PUBLIC TOILETS (L)	4.37	3.31	14.46
U15G	PUBLIC TOILETS (G)	2.47	5.01	12.37
U16	MESS ROOM	5.29	3.31	17.51
U19A	ECS PLANT ROOM (ECS)	42.85	22.63	766.45

ROOM SCHEDULE				
ROOM. NO.	ROOM NAME	SIZE OF ROOM (M)		AREA PROVIDED (SQ.M)
U19B	ECS PLANT ROOM (ECS)	44.25	22.63	830.10
U22	SIGNALLING EQUIPMENT ROOM (SER)	4.90	5.31	26.02
U23	TELECOM EQUIPMENT ROOM (TER)	7.92	5.31	42.06
U24	UPS ROOM FOR S & T	11.65	5.31	61.86
U28	CDMA ROOM	4.69	5.31	24.90
U29	GSM ROOM	4.45	5.31	23.63
U39	EMERGENCY ESCAPE STAIRCASE			
U40	FIREMAN ACCESS STAIRCASE			
U43	PUMP ROOM	16.70	25.20	420.83
U46	PUBLIC TOILETS (H)	1.80	2.00	3.60
U51	EMERGENCY EQUIPMENT ROOM	2.95	6.25	18.44
U63 & U64	E&M STAFF AND STORE ROOM	6.80	6.70	45.56
U10	STORE ROOM	5.49	2.10	11.10

ROOM SCHEDULE				
ROOM. NO.	ROOM NAME	SIZE OF ROOM (M)		AREA PROVIDED (SQ.M)
U18A	DB ROOM	2.24	6.60	13.77
U18B	DB ROOM	2.24	6.50	13.77
U20A	TUNNEL VENTILATION PLANT ROOM	13.85	10.40	143.28
U20B	TUNNEL VENTILATION PLANT ROOM	13.85	10.40	143.32
U21	PLATFORM PUBLIC AREA	118.80	12.60	1701.72
U25A	AUXILIARY SUB-STATION ROOM	21.68	10.40	227.29
U25B	AUXILIARY SUB-STATION ROOM	21.20	10.40	222.18
U27A	ELECTRICAL UPS ROOM	6.80	4.85	27.52
U27B	ELECTRICAL UPS ROOM	6.80	4.37	31.14
U31A	SEEPAGE ROOM	4.60	6.80	14.93
U31B	SEEPAGE ROOM	6.22	2.40	14.93
U32	SEWAGE ROOM	4.59	2.30	10.55
U39A & U39B	EMERGENCY ESCAPE STAIRCASE	7.17	1.50	11.55
U40	FIREMAN ACCESS STAIRCASE (Part-1) (Part-2)	1.20 3.60	4.37 1.37	10.19
U48	CHILLER PLANT ROOM	16.70	25.20	420.82



(SCALE: NTS)

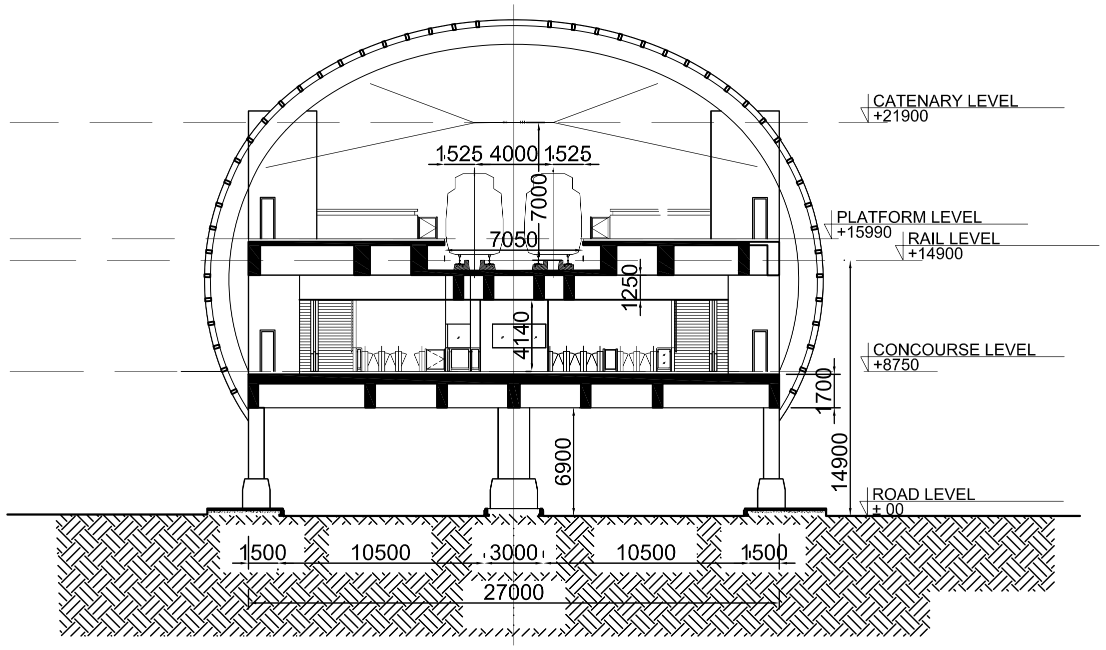
CROSS-SECTION

RAWATPUR RAILWAY STATION			
DPR FOR KANPUR MRTS			
STATION LAYOUT PLANS: TYPE III - INTERCHANGE UNDERGROUND			
INTERCHANGE STATION			
DRG. NO. KP/TYP III/ 04b	REV. R1	SCALE 1:1000	STATUS CONCEPT DESIGN

ARCHITECTURAL

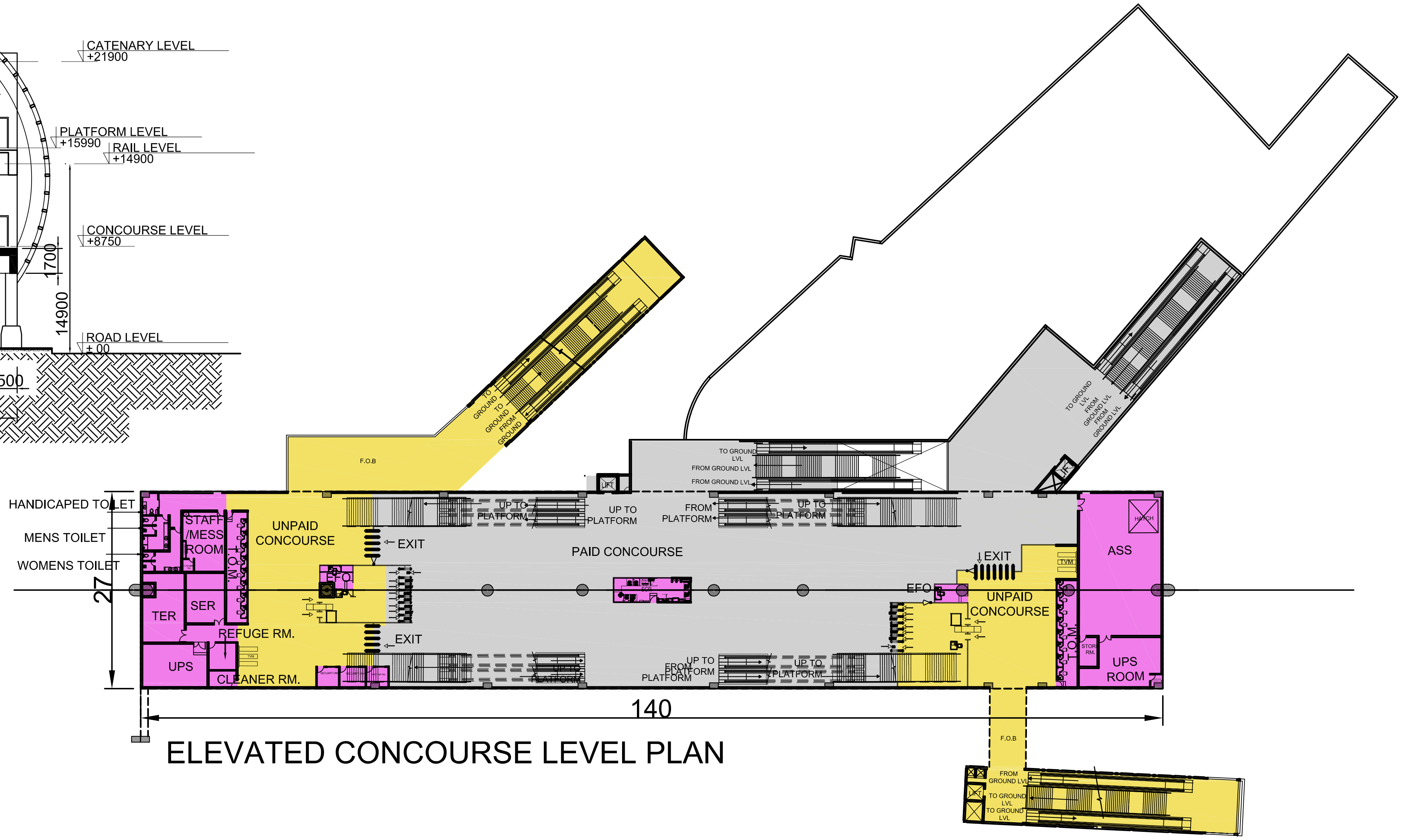
ANNEXURE 6.9

STATION DESIGN OF RAWATPUR RAILWAY STATION - 2

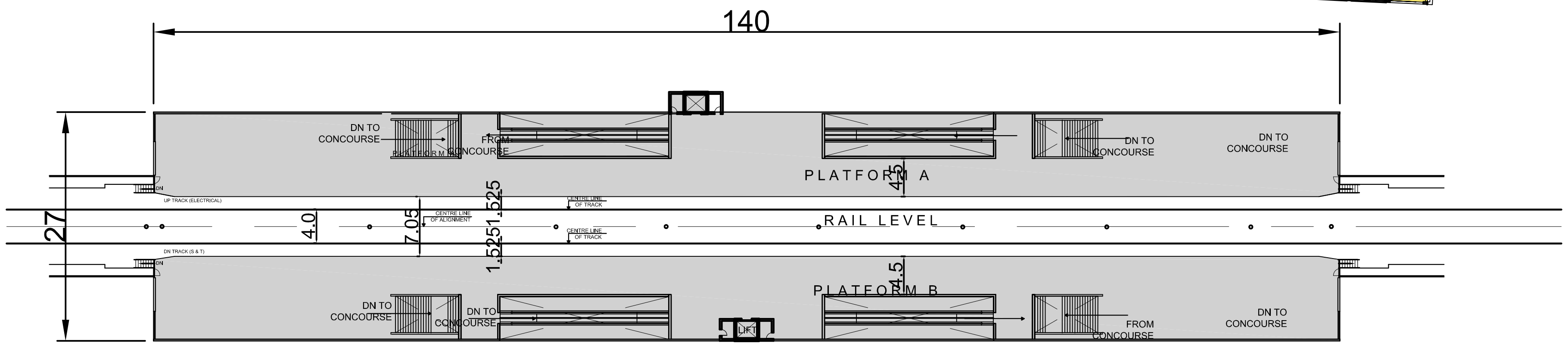


CROSS SECTION

(SCALE: NTS)



ELEVATED CONCOURSE LEVEL PLAN



ELEVATED PLATFORM LEVEL PLAN

ROOM SCHEDULE				
ROOM. NO.	ROOM NAME	SIZE OF ROOM (M)		AREA PROVIDED (SQ.M)
01	STAFF/MESS ROOM	5.8	8.2	47.56
02	CHANGING ROOM	1.50	1.7	2.55
03	WOMEN'S TOILET	5.3	2.7	14.31
04	MEN'S TOILET	3.6	4.7	16.92
05	HANDICAPPED TOILET	2.1	3	6.3
06	REFUGE ROOM	3.7	3.7	13.69
07	CLEANER ROOM	3.7	2.2	8.14
08	UPS	8.9	5.9	52.51
09	TER	5.8	9.5	55.1
10	SER	5.3	6.8	36.04
11	T.O.M	2.8	9.6	26.88
12	SECURITY ROOM 1	3.0	2.7	8.1
13	SECURITY ROOM 2	3.5	2.7	9.45
14	FIRST AID ROOM	3.0	2.7	8.1
15	SCR	10.69	3.47	37.13
16	STORE ROOM	2.50	4.0	10
17	UPS ROOM	11.2	6.8	76.16
19	ASS	11.2	19.5	218.4
20	EFO	4.7	3.4	15.98

RAWATPUR RAILWAY STATION

DPR FOR KANPUR MRTS

STATION LAYOUT PLANS: TYPE III - INTERCHANGE ELEVATED

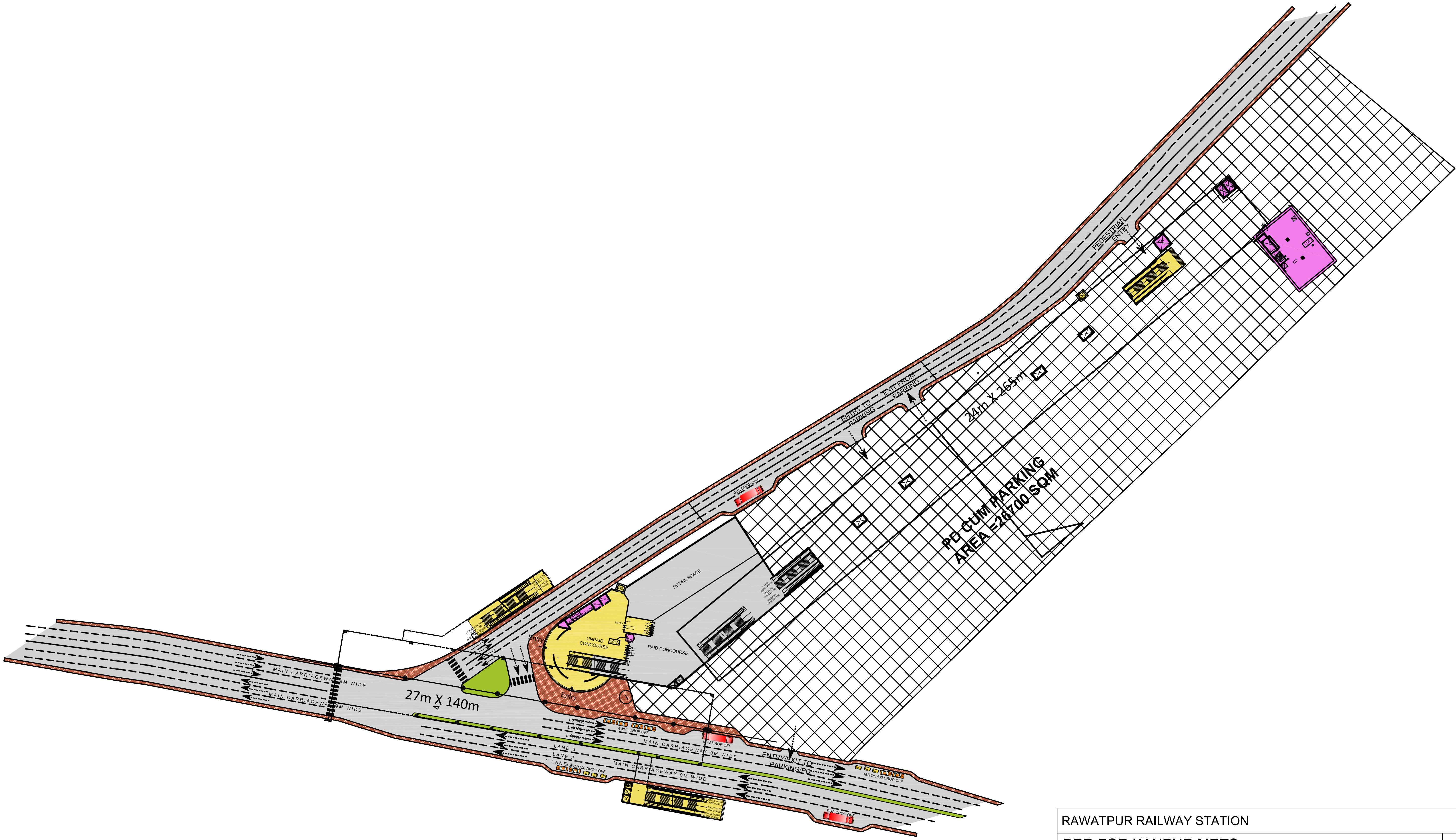
INTERCHANGE STATION

ARCHITECTURAL

DRG. NO.	REV.	SCALE	STATUS
KP/TYP III/ 01c	R1	1:650	CONCEPT DESIGN

ANNEXURE 6.10

STATION DESIGN OF RAWATPUR RAILWAY STATION - 3

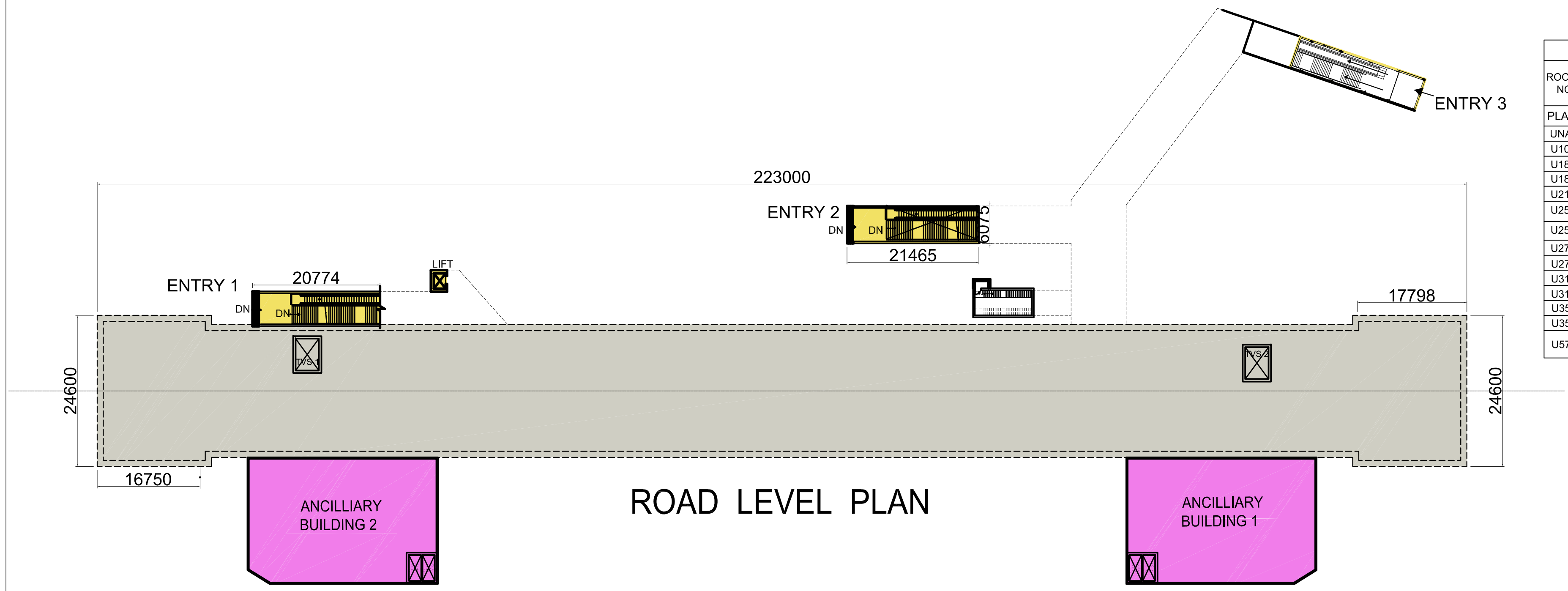


ROAD LEVEL PLAN OF BOTH ELEVATED AND UNDERGROUND STATION

RAWATPUR RAILWAY STATION			
DPR FOR KANPUR MRTS			ARCHITECTURAL
STATION LAYOUT PLANS: TYPE III - INTERCHANGE ELEVATED			
INTERCHANGE STATION			
DRG. NO. KP/TYP III/ 01c	REV. R1	SCALE 1:650	STATUS CONCEPT DESIGN

ANNEXURE 6.11

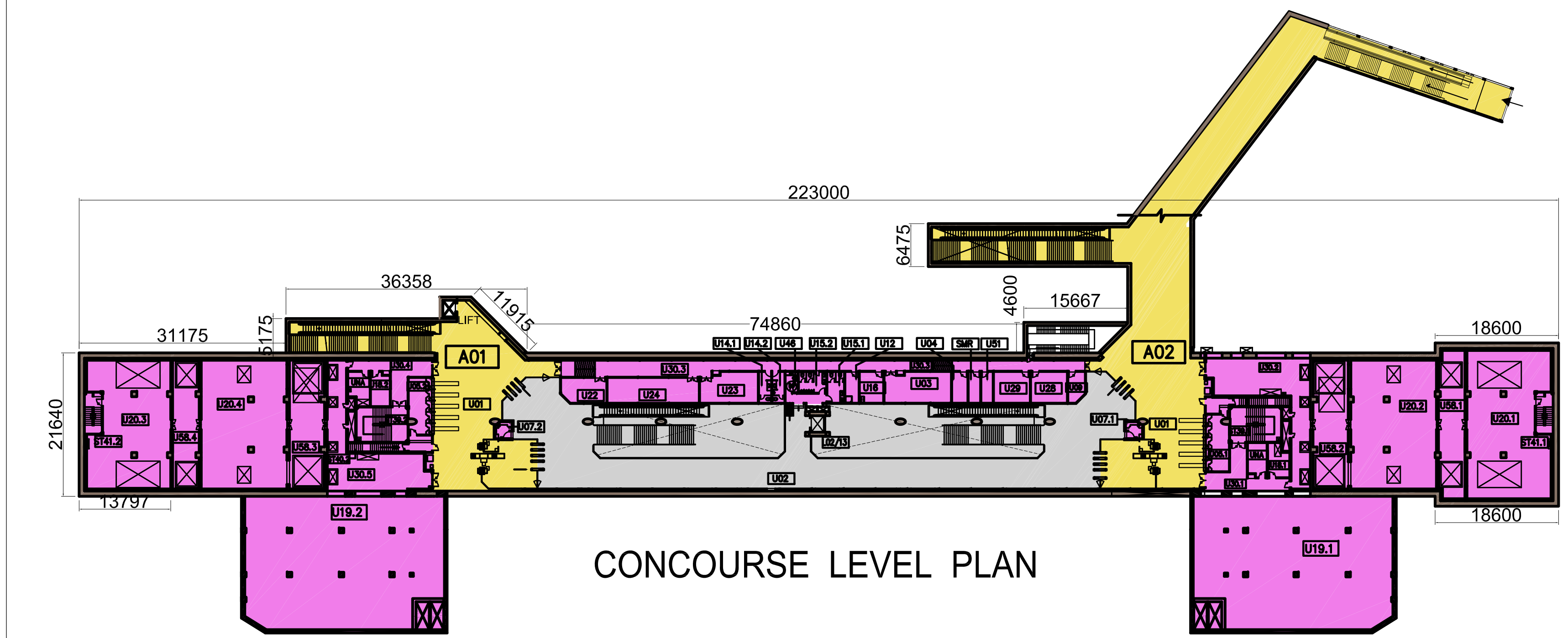
STATION DESIGN OF CHUNNIGANJ STATION



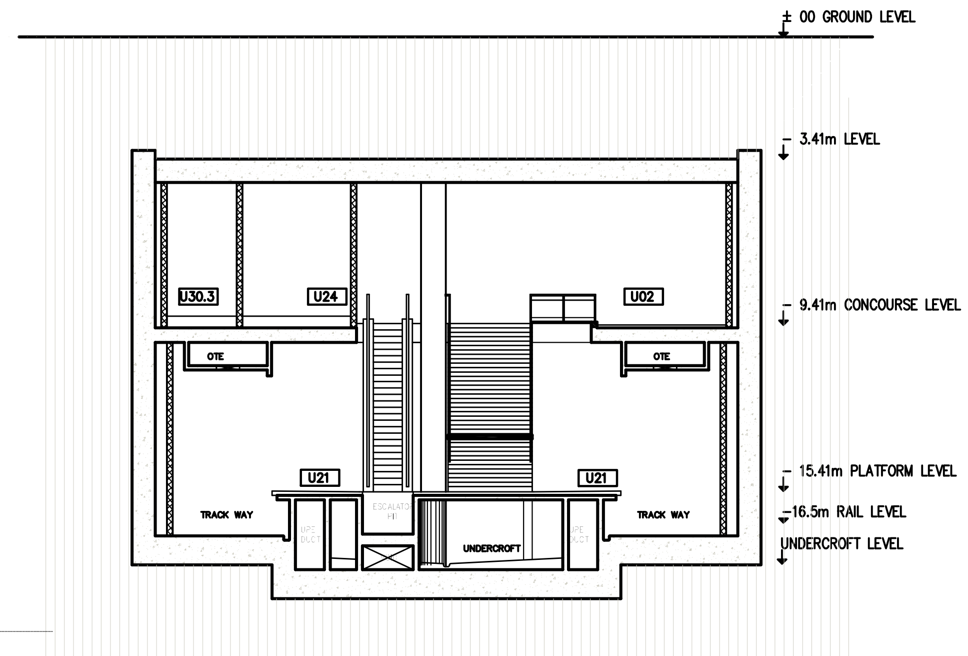
ROAD LEVEL PLAN

ROOM SCHEDULE				
ROOM. NO.	ROOM NAME	SIZE OF ROOM (M)		AREA PROVIDED (SQ.M)
PLATFORM LEVEL				
UNA	UNNAMED AREA	4.17	2.82	9.36
U10	STORE	4.17	2.82	9.36
U18.3	DISTRIBUTION BOARD ROOM	2.65	4.82	12.78
U18.4	DISTRIBUTION BOARD ROOM	2.65	4.82	12.78
U21	PAID PUBLIC AREA	123.60	11.85	1328.86
U25.1	ASS PLANT ROOM	95.86	25.30	218.13
U25.2	ASS PLANT ROOM	95.86	25.30	218.13
U27.1	ELECTRICAL UPS ROOM	5.20	7.97	40.75
U27.2	ELECTRICAL UPS ROOM	5.20	7.97	40.75
U31.1	SEEPAGE PANEL ROOM	4.37	1.80	7.86
U31.2	SEEPAGE PANEL ROOM	4.37	1.80	7.86
U35.1	INERT GAS ROOM	7.02	2.95	18.28
U35.2	INERT GAS ROOM	7.02	2.95	18.28
U57	PLATFORM SUPERVISOR'S BOOTH	2.81	4.62	8.90

ROOM SCHEDULE				
ROOM. NO.	ROOM NAME	SIZE OF ROOM (M)		AREA PROVIDED (SQ.M)
CONCOURSE LEVEL				
U01	UNPAID PUBLIC AREA	15.70	25.67	448.95
U02	PAID PUBLIC AREA	84.79	4.49	655.80
U03	STATION CONTROL ROOM (SCR)	10.00	4.62	45.41
U04	STATION MANAGER ROOM (SMR)	2.30	4.62	10.63
U05.1	TICKET WINDOW	3.45	8.50	28.96
U05.2	TICKET WINDOW	3.45	8.50	28.49
U07.1	CUSTOMER CARE (EFO)	2.30	2.40	5.45
U07.2	CUSTOMER CARE (EFO)	2.30	2.40	5.45
U09	SECURITY ROOM	2.50	4.62	10.60
U12	CLEANERS ROOM	2.00	4.62	9.25
U14.1	LADIES STAFF TOILET	1.80	4.62	8.32
U14.2	GENTS STAFF TOILET	1.80	4.62	8.32
U15.1	LADIES PUBLIC TOILET	2.50	4.62	11.56
U15.2	GENTS PUBLIC TOILET	4.10	3.10	12.73
U16	MESS ROOM	3.50	4.62	16.18
U18.1	DISTRIBUTION BOARD	3.30	5.12	15.07
U18.2	DISTRIBUTION BOARD	2.80	5.12	13.61
U19.1	ECS PLANT ROOM (ECS)	30.10	20.10	597.39
U19.2	ECS PLANT ROOM (ECS)	30.10	20.10	597.39
U20.1	TUNNEL VENTILATION PLANT ROOM	13.00	23.00	279.85
U20.2	TUNNEL VENTILATION PLANT ROOM	12.90	20.04	257.55
U20.3	TVS ROOM	13.00	20.04	241.37
U20.4	TVS ROOM	12.90	20.04	257.85
U22	SIGNALING EQUIPMENT ROOM	6.80	3.72	24.35
U23	TELECOM EQUIPMENT ROOM	8.70	4.62	37.80
U24	S & T UPS ROOM	13.74	3.72	51.18
U28	CDMA ROOM	5.40	4.62	24.97
U29	GSM ROOM	5.40	4.62	24.97
U30.1	SEEPAGE ROOM	12.65	7.22	41.22
U30.2	SEEPAGE ROOM	78.94	1.50	140.11
U30.3	PROTECTED B.O.H. CORRIDOR	15.75	20.04	127.98
U30.4	PROTECTED B.O.H. CORRIDOR	12.65	7.22	41.22
U30.5	PROTECTED B.O.H. CORRIDOR	15.75	20.04	127.98
ST39.1	EMERGENCY ESCAPE STAIRCASE	7.70	5.20	39.88
ST39.2	EMERGENCY ESCAPE STAIRCASE	7.70	5.20	39.88
ST40.1	FIREMAN ACCESS STAIRCASE	8.96	1.30	11.64
ST40.2	FIREMAN ACCESS STAIRCASE	8.96	1.30	11.64
ST41.1	STAIRCASE	2.60	6.15	15.87
ST41.2	STAIRCASE	2.60	6.15	15.87
U46	PUBLIC TOILETS (H)	1.80	3.00	5.40
U51	EMERGENCY EQUIPMENT ROOM	1.70	1.62	7.86
U58.1	VENTILATION PLENUM	4.00	23.00	90.63
U58.2	VENTILATION PLENUM	5.30	20.04	105.25
U58.3	VENTILATION PLENUM	5.30	20.04	105.25
U58.4	VENTILATION PLENUM	4.00	20.04	79.35
UNA 1	UNNAMED AREA	2.80	5.12	13.61
UNA 2	UNNAMED AREA	3.30	5.12	15.07
SMR	SIGNALING MAINTENANCE ROOM	1.70	4.62	7.86

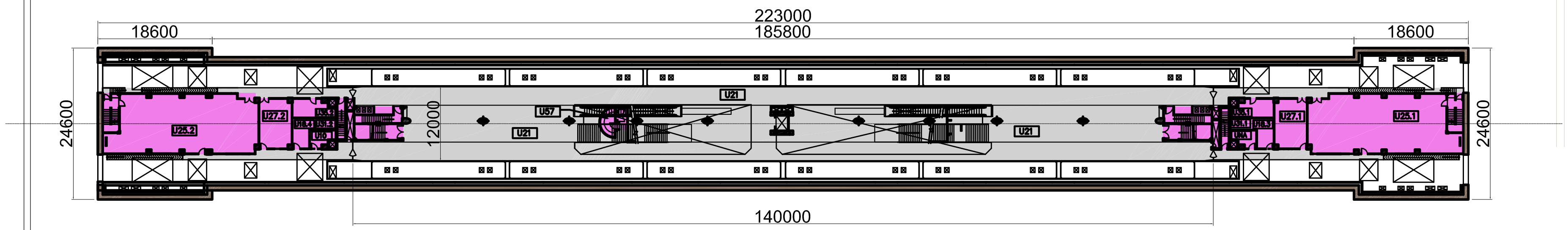


CONCOURSE LEVEL PLAN



CROSS SECTION

(SCALE: NTS)

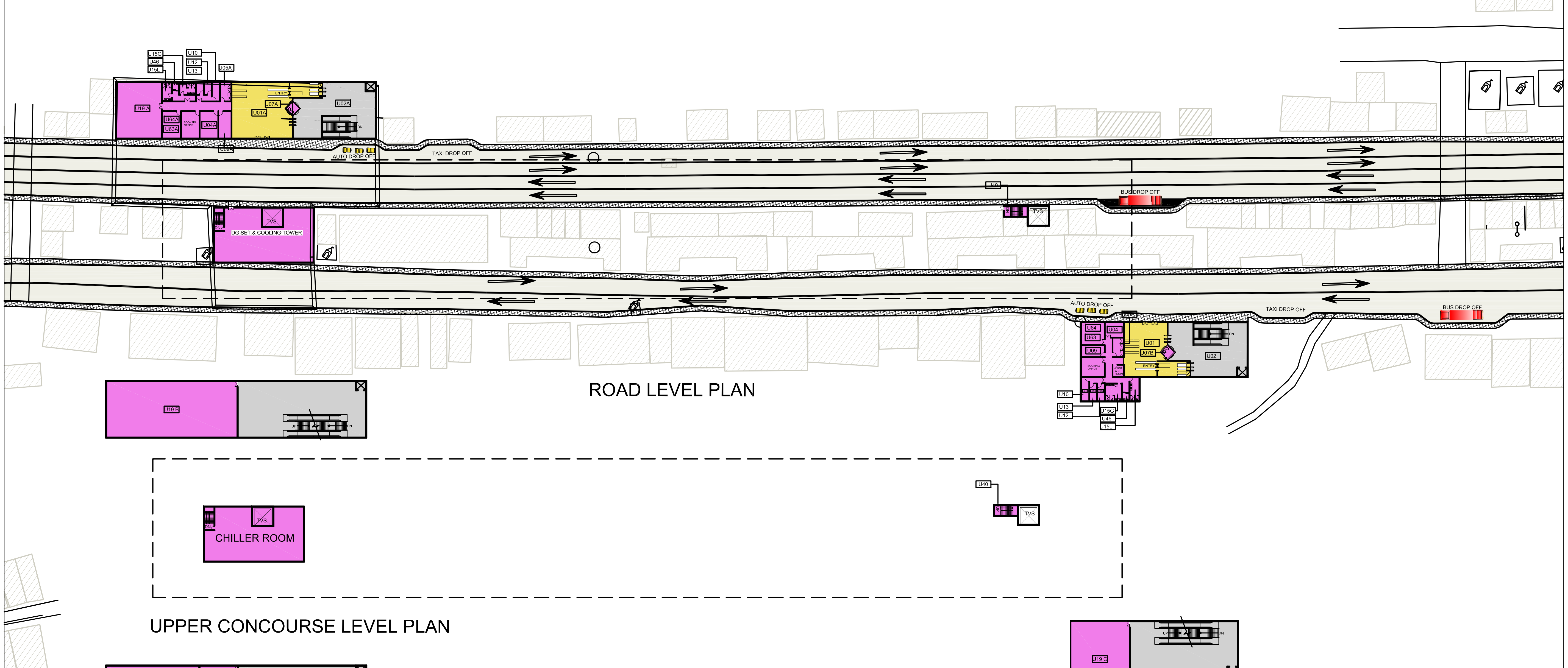


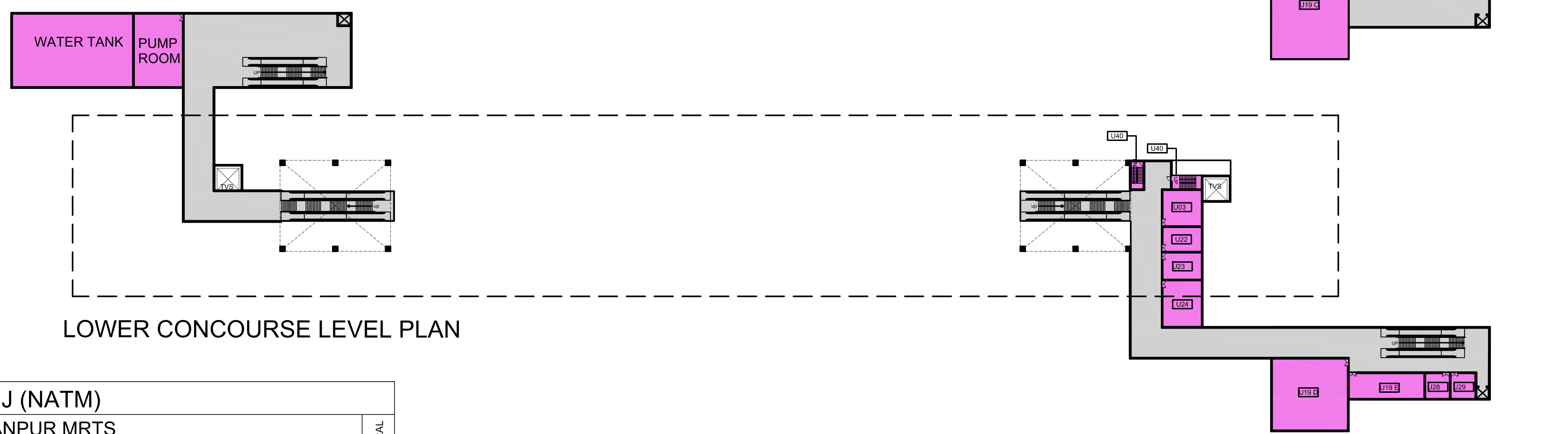
PLATFORM LEVEL PLAN

CHUNNIGANJ				
DPR FOR KANPUR MRTS				ARCHITECTURAL
STATION LAYOUT PLANS: TYPE IID UNDERGROUND - 24.6M X 223M				
IIT KANPUR - NAUBASTA CORRIDOR				
DRG. NO. KM-TYPEIID-06b	REV. R1	SCALE 1:650	STATUS CONCEPT DESIGN	

ANNEXURE 6.12

STATION DESIGN OF NAYAGANJ STATION





ROOM SCHEDULE				
ROOM. NO.	ROOM NAME	SIZE OF ROOM (M)		AREA PROVIDED (SQ.M)
CONCOURSE LEVEL				
U01	UNPAID PUBLIC AREA	11.60	14.50	191.40
U01A	UNPAID PUBLIC AREA	16.40	15.00	275.70
U02	PAID PUBLIC AREA	21.20	14.50	279.80
U02A	PAID PUBLIC AREA	22.30	15.00	300.60
U03	STATION CONTROL ROOM (SCR)	8.00	7.30	59.00
U04	STATION MANAGER ROOM (SMR)	5.00	4.00	20.00
U04A	STATION MANAGER ROOM (SMR)	4.80	7.20	34.56
U05.A	TICKET WINDOW	2.80	5.10	14.80
U05.B	TICKET WINDOW	2.80	5.10	14.80
U07.A	CUSTOMER CARE (EFO)	2.90	2.90	8.40
U07.B	CUSTOMER CARE (EFO)	2.90	2.90	8.40
U09	SECURITY ROOM	6.20	3.10	19.40
U09A	SECURITY ROOM	3.40	7.20	24.48
U10	STORE ROOM	2.00	6.30	13.30
U12	CLEANERS ROOM	1.90	4.60	9.30
U13	REFUSE STORE ROOM	1.90	4.60	9.30
U15.L	LADIES STAFF TOILET	2.50	6.20	15.90
U15.G	GENTS STAFF TOILET	4.30	4.50	20.00
U19.A	ECS PLANT ROOM (ECS)	12.00	15.00	181.70
U19.B	ECS PLANT ROOM (ECS)	35.00	15.00	527.04
U19.C	ECS PLANT ROOM (ECS)	15.50	20.00	310.00
U19.D	ECS PLANT ROOM (ECS)	15.50	14.70	226.00
U19.E	ECS PLANT ROOM (ECS)	15.40	5.20	80.60
U22	SIGNALING EQUIPMENT ROOM	8.00	5.00	40.00
U23	TELECOM EQUIPMENT ROOM	8.00	5.50	44.00
U24	S & T UPS ROOM	8.00	9.50	76.00
U28	CDMA ROOM	5.00	5.20	26.00
U29	GSM ROOM	5.00	5.20	26.00
U63 & U64	E&M STAFF AND STORE ROOM	6.20	6.00	37.20
U63A & U64A	E&M STAFF AND STORE ROOM	5.00	7.20	36.00

NAYAGANJ (NATM)

DPR FOR KANPUR MRTS

STATION LAYOUT PLANS: TYPE IIC UNDERGROUND - 37.18M X 260M

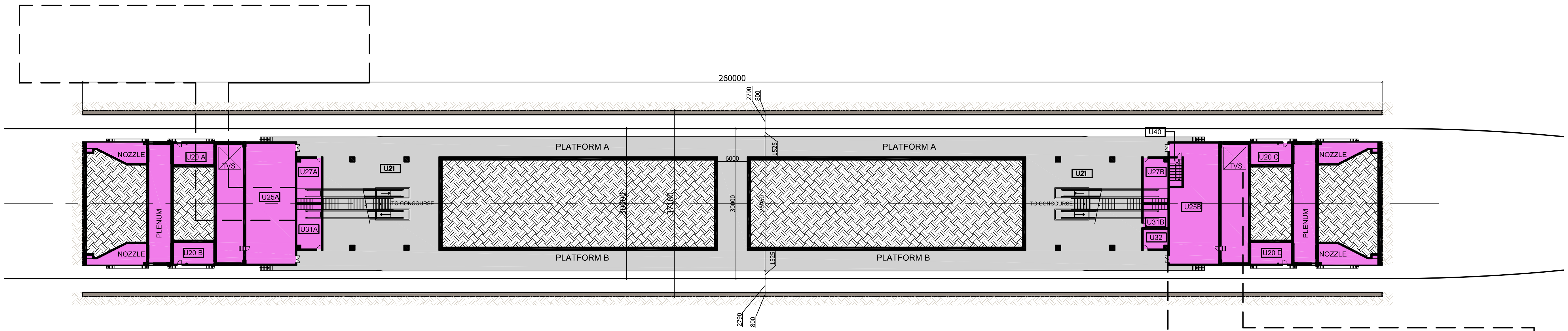
IIT KANPUR - NAUBASTA CORRIDOR

ARCHITECTURAL

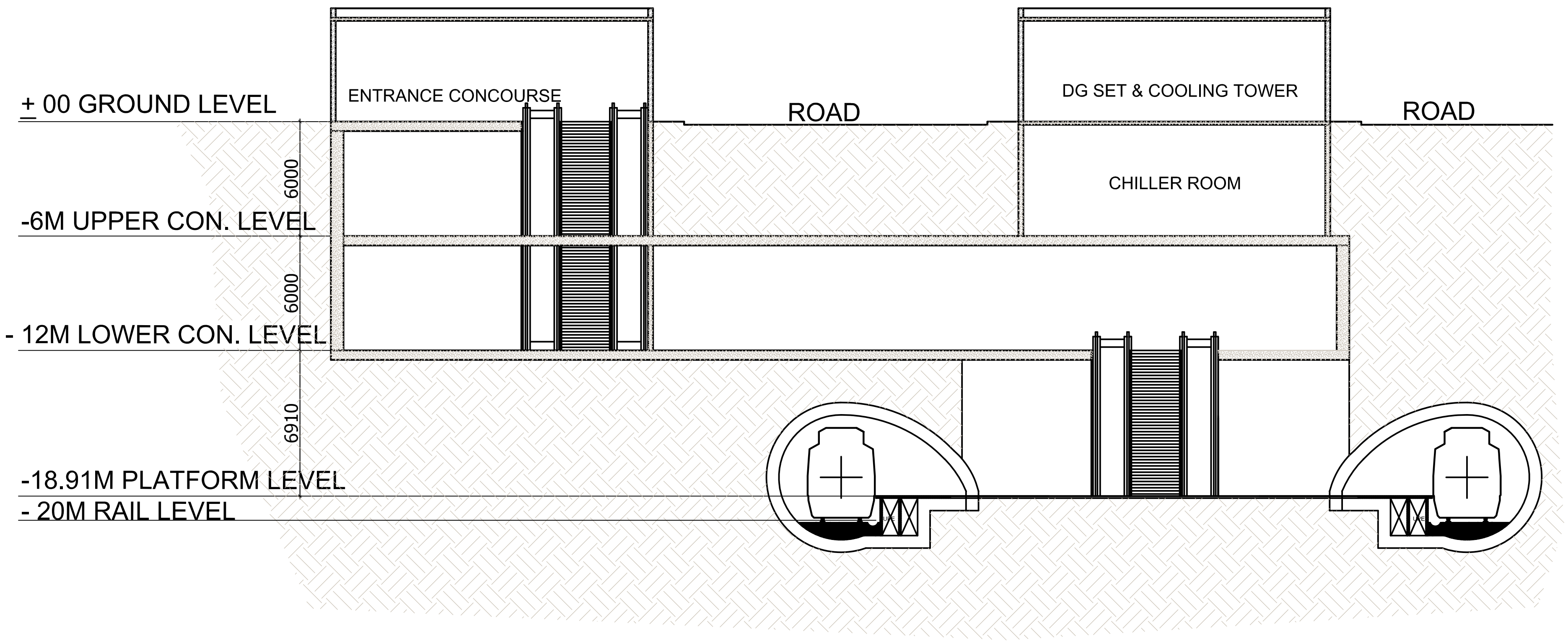
DRG. NO.	REV.	SCALE	STATUS
KM-TYPIIC-07b	R1	1:650	CONCEPT DESIGN

ANNEXURE 6.13

STATION DESIGN OF NAYAGANJ STATION



PLATFORM LEVEL PLAN

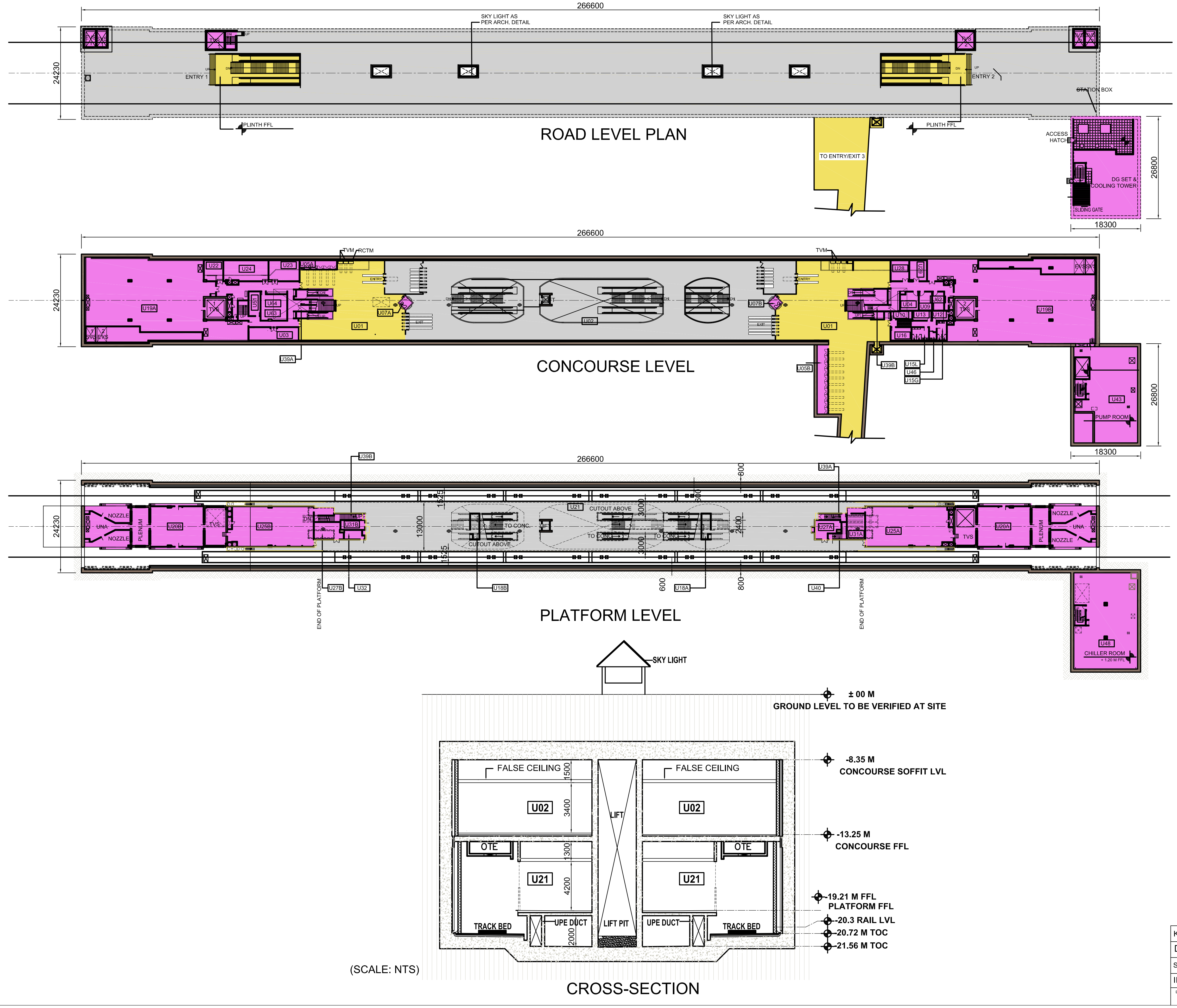


(SCALE: NTS) CROSS SECTION

ROOM SCHEDULE				
ROOM. NO.	ROOM NAME	SIZE OF ROOM (M)		AREA PROVIDED (SQ.M)
PLATFORM LEVEL				
U20A	TUNNEL VENTILATION PLANT ROOM	8.20	4.40	36.08
U20B	TUNNEL VENTILATION PLANT ROOM	8.20	4.40	36.08
U20C	TUNNEL VENTILATION PLANT ROOM	8.20	4.40	36.08
U20D	TUNNEL VENTILATION PLANT ROOM	8.20	4.40	36.08
U21	PAID PUBLIC AREA	174.5	26.95	2595.20
U25.A	ASS PLANT ROOM	10.00	24.10	241.00
U25.B	ASS PLANT ROOM	10.00	24.10	241.00
U27.A	ELECTRICAL UPS ROOM	5.00	8.99	44.95
U27.B	ELECTRICAL UPS ROOM	5.00	8.99	44.95
U31.A	SEEPAGE PANEL ROOM	5.00	8.99	44.95
U31.B	SEEPAGE PANEL ROOM	5.00	4.60	23.00
U32	SEWAGE ROOM	5.00	3.90	19.50

NAYAGANJ (NATM)			ARCHITECTURAL
DPR FOR KANPUR MRTS			
STATION LAYOUT PLANS: TYPE IIC UNDERGROUND - 37.18M X 260M			
IIT KANPUR - NAUBASTA CORRIDOR			
DRG. NO. KM-TYPIIC-07b	REV. R1	SCALE 1:650	STATUS CONCEPT DESIGN

STATION DESIGN OF KANPUR CENTRAL RAILWAY STATION



ROOM SCHEDULE				
ROOM. NO.	ROOM NAME	SIZE OF ROOM (M)		AREA PROVIDED (SQ.M)
U01	STATION ENTRANCE UNPAID AREA	27.85	17.83	393.85
U02	CONCOURSE PAID AREA	96.79	17.83	1733.43
U03	STATION CONTROL ROOM (SCR)	12.9	3.31	42.70
U04	STATION MANAGER ROOM (SMR)	4.74	4.80	21.67
U05A	TICKET OFFICE MACHINE (TOM)	9.62	2.30	22.13
U05B	TICKET OFFICE MACHINE (TOM)	3.0	18.16	54.48
U07A	EXCESS FARE OFFICE & CUSTOMER CARE (EFO)	2.50	2.50	6.25
U07B	EXCESS FARE OFFICE & CUSTOMER CARE (EFO)	2.50	2.50	6.25
U09	SECURITY ROOM	3.27	4.80	15.69
U12	CLEANERS ROOM	4.17	2.40	10.01
U13	REFUSE STORE ROOM	4.97	2.40	11.93
U15L	PUBLIC TOILETS (L)	4.37	3.31	14.46
U15G	PUBLIC TOILETS (G)	2.47	5.01	12.37
U16	MESS ROOM	5.29	3.31	17.51
U19A	ECS PLANT ROOM (ECS)	42.85	22.63	766.45

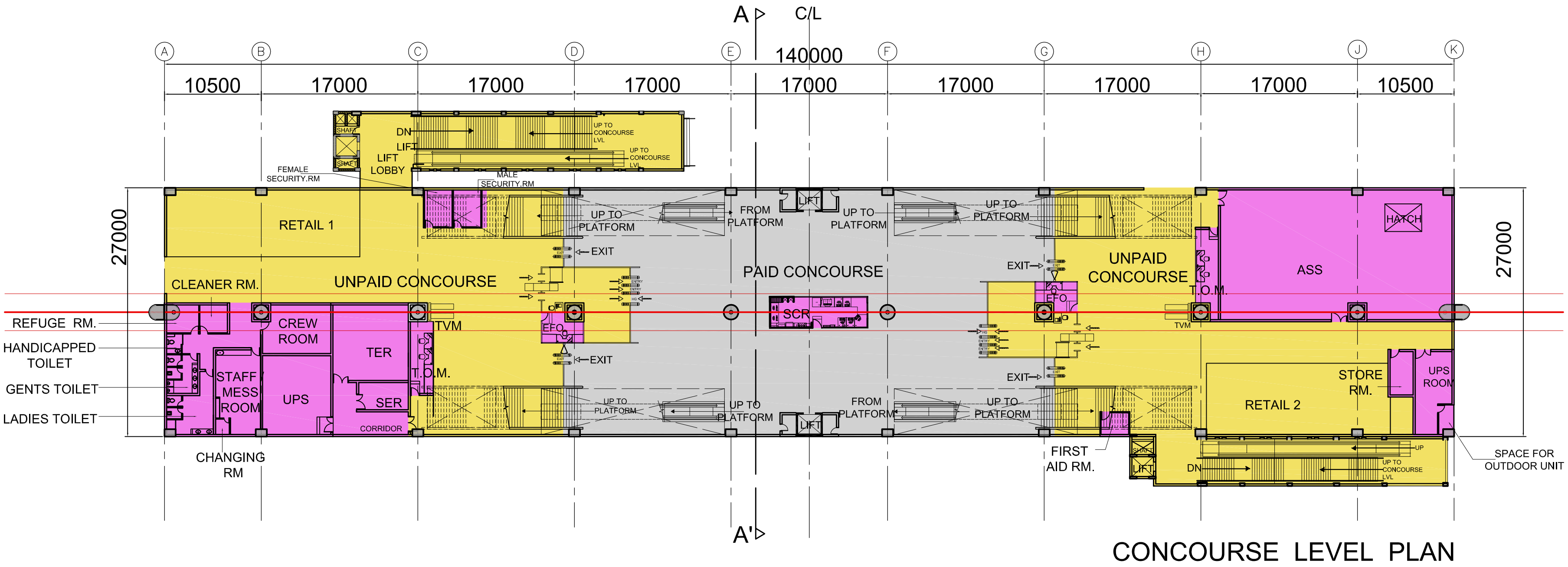
ROOM SCHEDULE				
ROOM. NO.	ROOM NAME	SIZE OF ROOM (M)		AREA PROVIDED (SQ.M)
U19B	ECS PLANT ROOM (ECS)	44.25	22.63	830.10
U22	SIGNALLING EQUIPMENT ROOM (SER)	4.90	5.31	26.02
U23	TELECOM EQUIPMENT ROOM (TER)	7.92	5.31	42.06
U24	UPS ROOM FOR S & T	11.65	5.31	61.86
U28	CDMA ROOM	4.69	5.31	24.90
U29	GSM ROOM	4.45	5.31	23.63
U39	EMERGENCY ESCAPE STAIRCASE			
U40	FIREMAN ACCESS STAIRCASE			
U43	PUMP ROOM	16.70	25.20	420.83
U46	PUBLIC TOILETS (H)	1.80	2.00	3.60
U51	EMERGENCY EQUIPMENT ROOM	2.95	6.25	18.44
U63 & U64	E&M STAFF AND STORE ROOM	6.80	6.70	45.56
U10	STORE ROOM	5.49	2.10	11.10

ROOM SCHEDULE				
ROOM. NO.	ROOM NAME	SIZE OF ROOM (M)		AREA PROVIDED (SQ.M)
U18A	DB ROOM	2.24	6.60	13.77
U18B	DB ROOM	2.24	6.50	13.77
U20A	TUNNEL VENTILATION PLANT ROOM	13.85	10.40	143.28
U20B	TUNNEL VENTILATION PLANT ROOM	13.85	10.40	143.32
U21	PLATFORM PUBLIC AREA	118.80	12.60	1701.72
U25A	AUXILIARY SUB-STATION ROOM	21.68	10.40	227.29
U25B	AUXILIARY SUB-STATION ROOM	21.20	10.40	222.18
U27A	ELECTRICAL UPS ROOM	6.80	4.85	27.52
U27B	ELECTRICAL UPS ROOM	6.80	4.37	31.14
U31A	SEEPAGE ROOM	4.60	6.60	30.36
U31B	SEEPAGE ROOM	6.22	2.40	14.93
U32	SEWAGE ROOM	4.59	2.30	10.55
U39A & U39B	EMERGENCY ESCAPE STAIRCASE	7.17	1.50	11.55
U40	FIREMAN ACCESS STAIRCASE (Part-1) (Part-2)	1.20 3.60	4.37 1.37	10.19
U48	CHILLER PLANT ROOM	16.70	25.20	420.82

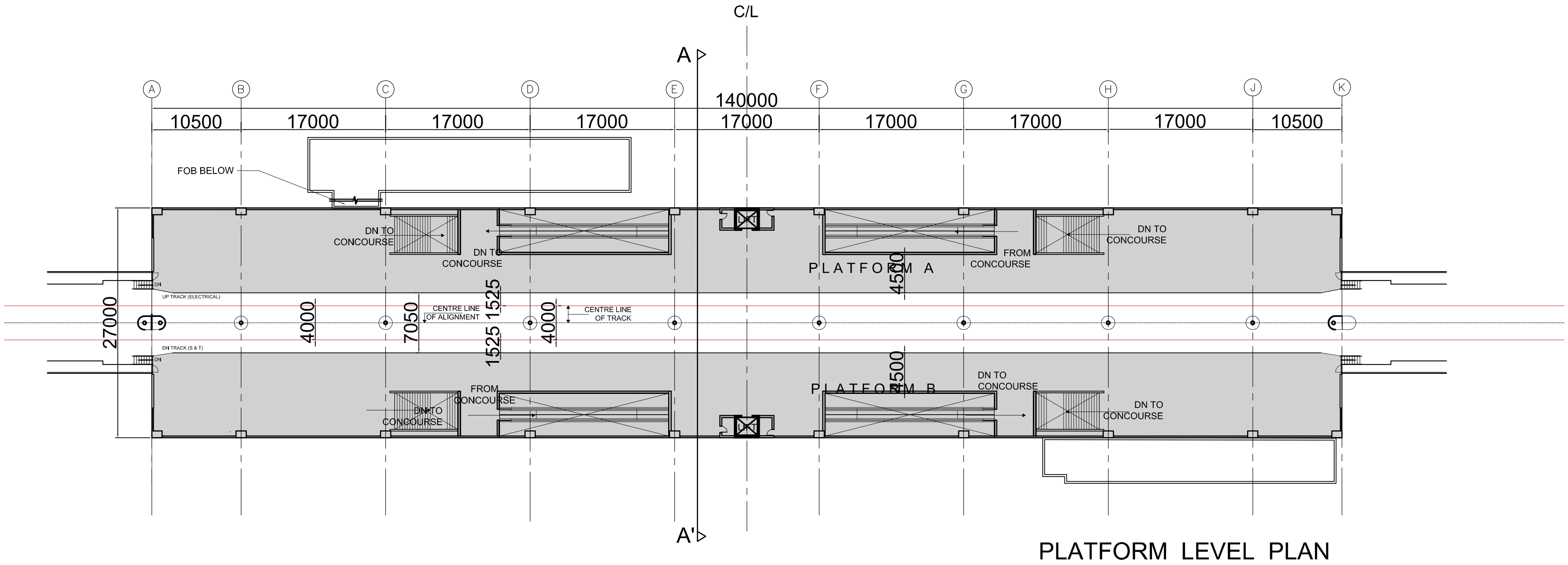
KANPUR CENTRAL RAILWAY STATION			
DPR FOR KANPUR MRTS			ARCHITECTURAL
STATION LAYOUT PLANS: TYPE IIB UNDERGROUND - 24M X 266M			
IIT KANPUR - NAUBASTA CORRIDOR			
DRG. NO. KM-TYPIIB-08b	REV. R1	SCALE 1:650	STATUS CONCEPT DESIGN

ANNEXURE 6.15

STATION DESIGN OF NAUBASTA STATION - 1



CONCOURSE LEVEL PLAN



PLATFORM LEVEL PLAN

ROOM SCHEDULE

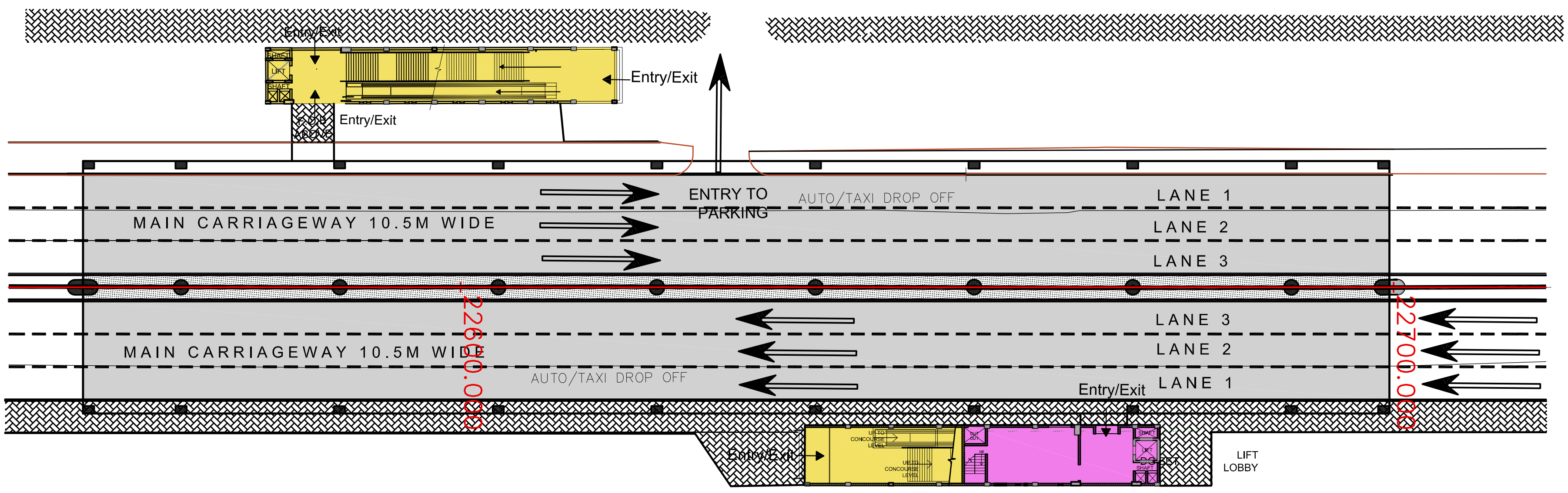
ROOM. NO.	ROOM NAME	SIZE OF ROOM (M)		AREA PROVIDED (SQ.M)
01	STAFF/MESS ROOM	4.87	9.18	41.53
02	CHANGING ROOM	1.50	1.66	2.50
03	WOMEN'S TOILET	5.08	4.22	24.77
04	MEN'S TOILET	3.36	4.20	14.14
05	HANDICAPPED TOILET	1.57	2.14	3.37
06	REFUGE ROOM	3.48	3.03	8.65
07	CLEANER ROOM	3.00	3.03	9.09
08	UPS	7.40	8.54	63.07
09	RETAIL-1	28.29	9.25	276.82
10	TER	8.18	6.70	57.76
11	SER	5.38	2.95	15.86
12	T.O.M 1	2.45	7.77	19.07
13	T.O.M 2	2.50	7.96	21.57
14	SECURITY ROOM 1	3.00	2.60	7.80
15	SECURITY ROOM 2	3.52	2.60	9.16
16	SCR	10.69	3.47	37.13
17	FIRST AID ROOM	3.01	2.35	7.09
18	STORE ROOM	2.50	4.70	11.75
19	UPS ROOM	3.99	8.99	30.73
20	ASS	25.13	14.08	347.01
21	EFO	4.66	3.44	13.77
22	RETAIL-2	21.35	7.72	174.47
23	CORRIDOR (PART-1)	5.61	2.45	28.21
	(PART-2)	2.57	5.62	

NAUBASTA
DPR FOR KANPUR MRTS
STATION LAYOUT PLANS : TYPE IA ELEVATED - 27M X 140M
IIT KANPUR - NAUBASTA CORRIDOR
ARCHITECTURAL

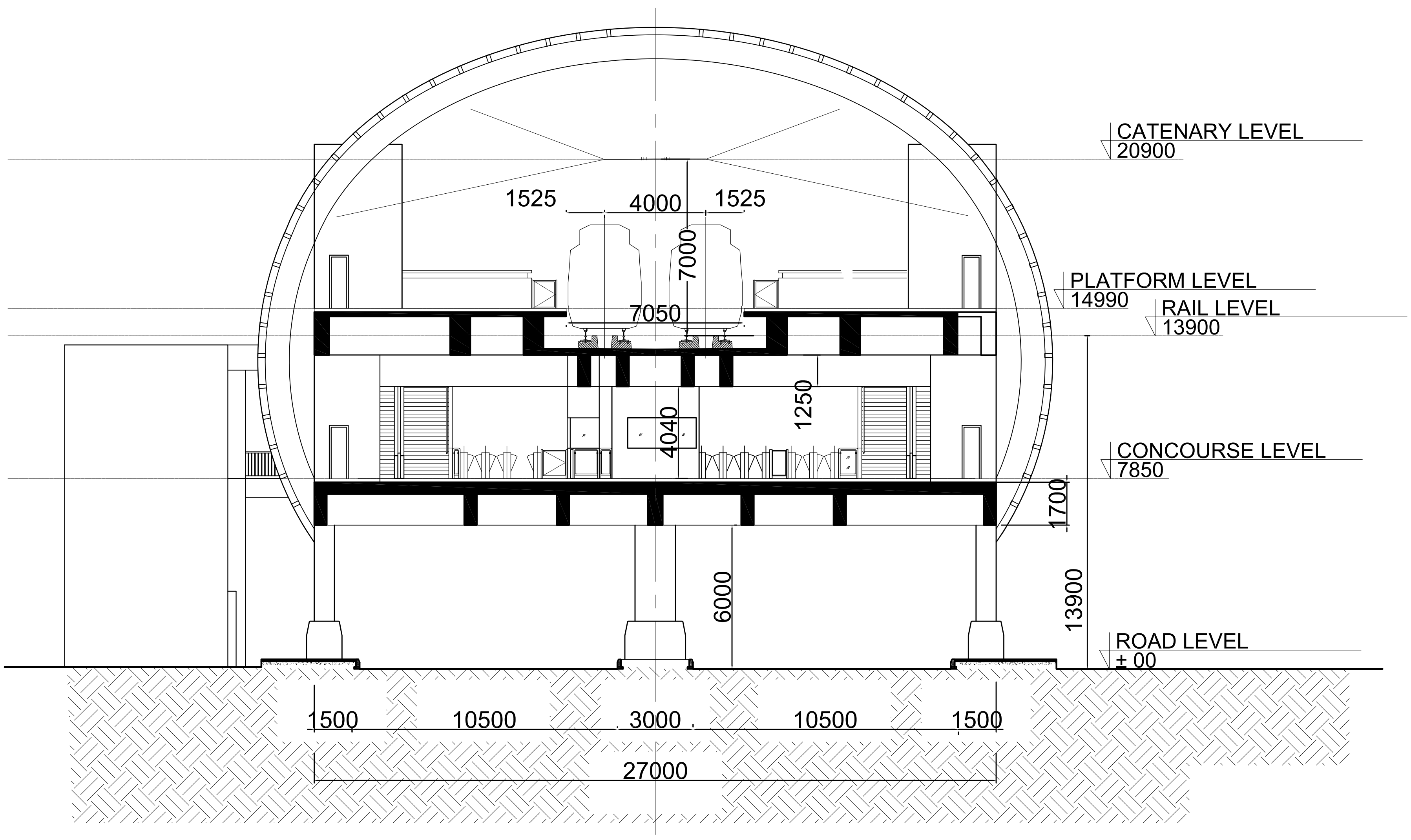
DRG. NO.	REV.	SCALE	STATUS
KP/TYP1A/09b	R1	1:650	CONCEPT DESIGN

ANNEXURE 6.16

STATION DESIGN OF NAUBASTA STATION - 2



ROAD LEVEL PLAN



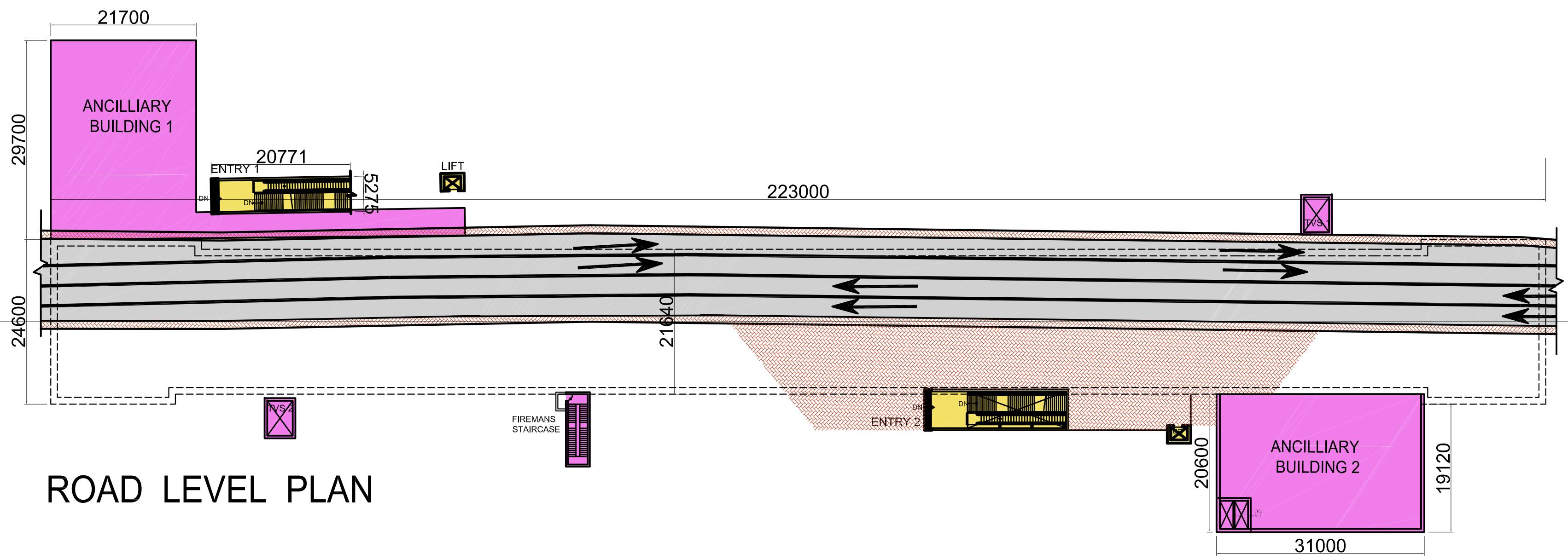
SECTION A-A'

(SCALE: NTS)

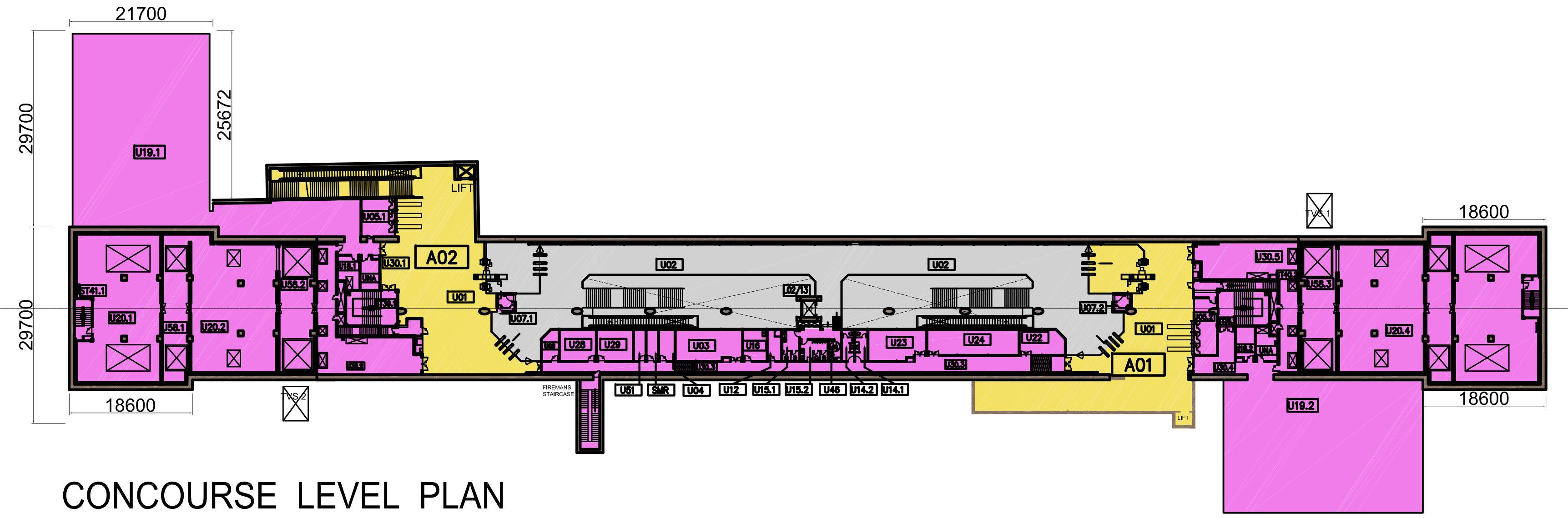
NAUBASTA			
DPR FOR KANPUR MRTS			ARCHITECTURAL
STATION LAYOUT PLANS : TYPE IA ELEVATED - 27M X 140M			
IIT KANPUR - NAUBASTA CORRIDOR			
DRG. NO. KP/TYP1A/09c	REV. R1	SCALE 1:650	STATUS CONCEPT DESIGN

ANNEXURE 6.17

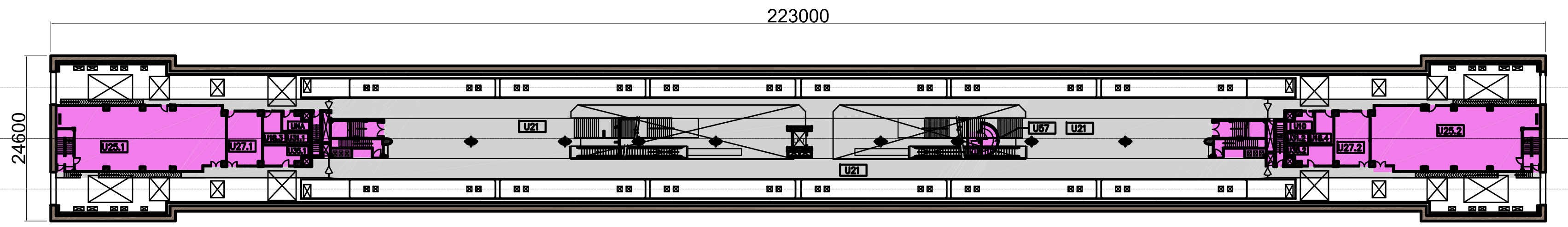
STATION DESIGN OF AGRICULTURE UNIVERSITY STATION



ROAD LEVEL PLAN



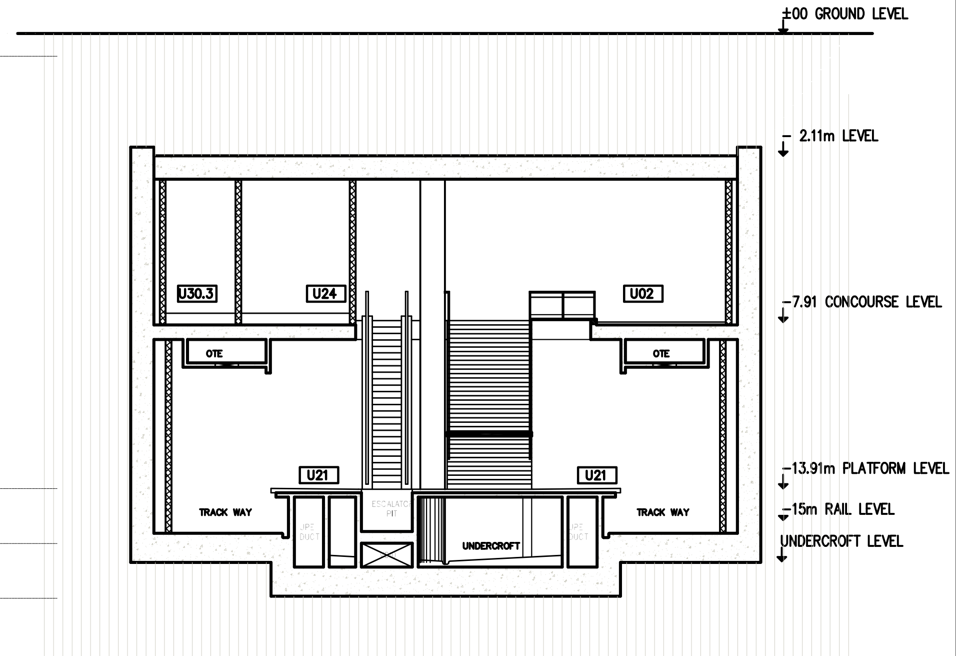
CONCOURSE LEVEL PLAN



PLATFORM LEVEL PLAN

ROOM SCHEDULE				
ROOM. NO.	ROOM NAME	SIZE OF ROOM (M)		AREA PROVIDED (SQ.M)
PLATFORM LEVEL				
UNA	UNNAMED AREA	4.17	2.82	9.36
U10	STORE	4.17	2.82	9.36
U18.3	DISTRIBUTION BOARD ROOM	7.02	4.82	20.65
U18.4	DISTRIBUTION BOARD ROOM	7.02	4.82	20.65
U21	PAID PUBLIC AREA			1131.29
U25.1	ASS PLANT ROOM	22.50	9.60	217.60
U25.2	ASS PLANT ROOM	22.50	9.60	217.60
U27.1	ELECTRICAL UPS ROOM	5.20	7.97	40.75
U27.2	ELECTRICAL UPS ROOM	5.20	7.97	40.75
U35.1	INERT GAS ROOM	7.02	2.95	18.28
U35.2	INERT GAS ROOM	7.02	2.95	18.28
U57	PLATFORM SUPERVISOR'S BOOTH	2.31	4.62	8.90

ROOM SCHEDULE				
ROOM. NO.	ROOM NAME	SIZE OF ROOM (M)		AREA PROVIDED (SQ.M)
CONCOURSE LEVEL				
U01	UNPAID PUBLIC AREA			685.32
U02	PAID PUBLIC AREA			629.99
U03	STATION CONTROL ROOM (SCR)	10.00	4.62	45.40
U04	STATION MANAGER ROOM (SMR)	2.30	4.62	10.63
U05.1	TICKET WINDOW	5.00	5.77	28.88
U05.2	TICKET WINDOW	3.45	8.50	28.48
U07.1	CUSTOMER CARE (EFO)	2.40	2.40	5.76
U07.2	CUSTOMER CARE (EFO)	2.40	2.40	5.61
U09	SECURITY ROOM	2.50	4.62	10.60
U12	CLEANERS ROOM	2.00	4.62	9.25
U14.1	LADIES STAFF TOILET	1.80	4.62	8.32
U14.2	GENTS STAFF TOILET	1.80	4.62	8.32
U15.1	LADIES PUBLIC TOILET	2.50	4.62	11.56
U15.2	GENTS PUBLIC TOILET	4.10	3.10	12.73
U16	MESS ROOM	3.50	4.62	16.18
U18.1	DISTRIBUTION BOARD	3.30	5.12	15.07
U18.2	DISTRIBUTION BOARD	2.80	5.12	13.61
U19.1	ECS PLANT ROOM (ECS)	20.70	29.20	722.96
U19.2	ECS PLANT ROOM (ECS)	30.10	20.10	601.14
U20.1	TUNNEL VENTILATION PLANT ROOM	13.00	23.00	278.57
U20.2	TUNNEL VENTILATION PLANT ROOM	13.00	23.00	278.57
U20.3	TVS ROOM	12.90	20.04	259.72
U20.4	TVS ROOM	12.90	20.04	255.72
U22	SIGNALING EQUIPMENT ROOM	6.80	3.72	24.35
U23	TELECOM EQUIPMENT ROOM	8.70	4.62	37.80
U24	S & T UPS ROOM	13.74	3.72	51.18
U28	CDMA ROOM	5.40	4.62	24.97
U29	GSM ROOM	5.40	4.62	24.97
U30.1	SEEPAGE ROOM	6.30	1.90	12.57
U30.2	SEEPAGE ROOM	15.75	5.62	127.98
U30.3	PROTECTED B.O.H. CORRIDOR	58.94	1.50	109.96
U30.4	PROTECTED B.O.H. CORRIDOR	12.65	7.22	41.47
U30.5	PROTECTED B.O.H. CORRIDOR	15.35	5.68	127.71
ST39.1	EMERGENCY ESCAPE STAIRCASE	7.70	5.20	39.75
ST39.2	EMERGENCY ESCAPE STAIRCASE	7.70	5.20	39.75
ST40.1	FIREMAN ACCESS STAIRCASE	8.96	1.30	11.64
ST40.2	FIREMAN ACCESS STAIRCASE	8.96	1.30	11.64
ST41.1	STAIRCASE	2.60	6.15	15.87
ST41.2	STAIRCASE	2.60	6.15	15.87
U46	PUBLIC TOILETS (H)	1.80	3.00	5.40
U51	EMERGENCY EQUIPMENT ROOM	1.70	4.62	7.86
U58.1	VENTILATION PLENUM	4.00	23.00	91.07
U58.2	VENTILATION PLENUM	5.30	20.04	105.25
U58.3	VENTILATION PLENUM	5.30	20.04	105.52
U58.4	VENTILATION PLENUM	3.35	23.00	90.63
UNA 1	UNNAMED AREA	2.80	4.52	13.61
UNA 2	UNNAMED AREA	3.30	5.12	15.07
SMR	SIGNALING MAINTENANCE ROOM	1.70	4.62	7.86



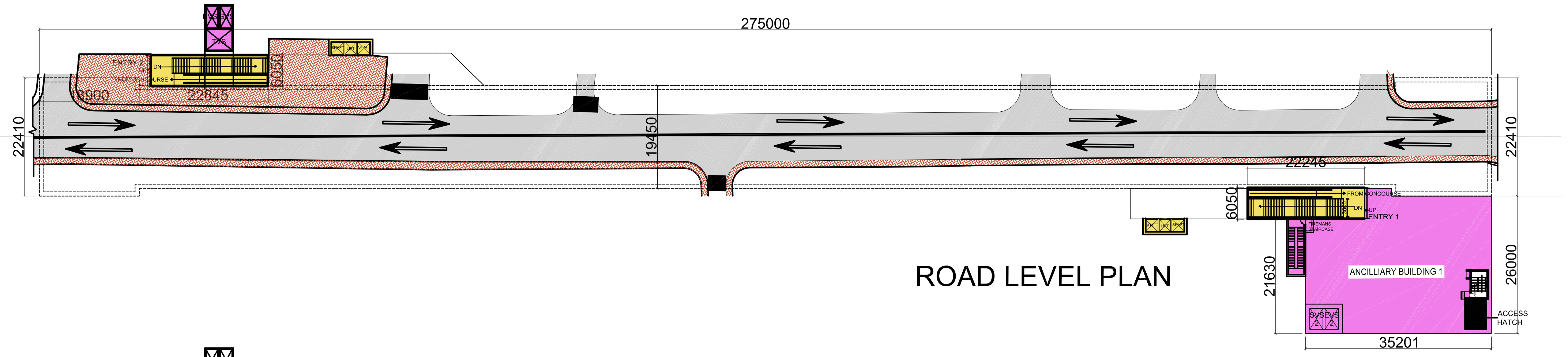
CROSS SECTION

(SCALE: NTS)

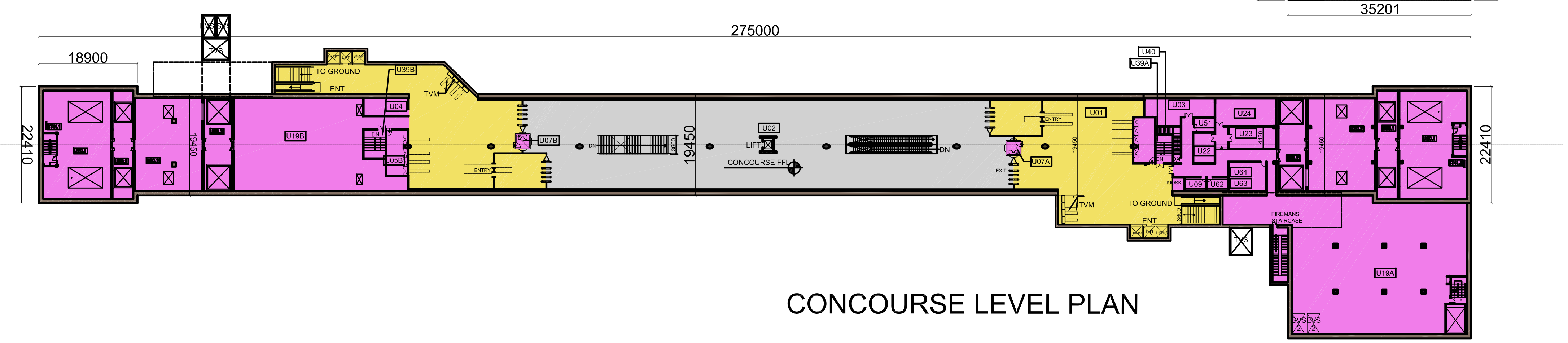
AGRICULTURE UNIVERSITY			
DPR FOR KANPUR MRTS			
STATION LAYOUT PLANS: TYPE IID UNDERGROUND - 24.6M X 223M			
AGRICULTURE UNIVERSITY - BARRA 8 CORRIDOR			ARCHITECTURAL
DRG. NO. KM-TYPIID-05b	REV. R1	SCALE 1:650	STATUS CONCEPT DESIGN

ANNEXURE 6.18

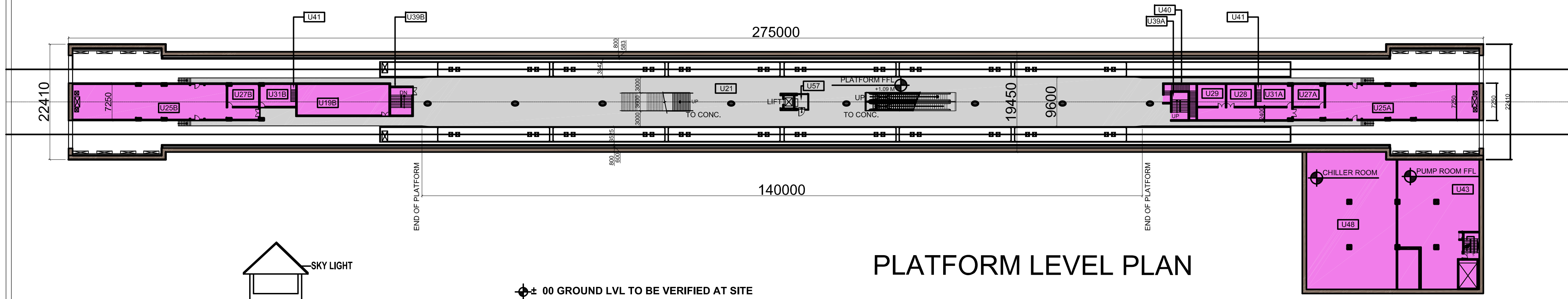
STATION DESIGN OF KAKADEO STATION



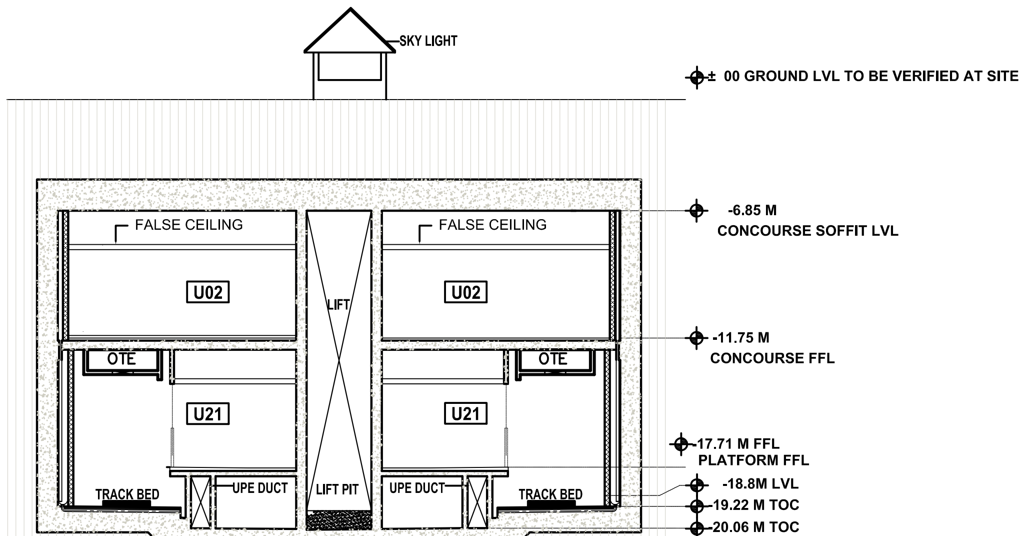
ROAD LEVEL PLAN



CONCOURSE LEVEL PLAN



PLATFORM LEVEL PLAN



(SCALE: NTS)

CROSS-SECTION

ROOM SCHEDULE

ROOM. NO.	ROOM NAME	SIZE OF ROOM (M)		AREA PROVIDED (SQ.M)
CONCOURSE LEVEL				
U01	UNPAID PUBLIC AREA			
U02	PAID PUBLIC AREA	88.20	14.05	1148.68
U03	STATION CONTROL ROOM (SCR)	13.31	3.52	55.39
U04	STATION MANAGER ROOM (SMR)	8.44	3.31	27.99
U05B	TICKET WINDOW	4.04	8.70	35.19
U07A	CUSTOMER CARE (EFO)	2.50	2.50	6.25
U07B	CUSTOMER CARE (EFO)	2.50	2.50	6.25
U09	SECURITY ROOM	4.00	2.62	10.49
U19A	ECS PLANT ROOM (ECS)	33.33	25.20	922.85
U19B	ECS PLANT ROOM (ECS)	24.72	17.85	501.87
U20.1	TUNNEL VENTILATION PLANT ROOM	13.00	20.81	251.49
U20.2	TUNNEL VENTILATION PLANT ROOM	13.00	20.81	252.19
U20.3	TVS ROOM	12.90	17.73	228.96
U20.4	TVS ROOM	12.90	17.85	228.98
U22	SIGNALING EQUIPMENT ROOM	4.00	5.74	22.99
U23	TELECOM EQUIPMENT ROOM	9.10	4.13	37.40
U24	S & T UPS ROOM	11.70	5.30	62.00
U39A	EMERGENCY ESCAPE STAIRCASE	3.20	5.40	17.27
U39B	EMERGENCY ESCAPE STAIRCASE	4.20	5.40	22.67
U40	FIREMAN ACCESS STAIRCASE	4.75	1.32	13.73
ST41.1	STAIRCASE	2.60	6.15	15.99
ST41.2	STAIRCASE	2.60	6.15	15.99
U51	EMERGENCY EQUIPMENT ROOM	4.00	2.75	11.00
U58.1	VENTILATION PLENUM	4.00	20.81	83.24
U58.2	VENTILATION PLENUM	4.00	20.81	83.24
U58.3	VENTILATION PLENUM	5.30	17.85	94.60
U58.4	VENTILATION PLENUM	5.30	17.85	94.60
U62		4.00	2.62	10.49
U63 & U64	E&M STAFF AND STORE ROOM	7.10	5.52	39.22

ROOM SCHEDULE

ROOM. NO.	ROOM NAME	SIZE OF ROOM (M)		AREA PROVIDED (SQ.M)
PLATFORM LEVEL				
U19B	ECS PLANT ROOM (ECS)	17.92	6.01	107.82
U21	PAID PUBLIC AREA	145.70	9.55	1489.02
U25A	AUXILIARY SUB-STATION ROOM	36.20	6.85	217.80
U25B	AUXILIARY SUB-STATION ROOM	29.90	6.85	217.88
U27A	ELECTRICAL UPS ROOM	6.10	4.32	26.14
U27B	ELECTRICAL UPS ROOM	6.10	4.32	26.14
U28	CDMA ROOM	5.50	4.32	23.78
U29	GSM ROOM	5.50	4.32	23.78
U31A	SEEPAGE ROOM	6.00	4.32	26.71
U31B	SEEPAGE ROOM	6.00	4.32	26.71
U39A	EMERGENCY ESCAPE STAIRCASE	3.20	5.40	17.27
U39B	EMERGENCY ESCAPE STAIRCASE	4.20	5.40	22.67
U40	FIREMAN ACCESS STAIRCASE	6.30	3.57	18.78
U41A	FIREMAN ACCESS STAIRCASE	1.00	3.32	3.32
U41B	FIREMAN ACCESS STAIRCASE	1.00	3.32	3.32
U43	PUMP ROOM	15.90	25.20	362.47
U48	CHILLER PLANT ROOM	17.50	26.68	497.94
U57	PLATFORM SUPERVISOR'S BOOTH (PSB)	2.50	2.80	6.84

KAKADEO

DPR FOR KANPUR MRTS

STATION LAYOUT PLANS: TYPE IIE UNDERGROUND - 19.45M X 275M

AGRICULTURE UNIVERSITY - BARRA 8 CORRIDOR

ARCHITECTURAL

DRG. NO.	REV.	SCALE	STATUS
KM-TYPIIE-10b	R1	1:650	CONCEPT DESIGN

Chapter – 7

INTER-MODAL INTEGRATION

7. INTER-MODAL INTEGRATION

7.1 INTER-MODAL INTEGRATION WITH EXISTING MODES

The concept of inter-modal integration with the modes is to provide last mile connectivity to the commuters residing/working in the metro influence zone. The MoHUA has also laid down policy guidelines to include this important aspect of last mile connectivity in the DPRs for the metro systems. This connectivity is expected to be achieved through proper access to the metro stations by city buses, intermediate public transport (auto rickshaws and cycle rickshaws) and pedestrian facilities etc.

Inter-modal integration explores the co-ordinated use of two or more modes of transport for efficient, speedy, safe, pleasant and comfortable movement of passengers in urban areas. It provides convenient and economical connection of various modes to make complete journey from origin to destination.

The inter-modal integration with existing modes have been planned at metro stations for efficient passenger movement. The proposals have been formulated for facilitating traffic dispersal and circulation facilities based on the following considerations:

- Dedicated linkages have been proposed like subways, skywalks, covered walkways etc upto existing bays which will reduce the passenger travel time and pedestrian load on the roads.

- Availability of total carriageway and footpath widths required to cater to the proposed traffic volumes to be augmented through strengthening of road shoulder areas and relocation of vendors/hawkers, on-street parking and all encroachments from the service/ access roads.

- Designated space for embarking and disembarking for vehicular traffic (pick-drop zones) and existing modes like Buses, IPTs and NMT have been proposed.

- Proper design of circulation area has been planned to adjoin the station building to ensure rapid/ efficient dispersal of the passengers and avoiding conflicts between pedestrian and vehicular traffic.

7.1.1 Interchange Stations

Major interchange stations have been planned with other existing bus/rail terminals which will serve as complementary/ feeder for the passengers from their respective origins to destinations and vice versa. For interchange station planning many factors such as nature of station, its catchment, availability of access/dispersal modes, and interchange with other public transport modes, distance from station, trip length and destinations etc. have been considered. Some of the passengers facilities as planned are described below:

- **Pedestrian facilities:** Interchange stations will be expected to experience heavy pedestrian movements during peak hour. Therefore, pedestrian infrastructure facilities i.e. pedestrian pathways, skywalks, subways and foot over bridges are proposed accordingly.

- **Traffic Dispersal Facilities:** Adequate traffic dispersal facilities in terms of continuous footpaths, city bus stops, IPT stands, pick-drop areas, traffic signages and parking within the proximity of the entries/exits, pedestrian crossing facilities, traffic calming measures along with signage, road markings, signals, speed table and NMT crossings has been planned near the interchange station influence area to facilitate the safe and smooth movement for both pedestrians & vehicles.

- **Embarking/Disembarking Zones/Parking Areas:** At interchange stations, long and short duration parking spaces, pick and drop facilities for different public & private modes are planned as per peak hour passenger station boarding/alighting. The parking areas will directly be connected to the proposed interchange stations through pedestrian pathways/ FOB/ subways.

The typical interchanges stations identified on the two priority metro corridors are classified into following categories;

i. Metro – Metro - Rail - Bus
ii. Metro - Bus
iii. Metro - Rail

i. Rawatpur Railway Station (Metro – Metro -Rail –Bus)

This is an interchange metro station along with bus, railway station and shared autos terminals making it a passenger transfer hub. To enable seamless transfer of passengers between one mode to another, it is proposed to connect the underground and elevated stations through a set of staircases and escalator.

Proper road markings, traffic signages, zebra crossings and pedestrian signals are proposed to provide safe and uninterrupted pedestrian movements.

Continuous foot path of 2.0 m is proposed near station influence areas for ease of passenger movement. IPT stands, Pick-Drop bays and bus bays have also been proposed as per land availability for ensuring efficient traffic circulation. Strengthening of road shoulder areas and relocation of vendors/ encroachments to increase the efficiency of available carriageway and footpath has been considered.

ii. Jhakarkati Station (Metro - Bus)

This proposed metro station of corridor-1 is Metro-Bus interchange station. It is an underground station, integrated with the existing Jhakarkati Bus Terminal by staircases, lifts and escalators. The passengers have directly access to the two public transport systems without creating hindrance to road traffic. Infrastructure facilities for such interchange station are proposed on the basis of peak hour passenger flow.

It is proposed to utilize the complete Right of Way to cater to the future traffic volume. The existing road shoulder areas and service lanes have been augmented/ strengthened in the design wherever possible. A continuous, encroachment free and well-maintained footpath of 2.0 m width has been proposed near station area. The circulating area adjoining the station building is proposed to be properly designed to ensure rapid/efficient dispersal of passengers, avoiding conflict between pedestrians and vehicular traffic.

Demarcated pick and drop zones and bays for feeder modes like buses, IPT have been proposed near the station. Relocation of vendors/hawkers and parking for unobstructed movement of pedestrians and vehicles is proposed. Proper road markings, traffic signages, zebra crossings and pedestrian signals are proposed to provide safe and uninterrupted pedestrian movement.

iii. Kanpur Station- (Metro – Rail)

This underground metro station integrates existing Kanpur Central Railway Station with the staircase, lifts and escalators. The circulating area adjoining the station building is proposed to be properly designed to ensure rapid/efficient dispersal of passengers, avoiding conflict between pedestrians and vehicular traffic.

The circulating area adjoining the station building is proposed to be properly designed to ensure rapid/efficient dispersal of passengers, avoiding conflict between pedestrians and vehicular traffic. Pick and drop zones and bays for feeder modes like buses, IPT have been proposed on the basis of land availability for smooth well-organized traffic circulation. A continuous, encroachment free and well-maintained footpath of 2m width has been proposed near station area.

Relocation of vendors/hawkers and parking for unobstructed movement of pedestrians and vehicles is proposed. Proper road markings, traffic signages, zebra crossings and pedestrian signals are proposed to provide safe and uninterrupted pedestrian movement.

iv. Kalyanpur Station (Metro – Rail)

The proposed station is located adjacent to Kalyanpur Railway Station on the south side. There is heavy development beyond the railway station which is proposed to be connected to the metro station by skywalks across the railway lines to provide easy and convenient access. The skywalks shall bring passengers to the concourse level directly. Other transport infrastructure facilities are provided as per peak hour passenger demand.

It is proposed to utilize the complete Right of Way to cater to the future traffic volume. The existing road shoulder areas and service lanes have been augmented/ strengthened in the design wherever possible. A continuous, encroachment free and well-maintained footpath of 2m width has been proposed near station area. The circulating area adjoining the station building is proposed to be properly designed to ensure rapid/efficient dispersal of passengers, avoiding conflict between pedestrians and vehicular traffic.

Demarcated pick and drop zones and bays for feeder modes like buses, IPT have been proposed near the station. Relocation of vendors/hawkers and parking for unobstructed movement of pedestrians and vehicles is proposed. Proper road markings, traffic signages, zebra crossings and pedestrian signals are proposed to provide safe and uninterrupted pedestrian movement.

The inter-modal integration plans are presented from **Annexure 7.1** to **7.30.**

7.2 FEEDER SERVICES PLANNING AT STATIONS

7.2.1 The planning of seamless transport integration facilities at the influence zones of various metro stations is of utmost importance. Feeder services to the proposed metro network are essential for convenient and quick transfer of passengers. As all commuters will not be living within walking distance of the proposed network, proper planning for feeder services will be necessary.

Various modes of transportation like feeder buses, auto rickshaw/taxi and bicycles can provide first mile as well as last mile connectivity to the metro station. For catchment area of about 0.5 -1 km from the proposed network, commuter can easily access it by walk. People residing in the next 1 km can reach the station by cycles, 2-wheeler and cycle / auto-rickshaws. Areas beyond the 2-km catchment will require feeder buses to reach metro station.

The feeder service facilities are proposed at metro stations to connect the trip generation/ attraction areas in the influencing zones. **Figure 7.1** shows the concept of provision of feeder services to a metro system. The facilities of footpaths, feeder buses and bicycles (bike sharing) have been planned for peak hour passenger demand.

7.2.2 Feeder Bus System

The feeder buses shall be of high quality, ultra-modern and customer oriented that can deliver fast, comfortable and cost-effective urban mobility. Easy-to-board (low floor), attractive and environmentally friendly mini buses with air conditioning having capacity of 35 (for minibuses) are proposed for feeder system.

The facilities of feeder buses have been estimated for peak hours of various horizon years 2024, 2031, 2041 and 2051. The fleets required along metro corridors are presented in **Table 7.1.** The total number of fleet required in the year 2024 is 113 for Corridor-1 and 35 for Corridor-2 respectively. The Cost of feeder buses has been included in the multi modal integration cost which is a part of the total project cost. The feeder route planning has been identified at 10 stations in corridor -1 and 4 stations at corridor -2 as presented in **Figure 7.2**. The operational hours of feeder services shall be same as that of metro services i.e. 6:00 am to 10:00 pm. Further, the feeder bus services have been planned at 14 metro stations based on station loads. The feeder services at more stations may be provided after detailed study at time of implementation.

FIGURE 7.1: CONCEPT OF FEEDER SERVICES AT METRO STATION

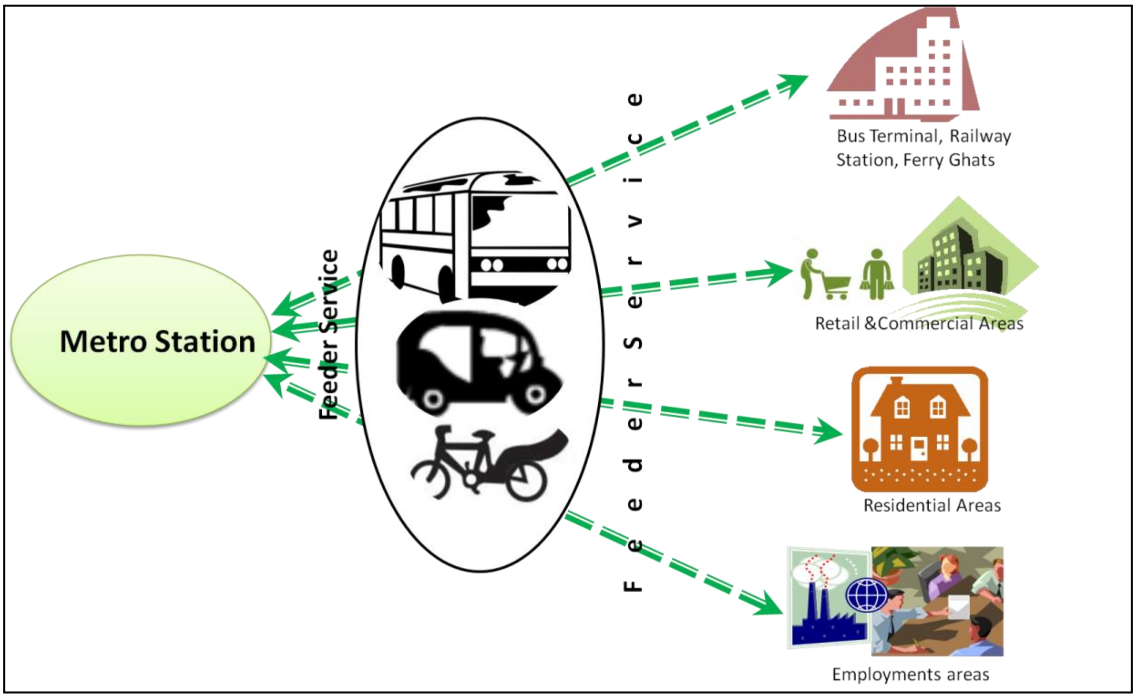


TABLE 7.1: FFEDER BUS FLEET REQUIREMENT FOR PHASE I KANPUR METRO

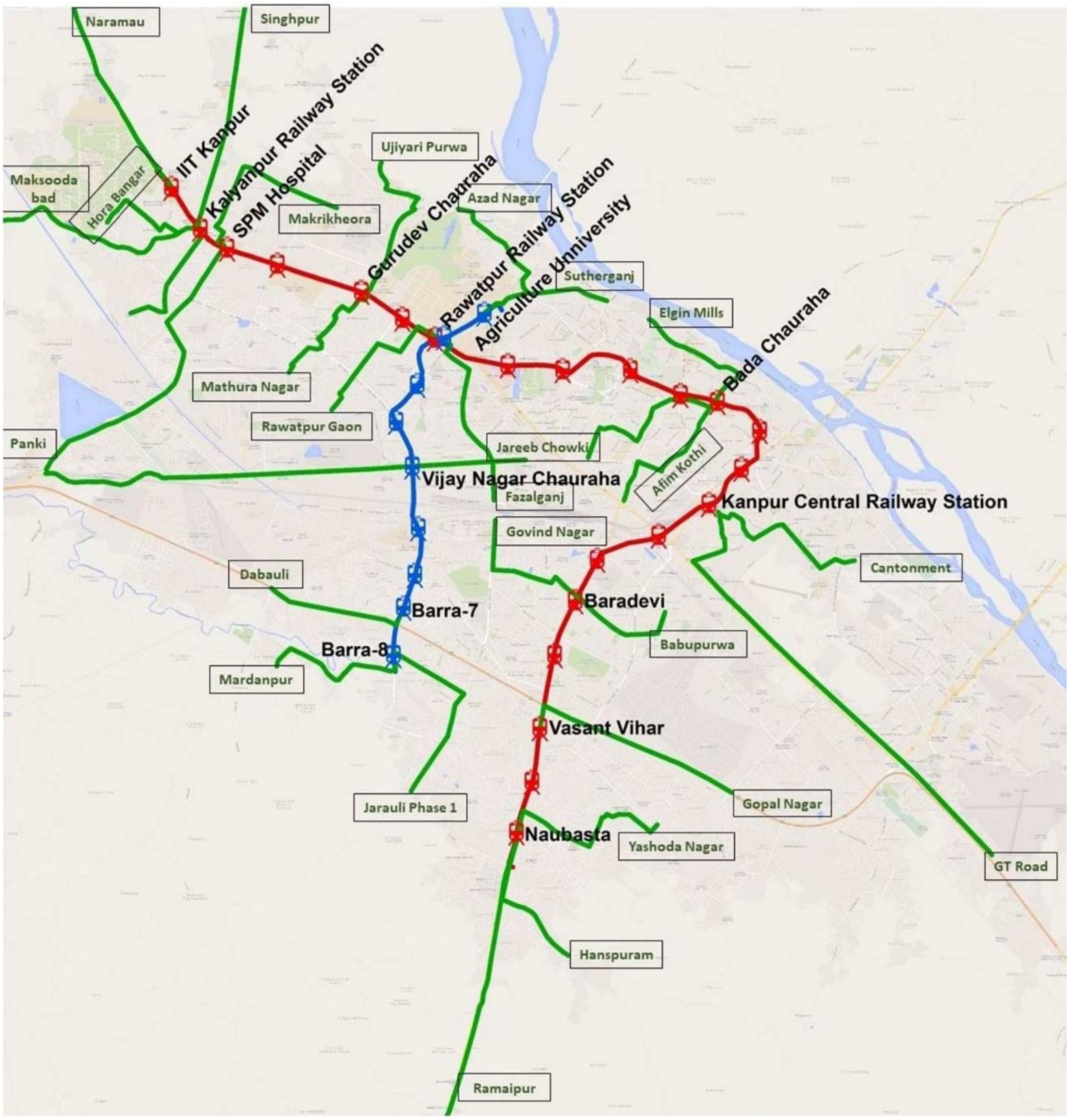
S N	Metro Station	Route No.	Feeder Bus Route Name	Length (Km)	Buses in Peak Hour			
					2024	2031	2041	2051
	Corridor-1: IIT Kanpur to Naubasta							
1	IIT Kanpur	R1	IIT Kanpur to Mandhana via Naramau	6.0	5	6	7	9
			Total Buses	-	**5**	**6**	**7**	**9**
2	Kalyanpur Rly Stn.	R1	Kalyanpur Railway Stn to Hora bangar via Gooba Gardens	3.0	3	4	7	10
		R2	Kalyanpur Railway to Singhpur via Dayanand Vihar	4.5	4	6	10	14
		R3	Kalyanpur Railway to Maksoodabad via Gautam Vihar	5.5	5	7	12	16
			Total Buses	-	**12**	**17**	**29**	**40**
3	SPM Hospital	R1	SPM Hospital to Panki via AwasVikas Colony	6.5	7	7	10	11
		R2	SPM Hospital to Makrikheora via Indira Nagar	5.5	6	6	8	10
			Total Buses	-	**13**	**13**	**18**	**21**
4	Gurudev Chauraha	R1	Gurudev Chauraha to Ujiyari Purwa via Vikas Nagar Bus Depot	3.5	4	4	11	13
		R2	Gurudev Chauraha to Mathura Nagar via Sharda Nagar	3.0	4	4	10	12
			Total Buses	-	**8**	**8**	**21**	**25**
5	Rawatpur	R1	Rawatpur to Rawatpur Gaon via Shivpuri	3.5	9	11	17	22
		R2	Rawatpur to Govindpuri Rly Stn. Via Fazalganj	4.0	9	12	19	25

S N	Metro Station	Route No.	Feeder Bus Route Name	Length (Km)	Buses in Peak Hour			
					2024	2031	2041	2051
			Total Buses	-	**18**	**23**	**36**	**47**
6	Bada Chauraha	R1	Bada Chauraha to Elgin Mills via Kaushalpuri	3.0	4	6	10	12
		R2	Bada Chauraha to Afim Kothi via Deputy Padao	3.5	4	7	11	13
		R3	Bada Chauraha to Jareeb Chowki via Chamanganj	4.0	5	7	12	15
			Total Buses	-	**13**	**20**	**33**	**40**
7	Kanpur Central Railway Station	R1	Kanpur Central Rly Stn to Cantonment	4.0	7	15	19	19
		R2	Kanpur Central Rly Stn to Chakeri via Ramadevi & GT Road	8.5	15	29	37	37
			Total Buses	-	**22**	**44**	**56**	**56**
8	Baradevi	R1	Baradevi to Govind Nagar via Juhi	3.0	4	4	6	7
		R2	Baradevi to Babupurwa via Kidwai Nagar	3.0	4	4	6	6
			Total	-	**8**	**8**	**12**	**13**
9	Vasant Vihar	R1	Vasant Vihar to Gopal Nagar	4.5	12	12	16	21
			Total	-	**12**	**12**	**16**	**21**
10	Naubasta	R1	Naubasta to Yashoda Nagar via Sainik Chauraha	4.0	3	4	4	4
		R2	Naubasta to Hanspuram	3.0	2	3	3	3
		R3	Naubasta to Ramaipur	6.2	5	5	5	5
			Total	-	**10**	**12**	**12**	**12**
			Total Buses Required for Corridor-1	-	**113**	**155**	**218**	**258**
Corridor-2: Agriculture University to Barra-8								
1	Agricultural University	R1	Agriculture University to Azad Nagar via Vishnupuri	4.0	4	4	4	4
		R2	Agriculture University to Sutherganj via Company Bagh	3.0	3	3	3	3
			Total	-	**7**	**7**	**7**	**7**
2	Vijay Nagar Chauraha	R1	Vijay Nagar Chauraha to Jareeb Chowki via Fazalganj	3.0	5	6	7	10
		R2	Vijay Nagar Chauraha to Panki Mor via Armapur	7.5	12	14	16	22
			Total	-	**17**	**20**	**23**	**32**
3	Barra-7	R1	Barra-7 to Dabauli	3.0	5	7	10	15
			Total	-	**5**	**7**	**10**	**15**
4	Barra-8	R1	Barra 8 to Jarauli Ph I via World Bank Colony	3.7	3	3	3	3
		R2	Barra 8 to Mardanpur	3.2	3	3	3	3
			Total	-	**6**	**6**	**6**	**6**
			Total Buses Required for Corridor-2	-	**35**	**40**	**45**	**59**

Note: Number of buses have been estimated assuming average peak hour bus speed of 15 kmph and turnout time of 5 minutes.

Headway of the buses for the planned feeder services will vary from 2-8 minutes for the proposed metro corridor.

FIGURE 7.2: PROPOSED FEEDER ROUTES AT METRO STATIONS



7.2.3 Public Bicycle Sharing Service (PBS)

This service will be provided for the passengers for 1 km to 2 km of the metro stations influence area. A bicycle sharing system is the service in which bicycles are made available for free and shared use to metro passengers on a short-term basis. The main purpose is to allow passengers to depart or arrive at metro stations. Further, the PBS services have been planned at 14 metro stations based on station loads. This PBS services at more stations may be provided at time of implementation. The requirement of bicycles along the metro corridors is estimated and is presented in **Table 7.2.**

TABLE 7.2: BICYCLE SHARING SCHEME FOR PHASE I METRO CORRIDORS

SN	Metro Station	Cycles in Peak Hour			
		2024	2031	2041	2051
	Corridor-1: IIT Kanpur to Naubasta				
1	IIT Kanpur	36	62	90	110
2	Kalyanpur Railway Station	18	25	49	60
3	SPM Hospital	7	14	18	22
4	Gurudev Chauraha	10	14	41	51
5	Rawatpur	38	58	65	79
6	Bada Chauraha	22	38	57	69
7	Kanpur Central Railway Station	23	53	54	66
8	Baradevi	7	13	21	25
9	Naubasta	80	86	90	110
	Total Sharing Bicycles required	**241**	**363**	**485**	**592**
	Corridor-2: Agriculture University to Barra-8				
1	Agricultural University	36	44	50	60
2	Vijay Nagar Chauraha	21	26	31	38
3	Barra-7	9	18	32	39
4	Barra-8	40	54	54	68
	Total Sharing Bicycles required	**106**	**142**	**167**	**205**

7.3 PHYSICAL INFRASTRUCTURE REQUIREMENT FOR INTERMODAL INTEGRATION

Physical infrastructure facilities have been planned to facilitate easy transfer of commuters between different modes of transport. Seamless mobility is proposed to remain connected between different transport modes i.e. metro, city bus system, IPT, NMT and private modes i.e. cars, two wheelers etc.

- Demarcations of designated bus bays have been proposed with proper shelter near station entry/ exits by utilizing road shoulder areas.
- Demarcations of planned IPT/private pick and drop facilities, wherever land is available have been proposed. Most of the passengers use IPT / taxis for short distances.
- Relocation of vendors/hawkers and removal of all encroachments from the station precinct.
- Off – street parking lots be identified to avoid on-street parking
- Continuous, encroachment free and well-maintained footpaths of 1.8-3 m width have been proposed near station areas.

- Proper road markings, Traffic Signages, Zebra crossings, pedestrian signals & table top crossings have been provided near the station influence area.

The physical infrastructure requirement for intermodal integration facilities and passenger traffic dispersal at all stations along both the metro corridors have been proposed on the basis of availability of land and suitably incorporated in station plans.

7.4 RECOMMENDATIONS FOR INSTITUTIONAL, PHYSICAL, FARE, OPERATIONAL AND TECHNOLOGY INTEGRATION

Some of the essential features of an integrated multi-modal urban transport system are the physical integration of public transport services, fares, ticketing, infrastructure provision, management, pricing, and integration of transport authorities.

7.4.1 Physical Integration

Physical integration refers to the provision of jointly used transport facilities & equipment to provide seamless mobility. Integration of physical space, network planning and physical infrastructure have been planned to facilitate easy transfer of commuters between metro, city bus system, IPT, NMT and private modes i.e. cars, two wheelers etc.

Augmentation of carriageway and footpath in station vicinity to cater to traffic volumes has been proposed through strengthening of road shoulder and relocation of vendors/hawkers, on-street parking and all encroachments.

7.4.2 Operational Integration

This involves application of management techniques to optimize the allocation of transit resources and coordinate services. The techniques/principles of network integration include:

- Coordinated Routing and Scheduling- in which high-capacity, such as metro system is considered as trunk system and buses act as feeder to the metro. Accordingly, the integrated route network may be planned by generating feeder bus routes for selected metro station.

- Rationalization of redundant services - wasteful duplication of transit service by competing systems may be eliminated and resources redeployed to reduce headways on existing routes and extend services into new areas.

- Network coordination and access- in which access facilities may be provided for non-motorized transport (pedestrians and cyclists) and private transport to support and enhance the public transport operations, to achieve overall network integration.

The service integration takes into account all modes implying the services will be complementary to each other with in the station area.

7.4.3 Fare Integration

The basic principle behind fare integration is that one ticket provides access to all modes of transport even when managed by different operators. Choice of fare structure is a very important part of public transport planning. It directly influences operators' revenue. At its simplest, integration of fares, allows a person to make a journey that involves transfers (within or between different transport modes) with a single ticket that is valid for the complete journey, modes being buses, trains, subways, taxies, parking, etc. The major benefits of fare integration are as follows:

- It encourages people to use public transport by simplifying the transfer between transport modes and by increasing the efficiency of the services
- Provides a common ticket across the modes
- Improves the experience of seamless mobility

Smartcard ticketing systems enable commuters to carry one durable card for use on all transit modes. A single multipurpose ticket makes using multiple transport modes much simpler and less time consuming. In turn, this facilitates the multimodal travel behaviour that is encouraged by operators and transport planners. In this regard, smartcard ticketing is proposed facilitating a genuinely seamless multimodal transport system in the Kanpur city.

7.4.4 Information Integration

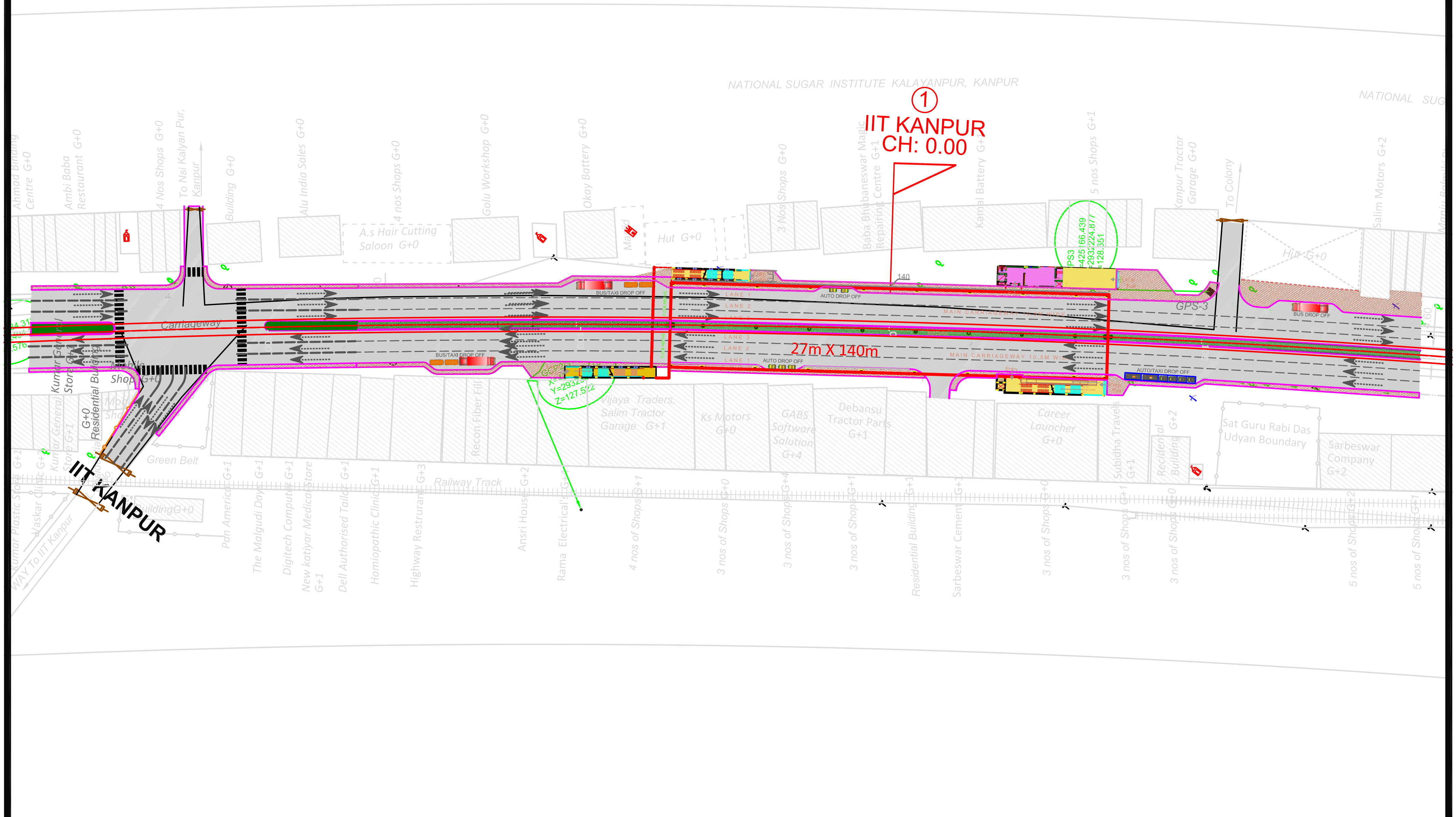
Creating the possibility to get information about the entire journey and not having to enquire at different sources. To take an informed decision during travel, real-time access to information is of strategic importance.

Information integration deals with the Information on routes, schedules, fares, and transfer points for all transit modes and services throughout the urban area, which is provided by a centralized source. Information services include route maps, timetables, fare schedules, and promotion materials, uniform street signs and vehicle identification, display at stops, transfer points and major stations, and telephone inquiry answering service. Providing integrated information during journey before and in between is important, to make them attractive. Information integration for all transit modes in the city is proposed for the metro network.

7.4.5 Institutional Integration

City growth strategies are usually guided by documents like land use plans, development plans and master plans etc. and the urban transport models are determined by parameters like existing road network, public transport and its related infrastructure, personal vehicles, licensing mechanism and authorities, land ownership, fare structure of public transport, Intelligent Transport System (ITS) mechanism, traffic enforcement agencies and traffic law enforcing mechanisms, goods and freight movement and their operators, road safety and accident management system etc. All these agencies which prepare these policy documents and oversee governing these functions generally work independently and usually there is no synergy between them. There exists no umbrella agency that monitors and integrates these multiple bodies in order to ensure smoother functioning of all aspects related to urban transport in any city.

ANNEXURE 7.1

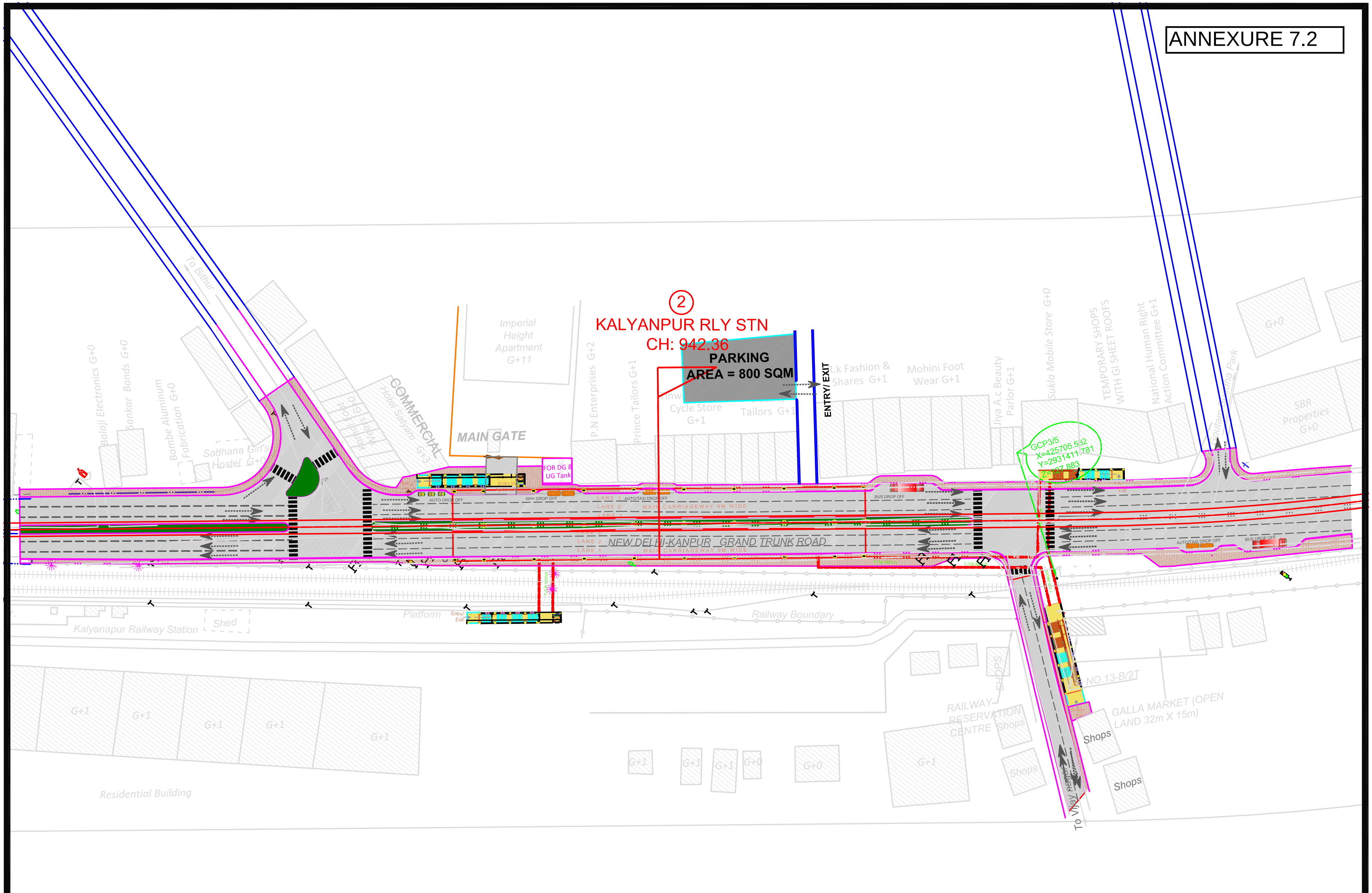


PROPOSED INTERMODAL INTEGRATION AND DISPERSAL PLAN OF IIT KANPUR

P.D. cum Parking Area	Proposed Parking Area
Proposed Road Geometry	Proposed Circulation
Proposed Auto Pick/Drop Bay	Proposed Bus Stop Bay Marking
Proposed Taxi cum Pvt. Pick/Drop Bay	Proposed Entry/Exit

N

ANNEXURE 7.2

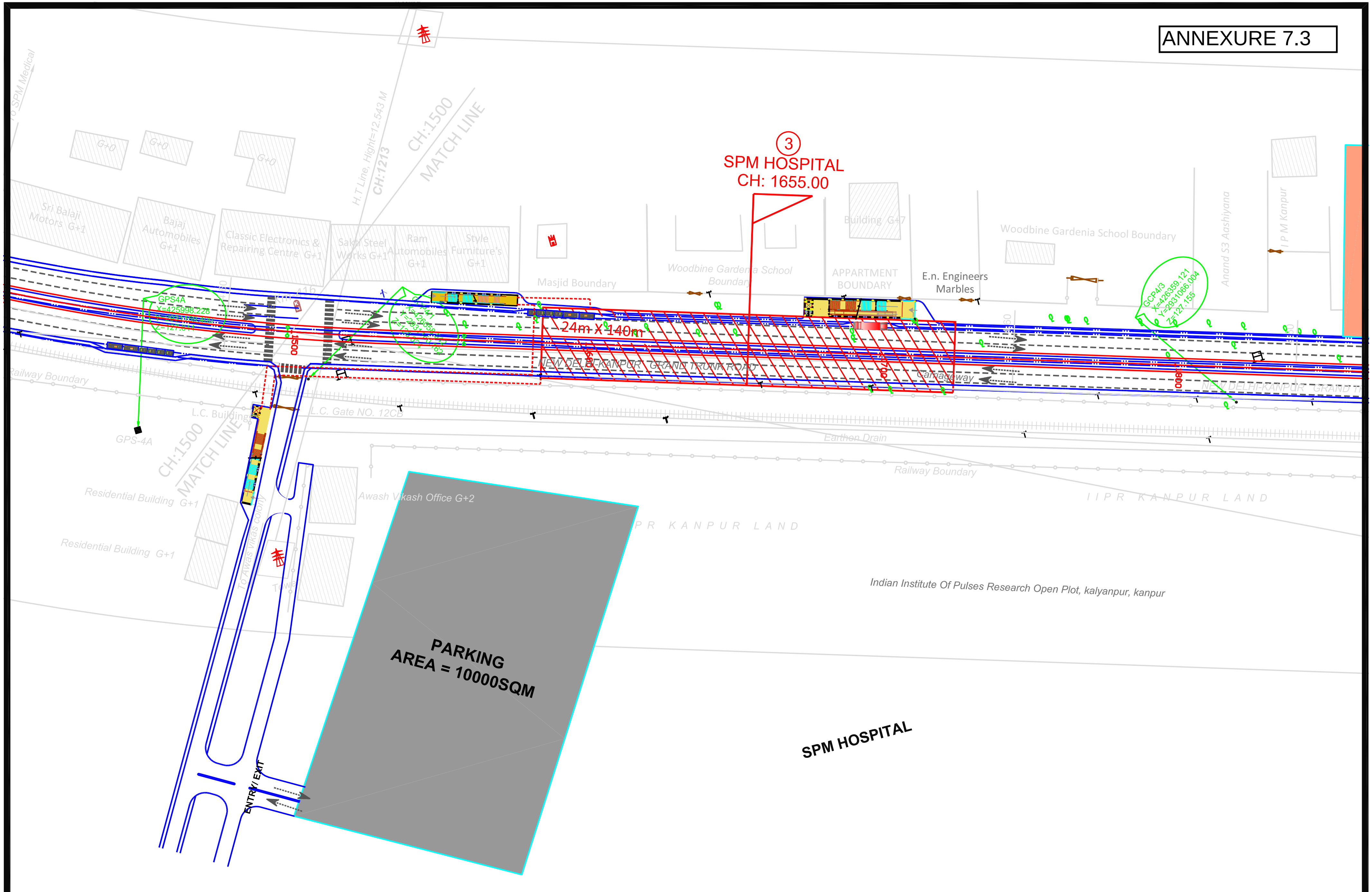


PROPOSED INTERMODAL INTEGRATION AND DISPERSAL PLAN OF KALYANPUR RAILWAY STATION

P.D. cum Parking Area	Proposed Parking Area
Proposed Road Geometry	Proposed Circulation
Proposed Auto Pick/Drop Bay	Proposed Bus Stop Bay Marking
Proposed Taxi cum Pvt. Pick/Drop Bay	**Proposed Entry/Exit**

N

ANNEXURE 7.3

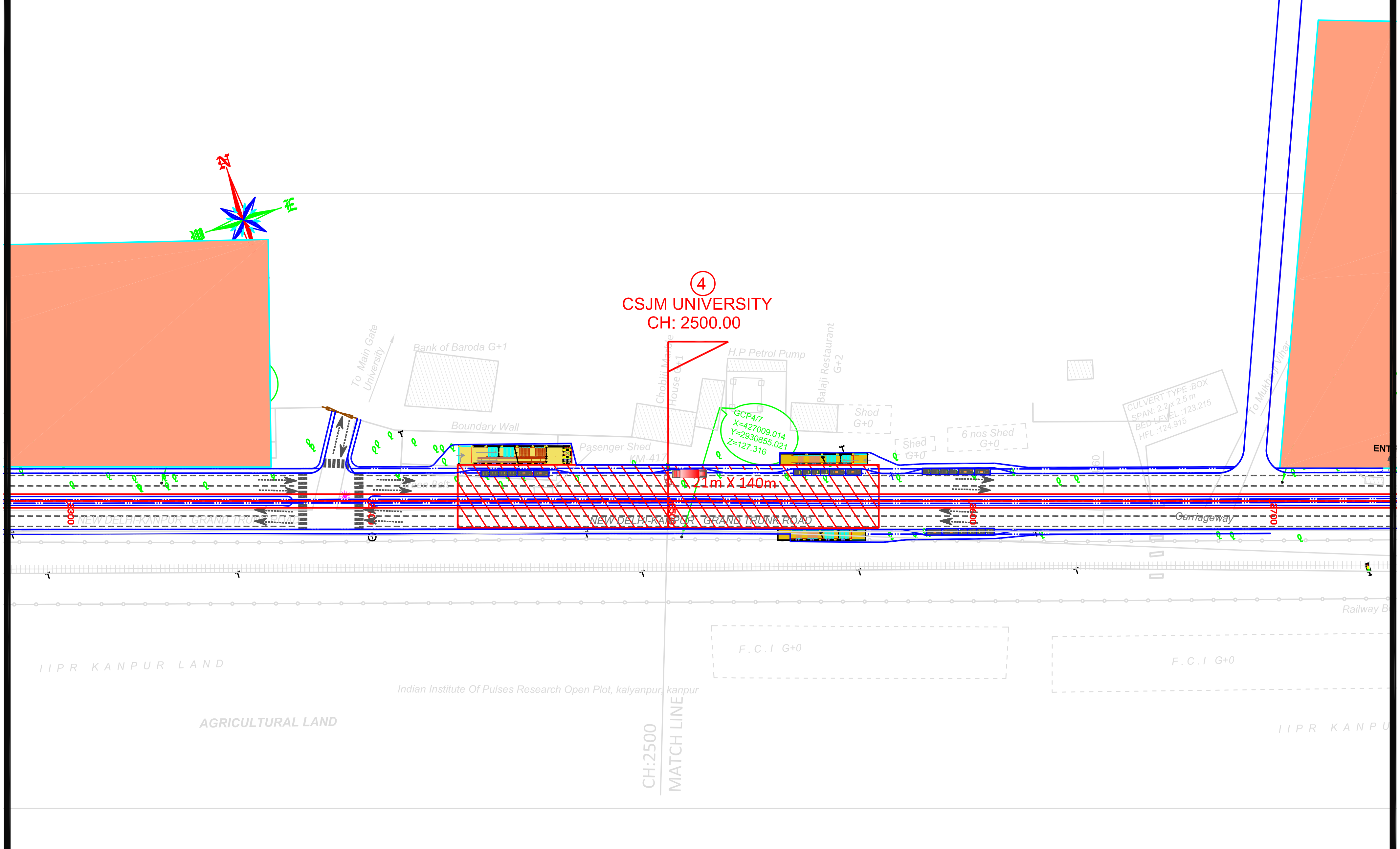


PROPOSED INTERMODAL INTEGRATION AND DISPERSAL PLAN OF SPM HOSPITAL

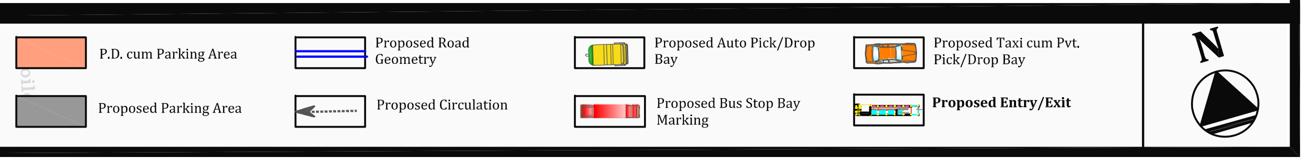
P.D. cum Parking Area	Proposed Parking Area
Proposed Road Geometry	Proposed Circulation
Proposed Auto Pick/Drop Bay	Proposed Bus Stop Bay Marking
Proposed Taxi cum Pvt. Pick/Drop Bay	**Proposed Entry/Exit**

N

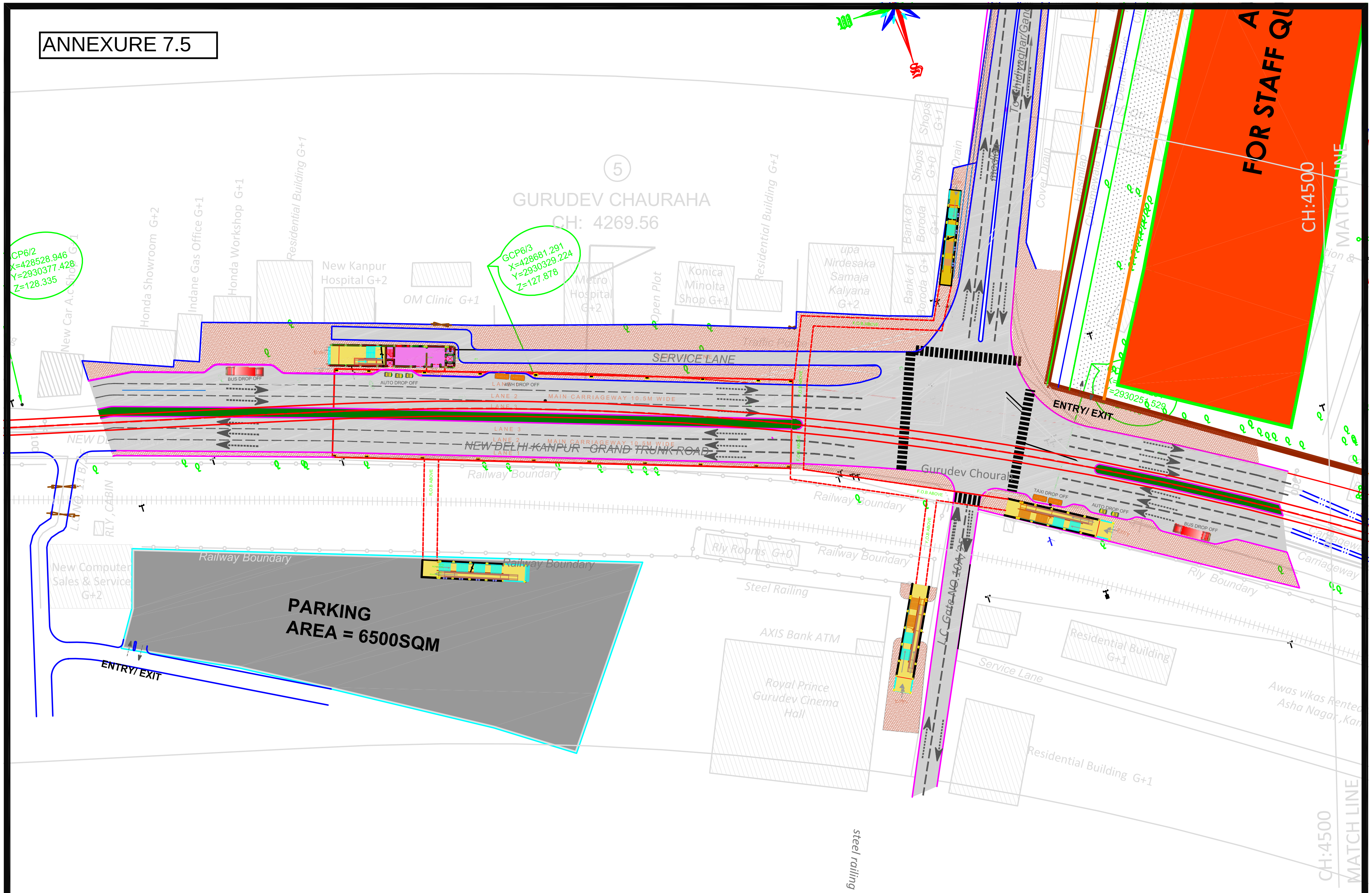
ANNEXURE 7.4



PROPOSED INTERMODAL INTEGRATION AND DISPERSAL PLAN OF CSJM UNIVERSITY



ANNEXURE 7.5

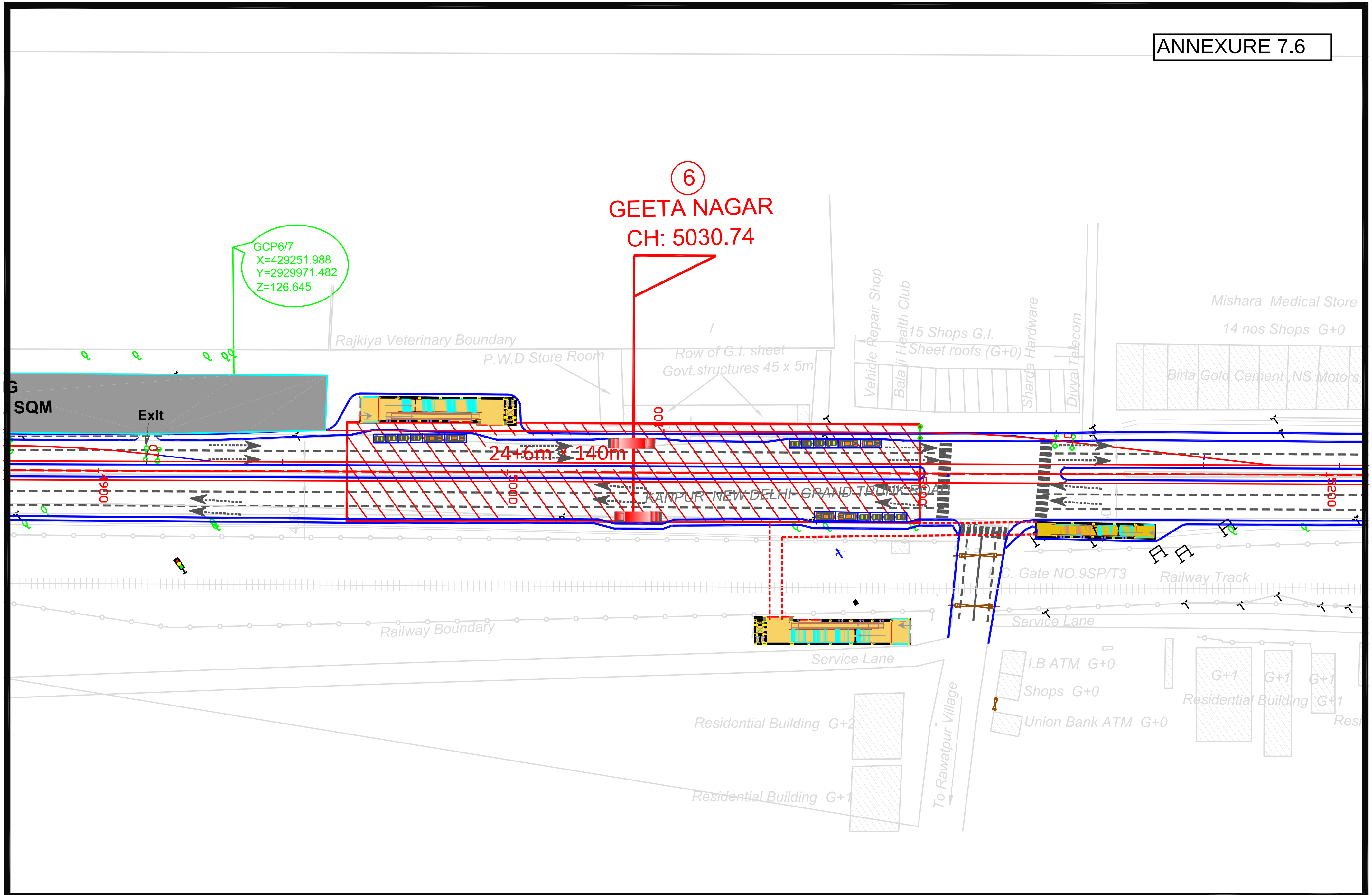


PROPOSED INTERMODAL INTEGRATION AND DISPERSAL PLAN OF GURUDEV CHAURAHA

P.D. cum Parking Area	Proposed Parking Area
Proposed Road Geometry	Proposed Circulation
Proposed Auto Pick/Drop Bay	Proposed Bus Stop Bay Marking
Proposed Taxi cum Pvt. Pick/Drop Bay	Proposed Entry/Exit

N

ANNEXURE 7.6

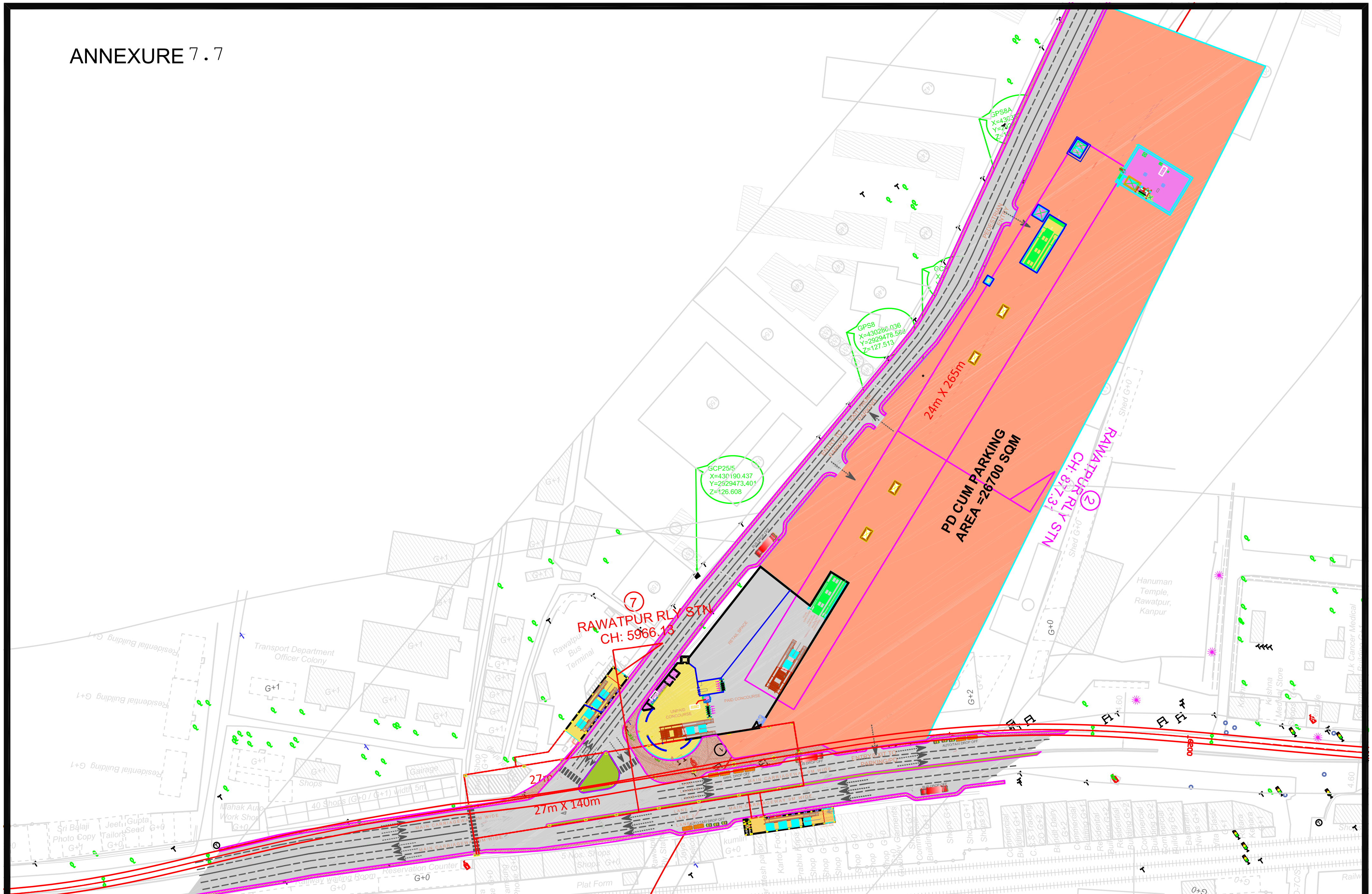


PROPOSED INTERMODAL INTEGRATION AND DISPERSAL PLAN OF GEETA NAGAR

P.D. cum Parking Area	Proposed Road Geometry	Proposed Auto Pick/Drop Bay	Proposed Taxi cum Pvt. Pick/Drop Bay
Proposed Parking Area	Proposed Circulation	Proposed Bus Stop Bay Marking	**Proposed Entry/Exit**

N

ANNEXURE 7.7

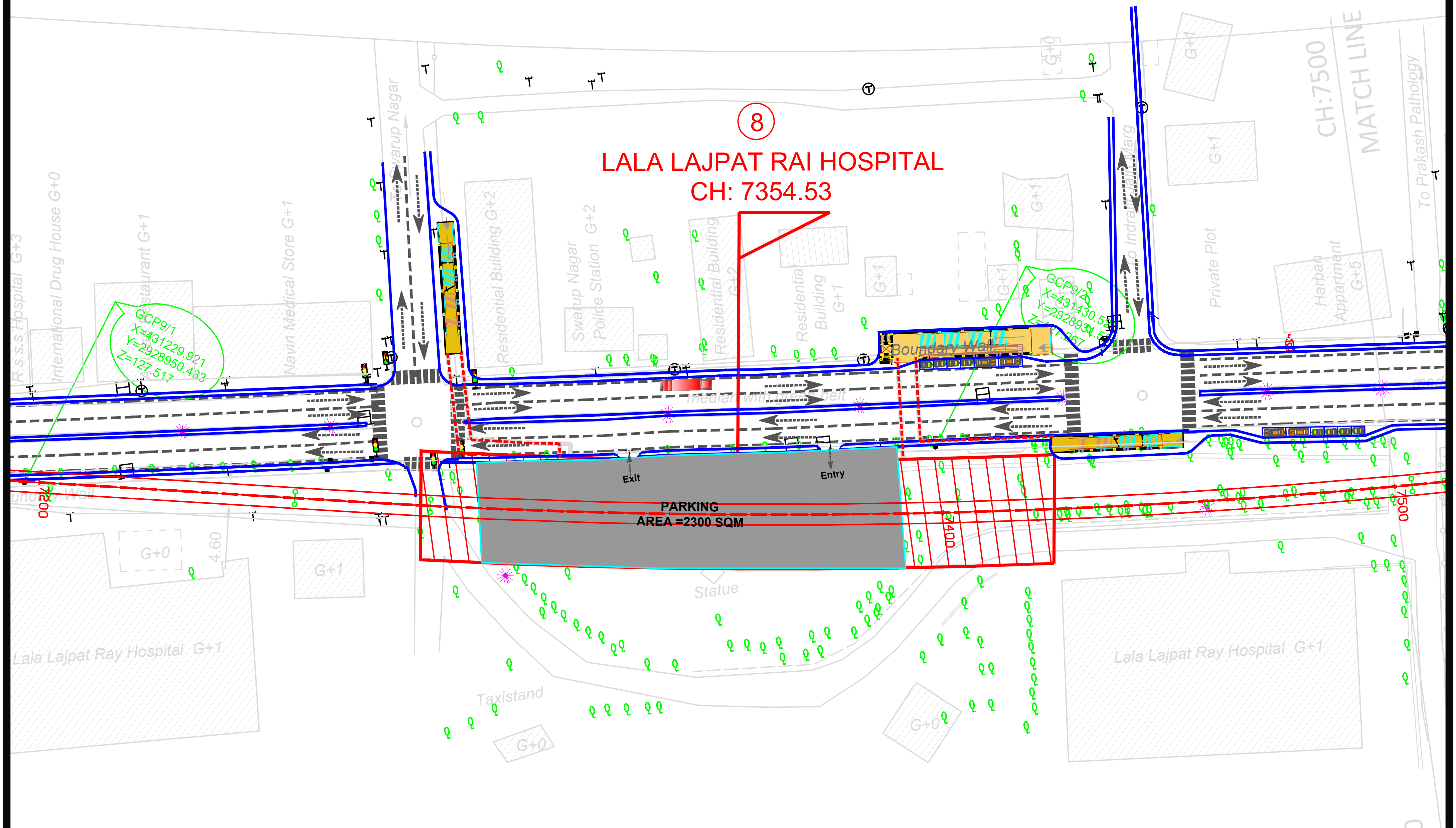


PROPOSED INTERMODAL INTEGRATION AND DISPERSAL PLAN OF RAWATPUR RAILWAY STATION

- P.D. cum Parking Area
- Proposed Parking Area
- Proposed Road Geometry
- Proposed Circulation
- Proposed Auto Pick/Drop Bay
- Proposed Bus Stop Bay Marking
- Proposed Taxi cum Pvt. Pick/Drop Bay
- **Proposed Entry/Exit**

N

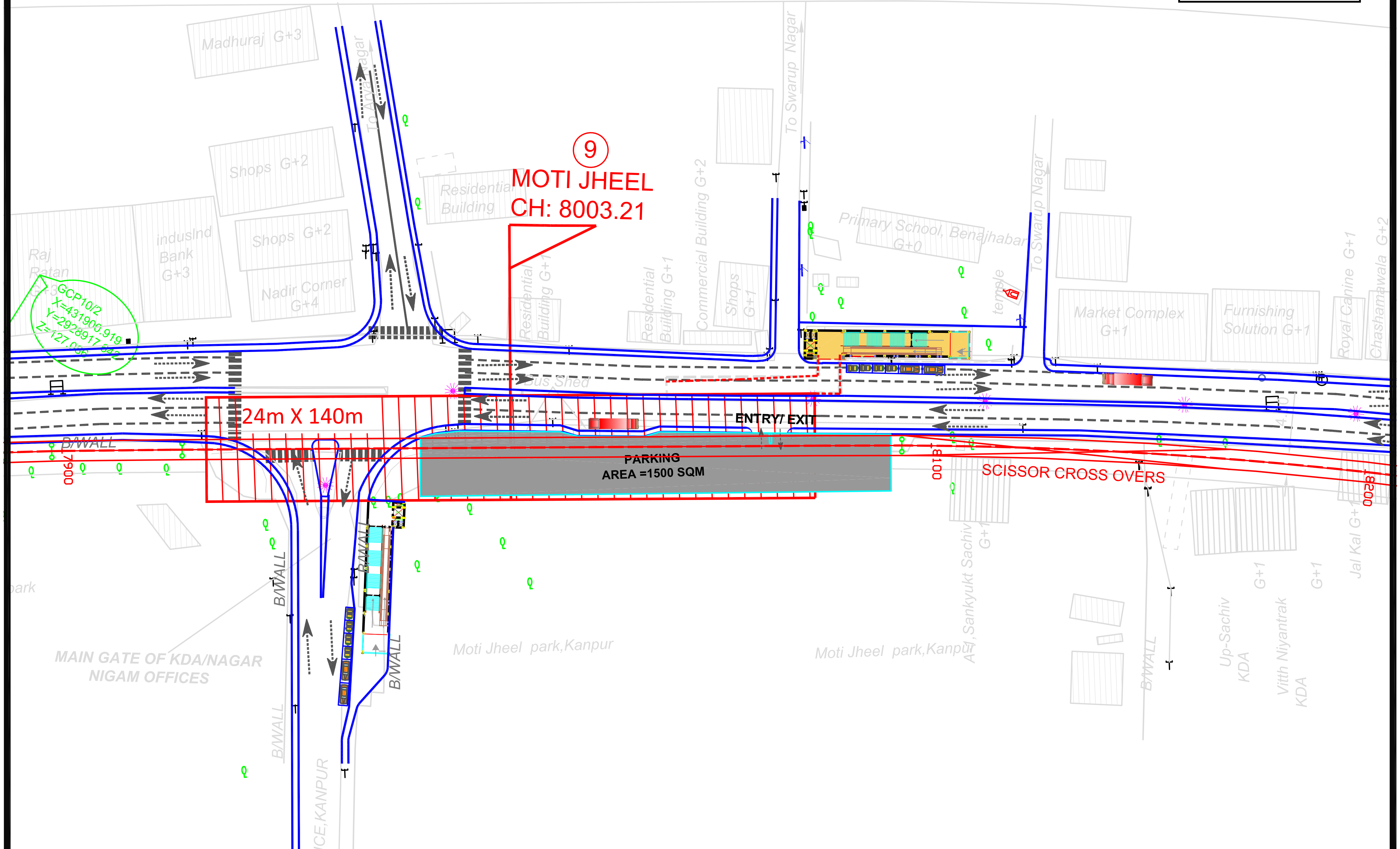
ANNEXURE 7.8



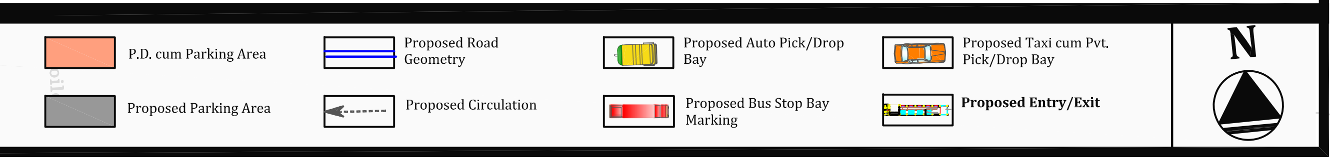
PROPOSED INTERMODAL INTEGRATION AND DISPERSAL PLAN OF LALA LAJPAT RAI HOSPITAL

P.D. cum Parking Area	Proposed Road Geometry	Proposed Auto Pick/Drop Bay	Proposed Taxi cum Pvt. Pick/Drop Bay	N
Proposed Parking Area	Proposed Circulation	Proposed Bus Stop Bay Marking	**Proposed Entry/Exit**	

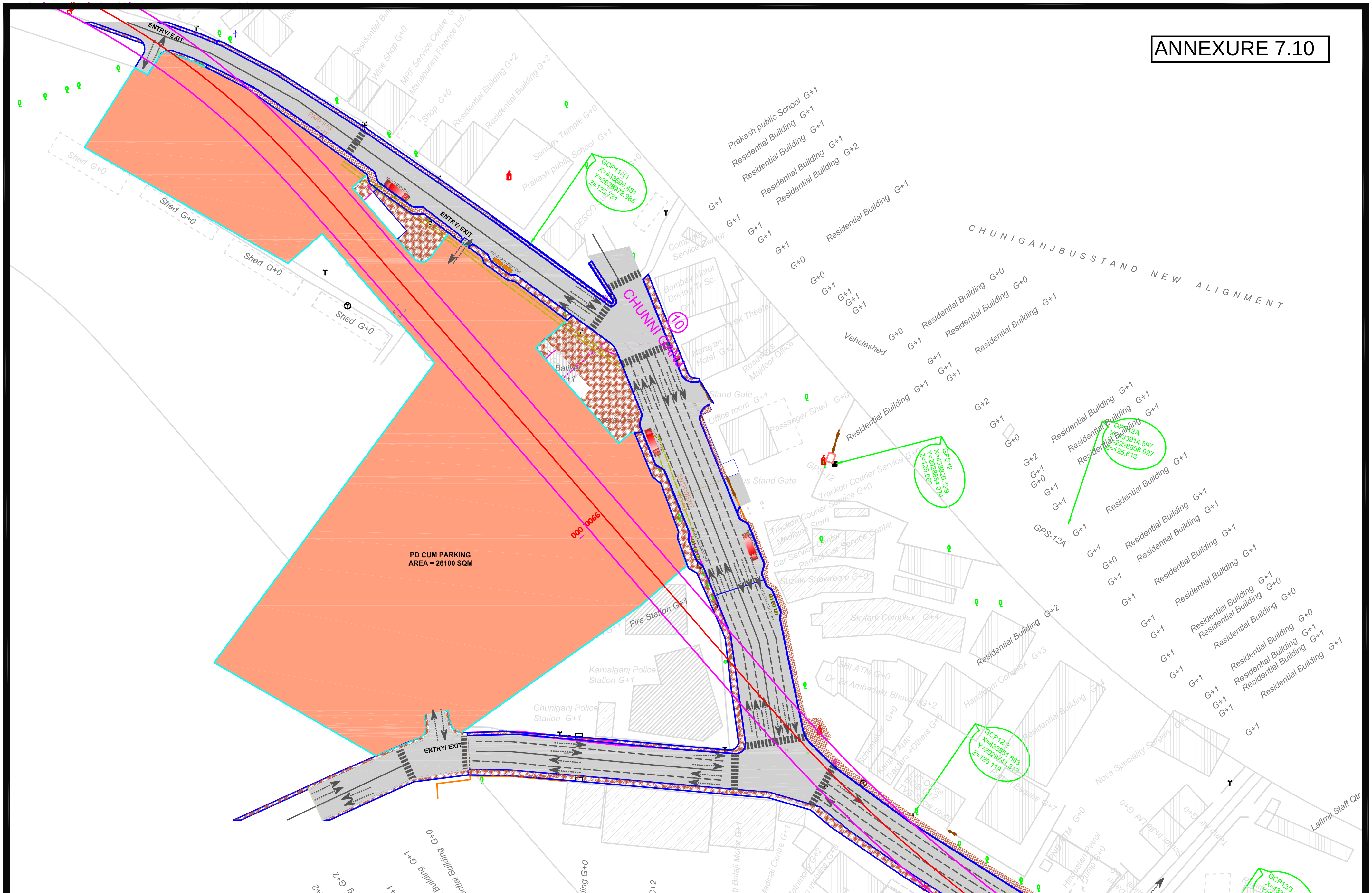
ANNEXURE 7.9



PROPOSED INTERMODAL INTEGRATION AND DISPERSAL PLAN OF MOTI JHEEL



ANNEXURE 7.10



PROPOSED INTERMODAL INTEGRATION AND DISPERSAL PLAN OF CHUNNIGANJ

P.D. cum Parking Area

Proposed Parking Area

Proposed Road Geometry

Proposed Circulation

Proposed Auto Pick/Drop Bay

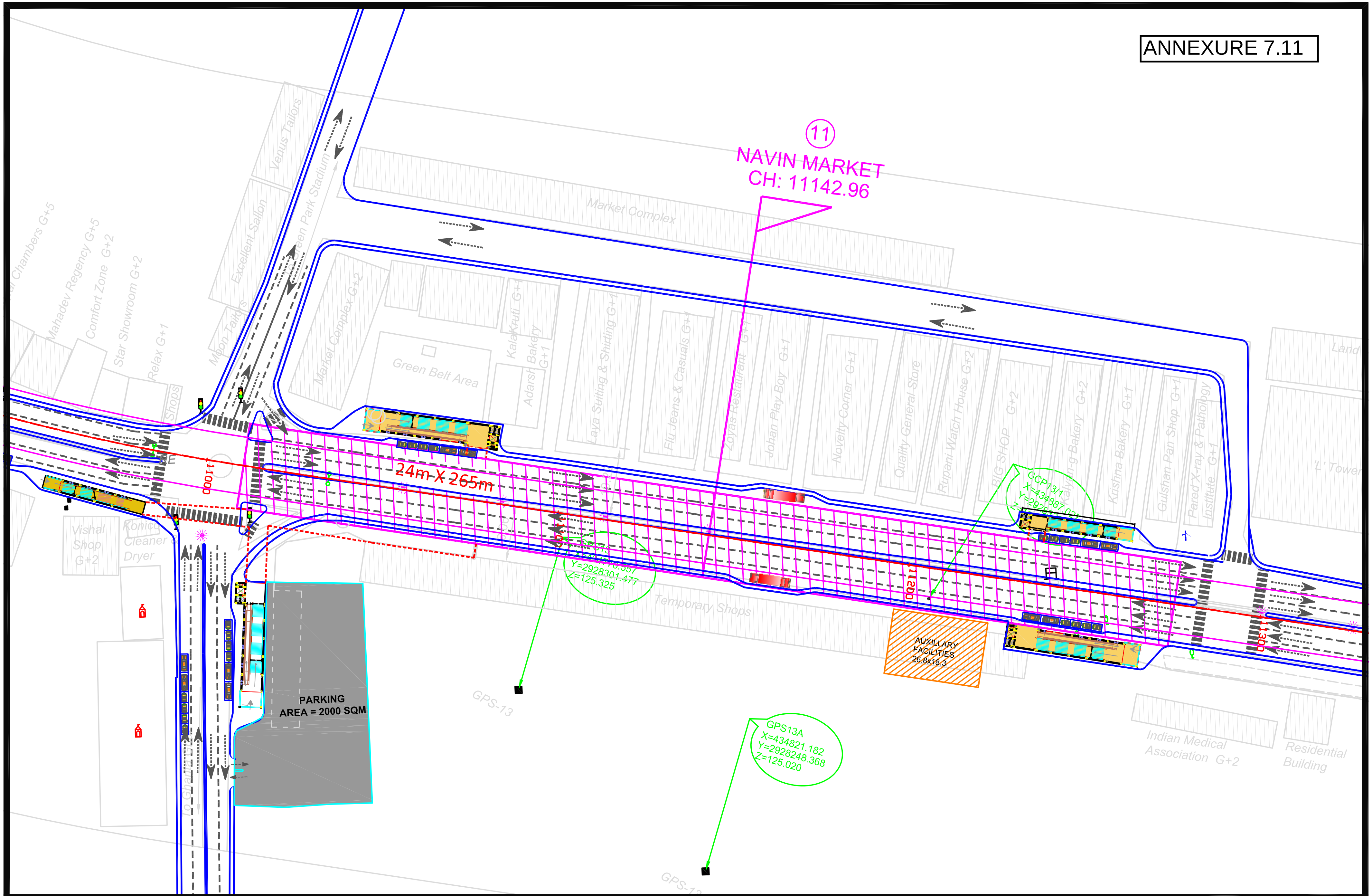
Proposed Bus Stop Bay Marking

Proposed Taxi cum Pvt. Pick/Drop Bay

Proposed Entry/Exit

N

ANNEXURE 7.11



PROPOSED INTERMODAL INTEGRATION AND DISPERSAL PLAN OF NAVIN MARKET

P.D. cum Parking Area

Proposed Parking Area

Proposed Road Geometry

Proposed Circulation

Proposed Auto Pick/Drop Bay

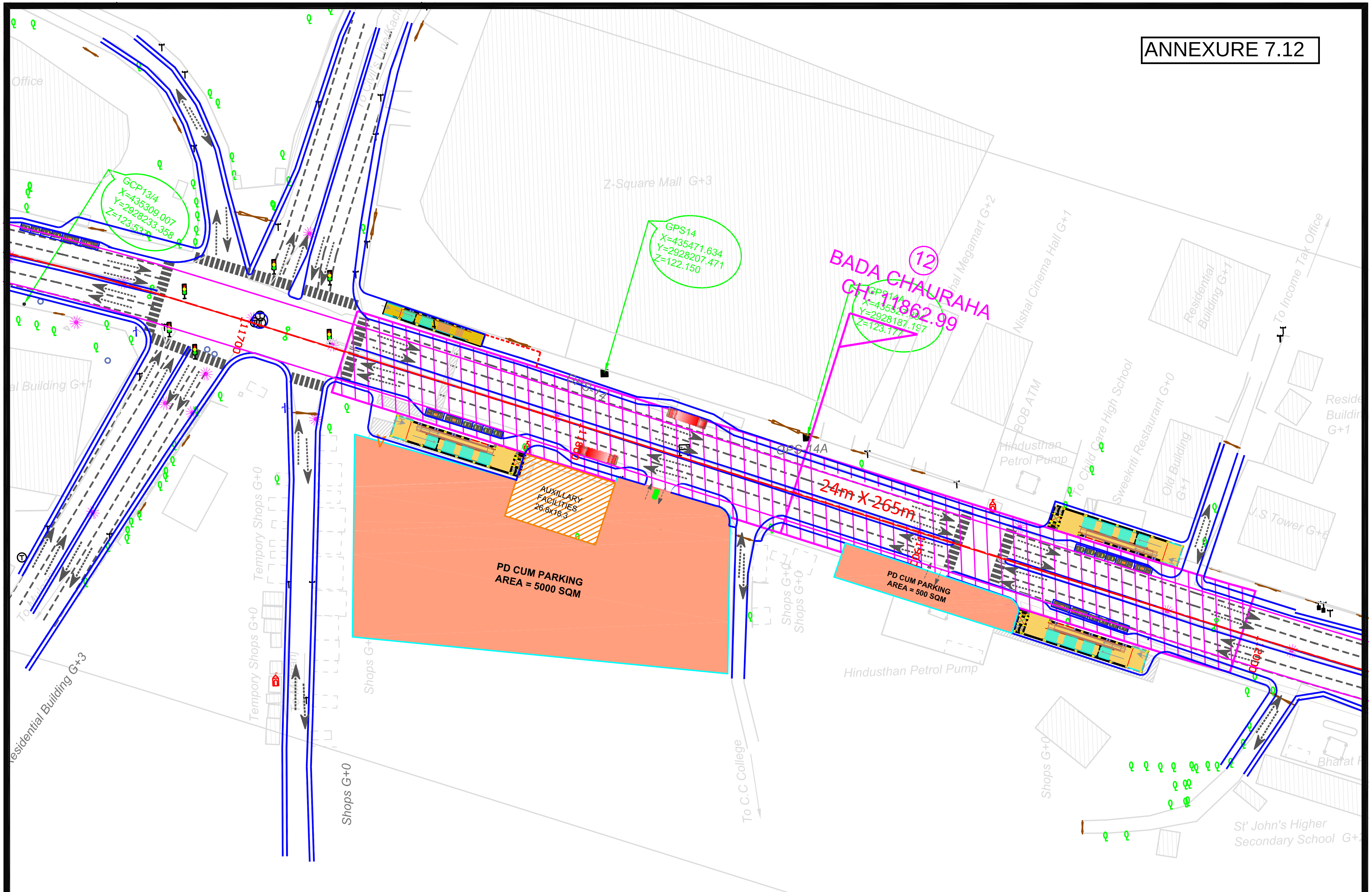
Proposed Bus Stop Bay Marking

Proposed Taxi cum Pvt. Pick/Drop Bay

Proposed Entry/Exit

N

ANNEXURE 7.12

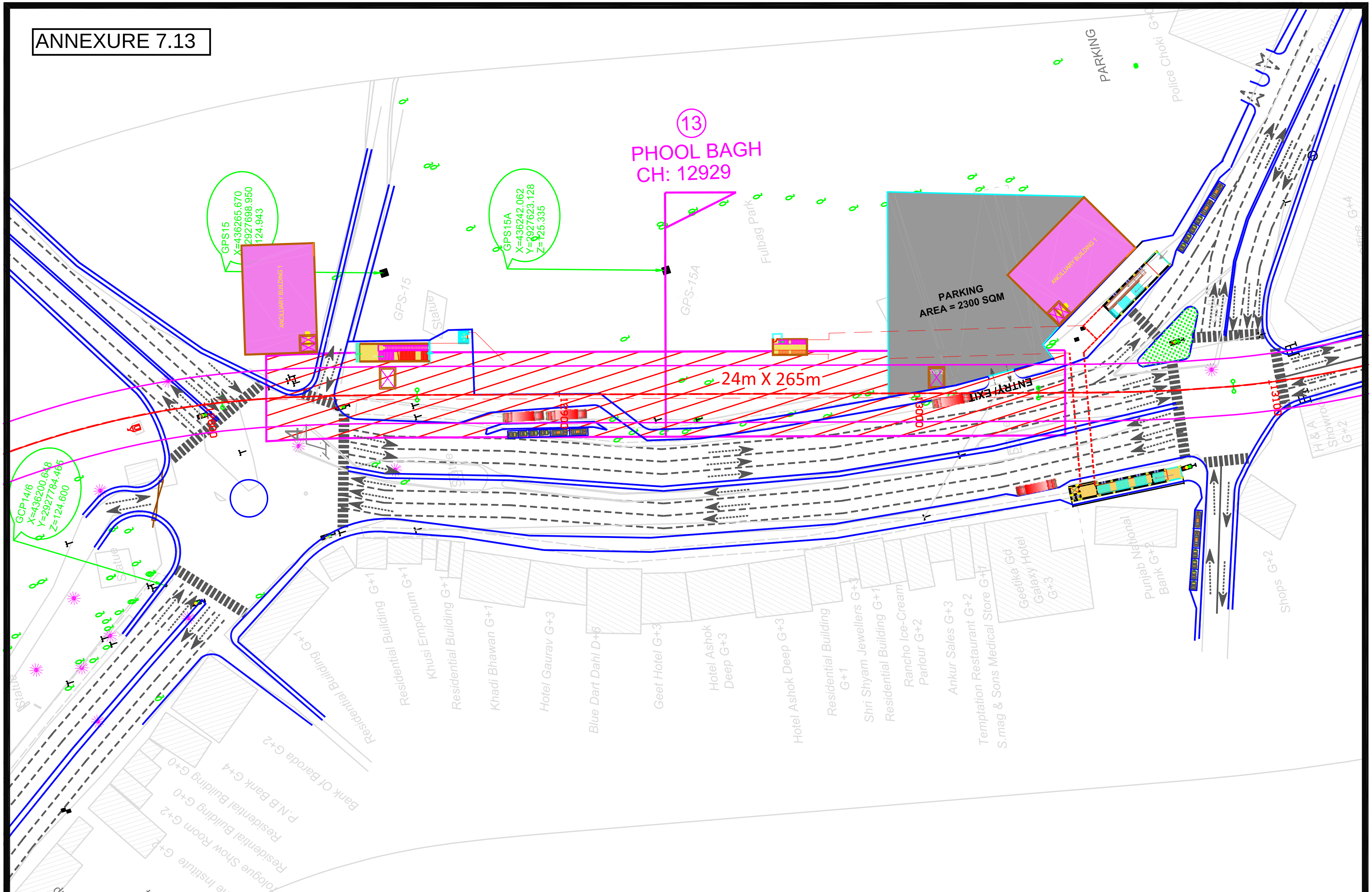


PROPOSED INTERMODAL INTEGRATION AND DISPERSAL PLAN OF BADA CHAURAHA

P.D. cum Parking Area	Proposed Parking Area
Proposed Road Geometry	Proposed Circulation
Proposed Auto Pick/Drop Bay	Proposed Bus Stop Bay Marking
Proposed Taxi cum Pvt. Pick/Drop Bay	**Proposed Entry/Exit**

N

ANNEXURE 7.13



PROPOSED INTERMODAL INTEGRATION AND DISPERSAL PLAN OF PHOOL BAGH

P.D. cum Parking Area

Proposed Parking Area

Proposed Road Geometry

Proposed Circulation

Proposed Auto Pick/Drop Bay

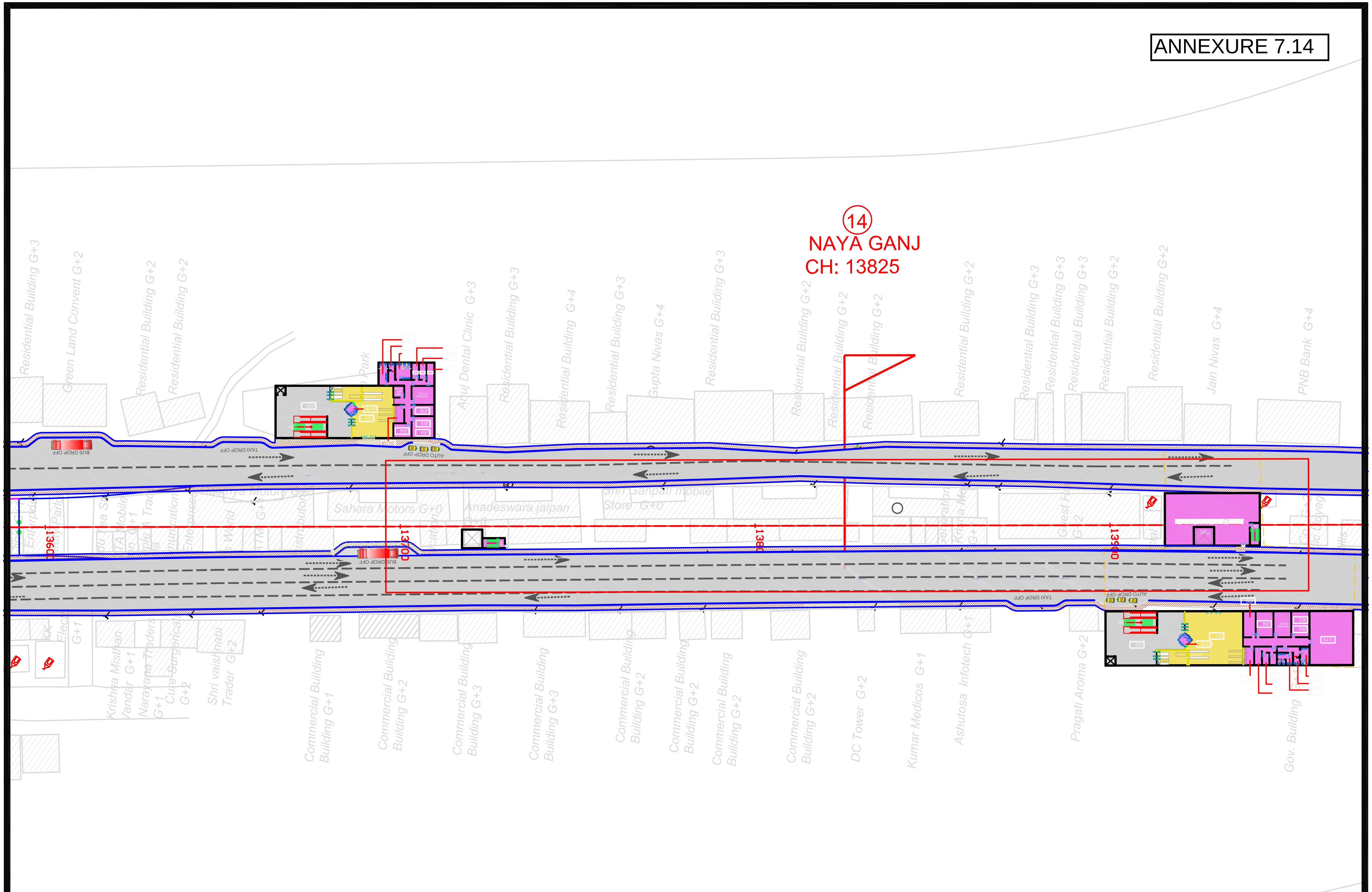
Proposed Bus Stop Bay Marking

Proposed Taxi cum Pvt. Pick/Drop Bay

Proposed Entry/Exit

N

ANNEXURE 7.14



PROPOSED INTERMODAL INTEGRATION AND DISPERSAL PLAN OF NAYAGANJ

P.D. cum Parking Area

Proposed Parking Area

Proposed Road Geometry

Proposed Circulation

Proposed Auto Pick/Drop Bay

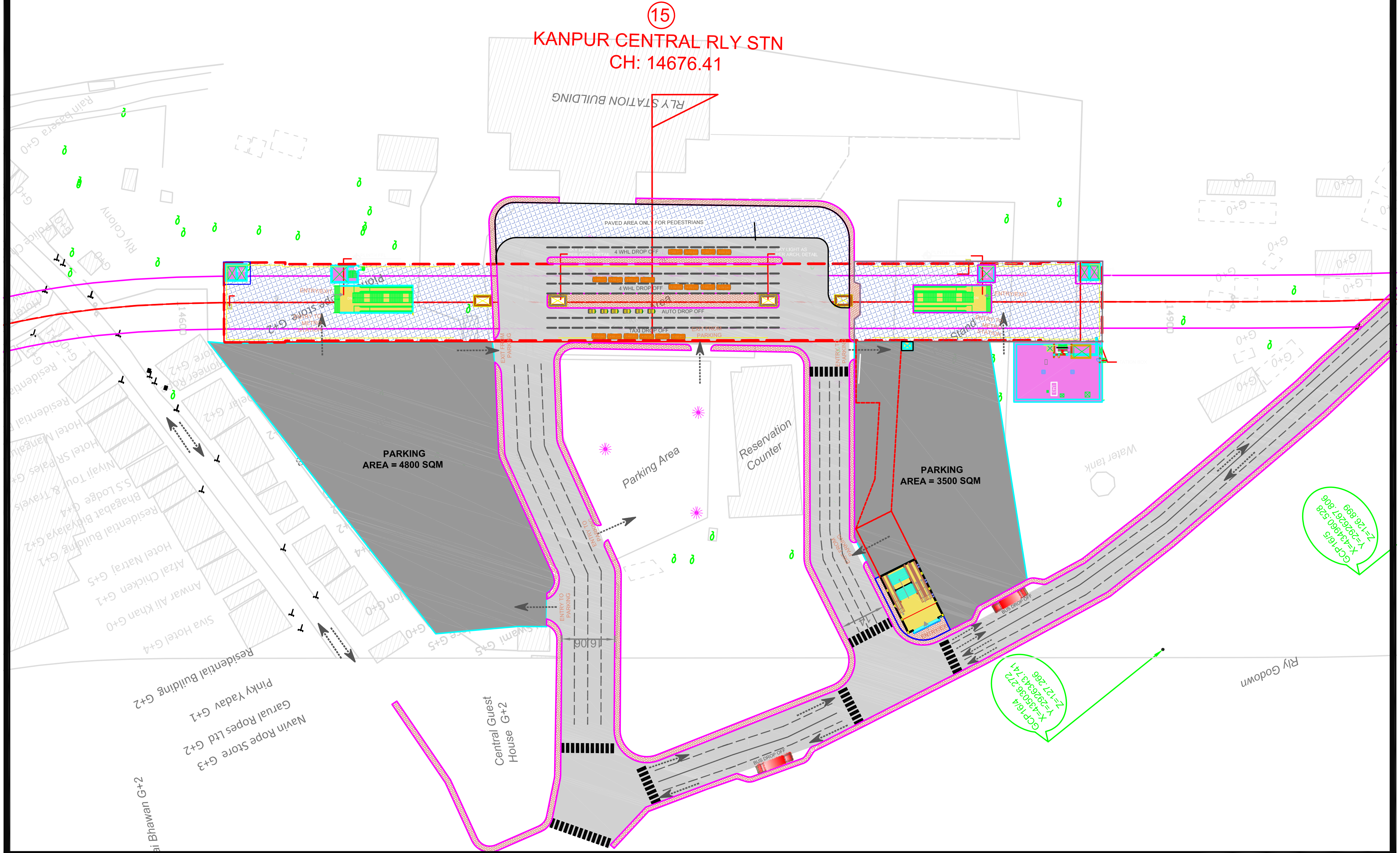
Proposed Bus Stop Bay Marking

Proposed Taxi cum Pvt. Pick/Drop Bay

Proposed Entry/Exit

N

ANNEXURE 7.15

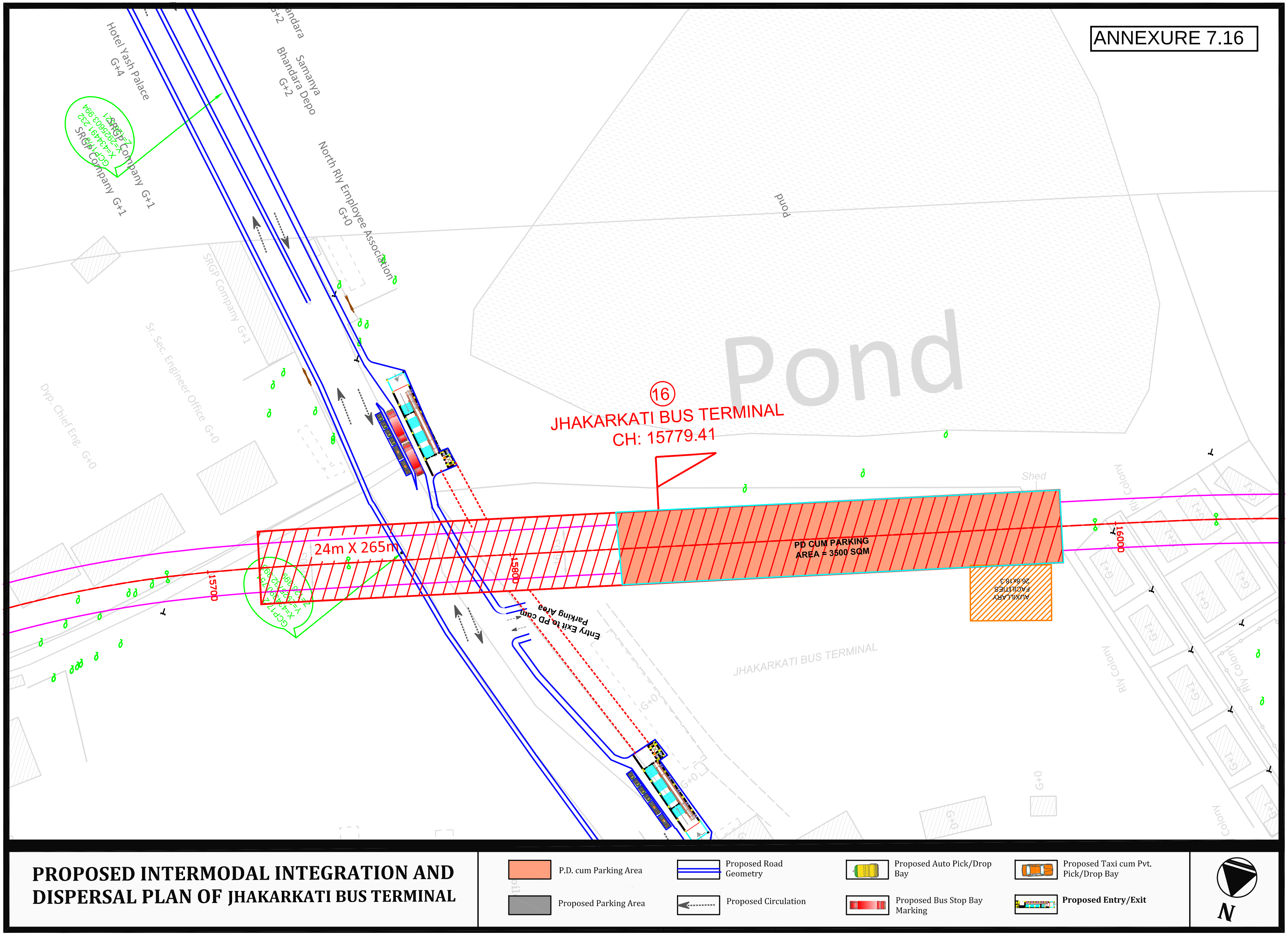


PROPOSED INTERMODAL INTEGRATION AND DISPERSAL PLAN OF KANPUR CENTRAL RLY STN

P.D. cum Parking Area	Proposed Parking Area
Proposed Road Geometry	Proposed Circulation
Proposed Auto Pick/Drop Bay	Proposed Bus Stop Bay Marking
Proposed Taxi cum Pvt. Pick/Drop Bay	**Proposed Entry/Exit**

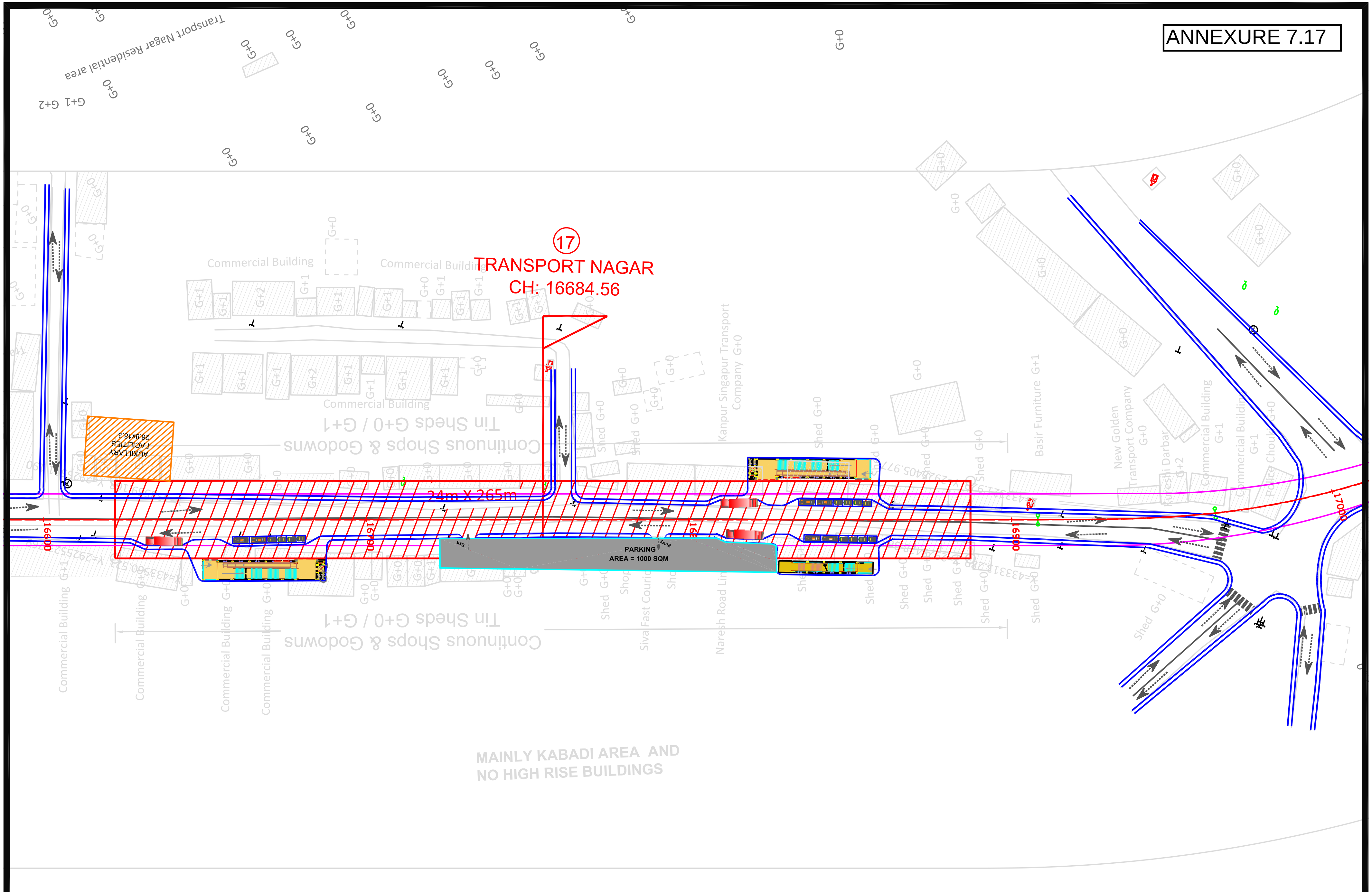
N

ANNEXURE 7.16



PROPOSED INTERMODAL INTEGRATION AND DISPERSAL PLAN OF JHAKARKATI BUS TERMINAL

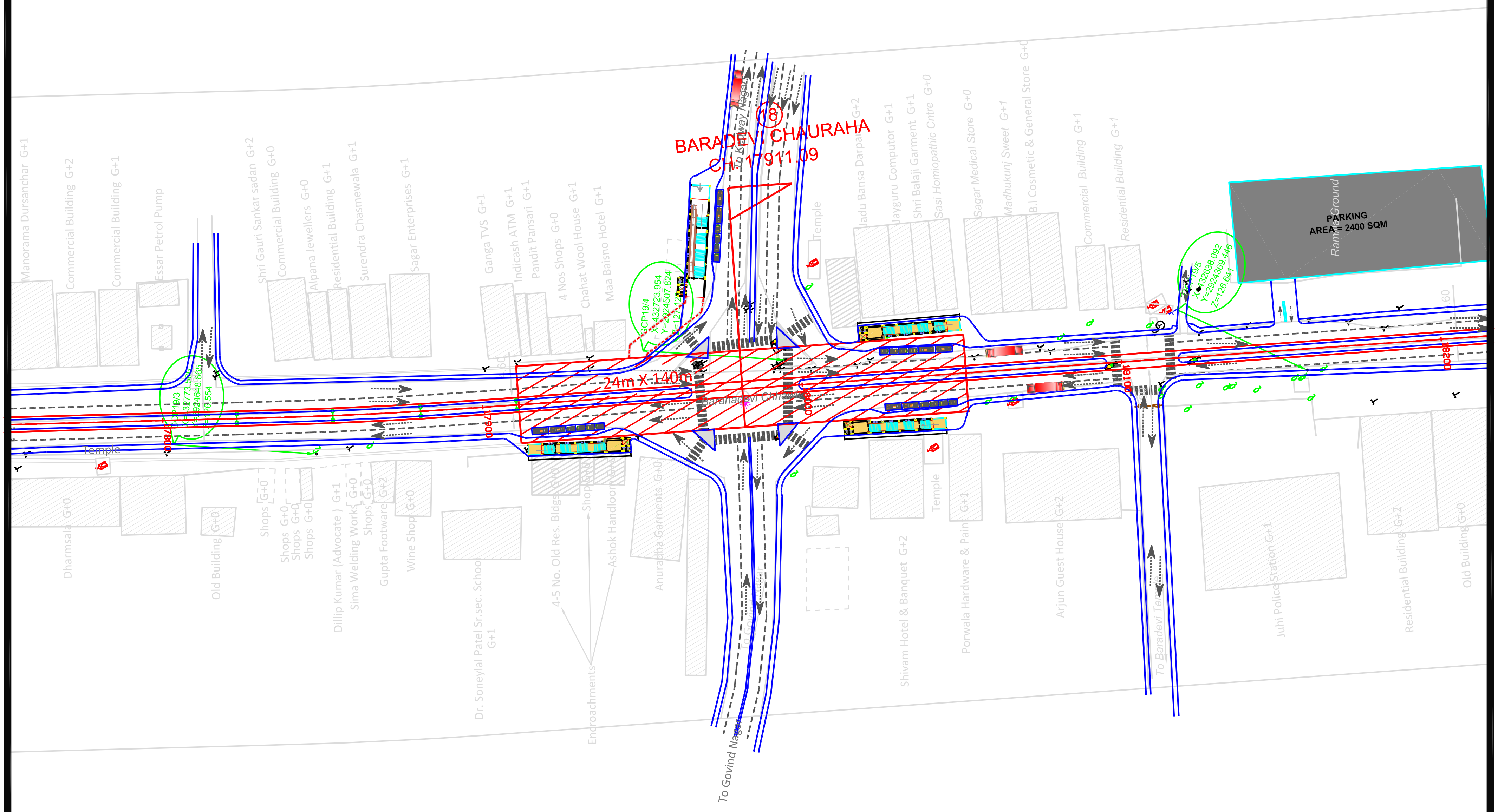
ANNEXURE 7.17



PROPOSED INTERMODAL INTEGRATION AND DISPERSAL PLAN OF TRANSPORT NAGAR

P.D. cum Parking Area	Proposed Road Geometry	Proposed Auto Pick/Drop Bay	Proposed Taxi cum Pvt. Pick/Drop Bay	N
Proposed Parking Area	Proposed Circulation	Proposed Bus Stop Bay Marking	Proposed Entry/Exit	

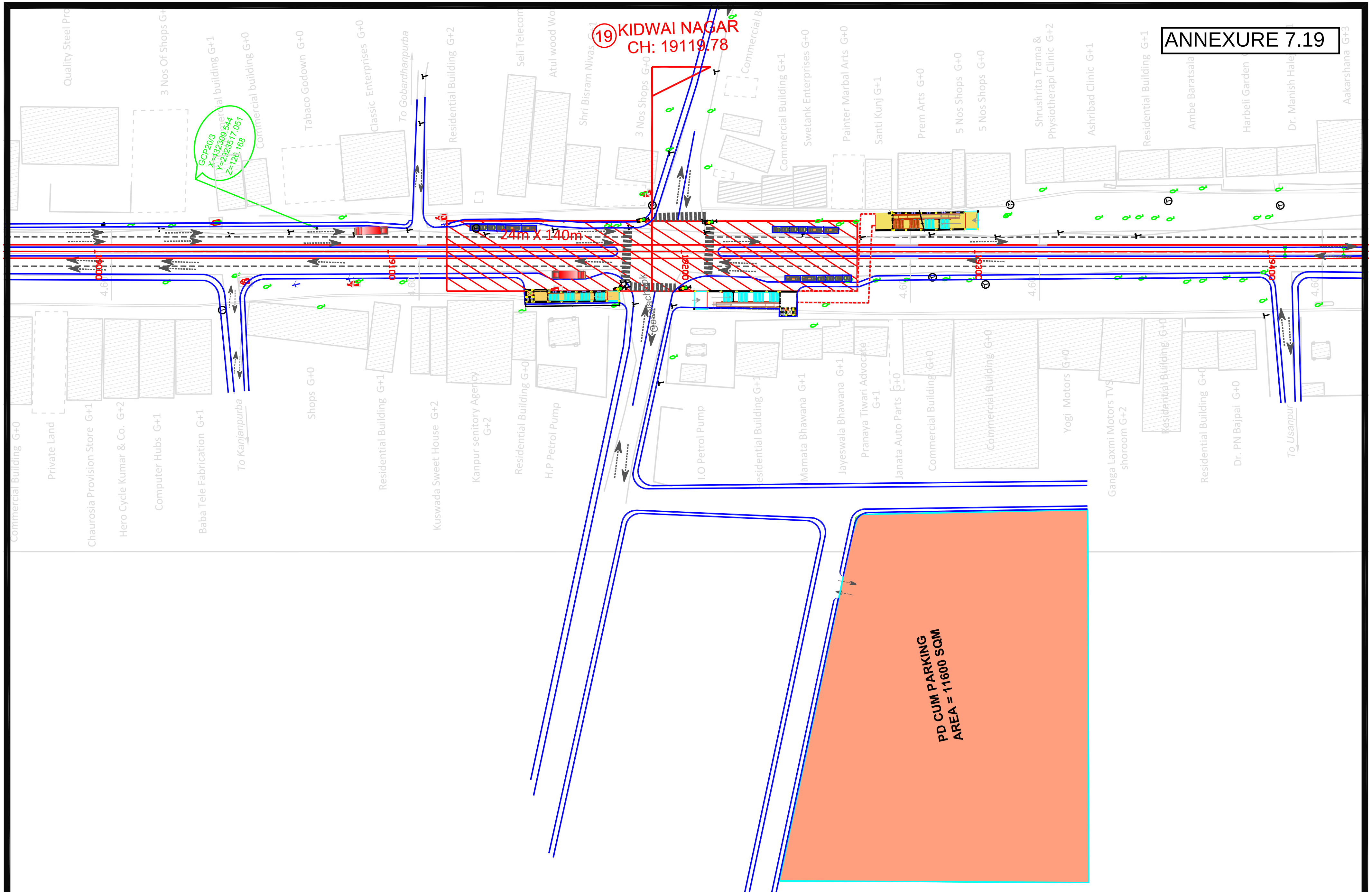
ANNEXURE 7.18



PROPOSED INTERMODAL INTEGRATION AND DISPERSAL PLAN OF BARADEVI CHAURAHA

P.D. cum Parking Area	Proposed Parking Area
Proposed Road Geometry	Proposed Circulation
Proposed Auto Pick/Drop Bay	Proposed Bus Stop Bay Marking
Proposed Taxi cum Pvt. Pick/Drop Bay	**Proposed Entry/Exit**

ANNEXURE 7.19

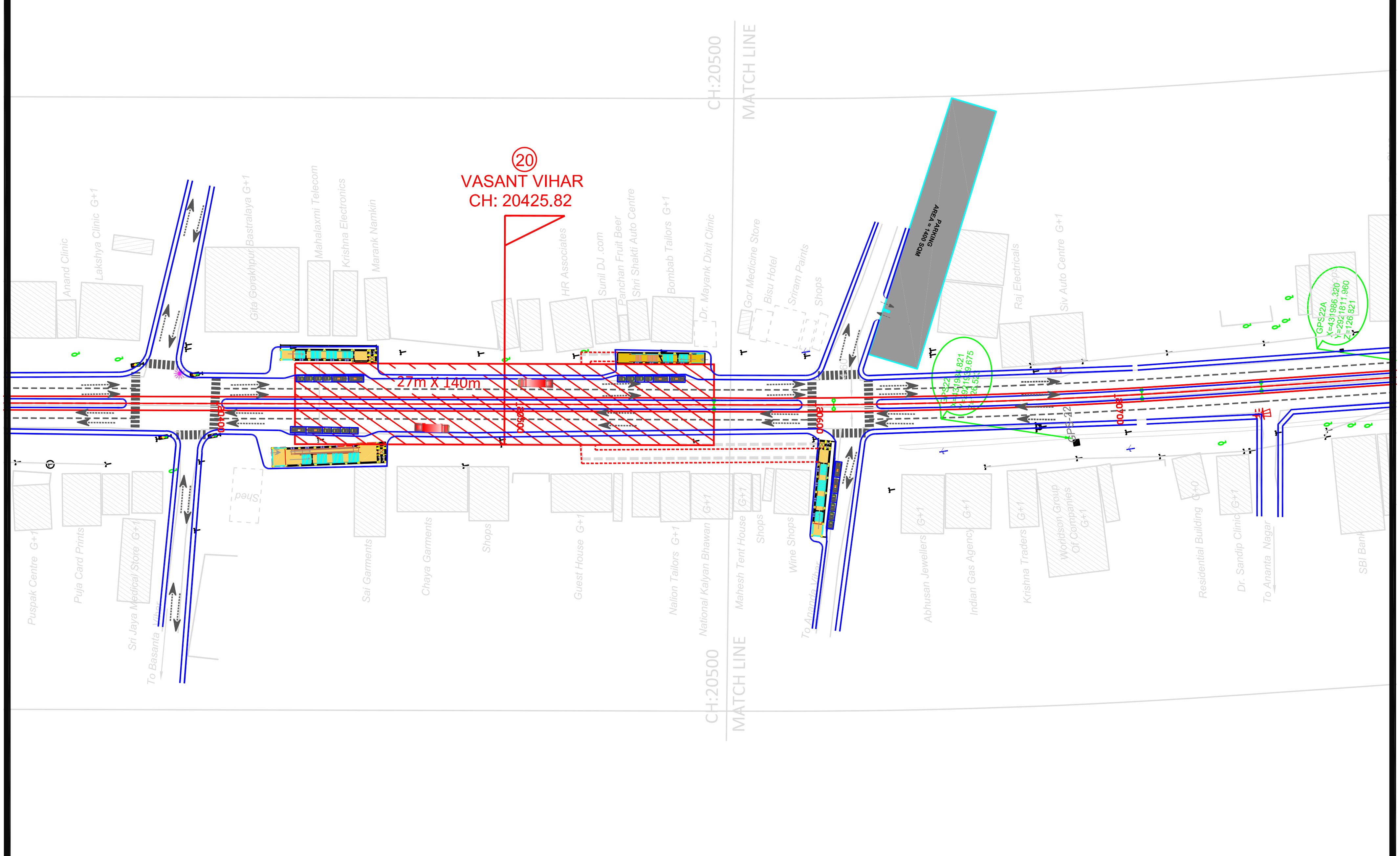


PROPOSED INTERMODAL INTEGRATION AND DISPERSAL PLAN OF KIDWAI NAGAR

P.D. cum Parking Area	Proposed Road Geometry	Proposed Auto Pick/Drop Bay	Proposed Taxi cum Pvt. Pick/Drop Bay	
Proposed Parking Area	Proposed Circulation	Proposed Bus Stop Bay Marking	**Proposed Entry/Exit**	

N

ANNEXURE 7.20

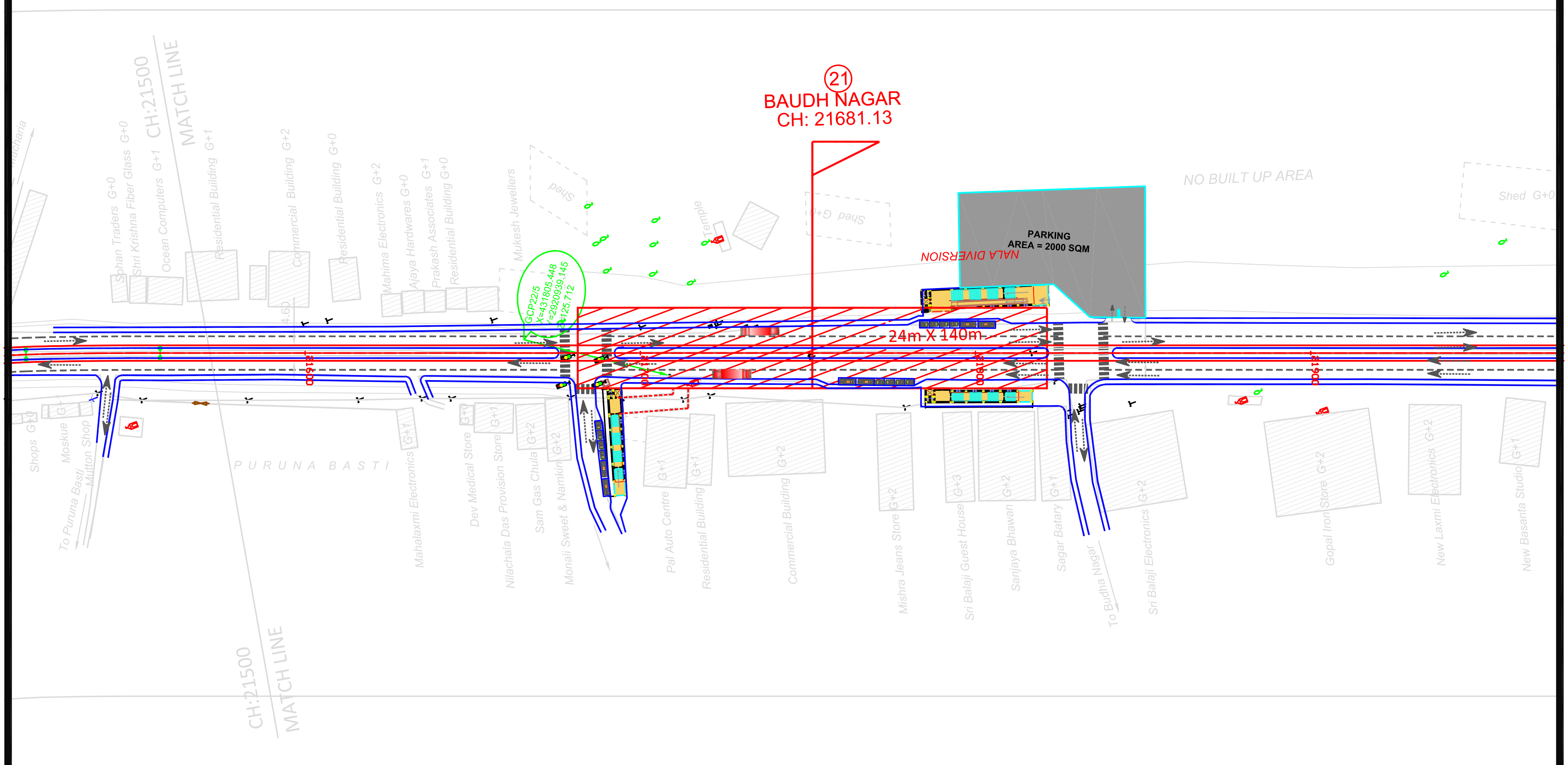


PROPOSED INTERMODAL INTEGRATION AND DISPERSAL PLAN OF VASANT VIHAR

P.D. cum Parking Area	Proposed Parking Area
Proposed Road Geometry	Proposed Circulation
Proposed Auto Pick/Drop Bay	Proposed Bus Stop Bay Marking
Proposed Taxi cum Pvt. Pick/Drop Bay	**Proposed Entry/Exit**

N

ANNEXURE 7.21

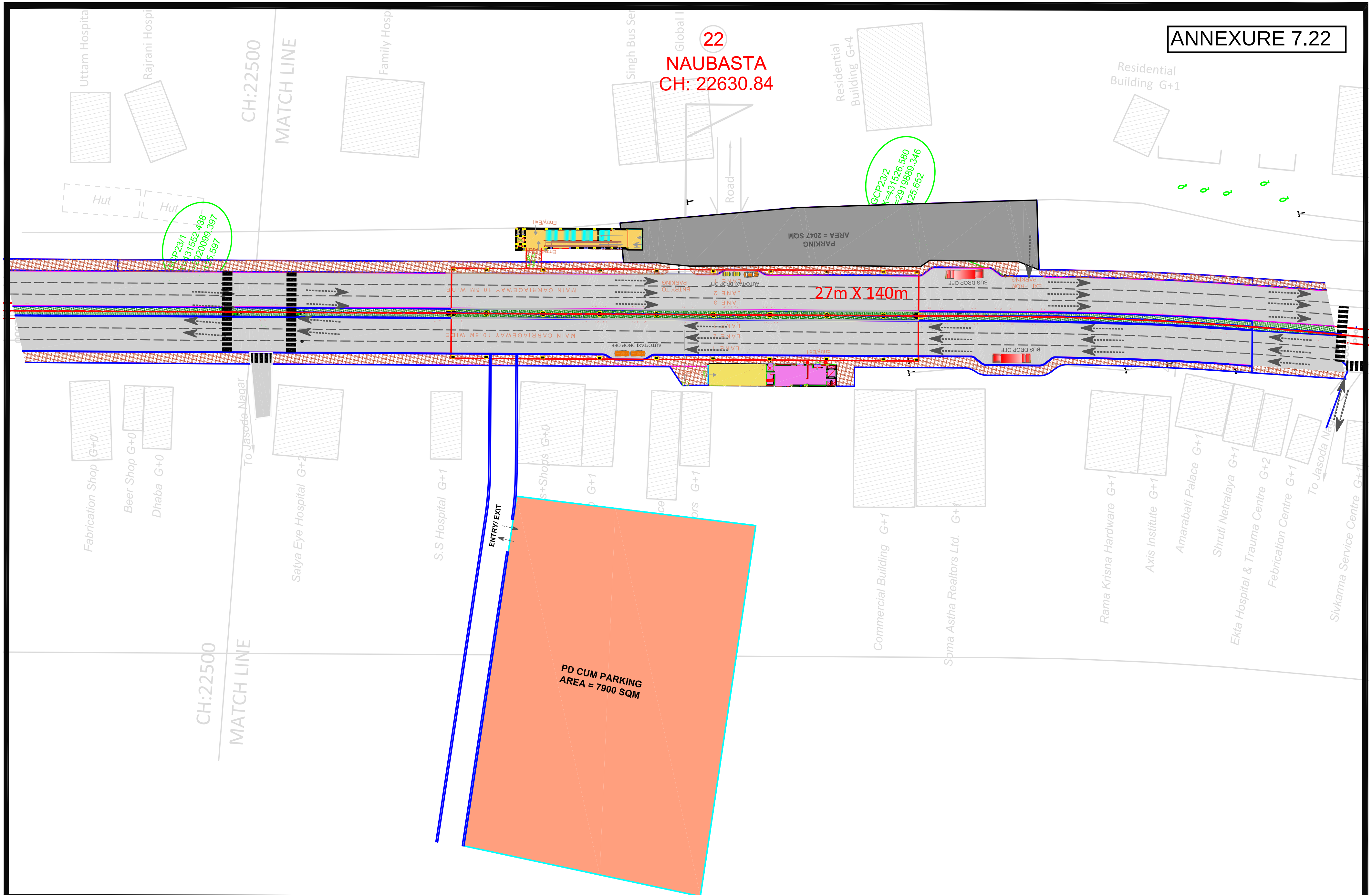


PROPOSED INTERMODAL INTEGRATION AND DISPERSAL PLAN OF BAUDH NAGAR

P.D. cum Parking Area	Proposed Parking Area
Proposed Road Geometry	Proposed Circulation
Proposed Auto Pick/Drop Bay	Proposed Bus Stop Bay Marking
Proposed Taxi cum Pvt. Pick/Drop Bay	**Proposed Entry/Exit**

N

ANNEXURE 7.22

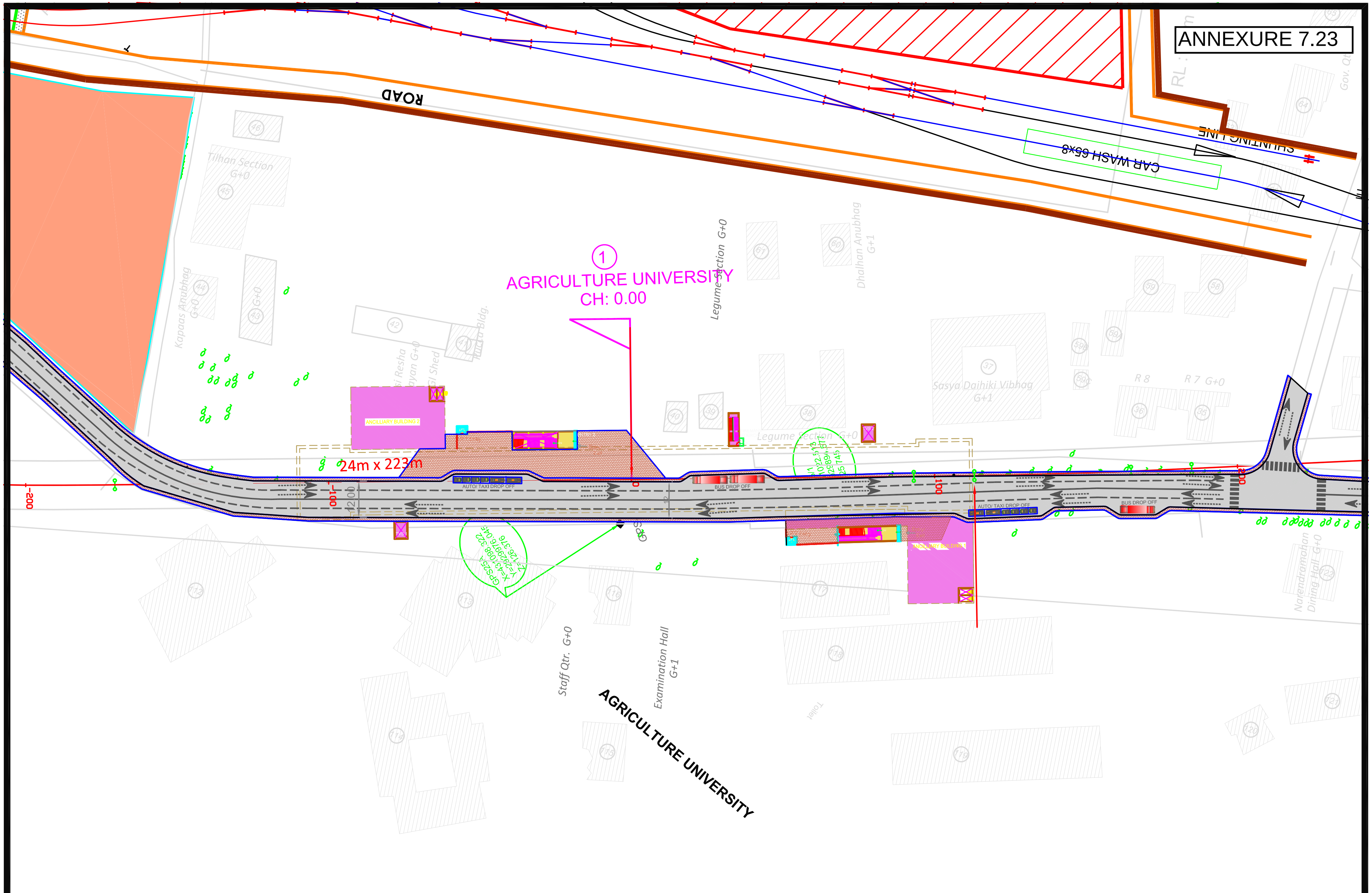


PROPOSED INTERMODAL INTEGRATION AND DISPERSAL PLAN OF NAUBASTA

- P.D. cum Parking Area
- Proposed Parking Area
- Proposed Road Geometry
- Proposed Circulation
- Proposed Auto Pick/Drop Bay
- Proposed Bus Stop Bay Marking
- Proposed Taxi cum Pvt. Pick/Drop Bay
- **Proposed Entry/Exit**

N

ANNEXURE 7.23

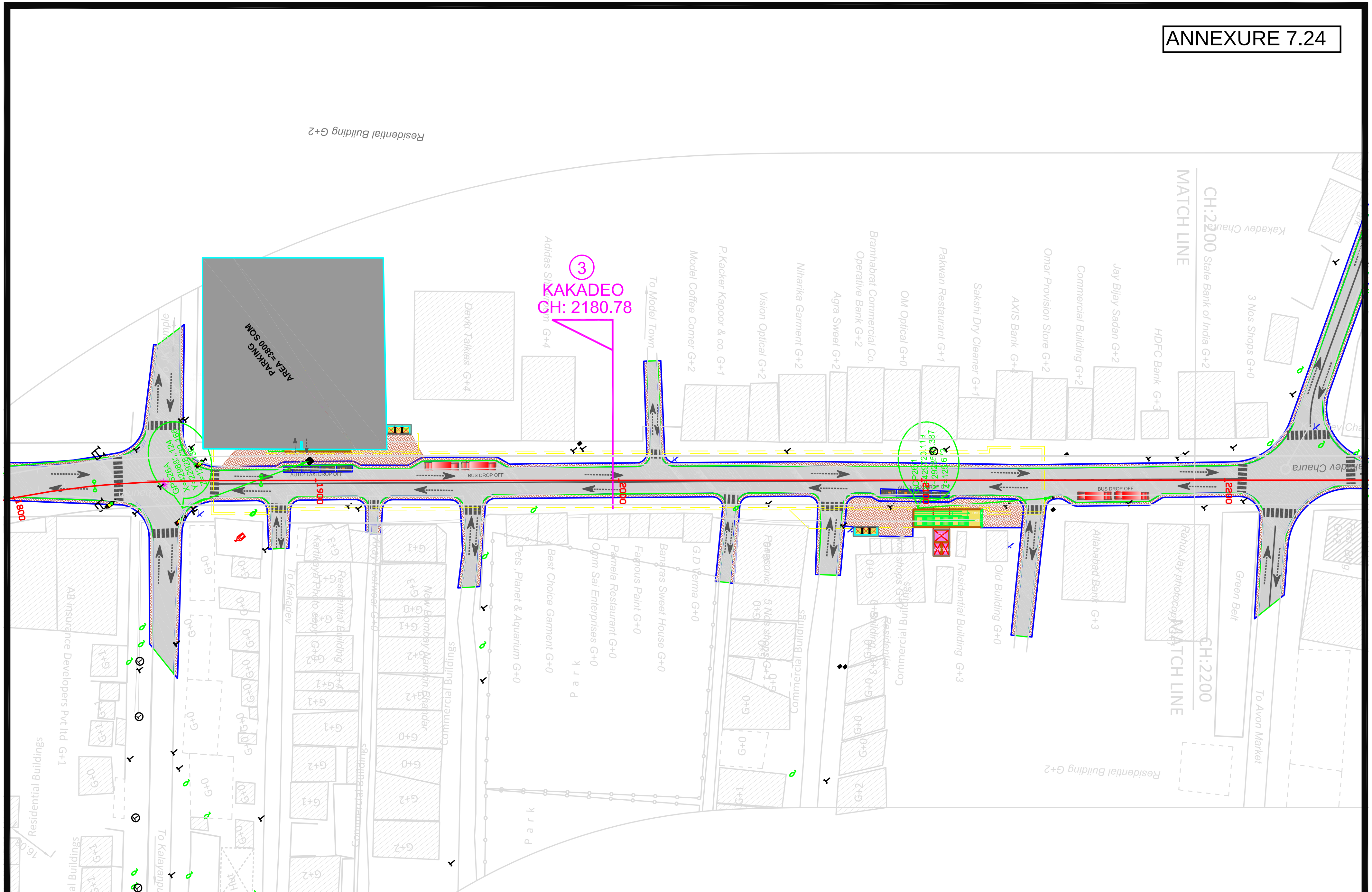


PROPOSED INTERMODAL INTEGRATION AND DISPERSAL PLAN OF AGRICULTURE UNIVERSITY

P.D. cum Parking Area	Proposed Parking Area
Proposed Road Geometry	Proposed Circulation
Proposed Auto Pick/Drop Bay	Proposed Bus Stop Bay Marking
Proposed Taxi cum Pvt. Pick/Drop Bay	**Proposed Entry/Exit**

N

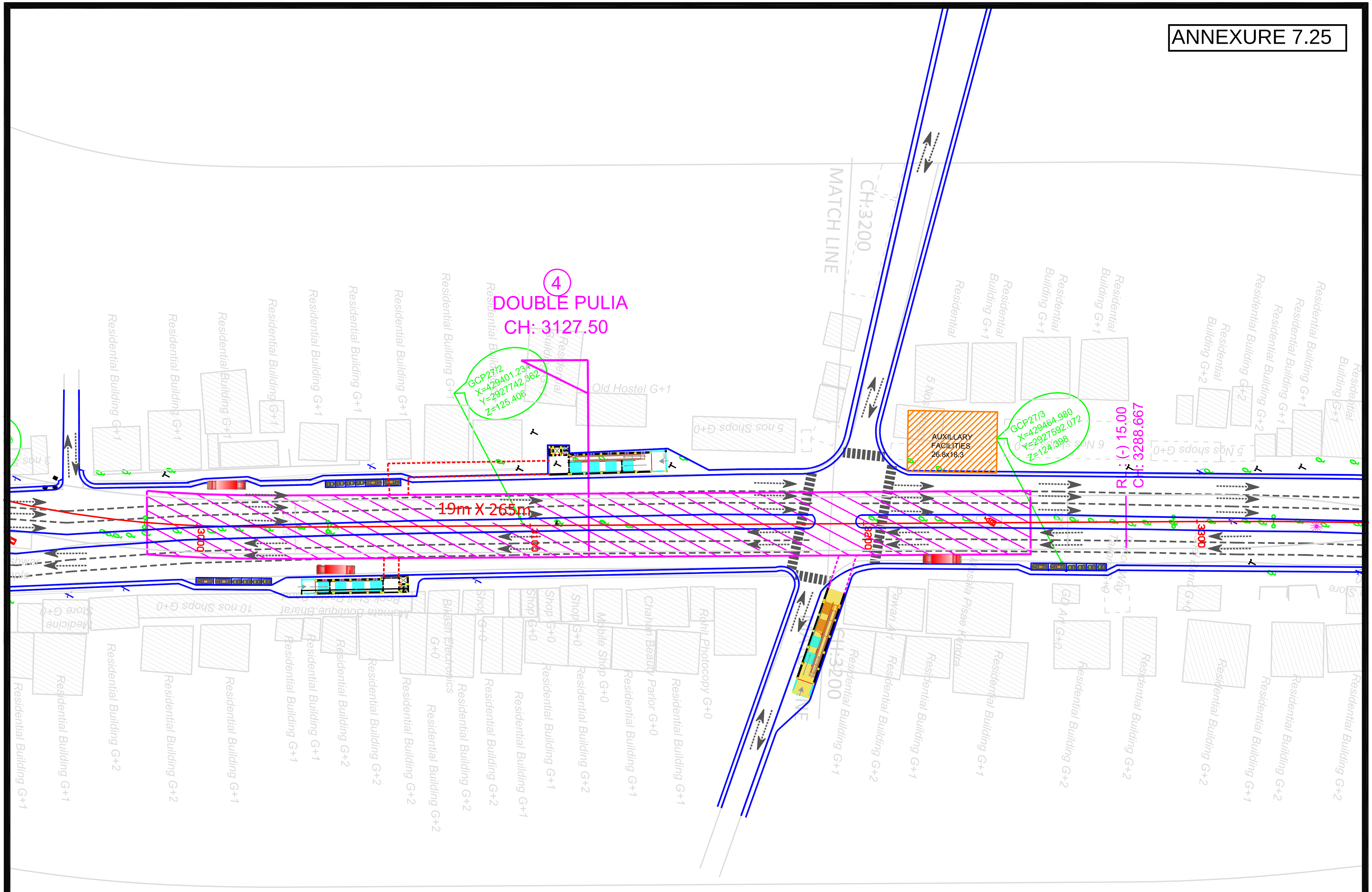
ANNEXURE 7.24



PROPOSED INTERMODAL INTEGRATION AND DISPERSAL PLAN OF KAKADEO

P.D. cum Parking Area	Proposed Road Geometry	Proposed Auto Pick/Drop Bay	Proposed Taxi cum Pvt. Pick/Drop Bay	N
Proposed Parking Area	Proposed Circulation	Proposed Bus Stop Bay Marking	**Proposed Entry/Exit**	

ANNEXURE 7.25

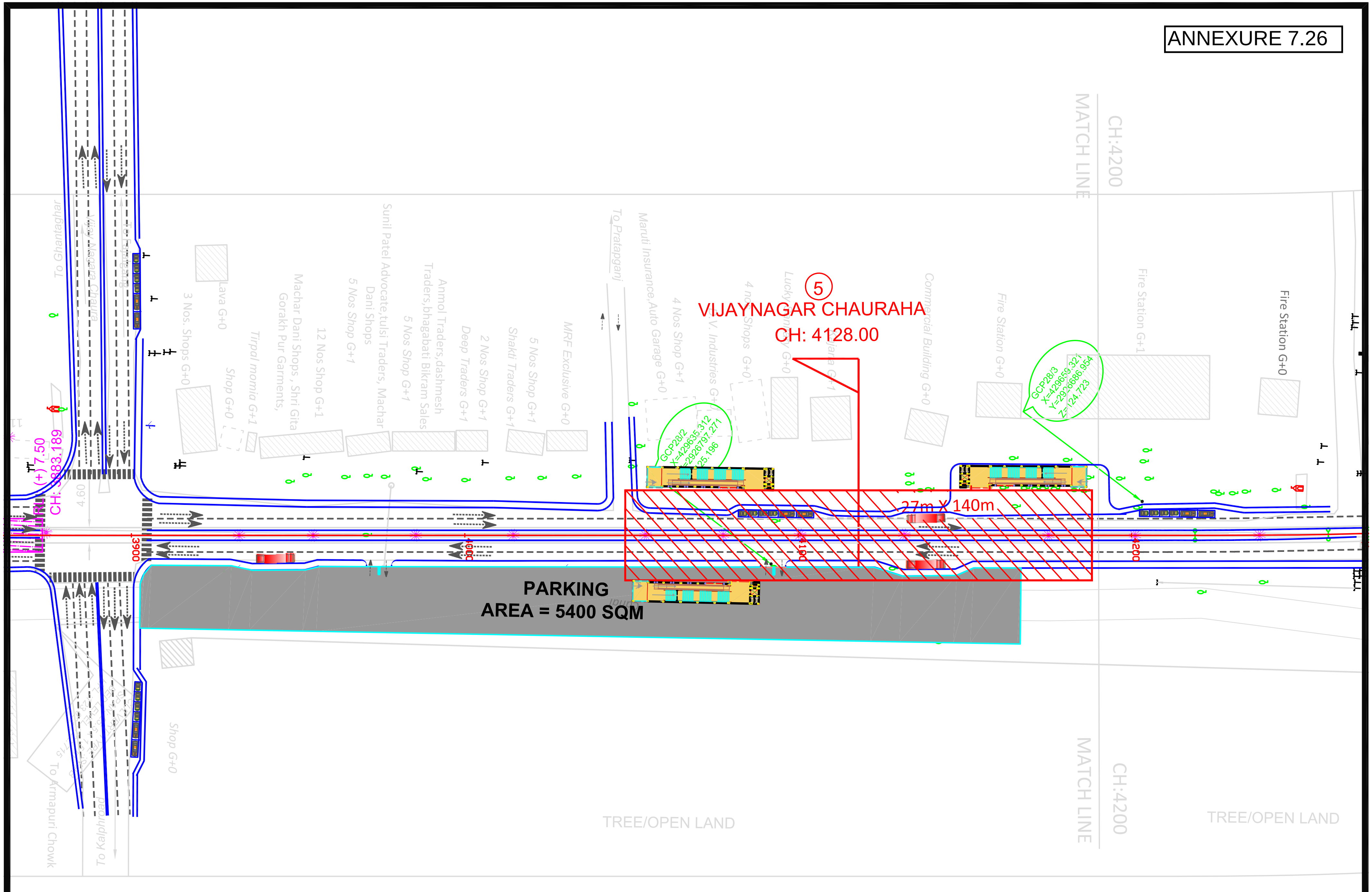


PROPOSED INTERMODAL INTEGRATION AND DISPERSAL PLAN OF DOUBLE PULIA

P.D. cum Parking Area	Proposed Parking Area
Proposed Road Geometry	Proposed Circulation
Proposed Auto Pick/Drop Bay	Proposed Bus Stop Bay Marking
Proposed Taxi cum Pvt. Pick/Drop Bay	**Proposed Entry/Exit**

N

ANNEXURE 7.26

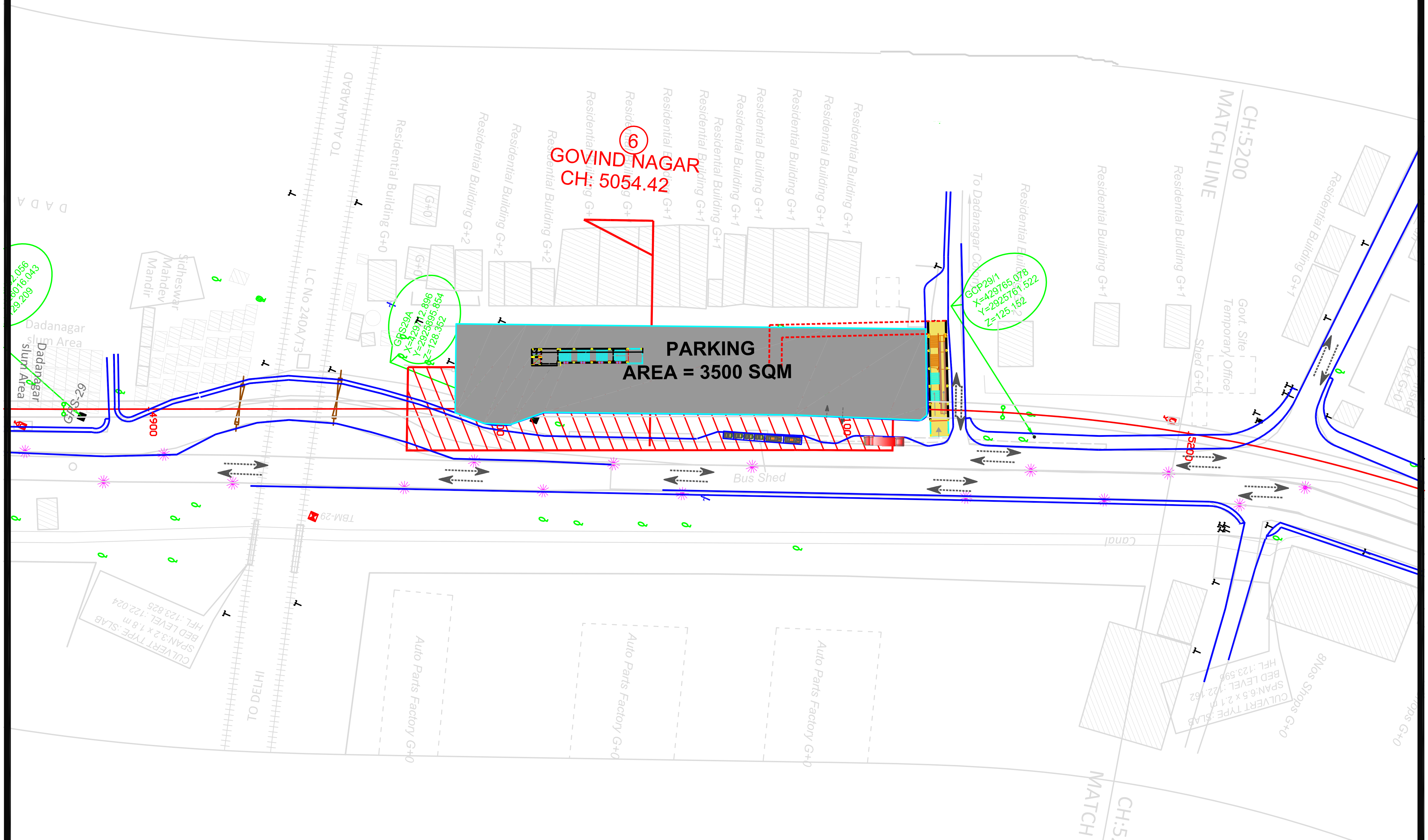


PROPOSED INTERMODAL INTEGRATION AND DISPERSAL PLAN OF VIJAYNAGAR CHAURAHA

P.D. cum Parking Area	Proposed Road Geometry	Proposed Auto Pick/Drop Bay	Proposed Taxi cum Pvt. Pick/Drop Bay
Proposed Parking Area	Proposed Circulation	Proposed Bus Stop Bay Marking	**Proposed Entry/Exit**

N

ANNEXURE 7.27



PROPOSED INTERMODAL INTEGRATION AND DISPERSAL PLAN OF GOVIND NAGAR

P.D. cum Parking Area

Proposed Parking Area

Proposed Road Geometry

Proposed Circulation

Proposed Auto Pick/Drop Bay

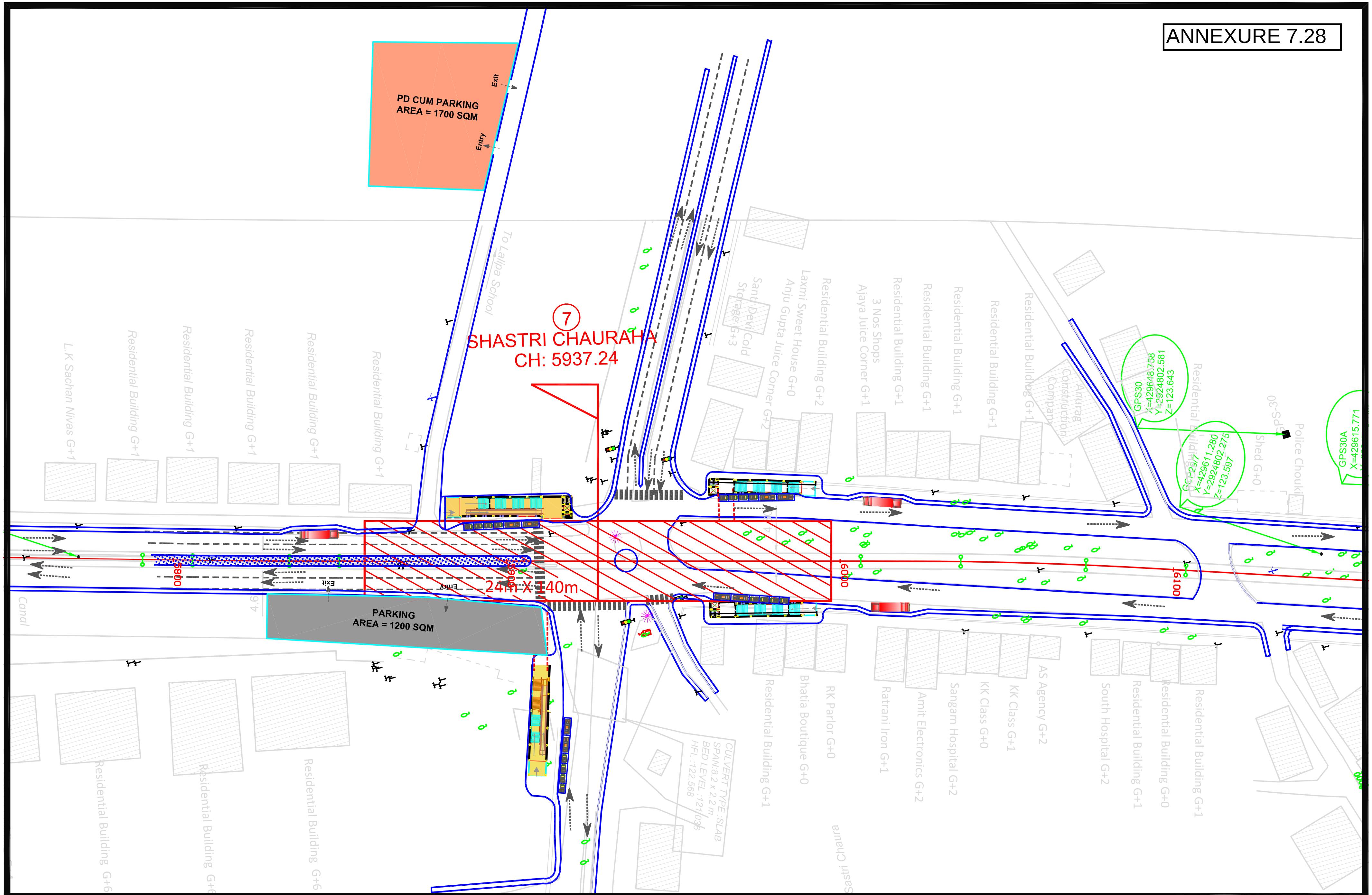
Proposed Bus Stop Bay Marking

Proposed Taxi cum Pvt. Pick/Drop Bay

Proposed Entry/Exit

N

ANNEXURE 7.28

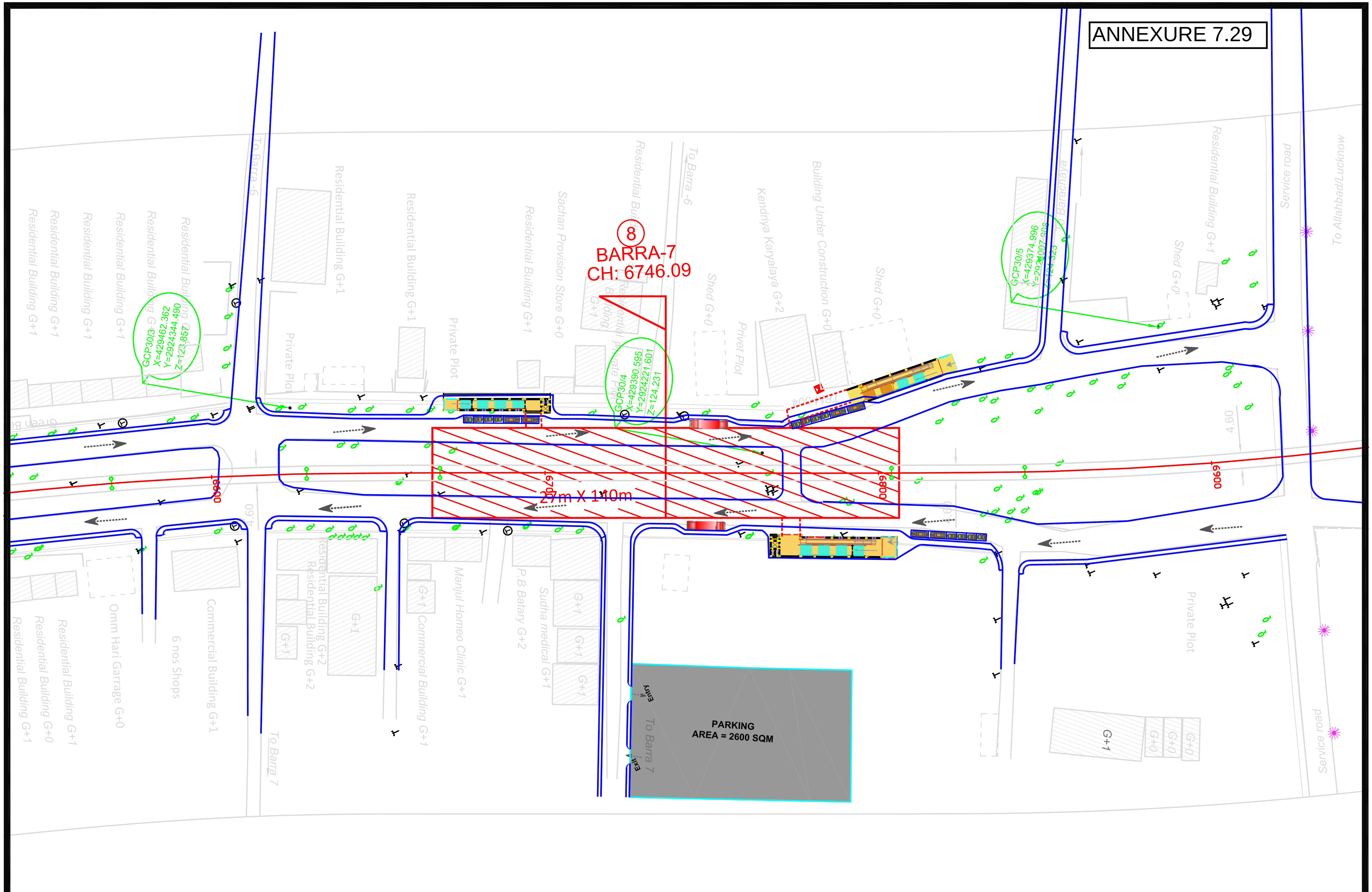


PROPOSED INTERMODAL INTEGRATION AND DISPERSAL PLAN OF SHASTRI CHAURAHA

P.D. cum Parking Area	Proposed Parking Area
Proposed Road Geometry	Proposed Circulation
Proposed Auto Pick/Drop Bay	Proposed Bus Stop Bay Marking
Proposed Taxi cum Pvt. Pick/Drop Bay	**Proposed Entry/Exit**

N

ANNEXURE 7.29



PROPOSED INTERMODAL INTEGRATION AND DISPERSAL PLAN OF BARRA - 7

P.D. cum Parking Area

Proposed Parking Area

Proposed Road Geometry

Proposed Circulation

Proposed Auto Pick/Drop Bay

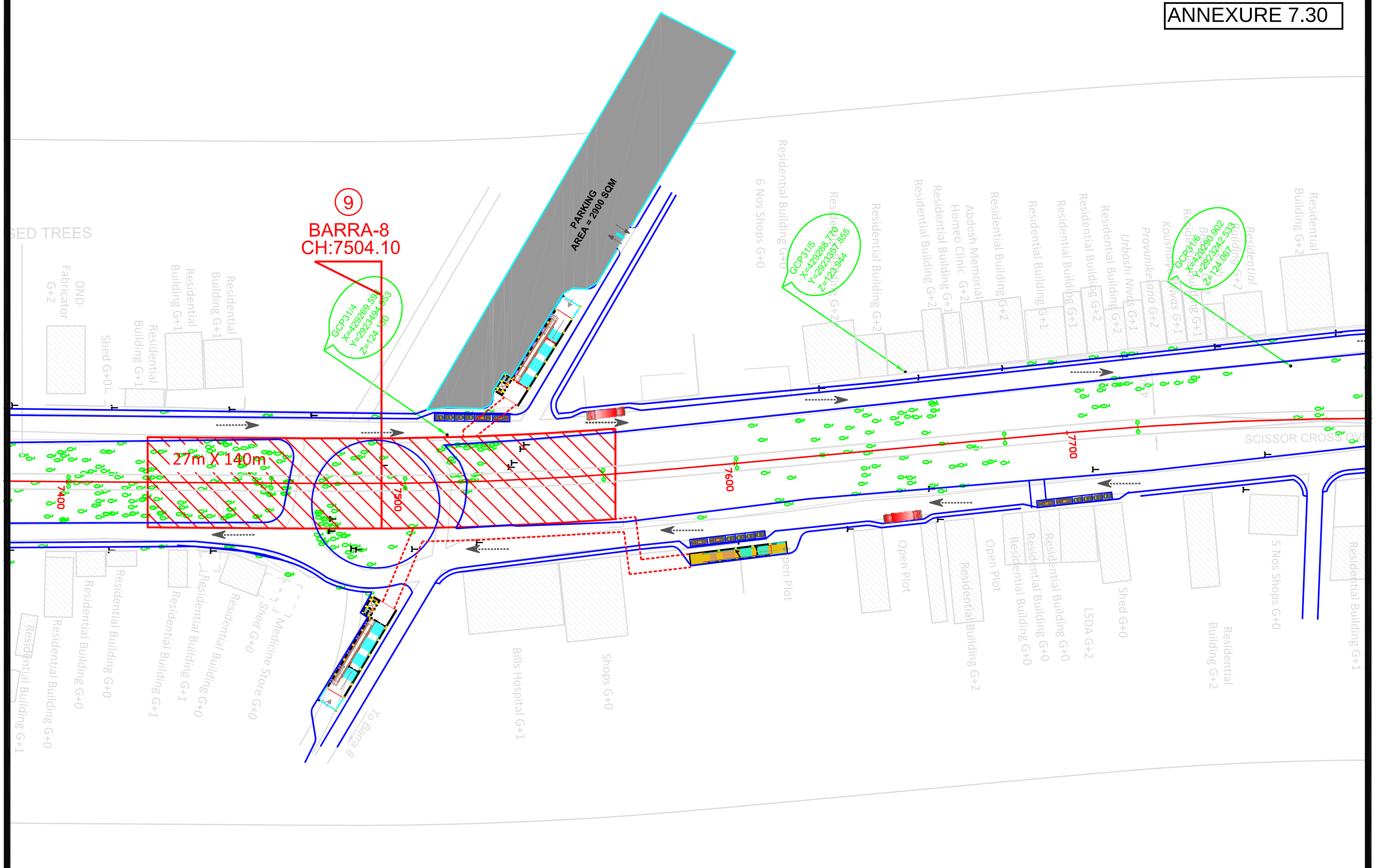
Proposed Bus Stop Bay Marking

Proposed Taxi cum Pvt. Pick/Drop Bay

Proposed Entry/Exit

N

ANNEXURE 7.30



PROPOSED INTERMODAL INTEGRATION AND DISPERSAL PLAN OF BARRA - 8

P.D. cum Parking Area	Proposed Parking Area
Proposed Road Geometry	Proposed Circulation
Proposed Auto Pick/Drop Bay	Proposed Bus Stop Bay Marking
Proposed Taxi cum Pvt. Pick/Drop Bay	**Proposed Entry/Exit**

N

Chapter – 8
TRAIN OPERATION PLAN

8. TRAIN OPERATION PLAN

8.1 SYSTEM OPERATION APPROACH

8.1.1 Train operation plan for proposed corridors of Kanpur Metro viz. IIT Kanpur to Naubasta Corridor (23.8 Km) and Agriculture University to Barra-8 (8.6 Km) has been envisaged based on the ridership assessment. The peak hour peak direction trips (PHPDT) is 40000 passengers for IIT Kanpur to Naubasta corridor and 30000 passengers for Agriculture University to Barra-8 corridor in the design year. The underlying operation philosophy is to provide mass rapid transit services at economical cost with fixed Infrastructure and rolling stock planning.

- The frequency of train services shall be optimized to provide sectional capacity commensurate with the peak direction traffic demand during peak hours.
- A minimum train service frequency shall be provided during lean period so as to keep the option of this service attractive during lean period as well
- The frequency of services shall be regulated to meet the growing traffic demand in horizon years
- Basic unit selected is one motor car and one trailer car

The train operation plan for the proposed corridors will be based on the following salient features:

- Running of services for 16 hours of a day (06:00 hrs to 22:00 hrs) with a station dwell time of 20-30 seconds.
- Scheduled speed of 34 kmph for IIT Kanpur to Naubasta corridor and 33 kmph for Agriculture University to Barra 8 corridor.
- Make up time of 5% with 8% coasting.
- Adequate services to ensure comfortable journey for commuters even during peak periods.

8.1.2 TRAFFIC DEMAND

The PHPDT for purpose of planning of services for the proposed corridors in the years 2024, 2031, 2041 and 2051 are indicated in **Table 8.1**.

TABLE 8.1: YEAR WISE MAXIMUM PEAK HOUR PEAK DIRECTION TRIPS (PHPDT)

SN	Corridor	MAXIMUM PHPDT				
		2024	2031	2041	2051	Design Year
1	IIT Kanpur to Naubasta	18040	21300	27900	33900	40000
2	Agriculture Univ. to Barra-8	12547	17800	20800	25300	30000

The section wise traffic for the proposed corridors for different horizon years is given in **Annexure 8.1.**

8.1.3 TRAIN FORMATION

To meet the above projected traffic demand, the train operation plan has been formulated considering the rolling stock of 2.9 m wide coaches. The train composition, capacity and headway required for the operation.

i. Composition

The car composition to be adopted is given below-

DMC : Driving Motor Coach

TC : Non Driving Trailer Coach

MC : Non Driving Motor Coach

3-Car Rake Composition: ***DMC-TC-DMC***

6-Car Rake Composition: ***DMC-TC-MC-MC-TC-DMC***

Every coach shall be fully interchangeable with any other coach of same type.

ii. Capacity

For the purpose of calculating rake requirement of rolling stock, passenger carrying capacity is considered as below in **Table 8.2**.

TABLE 8.2: CARRYING CAPACITY OF COACHES

Description	Driving Motor Car (DMC)			Trailer Car (TC)/ Motor Car (MC)			3 Car Train			6 Car Train		
	Normal	Crush	Dense Crush	Normal	Crush	Dense Crush	Normal	Crush	Dense Crush	Normal	Crush	Dense Crush
Seated	43	43	43	50	50	50	136	136	136	286	286	286
Standing	103	205	273	110	220	293	316	630	839	646	1290	1718
Total	145	247	316	160	270	343	452	766	975	932	1576	2004

Normal *- 3 Per/sqm,* ***Crush****- 6 Per/Sqm ,* ***Dense Crush*** *– 8 Per/Sqm of standee area*

iii. Headway

To meet the projected traffic demand, the possibility of running trains with 3 car and 6 car rake composition at different headways has been examined. The traffic capacity and demand have been matched by suitable regulation of headways.

The train operation plan is envisaged for IIT Kanpur to Naubasta corridor with 3 car rake composition in the inception year 2024 and year 2031, combination of 3 car & 6 car rake composition in the years 2041 and 2051 and 6 car rake composition in the design year. Similarly, the train operation for Agriculture University to Barra-8 corridor is planned with 3 car rake composition for year 2024 and 2031, combination of 3 car and 6 car rake for year 2041 and year 2051. The infrastructure and train operation plan for the two corridors of Kanpur Metro are proposed to be designed for 6 car rake composition for the ultimate/ design year. Based on above, the headway and capacity provided for different corridors for the various horizon years is presented in **Table 8.3**.

TABLE 8.3: TRAIN OPERATION PLAN, HEADWAY AND CAPACITY PROVIDED

Corridors	Items		Year				
			2024	2031	2041	2051	Design
IIT Kanpur-Naubasta (23.8 km)	Cars/ Train		3	3	3 & 6	3 & 6	6
	Headway (Min.)		2.9	2.5	2.5	2.5	2.4
	Trains/hr		21	24	24(18,6)	24(7,15)	25
	Capacity Provided	@6p/m^2	16086	18384	23244	29812	39400
		@8p/m^2	20475	23400	29574	37914	50100
	PHPDT Demand		18000	21300	27900	33900	40000
Agriculture University-Barra-8 (8.6 km)	Cars/ Train		3	3	3 & 6	3 & 6	6
	Headway (Min.)		4.0	3.2	3.2	3.2	3.2
	Trains/hr		15	19	19(12,7)	19(10,9)	19
	Capacity Provided	@6p/m^2	11490	14554	20224	21844	29944
		@8p/m^2	14625	18525	25728	27786	38076
	PHPDT Demand		12500	17800	20800	25300	30000

Keeping in view the traffic demand, it is proposed to initially operate 3-car trains. Subsequently, the passenger carrying capacity will be increased either by varying the train configuration to a combination of 3 & 6 car trains / 6-car trains or by regulating the headway to meet the growing traffic demand in horizon years.

8.1.4 TRAIN OPERATION PLAN

1) Corridor 1 - IIT Kanpur to Naubasta

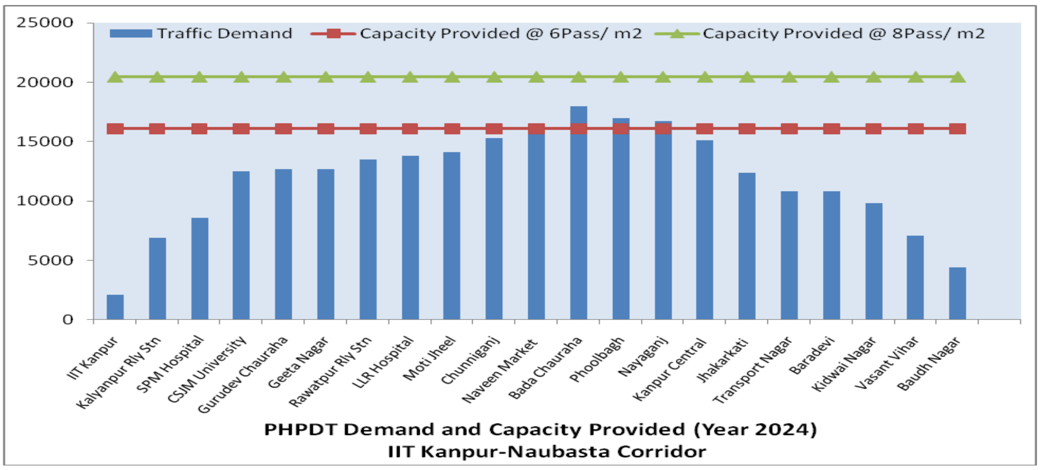
Train operation for the different horizon years for IIT Kanpur to Naubasta Corridor has been formulated such that there is optimum utilization of the rolling stock and the empty running of trains is reduced.

Since the elevated section of the corridor from IIT Kanpur to Moti Jheel is expected to be completed earlier, it is proposed to provide the mid terminal/reversal facilities at Moti Jheel so that initially the trains may be operated between IIT Kanpur to Moti Jheel section. After completion of the complete corridor, trains will operate between IIT Kanpur to Naubasta. The year wise train operation plan is described as below:

- **Year 2024**

Train operation plan for the corridor in year 2024 is planned with 3 car rake composition and 2.9 minutes headway during peak period. The planned peak hour peak direction trips (PHPDT) capacity is 16086 @ 6 passengers/m^2 of standee area (Capacity of 20475 @ 8 passengers/m^2 of standee area under dense loading conditions). The planned capacity is less than the PHPDT demand of 18000 passengers in section between Naveen Market and Kanpur Central Railway Station. However capacity in this section can be met by carrying standees @ 8 passengers/ m^2 which have been deliberatively planned for peak hour train operation for optimum utilization of rolling stock.

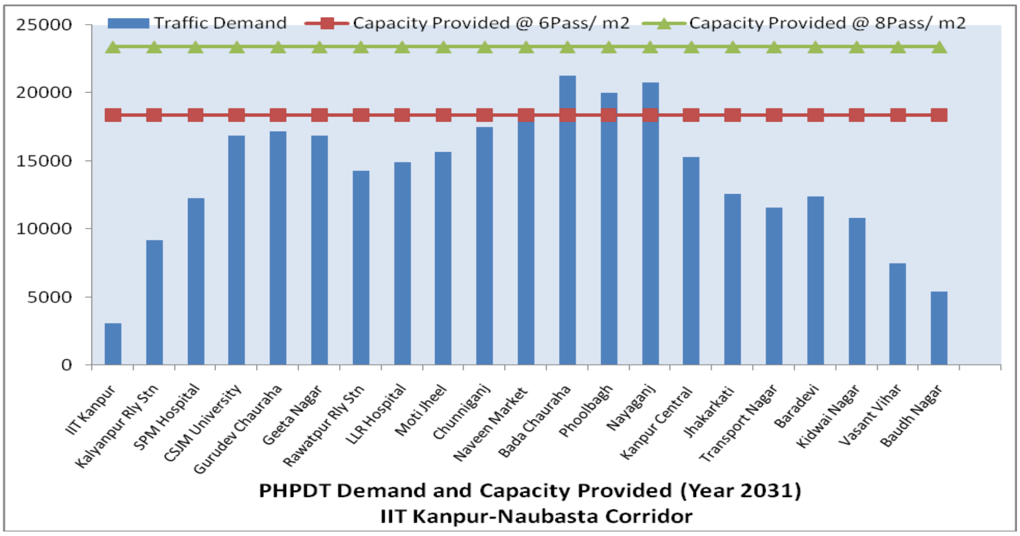
FIGURE 8.1: PHPDT DEMAND AND CAPACITY PROVIDED (2024) FOR IIT KANPUR – NAUBASTA CORRIDOR



- **Year 2031**

The train operation with 3 car trains at 2.5 minutes peak period headway has been proposed for year 2031 with PHPDT capacity of 18384 passengers with standees @ 6 persons/m^2 (capacity of 23400 passengers @8 persons /m^2). With the proposed headway, the planned capacity is slightly less than PHPDT demand of 21300 passengers in the section between Bada Chauraha and Kanpur central Railway station. However capacity in this section can be met by carrying standees @ 8 passengers/ m^2 which have been planned for peak hour train operation for optimum utilization of rolling stock.

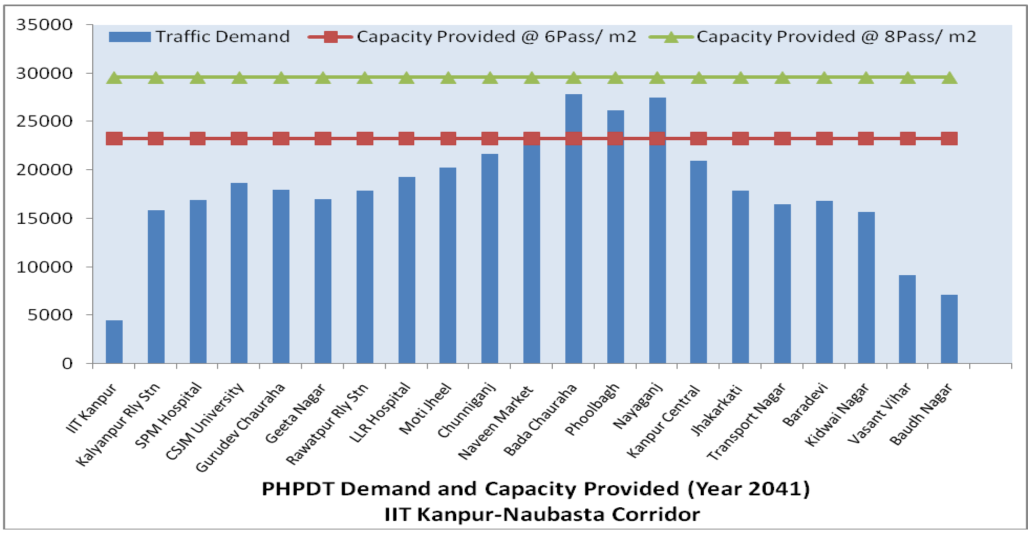
FIGURE 8.2: PHPDT DEMAND AND CAPACITY PROVIDED (2031) FOR IIT KANPUR – NAUBASTA CORRIDOR



- **Year 2041**

The train operation for corridor 1 in year 2041 is planned with combination of 3 car and 6 car rake composition at 2.5 minutes headway during peak period. The peak hour peak direction traffic will be met by running 18 trains of 3 car and 6 trains of 6 car during peak periods with the carrying capacity of 23244 @ 6 passengers/m^2 of standee area (Capacity of 29574 @ 8 passengers/m^2 of standee area). The planned PHPDT capacity is less than the demand of 27900 passengers in the section between Bada Chauraha to Kanpur Central Railway station. However capacity in this section can be met by carrying standees @ 8 passengers/ m^2 which have been deliberatively planned for peak hour train operation for optimum utilization of rolling stock.

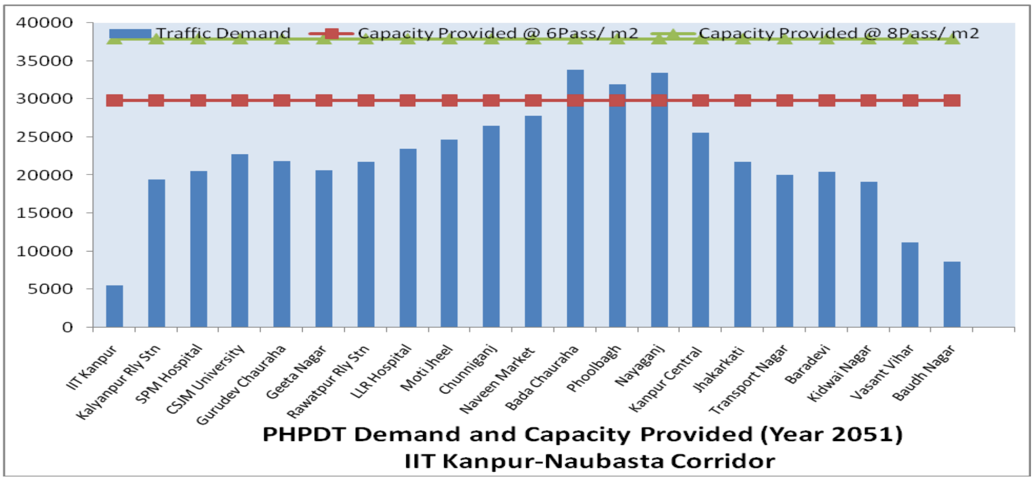
FIGURE 8.3: PHPDT DEMAND AND CAPACITY PROVIDED (2041) FOR IIT KANPUR – NAUBASTA CORRIDOR



- **Year 2051**

Train operation for the corridor in year 2051 is planned with combination of 3 and 6 car rake composition at 2.5 minutes headway during peak period. 7 trains of 3 car composition and 15 trains of 6 car composition will operate to meet the peak hour traffic demand. The carrying capacity of the trains during peak hours will be 29812 @ 6 passengers/m^2 of standee area (Capacity of 37914 @ 8 passengers/m^2 of standee area). The planned PHPDT capacity is less than the PHPDT demand of 33900 passengers in the section between Bada Chauraha to Nayaganj station. However capacity in this section can be met by carrying standees @ 8 passengers/ m^2 which have been deliberatively planned for peak hour train operation for optimum utilization of rolling stock.

FIGURE 8.4: PHPDT DEMAND AND CAPACITY PROVIDED (2051) FOR IIT KANPUR – NAUBASTA CORRIDOR



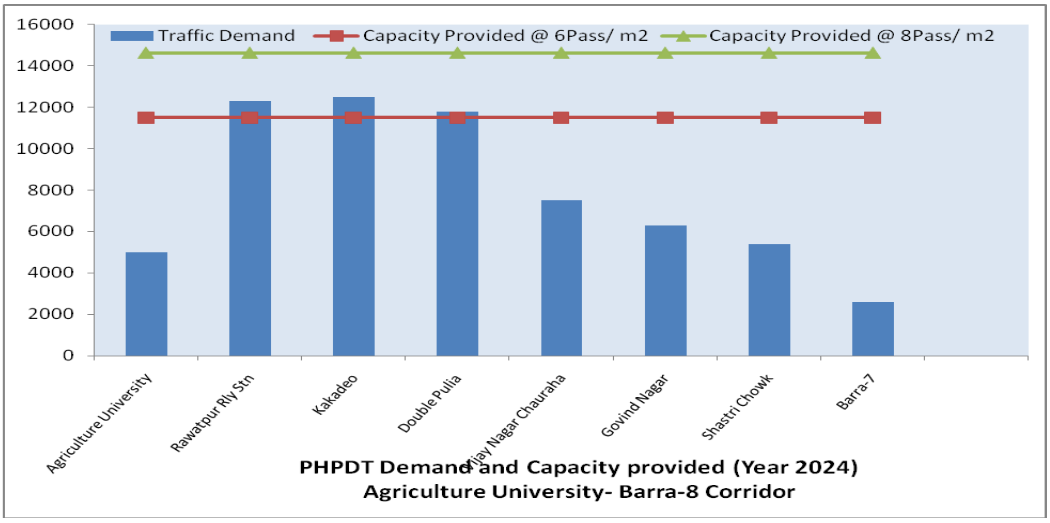
Train operation with 6 car rake composition at 2.4 minutes headway is envisaged for IIT Kanpur to Naubasta corridor to meet the capacity of 40000 PHPDT during the design year.

2) Corridor 2 - Agriculture University to Barra-8

- **Year 2024**

The train operation with 3 car trains at 4.0 minutes peak period headway has been proposed for year 2024 with PHPDT demand of 11490 passengers @ 6 passengers/m² of standee area (14625 passengers @8 passengers/m² of standee area). With the proposed headway, the planned capacity is slightly less than PHPDT demand of 12500 passengers in the section between Rawatpur Railway Station – Vijay Nagar Chauraha. However capacity in this section can be met by carrying standees @ 8 passengers/ m² which have been deliberatively planned for peak hour train operation for optimum utilization of rolling stock.

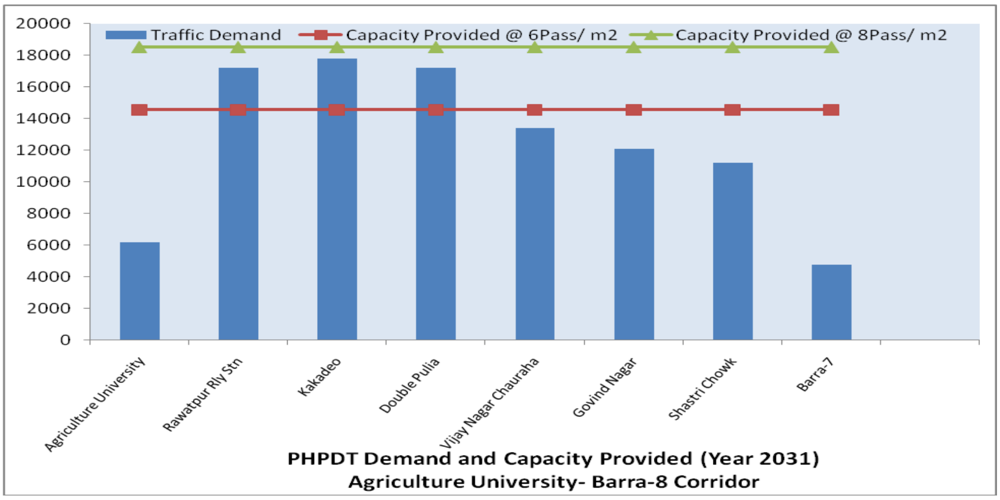
FIGURE 8.5: PHPDT DEMAND AND CAPACITY PROVIDED (2024) FOR AGRICULTURE UNIVERSITY TO BARRA 8



- **Year 2031**

Train operation for the corridor in year 2031 is planned with 3 car train composition and 3.2 minutes headway during peak period. The planned peak hour peak direction traffic (PHPDT) capacity is 14554 @ 6 passengers/m² of standee area (Capacity of 18525 @ 8 passengers/m² of standee area). The planned capacity is less than the PHPDT demand of 17800 passengers in the section between Rawatpur Railway Station to Vijay nagar Chauraha. However capacity in this section can be met by carrying standees @ 8 passengers/ m^2 which have been deliberatively planned for peak hour train operation for optimum utilization of rolling stock.

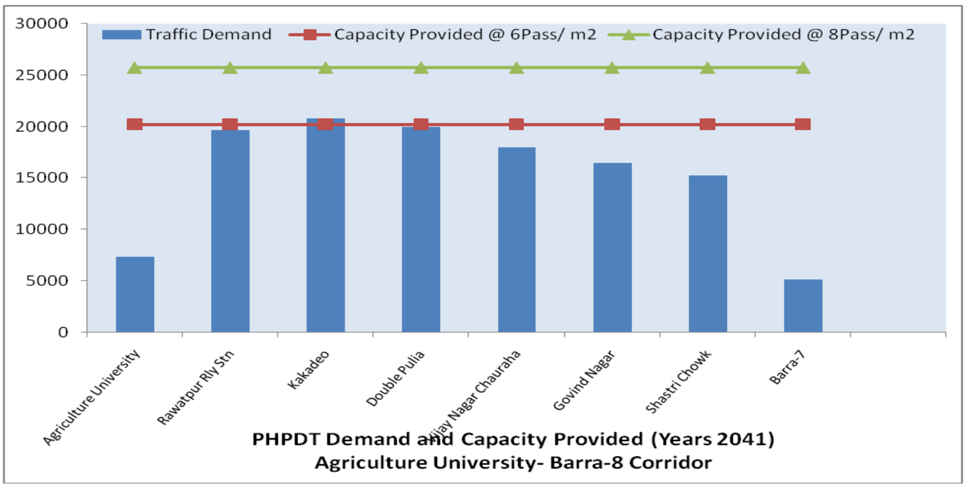
FIGURE 8.6: PHPDT DEMAND AND CAPACITY PROVIDED (2031) FOR AGRICULTURE UNIVERSITY TO BARRA 8



- **Year 2041**

The train operation with combination of 3 and 6 car trains at 3.2 minutes peak period headway has been proposed for year 2041. 12 No. 3-car trains and 7 No. 6 car trains will operate to meet the peak traffic demand of the corridor. The carrying capacity of the trains will be 20224 passengers with standee density @ 6 persons/m2 (capacity of 25728 @8 passengers/m^2). With the proposed headway, planned capacity is slightly less than PHPDT demand of 20800 passengers in the section between Kakadeo to Double Pulia. However capacity in this section can be met by carrying standees @ 8 passengers/ m^2.

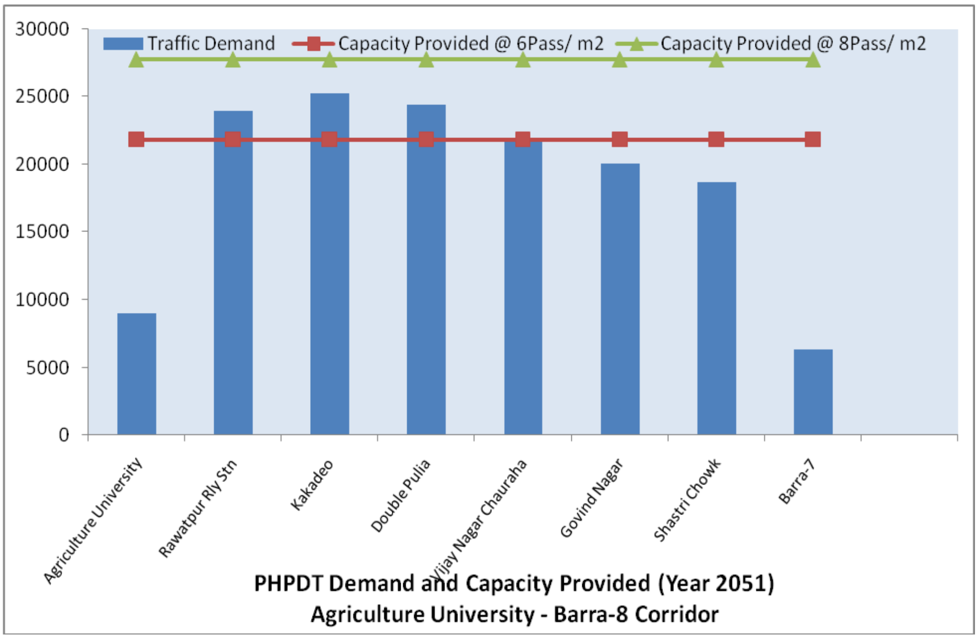
FIGURE 8.7: PHPDT DEMAND AND CAPACITY PROVIDED (2041) FOR AGRICULTURE UNIVERSITY TO BARRA 8



- **Year 2051**

The combination of 3 car and 6 car train configuration with train operation with 10 trains of 3 car configuration and 9 trains of 6 car train configuration is proposed for year 2051. The capacity of 21844 passengers with standee density @ 6 persons/m2 (capacity of 27786 @8 passengers/m²) is planned to be provided for the corridor. With the proposed headway, the planned capacity is slightly less than PHPDT demand of 25300 passengers in the section between Rawatpur Railway Station to Vijay Nagar chauraha. However capacity in this section can be met by carrying standees @ 8 passengers/ m^2 which have been deliberatively planned for peak hour train operation for optimum utilization of rolling stock.

FIGURE 8.8: PHPDT DEMAND AND CAPACITY PROVIDED (2051) FOR AGRICULTURE UNIVERSITY TO BARRA 8



To meet the design PHPDT of 30000 passengers, the train operation is planned with 6 car trains running at 3.2 minutes headway. It will ensure adequacy of system to meet unforeseen growth of traffic beyond the year 2051.

The rolling stock is designed for carrying higher density loading @ 8 standee passengers per square meter and in the sections where PHPDT demand exceeds the planned capacity, overloading during these periods will help in reducing the demand for increased deployment of rolling stock and the optimum utilization of rolling stock will be achieved.

8.2 SYSTEM FREQUENCY

The services for Kanpur Metro rail shall be operational for 16 hours of a day (6:00 hrs to 22:00 hrs). No services are proposed between 22:00 hrs to 6:00 hrs which are reserved for maintenance of infrastructure and rolling stock.

The frequency of train operation during the peak hours is presented in **Table 8.3**. It is expected that the traffic demand during other time of the day i.e. off peak hours will be less. Thus, less number of trains/hr are planned for operation during lean hours.

The hourly distribution of daily train operation between IIT Kanpur to Naubasta and Agriculture University to Barra-8 for various horizon years is enclosed in **Annexure 8.2(a)** & **8.2 (b).**

8.3 ROLLING STOCK REQUIREMENT

8.3.1 Requirements of coaches for the corridor are calculated based on following;

- Coach requirement has been calculated based on headway during peak hours.
- Scheduled speed of 34 kmph for IIT Kanpur to Naubasta corridor and 33 kmph for Agriculture University to Barra 8 corridor.
- Turn round time as **6 min** at terminal stations.
- The calculated number of rakes in fraction is rounded off to next higher number.
- Traffic reserve is taken as **5%** to cater to failure of train on line and to make up for operational time lost.
- Repair and maintenance has been estimated as **10%** of total requirement (Bare + Traffic Reserve).

Based on above assumptions and train operation plan, the rake requirement for various horizon years is indicated in **Table 8.4**.

TABLE 8.4: ROLLING STOCK REQUIREMENT

Train Operation / Corridor	Time horizon Year	Head way in min	Section length km	Rakes Reqd.	Bare Rake Reqmt	Traffic spare @5%	Maint. Spare @10%	Total rake req.	Total coach req.
IIT Kanpur to	2024	2.9	23.8	33.6	34	2	3	39	117
	2031	2.5	23.8	38.4	38	2	4	44	132

Train Operation / Corridor	Time horizon Year	Head way in min	Section length km	Rakes Reqd.	Bare Rake Reqmt	Traffic spare @5%	Maint. Spare @10%	Total rake req.	Total coach req.
Naubasta (23.8 Km)	2041	2.5	23.8	24.0	24	1	3	28	168
	2051	2.5	23.8	29.6	30	2	3	35	210
	Design	**2.4**	**23.8**	**40.0**	40	2	5	**47**	**282**
Agriculture Univ. to Barra 8 (8.6 Km)	2024	4.0	8.6	10.8	11	1	1	13	39
	2031	3.2	8.6	13.5	14	1	1	16	48
	2041	3.2	8.6	9.4	9	0	1	10	60
	2051	3.2	8.6	10.1	10	1	1	12	72
	Design	**3.2**	**8.6**	**13.5**	14	1	2	**17**	102

8.3.2 Stabling of Rakes

Stabling facility for the rakes of corridor 1 i.e. IIT Kanpur to Naubasta corridor has been provided at Polytechnic depot and Naubasta Stabling facility. The proposed facilities are sufficient to cater to the stabling needs of the corridor. Four rakes will be stabled at the terminal stations (2 at each terminal station) for the start of early morning services.

For the stabling requirements of corridor 2, the depot has been planned at Agricultural University. The planned stabling facility at depot will be able to cater to the stabling needs of the corridor till the design year. The depot layout plans have been discussed in detail in Chapter 14.

8.3.3 Vehicle Kilometer

Based on the above planning and assuming 340 days service in a year (after considering maintenance period) Vehicle Kilometers have been estimated. Vehicle Kilometers for the proposed train operation for years 2024, 2031, 2041 and 2051 is given below in **Tables 8.5** & **8.6**.

TABLE 8.5: VEHICLE KILOMETER: IIT KANPUR-NAUBASTA

Year	2024	2031	2041		2051		Design
Section Length	23.8	23.8	23.8		23.8		23.8
No of cars per Train	3	3	3&6		3&6		6
No of working Days in a year	340	340	340		340		340
Number of Trains per day each Way	233	263	197	67	79	167	277
Daily Train –KM	5545.4	6259.4	4688.6	1594.6	1880.2	3974.6	6592.6

Year	2024	2031	2041		2051		Design
Annual Train–KM(10^5)	18.85	21.28	15.94	5.42	6.39	13.51	22.41
Annual Vehicle-KM (10^5)	56.56	63.85	47.82	32.53	19.18	81.08	134.49

TABLE 8.6: VEHICLE KILOMETER: AGRICULTURAL UNIVERSITY- BARRA-8

Year	2024	2031	2041		2051		Design
Section Length	8.6	8.6	8.6		8.6		8.6
No of cars per Train	3	3	3&6		3&6		6
No of working Days in a year	340	340	340		340		340
Number of Trains per day each Way	167	209	133	79	110	99	209
Daily Train –KM	1436.2	1797.4	1143.8	679.4	946	851.4	1797.4
Annual Train - KM (10^5)	4.88	6.11	3.89	2.31	3.22	2.89	6.11
Annual Vehicle - KM (10^5)	14.65	18.33	11.67	13.86	9.65	17.37	36.67

Annexure 8.1

SECTION WISE PEAK TRAFFIC DEMAND FOR KANPUR CORRIDORS

From	To	2024	2031	2041	2051
Corridor 1: IIT Kanpur to Naubasta					
IIT Kanpur	Kalyanpur Railway Station	2100	3100	4500	5500
Kalyanpur Railway Stn	SPM Hospital	6900	9200	15900	19400
SPM Hospital	Kanpur University	8600	12300	16900	20600
Kanpur University	Gurudev Chauraha	12500	16900	18700	22800
Gurudev Chauraha	Geeta Nagar	12700	17200	18000	21900
Geeta Nagar	Rawatpur Railway Station	12700	16900	17000	20700
Rawatpur Railway Stn	Lala Lajpat Rai Hospital	13500	14300	17900	21800
Lala Lajpat Rai Hospital	Moti Jheel	13800	14900	19300	23500
Moti Jheel	Chunniganj	14100	15700	20300	24700
Chunniganj	Naveen Market	15300	17500	21700	26500
Naveen Market	Bada Chauraha	15700	18000	22800	27800
Bada Chauraha	Phoolbagh	18000	21300	27900	33900
Phoolbagh	Nayaganj	17000	20000	26200	31900
Nayaganj	Kanpur Central Rly. Stn	16700	20800	27500	33500
Kanpur Central Rly.Stn	Jhakarkati Bus Terminal	15100	15300	21000	25600
Jhakarkati Bus Terminal	Transport Nagar	12400	12600	17900	21800
Transport Nagar	Baradevi	10800	11600	16500	20100
Baradevi	Kidwai Nagar	10800	12400	16800	20500
Kidwai Nagar	Vasant Vihar	9800	10800	15700	19100
Vasant Vihar	Baudh Nagar	7100	7500	9200	11200
Baudh Nagar	Naubasta	4400	5400	7100	8700
Corridor 2: Agriculture University to Barra-8					
Agriculture University	Rawatpur Rly. Station	5000	6200	7400	9000
Rawatpur Rly. Station	Kakadeo	12300	17200	19700	24000
Kakadeo	Double Pulia	12500	17800	20800	25300
Double Pulia	Vijay Nagar Chauraha	11800	17200	20000	24400
Vijay Nagar Chauraha	Govind Nagar	7500	13400	18000	21900
Govind Nagar	Shastri Chowk	6300	12100	16500	20100
Shastri Chowk	Barra-7	5400	11200	15300	18700
Barra-7	Barra-8	2600	4800	5200	6300

Annexure-8.2(a)

HOURLY TRAIN OPERATION PLAN: IIT KANPUR TO NAUBASTA CORRIDOR

Time of Day	Year 2024		Year 2031		Year 2041			Year 2051			Design	
	Head way (min)	Train s/hr	Head way (min)	Train s/hr	Head way (min)	Trains/hr		Head way (min)	Trains/hr		Head way (min)	Trains /hr
		3 car		3 car		3 car	6 car		3 car	6 car		6 car
6 to 7	7.5	8	6.0	10	6.7	7	2	6.7	3	6	6.0	10
7 to 8	4	15	3.5	17	3.5	13	4	3.8	5	11	3.3	18
8 to 9	2.9	**21**	2.5	**24**	2.5	**18**	**6**	2.7	**7**	**15**	2.4	**25**
9 to 10	2.9	**21**	2.5	**24**	2.5	**18**	**6**	2.7	**7**	**15**	2.4	**25**
10 to 11	3.5	17	3.2	19	3.2	14	5	3.3	6	12	3.0	20
11 to12	4.6	13	4.3	14	4.0	11	4	4.6	4	9	4.0	15
12 to 13	5.5	11	5.0	12	5.0	9	3	5	4	8	4.6	13
13 to 14	10	6	8.6	7	8.6	5	2	8.6	2	5	7.5	8
14 to 15	5.5	11	5.0	12	5.0	9	3	5	4	8	4.6	13
15 to 16	4.6	13	4.3	14	4.0	11	4	4.6	4	9	4.0	15
16 to 17	3.5	17	3.2	19	3.2	14	5	3.3	6	12	3.0	20
17 to 18	2.9	**21**	2.5	**24**	2.5	**18**	**6**	2.7	**7**	**15**	2.4	**25**
18 to 19	2.9	**21**	2.5	**24**	2.5	**18**	**6**	2.7	**7**	**15**	2.4	**25**
19 to 20	3.5	17	3.2	19	3.2	14	5	3.3	6	12	3.0	20
20 to 21	4.6	13	4.3	14	4.0	11	4	4.6	4	9	4.0	15
21 to 22	7.5	8	6.0	10	6.7	7	2	6.7	3	6	6.0	10
Total No. of trains per direction per day		**233**		**263**		**197**	**67**		**79**	**167**		**277**

Annexure-8.2(b)

HOURLY TRAIN OPERATION PLAN: AGRICULTURE UNIV. TO BARRA-8 CORRIDOR

Time of Day	Year 2024		Year 2031		Year 2041			Year 2051			Design	
	Head way (min)	Train s/hr	Head way (min)	Trains /hr	Head way (min)	Trains/hr		Head way (min)	Trains/hr		Head way (min)	Train s/hr
		3 car		3 car		3 car	6 car		3 car	6 car		6 car
6 to 7	10.0	6	7.5	8	7.5	5	3	7.5	4	4	7.5	8
7 to 8	5.5	11	4.6	13	4.6	8	5	4.6	7	6	4.6	13
8 to 9	4.0	**15**	3.2	**19**	3.2	**12**	**7**	3.2	**10**	**9**	3.2	**19**
9 to 10	4.0	**15**	3.2	**19**	3.2	**12**	**7**	3.2	**10**	**9**	3.2	**19**
10 to 11	5.0	12	4.0	15	3.8	10	6	4	8	7	4.0	15
11 to12	6.7	9	5.5	11	5.5	7	4	5.5	6	5	5.5	11
12 to 13	7.5	8	6.0	10	6	6	4	6	5	5	6.0	10
13 to 14	12.0	5	10.0	6	10	4	2	10	3	3	10.0	6
14 to 15	7.5	8	6.0	10	6	6	4	6	5	5	6.0	10
15 to 16	6.7	9	5.5	11	5.5	7	4	5.5	6	5	5.5	11
16 to 17	5.0	12	4.0	15	3.8	10	6	4	8	7	4.0	15
17 to 18	4.0	**15**	3.2	**19**	3.2	**12**	**7**	3.2	**10**	**9**	3.2	**19**
18 to 19	4.0	**15**	3.2	**19**	3.2	**12**	**7**	3.2	**10**	**9**	3.2	**19**
19 to 20	5.0	12	4.0	15	3.8	10	6	4	8	7	4.0	15
20 to 21	6.7	9	5.5	11	5.5	7	4	5.5	6	5	5.5	11
21 to 22	10.0	6	7.5	8	7.5	5	3	7.5	4	4	7.5	8
Total No. of trains per direction per day		**167**		**209**		**133**	**79**		110	**99**		**209**

Chapter – 9
SIGNALING & TELECOMMUNICATION

9. SIGNALING & TELECOMMUNICATION

9.1 SIGNALING SYSTEM

9.1.1 Design Parameters

The signaling system shall provide the means of 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. The system will have the following design parameters:

- Ridership: 40000 PHPDT(Corridor-I)/ 30000 PHPDT(Corridor-II)
- Standard Gauge: 1435 mm
- Average Speed: 34 Kmph (corridor-I)/ 33Kmph (Corridor-II)
- Corridor Length: 23.8 Km (Corridor-I)/ 8.6 Km (Corridor -II)
- Total Stations: 22 (Corridor -I)/ 9 (Corridor -II)
- Train Configuration: 6 Car Rake
- Required Headway: 2.4 Minutes (Corridor-I)/ 3.2 Minutes (Corridor -II)

9.1.2 Options for Signaling Systems

Depending on type of the Railway Network, Main Line or Metro Rail, Signaling & Train Control can be achieved by adopting any of the following Signaling System / Technologies available:

- Automatic Signaling
- ETCS Level – 1
- ETCS Level – 2
- Distance to Go (DTG)
- Communication Based Train Control (CBTC)

While systems at S.No. (i) – (iii) have been developed / used for Main Line Railway networks, systems at S.No. (iv) – (v) are for Metro Railway Networks. Therefore, to have a fair idea of the Signaling & Train Control systems for metro railway, the relative merits & limitations of Distance to Go (DTG) and Communication based train control system (CBTC) are discussed as below:

a) Distance to Go (DTG) Signaling System:

Distance to Go (DTG) signaling system is mainly used for MRTS systems and adopted by most of the recently commissioned MRTS systems in India viz.

DMRC (Delhi Metro) Phase-I, Phase-II, Delhi Airport Metro Express Line, BMRCL Phase-I (Bengaluru Metro), JMRCL (Jaipur Metro) & Chennai Metro.

It has advanced features of Continuous Automatic Train Control (CATC) consisting of sub-systems like Automatic Train Supervision (ATS), Automatic Train Protection (ATP) and Automatic Train Operation (ATO).
These sub-systems are briefly described below:

- **Automatic Train Supervision (ATS)**

Automatic Train Supervision (ATS) is used to provide overall control of trains operation and remote control of the station. The main function of ATS is automatic management of train's movement by interfacing with ATP / CBI systems for route setting, train supervision and regulation. The system supervises train movements continuously and optimizes train movements in case of abnormalities. ATS system also logs each train movement and displays it on traffic controller work stations and over view display panel at the OCC and also on workstations placed in the Station Control Room (SCR) for Station Controller.

- **Automatic Train Protection (ATP)**

Automatic Train Protection (ATP) system (both on-board and way-side) in conjunction with Electronic interlocking , track profile and brake characteristics of rolling stock is provided to ensure safe as also optimal train services on the section . ATP system includes continuous transmission of various safety parameters (authorized speed, movement authority etc.) from track to train through coded audio frequency track circuit. This information received from way-side ATP systems by on-board ATC system provides Cab signaling i.e display of maximum safe speed, current speed and target speed / distance. Facilities for automatic enforcement of temporary / permanent speed restrictions are also built in to enhance safety during maintenance work.

- **Automatic Train Operation (ATO)**

Automatic Train Operation (ATO) operates the trains automatically from station to station within the safety envelope / parameters of ATP & also controls (opens / closes) the train doors. Train Operator (TO) is only required to Close the train doors and press a Start button when train is ready to depart. ATO in conjunction with ATP & ATS, can control / regulate running & dwell time at stations in accordance with headway / timetable regulation and also regulates the automatic reversal/turn back of trains at terminal stations.

- **Pros and Cons of DTG (Distance to Go) Signaling System:**

The Distance to Go (DTG) Signaling system provides safety level of CENELEC SIL-4 (Safety Integrity Level) and permits an operational headway of **150 seconds** with Continuous Automatic Train Control. DTG works on fixed block principle. It needs Audio Frequency Track Circuits (AFTC) for train detection and track to train communication. The reliability of the system depends on the reliability of AFTC.

With the advent of Communication Based Train Control (CBTC) at almost same costs, metro transport authorities / organizations are now favoring adoption of CBTC over DTG based Signaling System for all new projects. World over, for new MRTS projects, while adoption of DTG based systems is on a decline , adoption of CBTC based systems , because of their advanced features and low life cycle costs , are increasing steadily. In conclusion while DTG based System can be considered technology of the past, CBTC based system can be considered technology for the present & future.

Considering the high cost of Distance to Go (DTG) Signaling system and advent of new technology viz. Communication Based Train Control (CBTC*),* which supports advance features such as Unattended Train Operation, moving block etc. and is available at almost same cost, **Distance** to Go (DTG) Signaling system is **NOT recommended** for Kanpur Metro corridor.

b) Communication based Train Control (CBTC) Signaling System:

Communication based Train Control (CBTC) Signaling System is mainly used for MRTS networks. It is the latest Signaling and Train Control Technology available and is being adopted by modern metros around the world. It is also being adopted by all new MRTS Networks in India viz, **DMRC Phase-III, Kochi Phase-I, BMRCL Phase-II** etc.

Communication based Train Control (CBTC) Signaling System also has ATP , ATS , ATO/UTO functionality and works on the Moving or Virtual Block principle to reduce headways and increase transport capacity. CBTC relies on continuous two-way digital communication between each controlled train and a wayside control centre. On a moving block equipped railway, the line is usually divided into areas or regions, each area under the control of a computer and each with its own radio transmission system. Each train transmits its identity, location, direction and speed to the area computer which makes the necessary calculations for safe train separation (moving authority) and transmits this to the following train.

The radio link between each train and the area computer is continuous so the computer knows location of all the trains in its area all the time. It transmits to each train the location of the train in front and gives it a braking curve to enable it to stop before it reaches that train. In effect, it can be termed as a dynamic Distance-to-Go system.

As the CBTC based system has very few way side equipment and supports UTO, total life cycle cost of the system shall be substantially lower than other Signaling Systems due to low Maintenance & Operation (man power) costs.

- **Pros and Cons of CBTC Signaling System**

The Communication based Train Control (CBTC) Signaling system provides adequate safety level of CENELEC SIL-4 (Safety Integrity Level) and permits an operational headway of **90 seconds** with continuous automatic train control. The CBTC Technology is proven now in many Metros around the World and is also suitable for UTO (Unattended Train Operation) / DTO (Driverless Train Operation).

After reviewing all available Signaling & Train Control Signaling Technologies, **Communication based Train Control (CBTC)** system, which is the latest technology available, is recommended for Kanpur Metro corridor.

9.1.3 Interlocking System: Computer Based Interlocking (CBI)

Station with Points and Crossings called “Main” or “CBI” stations, will have Interlocking equipment for achieving Computer Based Interlocking (CBI) for operation of points and crossings and setting of routes. Fixed Signals will be provided at Entry & Exit to Interlocking stations.

- **Train Depot : Signaling**

All depot lines except the ones used for shunting in workshop shall be interlocked. A workstation each shall be provided in the Depot Control Centre for electrical operation of the points, signals and routes of the depot yard.

- **Signaling at Stations with Points and Crossings**

  LED type signals for increased reliability and less maintenance efforts shall be provided for Line side signals to protect the points (switches).

9.1.4 Operation Control Centre (OCC)

The OCC shall monitor and control all train operations. During abnormal working, train operation shall fall-back to the fall-back control facilities at interlocked Stations which shall provide the minimum facilities for smooth operations.

OCC operations shall facilitate the safe, secure and reliable operation of planned passenger services and management of unplanned events.

The key functions of the OCC shall be, but not limited to, as under:

(i) Automatic Train Control (ATC);
(ii) Equipment Control and Monitoring System
(iii) Communication systems management
(iv) Operation management functions
(v) Maintenance management functions

9.1.5 Maintenance Philosophy

For efficient operation and functioning of a metro signaling and telecom system, a robust maintenance organization and practices are necessary. Failure in signaling and telecom equipments have to be addressed in preventive and corrective manner. Otherwise, disruptions in Operations and passenger dissatisfaction may arise. The operations and maintenance practices have to be adequately planned with proper defect liability support, spares planning, trained manpower, annual maintenance contract of specific subsystems specifically wherever necessary etc. The spares and maintenance personnel also have to be suitably located all along the metro system to address the failures and remedy the same within a reasonable time.

9.1.6 Standards

Table 9.1 shows the standards that will be adopted.

TABLE 9.1: STANDARDS TO BE ADOPTED FOR SIGNALLING SYSTEM

Description	Standards
CBTC System	IEEE 1474.1

Description	Standards
Interlocking	Computer Based Interlocking (CBI) adopted for station having switches and crossing shall be Hot Standby system with object controller conforming to SIL4 level of CENELEC standards EN 50126, EN 50128 and EN 50129.
Operation of Points	With Direct current 110V D.C. point machines or 380 volts 3 phase, 50 Hz. AC point machines.
Signals at Stations with point & crossings	Line Side signals to protect the points (switches). LED type signals for increased reliability and less maintenance efforts.
Train Protection Systems(ATP)	Automatic train protection system conforming to SIL4 level of CENELEC standards EN 50126, EN 50128 and EN 50129.
ATS	Automatic Train Supervision System, movement of all trains to be logged on to a central computer and displayed on workstations in operation control centre (OCC) and at SCR. Remote control of stations from the OCC as well as local control from the interlocked stations. ATS/ATO will conform to SIL2 level of CENELEC standards EN 50126, EN 50128 and EN 50129.
Immunity to External Interference.	All data transmission on Optical Fiber Cables/Radio. All signaling cables will be separated from power cables. CENELEC standards EN50121-2&4 and EN50082-2 and EN 50081-2 as applicable for EMI/EMC.
Fail Safe Principles	SIL4 safety levels as per CENELEC standard for signal application.
Fall back system	Digital Axle Counter
Other Items	Suitable International Standards like CENELEC etc. shall be followed as per good industry practices.
Maintenance philosophy	Philosophy of continuous monitoring of system status and preventive & corrective maintenance of signaling equipment shall be followed. Card / module / sub-system level replacement shall be done in the field and repairs under taken in the central laboratory/manufacturer's premises.

9.2 TELECOMMUNICATION SYSTEM

9.2.1 Introduction

The telecommunication system acts as communication backbone for Signaling and other systems and provides telecommunication services to meet operational and administrative requirements of metro network.

9.2.2 Telecommunication System used in other Metros

The telecommunications system used in different Metros are as given **Table 9.2**.

TABLE 9.2: TELECOMMUNICATION SYSTEM USED IN DIFFERENT METROS

Metro Operator		System Used	
DMRC	Line 1	A	Digital Transmission System (DTS) Optical Fiber Cable Main Telecommunications Bearer: SDH - STM 4 155Mbps network
		B	Telephone System : EPABX
		C	Mobile Radio Communications: Digital Trunk Radio System (TETRA)
		D	Public Address (PA) System
		E	Centralized Clock System: Digital & Analog Clocks and Time Synchronization System
		F	Passenger Information Display System: LED based
		G	Network Management & Station Management System
		H	CCTV Cameras were provided later on for Security purposes
DMRC	Line 2 Line 3 Phase II		Same as above with Closed Circuit Television: fixed and PTZ Camera and PIDS LED and LCD based.
BMRCL	Phase I	A	Digital Transmission System (DTS) - Optical Fiber Cable - Main Telecommunications Bearer: SDH - STM 4 155Mbps network
		B	Telephone System : EPABX
		C	Mobile Radio Communications: Digital Trunk Radio (TETRA)
		D	Public Address System
		E	Centralized Clock System: Digital and Analog Clock System
		F	Passenger Information Display System: LED & LCD based. Network Management & Station
		G	Closed Circuit Television System : Fixed and PTZ Camera
		H	with monitors
Hyderabad Metro	Phase I	A	Digital Transmission System (DTS) - Optical Fiber Cable

Metro Operator		System Used	
			- IP based system with Layer 2 , Layer 3 and Access switches with OF interfaces
		B	Telephone System: EPABX
		C	Mobile Radio Communications: Digital Trunk Radio (TETRA)
		D	Public Address System
		E	Centralized Clock System: Digital and Analog Clock System
		F	Passenger Information Display System: LED & LCD based.
		G	Central Fault Reporting system (CFRS)
		H	Closed Circuit Television: fixed and PTZ Camera
JMRC	Phase I	A	Digital Transmission System (DTS) - Optical Fiber Cable - Main Telecommunications Bearer: SDH - STM 4 155Mbps network
		B	Telephone System : EPABX
		C	Mobile Radio Communications: Digital Trunk Radio (TETRA)
		D	Public Address System
		E	Centralized Clock System: Digital and Analog Clock System
		F	Passenger Information Display System: LED & LCD based.
		G	Network Management System
		H	Closed Circuit Television: fixed and PTZ Camera
CMRL	Ph1	A	Digital Transmission System (DTS) Optical Fiber Cable Main Telecommunications Bearer: SDH - STM 16
		B	Telephone System: Hybrid PBX
		C	Mobile Radio Communications: Digital Trunk Radio System (TETRA)
		D	Public Address/Voice Alarm (PA/VA) System
		E	Centralized Clock System: Digital & Analog Clocks and Time Synchronization System
		F	Passenger Information Display System: LCD based
		G	Network Management & Station Management System
		H	CCTV
		I	SCADA

9.3.3 Proposed Telecommunication System and Transmission Media

The state of the art latest technology being used in different metros worldwide, is proposed to be used for the Kanpur Metro.

9.3.4 Digital Transmission System (DTS)

Optical Fiber Cable - Main Telecommunication Bearer

IP, GE (Giga Ethernet) based system is proposed for the entire telecom network. OFC backbone network shall be formed by laying two outdoor single mode optical fiber cables (to be laid on either side of tracks). The normal and protected routes shall be arranged in two different cables for path diversity. Considering the channel requirement and keeping in view the future expansion requirements a minimum 96 Fiber, optical fiber cable is proposed to be laid in ring configuration with path diversity. Additional OFC can be considered to be provided if there is a demand for leasing Fiber from Telcos / Industries, providing a source of revenue generation.

The IP network shall consist of highly reliable and fault tolerant Layer-2, Layer-3 and Access switches configured with due redundancy both at Back bone and Access levels for the MAN/LAN. The switches shall have IP interface cards of 10 GBPS for backbone, 1 GBPS for interface with all telecommunication and non-telecommunication sub-systems and 2 MBPS and higher levels for access level. All interfaces with other sub systems shall be IP based with minimum 2 MBPS capacity.

➢ **Telephone Exchange**

A cost effective solution of an IP PBX having at least 50 IP extensions will be provided at each station and 500 IP extensions PBX will be provided at the central, intermediate location on corridor and depot. The Exchanges will serve the subscribers at all the stations, OCC and depot. Capacity of Exchanges can be suitably augmented, if required, depending on available subscribers. The exchanges will be interconnected at multiple IP interfaces (2 MBPS) through redundant optical fiber cable paths.

➢ **Mobile Radio Communication**

Mobile Radio communication system having minimum 8 logical channels is proposed for on-line emergency communication between Motorman (Front end and Rear end) of moving train and the Central Control. The system shall be based on Digital Trunk Radio Technology to TETRA International standard. All the stations 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 as shown in **Figure 9.1**

FIGURE 9.1: TRAIN CAB RADIO AND COMM. FACILITY FOR MAINTENANCE

The frequency band for operation of the system i.e 410-430 or 380-400 MHz may be taken as per 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. In addition to the TETRA Radio Coverage for the internal use of the Metro, the city is also having Mobile Coverage from Private Operators.

- **Public Address System**

The public Address System shall be capable of digitized voice announcements and long range PA functionality suitable for evacuation situations in emergency. The public address is to for stations will generally operate in automatic mode providing information for the time and destination of the next schedule train, special upcoming event, safety and security announcement at pre determined intervals and general information to enhance the travel experience for all users but more specially the visually impaired.

- **Centralized Clock System**

The Clock System shall provide synchronized time for the whole Rail system. The time source shall be obtained from the Cesium Master Clock and Global Positioning System (GPS). The synchronized time information shall be displayed on slave clock units and provided to all other sub systems including Rolling Stock & signaling via the Digital Transmission System and Track-Train Communication system as shown in **Figure 9.2**.

FIGURE 9.2: MASTER CLOCK

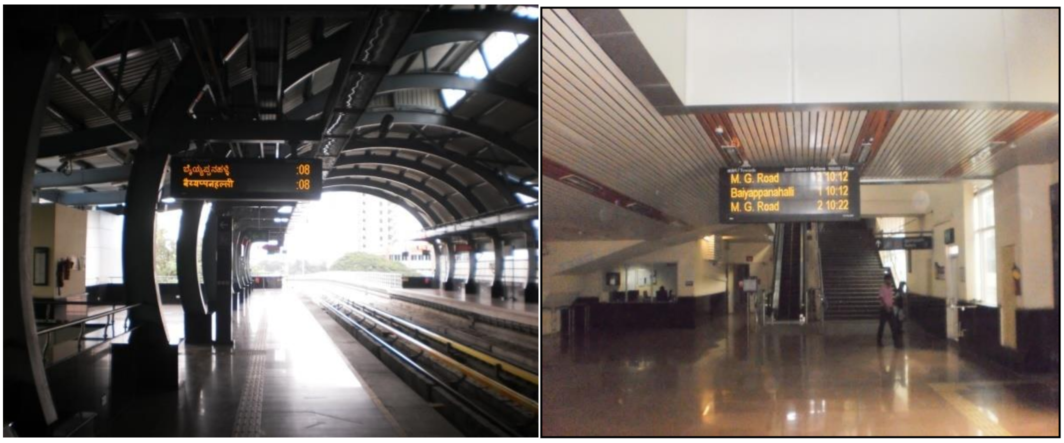
- **Passenger Information Display System**

At all stations, suitable Electronic Passenger Information Display Boards preferably LCD/LED (Flat Panel) will be provided as shown in **Figure 9.3**. The PIDS shall be train actuated (controlled by signaling system) along with facility for manual inputs from the local station as well as the central location (OCC).

FIGURE 9.3: PASSENGER INFORMATION DISPLAY SYSTEM

Passenger Information display boards will be provided at convenient locations at all stations to provide bilingual i.e Hindi & English visual indication of the status of the running trains and will typically indicate information such as destination, platform numbers, arrival/departure time, and also special messages in emergencies. The boards will be provided at all platforms and concourses of terminal & junction stations as shown in **Figure 9.4.**

FIGURE 9.4: PIDS AT PLATFORM AND CONCOURSE



It is envisaged that 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.

- **Close Circuit Television**

CCTV system should ensure real time full coverage, high quality surveillance of all public and selected areas such as tunnel cross passages, ancillary buildings, on board conditions for secure passenger management, crowed control and other emergency situations. Event reloading shall be possible for post video analysis. CCTV cameras shall also be provided in Operational rooms like OCC, SCR etc. A proper IP based recording and storing facility to record and store events for minimum of one month shall be ensured.

- **Central Voice Recording System (CVRS)**

A centralized digital voice recording system will be provided at OCC to record all Two-way Telephone conversation, PA calls from station and OCC, Two Way Radio Conversation of all controllers , TOs , SCRs and other users in OCC and

Depot. In addition all conversation of the Radio System including private calls of all subscribers including Controllers, TOs shall also be recorded. Arrangement of free space audio recording in OCC, SCRs and Driver Cab shall also be made available.

- **Central Fault Reporting System (CFRS)**

For efficient and cost effective maintenance of the entire communication network, it is proposed to provide a CFRS / SCADA system which will help in reporting and diagnosing the 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.

- **Uninterrupted Power Supply**

The uninterrupted power supply (UPS) of 60 KVA, 415 V ± 1%, 3 phase with Battery bank of 800AH capacity at each interlock station and 30 KVA with Battery bank of 300AH capacity at each non-interlock station will be provided for 2 hour back up.

The standards that will be adopted with regard to the Telecommunication systems is shown in **Table 9.3**. These will conform to appropriate IRS/International standards.

TABLE 9.3: STANDARDS TO BE ADOPTED FOR TELECOMMUNICATIONS SYSTEMS

Description	Standards
Transmission System	**IP, GE (Giga Ethernet) based** system for the entire telecom network. OFC backbone network shall be formed by laying two outdoor single mode optical fiber cables (to be laid on either side of tracks). The normal and protected routes shall arranged in two different cables for path diversity.
Optical Fiber cable	OFC for underground environment shall be steel armoured and manufactured from Fire Retardant/resistance, Low Smoke and zero halogen materials. For elevated portion of corridor, it shall be steel armored and conforming to IRS specifications.
Public Address System	Passenger Announcement System shall be interfaced with signaling system for online update of train information. IEC 60268 as applicable or any equivalent international/National standard. Fire resistant Low Smoke Zero Halogen cable shall be used to

Description	Standards
	maintain the circuit integrity in case of fire.
Telephone Exchange	IP based Electronic Exchange (IP PBX)
Passenger Display Information System	It shall be interfaced with signaling system for online update of train information. IEC as applicable or any equivalent international/National standard.
Synchronized Clock system	GPS based, master – slave system IEC 61588 or equivalent standard
CCTV/ Camera	CCTV network shall be as per IEEE standards.
Redundancy (Major System)	Redundancy on Radio base station equipment including server level for all communication sub-systems.
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 will be done in the field and repairs undertaken in the central laboratory/manufacture's premises.

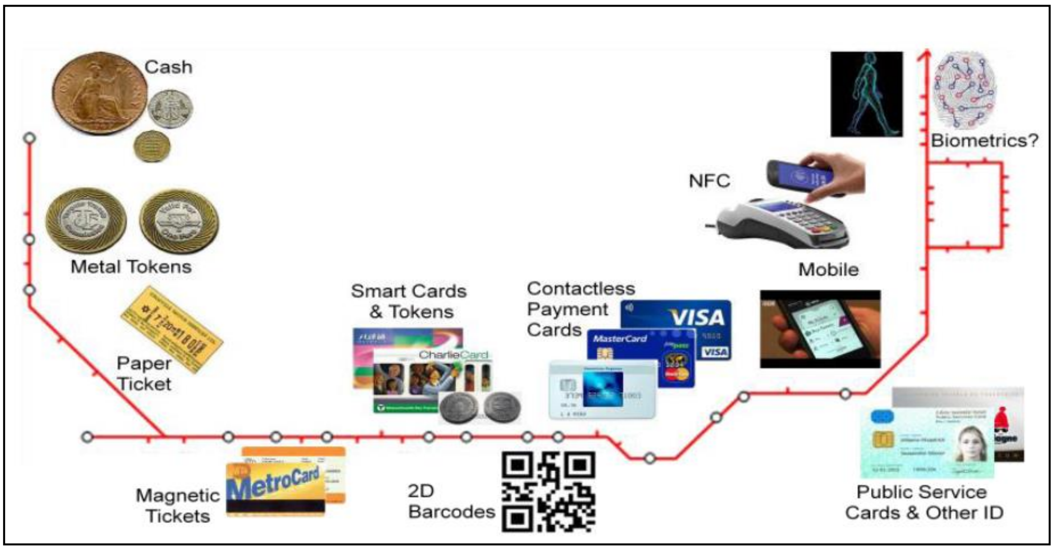
Chapter – 10
FARE COLLECTION SYSTEM

10. FARE COLLECTION SYSTEM

10.1 TICKETING & ACCESS CONTROL

Mass Rapid Transit Systems handle large number of passengers. Ticket issue and fare collection play a vital role in the efficient and proper operation of the system. To achieve this objective, ticketing system shall be simple, easy to use/operate, easy on accounting facilities, capable of issuing single/multiple journey tickets, amenable for quick fare changes and require overall lesser manpower. Automatic fare collection system meets these requirements. Fare collection technology development is as shown in **Figure 10.1**.

FIGURE 10.1: FARE COLLECTION TECHNOLOGY DEVELOPMENT



Keeping in view Metro Railways Automatic Fare Collection System and the fact that Contactless card/ token technology proves to be cheaper than other technologies in life cycle cost due to reduced maintenance as it has less wear and tear and is less prone to dusty environment, it is proposed to provide computer based automatic fare collection system with Contactless smart token/card type ticketing for the Kanpur MRTS.

The equipments for the same may be provided at each station viz. Automatic Fare Gates, Ticket Office Machines, Ticket Readers, Portable Ticket Decoders, Central and Station Computers, Passenger Operated Machines/ Ticket Vending Machines (POMs/ TVMs) and UPS. The typical AFC System Operation Process and Architecture is shown in **Figures 10.2** & **Figure 10.3** respectively.

The AFC System Central Computer (CC) has a capacity to cater for upto 256 stations. The AFC system shall also have functionality of interface to CCHS (Central Clearing House System) which is capable pf handling upto 32 operators and 10 million transactions with provision of integration with other transit (metro, bus etc) and non-transit (parking, toll etc) which may be planned in future in line with the state/ national policy.

FIGURE 10.2: AFC OPERATION PROCESS

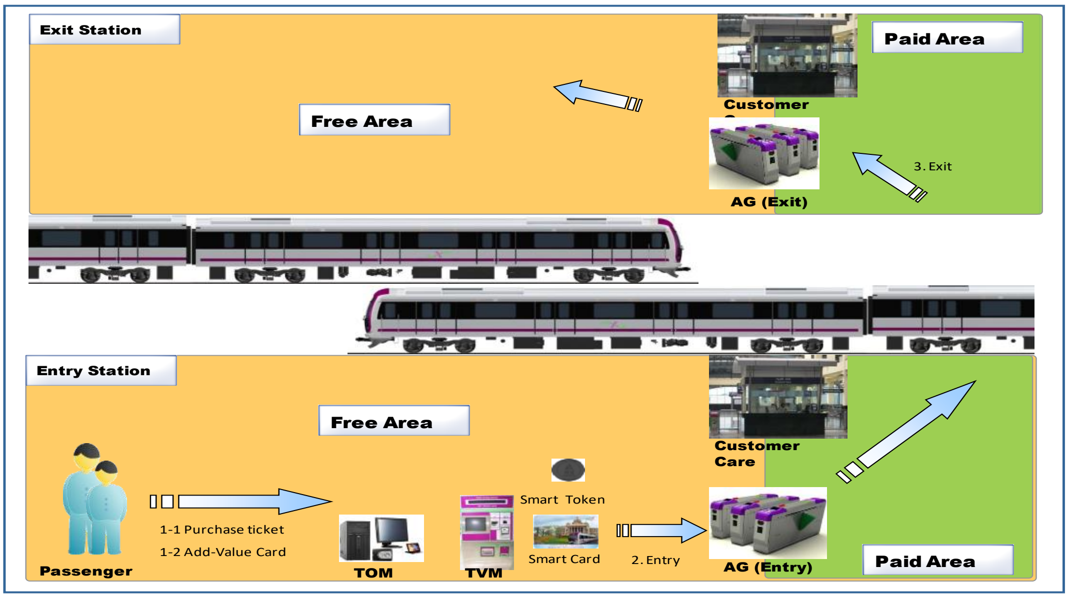
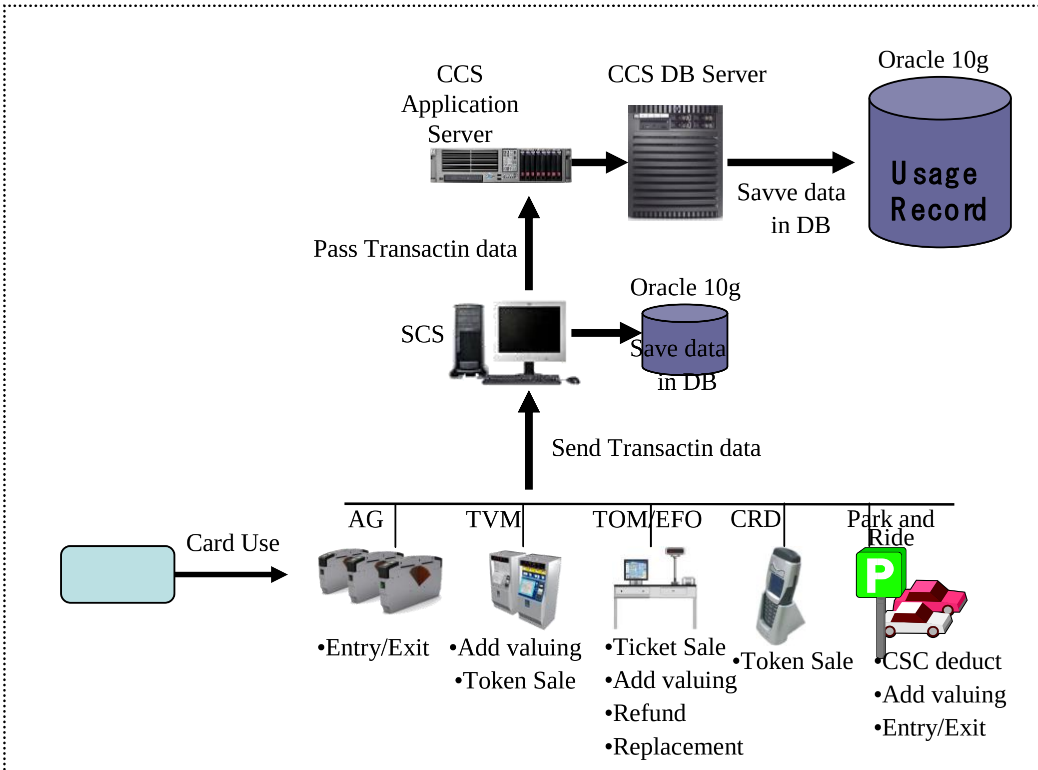


FIGURE 10.3: AFC SYSTEM ARCHITECTURE



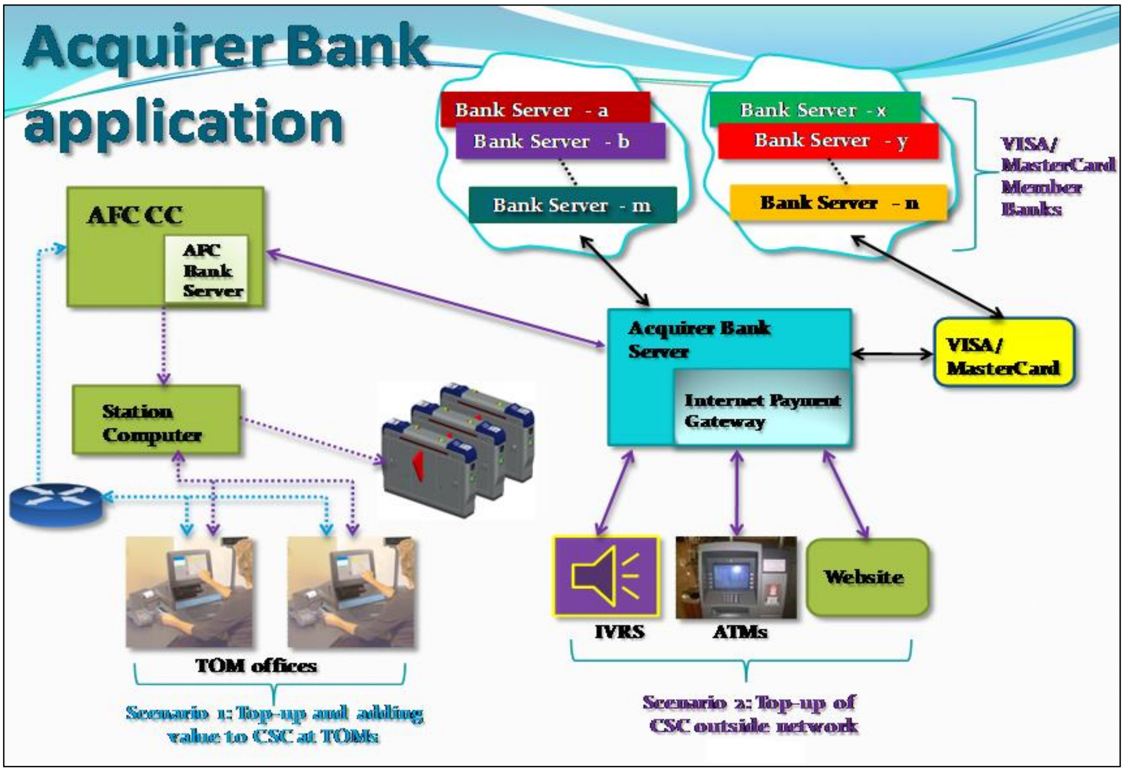
In addition, the proposed AFC system shall also be NFC (Near Field Communication) enabled so that customers can use their NFC enabled Mobile phones for metro travel. Facility of recharging of Travel Cards using Cash, Debit/ Credit Cards and Netbanking/ web portal shall also be available. AFC system shall also support offsite sales terminals also, wherein cards and tokens can be dispensed at locations outside metro premises.

10.2 AUTOMATIC FARE COLLECTION SYSTEM OPTIONS

A) Bank operator: AFC Ticketing system

Recent developments in the mass transit and financial payments industries have created opportunities for convergence and collaboration. The Banks are thus too keen to enter into the transit market. In the present dispensation the banks are only acting as a partner to distribute the combo cards. The ownership of card lies with bank, but the transit product on the card is owned by transit operator. Probably we can think of giving preferential treatment to passengers having links with acquirer Bank e.g. separate queue so that we reduce the rush at the counters. Banks will see this as value addition and probably will pay higher royalty. The Banking interface is shown in **Figure 10.4**

FIGURE 10.4: BANKING INTERFACE



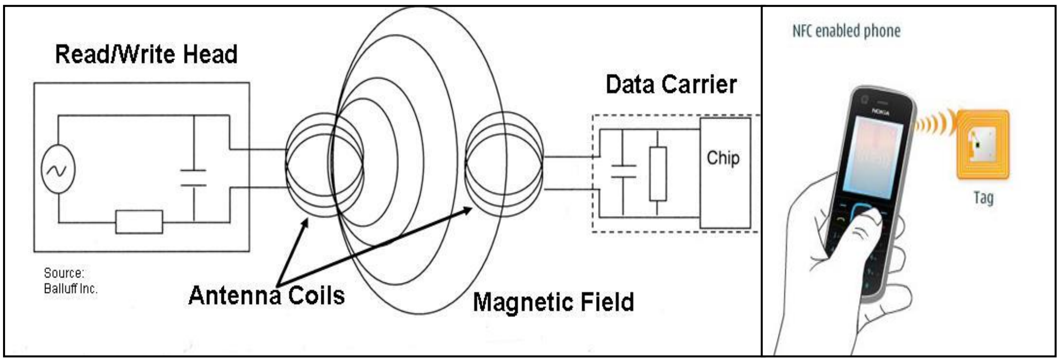
The scope of banks is to provide the following services:

- Providing POS terminals at ticket counters and Automatic Ticket Vending machines
- Topping-up of smart cards at ATMs
- Topping-up of smart cards through Net banking and Mobile banking
- Topping-up of smart cards through Payment gateway at website
- Topping-up of smart cards through Auto-top up using Standing Instructions from Bank customers/ commuter.

B) Near Field Communication (NFC)

It is a Wireless communication technology based on inductive-coupling, enables data transfer between machines and uses the concept of Radio Frequency Identification (RFID). RFID is a technology that does communication through radio waves, that exchanges data between an electronic tag put on an object and a reader. NFC works using magnetic induction between two loop antennas located within each other's 'near field' and its operating frequency is 13.56 MHz.data rate 106 kbit/s to 424 kbit/s. NFC use an initiator and a target; the initiator actively generates an RF field that can power a passive target. The near field communication is shown in **Figure 10.5.**

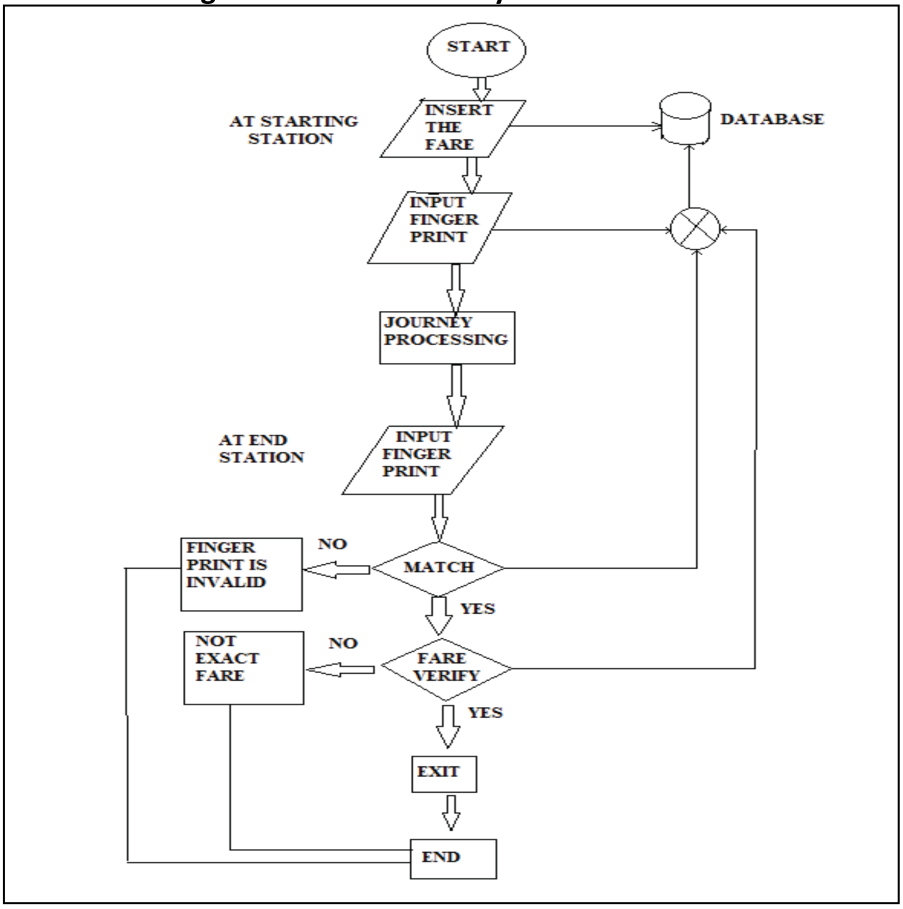
FIGURE 10.5: NEAR FIELD COMMUNICATION



C) Biometric System

The biometric system may easily be applicable to Railway Ticketing System Management in three ways: First, it takes an image of fingers by the finger print scanner machine. Second, it keeps the image as record in an easily manageable database. Lastly, when the passenger come in front of the biometric gate and touch the finger print, it tries to idetify and recognises the finger print from the previous database. The biometric system flowchart is shown in **Figure 10.6.**

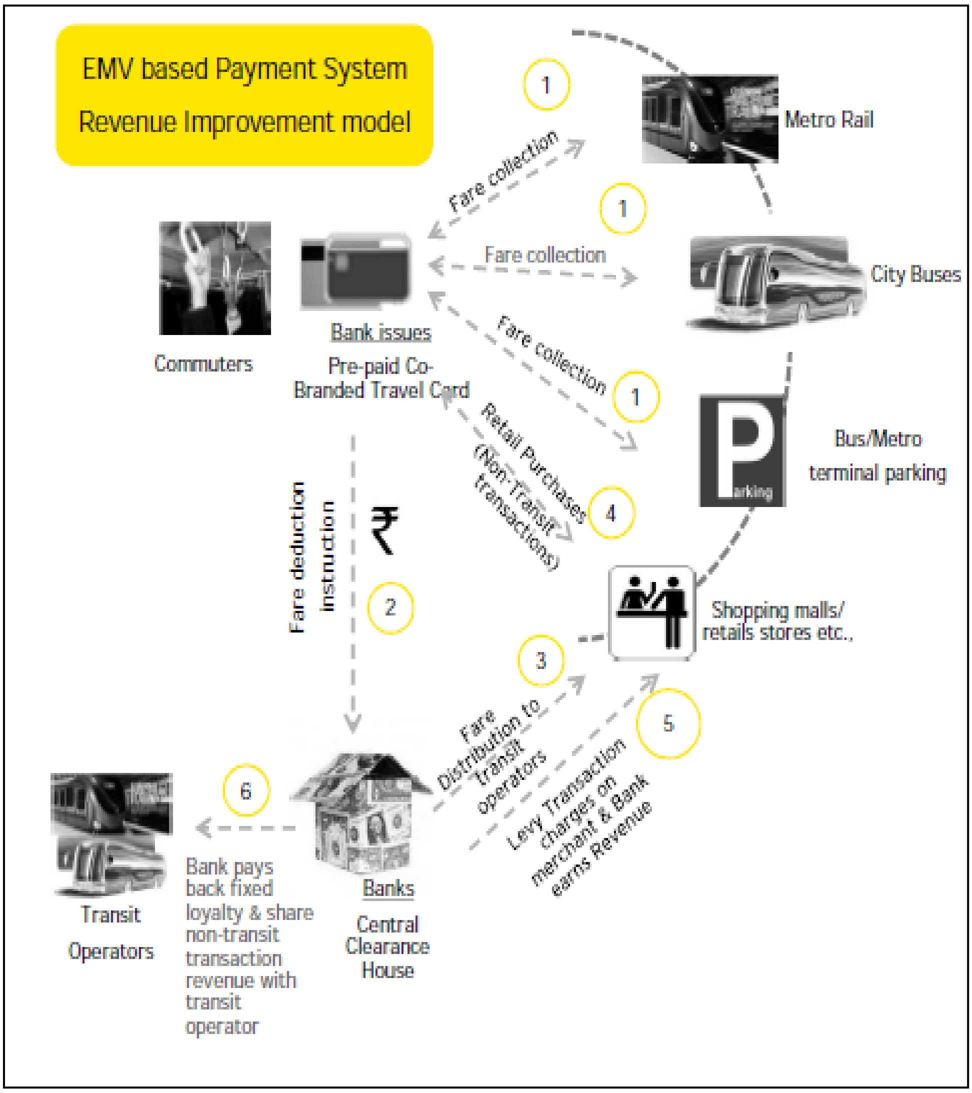
Figure 10.6: Biometric System Flow Chart



D) EMV Open Loop System

An EMV (Europay, Maser and Visa) a global standard is a credit or debit card with an embedded microchip designed to enable secure payment at compatible point of sale (POS) terminals. EMV cards can also support contactless payment through near-field communication (NFC) wireless connectivity. Transit Operator hires one or multiple financial institutions to issue a prepaid EMV enabled travel card to its commuters. The EMV based smart cards can be accepted within network of transit operator's terminals. The transit operators fare acceptance terminals would need EMV enabled card readers. The same card can be used on network of other payment methods at any merchant outlet. Model is convenient for a commuter as Transit Card and acts as an eWallet that can be used for all payment needs as single media. The EMV model also aids commuters to gain loyalty points for usage of cards on transit or non-transit network. The EMV based system is showm in **Figure 10.7.**

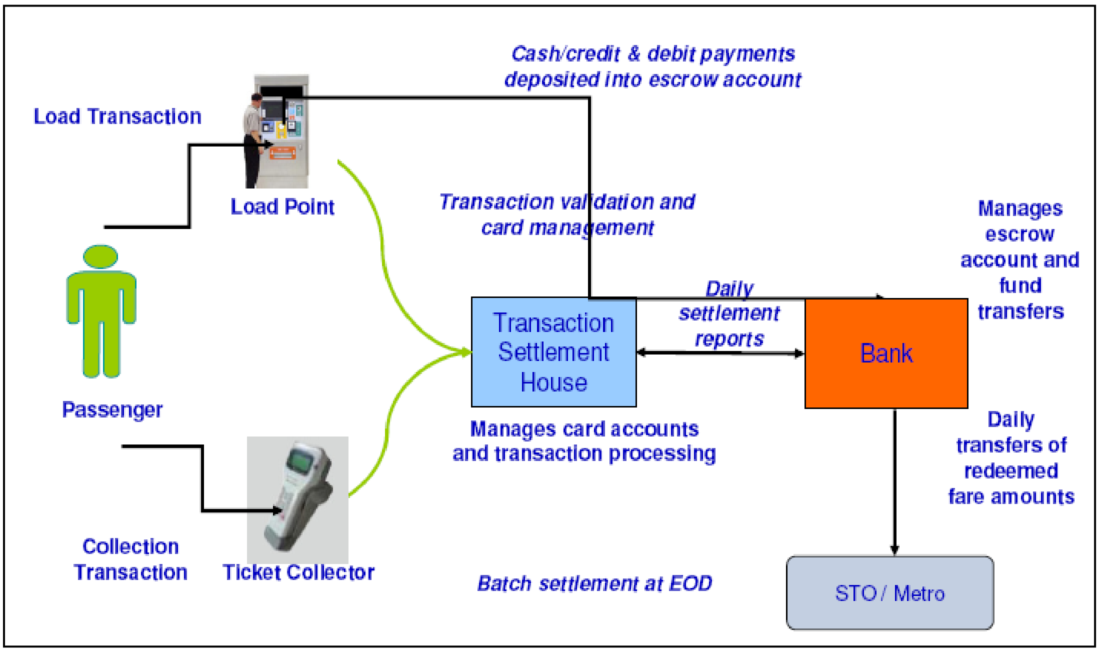
Figure 10.7: EMV based Payment System



10.3 COMMON MOBILITY CARD

Common Mobility Card (CMC) Smart Card will provide Common Fare Collection System across different operators (both Government and Private) and different modes of public transport. Tipped as a nationwide interoperable transport card, the card aims to be a single point of transaction, applicable in state buses, Metro and even parking. The whole system overview is presented in **Figure 10.8.**

FIGURE 10.8: COMMON MOBILITY CARD OVERVIEW



10.4 AFC SYSTEM EQUIPMENT STANDARDS

The standard equipment proposed for AFC systems are given in the **Table 10.1**.

Table 10.1: Standards proposed for AFC Systems

Equipment	Description
Fare media	**Contactless smart token** – For single journey. It will have stored value amount for a particular journey. Tokens will be captured at the exit gate. **Contactless smart card** – For multiple journeys.
Gates	Computer controlled automatic gates at entry and exit. There will be following types of gates: Entry Exit Reversible – can be set to entry or exit **Disabled –** Wide reversible gate for disabled people.
Station computer, Central computer and AFC Net work	All the **fare collection equipments** will 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 fiber communication channels. The centralized control of the system shall provide real time data of earnings, passenger flow analysis, blacklisting of specified cards etc.

Ticket office machine (TOM/EFO)	Manned **Ticket Office Machine** may be installed in the stations for selling cards/ tokens to the passengers.
Ticket reader and portable ticket decoder.	**Ticket reader will** be installed near EFO for passengers to check information stored in the token / cards.
Ticket Vending Machine (TVM)	**Ticket Vending Machines (TVMs)** having facility of issue of single journey tokens & recharge of travel cards using cash, debit/ credit cards shall be installed in non-paid areas.
UPS (uninterrupted power at stations as well as for OCC).	Common UPS of S&T system will be utilized.
Maintenance philosophy	Being fully Contactless system, manpower requirement for maintenance is much less compared to other systems. However, adequate facilities to be provided similar to that of S&T systems.

Chapter – 11
ROLLING STOCK

11. ROLLING STOCK

11.1 SELECTION OF TECHNOLOGY

The transport demand forecast for the corridors is the governing factor for the choice of physical parameters of the Rolling Stock viz. capacity, dimensions etc. Keeping in view, the traffic demand of the city, 2.9m wide coaches have selected for adoption in Kanpur Metro corridors. State of the art proven technology has been proposed for rolling stock of Kanpur corridors.

Following important criteria is proposed for selection of rolling stock:

- Passenger comfort & safety
- Proven equipment with high reliability
- Energy efficiency
- Light weight equipment and coach body
- High rate of acceleration and deceleration
- Optimized scheduled speed
- Flexibility to meet increase in traffic demand
- Aesthetically pleasing Interior and Exterior
- Low Life cycle cost

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

11.1.1 The selection of following technologies is proposed to ensure low life cycle cost.

(i) Car body

In the past carbon high tensile steel was invariably used for car bodies. In-fact almost all the coaches built by Indian Railways are of this type. These steel bodied coaches need frequent painting and corrosion repairs which may have to be carried out up to 4-5 times during the service life of these coaches. It is now standard practice to adopt stainless steel or aluminium car bodies.

(ii) Bogies

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

(iii) Braking System

The brake system shall consist of –

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

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

(iv) 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 traction motors required intensive maintenance because of commutators and electro-mechanical contractors, 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 Kanpur Mass Rapid Transit System, three phase AC traction drive with VVVF control is recommended for adoption.

(v) Interior and Gang Ways

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

(vi) Passenger Doors

For swift evacuation of the passenger in short dwell period, four doors of adequate width, on each side of the coach may be considered. These doors shall be of such dimensions and location that all the passengers inside the train are able to evacuate within least possible time without conflicting movement. Automatic door closing mechanism is envisaged from consideration of passenger safety.

(vii) Air Conditioning

With passenger loading of 6 persons/ m^2 for standee area and doors being closed from consideration of safety and with windows being sealed type to avoid transmission of noise, the air conditioning of coaches is considered essential. Each coach shall be provided with two air conditioning units capable of automatically controlling interior temperature throughout the passenger area at all times under varying ambient condition up to full load. For emergency situations such as power failure or both AC failures etc ventilation provision supplied from battery may be made.

(viii) Cab Layout

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

11.1.2 Broad Features of Rolling Stock

a) Rolling Stock proposed for the Kanpur MRTS corridors will be similar to Delhi Metro. The specifications of the rolling stock and its procurement may be decided on the basis of the project implementation mechanism. The broad features of Rolling Stock which may be followed are indicated in **Table 11.1**.

TABLE 11.1: BROAD FEATURES OF ROLLING STOCK

S. No.	Parameter	Rolling Stock
1	Basic Unit	3 Car basic unit 2 DMC and 1 TC. Every coach should be fully interchangeable with any other coach of same type.
2	Train Composition	3- Car: DMC-TC-DMC 6 –Car: DMC-TC-MC-MC-TC-DMC
3	Coach construction	Light weight stainless steel/Aluminum body
4	Axle load	≤16 T
5	Braking System	Regenerative Braking
6	Propulsion system	3 phase drive system with VVVF control
7	Type of traction supply	25kV AC OHE system

b) Coach Dimensions

The following dimensions of the coach are proposed for Kanpur Metro **(Table 11.2).**

TABLE 11.2:COACH DIMENSIONS

Type of 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*

c) 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, 6 persons in crush state of peak hour and 8 persons in dense crush state of peak hour.

The train composition is proposed as 3 - Car Train (DMC+TC+DMC) and 6- Car (DMC+TC+MC+MC+TC+DMC). The carrying capacity of Metro Rail Vehicle is indicated in **Table 11.3** below:

TABLE 11.3:CARRYING CAPACITY OF METRO RAIL

Description	Driving Motor Car (DMC)			Trailer Car (TC)/ Motor Car (MC)			3 Car Train			6 Car Train		
	Normal	Crush	Dense Crush	Normal	Crush	Dense Crush	Normal	Crush	Dense Crush	Normal	Crush	Dense Crush
Seated	43	43	43	50	50	50	136	136	136	286	286	286
Standing	103	205	273	110	220	293	316	630	839	646	1290	1718
Total	146	248	316	160	270	343	452	766	975	932	1576	2004

Normal - 3 Per/sqm of standee area, **Crush**- 6 Per/Sqm of standee area, **Dense Crush** – 8 Per/Sqm of standee area.

d) Weight

The weights of motor cars and trailers are estimated in **Table 11.4**, considering the average passenger weight as 65 kg.

TABLE 11.4: WEIGHT OF MASS RAIL VEHICLES (TONS)

Description	DMC	TC	MC	3 Car	6 Car
TARE WEIGHT (Max.)	40	40	40	120	240
Passenger					
(Normal@3p/m^2)	9.43	10.40	10.40	29.25	60.45
(Crush@6p/m^2)	16.06	17.55	17.55	49.66	102.31
(Crush@8p/m^2)	20.48	22.30	22.30	63.25	130.13
Gross					
(Normal@3p/m^2)	49.43	50.40	50.40	149.25	300.45
(Crush@6p/m^2)	56.06	57.55	57.55	169.66	342.31

Description	DMC	TC	MC	3 Car	6 Car
(Crush@8p/m^2)	60.48	62.30	62.30	183.245	370.13
Axle Load @6p/m^2	14.01	14.39	14.39		
Axle Load @8p/m^2	15.12	15.57	15.57		

The axle load @ 6persons/m^2 of standees works out in the range of 14.01T to 14.39T per coach.Heavy rush of passengers with loading @ 8 standees per sq. meter can be experienced occasionally during peak hours. It is recommended to design the coaches 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.

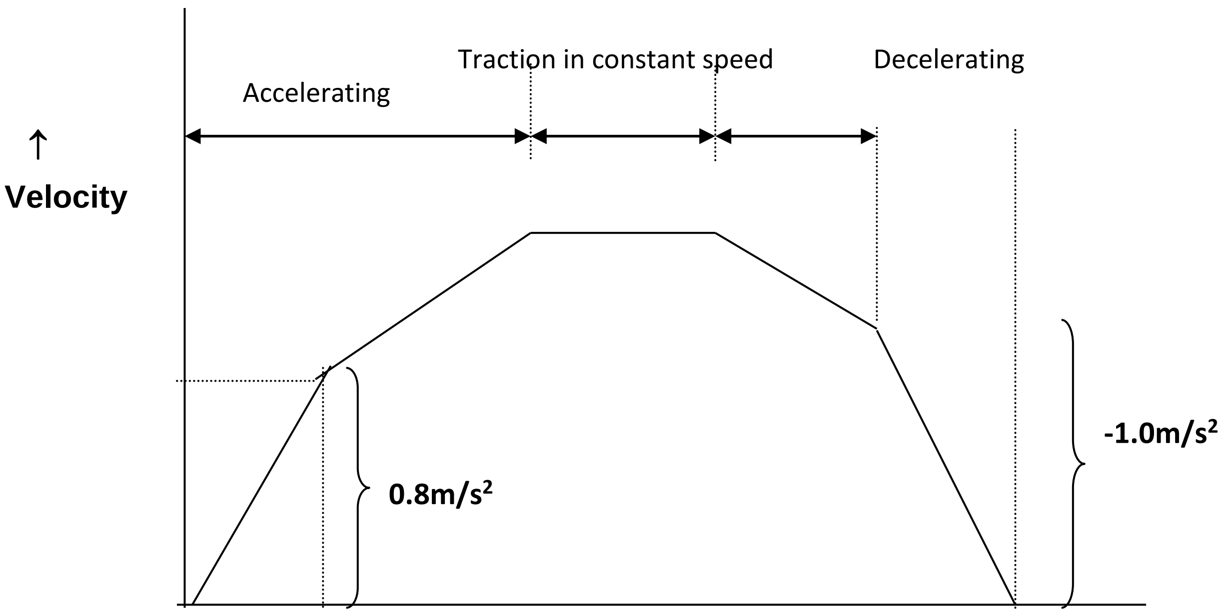
e) Performance Parameters

To achieve the desired schedule speed and running time between stations, the following values of acceleration and deceleration are recommended in consideration of riding comfort, adhesion and requirement of makeup time.

- Max. Design speed : **90 kmph**
- Max. Acceleration : **0.8 m/s^2**
- Max. Deceleration : **1.0 m/s^2 (Normal brake)**

  More than **1.3 m/s^2 (Emergency brake)**

Figure 11.1: SIMPLIFIED VELOCITY – TIME OPERATION CURVE



11.2 ROLLING STOCK REQUIREMENT

Rolling Stock requirement for different horizon years has been calculated based on the train operation plan. The calculation for the rake requirement of the two corridors for different horizon years has been given in Chapter 8 – Train Operation Plan. The coach requirement for the corridors of Kanpur Metro is given in Table 11.5:

Table 11.5: COACH REQUIREMENT FOR KANPUR CORRIDORS

Corridor	2024	2031	2041	2051	Design
IIT Kanpur – Naubasta	117	132	168	210	282
Agriculture Univ. – Barra 8	39	48	60	72	102

Chapter – 12
POWER SUPPLY & TRACTION

12. POWER SUPPLY & TRACTION

12.1 CHOICE OF ELECTRIC TRACTION SYSTEM

Traditionally, electric traction has been used to meet the requirement of high acceleration, pollution free services and to achieve the optimum performance in urban, Sub-urban and main line rail transport system. Selection of an appropriate technology for traction system may be based on following factors:

- Cost of the technology
- Previous experience & proven-ness
- Maintenance requirements
- Energy Efficiency
- Aesthetics, Economic viability & Sustainability

The Cost of traction power system depends upon the following factors:

- Maximum power demand of load
- Level of redundancy & reliability
- Land Cost particularly for Traction Sub-station and Sectioning Posts
- Availability of technology and equipment at Competitive price

There are three standard and proven systems of electric traction for use in suburban and metro lines:

- 750 V DC Third Rail System1500 V
- 1500 V DC Third Rail/ Overhead Catenary System
- 25 KV AC system

The merits and demerits of these systems are as follows;

12.1.1 750 V DC Third Rail System

750 V DC third rail system is the most primitive traction system which has been extensively used in metros and more than 60% of existing metro systems in the world utilize 600-750V DC third rail system. However, the traffic handling capacity of this system

is limited to 60,000 PHPDT.

Kolkata, Bangalore and Kochi metro are operational with 750V DC Third Rail system. Kolkata Metro was built with the primitive technologies i.e. use of Steel third rail with top contact, non-air conditioned rakes with tunnel air conditioning and non-regeneration. Bangalore Metro is using the advanced technology with Al composite third rail, air conditioned coaches and VVVF control of traction motor with regenerative braking.

750 V DC third rail system offers the best aesthetic solution because of the absence of any overhead conductors and supporting structures. The 750V dc third rail needs very little maintenance since by virtue of its solid rigid design it is able to withstand passing of current collector devices of the train without any significant wear & tear. However, maintenance of substation costs more as they are more in numbers. Because of lower voltage, the 750V DC traction power system handles much higher operating current resulting into higher voltage drop and line losses along the third rail distribution system. This necessitates closer spacing of sub-stations, leading to higher cost of construction. The presence of live third rail at ground may be hazardous to safety of commuters and maintenance personnel if they fail to adopt safety precautions.

In a third rail system, where the running rails are used as a return path, a part of the stray current leaks into the track structure. This current is called Stray current. The stray current corrosion is often encountered in DC-Electrified systems and therefore, suitable measures are required for protection against corrosion of metallic components in the track-structures as well as metallic reinforcement and metal pipes etc in the vicinity of metro alignment.

12.1.2 1500 V DC Third Rail/ Overhead Catenary System

1500V DC Third Rail/ Overhead Catenary System have been adopted by few metros to overcome the limitation imposed by 750V DC system for catering to traffic of 60,000-80,000 PHPDT. The voltage drop and line losses are lesser than the 750V DC system but much higher than the 25kV ac traction system.

The 1500V DC third rail system has been adopted in Chinese Metros by Guangzhou Metro and Shenzhen Metro during last decade from aesthetics and reliability considerations. It can meet higher traffic needs with low tunnel diameter. There is not much experience over use of 1500V DC third rail system and also it has major constraints on requirement of power block for any kind of attention to track, signalling, other equipment and side evacuation.

The 1500V DC Overhead Catenary System requires use of catenary masts on elevated viaducts thereby affecting aesthetics of the city. Overhead catenary may be prone to lightning and thunderstorm. In addition, suitable measures are required to manage the stray currents which may cause corrosion of metallic structures.

12.1.3 25 KV AC System

25 KV AC traction system has been adopted by Delhi, Jaipur, Chennai and Hyderabad metro rail corporations as well as Indian Railways. The system has the potential to carry large traffic (60,000-100,000) PHPDT and possibility of linking to mainline railways, if required.

In comparison to DC systems, the regeneration capacity for 25 KV AC system is more and the line losses are less. In case of 25KV AC traction, 100% recovery of regenerated energy is possible compared to 60% in case of 750 V DC if no special measures are taken to recover the regenerated energy. Energy saving on account of regenerative breaking is about 25-35% of traction energy in case of 25kV AC traction as compared to about 20% in case of 750V DC traction. This makes the 25kV AC traction system more energy efficient.

Suitable measures are required for mitigation of electro-magnetic interference (EMI) caused by single-phase 25kV AC traction currents. 25kV AC train will require the heavy transformers to be carried in the motor coach which will increase the weight and hence there will be an increase in the energy consumption. Unlike DC traction this system does not require substations at frequent intervals due to high voltage, reduced current levels and lower voltage drops as a result, there is substantial reduction in costs. Overall cost of land and equipments for 25kV AC traction system is significantly lower compared to that for 1500V AC or 750V DC traction system. In addition, it is widely used traction system on Indian Railways with availability of proven indigenous technology for all the components of 25 kV AC system.

12.1.4 Advantages of 25kV AC Traction System over 1500V DC or 750V DC System

The selection of proper traction system has a significant impact on capital cost, operational cost, traffic growth, operational flexibility and expandability of the system in future. It is also linked to the ultimate capacity being planned. Appropriate selection of traction system at design stage is essential to achieve optimum performance of a MRTS system.

25 KV AC is most economical followed by 1500 V DC and 750 V DC traction systems both from initial cost point of view as well as energy efficiency. But from the aesthetic point of view, 750 V DC Third rail system is better. 25 KV AC system has an ability to carry a high traffic at a reduced cost with higher efficiency of operation. Considering the ultimate traffic demand and the techno economic advantages offered by 25 kV AC system, it is proposed to adopt 25 kV AC system for Kanpur MRTS.

The elevated and at grade sections of the corridors will be provided with flexible OHE (Overhead Equipment) whereas the underground sections will be provided with the rigid overhead catenary system.

12.2 PROJECTED POWER DEMAND

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

The Power Supply System design has been conceptualized considering 6 car rake and train operation at 2.4 minutes and 3.2 minutes headway for IIT Kanpur to Naubasta corridor and Agriculture University to Barra-8 corridor respectively. The designed system shall ensure high reliability and adequacy of the system to meet unforeseen growth in traffic demand.

The ultimate (design) power requirement for this corridor will be conceptualized considering following norms, directives/guidelines,

- Train operation with 6 car rakes with carrying capacity of 1576 passengers (standing @ 6 passengers/ m²).
- Peak period headway of 2.4 minutes for IIT Kanpur to Naubasta corridor and 3.2 minutes headway for Agriculture University to Barra-8 corridor.
- Specific energy consumption of rolling stock – 75 KWh / 1000 GTKM
- Regeneration @ 30%
- At grade/ Elev. station load – initially 200kW, ultimate design 300 kW
- Underground station load – initially 2000kW, ultimate design 2500 kW
- Depot auxiliary load – initially 1500kW, ultimate design 2000 KW
- Power factor of load – 0.9
- Transmission losses @ 5%

Keeping in view of the above norms, the power demand estimation for the proposed metro corridors is given in **Table 12.1**.

TABLE 12.1 : POWER DEMAND ESTIMATION (MVA)

Corridor	IIT Kanpur to Naubasta Corridor					Agriculture Univ. to Barra-8 Corridor				
Year	**2024**	**2031**	**2041**	**2051**	**Design**	**2024**	**2031**	**2041**	**2051**	**Design**
Traction	12.00	13.90	17.28	21.56	29.30	3.96	5.01	6.56	7.03	9.74
Auxiliary	23.68	25.40	27.13	28.85	30.57	12.25	13.13	14.00	14.88	15.75
Total	**35.69**	**39.31**	**44.41**	**50.40**	**59.87**	**16.21**	**18.14**	**20.56**	**21.91**	**25.49**

The calculations for the traction and auxiliary power demand estimation are shown in **Annexure 12.1 (a) and Annexure 12.1 (b)**. This requirement has been worked out based on the conceptual design and therefore, needs to be reaffirmed and fine-tuned by conducting necessary simulation study during detailed design stage of project implementation.

12.3 SOURCES OF POWER SUPPLY

12.3.1 Need for High Reliability of Power Supply

The proposed metro corridors viz. IIT Kanpur to Naubasta and Agriculture University to Barra-8 are being designed to cater to about 40,000 and 30,000 passengers respectively per direction during peak hours (PHPDT) when trains are expected to run at high frequency of 2.4 minutes and 3.2 minutes respectively. 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. Effect on signal and communication may affect train operation and passenger safety as well. Therefore, uninterrupted power supply is mandatory for efficient metro operations.

In order to ensure high reliability of power supply, feed from more than one Receiving Sub Station (RSS) have been planned for the proposed corridors. Under normal circumstances, each RSS will feed specific sections of the corridor. In case of emergency condition i.e. when one RSS fails, the other RSS will feed the section of the RSS under outage. Therefore, it is essential that all the sources of supply and connected transmission & distribution networks are reliable and have adequate built in redundancies.

12.3.2 Sources of Power Supply

Kanpur City has 220kV, 132kV, 33kV power transmission and distribution network to cater to various types of demand in the vicinity of the proposed corridor. Keeping in view of the reliability requirements and considering the complete length of corridors, three Receiving Substations (RSS) are proposed to avail power supply for traction as well as auxiliary services from the U.P. Power Transmission Company Limited (UPPTCL) grid sub-stations at 220kV voltage through transmission lines or cable feeders for proposed Kanpur Metro corridors.

M/s UPPTCL has confirmed the availability of power supply at Bithoor (220kV), Phoolbagh (220kV) and Gujaini (220kV) Grid Substations (GSS) vide letter no. 4297 C.E.(TS)/Ag/ dated 16.07.15 (**Annexure 12.2**). The Receiving substations (220/33/25 kV) planned for the power requirements of the corridors of Kanpur Metro with the respective feeding zones and the length of cables of from the Grid Substations is shown in **Table 12.2.**

TABLE 12.2 : SOURCES OF POWER SUPPLY

Grid sub-station	RSS of Metro Authority	Feeding Zone	Distance from GSS to RSS
Bithoor GSS (220/33kV)	IITK RSS (220/33/25kV)	IIT Kanpur-Phool Bag Ch (-450 to Ch 12913)	5.5 km
Phoolbagh GSS (220/33 kV)	Phool Bag RSS (220/33/25 kV)	Phool Bag- Naubasta Ch (12913 to Ch 23250)	1 km
Gujaini GSS (220/33 kV)	Barra RSS (220/33/25 kV)	Agriculture Univ. to Barra-8 Ch (-800 to Ch 8170)	2.5 km

The location of the Grid Substation and respective RSS planned for the corridors of Kanpur Metro with approximate length of the cables from GSS to RSS is indicated in the **Figure 12.1.**

FIGURE 12.1: LOCATION OF GRID SUBSTATION AND RECEIVING SUBSTATION

The HT power supply from grid substations at 220kV will be stepped down to 25kV single phase supply for traction purpose and 33kV supply for auxiliary power supply at the Receiving cum Traction Substations (RSS/ TSSs) of MRTS authority. The traction power will be fed to 25kV OHE system through cable feeders and the auxillary power will be distributed along the alignment through 33kV Ring main cable network for feeding auxiliary loads. These cables will be laid in dedicated ducts/ cable brackets along the viaduct/ tunnel. The summary of expected power demand at various sources is given in **Table 12.3**.

TABLE 12.3 : POWER DEMAND PROJECTION FOR VARIOUS SOURCES

Name of RSS	Peak Demand – Normal (MVA)					Peak Demand – Emergency (MVA)				
	2024	**2031**	**2041**	**2051**	**Design**	**2024**	**2031**	**2041**	**2051**	**Design**
Bithoor GSS to IITK RSS (Feeding Zone (IIT Kanpur-Phool Bag))										
Traction	6.00	6.95	8.64	10.78	14.65	12.00	13.90	17.28	21.56	29.30
Auxiliary	10.85	11.70	12.54	13.39	14.23	23.68	25.40	27.13	28.85	30.57
Total (A)	**16.85**	**18.65**	**21.18**	**24.17**	**28.88**	**35.69**	**39.31**	**44.41**	**50.40**	**59.87**
PhoolBagh GSS to Phoolbagh RSS (Phool Bag -Naubasta)										
Traction	6.00	6.95	8.64	10.78	14.65	12.00	13.90	17.28	21.56	29.30
Auxiliary	12.83	13.71	14.58	15.46	16.33	23.68	25.40	27.13	28.85	30.57
Total (B)	**18.84**	**20.66**	**23.23**	**26.24**	**30.98**	**35.69**	**39.31**	**44.41**	**50.40**	**59.87**
Gujaini GSS to Barra RSS (Feeding Zone (Agriculture University-Barra-8))										
Traction	3.96	5.01	6.56	7.03	9.74	9.97	11.96	15.20	17.81	24.39
Auxiliary	12.25	13.13	14.00	14.88	15.75	23.10	24.82	26.54	28.26	29.98
Total (C)	**16.21**	**18.14**	**20.56**	**21.91**	**25.49**	**33.07**	**36.78**	**41.74**	**46.07**	**54.37**

For IIT Kanpur-Naubasta Corridor in normal conditions, IITK RSS will feed the section from IIT Kanpur to Bada Chauraha, Phoolbagh RSS will feed from Bada Chauraha to Naubasta and Barra RSS will feed Agriculture University - Barra-8 Corridor. In case IITK RSS fails, the feed can be extended from Phoolbagh RSS or Barra RSS. In case of failure of Phoolbagh RSS, then IITK RSS will feed from IIT Kanpur to Naubasta i.e. complete length of the corridor and in the eventuality of failure of Barra RSS, IITK RSS will feed the additional section from Agriculture University to Barra-8.

The equipment rating of the RSS cum TSS will be determined considering the normal as well as emergency situation. When one RSS fails, the traction supply will be maintained by extending feed from adjoining RSS. However, in case of total grid failure, all trains may come to a halt but emergency lighting, fire, hydraulics and other essential services can be catered to by stand-by UPS/ DG sets. A typical high voltage receiving sub-station is shown in **Figure 12.2.**

FIGURE 12.2 : TYPICAL HIGH VOLTAGE RECEIVING SUB – STATION (RSS)

The high voltage transmission lines or cables will be laid through public pathways from UPPTCL Sub-stations to RSS of Metro Authority.

Based on emergency demand expected at each RSS (**Table 12.3**), 2 traction transformers of 220/25 kV, 30 MVA (ONAN)/42 MVA (ONAF) capacity each at Phoolbagh RSS, Kanpur South RSS and Gujaini RSS are proposed. Similarly, 2 nos. Auxiliary transformers (220/33 kV) of 30 MVA capacity each are proposed to be provided at all the three RSSs. Indoor type Gas Insulated Substation (GIS), which offers the advantage of considerable saving in space requirement as well as reduced maintenance, is proposed for each Receiving cum Traction substation. Each of three RSS/ TSS would require land plot of about size 50m x 60m (3000 m^2).

33kV and 25kV switchgear shall be rated for 1250 A being standard design. 33kV XLPE insulated FRLSOH cable ring network is proposed for Aux. ring main network, which shall be adequately rated to transfer requisite auxiliary power during normal as well as emergency situations.

Adequate no. of cables is required for transfer of traction power from Metro’s RSS to 25kV Rigid OCS. Single-phase XLPE insulated cables with 240 mm^2 copper conductors are proposed for traction power. Based on current requirements, 2 cables are required for each of the six circuits to feed power to 25kV 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 and fine-tuned during detailed design stage of project implementation.

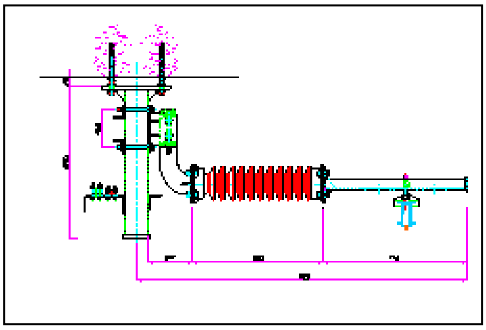
12.4 TRACTION POWER SUPPLY

12.4.1 25 KV Rigid OHE System

The proposed 25kV Rigid OHE system in underground section is similar to the one installed in underground sections of Delhi Metro. 25kV Rigid OHE system **(Figure 12.3)** comprises a hollow Aluminum Conductor Rail of adequate cross section with 150 sq.mm copper contact wire held with elastic pinch. The Al conductor rail is supported by an insulator and cantilever arrangement attached to drop-down supports fixed to tunnel roof. The supports are located at every 10 metre and there is no tension in the conductors and hence, no tensioning equipment is required in tunnel. The design of 25kv rigid OHE system shall be in accordance to electrical clearances and contact wire height as per IEC 60913 and EN50122, which is summarized below:

- Contact wire height = 4324mm (with Panto locked down height of 4048mm)
- Structure to Live parts clearances = 270/170/150mm (Static/Dynamic/Abs. min dynamic)
- Vehicle to Live parts clearances = 290/190/150mm (Static/Dynamic/Absolute/ min dynamic)

FIGURE 12.3 : 25KV RIGID OHE ARRANGEMENT

12.4.2 25 KV flexible Overhead Equipment System

25 kV ac Flexible Overhead equipment system shall comprise 150 sq mm HD-copper contact wire and 65sqmm Cd-copper catenary wire. Return conductor (RC) shall be All Aluminum Conductor (AAC) of 233 sq mm cross section. From

safety considerations, Hydraulic type Auto-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.

12.5 AUXILIARY POWER SUPPLY

12.5.1 The auxiliary power will be required for

- Lights & fans for station
- Service Buildings
- Foot over Bridges/Subways.
- Maintenance Depots
- Air-conditioning
- Lifts
- Escalators
- Water Supply Pumping Stations – for washing, toilets as well as fire protection measures.
- Equipment – Signalling, Telecom, Automatic Fare Collection etc.

Auxiliary sub-stations (ASS) are envisaged to be provided at each station for stepping down 33kV supply to 415V for auxiliary applications. The ASS will be located at mezzanine or platform level inside a room. The demand of power at each elevated station is expected to be about 200 kW in the initial years and is likely to reach 300 kW in the horizon year. Similarly, for the underground stations, the auxiliary load requirements have been assessed at 2000 kW for underground station which is likely to increase to 2500 kW in the horizon year. The average load considered for elevated station and underground station will have to be fine tuned to suit station requirement at the time of detailed design.

Each elevated station shall be provided with an Auxiliary Substation with two 33kV/415V, 3-phase, 500 kVA dry type cast resin transformers and the associated HT & LT switchgear. In addition, provision shall be made for one DG set at each station for emergency loads. Two transformers (33kV/415V, 3-phase) of 2500 kVA at each underground ASS for the underground stations are proposed to be installed (one transformer as standby). Apart from stations, separate ASS is required at each depot with 2x2500 kVA auxiliary transformers to cater to depot cum workshop load.

FIGURE 12.4: TYPICAL INDOOR AUXILIARY SUB-STATION (ASS)

12.5.2 E&M Systems

a) LT Power Distribution

33 kV ring main cables running all along the route shall feed each ASS by loop in loop out arrangement. The 33 kV power supply is stepped down to 415 V, 3 phase for distribution to the consumption points (service utilities) viz. Elevators, Escalators, Light & power sockets, Fire system, HVAC system and Signal & Telecom system etc.

The power distribution system shall be designed by using low voltage power cable run on the cable tray, raceway and conduit as suitable to supply power to various loads within station and buildings. The low voltage power distribution cables shall comply with IEC 60502 or other applicable international standard. Fire resistant cables shall be used for safety purpose and comply with the performance requirements of IEC 60331 and BS 6387.

b) Illumination System

For Illumination generally, all lighting fixtures shall be applied with 240V, single phase 50Hz power supply. The type and quality of fittings and their luminous intensity shall relate to the space being illuminated and will take into account the effect of architectural space concept and colour scheme as per IS 3646.

The LED lights offer advantages over conventional fluorescent lighting on account of Energy savings, lower life cycle cost, longer life span, rugged nature etc. Considering the benefits of LED light fixtures over the conventional/ fluorescent fixtures, the use of LED light fixtures is recommended at elevated and underground stations of the corridor and the office buildings of the depot. However, the conventional fluorescent light fittings may be adopted at selected locations wherever payback period for additional cost of LED light is much higher or non availability of efficient and proven LED light fixtures such as Medium/ High Bay lighting of high wattage (250W – 400W) in depot.

c) Lifts and Escalators

Lifts and escalators shall be provided at each station for the convenience of the passengers. The power supply for the operation of lifts and escalators is fed from the Auxiliary substation at each station. The number of lifts and escalators proposed to be provided for the passengers at each station of Kanpur Metro corridors is given in **Table 12.4.**

TABLE 12.4: LIFTS & ESCALATORS AT STATIONS

Corridor	Lift	Escalator
IIT Kanpur to Naubasta		
Elevated Stations	**58**	**83**
UG Stations	**26**	**70**
Total	**84**	**153**
Agricultural University to Barra-8		
Elevated Stations	**21**	**31**
UG Stations	**11**	**32**
Total	**32**	**63**
Grand Total	**116**	**216**

d) Fire Detection and Alarm System

The Fire Detection & Alarm System shall be in conformance to the applicable NFPA standard or Other International Standards &also comply with the codes of practice, standards, regulations and requirements of the Statutory Authorities. The coordination of Fire Detection & Alarm System with the following services should be verified, tested, and validated as a complete system before implementation-

i. Fire Detection & Alarm System,
ii. Public Address & Voice Alarm System,
iii. Emergency Lighting System,
iv. Conveying Systems (Lifts & Escalators),
v. HVAC systems (AHUs / fire dampers / staircase pressurization fans / chillers, motorized dampers / exhaust fans etc),
vi. Fire Fighting Systems (Fire Pumps / Sprinkler Valves),

vii. Automatic Doors,

viii. Traction SCADA,

ix. E&M SCADA,

x. Rolling Shutters,

xi. Networking of main fire alarm system, at station to the station control room, and backnet Interface on TCP/IP for third party systems.

xii. Systems not listed above but that requires interfacing with the Main Fire Alarm System.

E) Fire Suppression

- **Portable Fire Extinguishers**

The portable fire extinguishers shall be installed at all the stations in compliance with relevant BS EN Codes and codes of practice, standards, regulations & requirements of the Statutory Authorities. All the covered areas should be provided with suitable type of fire extinguishers. In the Concourse and Platform areas Fire Extinguishers shall be provided in a central location inside a suitably sized cabinet of approved construction. The location and design of the extinguisher cabinets provided shall comply fully to the local fire authority requirements.

Extinguishers shall be conspicuously located in positions where they will be readily accessible and immediately available in the event of fire. They shall be located near to room exits, corridors, stairways, lobbies and landings. Extinguishers shall be installed at a height of 1 metre above the floor level and shall be placed in a manner such that the extinguisher operating instructions face outward.

- **Wet Mains System**

The Fire Fighting wet mains system shall be based on BS- 9990: 2006, BS-9999: 2008 & National Building Code. The system shall comprise pipe work, breeching inlets, landing valves, automatic air release valves, fire hose cabinets and fire hose reels etc.

The wet mains system is charged by the Fire pumps set. The fire pump set shall have dual power supply and the system shall be designed to achieve a pressure of 3.5 Bar at the remote fire hydrant point. The system will draw water from the fire water storage tank provided near station building based on the NBC requirements.

Fire Hose Cabinets

The Fire Hose Cabinets shall be provided as per NBC and fire authority regulations in internal and external public areas of the station.

Fire Hose Reels

The hose reels shall meet the requirements of BS 5306.1: 2006 & BS EN 671 – 3:2004. Hose-reel shall be provided in such a way that it covers the entire Concourse/ Platform areas with suitable number of fire hose cabinets. The hose reels system will be based on direct feed from the Fire Water Wet mains.

Hose-reels shall be of the swing-recessed type. Each hose-reel shall be an integral unit consisting of a stop valve, reel, hose, and shut-off assembly. It shall be designed so as to facilitate the swift withdrawal of the hose in any direction with the reel axis horizontal.

- **Gas Flooding System**

  Gas Flooding System is proposed to be provided for protection of the equipments in electrical Auxiliary sub-stations and S&T Equipments in Depot Control Centre/ Operational Control Centre. The design of the system shall be in conformance to NFPA standards.

12.5.3 Standby Diesel Generator (DG) Sets

In the unlikely event of simultaneous tripping of all the RSSs or grid failure, the power supply to stations as well as to trains will be interrupted. It is, therefore, proposed to provide standby DG set of 180 kVA at all elevated stations and 2 x 1000 kVA capacity at underground stations to cater to the following essential services,

- Lift Operation
- Essential Lighting
- Signalling & Telecommunications
- Firefighting System
- Fare Collection System

Silent type of DG sets, which have low noise levels and do not require separate room for installation, are proposed. In addition, UPS with adequate power backup may be installed for the very essential lighting load.

12.6 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 cables 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. The SCADA system is shown in **Figure 12.5.**

FIGURE 12.5: SCADA SYSTEM

12.7 ELECTROMAGNETIC INTERFERENCE (EMI) & ELECTROMAGNETIC COMPATIBILITY (EMC)

25kV ac traction currents produce alternating magnetic fields that cause induced voltages in any conductor running along the track. Booster Transformer and Return Conductor (BT/RC) system is proposed for EMI mitigation.

Earthing & Bonding of the power supply & traction system shall be designed in accordance with the latest standards EN50122-1, IEEE80, IS3043 etc. Two earth conductors – Overhead Protection Cable (OPC) and Buried Earth Conductor (BEC) are proposed to be laid along with track. All the concrete and metallic structures, structural reinforcement, running rails etc. will be connected to these conductors to form an equiv-potential surface & a least resistance path to the fault currents. The overhead protection cable will also provide protection against lightning to the 25kV OHE on the section. Similar arrangements have been adopted on Delhi Metro as well.

Detailed specification of equipment e.g. power cables, transformer, switchgear, E&M equipment etc shall be framed to reduce conducted or radiated emissions as per appropriate international standards. The Metro system as a whole (trains, signalling & 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 and Earthing & Bonding plan require to be developed during design stage.

12.8 SOLAR ENERGY HARNESSING SYSTEM

12.8.1 Introduction

The solar mission, which is part of the National Action Plan on Climate Change has been set up by Govt. of India to promote the development and use of solar energy for power generation and other uses with the ultimate objective of making solar energy competitive with fossil-based energy options.

Considering the futuristic technology and potential for solar power generation, Delhi Metro has recently implemented roof top grid connected solar power systems at selected locations of elevated stations and maintenance depot. Metro Railways under implementation in different cities of the country viz. Jaipur, Lucknow, Nagpur etc are also exploring the possibilities of harnessing solar photovoltaic energy.

With the downward trend in the cost of harnessing solar energy and appreciation for the need for development of solar power, provision of a grid connected solar photovoltaic power plant utilizing all possible areas viz. roof top of stations/ sheds and buildings is proposed for Kanpur MRTS.

12.8.2 Solar PV Power Generation Potential

The roof top on the elevated stations of Kanpur Metro corridors and the different sheds and buildings of the depot viz. Stabling, Inspection and Heavy Repair Shed, Administrative Building, Training Centre, DCC/OCC Building etc. is proposed to be used for SPV installation at suitable orientation and inclination to optimize the solar energy potential. The roof of the sheds should be south facing to maximize the Solar power generation in depot. The solar power would be used locally to the extent of load in the building and the generation over and above the requirement of the building would be fed into the grid.

The average raw sunshine available which can be harnessed for the power generation depends on the geometrical coordinates of the place. The intensity of solar radiation varies with time of the day. The combined effect of these factors and the additional complication of the wobble of the seasons is that the average raw power of sunshine per square meter of south-facing roof in India is roughly 100 to 120W/m^2.

The mean global solar radiant exposure at Kanpur varies from 3.7 kWh/m^2/day in the month of December to 6.6 kWh/m^2/day in the month of May. Based on the solar radiation intensity in the city of Kanpur, the peak solar power generation of Kanpur Metro corridor is expected to be about 50 kWp for the elevated stations and about 2000kWp for maintenance depot.

The power generation depends upon various factors such as the intensity of the solar radiation, the net useable area available on the roof top, the obstructions due to shadow or the shading factor, the orientation of the solar panels, efficiency of the solar cells etc. The solar power generation potential in Kanpur metro corridors is required to be reviewed and finalized during detail design stage.

12.9 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 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 OCS 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 (operation or maintenance hours etc).

iv. Machine-room less type lifts with gearless drive and 3-phase VVVF drive. These lifts are highly energy efficient.

v. The proposed heavy-duty public services escalators 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.

vi. The latest state of art and energy efficient electrical equipment (e.g. transformers, motors, light fittings etc).

vii. Efficient energy management is possible with proposed modern SCADA system by way of maximum demand (MD) and power factor control.

Annexure 12.1 (a)

POWER REQUIREMENT FOR IIT KANPUR-NAUBASTA

(A)	**TRACTION LOAD**						
			2024	2031	2041	2051	Design Year
1	Average speed (KMPH)	S	34	34	34	34	34
2	Frequency of service (Sec.)	F	2.9	2.5	2.5	2.5	2.4
3	Headways (Km.)	H	1.6	1.4	1.4	1.4	1.4
4	Nos of trains per hour	N	21.0	24.0	24.0	24.0	25.0
5	Specific energy consumption (KWh/Thou GTKM)	SEC	75	75	75	75	75
6	Gross tonnage of ***rake***	T	177	177	222	274.75	370
7	Corridor length (Km)	D	23.8	23.8	23.8	23.8	23.8
8	Power factor of load	PF	0.9	0.9	0.9	0.9	0.9
9	Max. demand on TSS (KW)		13270	15165	19021	23541	33023
10	Energy Saving on the account of Regeneration @30%		3981	4550	5706	7062	9907
11	Net Demand		9289	10616	13315	16478	23116
12	Depot Traction Load		1000	1300	1500	2000	2000
	Total Traction load of the corridor		10289	11916	14815	18478	25116
	Max. demand on TSS in KVA		**11432**	**13240**	**16461**	**20532**	**27906**
	considering 5 % loss (MVA)		12.00	13.90	17.28	21.56	29.30
(B)	**AUXILIARY LOAD**						
1	Load of each elevated stations (KW)		200	225	250	275	300
2	Nos of at grade/elevated station		14	14	14	14	14
3	Load of each U/G stations (KW)		2000	2125	2250	2375	2500
4	Nos of U/G stations		8	8	8	8	8
5	Load of shed (KW)		1500	1625	1750	1875	2000
6	Total load of the stations & 1 Depot (KW)		20300	21775	23250	24725	26200
7	Power factor of the load		0.9	0.9	0.9	0.9	0.9
	Total max. power demand of Stations and Depot (KVA)		**22556**	**24194**	**25833**	**27472**	**29111**
	considering 5 % loss (MVA)		23.68	25.40	27.13	28.85	30.57
	Total Max. power Demand Traction + Aux. (MVA)		33.99	37.43	42.29	48.00	57.02
	Net demand (MVA) considering 5% distrbution loss		**35.69**	**39.31**	**44.41**	**50.40**	**59.87**

Annexure 12.1 (b)

POWER REQUIREMENT FOR AGRICULTURE UNIVERSITY TO BARRA-8 CORRIDOR

(A)	**TRACTION LOAD**						
			2024	2031	2041	2051	Design Year
1	Average speed (KMPH)	S	33	33	33	33	33
2	Frequency of service (sec.)	F	4	3.2	3.2	3.2	3.2
3	Headways (Km.)	H	2.2	1.8	1.8	1.9	1.7
4	Nos of trains per hour	N	15	19	19	17	19
5	Specific energy consumption (KWh/Thou GTKM)	SEC	75	75	75	75	75
6	Gross tonnage of ***rake***	T	177	177	243.32	262.26	370
7	Corridor length (Km)	D	8.6	8.6	8.6	8.6	8.6
8	Power factor of load	PF	0.9	0.9	0.9	0.9	0.9
9	Max. demand on TSS (KW)		3425	4281	5885	5751	9069
10	Energy Saving on the account of Regeneration @30%		1027	1284	1766	1725	2721
11	Net Demand		2397	2997	4120	4026	6348
12	Depot Traction Load		1000	1300	1500	2000	2000
	Total Traction load of the corridor		3397	4297	5620	6026	8348
	Max. demand on TSS in KVA		**3775**	**4774**	**6244**	**6696**	**9276**
	considering 5 % loss (MVA)		3.96	5.01	6.56	7.03	9.74
(B)	**AUXILIARY LOAD**						
1	Load of each elevated stations (KW)		200	225	250	275	300
2	Nos of at grade/elevated station		5	5	5	5	5
3	Load of each U/G stations (KW)		2000	2125	2250	2375	2500
4	Nos of U/G stations		4	4	4	4	4
5	Load of shed (KW)		1500	1625	1750	1875	2000
6	Total load of the stations & 1 Depot (KW)		10500	11250	12000	12750	13500
7	Power factor of the load		0.9	0.9	0.9	0.9	0.9
	Total max. power demand of Stations and Depot (KVA)		**11667**	**12500**	**13333**	**14167**	**15000**
	considering 5 % loss (MVA)		12.25	13.13	14.00	14.88	15.75
	Total Max. power Demand Traction + Aux. (MVA)		15.44	17.27	19.58	20.86	24.28
	Net demand (MVA) considering 5% distribution loss		**16.21**	**18.14**	**20.56**	**21.91**	**25.49**

Annexure 12.2

U.P. POWER TRANSMISSION CORPORATION LIMITED
उ0प्र0पावर ट्रांसमिशन कारपोरेशन लिमिटेड
(उ0प्र0 सरकार का उपक्रम)

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No 4297.. C. E.(TS)/Ag/ Dated- 16-07-15

Subject:-Availability of Power Supply for Metro Rails Corridors in Agra & Kanpur

Group General Manager
Urban Transport Division
RITES Limited, Gurgaon.
Email:-vikas_haritkr@yahoo.com

Dear Sir,

In reference your office letter no. RITES/UT/CO/AGRA/624/2015 dt. 21.05.15 & letter no. RITES/UT/CO/KDA/623/2015 dt. 21.05.15 for availability of Power supply for metro rails corridors in Kanpur & Agra cities. In this regard it is to inform you that for Agra Metro Rail power supply shall be given at 400KV S/S Pili Pokhar Agra, 220KV S/S Sikandra, Shamshabad and 400KV S/S Agra South (under construction). Power supply can not be given from exixting 132KV S/S Taj, Agra Cantt, Dayalbagh & Foundry nagar as there are overloading.

For Kanpur Metro Rails project the load/power can not be given from existing RPH S/S, 220KV Naubasta & 132KV MSKP S/S due to overloading. Same is to be availed at planned 220/33KV GIS/AIS S/S near phool bagh. 220/33KV S/S Kanpur South , newly proposed upcoming 220KV Gujeni S/S and 220KV Bithoor (existing) S/S.

This is for your kind necessary action.

(Ashok Saxena)
Chief Engineer (TS)

No .. C. E.(TS)/Ag/ Dated-

Copy forwarded to the following for information & necessary action.

1. Superintending Engineer, Electy Trans. Circle, Agra/Kanpur-I/II.

(Puran Chanra)
Executive Engineer (A)

My document (M)/English letter (b)/751

Chapter – 13
VENTILATION AND AIR CONDITIONING SYSTEM

13. VENTILATION AND AIR CONDITIONING SYSTEM

13.1 NEED FOR VENTILATION AND AIR CONDITIONING

The alignment of Kanpur Metro corridors is the combination of underground and elevated section. The elevated section of the corridor generally has less requirement for air conditioning and ventilation system. The air conditioning is required for a few equipment rooms within the station premises. However, in the underground section, air conditioning and ventilation is very important for proper functioning of the system. The Ventilation and Air-conditioning (VAC) system requirements for the underground sections include the following:

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

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

- Supplying fresh air for the physiological needs of passengers and the authority’s staff;
- Removing body heat, obnoxious odours and harmful gases like carbon dioxide exhaled during breathing;
- Preventing concentration of moisture generated by body sweat and seepage of water in the sub-way;
- Removing large quantity of heat dissipated by the train equipment like traction motors, braking units, compressors mounted below the under-frame, lights and fans inside the coaches, A/c units etc.
- Removing vapour and fumes from the battery and heat emitted by light fittings, water coolers, Escalators, Fare Gates, etc. working in the stations;

- Removing heat from air conditioning plant and sub-station and other equipment, if provided inside the underground station.

This large quantity of heat generated in underground stations cannot be extracted by simple ventilation, especially when the outdoor air temperature and humidity is high. It is, therefore, essential to provide mechanical cooling in order to remove the heat to the maximum possible extent. As the passengers stay in the stations only for short periods, a fair degree of comfort conditions, just short of discomfort are considered appropriate.

13.2 INTERNAL DESIGN CONDITIONS IN UNDERGROUND STATIONS

It is essential to maintain appropriate conditions in the underground stations in order to provide a comfortable and pollution-free environment. The plant capacity and design of VAC system needs to be optimized for the designed inside conditions.

The Indian Standards & Codes, which pertain to office-buildings, commercial centres and other public utility buildings, have no guidelines on temperature standards to be maintained for the underground mass rapid transit systems as yet. The standards used for buildings cannot be applied straightaway for the underground spaces, because the patrons will stay for much shorter durations in these underground stations.

The comfort of a person depends on rapidity of dissipation of his body heat, which in turn depends on temperature, humidity and motion of air in contact with the body. Body heat gets dissipated by the process of evaporation, convection and conduction. Evaporation prevails at high temperature. Greater proportion of heat is dissipated by evaporation from the skin, which gets promoted by low humidity of air. The movement of air determines the rate of dissipation of body heat in the form of sensible and latent heat.

There are different comfort indices recognized for this purpose. The 'Effective Temperature' criterion was used in selecting the comfort conditions in the metro systems. In this criterion, comfort is defined as the function of temperature and the air velocity experienced by a person. More recently a new index named RWI (Relative Warmth Index) has been adopted for metro designs worldwide. This index depends upon the transient conditions of the metabolic rate and is evaluated based on the changes to the surrounding ambience of a person in a short period of about 6 to 8 minutes. It is assumed that during this period human body adjusts its metabolic activities. Therefore, in a subway system where the train headway is expected to be six minutes or less, RWI is the preferred criterion.

13.2.1 Sub Soil Temperature

The temperature conditions of sub-soil play a vital role in the system design of the underground stations. It is also expected that water table surrounding the underground alignment is not very much below the surface level, thereby facilitating adequate heat exchange between the tunnel structures and soil.

13.3 DESIGN PARAMETERS AND DESIGN CONCEPTS FOR VAC SYSTEM

Kanpur has a humid subtropical climate with extremely hot summers from late March to early June, the monsoon season from late June to late September and chilly winter nights and foggy or sunny days from November to February. Based on prevalent practices and ambient conditions of Kanpur, the following VAC system design parameters are assumed to be provided for underground sections of the proposed corridors of Kanpur Metro

(i) Outside ambient conditions:
- Summer: - 42.1°C (DB), 23°C (WB)
- Monsoon: - 29°C (DB), 33°C (WB)

(ii) Inside design conditions:
- Platform areas - 27°C at 55 % RH
- Concourse - 28°C at 60 % RH

(iii) Tunnel design conditions:
- Normal conditions - Max. DB 40°C
- Congested conditions - Max. DB 45°C

(iv) Minimum fresh air - 10 % or 18 cmh/ person (in station public area)

There are various VAC design concepts technically feasible in a subway system that can provide and maintain acceptable subway environment conditions under different requirement and constraints. These are: Open type; Closed type; Mid - Tunnel Cooling; Semi Transverse Ventilation; Use of jet fans; use of mid-shafts. The experience available from the design of VAC system for Delhi Metro also provides key guidelines.

From the experience of DMRC, for such conditions it can be concluded that with open shaft system the piston effects can be sufficient to maintain acceptable conditions inside the tunnel, as long as the ambient DB temperature is below 33^0C. When the outside temperature is higher than 33^0C, the tunnel shafts should be closed to prevent any further exchange of air with atmosphere. The station premises (public areas) can be equipped with separate air-conditioning system during the summer and monsoon months to provide acceptable environment for patrons. There shall be provision of Trackway Exhaust System (TES) by which platform air can be re-circulated. The train cars reject substantial heat inside subway. When the trains dwell at the stations, TES would capture a large portion of heat released by the train air-conditioners mounted on the roof tops and under gear heat because of braking, before it is mixed with the platform environment. The TES includes both an under platform exhaust (UPE) duct and an Over-trackway (OTE) exhaust duct. The TES uses ducts formed in the under platform void and over the trackway. Exhaust intakes are located to coincide with the train-borne heat sources.

The train heat generated inside the tunnel sections would be removed by the train piston action. It is envisaged that for the design outside conditions, it may not be necessary to provide forced ventilation using Tunnel Ventilations Fans for normal operating conditions. The number of shafts required would be two or three depending on the inter-station distances. The two shafts would be at the end of the stations and the third shaft, if required, can be built at the mid-tunnel section. These end-shafts at the stations also serve as Blast Relief Shafts, i.e. the piston pressure is relieved to the atmosphere before the air-blast reaches the station. All these shafts are connected to the tunnels through dampers. The dampers are kept open when the exchange of air with the atmosphere is permitted (Open system). For the closed system, the shaft dampers can be in closed mode and the displaced air is dumped in the adjacent tunnel.

Generally, each tunnel ventilation shaft has a fan room in which there are two fully reversible tunnel ventilation fans (TVF) are installed with isolation dampers. These dampers are closed when the fan is not in operation. There is a bypass duct around the fan room, which acts as a pressure relief shaft when open during normal conditions, and enables the flow of air to bypass the TV fans, allowing air exchange between tunnels with flows generated by train movements.

Dampers are also used to close the connections to tunnels and nozzles when under different operating conditions. The details for the shaft sizes, airflow exchange with the atmosphere, fan capacities can be estimated in more accurate manner with the help of Computer Simulations during the detailed design stage.

13.4 STATION VENTILATION AND AIR CONDITIONING OF ANCILLARY SPACES

Ancillary spaces such as staff room, equipment plant room, will be mechanically ventilated or air conditioned in accordance with the desired air change rates and temperatures/humidity.

All ancillary areas that require 24-hour air conditioning will be provided with fan-coil units (FCU) and standby AC units. During the revenue hours when the main chilled water system is running the FCU will be used for air-conditioning and in non-revenue hours standby AC units will be operated. Return air grilles will be fitted with washable air filters for the re-circulation of the air.

Where fresh air is required it will be supplied to the indoor unit via a fresh air supply system, complete with filter, common to a group of ancillary areas. The fresh air unit will be located in the VAC plant room and will be time switch controlled with local override. Temperature control will include an alarm setting, which is activated on attaining high temperature.

- **Station Air Conditioning**

The platform and concourse areas will be air-conditioned using supply ‘air handling units’ located in air-handling plant rooms throughout the station as shown in **Figure 13.1.** Each platform will be served by at least two separate air handling units (AHU’s) with the distribution systems combined along each platform to ensure coverage of all areas in the event of single equipment failure. Based on the initial estimation about 6 units (2 for the concourse each with 18 cum/s and 4 for the platform each having 24 cum/s air-flow) would be needed for the full system capacity.

These air conditioning systems mix return air with a desired quantity of outside air. The outside air requirement is based on occupancy, with a minimum of 5 litres per second per person or 10% of circulated air volume, whichever is the greater. The provision of free cooling by a simple two-position economizer control system will be included, with the use of enthalpy sensors to determine the benefits of using return air or outside air. This will signal the control system to operate dampers between minimum and full fresh air, so as to minimize the enthalpy reduction needed to be achieved by the cooling coil. This mixture of outside and return air is then filtered by means of suitable filters and then cooled by a cooling coil before being distributed as supply air via high level insulated ductwork to diffusers, discharging the air into the serviced space in a controlled way to minimize draughts. Return air to the platform areas is extracted via the trackway exhaust system and either returned to the AHU's or exhausted as required.

FIGURE 13.1:CONCOURSE AIR HANDLING UNIT

The station air conditioning closed system scheme and section view are shown in **Figure 13.2** and **Figure 13.3.**

FIGURE 13.2: STATION AIR CONDITIONING CLOSED SYSTEM SCHEME

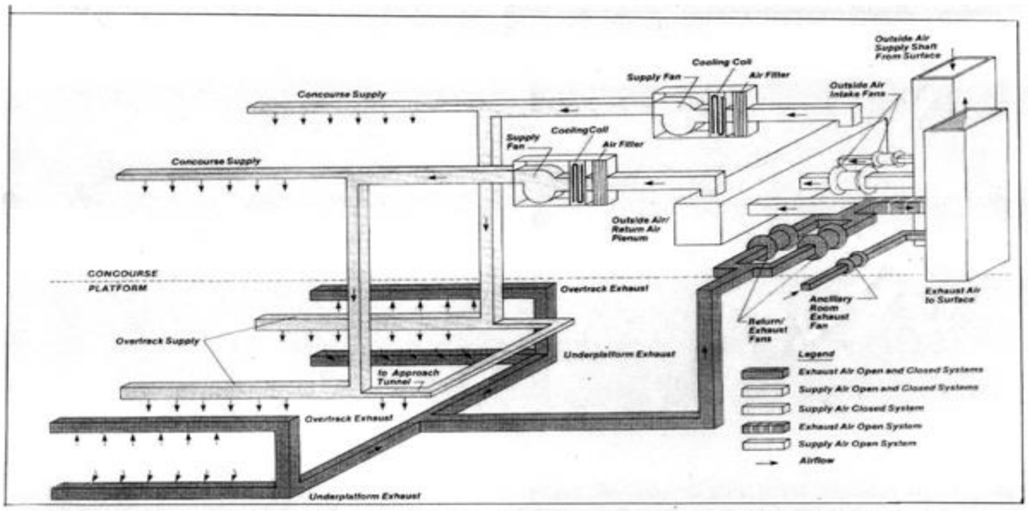
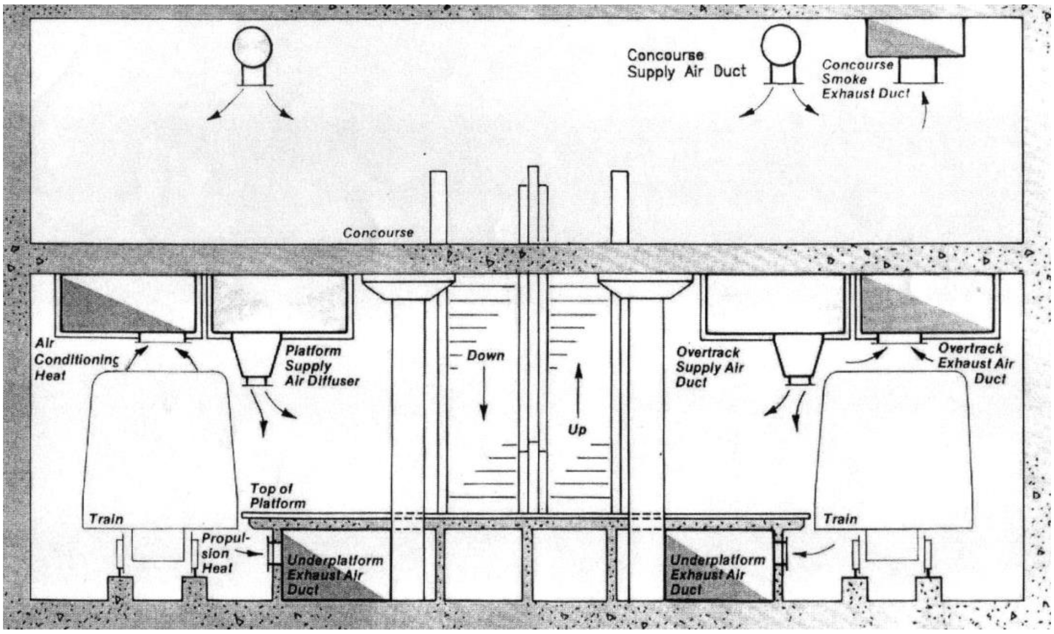


FIGURE 13.3: STATION AIR CONDITIONING SECTION VIEW



Water-cooled chiller units with screw compressors are recommended to be provided at each station, which are energy efficient. These units can be installed in a chiller plant room at surface level or in the underground premises. Based on the initial concept design, the estimated capacity for a typical station would be around 400 TR, hence three units of 200 TR (including one stand-bye) may be required for full system capacity (i.e. design PHPDT traffic requirement). This capacity needs to be reaffirmed during the detail design stage for individual station depending on the heat loads. It is recommended that initially two units of 200 TR may be installed with the provision in terms of space be kept for the future addition.

In view of the temperate outdoor conditions, alternatively, it is possible to utilize air-cooled chiller units, which can save large amount of water requirement. The air-cooled chillers should be equipped with screw compressors so that they can be operated at a very less load with high efficiency. These units also eliminate requirement of condenser water circuits including pumps, cooling towers and make up water plants, but are less efficient as compared to the water-cooled- units.

13.5 TUNNEL VENTILATION SYSTEM (TVS)

The TVS is provided in a Subway system essentially to carry out the following functions:

a) Train Pressure relief during normal operation

b) Ventilation during maintenance periods, if required

c) Removal of smoke during emergency conditions

d) Maintenance of smoke free evacuation route and provision of adequate fresh air during fire related emergencies.

TUNNEL VENTILATION FAN

There are various operating modes (scenarios) for the Tunnel Ventilation system. These are described as under:

- **Normal Conditions**

Normal condition is when the trains are operating to timetable throughout the system, at prescribed headways and dwell times, within given tolerances. The primary source of ventilation during normal conditions is generated by the movement of trains operating within the system and, in some cases, the trackway exhaust system.

During summer and the monsoon seasons, the system will be functioning essentially with the station air conditioning operating. The vent shafts to the surface will enable the tunnel heat to be removed due to train movements. The platform air captured by the trackway exhaust system shall be cooled and recirculated in the station. For less severe (i.e. cool) environmental conditions (or in the event of an AC system failure), station air conditioning will not be used and ventilation shafts will be open to atmosphere (open system) with the trackway exhaust system operating. For cold conditions, the closed system or open system mode may be used without any station air conditioning. System heating is achieved by the train heat released into the premises.

- **Congested Conditions**

Congested conditions occur when delays cause disruption to the movement of trains. It is possible that the delays may result in the idling of a train in a tunnel section. Without forced ventilation, excessive tunnel temperatures may result reduced performance of coach air conditioners that may lead to passenger discomfort.

During congested operations, the tunnel ventilation system is operated to maintain a specific temperature in the vicinity of the car air conditioner condenser coils (i.e. allowing for thermal stratification). The open system congested ventilation shall be via a 'push-pull' effect where tunnel vent fans behind the train are operated in supply and tunnel vent fans ahead of the trains are operated in exhaust mode. Nozzles or booster (jet) fans will be used to direct air into the desired tunnel, if required.

- **Emergency Conditions**

Emergency conditions are when smoke is generated in the tunnel or station trackway. In emergency conditions, the tunnel ventilation system would be set to operate to control the movement of smoke and provide a smoke-free path for evacuation of the passengers and for the fire fighting purposes. The ventilation system is operated in a 'push-pull' supply and exhaust mode with jet fans or nozzles driving tunnel flows such that the smoke is forced to move in one direction, enabling evacuation to take place in the opposite direction depending upon the location of fire on the train.

- **Pressure Transients**

The movement of trains within the underground system induces unsteady air motion in the tunnels and stations. Together with changes in cross section, this motion of air results in changes in air pressure within trains and for wayside locations. These changes in pressure or 'pressure transients' can be a source of passenger discomfort and can also be harmful to the wayside equipment and structures. Two types of transient phenomenon are generally to be examined:

a) Portal Entry and Exit Pressure Transients – As a train enters a portal, passengers will experience a rise in pressure from when the nose enters until the tail enters. After the tail enters the pressure drops. Similarly, as the nose exits a portal, pressure changes are experienced in the train.

b) Wayside Pressure Transients – As trains travel through the system they will pass structures, equipment and patrons on platforms. Equipment would include cross passage doors, lights, dampers, walkways etc. Pressures are positive for the approaching train and negative for retreating trains.

Most rapid changes occur with the passage of the train nose and tail. The repetitive nature of these pressures may need to be considered when considering fatigue in the design of equipment.

The detailed analysis to assess the effect of pressure transients will be done during the design stage. For the portal entry/exits the effect of higher train speed may pose discomfort to the passengers. The estimation of Way-side transients during design stage would be necessary to select design mechanical strength of the trackside fixtures, e.g. false ceilings, light fittings etc at the platform levels.

- **Tunnel Ventilation Fans**

As described earlier tunnel ventilation fans will be installed in each of the fan rooms near vent shafts. There shall be two fans in a fan room at each end of the station. The fan capacity depends on the inter-station distances and may vary from 60 cum/s to 100 cum/s. The exact capacity will be obtained through the simulation during detailed design stage. If necessary, nozzle type structures made up of concrete or steel may also be constructed to achieve desired airflow and air velocity in the tunnel sections. Alternatively, booster fans (jet fans) may be installed to direct the flow in the desired direction. These fans may also be used for emergency ventilation at crossover locations.

The trackway exhaust system will have two fans of each 30 cum/sec. for each platform. The connections to tunnels and shafts will be through damper units that may be either electrically or pneumatic actuated.

- **Space Requirement for Tunnel Ventilation System**

The tunnel ventilation equipment plant rooms are normally located at each end of the concourse for the two level stations. The approximate area for tunnel ventilation fan room would be 600 sq. m. respectively at each end of the station. The tunnel vent shafts of approximately 20 sq. m. area will be constructed at each end of the stations. There shall be supply shaft and exhaust shafts of similar dimensions at the stations. For large inter station distances on the underground corridor, there may be necessity of constructing mid tunnel ventilation shaft for effective ventilation requirements.

13.6 CONTROL AND MONITORING FACILITIES

For the underground stations the control and monitoring of station services and systems such as station air-conditioning, ventilation to plant rooms, lighting, pumping systems, lifts & Escalators, etc shall be performed at Station Control Room (SCR). However, the operation and control of Tunnel Ventilation as well as Smoke Management system will normally be done through OCC. All these systems shall be equipped with automatic, manual, local and remote operation modes. The alarms and signals from the equipment at stations shall be transmitted to the OCC via communication network.

13.7 CODES AND STANDARDS

The concept VAC design is guided by the following codes and standards:

a) SEDH – Subway Environment Design Handbook

b) ASHRAE – Handbook, current series.

c) CIBSE – relevant document.

d) NFPA – 130, 2003 edition.

e) ECBC – Energy Conservation Building Code

Chapter – 14
DEPOTS

14. DEPOTS

14.1 DEPOT LOCATION AND APPROACH TO MAINTENANCE

14.1.1 The maintenance facilities for IIT Kanpur to Naubasta Corridor are proposed to be provided at Polytechnic Depot for about 47 rakes of 6 car each and the maintenance facilities for Agriculture University to Barra-8 corridor are proposed at Agriculture University Depot for about 17 rakes of 6 cars each. The depots will have infrastructure to maintain the rakes with necessary facilities viz stabling lines, scheduled inspection lines, workshop for overhaul, unscheduled maintenance including major repairs, wheel profiling, heavy interior/under frame/roof cleaning etc. for the rolling stock as well as maintenance facilities for track, buildings, water supply, traction, E&M, Signalling & Telecomm, Automatic Fare Collection etc. The depots will have flexibility to provide maintenance support for the future extensions of these corridors.

The following aspects of the Depots are covered in the planning of the facilities:

- Conceptual design and layout of Servicing Shed and Workshop to provide maintenance facilities and stabling facilities for 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

14.1.2 Maintenance Philosophy

The outline of the maintenance philosophy followed is as follows:

- Typical maintenance schedules being followed by Delhi Metro have been considered for determining the requirement of lines in depot.
- Unit replacement and to get essential repairs to major equipments done by the OEMs.
- Automation with state-of-the-art machinery to ensure quality and reliability. Labour intensive procedures are proposed to be kept to the minimum.

- Maintenance staff shall be given special training to develop high-level skills in their trade to ensure quality and productivity in their performance.
- Adequate facilities for the stabling have been provided at the depot.
- To maintain high degree of cleanliness, Automatic washing plant has been proposed.

14.1.3 Planning of the Maintenance Facilities Setup

The rolling stock requirements in different horizon years for the proposed corridors are indicated in **Table 14.1**.

TABLE 14.1: RAKE REQUIREMENT FOR DIFFERENT HORIZON YEARS

Corridor	Year	2024	2031	2041	2051	Design Year
IIT Kanpur-Naubasta (23.8 km)	Headway (minutes)	2.9	2.5	2.5	2.5	2.4
	No. of Cars/Train	3	3	3 & 6	3 & 6	6
	Cars Required	117	132	168	210	282
Agriculture University-Barra-8 (8.6 km)	Headway (minutes)	4.0	3.2	3.2	3.2	3.2
	No. of Cars/Train	3	3	3 & 6	3 & 6	6
	Cars Required	39	48	60	72	102

14.1.4 Rolling Stock Maintenance Needs

➢ **Maintenance schedule**

Servicing requirements shall be determined from the rolling stock manufacturer. Depending upon manufacturer's requirements, servicing facilities may be provided to include the ability to carry out the inspection, maintenance, overhaul and repair of the rolling stock fleet, including the following components:

- Body
- Bogies
- Wheels (Re-discing / re-axling is planned at workshop only)
- Traction motors
- Electrical components
- Electronics; PA/ PIS
- Mechanical components
- Batteries

- Rolling stock air conditioning
- Brake modules
- Vehicle doors, windows and internal fittings

The modern, fully equipped facilities are to be provided that meet these requirements efficiently and in full. In meeting these requirements, it shall be assumed that the average daily distance travelled by each rolling stock unit is approximately 300 km. **Table 14.2** shows the maintenance schedule that has been followed for the conceptual design.

TABLE 14.2: PROPOSED MAINTENANCE SCHEDULE

Type of Schedule	Interval	Work content	Locations
Daily	Daily	Check on the train condition and function at every daily service completion. Internal 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
Inter-mediate Overhaul (IOH)	420,000 Km (approx. 3.5 years)	Check and testing of all sub-assemblies (Electrical + Mechanical). Overhaul of pneumatic valves, Compressor. Condition based maintenance of sub-systems to bring them to original condition. Replacement of parts and rectification, trial run.	Workshop
Periodical Overhaul (POH)	840,000 Km (approx. 7 years)	Dismantling of all sub-assemblies, bogies suspension system, traction motor, gear, control equipment, air-conditioning units etc. Overhauling to bring them to original condition. Checking repair and replacement as necessary. Inspection and trial.	Workshop
Heavy Repairs	-	Changing of heavy item such as bogies, traction motor, axles, gear cases & axle boxes etc.	Workshop

The above schedule may need slight revision based on the actual earned kilometers per train and the specific maintenance requirements of rolling stock finally procured.

- **Washing needs of Rolling Stock**

The metro trains are maintained to a high degree of cleanliness and needs the maintenance schedule as mentioned in **Table 14.3**.

TABLE 14.3: SCHEDULE OF CLEANING

SN	Kind of Inspection	Maintenance Cycle	Time	Maintenance Place
1	Outside Cleaning (wet washing on automatic washing plant)	3 Days	10 mins	Automatic washing plant of Depot Single Pass
2	Outside heavy Cleaning (wet washing on automatic washing plant and Front Face, Vestibule/Buffer area, Floor, walls inside/outside and roof. Manually)	30 days	3 Hrs	Automatic washing Plant & washing line

14.2 DESIGN OF DEPOT FACILITIES AND DEPOT LAYOUT PLANS

14.2.1 Depot Layout Plans

- **Polytechnic Depot**

The Polytechnic depot is located between Gurudev Chauraha and Geeta Nagar Metro Stations. Gurdev Chauraha is 5^{th} station from IIT Kanpur end. The options of connection of Polytechnic Depot from Gurdev Chauraha side and Geeta Nagar side have been examined and are discussed below:

- **Option 1- Connection of Depot from Gurdev Chauraha Station**

The Gurudev Chauraha Station is located about 300 m from depot and height of station is 13.0 m. Even with maximum possible gradient, the zero level of the track connection is landing approximately 200 m inside and at extreme corner of area marked for depot. Further 400 m will be required for stabling lines and its ladder. The depot cannot be fitted in the area identified and will necessitate acquisition of dense forest area and some additional buildings which can be avoided if depot connection is taken from Geeta Nagar.

Consultants have also considered the location of Automatic Wash Plant on ramp area which will slightly reduced the land acquisition. We have considered option of having workshop and inspection at start of depot. Consultants have also examined layout similar to Transport Nagar Depot of Lucknow Metro with option of having workshop and inspection at start of depot. This option will have constraint that all movement to workshop and inspection lines will require reverse shunting and still the layout cannot be fitted in area earmarked. Moreover there will be empty running of trains from depot to IIT Kanpur during induction and from IIT Kanpur to depot during withdrawal of Rolling Stock from the corridor. A layout with this option is shown in **Figure 14.1**.

- **Option 2- Connection of Depot from Geeta Nagar Station**

Geeta Nagar is 6th station from IIT Kanpur. The distance of Depot boundary from Geeta Nagar is sufficient for bringing track to depot level near entry point. Geeta Nagar Station with one additional line has been proposed facilitating simultaneous entry and exit of trains to depot.

This option doesn’t have any reverse shunting for movement from maintenance to inspection shed/workshop. The traffic pattern on different sections of IIT- Naubasta Corridor has been examined and it is observed that the traffic is more in sections ahead of Geeta Nagar towards Kanpur Central Railway Station. Moreover the trains coming out from depot can be started from Geeta Nagar/ Rawatpur which matches the traffic requirement.

During morning hours the headway between IIT Kanpur to Geeta Nagar will be about 10 minutes which can be met with 4 rakes stabled at IIT Kanpur, subsequently rakes starting from Naubasta will reach to IIT Kanpur and Normal Operation of trains will continue between IIT Kanpur to Naubasta. Similarly during withdrawal some of the trains will be terminated at Rawatpur and will be taken into depot. This arrangement will help in reducing empty running during induction and withdrawal of rakes.

Therefore, **Consultant recommends option-2** for polytechnic depot with connection from Geeta Nagar Station. The layout plan of proposed Depot with connection from Geeta Nagar is shown in **Figure 14.2**.

In addition to polytechnic depot, **stabling facilities at Naubasta** have also been proposed. The layout plan of Naubasta stabling facility is shown in **Figure 14.3**.

FIGURE 14.1: LAYOUT PLAN FOR POLY TECHNIC DEPOT (OPTION-1)

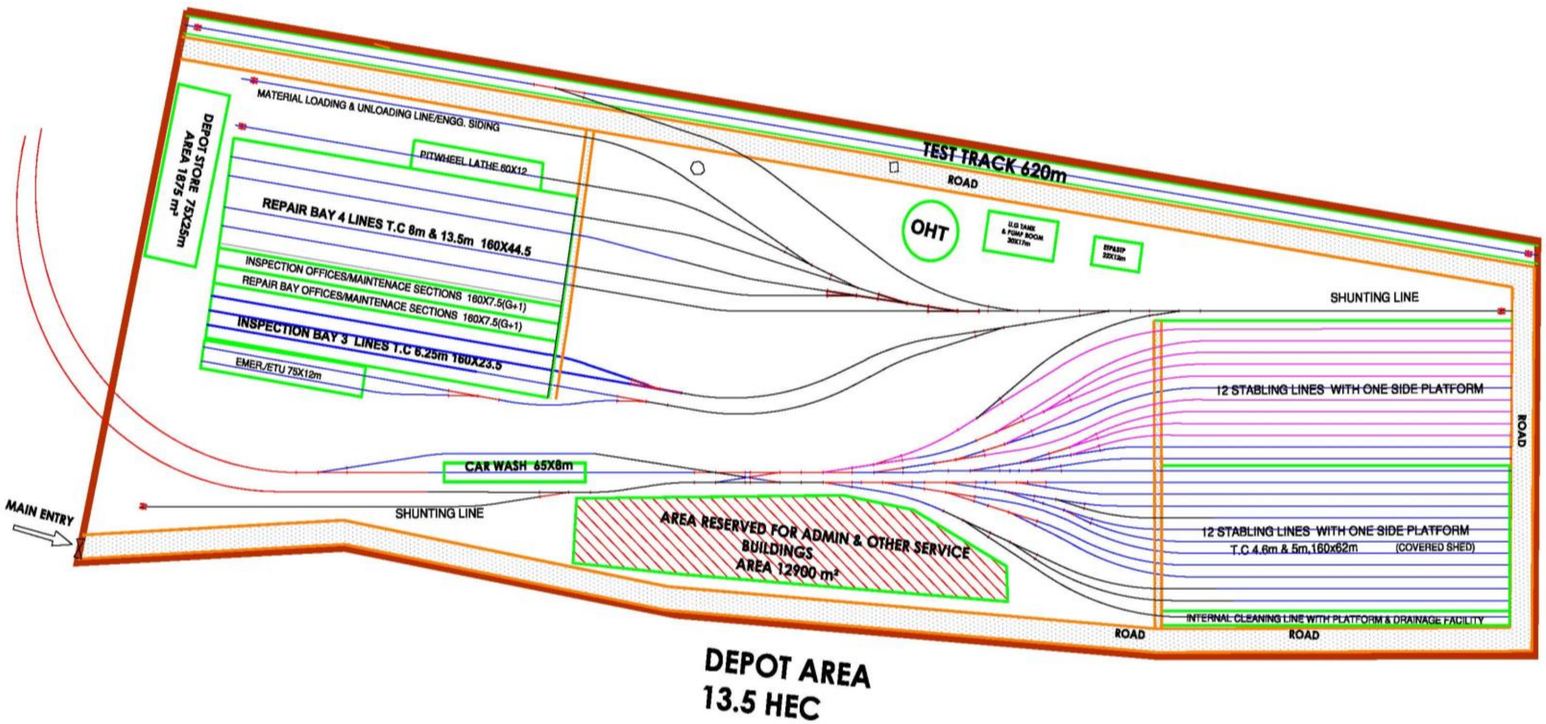


FIGURE 14.2: LAYOUT PLAN FOR POLY TECHNIC DEPOT (OPTION-2)

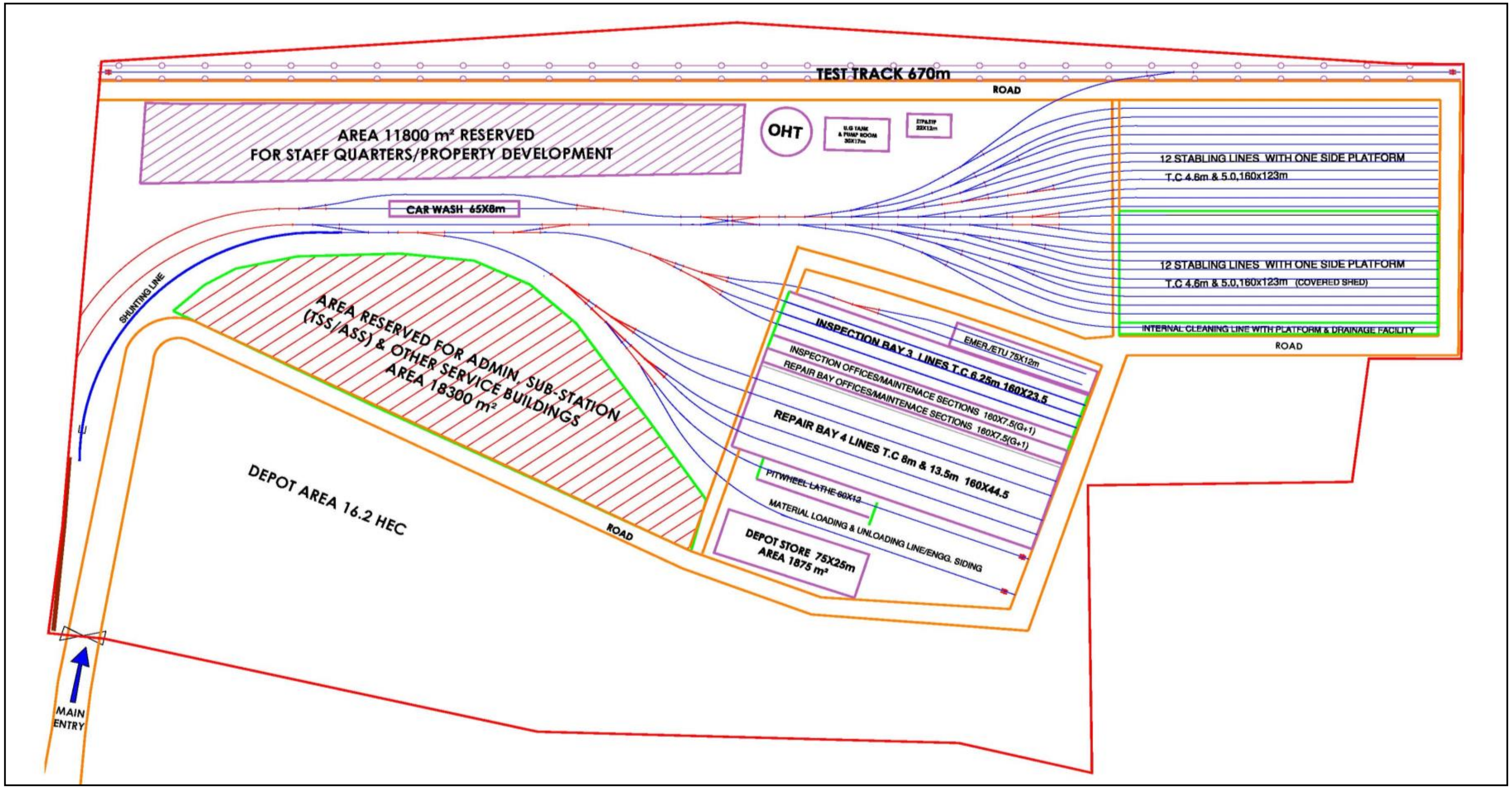
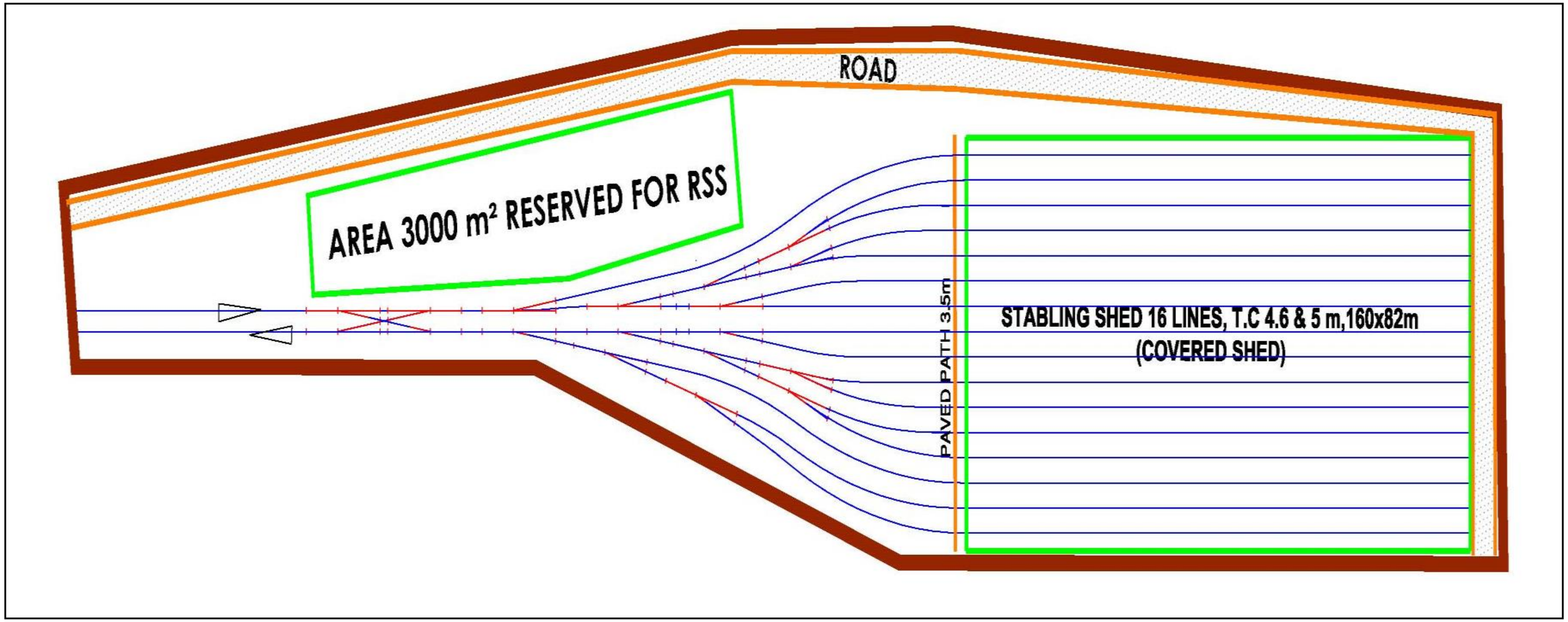


FIGURE 14.3: STABLING FACILITY AT NAUBASTA FOR IIT KANPUR TO NAUBASTA CORRIDOR



- **Agriculture University Depot**

The Agriculture University depot is located at the end of Barra-8 to Agriculture University corridor with provision of future extension of the corridor beyond Agriculture University. Two options of connection of Agriculture University depot from proposed corridor have been examined and are discussed below:

- **Option 1- Connection of Depot from corridor without any curve**

The entry to Agriculture University Depot is proposed straight from Rawatpur Underground Station to the identified plot for depot without any curve as shown in the depot layout kept at **Figure 14.4**. This option will require additional length of tunnel for depot connectivity and the location of the Agriculture University station is proposed after the depot branch line. However, this option requires relatively lesser area for depot layout and property acquisition is also minimized.

- **Option 2- Connection of Depot from corridor with U - curve**

The entry to Agriculture University Depot is proposed with U – curve after Agriculture University station as shown in the depot layout kept at **Figure 14.5**. In this option, relatively lesser tunnel length for connection to the depot from the corridor is required. However, this option requires more property acquisition and the area requirement is also higher than Option-1.

From operational point of view, there are no constraints for both options of depot layout. However, to optimize area requirement and avoid more property acquisition, **Option-2 is recommended**.

The rake induction and withdrawal from depot to the open line will have to be so planned that the headway of open line is not affected. For the purpose, facilities for simultaneous receipt and dispatch of trains from depot to open line should be created. The stabling area should be interlocked with the open line so that the induction of train from the stabling can be done without loss of time. The rake washing can be done at automatic coach washing plant provided at the entry of depot i.e. before rake is placed on stabling lines.

FIGURE 14.4: LAYOUT FOR AGRICULTURE UNIVERSITY DEPOT (OPTION-1)

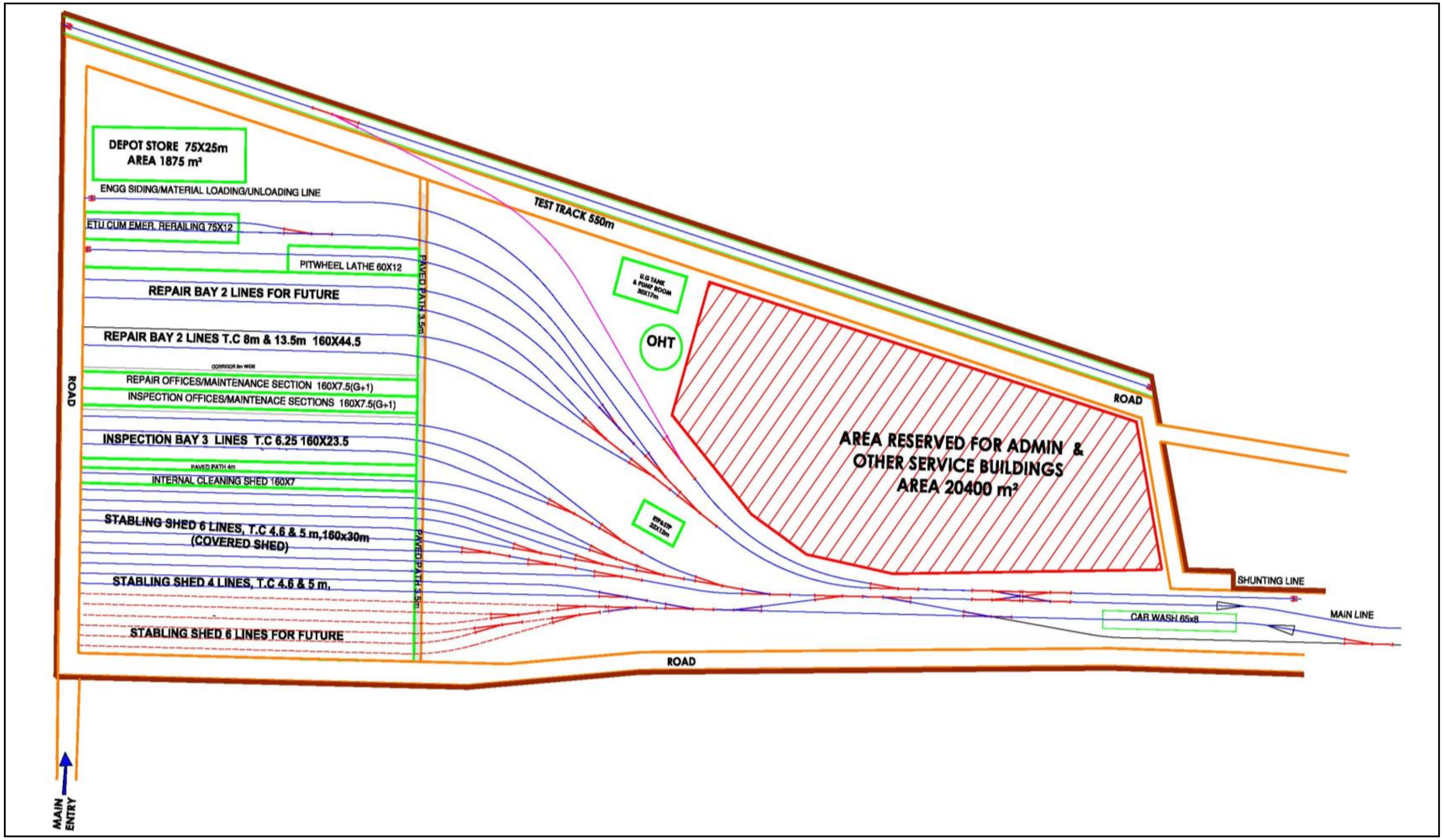
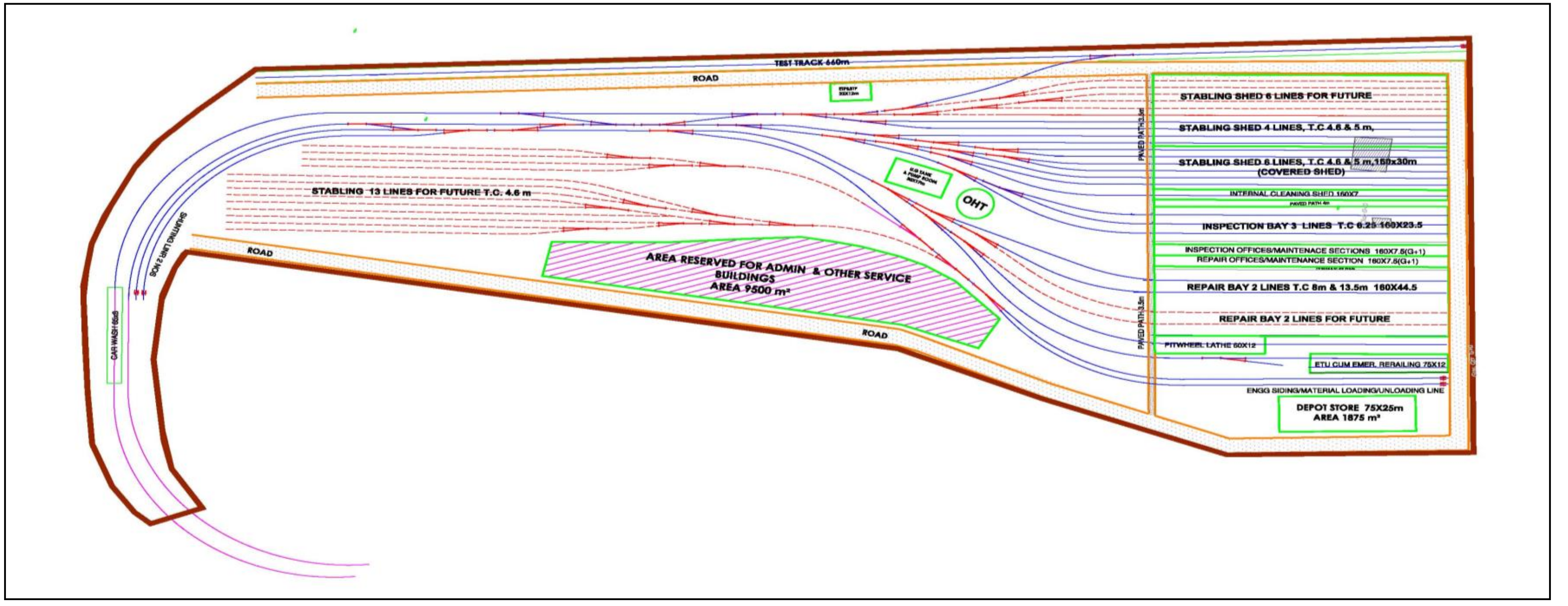


FIGURE 14.5: LAYOUT FOR AGRICULTURE UNIVERSITY DEPOT (OPTION-2)



The other movements in the depot, viz from the stabling to the inspection shed or workshop and vice versa may be non-interlocked. Two emergency re-railing lines have been provided from which emergency rescue vehicles can be dispatched to open line in the event of any emergency. To cater to the peak requirements, all trains would be in the service, only trains under maintenance would be in the shed. However during the off-peak hour in daytime, approximately half of the trains will be withdrawn from the service. The scheduled inspections are envisaged to be carried out during the day off-peak hours and night.

The stabling and the yard layout would be at grade level for least power requirements in shunting movements and to avoid accidental rolling of rolling stock resulting into accidents and damages to the property.

14.2.2 Design of Depot Facilities

14.2.2.1 Inspection Lines and Workshop Lines in Depot

As per the frequency of inspections indicated in **Table 14.2**, the visits of rakes to Depots are as shown in **Figure 14.6**.

To assess the number of lines required to maintain the rakes, following assumptions are made:

i. For Washing of rakes, an automatic washing plant is proposed. Hence, no separate washing line is needed exclusively for washing. However, one line is provided for heavy cleaning (Manual cleaning of Floor, walls inside/outside and roof)
ii. In a day, two rakes are taken for ‘A check’ on a pit line
iii. In a day, one rake is taken for ‘B checks’ on a pit line
iv. Based on the number of holidays as given below, total numbers of working days are taken as 300 for calculating the requirement of lines

- No. of days of Public holidays in a year : 13
- No. of Sundays in a year : 52
- No. of available working days in a year : 365 - 65 = 300 days

As against above requirement, the infrastructure provided for Schedule inspection of the rakes is indicated in **Table 14.4**.

FIGURE 14.6: RAKE VISITS TO DEPOTS AND WORKSHOPS

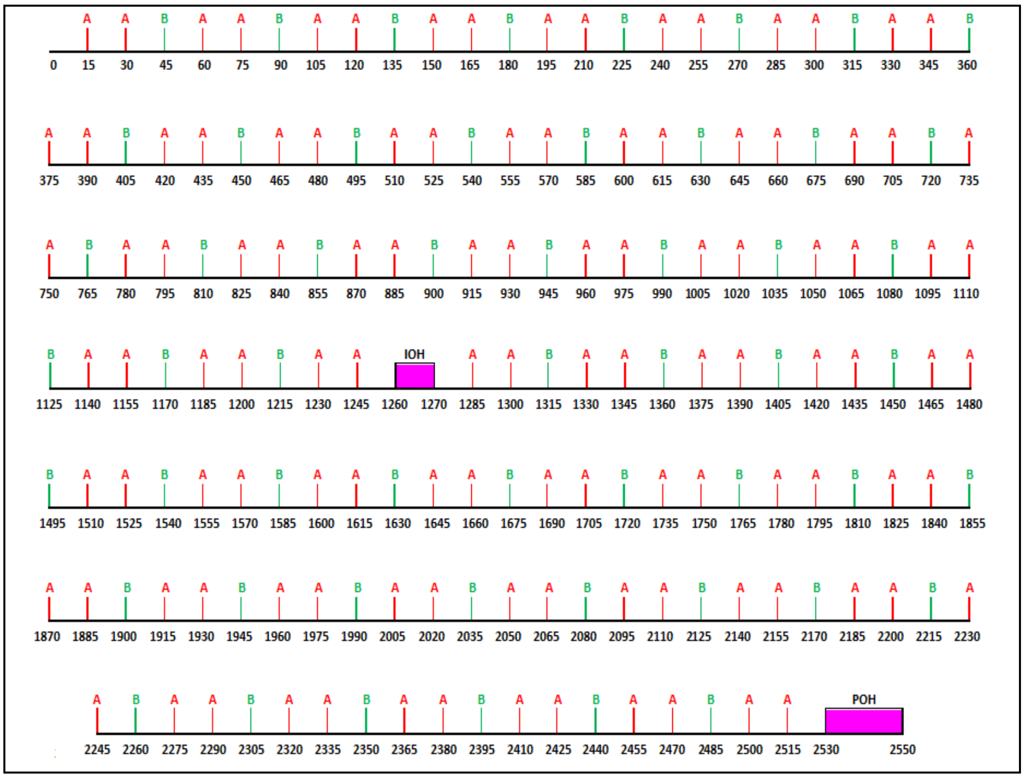


TABLE 14.4: INSPECTION AND WORKSHOP LINES PROVIDED FOR IIT KANPUR-NAUBASTA CORRIDOR

Schedule	Total visits per rake in 7 years	Avg. visits /year	Total Arising	Line Occupancy	Lines Required	Lines Provided
Inspection Shed						
A Service Check	112	16	768	2 rakes/ day	1.28	3
B Service Check	54	7.71	370	1 rakes/ day	1.23	
Adjustment line for minor repair/testing after POH						
Workshop Shed						
IOH	1	0.14	6.72	1 rake 10 days	0.224	1
POH	1	0.14	6.72	1 rake 20 days	0.448	1
Unscheduled Repair / Lifting /Wheel/Bogie sections etc.						2
Workshop Lines Provided						**4**

IIT Kanpur to Naubasta corridor will have maintenance facility at Polytechnic Depot which will have the infrastructure to maintain 47 rakes of 6 car. Based on the calculations indicated in **Table 14.4**, the depot is proposed to be planned with 3 inspection lines and 4 workshop lines.

TABLE 14.5: INSPECTION AND WORKSHOP LINES PROVIDED FOR AGRICULTURE UNIVERSITY-BARRA-8 CORRIDOR

<table>
<tr><th>Schedule</th><th>Total visits per rake in 7 years</th><th>Avg. visits /year</th><th>Total Arising</th><th>Line Occupancy</th><th>Lines Required</th><th>Lines Provided</th></tr>
<tr><td colspan="7">Inspection Shed</td></tr>
<tr><td>A Service Check</td><td>112</td><td>16</td><td>272</td><td>2 rakes/ day</td><td>0.453</td><td rowspan="2">1</td></tr>
<tr><td>B Service Check</td><td>54</td><td>7.71</td><td>131</td><td>1 rakes/ day</td><td>0.44</td></tr>
<tr><td colspan="6">Adjustment line for minor repair/testing after POH</td><td>1</td></tr>
<tr><td colspan="6">Additional line for future extension of corridor (Future)</td><td>1</td></tr>
<tr><td colspan="6">Total Inspection Lines Provided</td><td>3</td></tr>
<tr><td colspan="7">Workshop Shed</td></tr>
<tr><td>IOH</td><td>1</td><td>0.14</td><td>2.38</td><td>1 rake 10 days</td><td>0.079</td><td rowspan="2">1</td></tr>
<tr><td>POH</td><td>1</td><td>0.14</td><td>2.38</td><td>1 rake 20 days</td><td>0.159</td></tr>
<tr><td colspan="6">Unscheduled Repair / Lifting /Wheel/Bogie sections etc.</td><td>1</td></tr>
<tr><td colspan="6">Additional lines for future extension of corridor (Future)</td><td>2</td></tr>
<tr><td colspan="6">Workshop Lines Provided</td><td>4</td></tr>
</table>

Agriculture University Depot will have the infrastructure for the inspection and overhaul of 17 rakes of 6 cars. Accordingly, 3 lines are proposed to be provided for the schedule inspections & 4 lines for periodical overhaul/major unscheduled repairs etc.

14.2.2.2 Stabling Facility for Rakes

- **IIT Kanpur to Naubasta Corridor**

The Polytechnic depot will have stabling facility for 24 rakes of 6-car and an additional stabling facility will be at Naubasta for 16 rakes of 6 car. At a given time, three rakes would remain under inspection and the remaining rakes will be stabled at terminal stations for the start of early morning services.

- **Agriculture University to Barra-8 Corridor**

Agriculture University depot will have stabling facility for 29 rakes of 6 car (including 19 lines of 6 car for future extension of the corridor). The stabling facility for 10 rakes of 6 car is planned for proposed corridor. At a given time, three rakes would remain under inspection and the remaining 4 rakes will be stabled at terminal stations for the start of early morning services.

Hence, the depot layouts for the proposed corridors are sufficient to cater to the maintenance requirements of the rolling stock operational on the corridors for the design/ultimate year.

14.2.3 Depot cum Workshop Planning

For the design of the stabling lines in the depot, following approximate lengths have been taken in consideration:

- Length of one 6-car rake= 135.6 m
- Free length at outer ends of the rake (for cross pathway, Signal and Friction buffers)= 10m each side
- Total length of Stabling line = (ii)+(i)+(ii)+= 10+ 135.6+ 10= 155.6 m (say 160)

Looking to the car width of 2900 on Standard Gauge, 4.2 & 5m Track Centre is proposed for all the stabling lines. Thus, space between stabling shall be sufficient to include a pathway to be constructed between tracks to provide access for internal train cleaning and undercarriage inspection.

50% of stabling lines 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.

➢ **Inspection Lines in Depot**

For the design of the Inspection Bay Lines in the depot, following approximate lengths have been taken in consideration:

- Length of one 6-car rake= 135.6 m
- Cross path at each end = 10 m
- Total length of Inspection line = (ii)+(i)+(ii)+= 10+ 135.6+ 10= 155.6 m (say 160)

The inspection bay in Polytechnic Depot and Agriculture University Depot shall be of 160 X 23.5m² size with three inspection lines having sunken floor. The track spacing between the adjacent inspection Bay Lines shall be 6.25 m.

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, 10 m cross pathways are left at each end for movement of material by fork lifter/ Leister/ Hand trolley. 415V 3 phase 50 Hz, 230V 1 phase 50 Hz AC supply and Pneumatic supply shall also be made available on each inspection shed columns. Air-circulators shall be provided on each column.

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.

- **Workshop in Depot**

The size of the workshop shed in Polytechnic depot and Agriculture University Depot shall be 160 x 44.5 m² and an additional covered space of 160 x 7.5 m² shall be provided in the depots to cater for offices cum maintenance sections, costly item store, locker room, toilet etc. Following equipment repair/overhaul facilities are planned in the workshop.

- Body furnishing
- Bogie
- Wheels
- Traction Motor
- Axle box and axle bearing
- Pantograph
- Electrical equipment like transformer, converter/inverter, circuit breaker, relays
- Battery
- Air compressor
- Air conditioning equipments
- Brake equipment

- Door actuators
- Control and measuring equipments
- Pneumatic equipments
- Dampers and Springs
- Couplers/ Gangways

List of major M&P required for maintenance activities in the workshop is given in **Annexure 14.1** and **14.2**.

Cross track equipped with bogie turntables have been provided for movement between bays. 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.

- **Engineering Train Unit Workshop**

  Since the workshop cum depot is designed optimally, it would not be wise to waste its capacity in maintaining the other than passenger rolling stock vehicles. Carrying these vehicles to the inspection shed affects the rolling stock maintenance as shunting is also involved. Therefore, other vehicles like rail cum road vehicle, tower wagons, etc. may be housed and given required inspection attention in a separate shed called ETU workshop, for which 2 lines have been provided in the depots. However for the heavy lifting needs, these vehicles may be taken to main workshop for required attention.

- **Car Delivery Area**

  The newly procured coaches, which are transported by road, 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. 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.

- **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 six 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.

- **Test Track**

  A test track of 700m length in Polytechnic Depot and 660m length in Agriculture University Depot will be provided beside workshop. It shall be equipped with signaling equipments (ATP/ATO). It shall be used for the commissioning of the new trains, their trials and testing of the trains after the IOH and POH. Entry into the test track shall be planned for a 6-car train. In compliance to safety norms, the boundary of the track shall be completely fenced to prevent unauthorized trespassing across or along the track.

- **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.

- **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 cycle/scooter/car stand facility for convenience of the train operating staff.

- **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.

- **Parking Facilities**

  - Ample parking space shall be provided for the two wheelers and four wheelers at the following points

- Close to the depot entry.
- Close to the stabling lines.
- Close to the Workshop/ IBL.

- Space for parking of road and re-railing equipments

Enough space for parking of road vehicle/ trailers/ trucks etc. Enough space will also have to be earmarked adjacent to workshops. Similarly, provision of space for parking of re-railing equipments will have to be made close to the main exit gate of the Depot.

- **Watch Towers**

There shall be provision of adequate number of watchtowers for the vigilance of depot boundary.

- **Power Supply**

An auxiliary substation of 2500 KVA capacity has been planned for catering to the power supply requirement of the depot. Details of connected load, feeder may be worked out during detailed designing stage.

- **Standby Power Supply**

The standby power supply is proposed through silent DG set of 2X320 KVA adequate capacity to supply all essential loads without over loading.

- **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.

- **Water Supply, Sewerage and Drainage Works**

In house facilities shall be developed for the water supply of each depot. Sewerage, storm water drainage shall be given due care while designing the depots for efficient system functioning. Past records of Municipal Corporation shall be used to design the drainage system. Rainwater harvesting would be given due emphases to charge the underground reserves.

Annexure 14.1

LIST OF MAJOR PLANT AND MACHINERY FOR POLYTECHNIC DEPOT

SN	Plant & Machinery	Depot
A.	MATERIAL HANDLING	
	Travelling over head EOT cranes for workshop 15/2T	2
	Travelling over head EOT cranes for	2
	Travelling over head EOT cranes for inspection bay 1.5T	2
	Travelling over head EOT cranes for	1
	Travelling over head EOT cranes for pit wheel lathe 3.2T	1
	Jib crane for workshop 3 T	2
	Synchronized pit jacks system for 2	1
	Car body stands for keeping 2 car	24
	Dummy bogies	6
	Mobile lifting jacks-15T	8
	Mobile lifting jacks 10T	16
	Battery powered locomotive	2
	OHE Inspection car	2
	Road mobile Crane 5T cap	1
	Fork lift truck 3T cap	2
	Fork lift trucks 2T cap	2
	Pallet trucks	4
	TATA Truck	1
	Scissors type lifting trolley - 2T	2
	Hydraulic trolleys - 2T capacity	2
B.	**Wheel shop**	
	500T wheel press	1
	Vertical boring m/c (Turret Lathe)	1
	Sunken Wheel Lathe	1
	Axle turning lathe	1
	Axle UST inspection machine	2
	Radial drill m/c	1
	Induction Heater	2
	Bearing/Coupling Extractor	4
C.	**Bogie shop**	
	Bosch Tank : Bogie wash/cleaning	1
	Bogie static load testing m/c	1
	Shock absorber testing m/c	1

SN	Plant & Machinery	Depot
	Spring scragging &testing m/c	1
	Magnaflex crack detector	1
	Glowcheck crack detector	1
D.	**Rotating m/cs**	
	Baking Oven	1
	Dynamic balancing	1
	Traction motor test console	1
	Motor compressor test bench	1
	Tan Delta testing instrument	1
E.	**Other m/cs**	
	Re-railing equipment	1
	Under floor Pit wheel lathe	1
	Chip crusher and conveyor for pit	1
	Automatic Washing plant for Metro	1
	High-pressure washing pump for front and rear end cleaning of cars.	1
	Turn table for one car	1
	Turntable for bogies	4
	Driving Cab Simulator	1
	Water de-mineralizing plant	2
	Painting booth for separate parts	1
	Floor cleaning machine	4
	Welding equipments	5
	Compressor 500Cfm	2
	DG set 320 KVA	3
	Battery charger	2
F.	**Machine shop**	
	Guillotine Shearing m/c	1
	Shearing, punching & cropping	1
	Universal tool cutter & grinder	1
	Vertical surface grinder	1
	Centre lathe 2m bed	1
	Centre lathe 1m bed	1
	Radial drill m/c	1
G.	**Test Benches/Instruments**	
	Pneumatic test bench	1
	Brake test bench	2
	SPM test bench	2
	Door test bench	2
	Inverter test bench	1
	Other test benches (MCB, RMPU etc.)	1

SN	Plant & Machinery	Depot
	Oscilloscope	1
H.	**Furniture/material storage/Small**	
	Vertical storage system for DCOS	1
	Computer MMIS with LAN	1
	Storage racks	LS
	Industrial furniture	LS
	Electric and pneumatic tools	LS
	Measuring and testing equipments	LS
	Tool kits	LS
	Mobile safety steps	10

Annexure 14.2

LIST OF MAJOR PLANT AND MACHINERY FOR AGRICULTURE UNIVERSITY DEPOT

SN	Plant & Machinery	Quantity
A.	**MATERIAL HANDLING**	
	Travelling over head EOT cranes for	2
	Travelling over head EOT cranes for	1
	Travelling over head EOT cranes for ETU	1
	Synchronized pit jacks system for 2 car	1
	Car body stands	24
	Dummy bogies	6
	Mobile lifting jacks-15T	8
	Battery powered locomotive	2
	OHE Inspection car	2
	Road mobile Crane 5T cap	1
	Fork lift truck 3T cap	2
	Fork lift trucks 2T cap	2
	Pallet trucks	4
	TATA Truck	1
	Scissors type lifting trolley - 2T capacity	2
	Hydraulic trolleys - 2T capacity	2
	Induction Heater	2
	Bearing/Coupling Extractor	2
B.	**Bogie shop**	
	Bogie wash plant	1
	Bogie static load testing m/c	1
	Shock absorber testing m/c	1
	Spring scragging &testing m/c	1
	Magnaflex crack detector	1
	Glowcheck crack detector	1
C.	**Rotating m/cs**	
	Baking Oven	1
	Dynamic balancing	1
	Traction motor test console	1
	Motor compressor test bench	1
	Tan Delta testing instrument	1
D.	**Other m/cs**	
	Re-railing equipment	1
	Under floor pit wheel lathe	1
	Automatic Washing plant for Metro	1
	High-pressure washing pump for front and rear end cleaning of cars.	1

SN	Plant & Machinery	Quantity
	Turn table for one car	1
	Turntable for bogies	4
	Painting booth for separate parts	1
	Floor cleaning machine	4
	Welding equipments	5
	Compressor 500Cfm	2
	DG set 320 KVA	3
	Battery charger	2
E.	**Test Benches/Instruments**	
	Pneumatic test bench	1
	Brake test bench	2
	SPM test bench	2
	Door test bench	2
	Inverter test bench	1
	Other test benches (MCB, RMPU etc.)	1
	Oscilloscope	1
F.	**Furniture/material storage/Small tools**	
	Vertical storage system for DCOS store	1
	Computer MMIS with LAN connectivity	1
	Storage racks	LS
	Industrial furniture	LS
	Electric and pneumatic tools	LS
	Measuring and testing equipments	LS
	Tool kits	LS
	Mobile safety steps	10

Chapter – 15
ENVIRONMENT AND SOCIAL IMPACT ASSESSMENT

15. ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

15.1 EXISTING SCENARIO

15.1.1 Environmental Baseline

Data on land environment has been collected and compiled from various sources and during field surveys. Information about geology, hydrology, prevailing natural hazards like earthquakes etc have been collected from literature reviews and authenticated information made available by government departments. Water quality, soil quality, ambient air and noise environment in the surrounding areas were assessed primarily through field studies, and by undertaking monitoring and analysis of samples collected from field. Meteorological data was collected from Indian Meteorological Department (IMD). A scoping matrix was formulated to identify the attributes likely to be affected due to the development of proposed project and is presented in **Table 15.1**. The general environmental attributes pertaining to the proposed metro project along with parameters to be collected and its frequency are presented in **Table 15.2**.

TABLE 15.1: SCOPING MATRIX

ASPECT OF ENVIRONMENT	LIKELY IMPACTS
A. Land Environment	
Construction Phase	Increased soil erosion
	Pollution by construction spoils
	Solid waste from worker colonies, construction sites
B. Water Resources & Water Quality	
Construction Phase	Water quality impacts due to disposal of wastewater from worker camps and construction sites, spoils.
	Depletion of groundwater resources
Operation Phase	Drainage, Water requirement, and Disposal of waste water
C. Air Pollution	
Construction Phase	Impacts due to emissions generated by construction machinery
D. Noise Pollution	
Construction Phase	Noise due to operation of various equipment
	Noise due to increased vehicular movement
Operation Phase	Noise from Metro operation

ASPECT OF ENVIRONMENT	LIKELY IMPACTS
	Noise due to DG sets
E. Ecology	
Construction Phase	Removal of vegetation cover/loss of biomass
F. Socio-Economics	
Construction Phase	Improved employment potential during project construction phase
	Development of allied sectors leading to greater employment
	Pressure on existing infrastructure facilities
Operation Phase	Increase in Employment Opportunities in direct and indirect sectors
	Increased revenue from business development

The collection and compilation of environmental baseline data is essential to assess the impacts on environment due to the project activities. The environment includes water, land, air, ecology, noise, vibration and socio–economic issues etc.

TABLE 15.2: ENVIRONMENTAL ATTRIBUTES AND FREQUENCY OF BASELINE MONITORING

Sl. No.	Attribute	Parameter	Frequency	Source
Land Environment				
1	Soil	Soil Characteristics	Once	1/2
2	Geology	Geological Status	---	1
3	Seismology	Seismic Hazard	---	1
Water Environment				
4	Water Quality	Physical, Chemical and Biological parameters	Data	1/2
Air, Noise And Meteorology				
5	Air Quality	$PM_{2.5}$, PM_{10}, NOx, SO_2, CO, O_3, NH_3, Pb and HC	24 hourly	1/2
6	Meteorology	Temperature, Relative humidity, Rainfall, wind direction and speed	Data	ITD/1
7	Noise	Noise levels in dB (A)	24 hourly	3/1
Scio-Economic				
8	Socio-economy	Socio-economic characteristics	Once	1/2
Ecology				
9	Trees	Number/species	Once	2

1= Literature review, 2= Field Studies, 3= Field monitoring,
IMD=India Meteorological Department

15.1.1.1 **Land Environment**

Kanpur City is situated between the parallels of $25^{O}26'$ and $26^{O}58'$ North latitude and $79^{O}31'$ and $80^{O}34'$ East longitude. It is flat plain with some minor undulations. Kanpur City along with Kanpur Dehat lie between the fertile Doab region of the Ganges and Yamuna rivers. Kanpur City comes under the Indo-Gangetic plains of India.

Landuse Pattern of Kanpur Nagar

In 1997-98, Kanpur Metropolitan Area including Kanpur City, Cantonment and other municipalities and villages was spread over 89131.15 hectare out of which 4,743.9 hectare (5.31 %) was non-defined (prohibited area) and rest 29,683 hectare and 54,704 hectare (61.39%) was urban and rural area respectively. Over a period of time, Kanpur has developed linearly from east to west along Ganga River and G.T road.

The Central Business District (inner city) is located in the north central part. It is heavily built up and characterized by mixed commercial and transport related activities. The public, semi-public, residential and other land use activities have been mostly concentrated in the west. Due to physical constraints of river in the north and cantonment in the east, industrial concentration followed western/ southern expansion. The landuse pattern of Kanpur city is given in **Table 15.3**.

TABLE 15.3: LANDUSE PATTERN OF KANPUR CITY

Sl. No.	Particular	Area (in '000 Hec)
1	Cultivable area	234.8
2	Forest area	5.6
3	Land under nonagricultural use	42.4
4	Permanent pastures	3.7
5	Cultivable wasteland	8.9
6	Land under Misc. tree crops and groves	3.1
7	Barren and uncultivable land	14.8
8	Current fallows	25.0
9	Other fallows	8.7

Source: Agriculture Contingency Plan for District: Kanpur Nagar

Geology and Soils

The Kanpur Nagar is part of Indo Gangetic Plain. Soil samples were collected at representative locations along the corridors and results of analysis are presented in **Table 15.4**. The low sulphate content implies no special design considerations are needed in the structural design.

TABLE 15.4: SOIL TEST RESULTS

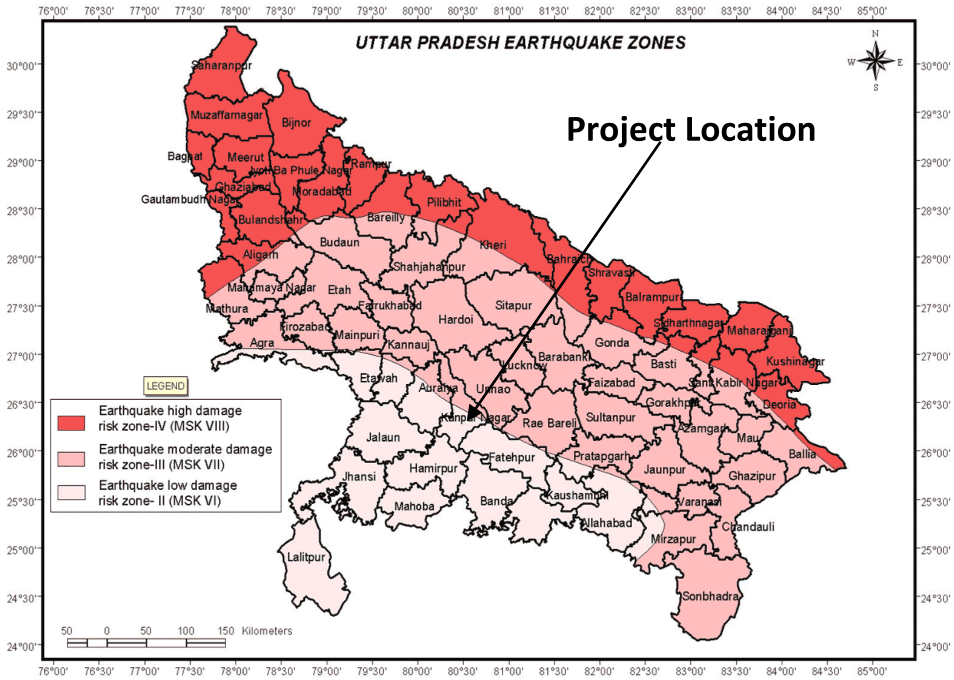
S. N.	Parameter	Unit	Location Nos.				
			1	2	3	4	5
1	**pH**		**7.81**	**7.73**	**7.95**	**7.88**	**7.72**
2	Soil Textures						
	Sand	%	12.40	13.20	14.20	10.60	15.80
	Silt	%	76.10	75.40	78.50	81.10	76.70
	Clay	%	11.50	11.40	7.30	8.30	7.50
3	Calcium as Ca	mg/kg	1324.5	1095.6	1389.9	1349.0	564.1
4	Potassium as K	Kg/ha	840.21	925.12	918.10	640.10	687.68
5	Sodium as Na	mg/kg	228.00	586.00	760.10	257.01	276.00
6	Magnesium as Mg	mg/kg	74.42	128.99	148.84	84.34	54.57
7	Chloride	mg/kg	335.00	593.43	640.12	392.43	287.15
8	Bicarbonate (HCO_3)	mg/kg	3.16	3.60	4.23	3.76	3.43
9	**Sulphate**	mg/kg	**32.14**	**28.16**	**46.14**	**44.18**	**41.86**
10	Total Nitrogen	Kg/ha	210.06	203.16	268.46	251.46	241.04
11	Total Phosphate	Kg/ha	78.10	81.46	92.48	82.41	72.15
12	Avail. Phosphorus	Kg/ha	16.80	15.23	18.13	17.42	16.02
13	Organic Matter	%	1.56	1.41	1.19	1.40	1.24
14	Organic Carbon	%	0.90	0.82	0.69	0.81	0.72
15	Orthophosphate	mg/kg	80.44	83.90	95.23	84.88	74.31
16	Carbonate	mg/kg	3.88	4.10	4.88	4.10	3.72
17	Sulphur	Kg/ha	21.46	19.88	24.61	21.56	19.68
18	Arsenic	mg/kg	BDL	BDL	BDL	BDL	BDL
19	Boron	mg/kg	0.61	0.56	0.78	0.52	0.41
20	Cadmium as Cd	mg/kg	21.46	19.62	25.46	30.14	21.18
21	Copper as Cu	mg/kg	32.71	30.18	32.15	23.14	28.16
22	Iron	mg/kg	76.14	73.18	83.14	74.18	68.46
23	Lead as Pb	mg/kg	7.84	7.22	9.46	8.18	7.88
24	Manganese as Mn	mg/kg	355.14	339.14	422.18	402.36	388.24
25	Mercury	mg/kg	BDL	BDL	BDL	BDL	BDL
26	Molybdenum	mg/kg	0.1	0.08	0.16	0.14	0.11
27	Nickel	mg/kg	8.41	8.04	9.66	8.26	7.88
28	Total Zinc as Zn	mg/kg	28.16	24.62	28.42	26.21	23.14

1. Near IIT Kanpur 2. Near Rawatpur Railway Station, 3. Naubasta, 4. Parade Chauraha, 5. Bara 8
Source: Primary Surveys, June 2015

Seismicity

Most of the state of Uttar Pradesh lies in the Gangetic Plain. Beneath Uttar Pradesh, runs the Delhi-Haridwar Ridge (DHR), trending NNE-SSW along New Delhi to the Gharwal region. Earthquakes have occurred in mostly all parts of Uttar Pradesh. The districts of Etawah, Kanpur, Jalaun, Jhansi, Hamirpur, Banda, Fatehpur, Allahabad and Lalitpur lie in Zone III. Seismic zoning map of Uttar Pradesh is given in **Figure 15.1.** Structural design for the Project has to be done accordingly.

FIGURE 15.1: SEISMIC ZONING MAP OF UTTAR PRADESH



15.1.1.2 **Water Environment**

Total demand of Kanpur city is 520 mld whereas supply is 413 mld. Hence, there is deficit in supply versus demand. Assuming that this deficit will remain same during the construction period and cost of treated surface water for construction is high, ground water is proposed to be used during construction.

Use of treated waste water is an option however in view of relatively high capital and operating cost of such facility for metro construction vis a vis small quantify of water required, this option is not considered. For extraction of ground water approval from competent authority i.e. Central Ground Water Board must be taken.

Hydrogeology

In Kanpur Nagar silt, gravel, and sands of different grades are main water bearing formations. In southern part specially along Yamuna river, feldspar-quartz, Jaspar sands and gravel (Mourum) are the main constituents of the granular zones that occurs comparatively at shallow levels i.e. 24 to 57 meter below ground level (mbgl) whereas in the northern parts along the Ganga river, these reworked sedimentary formations are existing at deeper levels i.e. 265 to 310 mbgl.

Depth to Water Level: The water level is measured four times in a year in C.G.W.B. National Hydrograph Network Stations in Kanpur Nagar district at eleven hydrograph stations. *The pre-monsoon period (year 2007) depth to water level varies from 2.20 to 27.13 mbgl whereas in post-monsoon period it varies from 2.08 to 27.13 mbgl*.

Long Term Water Level Trend: The long term water level trend for last ten years (1998-2007) shows annual declining trend in 14 numbers of hydrograph stations. In pre-monsoon period three hydrograph stations shows rising trend & these are Naramau (07 cm/year), Motipura (19 cm/year) and Chaubepur (43cm/year) and rest are showing declining trend which varies from 4 to 63 cm/year. *In post monsoon period except Motipura all hydrograph stations are showing declining trend and it varies from 4 to 84 cm/year.*

Status of Ground Water Development

The depth of irrigation borewell in Kanpur district varies from 20m to 96 mbgl. At present 74% of irrigation is through ground water. The net availability of ground water for future development is 28628 hectare meter.

Water Quality

As per CGWB study, the ground water of Kanpur Nagar district is colourless, odourless and slightly alkaline in nature. It is observed that quality of water is good for drinking, domestic and all other purposes. The arsenic content has been found ranging from Not Detectable to 42mg/l. The trace metals Zn, Mn, Ni, Pb are within the permissible limit except for copper 1249mg/l and iron 6.236 mg/l at Kanpur. Ground water quality of the project area was assessed and the results are given in **Table 15.5**. Cost of water treatment facilities to be installed in the Metro Depots is included in the EMP.

TABLE 15.5: WATER QUALITY AT PROJECT SITE

S.N	Parameters	Location				
		1	2	3	4	5
1	pH (at $25^{O}C$)	7.36	7.19	7.02	7.43	7.63
2	Turbidity, NTU	***161.9***	0.0	***45.7***	***6.4***	0.0
3	Total Dissolved Solids, mg/l	***1254***	***756***	***1684.0***	***816.0***	***1224***
4	Aluminium (as Al), mg/l	0.01	BDL	BDL	BDL	BDL
5	Free Ammonia (as NH3), mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
6	Barium (as Ba), mg/l	0.01	0.009	BDL	BDL	0.177
7	Boron (as B), mg/l	BDL	BDL	BDL	BDL	BDL
8	Calcium (as Ca), mg/l	56.7	***105.3***	***178.1***	***105.3***	***105.3***
9	Chlorides (as Cl), mg/l	187.2	39.4	***325.2***	98.6	177.4
10	Copper (as Cu), mg/l	0.002	BDL	0.004	0.005	BDL
11	Fluorides (as F), mg/l	***>1.0***	<1.0	***>1.0***	<1.0	***>1.0***
12	Free Residual Chlorine, mg/l	NA	NA	NA	NA	NA
13	Iron (as Fe), mg/l	BDL	BDL	BDL	BDL	BDL
14	Magnesium (as Mg), mg/l	***49.2***	***44.3***	128.0	4.9	***69.0***
15	Manganese (as Mn), mg/l	0.060	BDL	0.065	0.007	0.005
16	Nitrates (as NO_3), mg/l	BDL	6.3	BDL	BDL	7.2
17	Phenolic Compounds (as C_6H_5OH) , mg/l	BDL	BDL	BDL	BDL	BDL
18	Selenium (as Se), mg/l	BDL	BDL	0.007	0.002	0.007
19	Silver (as Ag), mg/l	BDL	BDL	BDL	BDL	BDL
20	Sulphates (as SO_4),mg/l	58.0	48.0	61.6	52.0	65
21	Sulphide (as S), mg/l	BDL	BDL	BDL	BDL	BDL
22	Alkalinity (as $CaCO_3$), mg/l	***626.2***	***37.37***	***515.1***	***404.0***	***626.2***
23	Total Hardness (as $CaCO_3$), mg/l	***343.4***	***444.4***	***969.6***	***282.8***	***545.4***
24	Zinc (as Zn), mg/l	0.022	BDL	0.057	0.05	BDL
25	Cadmium (as Cd), mg/l	BDL	BDL	BDL	BDL	BDL
26	Cyanides (as CN), mg/l	BDL	BDL	BDL	BDL	BDL
27	Lead (as Pb), mg/l	BDL	BDL	BDL	0.004	BDL
28	Mercury (as Hg), mg/l	BDL	0.0002	BDL	BDL	BDL
29	Nickel (as Ni), mg/l	0.002	BDL	BDL	BDL	BDL
30	Total Arsenic (as As), mg/l	BDL	BDL	BDL	0.003	BDL
31	Total Chromium (as Cr) , mg/l	BDL	BDL	BDL	BDL	

S.N	Parameters	Location				
		1	2	3	4	5
32	Total Suspended Solid, mg/l	124.0	0.0	21.0	8.0	0.0
33	Vanadium (as V), mg/l	BDL	BDL	BDL	0.003	BDL
34	Ammonical Nitrogen (as N), mg/l	<0.1	<0.1	<0.1	<0.1	<0.1
35	Total Kjeldahl Nitrogen (as N), mg/l	<0.1	1.58	<0.1	<0.1	1.75
36	Chromium (as hexavalent Cr), mg/l	BDL	BDL	BDL	BDL	BDL
37	Oil & Grease, mg/l	0.0	0.0	0.0	0.0	0
38	Dissolved Oxygen, mg/l	6.8	7.0	6.1	6.7	6.7
39	COD , mg/l	3.8	0.0	65.3	3.8	3.8
40	Biochemical Oxygen Demand (3 day 27 deg C) , mg/l	1.0	Nil	23.0	1.0	1.0
41	Total Phosphate, mg/l	BDL	0.5	BDL	BDL	0.8
42	Dissolved Phosphate (as P) , mg/l	BDL	0.5	BDL	BDL	0.8
43	Sodium (as Na) , mg/l	265	53.5	145.0	175	210
44	Potassium (as K), mg/l	12.0	9.5	18.5	12	15.5
45	Nitrate Nitrogen, mg/l	BDL	1.42	BDL	BDL	1.63
46	Total Nitrogen, mg/l	<0.1	1.58	<0.1	<0.1	1.75
47	Organic Phosphorus, mg/l	BDL	BDL	BDL	BDL	BDL
48	Coliform Count (MPN)	Absent	Present	Absent	Absent	***Present***
49	Faecal Coliform	Absent	Absent	Absent	Absent	Absent
50	Total Coliform Organism	Absent	***Present***	Absent	Absent	***Present***

1. Near IIT Kanpur, 2. Near Rawatpur Railway Station, 3. Naubasta, 4. Parade Chauraha, 5. Bara 8;
2. ***37.37*** Values more than acceptable limit but less than permissible limit as per IS 10500:2012; ***<u>626.2</u>*** values more than permissible limit.

Source: Primary Surveys, June 2015

15.1.1.3 Meteorology and Air Environment

All air pollutants emitted by point and non-point sources are transported, dispersed or concentrated by meteorological conditions. The main parameters are: temperature, humidity, rainfall, winds and cloud cover.

Meteorology

About 90% of rainfall takes place from third week of June to September. The mean daily maximum temperature in May is 41.7^0C, mean daily minimum temperature is 27.2^0C and maximum temperature rises up to 45^0C or over. The January is the coldest month with mean daily maximum temperature at 22.8^0C and mean daily minimum temperature at 8.6^0C. The mean wind velocity is 9.6 Kmph. Meteorological data of Kanpur from January 2014 to April 2015 as collected from Indian Meteorological Department Lucknow is presented in the separate EIA Report.

Air Quality

The source activities for air pollution in the city of Kanpur can be broadly classified as: transport sector (motor vehicles and railways), commercial activities, industrial activities, domestic activities, institutional & official activities and fugitive sources. Under commercial activities, diesel/ kerosene generators are the most prevailing sources for air pollution in the city. The combustion of fuels like coal, kerosene, liquefied petroleum gas (LPG) and wood come under the source for domestic activities. As far as the industrial activities are concerned, the dominant source is the Panki Thermal Power Plant. Lots of small and medium scale industries are also responsible for the air pollution. In most of the institutions and offices, the diesel generators are used at the time of power failure. Unlike other cities, at several locations, garbage burning (mostly in the evening) is a common practice; it can be an important contributor to air pollution. The World Health Organization (WHO) urban air pollution database, released in September 2011, states that Kanpur is the second most polluted city in India. For Kanpur, vehicular emissions were found to contribute 21% of SPM (Suspended Particulate Matter) load in 2007. This secondary data is presented in the separate EIA Report.

In order to establish the baseline concentrations of air pollutants, air quality monitoring was carried out near to the corridors by setting up ambient air quality monitoring stations. The locations chosen near to habited area or near to sensitive receptors. Air Monitoring was carried out for PM2.5, PM10, NOx, SO2, CO, O3, NH3, Pb and HC. Results of the air quality monitoring are presented in **Table 15.6**.

The values shown in bold and italic exceeds the standards. Particulate matter exceeds the permissible limits. Other parameters are within permissible limits. Therefore measure to mitigate air pollution during construction will be recommended. Operation of the proposed Metro system will result in decrease of particulate pollution generated by road based vehicles. Cost of mitigation measures to be implemented during construction forms part of civil engineering cost.

TABLE 15.6: AMBIENT AIR QUALITY ALONG THE CORRIDORS

Parameter	Time	Location								Standard
		1	2	3	4	5	6	7	8	
PM $_{10}$ ($\mu g/m^3$)	24 Hr	***142***	***158***	***175***	***168***	***110***	***210***	***105***	98	100
PM $_{2.5}$ ($\mu g/m^3$)	24 Hr	59	***65***	***69***	***70***	56	***80***	50	48	60
SO_2 ($\mu g/m^3$)	24 Hr	12.6	18.5	25	15.5	10.6	7.5	8.5	5.5	80
NO_2 ($\mu g/m^3$)	24 Hr	22.5	34.6	39.5	28.8	25.8	19.9	29.9	12.5	80
Ammonia (NH_3) ($\mu g/m^3$)	24 Hr	44	30	35	38.5	24	15	20	10	400
Ozone (O_3) ($\mu g/m^3$)	16-00	25.5	28.5	36.2	37.8	18.9	8.5	9.5	7.5	100
	00-08	8.9	18	12.5	12.6	36.4	12.5	20.5	15.8	100
	08-16	55.2	66	69	89.9	88	50.2	66.8	48.5	100
Carbon monoxide (CO) ppm	16-00	23.0	575	1725	345	115	115	115	115	2000
	00-08	115	115	575	230	115	BDL DL=115	BDL DL=115	BDL DL=115	2000
	08-16	345	345	1035	690	230	BDL DL=115	115	BDL DL=115	2000
Lead (pb) ($\mu g/m^3$)	24 Hr	0.15	0.5	0.8	0.3	0.08	0.02	0.05	BDL DL=.01	1.0
HC as (CH_4) (ppm)	24 Hr	BDL DL=1	BDL DL=1	2.5	BDL DL=1	BDL DL=1	BDL DL=1	BDL DL=1	BDL DL=1	-

1. Kalyanpur Railway Station, 2) Rawatpura Railway Station, 3) Parade Chauraha, 4) Kanpur Central Railway Station, 5) Kidwai Nagar, 6) Naubasta, 7) Govind Nagar, 8) Barra 8

Source: Primary Surveys, 2015

15.1.1.4 Noise Environment

Noise is responsible for adverse impact on physical and mental health of the people.

The impact depends on:

- Characteristics of noise sources (instantaneous, intermittent or continuous in nature).
- Time of day at which noise occurs, for example high noise levels at night in residential areas are not acceptable because of sleep disturbance.
- Location of noise source, with respect to noise sensitive land use, which determines the loudness and period of exposure.

In Kanpur the factors/agents such as generators, loud speakers, automobile horns and fireworks/ crackers are responsible for noise pollution. Some commercial areas like Ghantaghar has noise level as high as 78.2 dB(A) and industrial area like Dada Nagar’s noise level is 75.1 dB(A) against a permissible limit of 65 dB during day time. Corresponding to that the permissible noise pollution level during night time fixed at 55 dB (A) for the above two localities have recorded 71.8 dB and 69.5 dB respectively.

A noise level survey was conducted along the alignments with an objective to establish the baseline noise levels and assess the impacts of total noise expected due to the proposed metro. The noise levels so obtained are summarized in **Table 15.7**. It could be concluded that the day time and night time noise levels recorded at various places are higher than prescribed permissible levels of 65-dBA (day) and 55-dBA (night) for commercial area and 55-dBA (day) and 45-dBA (night) for residential area.

Therefore measure to mitigate noise pollution during construction will be recommended. Estimated cost of noise barriers along the viaduct to mitigate noise generated by operation of Metro is included in the Civil Cost. Operation of the proposed Metro system will result in decrease of noise pollution generated by tempos and other road based vehicles on the Metro corridor.

TABLE 15.7: NOISE LEVEL

Sl. No.	Location	1	2	3	4	5	6	7	8
1	L_{eq}	66.4	67.8	66.0	70.8	58.9	66.8	64.5	67.2
2	L_{10}	74.4	74.1	72.4	75.9	66.6	72.9	68.6	70.5
3	L_{50}	65.2	66.2	64.2	69.2	56.3	64.3	63.3	65.1
4	L_{90}	57.1	57.7	55.6	61.1	47.0	54.5	55.1	54.8
5	L_{max}	75.1	76.3	74.8	77.2	67.3	75.1	70.7	72.1
6	L_{min}	52.0	53.5	53.6	56.3	45.2	50.1	50.1	50.1
7	L_{day}	71.0	71.5	69.7	73.1	64.7	66.9	67.8	68.0
8	L_{night}	63.2	64.2	63.2	64.5	55.6	52.8	54.1	51.2
9	L_{dn}	72.7	73.7	71.5	75.3	62.5	70.1	67.1	72.1

1) Kalyanpur Railway Station (C), 2) Rawatpur Railway Station (C), 3) Parade Chauraha (C), 4) Kanpur Central Railway Station (C), 5) Kidwai Nagar(C), 6) Naubasta(R), 7) Govind Nagar(R), 8) Barra 8(R)

Source: Primary Surveys, July 2015

15.1.1.5 Ecology

The project site is located in city area and it is free of any wildlife fauna. Kanpur city and Dehat has 5400 hectares of forest area. The city currently has negligible area under forest: Allan Forest on 50 hectares which harbours the Kanpur Zoological Garden: the alignment at Gurudev Chauraha is around 1 km away from the zoo. The other area called Sanjay Van Banglia has 20 hectares. On site construction activities will result in loss of trees. The main species along the corridors are Bargad, Cassia, Champa, Gulmohar, Karanj, Neelgiri, Neem, Pakad, Peepal, Sagwan, Seijan and Sheesam. An inventory of trees in the two corridors and three depots likely to be lost has been prepared and summarized in the EIA Report. Estimated cost of compensatory afforestation is included in the EMP.

15.2 ENVIRONMENT NORMS AND REGULATIONS

The Environmental Acts, Legislation, Guidelines and Standards implementation is the responsibility of different government agencies like Central/State Pollution Control Boards, Project Authorities and State Level Committees. The principal environmental regulatory agency is the Ministry of Environment Forests and Climate Change (MoEFCC), New Delhi. The following Acts, legislation and laws are consulted with a view to ensure compliance with various requirements.

- Amendment dated 9 December 2016 to EIA Notification 2006: Integration of environmental Conditions in local building byelaws
- The Air (Prevention and Control of Pollution) (Union Territories) Rules 1982, 1983 (Consent to establish and operate)
- The Water (Prevention and Control of Pollution) Rules 1975 (Consent to establish and operate)
- Environment (Protection) Act, 1986
- National Ambient Air Quality Standards November 2009
- Guidelines for Ambient Air Quality Monitoring , CPCB, 2003
- The Water (Prevention and Control of Pollution) Act 1974 amended 1988
- Guide Manual – Water and waste water analysis, CPCB
- Drinking water – Specifications IS 10500: 2012 and CPHEEO Manual 2012
- Protocol for Ambient Level Noise Monitoring, CPCB, 2015
- Noise Pollution (Regulation and Control) Rules, 2000 amendment in 2010
- Construction and Demolition Waste Management Rules 2016

- Hazardous and Other Wastes (Management and Transboundary Movement) Rules 2016
- Solid Waste Management Rules 2016
- Forest (Conservation) Act, 1980, amended 1988.
- Forest (Conservation) Rules 2003 and Forest (Conservation) Amendment Rules, 2014 (procedure for FC)
- The Indian Wild Life (Protection) Act 1972 and The Wildlife (Protection) Amendment Act 2002
- The Ancient Monuments and Archaeological sites and Remains (Amendment and Validation Act) 2010
- The Uttar Pradesh Ground Water (Management and Regulation) Bill 2017 and Guidelines/Criteria for evaluation of proposals/requests for ground water abstraction (With effect from 16.11.2015), Central Ground Water Authority
- Right to Fair Compensation and Transparency in land acquisition, Rehabilitation and Resettlement Act, 2013(RTFCTLARR Act).

15.3 DETAILED ENVIRONMENTAL IMPACT ASSESSMENT

15.3.1 Impacts Due to Project Location

During this phase, those impacts, which are likely to take place due to the layout of the project, have been assessed. These impacts are:

- Displacement and loss of livelihood of Project Affected People (PAPs)
- Change of Land use
- Impact on/loss of wildlife/trees/forest
- Utility/Drainage Problems
- Impact on archaeological monuments.

i. Displacement and loss of livelihood of Project Affected People (PAPs)

People who have their properties along the alignment will be affected due to the acquisition of land for proposed Kanpur Metro corridors.

ii. Change of Land Use

Land will be required permanently for stations, Depot, Ramp and running section. Both government and private land will be acquired for the project the details of which are given in the section on Civil Engineering.

iii. Impact on/loss of wildlife/trees/forest

The proposed corridors are in urban/city area and will not pass through any forests. There are approximately 1450 trees along the two corridors and in three depots. These trees are likely to be cut during construction. Trees are major assets in purifications of urban air, which by utilizing CO_2 from atmosphere, release oxygen into the air. Therefore with removal of these trees, the process for CO_2 conversion will get adversely affected and the losses are reported below:

i.	Total number of Trees	:	1450
ii.	Decrease in CO_2 absorption due to loss of trees	:	31,610kg/year
iii.	Decrease in Oxygen production due to tree loss	:	71,050 kg/year

The above loss of oxygen production is equivalent to loss of oxygen requirement of about 390 people round the year.

iv. Utility/Drainage Problems

The proposed Metro corridors are planned to run through the urban area above the ground i.e. elevated in less densely populated and underground in populated and sensitive areas. The alignment will cross drains, 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. Cost of such diversions is covered in the section on Civil Engineering.

v. Impact on archaeological monuments

No archaeological monuments will be lost as a result of the proposed development.

15.3.2 Impacts due to Project Design

Impacts due to project design are seen in following ways:

- Consumption of energy and water at stations and vibration impact of underground line in trade off with visual intrusion.
- Inter-modal integration will lead to increased use of metro while avoiding congestion outside stations.

15.3.3 Impacts Due to Project Construction

Environmental hazards related to construction works are mostly of temporary nature. Appropriate measures should be included in the work plan and budgeted for. The most likely negative impacts related to the construction works are

- Soil erosion and pollution
- Traffic diversion and risk to existing buildings
- Excavated Soil Disposal and Debris Disposal
- Pollution Generation due to transportation of earth and material
- Increased water demand
- Labour Camp
- Welfare of Labour on construction site
- Safety of labor
- Impact due to Supply of Construction Material
- Impact of construction near archaeological monuments
- Impact on ground and surface water quality
- Noise and vibration

i. Soil Erosion and Pollution

Run off from unprotected excavated areas can result in excessive soil erosion, especially when the erodability of soil is high.

ii. Traffic Diversions and Risk to Existing Buildings

During construction period, complete/partial traffic diversions on road will be required, as most of the construction activities are on the road. Such plans and their cost form part of the section on Engineering. The elevated and underground corridor does not pose any serious risk to existing buildings because minimum horizontal distance from centre of track to any structure is maintained in accordance with engineering norms. As part of pre-construction/construction/post-construction activities building condition survey will have to be conducted cost of which is not included in EMP.

iii. Excavated Soil Disposal and Debris Disposal

The metro route is both elevated and underground. The construction activity involves cut and cover, tunnel (bored and rock), foundation, fill and embankment. Owing to paucity of space in busy cites and for safety reasons, elaborate measures need to be adopted for collection, storage, transfer and disposal of soil. All these activities will generate about 1.994 Mm^3 of soil. Out of this, about 0.578 Mm^3 is likely to be reutilized in backfilling in underground stations and Depots. The balance 1.416 Mm^3 shall be disposed off in environmental friendly manner. Disposal of excess soil should be permitted in low lying areas owned by KDA. The excess soil disposal site will be those identified by KDA and communicated to UPMRC. Identification of measures required at soil disposal sites and their indicative cost forms part of EMP. About 10-15% of the construction material such as waste material from contractor camps is left behind by the contractor as construction waste/spoils. Dumping of construction waste/spoil in a haphazard manner may cause surface and ground water pollution near the construction sites.

iv. Pollution Generation due to transportation of earth and material

Transportation of earth and establishment of the material will involve use of heavy machinery like compactors, rollers, water tankers, and dumpers. This activity is machinery intensive resulting in dust generation. However, this activity will be only short-term. Protective measures shall be undertaken during construction phase.

It is estimated that, about 1.994 Mm^3 of earth will be transported in trucks for backfilling in depots and final disposal. The estimated truck movement required to transport the soil/earth will be about 219 truck trips per day for the entire length of construction period. On an average a truck is anticipated to move about 20 km per trip. Hence the total dust emission/pollution would be 5.5.427 kg/day of particulate matter, 26.23 kg/day of CO, 1.62 kg/day of HC, 40.65 kg/day of NOx and 3332.41 kg/day of CO_2.

v. Increased Water Demand

The water demand will increase during construction phase. Water requirement for construction of metro will be met through municipal supply: in exceptional cases and for short term tube-wells bored specially for the purpose of metro construction will be used after taking approval from competent authority i.e. Central Ground Water Board (CGWB).

vi. Labour Camp

Facilities such as temporary living accommodation for construction workers at locations away from construction sites; facilities for water supply, treatment /

disposal of waste water, sewage and solid waste; collection and disposal of solid waste; health care are statutory requirement and essential to productivity.

vii. Welfare of Labour on construction site

Facilities such as shelter at workplace, canteen, first aid and day crèche are statutory requirement and essential to productivity.

viii. Safety of Labour

Safety of labour during construction on elevated and underground sections is a statutory requirement and also has impact on progress of work.

ix. Impact due to Supply of Construction Material

A summary of approximate construction material required for the corridors is given in **Table 15.8**. Construction material such as aggregate and earth are sourced from approved quarries such that environmental impacts as well as wastage of natural resources are minimized and mitigated.

TABLE 15.8: CONSTRUCTION MATERIAL REQUIREMENT

Material	Unit	Total Quantity
Underground station		
Cement	MT	147433
Fly Ash	MT	53417
Sand	MT	323778
Aggregate 20mm	MT	315159
Aggregate 10mm	MT	234624
Reinforcement	MT	85059
Stone Work	sqm	123500
MS Structure	kg	312000
Stainless Steel	kg	447850
Paint	Ltr	78000
Tiles Work	sqm	22100
Tunnel		
Cement	MT	26461
Fly Ash	MT	4281
Sand	MT	47507
Aggregate 20mm	MT	34551
Aggregate 10mm	MT	42233
Silica	MT	7542
Reinforcement	MT	7542
Elevated Station		
Concrete	Cum	144591

Material	Unit	Total Quantity
Steel	MT	19623
Viaduct		
Concrete	Cum	326856
Steel	MT	46319
HT stand	MT	2353

x. Impact due to Construction near Archaeological Monuments

No archaeological monuments are involved.

xi. Impact on Ground and Surface Water Quality

Ground water contamination can take place if chemical substances get deposited in soil and are leached by water and percolate to the ground water table. Surface water source can be contaminated if untreated construction wash water is let in from construction sites.

xii. Noise and vibration

Construction noise and vibration may disturb people at home, office, school or retail religious buildings depending upon their vicinity to construction site. The major sources during construction are movement of vehicles for transportation of construction material and operation of construction equipment. There are number of sensitive receptors like School, College, Hospital, Temple, Mosque, near the alignment. The Result of the noise prediction is presented in **Table 15.9**. Damage to structures due to vibration is a possibility in case of pile driving or trains passing within 7.5 m from normal buildings or unreinforced structures or between 15m to 30m from historical buildings or buildings in poor condition; heavy truck traffic within 30m, major construction within 60m, freight trains within 90m or pile diving within 180m can cause disruption of operation of sensitive instrumentation (*Transportation and Construction Vibration Guidance Manual, Caltrans, September 2013*).

TABLE 15.9: NOISE LEVEL PREDICTION DURING CONSTRUCTION dB (A)

Distance	Concrete Batch Plant + Concrete Mixer Truck		Auger Drill Rig +Dump Truck + Generator + Slurry Plant		Dump Truck + Excavator + Pneumatic Tools	
	Lmax	Leq	Lmax	Leq	Lmax	Leq
5	92.7	87.5	94	92.5	94.9	93.3
10	86.7	81.5	88	86.5	85.8	85.3

Distance	Concrete Batch Plant + Concrete Mixer Truck		Auger Drill Rig +Dump Truck + Generator + Slurry Plant		Dump Truck + Excavator + Pneumatic Tools	
	Lmax	Leq	Lmax	Leq	Lmax	Leq
15	83.1	77.9	84.5	83	82.3	81.8
20	80.6	75.4	82	80.5	79.8	79.3
25	78.7	73.5	80.1	78.6	77.9	77.4
30	77.1	71.9	78.5	77	76.3	75.8
35	75.8	70.6	77.1	75.6	75	74.5
40	74.6	69.4	76	74.5	73.8	73.3
45	73.6	68.4	75	73.4	72.8	72.3
50	72.7	67.5	74	72.5	71.9	71.4
55	71.9	66.7	73.2	71.7	71	70.5
60	71.1	65.9	72.5	71	70.3	69.8
65	70.4	65.2	71.8	70.3	69.6	69.1
70	69.8	64.6	71.1	69.6	68.9	68.4
75	69.2	64	70.5	69	68.3	67.8
80	68.6	63.4	70	68.5	67.8	67.3
85	68.1	62.9	69.4	67.9	67.3	66.8
90	67.6	62.4	68.9	67.4	66.8	66.3
95	67.1	61.9	68.5	67	66.3	65.8
100	66.7	61.5	68	66.5	65.8	65.3

15.3.4 Impacts Due to Project Operation

Along with many positive impacts, the project may cause the following negative impacts during operation of the project due to the increase in the number of passengers and trains at the stations:

- Noise and Vibration
- Water supply and sanitation at Stations
- Traffic congestion
- Impact due to depot

i. Noise and Vibration

There are number of sensitive receptors like School, College, Hospital, Temple, Mosque, near the alignment. The major impacts on sensitive receptors during operation phase will be noise and vibration impact due to train operation. During the operation phase the main source of noise will be from running of metro trains. Airborne noise is radiated from at-grade and elevated structures, while ground-borne noise and vibration are of primary concern in underground operations. Basic Sources of wayside airborne noise are wheel / rail interaction, propulsion equipment, auxiliary equipment, elevated structures.

Noise prediction with average train speed of 35 km/hr and no noise barriers is presented in **Table 15.10**. Impact of vibration during operation is mentioned in para xii under impacts due to construction.

TABLE 15.10: NOISE LEVELS AT DIFFERENT DISTANCES dB(A)

Distance (m)	IIT Kanpur to Naubasta			Agriculture University to Barra-8		
	2021	2031	2041	2021	2031	2041
10	71	72	79	70	71	72
20	67	68	69	65	67	68
30	64	65	66	62	64	65
40	62	63	64	60	62	63
50	61	62	63	59	61	62
60	60	61	62	58	60	60
70	59	60	61	57	59	59
80	58	59	60	56	58	58
90	57	58	59	55	57	58
100	56	57	58	55	56	57

ii. Water Supply and Sanitation

The water demands will be on station for drinking and toilet primarily of staff, station cleaning and AC chiller. Water Demand is calculated and presented in **Table 15.11**. Water should be treated before use upto WHO drinking water standards. The water requirement for the stations will be met through the public water supply system after taking necessary approvals.

TABLE 15.11: WATER REQUIREMENT

Sl. No.	Particular	Water Demand (KLD)
1	At Stations for Drinking Purpose	186
2	In Underground Section	3185
3	In Elevated stations	540
	Total	**3911**

iii. Traffic Congestion at stations

Upon operation of metro services passenger rush at stations will increase resulting in congestion around stations.

iv. Impacts due to Depot

Three maintenance depots are planned for Kanpur Metro at Polytechnic, Agriculture University and stabling depot at Naubasta. In order to develop these areas as depot, it will need filling by earth brought from outside. The depots will have following facilities:

- Washing Lines,
- Operation and Maintenance Lines,
- Workshop, and
- Offices

These facilities will could generate water and noise issues. The earth from underground metro corridor tunnelling and cut and cover will be utilised to fill the deport site. Problems anticipated at depot sites are Water supply, Oil Pollution, Cutting of trees, Sanitation, Effluent Pollution, Noise Pollution, Loss of livelihood, Impact due to filling of area, and Surface drainage.

➢ **Water Supply**

Water supply will be required for different purposes in the depot. The water will be required for train washing purpose and for other requirement (Departments and Contractors office). A three day cycle is assumed for outside Cleaning (wet washing on automatic washing plant). Projected water demands are summarised in **Table 15.12**. This water will be collected through municipal supply at each Depot.

TABLE 15.12: WATER REQUIREMENT

S.No.	Depot	Year		
		2021	2031	2041
1	IIT Kanpur To Naubasta	117	121	127
2	Agriculture University to Barra-8	105	108	109

The water after conventional treatment can be processed through Reverse Osmosis (RO) technology for specific use such as drinking/ cooking and final washing of equipment/ trains.

➢ **Sewage and Effluent**

About 80 KLD of sewage will be generated from the each depot and estimate effluent that will be generated from the washing of trains is presented in **Table 15.13**. The wastewater will be treated and will be recycled to use at depot horticulture purpose. The remaining domestic waste /sewage generated at the Depot will be collected at one suitable point inside the depot from where it will discharge to the nearest manhole of existing sewerage system. Based on past experience in similar projects the wastewater characteristics could be as reported in **Table 15.14**.

TABLE 15.13: EFFLUENT QUANTITY (KLD) AT DEPOTS

S.No.	Depot	2021	2031	2041
1	Corridor 1	13	17	22
2	Corridor 2	4	6	7

TABLE 15.14: SEWAGE & EFFLUENT CHARACTERISTICS

S. No.	Parameter	Unit	Sewage	Effluent
1.	pH	---	6-8	6-8.5
2.	BOD	mg/l	250-350	150
3.	Suspended Solids	mg/l	200-450	500
4.	COD	mg/l	600-800	300
5.	Oil and Grease	mg/l	Upto 50	500
6.	Detergents	mg/l	---	100

➢ **Oil Pollution**

Oil spillage during change of lubricants, cleaning and repair processes, in the maintenance Depot cum workshop for maintenance of rolling stock, is very common. The spilled oil should be trapped in oil and grease trap. The collected oil would be disposed off to authorised collectors, so as to avoid any underground/ surface water contamination.

➢ **Noise Pollution**

The main source of noise from depot is the operation of workshop. The roughness of the contact surfaces of rail and wheel and train speed is the factors, which influence the magnitude of rail - wheel noise. The vibration of concrete structures also radiates noise.

➢ **Surface Drainage**

Due to the filling of the low-lying area for the construction of depots, the surface drainage pattern may change specially during monsoon. Suitable drainage measures will be required to drain off the area.

➢ **Solid Waste**

Solid waste will be generated from each of the Depot sites which will be taken by the cleaning contractor weekly and disposed to the KDA waste disposal sheds. Sludge will be generated from ETP/STP, oil and grease will be produced from car maintenance and iron turning of the PWL for the wheel profiling will be generated from each of the metro Depot.

15.3.5 Benefits

- Employment Opportunities
- Benefits to Economy
- Traffic Congestion Reduction, Quick Service and Safety
- Traffic Noise Reduction
- Reduction of Traffic on Road
- Decreased air pollution
- Carbon Credits

15.3.5.1 **Employment Opportunities**

The civil works of the project is likely to be completed in a period of 5 years. During this period manpower will be needed for various project activities. More people would be indirectly employed for allied activities. In post-construction phase, about 1460 people will be employed for operation and maintenance of the system. The system would result in growth in the entire City as well as the Metropolitan Area.

15.3.5.2 **Benefits to Economy**

In the present context, the project will streamline and facilitate movement of public from different parts of Meerut. These corridors will yield tangible and non tangible saving due to equivalent reduction in road traffic and certain socio-economic benefits. Introduction of this metro will result in the reduction in number of busses, usage of private vehicles. This in turn will result in significant social benefits due to reduction in fuel consumption, vehicle operating cost and travel time of passengers. With the development of the 2 corridors of Meerut Metro project, it is likely that more people will be involved in trade, commerce and allied services.

15.3.5.3 **Traffic Congestion Reduction, Quick Service and Safety**

With the implementation of two metro corridors, travel time of passengers travelling by other modes will get reduced. The proposed development will reduce journey time and hence congestion and delay. Also, implementation of the metro will provide improved safety and lower number of accidents, injuries and accidental deaths and increase safety of persons.

15.3.5.4 **Traffic Noise Reduction**

Reduction in road traffic volume affects the noise levels. A 50% reduction of the traffic volume may results in a 3 dB reduction in noise levels, regardless of the absolute number of vehicles. Reduction in traffic volume of 10% & 50% reduces noise at the tune of 0.5 dB & 3.0 dB respectively.

15.3.5.5 **Reduction of Traffic on Road**

The estimated numbers of vehicle km that will be reduced daily due to construction of Kanpur Metro Phase I are given in **Table 15.15**. Based on number of vehicle trips reduction, reduction in fuel (diesel, petrol and CNG) consumption and respective cost is reported in **Table 15.16.**

TABLE 15.15: REDUCTION IN DAILY VEHICLE KM

Metro	Fuel	2024	2031	2041
Bus	CNG	272744	316934	390242
2 wheeler	Petrol	972586	1170139	1614587
Car(petrol)	Petrol	74489	68411	71725
Car(diesel)	Diesel	37244	34206	35862
Car(CNG)	CNG	12415	11402	11954
Auto	CNG	54615	22226	6633

15.3.5.6 **Decreased Air Pollution**

The major vehicular pollutants that define the ambient air quality are: Particulate matter, Nitrogen oxides, Carbon monoxide, Hydro Carbons and

Carbon dioxide. In addition to the above pollution, un-burnt products like aldehydes, formaldehydes, acrolein, acetaldehyde and smoke are by products of vehicular emissions. The reduction of air pollutants with the Metro corridors are presented in **Table 15.17.**

TABLE 15.16: REDUCTION IN ANNUAL FUEL CONSUMPTION AND ANNUAL SAVINGS IN FUEL COSTS

Metro	Diesel (million litre per year)	Petrol (million litre per year)	CNG (million kg per year)	Fuel Type	Total Cost (Rs million per year)
2024					
Bus			19.9	Diesel	38.7
2 wheeler		4.2		Petrol	395.5
car	0.6	1.3	0.2	CNG	370.9
Auto			0.5		
Total	**0.6**	**5.5**	**20.6**		
2031					
Bus			23.1	Diesel	35.5
2 wheeler		5.1		Petrol	449.4
Car	0.6	1.2	0.2	CNG	423.3
Auto			0.2		
Total	**0.6**	**6.3**	**23.5**		
2041					
Bus			28.5	Diesel	37.2
2 wheeler		7.0		Petrol	591.9
Car	0.6	1.2	0.2	CNG	517.2
Auto			0.1		
Total	**0.6**	**8.3**	**28.7**		

TABLE 15.17: POLLUTION REDUCTION (TON/YEAR)

Pollutants	**2024**	**2031**	**2041**
Carbon Monoxide (CO)	788	911	1177
Hydro-Carbons (HC)	512	595	752
Nitrogen Oxide (Nox)	772	895	1120
Particulate Matter (PM)	14	16	22
Carbon Dioxide (CO_2)	93812	106718	130987

Cost of Human Health saving from lifecycle emissions of $PM_{2.5}$ and cost of carbon capture from lifecycle emissions of Green House Gases (GHG) caused by gasoline and diesel is worked out (Climate change and health costs of air emissions from biofuels and gasoline, Jason Hill et al, PNAS, 2008) is presented in **Table 15.18.**

TABLE 15.18: LIFE CYCLE SAVINGS FROM EMISSIONS (RS LAKH)

Year	Diesel (Lakh liters)	Petrol (Lakh liters)	Total (Lakh liters)	Cost of Human Health saving from lifecycle emissions of $PM_{2.5}$	Cost of Carbon Capture (INR) Savings from Lifecycle Emissions of GHG
2024	6.5	55.3	61.7	359.4	396.4
2031	5.9	62.8	68.8	400.1	441.4
2041	6.2	82.7	89	517.7	571.1

15.3.5.7 **Carbon Credits**

Carbon credits earned by projects in developing countries are bought by the companies of developed countries - mostly European. Carbon credits are measured in units of Certified Emission Reductions (CERs). Each CER is equivalent to one ton of carbon dioxide reduction. With the construction of 2 corridors of Kanpur Metro, Carbon credits of the tune of Rs 12 lakh in 2024, which will increase to Rs 17 lakh in 2041 at current price level can be earned due to reduction of vehicles.

15.4 POSITIVE AND NEGATIVE ENVIRONMENTAL IMPACTS

15.4.1 Negative Impacts

15.4.1.1 **Impacts due to Project Location**

- Displacement and loss of livelihood of Project Affected People (PAPs)
- Change of Land use
- Loss of trees
- Utility/Drainage Problems
- Impact on archaeological monuments.

15.4.1.2 **Impacts due to Project Design:**

- Consumption of energy and water at stations and vibration impact of underground line in trade off with visual intrusion.
- Inter-modal integration will lead to increased use of metro while avoiding congestion outside stations.

15.4.1.3 **Impacts due to Project Construction:**

- Soil erosion and pollution
- Traffic diversion and risk to existing buildings
- Excavated Soil Disposal
- Pollution Generation due to transportation of earth and material

- Increased water demand
- Labour Camp
- Welfare of Labour on construction site
- Safety of labour
- Impact due to Supply of Construction Material
- Impact of construction near archaeological monuments
- Impact on ground and surface water quality
- Noise Pollution

15.4.1.4 **Impacts due to project Operation:**

- Noise pollution,
- Water supply and sanitation at Stations,
- Traffic congestion
- Impact due to depot

15.4.2 Positive Impacts

- Employment Opportunities
- Benefits to Economy
- Traffic Congestion Reduction, Quick Service and Safety
- Traffic Noise Reduction
- Reduction of Traffic on Road
- Decreased air pollution
- Carbon Credits

15.5 ENVIRONMENTAL MANAGEMENT PLAN

Environmental Management Plan is presented in two sections:

- Mitigation Measures
- Enhancement Measures

15.5.1 Mitigation Measures

i. Compensatory Afforestation
ii. Construction Material Management
iii. Safety Management
iv. Labour Camp
v. Welfare of Labour on construction site
vi. Safety of labour
vii. Energy Management

viii. Hazardous Waste Management
ix. Water Pollution Management
x. Environmental Sanitation
xi. Utility Plan
xii. Air Pollution Control Measures
xiii. Noise Control Measures
xiv. Vibration Control Measures
xv. Traffic Diversion/Management
xvi. Soil Erosion Control
xvii. Muck Disposal
xviii. Construction and Demolition Waste Management Plan
xix. Draining of Water from Tunnel
xx. Water Supply, Sanitation and Solid Waste management
xxi. Management Plan for Depot
xxii. Training
xxiii. Environmental Division
xxiv. Disaster Risk Management

i. Compensatory Afforestation

The Department of Forests, Government of Uttar Pradesh is responsible for the conservation and management of trees/forests in the project area. According to the results of the present study, it is found that about 1450 trees are likely to be lost along the two corridors and three depots. It is proposed to plant 10 saplings for each tree to be cut. Hence 14500 trees need to be planted. Cost of afforestation is taken as Rs. 3,000/- per tree. Compensatory afforestation cost thus will be about Rs 4.35 Crore. During Afforestation Plan, the planting of miscellaneous indigenous tree species should be applied. 14500 trees, on maturing will absorb about 316 ton of CO_2 per year and will release 711 ton of Oxygen per year meeting oxygen demand of 488 persons per year.

ii. Construction Material Management

The duties of contractor will include monitoring all aspects of construction activities, commencing with the storing, loading of construction materials and equipment in order to maintain the quality. During the construction period, the construction material storage site is to be regularly inspected for the presence of uncontrolled construction waste. The scheduling of material procurement and transport shall be linked with construction schedule of the project. The Contractor shall be responsible for management of such construction material during entire construction period of the project.

iii. Safety Management Measures

Prior to the construction/operation, identification of safety hazards would be made by Project Authority and prepare safety programmes following rules, regulations and guidelines.

iv. Labour Camp

In accordance with the Construction Contract the Contractor shall provide the following facilities at the labour camps: (temporary) living accommodation, sanitation facilities like toilets and drains, health awareness campaigns, facilities for water supply and waste water treatment and solid waste management. Capital and operating cost are included in engineering cost and therefore is not included in EMP.

v. Welfare of Labour on construction site

In accordance with the Construction Contract the Contractor will be required to provide shelter at workplace, canteen facilities, first aid facilities, day crèche facilities on work sites.

vi. Safety of Labour

Construction works shall be executed as laid down in the Safety Health and Environment (SHE) manual prepared by the Contractor and approved by PIU.

vii. Energy Management during construction

The contractor shall use and maintain equipment so as to conserve energy. Measures to conserve energy include but not limited to the following: use of tools, plant and equipment of correct specifications; energy efficient motors and pumps; efficient lamps; optimal maintenance. Capital and operating cost are included in engineering cost and therefore is not included in EMP.

viii. Hazardous Waste Management

The contractor shall identify the nature and quantity of hazardous waste generated as a result of his activities and shall obtain authorization from State Pollution Control Board. Hazardous waste would mainly arise from the maintenance of equipment which may include used engine oils, hydraulic fluids, waste fuel, spend mineral oil/cleaning fluids from mechanical machinery, scrap batteries or spent acid/alkali, spend solvents etc. Hazardous Waste needs to be stored in a secure place and adequately labelled and packaged. The contractor shall maintain a record of sale, transfer, storage of such waste and make these records available for inspection. The contractor shall approach only Authorized Recyclers for disposal of Hazardous Waste, under intimation to UPMRC.

ix. Water Pollution Management

Precipitation systems will be installed to prevent wash water from construction sites polluting surface water courses.

x. Environmental Sanitation

Environmental sanitation also referred to as Housekeeping is the act of keeping the working environment cleared of all construction material/debris, scrap and used material/items, thereby providing a first-line of defence against accidents and injuries. General environmental sanitation shall be carried out by the contractor and ensured at all times at Work Site, Construction Depot, Batching Plant, Stores, Offices and toilets/urinals.

xi. Utility Plan

The proposed metro alignment run along major arterial roads of the city, which serve Institutional, Commercial and Residential areas. Large number of sub-surface, surface and overhead utility services, viz. sewers, water mains, storm water drains, telephone cables, electrical transmission lines, electric poles, traffic signals etc. already exist along the proposed alignments. These utility services are essential and have to be maintained in working order during different stages of construction by temporary/permanent diversions or by supporting in position. As such, these may affect construction and project implementation time schedule/costs, for which necessary planning/action needs to be initiated in advance.

Prior to the actual execution of work at site, detailed investigation of all utilities and location will be undertaken well in advance by making trench pit to avoid damage to any utility. While planning for diversion of underground utility services e.g. sewer lines, water pipe lines, cables etc., during construction of Metro, the following guidelines could be adopted:

- Utility services shall be kept operational during the entire construction period and after completion of project. All proposals should therefore, ensure their uninterrupted functioning.

- In case of underground utility services running across the alignment, the spanning arrangement of the viaduct may be suitably adjusted.

xii. Air Pollution Control Measures

During the construction period, impact on air quality will be mainly due to increase in Particulate Matter (PM) along haul roads and emission from vehicles and construction machinery. Mitigation measures which shall be adopted to reduce the air pollution are presented below:

- The Contractor shall take all necessary precautions to minimize fugitive dust emissions from operations involving excavation, grading, and clearing of land transportation and disposal of waste and soil.
- Contractor's transport vehicles and other equipment shall conform to emission standards fixed by Statutory Agencies. The Contractor shall carry out periodical checks and undertake remedial measures including replacement, if required, so as to operate within permissible norms.
- The temporary dumping areas shall be maintained by the Contractor at all times until the excavation is re-utilised for backfilling or as directed by Employer.
- The Contractor shall water down construction sites as required to suppress dust, during handling of excavation soil or debris or during demolition. The Contractor will make water sprinklers, water supply and water delivering equipment available at any time that it is required for dust control use. Dust screens will be used, as feasible when additional dust control measures are needed especially where the work is near sensitive receptors.
- The Contractor shall design and implement blasting techniques so as to minimize dust, noise, and vibration generation and prevention fly rock.
- It is proposed to have mix concrete directly from batching plant for use at site. Batching plants will be located away from the site and from human settlement. The other construction material such as steel, bricks, etc. will be housed in a fenced stored yard.

xiii. Noise Control Measures

There may be an increase in ambient noise level due to construction. The exposure of workers to high noise levels can be minimized by job rotation, automation, protective devices and soundproof compartments, control rooms etc. Cost is to be included in the project engineering cost.

Cost of noise barriers required to be deployed during operation is estimated as part of EMP cost. Noise barriers shall be placed along the curved portion of the viaduct and at sensitive places during operation.

xiv. Vibration Control Measures

In the case of vibrations from pile driving very deep barriers (in excess of 10 m) were found to reduce vibration. In-ground barriers are trenches that are either left open or filled with a material (such as bentonite or concrete) that has stiffness or density significantly different from that of the surrounding soil. However, trenches may be too costly for situations involving houses. They could perhaps be justified for larger buildings with strict vibration limits, such as operating theatres of hospitals or high-tech factories with sensitive processes.

An economical alternative to trenches in a residential area could be a row of lime or cement piles of diameter 0.5 m to 1 m and a depth of 15 m in the right-of-way adjacent to the road. However, the effectiveness of such pile-walls has not yet been demonstrated.

Ballast-less track is supported on two layers of rubber pads to reduce track noise and ground vibrations.

xv. Traffic Diversion/ Management

In order to retain satisfactory levels of traffic flow during the construction period; traffic management and engineering measures need to be taken. They can be road widening exercises, traffic segregation, one-way movements, traffic diversions on influence area roads, acquisition of service lanes, etc.

- All construction workers should be provided with high visibility jackets with reflective tapes at most of viaduct/tunneling and station works or either above or under right-of-way.
- Warn the road user clearly and sufficiently in advance.
- Provide safe and clearly marked lanes for guiding road users.
- Provide safe and clearly marked buffer and work zones

- The primary traffic control devices used in work zones shall include signs, delineators, barricades, cones, pylons, pavement markings and flashing lights.

Various construction technologies like cut and cover can be employed to ensure that traffic impedance is minimised. During operation decongestion scheme should involve taxi and auto rickshaw stands, a halting space for public buses, drop off-pick up for owned modes. Parking space at stations if any is to be planned well.

xvi. Soil Erosion Control

Prior to the start of the relevant construction, the Contractor shall submit to the UPMRC for approval, his schedules for carrying out temporary and permanent erosion/sedimentation control works as are applicable for the items of clearing and grubbing, roadway and drainage excavation, embankment/sub-grade construction and other structures across water courses, pavement courses and shoulders and his plan for disposal of waste materials. The surface area of erodible earth material exposed by clearing and grubbing, excavation shall be limited to the extent practicable. Works such as construction of temporary berms, slope drains and use of temporary mulches, fabrics, mats, seeding, or other control devices or methods as necessary to control erosion and sedimentation may be involved. Mitigation measures include careful planning, timing of cut and fill operations and re-vegetation. In general, construction works are stopped during monsoon season.

xvii. Muck Disposal

Measures need to be adopted for collection, transfer, temporary storage and disposal of excavated muck. Sites for muck disposal will be decided by UPMRC before start of construction in consultation with respective authority like Municipal Corporation etc. such that the sites are away from residential areas and do not require displacement. The transfer and disposal of surplus soil may create air pollution and leached water problem. To mitigate these problems following mitigation measure are proposed to be adopted:

- The disposal sites will be cleaned and then treated so that leached water does not contaminate the ground water
- Material will be stabilised each day by watering or other accepted dust suppression techniques

- The height from which soil will be dropped shall be minimum practical height to limit the dust generation
- The stockpiling of earth in the designated locations with suitable slopes
- During dry weather, dust control methods such as water sprinkling will be used daily especially on windy, dry day to prevent any dust from blowing
- Sufficient equipment, water and personnel shall be available on dumping sites at all times to minimise dust suppression
- Dust control activities shall continue even during work stoppages
- The muck shall be filled in the dumping site in layers and compacted mechanically. Dumping sites on sloping ground shall be protected adequately against any possible slide/slope failure through engineering measures
- It is desirable to first clean the disposal area site for vegetation biomass exists over it. The faces and top should be treated/vegetated to avoid erosion. Once the filling is complete, the entire muck disposal area shall be provided with a layer of good earth on the top, dressed neatly, and covered with vegetation.

xviii. Construction and Demolition Waste Management

Construction and Demolition (C&D) debris is defined as that part of the solid waste stream that results from land clearing, excavation, construction, demolition, remodeling and repair of structures, roads and utilities. C&D waste needs to be focused upon in view of the potential to save natural resources (stone, river sand, soil etc.) and energy, its bulk which is carried over long distances for just dumping, its occupying significant space at landfill sites and its presence spoils processing of bio-degradable waste as well as recyclable waste. C&D waste generated from metro construction has potential use after processing and grading. Post-grading the waste should be disposed at sites identified by UPMRC in consultation with respective authority like Municipal Corporation etc. such that the sites are away from residential areas, water body/ water course and do not require displacement.

xix. Draining of Water from Tunnel

Water from underground works shall be led by construction drains into sumps and then to trunk sewers or used to recharge groundwater or re-use for construction. Capital and operating cost are included in engineering cost and therefore is not included in EMP.

xx. Water Supply, Sanitation and Solid Waste Management

Public health facilities such as water supply, sanitation and toilets are needed at the stations. Drinking water and raw water requirement for underground and elevated stations can be provided from municipal source in consultation with local agencies. Water should be treated to WHO drinking water standards before use. During operation rainwater harvesting will be carried out at elevated stations and Depots. To avoid excess usage of water during construction following measures will be taken to reduce water consumption: recycle of water consumed in wheel washing; discarded water from the R/O plant at Batching Plants shall be used for re-charge of ground water; water from dewatering will also be used for ground water re- charge.

Solid waste will be collected and transported to local municipal bins for onward disposal to disposal site by municipality. Capital and operating cost are included in engineering cost and therefore is not included in EMP:

xxi. Management Plan for Depot

Three maintenance depots are planned for Kanpur Metro. These are at i) Polytechnic College (16.2 Ha), ii) Agriculture University (12.0 Ha) and iii) Naubasta (3.3 Ha). Depot at Naubasta will have stabling lines only. The management plan for depot site includes:

- Water Supply
- Oil Pollution Control
- Sewage/Effluent Pollution Control
- Surface Drainage
- Green belt development
- Rain water harvesting
- Recycling of treated waste water

Water Supply: Water will be sourced from municipal supply. The estimated cost of water supply treatment plant for two depots is about Rs. 3.30 Crore.

Oil Pollution Control: The oil tends to form scum in sedimentation chambers, clog fine screens, interfere with filtration and reduce the efficiency of treatment plants. Hence oil and grease removal tank has to be installed at initial stage of effluent treatments. Such tanks usually employ compressed air to coagulate the oil and grease and cause it to rise promptly to the surface. Compressed air may be applied through porous plates located in bottom of the tank. The tank may be designed for a detention period of 5 to 15 minutes.

Sewage/Effluent Pollution Control: Sewage will be generated from depot which could be treated up to the level so that it could be used for horticulture purpose in the campus and can also be discharged into the stream. Similarly effluent is likely to be generated from Depots. This will have oil, grease and, detergent as main pollutants. This has to be treated as per requirement of UP Pollution Control Board. Total estimated cost of sewage treatment plant at two depots is about Rs 2.10 Crore. Cost of effluent treatment plant at two depots will be about Rs 2.40 Crore.

Surface Drainage: The area should have proper drainage. The Storm water of the depot will be collected through the drains. Rain water harvesting pits shall be provided at different locations in the drains and for surplus storm water, the drainage system should be connected to a nearby disposal site.

Green belt development: The greenbelt development/ plantation in the depot area not only functions as landscape features resulting in harmonizing and amalgamating the physical structures of proposed buildings with surrounding environment but also acts as pollution sink noise barrier. In addition to augmenting present vegetation, it will also check soil erosion, make the ecosystem more diversified and functionally more stable, make the climate more conducive and restore balance. Estimated cost for green belt development is about Rs 1.10 Crore.

Rain water harvesting: To conserve and augment the storage of groundwater, it has been proposed to construct roof top rainwater harvesting structure of suitable capacity in the proposed depots. Most of the area in depots will be open to sky and it is estimated that approximately 10% area will be covered. Rainwater harvesting potential of depots is calculated as 37,621 cum per year. Estimated cost for rainwater harvesting is about Rs 0.20 Crore for depots.

Recycling of treated waste water: Waste Water generated at depots is proposed to be collected at ETP & STP through separate sewer lines for treatment and the treated waste water will be recycled for horticulture work of the depots. Estimated cost of recycling of treated waste water for depots is about Rs 1.10 Crore.

xxii. Training

The training for engineers and managers will be ensured by UPMRC on regular basis to implement the environmental protection clauses of the tender document and to implement the best environmental practices during the construction phase. Such programme should include guidelines for safety, methods of disaster prevention, etc. The cost involved for such programme is presented in **Table 15.19.**

TABLE 15.19: COST FOR TRAINING PROGRAMME

S. N.	ITEM	COST (Rs)
1	Curriculum Development and course preparation 2 months Rs.50000/month	100,000
2	10 Extension Officer (1 year) Rs.20, 000/ month	1200000
3	Instructor 20 sessions of 10 days each	600000
4	Demonstration/Presentation Aids	100,000
5	Material etc.	150000
	Total	**2,150,000**

xxiii. Establishment of Environmental Division

It is recommended that UPMRC establishes an Environment Division at the initial stage of the project itself. This division should have an Environmental Officer and an Environment Engineer. The task of the division would be to supervise and coordinate studies, environmental monitoring and implementation of environmental mitigation measures, and it should report directly to Chief Engineer of the project authority. Progress of the division should be reviewed by an Environmental Advisor once in a year. The environmental advisor should be an experienced expert familiar with environmental management in similar projects. Estimated cost of the Division is summarized in **Table 15.20**.

TABLE 15.20: ANNUAL ENVIRONMENTAL DIVISION COSTS

S. N.	Particulars	Cost (in Rs.)
1.	Environmental Officer (1No.)	9,60,000
2.	Environmental Engineer (1No.)	6,00,000
3.	Miscellaneous Expenditure	5,00,000
	Total Cost for One Year	**20,60,000**
	Total Cost for Ten Years with 10% annual increase	**3,28,31,095**

xxiv. Disaster Risk Management

Some basic concepts: Hazard is a threat or event which can cause damage; disaster is a major hazard event. Disaster risk is expressed as the likelihood of loss of life, injury or destruction and damage from a disaster.

The recommended approach (UNISDR) is to manage disaster risk rather than managing disasters. Disaster risk is the combination of the severity and frequency of a hazard, the numbers of people and assets exposed to the hazard, and their vulnerability to damage. The main opportunity in reducing risk lies in reducing exposure and vulnerability.

Disaster Risk Management includes the following actions:

i. **Reduction and prevention:** Measures to reduce existing and avoid new disaster risks, for instance relocating exposed people and assets away from a hazard area. In case of mass transit like Metro such measures are not actionable.

ii. **Mitigation:** The lessening of the adverse impacts of hazards and related disasters. For instance implementing strict land use and building construction codes. This aspect is accounted for in design and construction of the project.

iii. **Transfer:** The process of formally or informally shifting the financial consequences of particular risks from one party to another, for instance by insurance. This is not yet available.

iv. **Preparedness:** The knowledge and capacities of governments, professional response and recovery organisations, communities and individuals to effectively anticipate, respond to, and recover from the impacts of hazard events or conditions, for instance installing early warning systems, identifying evacuation routes and preparing emergency supplies.

Risk Management process *(A. Berrado, Em El-Koursi, A. Cherkaoui, M. Khaddour. A Framework for Risk Management in Railway Sector: Application to Road-Rail Level Crossings. Open transportation Journal, Bentham Open, 2010, 19p. HAL Id: hal-00542424 https://hal.archives-ouvertes.fr/hal-00542424 Submitted on 2 Dec 2010*) comprises the following stages:

a) Description of the system that is at risk
b) Identify the potential hazards or sources of risk (the list of initiating events or scenarios of events leading to the undesired outcome – technological and human)
c) Risk analysis to estimate the likelihood of the scenarios or events occurring and each scenario's consequence
d) Compare and rank the various risk drivers
e) Action plan in response to the identified major risks
f) Regular monitoring, review and updation of the process.

1) The system at risk needs to be defined as to include inter-modal integration.

2) Examples of potential hazards are fire risk or security alarms or failure of train control or motive power or passenger doors / escalators / platform screen doors on trains or in stations; staff training and work environment; inadequate maintenance.

3) Action plan shall include the following:

Reporting procedures: Surveillance and incident reporting schedules shall be established.

Identification of resources: Sources of repair equipment, personnel, transport and medical aid for use during emergency will be identified.

Emergency systems: Back-up systems for ventilation, communication and train control, lighting etc shall be established.

Evacuation procedures: Evacuation procedures will be prepared in consultation with local administration and notified. To ensure coordinated action, an Emergency Action Committee shall be constituted.

Communication System: Primary and back-up system shall be put in place

4) **Review and Updation:** Drawing inputs from the incident reporting system the Action Plan shall be reviewed at pre-decided intervals and upon occurrence of defined 'trigger events' and suitably updated.

15.5.2 Measures to Enhance Positive Impacts

i. Rain water harvesting

Rainwater harvesting has been made mandatory in all new buildings with an area of 1000 sqm or more in Kanpur. To conserve and augment the storage of groundwater, it has been proposed to construct roof top rainwater harvesting structure of suitable capacity at the elevated stations and in the elevated alignment. Each pillar can have inbuilt downpipes to collect the rainwater from the viaduct and into the underground tanks. A recharge tank shall be constructed at suitable distance. The water collected will percolate down to the subsoil through numerous layers of sand, gravel and boulders. Total elevated length of the corridor is about 19.610 km. Annual rainfall of Kanpur is 821.9mm per year. Considering a runoff coefficient of 0.85, annual rainwater harvesting potential of elevated stations / section is estimated as 1,53,915 cum/year.

ii. Green Buildings

Green building (also known as sustainable building) refers to both a structure and the using of processes that are environmentally responsible and resource-efficient throughout a building's life-cycle: from siting to design, construction, operation, maintenance, renovation, and demolition. Green buildings help in better preservation of environment as in such structures there are provisions for better saving of energy, water and CO_2. Such buildings also have better waste management arrangements.

The Indian Green Building Council (IGBC) conducts a rating process for New Buildings which addresses the green features under the following categories:

- Sustainable Architecture and Design
- Site Selection and Planning
- Water Conservation
- Energy Efficiency
- Building Materials and Resources
- Indoor Environmental Quality

- Innovation and Development

All stations and Depots can be designed as green buildings.

15.6 ENVIRONMENTAL MONITORING PLAN AND ENVIRONMENT MANAGEMENT SYSTEM

15.6.1 Environmental Monitoring Plan

The environmental monitoring programme is a vital process of any Environmental Management Plan (EMP) of development project for review of indicators and for taking immediate preventive action. Environment monitoring should be an integral part of works towards better environmental management of air, noise, vibration, water quality etc both during construction and in operation phases of the project. The following parameters are proposed to be monitored:

- Water Quality,
- Air Quality,
- Noise and Vibration,
- Environmental Sanitation and Waste Disposal
- Ecological Monitoring and Afforestation,
- Workers Health and Safety

Environmental monitoring during pre-construction phase is important to know the baseline data and to predict the adverse impacts during construction and operations phases. The preconstruction stage environment monitoring has been carried out during this EIA study and proposed construction and operation stage monitoring is presented below:

15.6.1.1 Construction Phase

During construction stage environmental monitoring will be carried out for air quality, noise levels, vibrations, water quality, and ecology. Keeping a broad view of the sensitive receptors and also the past experience an estimate of locations has been made.

Water Quality

Since water contamination leads to various water related diseases, the project authorities shall establish a procedure for water quality surveillance and ensure safe water for the consumers. The water quality parameters are to be monitored during the entire period of project construction. Monitoring should be carried out by NABL Accredited / MoEF recognized private or Government agency. Water quality should be analyzed following the procedures given in the standard methods. Parameters for monitoring will be as per BIS: 10500. The monitoring points could be ground and surface water.

Air Quality

Air quality is regularly monitored by Central Pollution Control Board at number of places in Kanpur. In addition to these, air quality should be monitored at the locations of baseline monitoring. The parameter recommended is Particulate Matter (PM2.5 and PM10), SO2, NOX, CO and HC. The contractor will be responsible for carrying out air monitoring during the entire construction phase under the supervision of UPMRC.

Noise and Vibration

The noise and vibration will be monitored at construction sites for entire phase of construction by the site contractor and under the supervision of UPMRC.

Ecological Monitoring

The project authority in coordination with the Department of Forest shall monitor the status of ecology/trees along the project corridors at least 4 times in a year during construction phase in order to maintain the ecological environment. The plantation/afforestation of trees by Department of Forest Government of Uttar Pradesh will be reviewed four times a year during construction phase.

Workers Health and Safety

Monitoring of health risk issues that might arise throughout the project life time will be done. Regular inspection and medical checkups shall be carried out to workers health and safety monitoring. Any recurring incidents such as irritations, rashes, respiratory problems etc shall be recorded and appropriate mitigation measures shall be taken. Contractor will be the responsible person to take care health and safety of workers during the entire period of the construction and project proponent is responsible to review/audit the health and safety measures/plans. The schedule is presented in **Table 15.21**.

TABLE 15.21: CONSTRUCTION STAGE MONITORING SCHEDULE

Parameter	Frequency	Locations	Years
Air Quality	2x24 hours, twice a month	8	5
Noise	24 hours, once a week	8	5
Vibration	24 hours, once a week	5	5
Water	Once in 6 months	5	5

15.6.1.2 Operation Phase

In order to evaluate impact of the Metro system and mitigate the reduced environmental hazards during the operation phase, the environmental monitoring will be carried out for air, noise, vibration, water and ecology during operation phase of the project. The parameters monitored during operation will be Particulate Matter ($PM_{2.5}$ and PM_{10}), SO_2, NO_X, CO and HC for air. Water quality parameters that will be monitored will be as per BIS 10500. The monitoring schedule is presented in **Table 15.22**. The monitoring program shall be conducted by an external agency which is NABL Accredited / MoEFCC recognized under the supervision of Uttar Pradesh Metro Rail Corporation. Project Operator i.e. UPMRC will be responsible for successful environmental monitoring of the proposed project during operation phase.

TABLE 15.22: OPERATION STAGE MONITORING SCHEDULE

Parameter	Frequency	Locations	Years
Air Quality	2x24 Hour, once in a month	8	3
Noise	24 hours once a year	8	3
Vibration	24 hours once a year	5	3
Water	Once a year	2 (Depots)	3
Waste Water	Once in 4 months	2 (Depots)	3
Solid Waste	Once a year	2 (Depots)	3

The results of air quality, water quality, noise and vibration will be submitted to management quarterly during construction phase and semiannually during operation phase.

15.6.2 FORMATION OF ENVIRONMENT MANAGEMENT SYSTEM (EMS)

Environment Management System is intended to facilitate implementation, tracking and reporting of mitigation and monitoring measures proposed for the project. Roles and responsibilities are summarized in **Table 15.23** and **Table 15.24**.

TABLE 15.23: ROLES AND RESPONSIBILITIES - SECURING APPROVALS/CLEARANCES

SN	Issue	Provision of Laws & Regulations	Due Date	Approving Authority
Pre-Construction Phase				
1.	Permission for felling of trees and compensatory afforestation	Tree removal will be guided as per state government rules.	Before Construction	Municipal Corporation/Forest Department
2.	Environmental Clearance for Depot, stations, property development	Amendment dated 9 December 2016 to EIA Notification 2006		Municipal Corporation
3.	Utility / traffic diversion	Respective Acts and Rules		Local Offices of respective Agencies.
4.	Consent to Establish Depot	Water (Prevention and Control of Pollution) Act 1974; Hazardous Waste (Management and Handling and transboundary movement) Rules 2016		State Pollution Control Board; Development Authority for landuse clearance
Construction Phase				
5.	• Consent to Establish and Operate hot mix plant, crushers, batching plant etc and • Consent to Establish labour camps	Air (Prevention and Control of Pollution) Act 1981	Before Construction	• State Pollution Control Board • Municipal Corporation

SN	Issue	Provision of Laws & Regulations	Due Date	Approving Authority
6.	Permission for withdrawal of groundwater for construction (**not recommended**)	Environment (Protection) Act, 1986	Before Construction	Regional Director, Central Ground Water Board and Municipal Corporation
7.	Authorization for Disposal of Hazardous Waste	Hazardous Waste (Management and Handling and transboundary movement) Rules 2016	Before Construction	State Pollution Control Board
8.	Consent for disposal of waste water from construction sites and sewage from labour camps	Water (Prevention and Control of Pollution) Act 1974	Before Construction	State Pollution Control Board
9.	Labour employment, safety, welfare measures	The Building and Other Construction Workers (Regulation of Employment and Conditions of Service) Act, 1996	Before Construction	District Labour Commissioner
10.	Permission for management of C&D waste and muck	Environment Protection Act 1956	Before Construction	Municipal Corporation and State Pollution Control Board
Operation Phase				
11.	Consent to Operate Depot	Environment Protection Act 1956	After Construction	State Pollution Control Board
12.	Installation and operation of DG sets at stations	Air (Prevention and Control of Pollution) Act 1981	After construction	State Pollution Control Board

Note: This project is not located near and has no impact on forests, wildlife / bird sanctuaries / bio-reserves, wetlands or their associated ecologically sensitive zones.

TABLE 15.24: ROLES AND RESPONSIBILITIES – PREPARATION AND IMPLEMENTATION OF EMP AND ENVIRONMENTAL MONITORING PLAN (EMOP)

SN	Environmental Impact	Mitigation Measure	Implementing Entity	Responsible Entity
Location and Design Phase				
1	Displacement and private property acquisition, impact of environmentally sensitive areas.	Alignment design to avoid or minimize impact.	DPR and design consultant	PIU
2	Loss of trees and water bodies		DPR and design consultant	PIU
3	Visual intrusion	Capital and operating cost and vibration impact of underground line in trade off with visual intrusion. To design aesthetic structures of viaduct and stations on elevated sections.	DPR and design consultant	PIU
Pre-construction Phase				
5	Displacement and private property acquisition.	Implement R&R Plan	PIU	PIU
6	Loss of trees and water bodies	Implement compensatory afforestation	Forest Department	Forest Department
7	Site measures	Prepare Safety, Health and Environment (SH&E) Manual and secure approval.	Contractor	PIU
8	Water supply; sewage and solid waste disposal	Requirement for construction to be planned so as to avoid use of ground water.	Contractor	PIU
9	Environmental Management and Monitoring	Implement institutional requirements for implementation of EMP and EMoP	Contractor	PIU
Construction Phase				
10	Soil erosion, fugitive dust generation,	Implement suitable construction methods and as per SH&E Manual	Contractor	PIU

SN	Environmental Impact	Mitigation Measure	Implementing Entity	Responsible Entity
	muck disposal and C&D waste management			
11	Air and noise Pollution	Vehicles and machinery are to be maintained to emission standards; machinery noise muffles etc and personal protective gear to workers.	Contractor	PIU
12	Vibration	Implement vibration monitoring and building condition surveys at sensitive structures	Contractor	PIU
13	Water pollution	Implement measures such as precipitation tanks on site	Contractor	PIU
14	Soil pollution	Implement measures to prevent ingress of toxic / heavy metals	Contractor	PIU
15	Labour camp: water supply; sewage and solid waste disposal; health	Implement measures as per SH&E Manual	Contractor	PIU
16	Facilities on site and workplace safety		Contractor	PIU
17	Incident Management	Prepare Incident Management Plan with reporting formats.	Contractor	PIU
18	Environmental Monitoring	Prepare Environmental Monitoring Plan.		
19	Availability of institutional capacity	Implement training and establish environment unit.	Contractor	PIU
Operation Phase				
20	Noise Pollution	Implement and maintain noise barriers on viaduct	PIU	PIU
21	Vibration	Implement vibration monitoring and building condition surveys at sensitive structures.	PIU	PIU
22	Water supply, sanitation, sewage and solid waste disposal at stations and depots	Implement prescribed measures including rain water harvesting at stations and depots; green belt and water recycling at depots.	PIU	PIU

SN	Environmental Impact	Mitigation Measure	Implementing Entity	Responsible Entity
23	Sewage and effluent disposal	Implement STP and ETP at depots.	PIU	PIU
24	Incident Management	Implement Incident Management Plan.	PIU	PIU
25	Environmental Monitoring	Implement Environmental Monitoring Plan.	PIU	PIU

The range of documentation required to be generated and maintained as part of EHS before and during construction and during operation is as follows:

- Controlled documents of mandatory environmental Approvals and clearances along with record extensions thereof
- Controlled documents of approved SH&E Manual, EMP and EMoP with revisions thereof and time schedule of such revisions if any.
- Controlled documents of formats of site inspection checklists with revisions thereof and time schedule of such revisions if any
- Reports of site inspections, monitoring data, reports of internal or external audit, observations of PIU and local statutory agency if any like Pollution Control Board, local municipal authority, Forest Department etc. and subsequent remedial action taken by Contractor if any.
- Records of coordination meetings of PIU/GC and Contractor with subsequent remedial action taken by Contractor if any.
- Records of incident reporting and remedial action taken by Contractor if any and follow up of such incidents.

A typical EMS organization is depicted in **Figure 15.2.** One indicative activity i.e. approval of EMS documents is shown in this organisation chart.

15.7 SUMMARY OF COSTS

Cost towards environmental management is presented in **Table 15.25**.

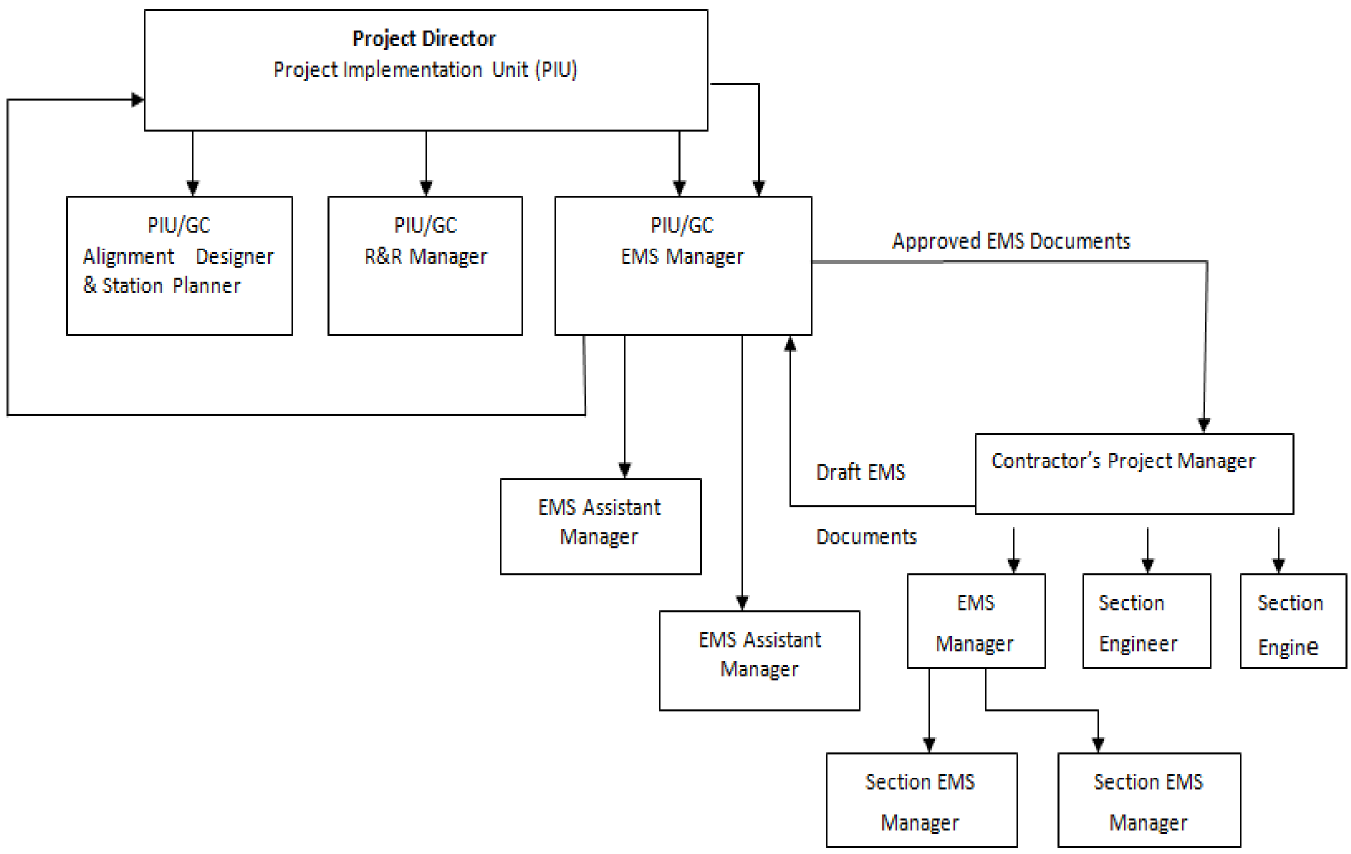
TABLE 15.25: COST OF ENVIRONMENTAL MANAGEMENT PLAN

SN	Item	Amount (Rs. In Crore)
1.	Compensatory Afforestation	4.35
2.	Water Supply Treatment for Depot	3.30
3.	Sewage Treatment for Depot	2.10

SN	Item	Amount (Rs. In Crore)
4.	Effluent Treatment for Depot	2.40
5.	Drainage for Depot	1.60
6.	Rainwater harvesting for Depot	0.20
7.	Management of Muck disposal site	14.51
8.	Sanitation facilities at labour Camps	0.69
9.	Green Belt Development for Depot	1.10
10.	Recycling of Treated Waste Water for Depot	1.10
11.	Air, Noise, vibration, Water, during construction and operation	5.45
12.	Ecological monitoring	0.30
13.	Environment Division	3.28
14.	Training And Extension	0.22
	Total	**40.60**

* Cost of items 5 and 6 in respect of stations is included in Civil Engineering cost

FIGURE 15.2: EMS Organization



* GC: General Consultant as Project Management Consultant

15.8 SOCIAL IMPACT ASSESSMENT

Development of proposed two metro rail corridors involves acquisition of land for stations, running sections, TSS, Depot and for other facilities. Acquisition of this private land may cause social disruption and economic loss for the families/people who are likely to be affected. While implementing the project, there is a need to take into account these disturbances and losses due to the project, their impact on socio-economic condition of the people and plan for their mitigation measures to minimise any negative impacts. The details of land acquisition, number of affected structures (legal and illegal) and affected families and socio-economic profile of affected families on the basis of sample survey and Resettlement Action Plan (RAP) is presented in this section.

15.8.1 Objective of SIA and RAP

The objective of Social Impact Assessment is (i)Identify PAPs by type and extent of loss (ii)Identify the possible adverse effects of the project on the people and the area (ii)Suggest culturally and economically appropriate measures for mitigation of adverse effects of the project (iii)Provision of institutional mechanism for implementation of RAP (iv)Provision for grievance redress mechanism;(v)A time frame for implementation of RAP (vi)Provision of budget for each activity of RAP, and (vii) Monitoring and Evaluation (M&E) of implementation of RAP. The SIA includes RAP is based on an integrated and holistic approach to deal with project impacts and aims at rebuilding lives and livelihoods of those affected as quickly as possible.

15.8.2 Approach & Methodology

Socio-economic survey was conducted in the corridor of impact zone to identify the affected structures, families/persons and list out the adverse impacts of the project. The SIA which includes RAP has been prepared in accordance with Right to Fair Compensation and Transparency in land acquisition, Rehabilitation and Resettlement Act, 2013 and Resettlement Policy Framework of Lucknow Metro Rail Corporation. The methodology adopted to prepare SIA report was desk research, site visits and information dissemination, enumeration of structure, socio-economic survey, compilation, verification and analysis of data, public consultation at local level. Various steps involved in the study have been described in brief in the following paragraphs.

- Consultant reviewed the final topographical maps and Detailed Project Report (DPR) of the project.
- Conducted sample socio-economic survey covering affected households, squatters, kiosks and small business entrepreneurs with the help of pretested “Household Questionnaire”. Important aspects covered in the questionnaire were identification particulars of PAPs, his or her family details, social profile, occupation, income, details of structure, commercial / self-employment activities, household income, annual expenditure, employment pattern, type of effects / loss etc. Most part of the questionnaire has been pre-coded except those reflecting the opinion and views of the PAP, which have been left open-ended.
- In order to understand social issues associated with the proposed project we require baseline data. The base line data have been collected from secondary sources such as the Census and the Statistical Hand Book. Primary data have been collected through household survey conducted in 2015.
- Development of proposed metro project has significant positive impacts. The project may also bring myriad forms of unavoidable adverse impacts on the socio and economic environment around. ‘Social Risk Assessment’ approach has been used to determine the associated risk of adverse impacts.
- Consultations with concerned stakeholders at the project level with affected families, communities, local leaders, and vulnerable groups were conducted for the purpose of disseminating information among the people and obtaining their views, comments and concerns.

15.8.3 Potential Social Impacts

The proposed metro rail will have positive impacts like (i) generate Employment opportunity (ii) economic growth (iii) mobility (iv) safety in travelling (v) reduced traffic congestion (vi) savings in fossil fuel (reduction in air pollution) (vii) more systematic and cheaper way of commute. At the same time project may bring myriad forms of adverse impacts on socio-economic condition of families/people who are likely to be affected due to acquisition of land. The anticipated negative impacts are (i) loss of land (ii) loss of structures (iii) loss of livelihood (iv) loss of residence (v) impact on vulnerable families/persons (vi) impact on gender (vii) loss of common property and religious structures. Both the Depot lands at Polytechnic and Agricultural University belong to the State Government and will be transferred to Metro Rail Authority free of cost by the State Government. The land belonging to Agricultural University is open land. Hence, no rehabilitation is involved. In Polytechnic land relocation of some buildings will be required, which will be done in the same campus.

15.8.3.1 Land Requirement and Acquisition

Summary of land requirement and acquisition are presented in **Table 15.26**.

TABLE 15.26 LAND REQUIREMENT AND ACQUISITION (in Ha)

Corridor	Type of Land	Permanent	Temporary
IIT Kanpur to Naubasta	Government	91.06	25.86
	Private	2.34	0
	Sub Total	*93.40*	*25.86*
Agriculture University to Barra 8	Government	18.86	11.50
	Private	0.12	0
	Sub Total	*18.98*	*11.50*
	Total	**112.38**	**37.36**

15.8.3.2 Inventory of Affected Structures

Table 15.27 presents the usage type of structures likely to be affected.

TABLE 15.27: CORRIDOR WISE IMPACT ON STRUCTURES

Corridor/Station	Type of Structures			Total
	Residential	Commercial	Others	
IIT Kanpur to Naubasta				
CSJM University	0	0	1	1
Gurudev Chauraha	0	0	2	2
Geeta Nagar	0	15	0	15
Rawatpur Railway Station	0	50	2	52
Lala Lajpat Rai Hospital	0	0	7	7
Moti Jheel	1	4	0	5
Naya Purva upto Nala	10	0	0	10
Chunni Ganj	0	0	2	2
Navin Market	0	7	0	7
Bada Chauraha	0	15	2	17
Phool Bagh	0	0	2	2

Corridor/Station	Type of Structures			Total
	Residential	Commercial	Others	
Naya Ganj*	0	18	0	18
Transport Nagar	2	38	0	40
Baradevi Chauraha	5	2	0	7
Sub Total	**18**	**149**	**18**	**185**
Agriculture University to Barra 8				
Double Pulia	0	10	1	11
Vijay Nagar Chouraha	0	0	1	1
Dada Nagar	208	13	1	222
Shastri Chouraha	1	11	0	12
Sub Total	**209**	**34**	**3**	**246**
Total	**227**	**183**	**21**	**431**

Source: Primary Surveys, 2015

*Number of structures are identified based on sample socio-economic survey, site visits with the help of alignment drawings and not on the basis of peg marking on the ground. Therefore, these are only approximate figures and not exact. The exact number of affected families, persons, properties and detail of ownership will be considered after census (100%) survey.

The magnitude of project impact on the structures, which is categorized as partially and fully affected structures are presented here. On the basis of alignment drawings it was found during site visit that out of total 431 structures, about 375 structures (87%) will be fully affected and remaining about 56 structures (13%) will be partially affected (**Table 15.28**). However, the exact number of fully and partially affected structures will be known after peg marking on the ground level.

TABLE 15.28: MAGNITUDE OF PROJECT IMPACTS

Name of Corridor	Magnitude of Impacts		
	Fully	Partially	Total
IIT Kanpur to Naubasta	152 (82.2)	33 (17.8)	185 (100)
Agriculture University to Barra 8	223 (90.6)	23 (9.4)	246 (100)
Total	**375 (87.0)**	**56 (13.0)**	**431 (100)**

Source: Primary Surveys, 2015

15.8.3.3 Impact on PAFs/PAPs

About 458 families consisting 2178 persons will be affected due to the proposed metro project. Majority of

families will be affected at Dada Nagar Slums in Agriculture University to Barra 8 corridor and Navin Market and Transport Nagar in IIT Kanpur to Naubasta corridor. Corridor wise number of PAFs and PAPs is presented in **Table 15.29**. *Exact number of affected and displaced families/persons will be quantified during detailed Census/Baseline Socio-Economic Survey (BSES) after peg marking of alignment on the ground.*

TABLE 15.29: IMPACT ON PAFs AND PAPs

Name of Corridor	Total PAFs	Total PAPs*
IIT Kanpur to Naubasta	215	968
Agriculture University to Barra 8	243	1210
Total	**458**	**2178**

Source: Primary Surveys, 2015

*Number of PAPs is counted based on average size of family

Out of the total 458 families, 22.5% are in the category of Title Holders (TH) and the remaining 77.5% are in Non-Title Holders (NTH) category. The NTH category includes tenants, squatters and kiosks. The squatters and kiosks are on public land without any legal permission. Corridor wise detail of title holders and non-title holders are given in **Table 15.30**.

TABLE 15.30 TITLEHOLDERS AND NON-TITLEHOLDERS

Name of Corridor	Titleholders	Non-Titleholders	Total PAFs
IIT Kanpur to Naubasta	98 (45.6)	117 (54.4)	215 (100)
Agriculture University to Barra 8	5 (2.1)	238 (97.9)	243 (100)
Total	**103 (22.5)**	**355 (77.5)**	**458 (100)**

Source: Primary Surveys, 2015

Table 15.31 indicates that out of the total 458 PAFs, 227 PAFs shall be affected physically as their residential units are getting affected due to the proposed project. Majority of PAFs are likely to be affected residentially in Agriculture University to Barra 8 corridor.

TABLE 15.31: LOSS OF RESIDENCE

Name of the Location	Total PAFs	Residentially Affected Family
IIT Kanpur to Naubasta	215	18
Agriculture University to Barra 8	243	209

Total	**458**	**227**

Source: Primary Surveys, 2015

Table 15.32 indicates that out of total 458 affected families, there are 183 PAFs whose business/livelihoods will be affected due to the loss of the commercial structures vis-a-vis business base in both corridors. Majority (149) of commercial PAFs are likely to be affected in IIT Kanpur to Naubasta corridor. About 34 PAFs are likely to be affected in Agriculture University to Barra 8 corridor.

TABLE 15.32: LOSS OF LIVELIHOOD

Name of the Location	Total PAFs	Commercially Affected Family
IIT Kanpur to Naubasta	215	149
Agriculture University to Barra 8	243	34
Total	**458**	**183**

Source: Primary Surveys, 2015

15.8.3.4 Impact on Community and Religious Structures

The proposed project shall also affect the common property resources. The common property includes religious structures and public toilets. **Table 15.33** indicates that eight religious structures and three public toilets shall be affected. These structures may not be saved as they are falling within the right of way and the corridor of impact. These common properties of the same size and type shall be redeveloped by the project developer at the desired place in consultation with local people.

TABLE 15.33: LOSS OF COMMON PROPERTY RESOURCES

Name of the Corridors	Common Property Resources			Total
	Religious structures	Public toilet	Others	
IIT Kanpur to Naubasta	3	2	11	16
Agriculture University to Barra 8	4	0	1	5
Total	**7**	**2**	**12**	**21**

Source: Primary Surveys, 2015

15.8.4 Demographic and Socio-Economic Profile of PAFs

The socio-economic analysis of surveyed household has been presented here. The data collected through sample socio-economic survey generated demographic and socio-economic profile of project affected families. The data has been compiled and presented in tabular form.

15.8.4.1 Gender and Sex Ratio

The data on gender and sex ratio is very helpful indicator to know the participatory share of male and female in the society, which is also an important indicator for human development index. Among the surveyed population it is observed that there are 55.6% are male and remaining 44.6% are female. It is observed that male dominate in both corridors. The sex ratio is 821 per 1000 males in IIT Kanpur to Naubasta corridor and 778 is Agriculture University to Barra 8 in corridor (**Table 15.34**).

TABLE 15.34: GENDER AND SEX RATIO

Corridor	Total Surveyed PAFs	Total PAPs	Gender		Sex Ratio
			Male	Female	
IIT Kanpur to Naubasta	88	386 (100)	212 (54.9)	174 (45.1)	821
Agriculture University to Barra 8	76	359 (100)	202 (56.3)	157 (43.7)	778
Total	**164**	**745 (100)**	**414 (55.6)**	**331 (44.6)**	**800**

Source: Primary Surveys, 2015

15.8.4.2 Religious and Social Group

Data on religious groups were collected in order to identify people with the specific religious belief among the surveyed families. The religious beliefs and social affiliation of the people are indicators that help understand cultural behaviour of the groups. The social and cultural behaviour will help understand the desires and preferences of PAPs, which is a prerequisite to rehabilitate the affected people and their families. **Table 15.35** shows that only two religions are followed in the study area viz., Hindu and Muslims. The study result shows that about 84.7% of the surveyed families are Hindu followed by Muslim (15.3%). Majority of families are Hindu in both corridors.

TABLE 15.35: RELIGIOUS GROUP

Corridor	Hindu	Muslim	Total PAFs
IIT Kanpur to Naubasta	75 (85.2)	13 (14.8)	88 (100)
Agriculture University to Barra 8	64 (84.2)	12 (15.8)	76 (100)

Total	**139 (84.7)**	**25 (15.3)**	**164 (100)**

Source: Primary Surveys, 2015

Table 15.36 discloses information about social affiliation of a group. The social affiliation of the group differentiates them for benefits under government schemes. Social groups indicate ranking within the society, preferences and vulnerability. In general, the families belonging to Scheduled Castes (SCs) and Scheduled Tribes (STs) under the provisions of Constitution of India get preferential treatment in the government benefits because the group includes the people who are traditionally vulnerable. Except general category, all other groups need attention and to be addressed for their backward socio-economic conditions. The survey results show that about 48.9% belong to Other Backward Caste followed by general (36.7%) and Scheduled Caste (12.2%) and Scheduled Tribe (17%). Scheduled Castes families are found in both corridors whereas Scheduled Tribe families are found only in Agricultural University to Barra 8 corridor. Therefore, special attention is required to address their issues.

TABLE 15.36: SOCIAL GROUP

Corridor	General	OBC	Schedule Castes	Schedule Tribes	Total PAFs
IIT Kanpur to Naubasta	20 (26.7)	44 (58.7)	11 (14.6)	0	75 (100)
Agriculture University to Barra 8	31 (48.4)	24 (37.5)	6 (9.4)	3 (4.7)	64 (100)
Total	**51 (36.7)**	**68 (48.9)**	**17 (12.2)**	**3 (2.2)**	**139 (100)**

Source: Primary Surveys, 2015

15.8.4.3 Mother Tongue and Place of Nativity

It was found in both corridors that all surveyed families speak Hindi as a mother tongue. Majority of surveyed families are from Uttar Pradesh followed by Bihar state.

15.8.4.4 Age Group

The distribution of person’s age in various group shows that 5.4% of the total persons belong to below five years, about 10.3% belong to the 5-18 years age group. About 23% belong to 18-35 years that is potentially productive group. About 48% belong to the age group of 35 to 60 years. About 13% of total persons belong to above 60 years, who are dependent population. It is observed that majority of persons belong to 35 to 60 years age group.

15.8.4.5 Marital Status

The marital status of the surveyed family members is indicated under three categories – married, unmarried, and other (widow/widower, separated, divorced). It is observed that out of total surveyed people, majority of them (56%) are married, 42 % are unmarried and about two percent are widowed/divorced/separated.

15.8.4.6 Family Pattern and Family Size

Majority of surveyed families are nuclear (57.9%) followed by joint (43.3%). Majority of surveyed families belong to nuclear family (51.1%) in IIT Kanpur to Naubasta corridor and Joint family (52.6%) in Agriculture University to Barra 8 corridor. Family size has been classified into three categories i.e. individual, small (2-4), medium (5-7) and large (7 & above). Majority of families (48.8%) are medium in size followed by 33.5% families are small type and remaining 17.7% families have their members more than seven. Medium size families are found in both corridors.

15.8.4.7 Educational Attainment

The analysis indicates that out of the total surveyed people, about 19.4% are illiterate, 18.4% are educated up to primary class, 24.7% are educated up to High School, and 23.3% have studied up to higher secondary level. Other than this, about 11.5% of persons have attained college. More illiterate are found in Agriculture University to Barra 8 corridor. Education level of surveyed people is better in IIT Kanpur to Naubasta corridor as compared to Agriculture University to Barra 8 corridor.

15.8.4.8 Economic Conditions

The economic condition of PAFs describes occupational pattern, family income, employment information and number of earning and dependent members. The occupational pattern includes work in which the head of the project affected families are involved. The family income includes income of all the earning members. The earning members include the people who work and earn to contribute to the family; however dependents include housewife, children, elderly people and others who cannot work and earn.

About 33.5% of families reported less than Rs.5000/- monthly income. About 31.7% of families' monthly income is less then Rs.5001-10000, 18.3% of families' income is between Rs.10001 to 20000/-, 9.8% of families' income is between Rs.20001 to 40000.Families' earning more than Rs.40000/- monthly constitutes about 6.7%. The average income of a family is Rs.12400/- per month. Average family expenditure is Rs.10200/- per month. On an average earning member per family is two **(Table 15.37)**.

TABLE 15.37 FAMILY MONTHLY INCOME

Corridor	Family Monthly Income (in INR)					Total PAFs
	<5000	5001 - 10000	10001 - 20000	20001 - 40000	>40000	
IIT Kanpur to Naubasta	17 (19.3)	28 (31.8)	18 (20.5)	14 (15.9)	11 (12.5)	88
Agriculture University to Barra 8	38 (50)	24 (31.6)	12 (15.8)	2 (2.6)	0 (0.0)	76
Total	**55 (33.5)**	**52 (31.7)**	**30 (18.3)**	**16 (9.8)**	**11 (6.7)**	**164 (100)**

Source: Primary Surveys, 2015

15.8.4.9 Occupational Pattern

Occupational pattern of the surveyed persons is recorded to assess their skill so that income generation plan can be prepared accordingly for alternative income generating scheme. Secondly, occupational pattern helps in identifying dominating economic activity in the area. The survey shows that majority of surveyed persons are employed in business and trade activities. Out of the total surveyed PAPs, about 62.8% of them are involved in business, 25% are in daily labour and 6.1% are in private sector. About two percent are working as maid servant and 3.7% are unemployed. It is observed in both corridors that majority of PAPs are involved in business/trade activities.

15.8.4.10 Household Assets

The TV, Refrigerator, two wheeler, and telephone are owned by majority. The other prominent assets are bicycle and computer.

15.8.4.11 Vulnerable Groups

As per the JICA guidelines vulnerable group is defined as indigenous people, ethnic minorities, the poorest, women, the aged, the disabled and other socially/economically vulnerable groups who would be adversely affected from a project. As regards vulnerability among surveyed PAFs, there are 64 families belong to vulnerable category. Out of these about three families are women headed households, 17 families are Scheduled Castes, three families are Scheduled Tribes, 35 families are below the line of poverty including women headed households, and six families having disability people. Numbers of vulnerable families are found more in Agriculture University to Barra 8 corridor.

15.8.4.12 Gender Issues

There are three woman-headed household among the surveyed vulnerable families found in the Agriculture University to Barra 8 corridor. About 45 percent of total surveyed population is female. Socio-economic parameters like literacy, work force participation rate and general health conditions etc. reveals that social status of women is low respectively, thereby brought forward the scope of considering the families headed by women as vulnerable.

The proposed project is expected to open up new economic opportunities for women to upgrade their skills and also better accessibility to educational and health facilities. Women as a segregated class are not involved in any economic activity, which demands attention for their special needs. To ensure that women are secure in receiving payments all benefits will be provided in joint-account where the woman will be the first beneficiary accounts. During discussion with PAPs, women members of the family are also consulted. Consultations with women will be carried out during project implementation stage to provide more opportunities to them to voice their concerns and suggestions.

15.8.4.13 Tribal Issues

There are three families who belong to scheduled tribes. Moreover, they are found in the project area no longer live in forests/hills. The tribal population has integrated with the main stream population. Few of them fall within the category of BPL population, compensation packages provided in the Entitlement Matrix would sufficiently take care of their R&R needs. There is also a number of State and Central Government schemes targeted at this population and annually about 5 to 6 percent of budget allocation is made to finance special programmes for tribal development.

15.8.4.14 Awareness and Opinion about the Project

During socio-economic survey, some questions were asked to the families regarding the awareness, source of information and opinion about the proposed metro rail project. The findings of the survey with regards to awareness, source of information and opinion about the proposed project is presented in **Table 15.38**.

TABLE 15.38: PROJECT RELATED INFORMATION

S. N.	Description	IIT Kanpur to Naubasta	Agriculture University to Barra 8
1	**Awareness about the Project**		
	Yes	82	63
	No	6	13
2	**Source of Information**		
	News Paper	42	26
	Survey Team	10	9
	Television	21	15
	Friends/People	13	26
3	**Opinion about the Project**		
	Good	80	58
	Bad	4	11
	Can't Say	4	7

Source: Primary Surveys, 2015

15.8.5 Public Consultation and Participation

The consultant briefed the participants about the objectives of the meeting regarding various social issues related to the project i.e., alignment plan, land acquisition, displacement, rehabilitation & resettlement and compensation and employment etc. The participants were invited to give their valuable suggestions on the above issues and were assured for suitable incorporation of such suggestions in the project within the technical limitations and scope of the project. Some of the views expressed, suggestion given or queries raised by the participants are as follows:

- People at Rawatpur station demanded that alignment and metro stations should be underground from IIT to Medical College.
- Vacant Government land should be used for metro station instead of acquiring residential and commercial plots or structures of local people.
- Commercial buildings and shops should not be disturbed.
- People should be informed properly before start of construction work of the project.
- In case, any property affected due to the project, adequate compensation should be provided to the affected people.
- Government should cooperate local people and people should be informed and involved in all stages of the project for its successful completion.
- Government has declared Kanpur to be developed as smart city and introduction of metro rail project in the city is a positive step.
- Employment opportunity should be provided to the local people particularly to the project-affected people on priority basis in all stages of the metro project.
- Safety should be given first priority during construction and operation of the metro rail project.
- People at Dada Nagar (near proposed Govind Nagar station) said that if the people of Dada Nagar are displaced due to the proposed metro rail project, then people should be rehabilitated properly in resettlement colony before start of construction work. Majority of people in Dada Nagar are labour class. Therefore, people of this area should be provided jobs opportunity during construction and operation of the project.
- Shop for shop- All shop keepers should be rehabilitated by constructing market complex in nearby area.
- Government should provide a constructed house for each affected family.

- All development facilities should be centered for the utilization of project affected people and community development programmes should be implemented in project affected areas.
- People feel that common people will get better transportation facilities, avoid traffic jam, commuting time will be reduced, accidents will be avoided, people will get more jobs etc.
- Some persons were thinking beyond the personal level and reported that Kanpur city will progress and will look better and will be free from pollution.

It is evident from the discussion with local people during social survey that the people in Kanpur have no objection to the proposed metro rail project. According to them loss of residential, commercial structures and homestead land will mean a lot of problem for people. Compensation for acquisition of private land should be given to those who are likely to lose their land at the current market price.

15.8.6 Resettlement Policy, Framework and Entitlement Matrix

The applicable laws on land acquisition, rehabilitation and resettlement for the proposed metro rail project are:

1. Right to Fair Compensation and Transparency in land acquisition, Rehabilitation and Resettlement Act, 2013(RTFCTLARR Act).
2. Government Order (G.O) of Government of Uttar Pradesh bearing no. 24/2015/387/8-1-15-50-LDA/204 specifically for LMRP Project dated 04.02.2015. This is in accordance with provisions of Section 46 of the Act, 2013 formulating a committee of officials from relevant Government departments for determination of negotiated price for land acquisition.

The Entitlement Matrix

An Entitlement Matrix **(Table 15.39 & Table 15.40)** has been developed in compliance with National Laws. The entitlement matrix summarizes the types of losses and corresponding nature and scope of entitlements. PAPs who are squatters and not legal titleholder of land and buildings shall also be eligible for R&R if enumerated during the census survey. Therefore, the date of completion of census survey shall be the Cut-off Date. It is on this date that all impacted persons will be identified and the nature of the impact disclosed. PAPs who settle in the affected areas after the cut-off date will not be eligible for compensation and/or other assistance. They, however, will be given sufficient advance notice, requested to vacate premises and dismantle affected structures prior to project implementation. Their dismantled structures will not be confiscated and they will not pay any fine or suffer any sanction. The entitlement matrix presents the entitlements of the affected and displaced people in the following order.

a) Entitlement for titleholders consisting of
   - loss of private land;
   - Loss of private residential structure;
   - Loss of private commercial structures;
   - Impact to tenants(residential/commercial/residential cum commercial)
b) Entitlement to Non-Titleholders consisting of
   - Impact to squatters, encroachers, kiosks
c) Loss of Employment to workers/employees
d) Assistance to affected and displaced vulnerable people
e) Common infrastructure and Common Property Resources(CPRs)

TABLE 15.39: ENTITLEMENT MATRIX – LAND ACQUISITION

(Compensation for Land Acquisition)

S.No	Category of Impact	Eligibility for Entitlement	LMRC Adopted Policy/Entitlement
1.	Loss of Land	Titleholder	Market value/ Circle rate as per stamp Act.
2.	Loss of other immovable assets (value of assets attached to land or building)	Titleholder	Will be determined on the basis of valuation by authorized expert based on a replacement value.
3.	Solatium for loss of Land, Structure and other immovable assets	Titleholder	100% of arrived value of land and building. The compensation is calculated for land, structures and such assets attached to the building or land as applicable and the total of all considered before considering

S.No	Category of Impact	Eligibility for Entitlement	LMRC Adopted Policy/Entitlement
			the solatium, including any transaction costs and fees.
4.	Loss of other immovable assets (value of assets attached to land or building)	Squatters	Onetime financial assistance based on valuation of the property subject to a minimum of **Rs. 25,000.**

TABLE 15.40 ENTITLEMENT MATRIX – REHABILITATION

(Compensation for Rehabilitation)

S.No	Category of Impact	Eligibility of Entitlement	LMRC Adopted Policy/Entitlement
1.	Construction allowance	Displaced family whose residential structure is lost due to acquisition	**Rs. 1,50,000** will be given to displaced family whose dwelling units are lost completely or become unviable due to displacement. The amount has been worked out on the basis of construction of house as per Indra Awas Yojana of GOI.
2.	Subsistence grant for displaced family	Displaced family	Onetime payment of **Rs. 36,000** shall be paid to each Displaced Family. Displaced Family belonging to the Scheduled Castes or the Scheduled Tribes or vulnerable group shall receive an amount equivalent to fifty thousand rupees. (**Rs. 50,000**). This amount is additional to subsistence grant. Additionally, Vulnerable groups who are impacted will be extended facility of Skill Improvement Training.
3.	Transportation cost	Displaced family	One time financial assistance of **Rs.50,000** for shifting family, building material, belongings and cattle shall be given to each displaced family.
4.	Cattle shed / petty shops cost	Affected Family	Each Affected Family having cattle shed or having a petty shop in the acquired

S.No	Category of Impact	Eligibility of Entitlement	LMRC Adopted Policy/Entitlement
			land shall get one-time financial assistance based on valuation of the structure subject to a minimum of **Rs. 25,000** for re-construction of cattle shed or petty shop out of as the case may be.
5.	One time grant to artisan, small traders and certain others	Affected Family	Each Affected Family of an artisan, small trader or self-employed person or a Displaced Family which owned non-agricultural land or commercial, industrial or institutional structure in the affected area, shall get one-time financial assistance based on valuation subject to minimum of **Rs. 25,000**.
6.	One time resettlement allowance	Affected Family	Each Affected Family will be given a one-time resettlement allowance of **Rs. 50,000**.
7.	Loss of community structures	Community	100% replacement cost of equal type.

15.8.7 Institutional Framework

The SPV formed will facilitate land acquisition, capacity building and implementation of RAP. The PIU headed by the Project Director (PD) is responsible for the overall execution of the project and planning and implementation of resettlement and rehabilitation component of the project. The PIU will coordinate with all implementing agencies and monitoring the progress of the project. Implementing Agency will set up a Social Management Unit (SMU) which shall look after land acquisition, resettlement and rehabilitation activities. A Social Development Officer (SDO) with educational background of Social Work or Sociology will be appointed in SMU as full time by IA. The SMU shall ensure that all land acquisition issues are handled according to the Land Acquisition and Rehabilitation & Resettlement policy/guidelines as it is laid down in this report. It will also monitor that all the procedural and legal issues involved in land acquisition are fulfilled. The SMU will assist the IA for getting all the necessary clearances and implementation of the resettlement activities prior to start of any civil work. A Resettlement and Rehabilitation

Officer (RRO) with background of social science may be appointed in this SMU to supervise and monitor overall activities of RAP and he/she will report day to day progress to SDO. RRO will also work closely with the District Collector to expedite the payment of compensation for land acquisition and assistance to APs. The RRO will form Local Resettlement Committees (LRC) in each project affected areas consisting of local representatives and other stakeholders including APs, women to assist in the implementation of RAP activities within the project area. Some of the specific functions of the SMU in regards to resettlement management will include the following:

- Overall responsibility of planning, implementation and monitoring of land acquisition, resettlement and rehabilitation activities in the project;
- Ensure availability of budget for R&R activities;
- Liaison lined agencies support for land acquisition and implementation of land
- acquisition and resettlement;
- Coordinating with line Departments.

NGO will be appointed by IA to extend implementation support to IA in the form of assisting affected families/persons during relocation and preparation of Income Restoration Plan (IRP). The NGO will help educating PAPs on proper utilization of compensation and rehabilitation grant and help them in getting financial assistance.

During implementation phase of RAP, IA will appoint a consultant(R&R) through General Engineering Consultancy (GEC) to assist IA in implementation of resettlement plan. The consultant will carry out due diligence in the implementation of resettlement and rehabilitation programmes as per the provisions of Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013 through periodic monitoring. The consultant will be responsible for (i)preparation of database of affected structures, families, persons, (ii)verification of database through field survey,(iii)improve monitoring system,(iv)capacity building of implementation staffs ,(v)regular follow up implementation activities and other relevant activities.

Efficient grievance redressal mechanism will be developed to assist the PAPs resolve their queries and complaints. Grievances of PAPs will be first brought to the attention of field level staffs of IA. Grievances not redressed by the staffs (field level) will be brought to the Grievance Redressal Committee (GRC). The composition of the proposed GRC will have representatives from PAPs, women representative, Project Director (PIU), SDO, SMU of IA, NGO representative, representative of local body, and Land Acquisition Officer (LAO). The main responsibilities of the GRC are to: (i) provide support to PAPs on problems arising from land/property acquisition; (ii) record PAPs grievances, categorize, and prioritize grievances and resolve them; (iii) immediately inform the SMU of serious cases; and (iv)report to PAPs on developments regarding their grievances and decisions of the GRC.

15.8.8 Work Schedule

The R&R activities of the proposed project are divided in to three broad categories based on the stages of work and process of implementation. In the project preparation stage, identification of required land for acquisition, census & socio-economic survey, public consultation, preparation and review/approval of draft RAP, disclosure of RAP, establishment of GRC and preparation of resettlement site shall be carried out. Activities like notification of land acquisition, valuation of structure, payment by competent authority, shifting of PAPs shall be taken up during RAP implementation. During monitoring and evaluation stage internal monitoring will be carried out by IA and mid and end term evaluation will be carried out by an independent evaluation agency, **Figure 15.3**.

15.8.9 Monitoring and Evaluation of RAP

RAP implementation will be monitored both internally and externally. IA will be responsible for internal monitoring through their field level officers of Social Management Unit and will prepare quarterly reports on the progress of RAP implementation. An Independent Evaluation Consultant may be hired by IA for mid and end term evaluation of RAP implementation.

FIGURE 15.3: RAP IMPLEMENTATION SCHEDULE FOR KANPUR METRO PHASE-I CORRIDORS

SN	Description	2018				2019			
A	**Project Implementation**								
1	**Approval of DPR and Notification of detailed SIA - Jan 2018**								
2	Community /Public Consultation								
3	Preparation of Detailed SIA by Government after Notification								
4	Review/Approval of SIA and Preliminary Notification of Acquisition								
5	Census Survey								
6	Finalization of updated R&R Scheme								
7	Disclosure of SIA and R&R Scheme								
B	**RAP Implementation**								
8	Notice to Persons Interested								
9	Joint Measurement Survey								
10	Suggestion & Objection of PAPs								
11	Declaration of Award of Compensation and R&R amounts as per RTFCTLARR,Act and payment								
12	Shifting of PAPs								
13	Grievance Redress								
14	Start of Civil Works in affected areas								
C	**Monitoring and Evaluation**								
15	Internal Monitoring								
16	External Monitoring								

Internal Monitoring

The internal monitoring for RAP implementation will be carried out by IA. The main objectives of internal monitoring are to:

- Measure and report progress against the RAP schedule;
- Verify that agreed entitlements are delivered in full to affected people;
- Identify any problems, issues or cases of hardship resulting from the resettlement process, and to develop appropriate corrective actions, or where problems are systemic refer them to the management team;
- Monitor the effectiveness of the grievance system
- Periodically measure the satisfaction of project affected people.

Internal monitoring will focus on measuring progress against the schedule of actions defined in the RAP. Activities to be undertaken by the IA will include:

- Liaison with the Land Acquisition team, construction contractor and project affected communities to review and report progress against the RAP;
- Verification of land acquisition and compensation entitlements are being delivered in accordance with the RAP;
- Verification of agreed measures to restore or enhance living standards are being implemented;
- Verification of agreed measures to restore or enhance livelihood are being implemented;
- Identification of any problems, issues, or cases of hardship resulting from resettlement process;
- Through household interviews, assess project affected peoples' satisfaction with resettlement outcomes;
- Collection of records of grievances, follow up that appropriate corrective actions have been undertaken and that outcomes are satisfactory.

Monitoring is a continuous process and will be carried out by field level officers of Social Management Unit on regular basis to keep track of the R&R progress. For this purpose, the indicators suggested have been given in **Table 15.41**.

TABLE 15.41: INDICATORS FOR MONITORING OF RAP PROGRESS

Indicators	Parameters Indicators
Physical	Extent of land acquired Number of structures dismantled Number of land users and private structure owners paid compensation Number of families affected Number of families purchasing land and extent of land purchased Number of PAPs receiving assistance/compensation Number of PAPs provided transport facilities/ shifting allowance Extent of government land identified for house sites
Financial	Amount of compensation paid for land/structure Cash grant for shifting oustees Amount paid for training and capacity building of staffs
Social	Area and type of house and facility at resettlement site PAPs knowledge about their entitlements Communal harmony Morbidity & mortality rate Taken care of vulnerable population Women concern
Economic	Entitlement of PAPs-land/cash Number of business re-established Utilization of compensation House sites/business sites purchased Successful implementation of Income Restoration Schemes
Grievance	Number of community level meeting Number of GRC meetings Number of cases disposed by IA to the satisfaction of PAPs Number of grievances referred and addressed by GRC Cases of LA referred to court, pending and settled

Independent Evaluation

As mentioned earlier, an Independent Evaluation Agency (IEA) will be hired by IA for mid and end term evaluation. The external evaluation will be carried out to achieve the following:

- Verify results of internal monitoring,
- Assess whether resettlement objectives have been met, specifically,

whether livelihoods and living standards have been restored or enhanced,

- Assess resettlement efficiency, effectiveness, impact and sustainability, drawing lesions as a guide to future resettlement policy making and planning, and
- Ascertain whether the resettlement entitlements were appropriate to meeting the objectives, and whether the objectives were suited to affected persons' conditions,
- This comparison of living standards will be in relation to the baseline information available in the BSES. If some baseline information is not available then such information should be collected on recall basis during the evaluation.

Reporting Requirement

IA will be responsible for supervision and implementation of the RAP. IA will prepare quarterly progress reports on resettlement activities. The Independent Evaluation Agency will submit draft and final reports of their assignment to IA and determine whether resettlement goals have been achieved, more importantly whether livelihoods and living standards have been restored/ enhanced and suggest suitable recommendations for improvement. Submission of the draft report would be carried out after completion of assignment and the final report should be submitted after receiving feedback from IA.

15.8.3 Cost Estimate of R&R

The cost for implementation of Resettlement and Rehabilitation Plan on account of two corridors of Kanpur Metro is presented in **Table 15.42**. The total cost for R&R implementation plan is **Rs.5.32 crore**.

TABLE 15.42: COST FOR RESETTLEMENT & REHABILITATION*

Sl. No.	Description	Unit	Quantity	Rate (Rs.)	Amount (Rs.in crore)
A	Compensation for loss of private land and structure has been presented in capital estimate of DPR				
Compensation for Titleholders					
B	**Residential PAFs**				
C	Subsistence allowance	no	19	36000	0.068

Sl. No.	Description	Unit	Quantity	Rate (Rs.)	Amount (Rs.in crore)
D	Transportation allowance	no	19	50000	0.095
E	Resettlement Allowance	no	19	50000	0.095
F	**Commercial PAFs**				
G	Subsistence allowance	no	97	36000	0.349
H	Transportation allowance	no	97	50000	0.485
I	Loss of Small traders/self-employment	no	97	25000	0.242
J	Resettlement Allowance	no	97	50000	0.485
Compensation for Non-Titleholders					
	Squatters				
K	One time financial assistance	no	355	25000	0.887
Assistance for SCs ,STs or Vulnerable group					
L	Additional Subsistence Allowance	no	64	50000	0.320
Training for Skill Development					
M	Training Assistance(LS)	no	64	15000	0.096
Compensation for Community Structures					
N	Religious structures(LS)	no	7	2000000	1.400
O	Public Toilets(LS)	no	2	1000000	0.200
Engagement of NGO					
P	NGO Cost (LS)	no	1	4000000	0.400
Monitoring & Evaluation					
Q	Cost of Independent Evaluation Agency(LS)		1	2000000	0.200
	Total (B+C+D+E+F+G+H+I+J+K+L+M+N+O+P+Q)				4.838
	Miscellaneous items @ 10% of sub total				0.483
	TOTAL				**5.322**

*R&R cost is calculated as per the Resettlement Policy Framework of Lucknow Metro Rail Corporation provided by LMRC, Lucknow.

Chapter – 16
DISASTER MANAGEMENT & SECURITY MEASURES

16. DISASTER MANAGEMENT & SECURITY MEASURES

16.1 DISASTER MANAGEMENT AND IMPERATIVES

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 insubstantial 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.

World Health Organization (WHO), defines disaster as "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."

16.2 NEED FOR DISASTER MANAGEMENT

Disaster brings about sudden and immense misery to humanity and disruptions to normal human life in established social and economic patterns. It has the potential to cause large scale human suffering.

Metro systems will carry thousands of passengers daily, therefore the effect of any disaster spread over in operational area (station, tunnels, viaducts etc.) is likely to be considerable. It may also cause destruction or damage to infrastructure, buildings and communication channels of Metro.

16.3 TYPES OF DISASTERS IN METRO SYSTEM

Metro specific disasters can be classified into two broad categories e.g.: Man-made and Natural.

a. Man Made Disaster

i. Terrorist attack
ii. Bomb threat/ Bomb blast
iii. Hostage Situations
iv. Release of Chemical or biological gas in trains, stations or tunnels
v. Fire in metro buildings, underground/ elevated infrastructures, power stations, train depots etc.
vi. Train accident and train collision/derailment of a passenger carrying train
vii. Sabotage
viii. Stampede

b. Natural Disaster

i. Earthquakes
ii. Floods

16.4 OBJECTIVES OF DISASTER MANAGEMENT PLAN

The main objectives of Disaster Management Measures are as follows:

- Save life and alleviate the sufferings.
- 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 as early as possible.
- Lay down the actions required to be taken by staff in the event of a disaster in Uttar Pradesh Metro Rail Corporation in order to ensure prompt handling of crisis situation in a 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.

16.5 PREPAREDNESS OF STAFF FOR DISASTERS

16.5.1 Being a technologically complex system with a new set of staff, intensive mock drills for the staff concerned is very essential to train them to become fully conversant with the actions required to be taken up 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 - This shall include

- Making announcements
- Protecting the area
- Summoning assistance
- Using fire fighting equipments locally available
- Passenger evacuation in case of need

B. Rescue of a disabled train

- Identifying causes, isolating fault.
- Announcement to passengers
- Passenger evacuation
- Coupling / Uncoupling of trains for clearing a failed train by an assisting train.
- Driving from an intermediate cab with Cab to Cab telephone communication from front cab.

C. Detrainment of passenger between stations

- Blocking adjacent line
- Announcement to passengers.
- Use of emergency doors.
- Guiding passengers to next station.

D. Passenger evacuation from station

- Announcement to passengers.
- Closing of booking offices.
- Opening of AFC gates/ Emergency exits
- Changing the direction of escalators.
- Crowd control with assistance of security staff and Police/Metro Police.
- Working of TVS system.
- Working of fire suppression and detection system

E. Drill for use of Rescue & Relief Train

The following items need to be noted

- Time taken by the staff to report for duty from the time of first information.
- Departure time of rescue and relief train.
- Testing of all vital systems like generators, control panel.etc.
- Demonstrating a few key functions

F. Hot line telephone communication with state disaster management authority.

16.5.2 Authorities Coordination in Case of Disaster, Command & Control at National, State & District Level

Authorities coordination is essential for disasters of such a nature or magnitude as to be beyond the coping capacity of the community of the affected area. Following provisions have been considered for Kanpur Metro Phase I corridors:

16.5.2.1 Provision under Disaster Management Act, 2005

A. National Disaster Management Authority (NDMA)

Establishment of National Disaster Management Authority:

i. 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.

ii. 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.

iii. The Chairperson of the National Authority may designate one of the members nominated under clause (b) of sub-section (ii) to be the Vice-Chairperson of the National Authority.

iv. 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:-

i. 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.

ii. A State Authority shall consist of the Chairperson and such number of other members, not exceeding nine, as may be prescribed by the State Government and, unless the rules otherwise provide, the State Authority shall consist of the following members, namely:

   a. The Chief Minister of the State, who shall be Chairperson, ex officio;
   b. Other members, not exceeding eight, to be nominated by Chairperson of State Authority;
   c. The Chairperson of State Executive Committee, ex officio.

iii. The Chairperson of State Authority may designate one of the members nominated under clause (b) of sub-section (ii) to be the Vice- Chairperson of the State Authority.

iv. The Chairperson of the State Executive Committee shall be Chief Executive Officer of the State Authority, the Chief Minister shall be the Chairperson of the Authority established under this section.

v. 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 chairmanship of Cabinet Secretary
2. Crisis Management Group (CMG) under chairmanship of Union Home Secretary.
3. State Level Committee under the chairmanship of Chief Secretary.
4. District Level Committee under the Chairmanship of District Collector.

All agencies of Government at National, State and district levels will function in accordance with 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:

i. Prepare a disaster management plan setting out following, namely:-
   a. Provisions for prevention and mitigation measures as provided for in the District Plan and as is assigned to the department or agency concerned;
   b. Provisions for taking measures relating to capacity-building and preparedness as laid down in the District Plan;
   c. The response plans and procedures, in the event of, any threatening disaster situation or disaster;

ii. 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;

iii. Regularly review and update the plan; and

iv. Submit a copy of its disaster management plan, and of any amendment thereto, to the District Authority.

16.6 PROVISION AT METRO STATIONS / OTHER INSTALLATIONS

An effective system needs to be provided which includes Fire Detection and Suppression System, Smoke Management, Environmental Control System (ECS), Tunnel Ventilation System, Track-way Exhaust System (TES), Lighting System, Station Power Supply System, DG Sets & UPS, Seepage system, Water Supply and Drainage System, Sewage System, Station Area Lights and other facilities which may be deemed necessary.

The above said provisions are suggestive and an exhaustive set of facilities have to be provided based on site conditions, location and other internal and external factors.

16.6.1 Measures in Case of Fire

Fire has been recognized as one of the most dreaded accidents on metros primarily because of large concentration of passengers at stations and in trains. Fire prevention and prompt response to any incident of fire or smoke emission is therefore the most important component of disaster management on Metros. Universally accepted measures for fire prevention include:

i. Rigid observance of non smoking regulations

ii. Total ban on carriage of inflammable/ explosive substance within metro premises and in trains
iii. Non accumulation of garbage in the metro station premises and inside trains
iv. All staffs posted at stations must ensure instructions are rigidly enforced by regular checks.

A. Fire and Smoke

In the event of fire and / or smoke either in train , station premises, right of way including the tunnel or other metro premises, every Metro Rail official whether on duty or not shall,

i. Report the occurrence to the nearest Station Controller (SC) or Chief Controller (OCC)
ii. Take all possible steps to extinguish fire
iii. Disconnect electric supply, if required
iv. Prevent the fire from spreading
v. Seek assistance of Fire services

B. Fire in a Train

The guidelines set out below are based on the content analysis of past accidents on other Metros and are in the nature of best practices. Since every fire incident is unique, the train operator is to exercise quick judgment based on:

i. The nature of fire whether localized or widespread in passenger area.
ii. The extent of occupation of the train-number of passengers-if the number is manageable he will ask passengers of the affected coach to move away to other coaches.
iii. Proximity of the next station – passenger evacuation and handling of emergency is much easier at station than in between stations. Train Operator (TO) has to exercise his judgment about those extreme cases where the train has to be stopped forthwith to save life by prompt evacuation or taken to the next station expeditiously.

C. Fire in Train at the Station Platform

The Train Operator shall open all train doors on the platform side and ask passengers to vacate the train. He will inform OCC and Station Controller and take assistance from station staff as required.

D. Special Instructions for Underground Sections

Entire underground Metro network is equipped with Tunnel Ventilation system, capable of Centralized operation from OCC and also local operation from Station Control Rooms.

In the event of a 'fire incident' the system is designed to:

- Provide smoke free evacuation route
- Make available adequate fresh air
- Remove smoke and heat
- Cut off supply to the fire affected area during emergency.

A water pipeline should run along the entire underground Metro corridor. These pipelines have hydrants fixed every 15 m where hose pipes can be connected. The pipes are of great help to quickly extinguish any fire outbreak. Each underground section should equip with one to three cross passages between the up and down tunnels. These passages can be used for speedy evacuation of commuters in case of emergency. There is a Fire Detection and Suppression system equipped to automatically activate alarms for Vents, Fans and Dampers & Suppression equipments. The system is operated from a panel located in the Station Control Room.

E. Fire Suppression System

A wet Fire Main System covers the station area as well as the entire length of the tunnels. In addition there are automatic sprinklers, inert gas based suppression systems and portable fire extinguishers at various locations. Immediately on receipt of information about a train with fire incident held up between stations – Auxiliary System Controller (ASC) will

- Identify the location of fire (front/rear of the train)
- Identify affected ventilation zone/s
- Other trains held up needing increased ventilation
- Help OCC to decide the correct direction of passenger evacuation.
- Identify the appropriate TVS Master mode and operate TVS system.
- Inform TO through TC the direction of evacuation.

Before starting evacuation, ASC/ Traction Power Controller (TPC) shall check for the adequacy of Tunnel Lighting and correct Operation of TVS & ECS and Tunnel lights can be switched on from Station control room by BMS controller/ nominated E&M staff.

F. Fire at Metro Station Premises

The fire can be at the following locations:

i. In areas, where the passengers enter for purchasing tickets or leave the station after performing their train journey including lifts, staircases and escalators.
ii. Concourse
iii. Auxiliary electrical substations.

In case of fire in areas where passengers enter/leave the station premises, the endeavor of station staff should be to cordon off the area so that it is not approachable for intending Metro users or by Metro passengers leaving the station area.

16.6.2 Measures in Case of Collision of Trains

In the event of a train collision involving Metro trains, any employee witnessing, discovering or being involved in a train collision shall inform the Operations Control Center (OCC) and provide the following information-

- Callers name and identification,
- Reason for the call,
- Train identification,
- Location of the collision (Line identification , track (UP/DN), OHE mast no., nearest station if not at station),
- Need for medical assistance,
- Presence of smoke or fire

If the employee making the first report is a Train Operator (TO), Traffic Controller (TC) shall instruct the Train Operator to secure the train, inform the passengers about the incident, check if any passenger or employee needs medical attention. The TO will inform TC accordingly. If the other TO has not communicated with OCC, TC will ask TO to collect similar information about the second train and report.

A. Train Operator (TO) shall

i. Look for presence of smoke or fire. Furnish details of visible damage, if any coaches are derailed or
ii. If the other track is obstructed.
iii. The OCC /TC shall instruct Train Operators of trains in approach of the collision site, in both directions, to stop their trains at stations and report their positions.

B. Duties of Train Operator:

i. In the event of collision taking place involving his train, the train operator shall inform OCC by giving as many details as possible.
ii. In case of adjacent track is infringed, he will first protect the adjacent track to avoid multiple accidents as per prescribed procedure.
iii. He will inform passengers about the incident advising them about rescue and relief arrangements being made.
iv. He shall quickly assess the situation particularly in respect of passenger's injury and again inform OCC with as much details as available seeking medical and other assistance as required.
v. He will render first aid to passengers and check for injury and damage to the train (both his train and other train).
vi. Shall seek OCC's permission for passenger evacuation.
vii. Shall await further instructions from OCC.

C. Duties of Station Controller:

i. The Station Controller on receipt of information about collision at his station shall inform OCC.
ii. Arrange for immediate medical assistance as required.
iii. Inform Metro rail police/Local police.
iv. Mobilize the staff for evacuation of passengers and rendering of first aid to the injured and their hospitalization as required.
v. Inform passenger awaiting at the station of the likely delays.
vi. Station controller will evacuate passengers as per instructions of OCC.

D. Duties of Traffic Controller:

i. On receiving information about train collision the Traffic Controller shall block all movement on both the tracks to protect the site of accident.
ii. Inform CMRL Disaster Management Team members.
iii. And other designated CMRL departments and Personnel.
iv. Mobilize medical assistance as required.
v. Inform the train depot to be in readiness to move rescue and relief train.
vi. Instruct Station Superintendent to depute staff for evacuation of passengers and providing medical aid to the injured.
vii. Regulate train services and inform all stations on the route about the likely dislocation in train services.

viii. Activate ventilation system based on condition of the scene (for tunnel section only).
ix. Arrange for Public Address announcements to be made to passengers in trains and at stations.
x. Initiate operating procedure to relieve train congestion at collision site by: a) Single track operation (Single Line Working), b) Turning trains on both sides of collision site (Short Loop Operation) etc.
xi. The OCC Chief Controller shall inform the Disaster Management Team, ED/OP, GM/OP and all controllers in OCC, the Police/Metro Police and Security Controller to secure the accident scene and Station Superintendent/Station Controllers on the affected line. Chief Controller shall also inform emergency services. All controllers in OCC shall inform their respective officers, maintenance/emergency team and others as applicable.

E. Medical Assistance

The TO/SC requesting medical assistance to OCC shall provide an estimate of the likely number of people requiring medical assistance and also indicate the most convenient access point for medical personnel to enter. (The names and addresses of person requiring/receiving medical assistance and the names of medical agencies and personnel shall be recorded in the Accident Log book maintained at site/at OCC).

16.6.3 Measures in Case of Train Derailment

A. Duties of Train Operator:

i. The TO becoming aware that his train has derailed shall stop the train immediately if not, already stopped and secure the train.
ii. Inform passengers of the problem and action being taken.
iii. Inform OCC providing following information:
- Train Operator identification
- Location (line identification, Track (UP/DN), & Mast No.)
- Train description (Train no. & train set no.)
- Adjacent track obstructed or clear.
- Passenger injury or presence of smoke or fire.
- Seek instruction for passenger evacuation.

B. Duties of Traffic Controller:

i. TC shall instruct TOs of trains approaching the derailment site on both tracks to stop their trains and report their positions.

ii. TC shall immediately notify DMT and all concerned Metro departments, Police/Metro Police and Security Controller to secure the accident site and Station Superintendents on the affected line for informing waiting passengers at stations about the likely delay. OCC/TC will also arrange to inform passengers aboard trains held up.

iii. Mobilize medical assistance as required.

iv. Inform the depot to be in readiness to move the rescue and relief train.

v. Instruct Station Managers to depute staff for evacuation of passengers and providing medical aid to the injured in case of derailment between stations.

vi. Regulate train services and inform all stations on the route about the likely dislocation in train services.

vii. Activate ventilation system based on condition of the scene (for tunnel section only).

viii. Arrange for Public Address announcements to be made to passengers in trains and on stations.

ix. Request assistance of Police / Metro Police / Security/ Watch & Ward for crowd control at critical stations.

x. Initiate operating procedure to relieve train congestion at derailment site by:

- Single track operation (Single Line Working),
- Turning trains on both sides of derailment site (Short Loop Operation) etc.

C. Medical Assistance:

The employee requesting medical assistance to OCC shall provide an estimate of likely number of people requiring medical assistance and will also indicate the most convenient access point for medical personnel to enter. (The names and addresses of passengers requiring medical assistance and the names of medical agencies and personnel shall be recorded in the Accident Log book maintained at site/in OCC).

16.6.4 Measures in Case of Terrorist Actions

Increase in terrorist actions against public transport worldwide, indicates that public transport systems are becoming more vulnerable and potential targets for terrorist. It is clear that preventing terrorist activities is the primary responsibility of security agencies and state police.

However, concern for passenger well being and their security and adverse effects of such mishaps on the public image of transport systems itself, requires best possible level of preparedness for prevention of such threats within Metro premises. Key components of such preparatory and preventive action include:

- Encouraging and guiding passengers to be cautious themselves.
- An awareness program – appealing users to be on the alert and report any suspect package.
- Well thought out crisis communication to prevent misinformation, confusion, panic and shock.
- Clear procedures and systems of communications need to be established for emergencies and regularly tested, in order to ensure a working communication during crisis situation.
- Frequent mock drills to test effectiveness of passenger evacuation systems including the collaboration and response of passengers.
- Training all frontline staff to prevent dangerous situations and handle incidents.
- Once they have happened act with courage, promptitude and alertness, reassuring passengers and providing regular information for their guidance.
- Terrorist attack may take place anywhere in the metro rail's jurisdictions, however when it takes place, on the right of way particularly underground section, at metro station and in running trains it may have serious impact in terms of human distress and restoration of normal operation. On receipt of information of any terrorist act on Metro Trains, stations or on the Right of Way, OCC will take prompt action to get the entire metro network cleared of all passengers.

A. Terrorist attack at Station

Duties of Station Superintendent/Station Controller:

i. Shall visit the affected spot, assess the extent of impact on human life and also how it may affect train services.
ii. Shall inform the OCC about details of incident.
iii. Sound the hooter and get the station premises vacated of all the passenger
iv. Depute staff to announce at 5 minute interval, through the station PA system what has happened and what the passengers are expected to do without getting panic.
v. Mobilize resources to render first aid and evacuate the injured.
vi. In case any person is seen moving in a suspicious manner, he may be detained for interrogation with the help of security staff.

vii. Passengers found near the affected area may also be asked about their first hand knowledge of the occurrence and their statement with name and addresses recorded.

viii. Inform Police/Metro Police and depute station security staff to protect and cordon the site to preserve the clues and leave the site undisturbed for police investigation.

Duties of Traffic Controller/Chief Controller:

Immediately on receipt of the information about terrorist attack, Chief Controller shall:

i. Inform Police/Metro Police and security personnel and ask them to rush to the spot of occurrence.

ii. Mobilize Medical Assistance and/ or Fire Services to reach the spot.

iii. Inform the DMT and other CMRL departments and personnel.

iv. Hold trains at stations. Train movement shall only be resumed after confirming that the running of train through the affected station is safe, till the position becomes clear regular announcement to be made to passengers in train and at station of the likely delay and evacuation procedures started. The entire Metro network shall remain closed till rescue and search operations have been completed. Revenue operations shall only be started after ensuring that the system is fully safe and secure.

B. Terrorist Attack in Train:

Of all the cases of terrorist attack, those within a train will have most disastrous consequences and very prompt action will be necessary to restrict the damage to men and material. Such a situation may include:

i. A Bomb on the track which detonates under a train.

ii. Detonation of Bomb / igniting of inflammable material inside a train.

iii. Release of chemical / biological gases in a train.

iv. Criminal interference with train running equipments which causes fire in the coaches while on run.

v. Other terrorist activities incapacitating the train on run.

C. Bomb Blast on Track:

There may be derailment of the train with large scale damage to the train and fixed structures as well as injury to the passengers in the train. In case of derailment, the train will immediately come to a stop. The Train Operator shall immediately inform

Traffic Controller about the occurrence and ask for immediate assistance as required. TO shall seek permission for evacuation of passengers. In case the situation does not permit detrainment from one end, it may be arranged from both ends. The injured passengers should be evacuated as soon as the Medical Team arrives on the spot.

D. Bomb Blast inside the Train:

The Train operator shall:

i. Inform Traffic Controller
ii. Inspect the impact of explosion and if the train is in a position to move, he will try to take the train to the next station at reduced speed.
iii. In case he is not able to take the train to the next station, Shall stop the train and inform the Traffic Controller about the incident.
iv. Shall seek assistance of fire services and medical services as required, take the permission of the TC to detrain the passengers.
v. Shall make an on the spot assessment of the situation including the injury/death of passengers and inform the Traffic Controller for immediate appropriate action.
vi. The TO shall make announcement to the passengers through the train PA system about the situation and ask them to remain calm indicating that action has already been taken to arrange for detrainment of passengers.
vii. The TO will arrange evacuation of the passenger when authorized by OCC.
viii. This will help in reaching prompt assistance to the injured and disabled passengers on arrival of the Security and Medical Team.
ix. Train Operator will thereafter arrange to detrain the injured passengers with the help of security and medical staff.

E. Release of Chemical Poisonous or biological gases in tunnels, trains or at stations

Whenever other terrorist activities described above produce loud noise, explosion, fire and smoke, release of lethal or harmful gases works silently and can only be generally inferred from-

- Unusual smell
- Passengers or employees complaining of Breathing problems- including choking/fainting, Severe eye/Skin irritation and Vomiting etc.

Receiving any such complaint the Train Operator or Station Controller/ Station Manager will take serious note of it and immediately inform OCC to take prompt action to handle the emergency as case of suspected release of poisonous gases. If gas release is detected in a train, TO will inform OCC and expeditiously bring the train to the next station, open train doors and request all passengers to detrain. He will personally check with station staff, security and Police/Metro Police that the train has been completely vacated.

To prevent further spreading of gas in platform area and to help Police and Medical teams to investigate and identify the gas he will close the train doors. In the event of gas release in station premises, the station should be fully vacated and kept closed unless certified free of contamination by medical authorities.

Whereas, release of gases on the Right of Way in Rail corridors may not have serious impact, with gas spreading into atmosphere. In tunnel sections it will be necessary to

- Locate the presence of gas in specific ventilation zones.
- Activate appropriate TVS modes to dilute the gas.
- Degasify the tunnel portion or the entire tunnel, depending upon the severity of the case informing civil authorities of the likely discharge of gas in certain areas which may require to be protected.
- Pending this, the affected portion or the entire tunnel will have to be vacated of all passengers and staff.

Normal operation should only be resumed after running of a trial train with Police, Medical and metro authorities confirming that the section has been made free of contamination.

16.6.5 Measures in Case of Natural Calamities

On being informed about an earthquake in the city of Kanpur or experiencing the same, OCC Traction Power Controller (TPC) will switch off Traction power Supply in a manner which does not shut down station supplies informing the Traffic Controller who will instruct the TOs to stop their trains and report their position.
In the event of a significant earthquake, TO experiencing the impact or being informed by passengers or OCC will bring his train to a stop and inform OCC the location of the train.

- If at station, he will not move the train, inform OCC and advice passengers to remain inside the train.
- After receiving OCC instructions that the earthquake has subsided, the trains waiting at stations will detrain passengers.
- For the trains held up between stations, TOs to visually check the track. If the track is unaffected and there are no visible obstruction after informing OCC/TC,

train can be moved at walking speed up to the next station where passengers shall be detrained.

- Train Operator (TO) will keep passengers informed of the problem and request them to maintain calm.

In case of any doubt, OCC will arrange for passenger evacuation on the right of way as per procedure. Normal operation of revenue trains shall only be resumed after the track and structures department issuing of a certificate of fitness for normal operations which will be issued after detailed physical inspection. OCC and Station Superintendent/Station Controllers will continuously inform passengers of the situation and likely time for commencement of train services.

16.7 SECURITY MEASURES

16.7.1 Essentials of Security Management

Metro Rail System has emerged as the most reliable mode of urban transportation system in India. 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, high cost of infrastructure, its economic impacts to the society, being the life line of city with high news value pose greater threat to its security. Security is a relatively new challenge in the context of public transport. It addresses problems caused intentionally and 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 terror threat.

The public transportation system is increasingly becoming important for urban areas to prosper in the face of challenges such as reduction in congestion and pollution. Therefore, security system for public transportation like metro rail plays an important role in helping the system to become the preferred mode choice for commuters. Therefore, provision of an excellent and reliable security system is a prerequisite for metro system for increasing its market share. Metro railway administration must ensure that security model keep pace with the rapid expansion of the metro and changing security scenario.

16.7.2 Security System Design Parameters - Three Pillars of Security

Security means protection of human, intellectual assets and infrastructure either from criminal interference, destruction by terrorists or criminals or incidental to technological failures or natural hazardous events. Three important pillars of security are as follows:

i. The Human factor;
ii. Procedures; and
iii. Technology

Staff interaction with passengers creates a sense of re-assurance which cannot fully be achieved by technology. For human factor to be more effective, staff has to be qualified, trained, well equipped and motivated. The staff members should be skillful, trained, drilled and experienced. 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 tested in advance. There are number of technologies which can be used to enhance security e.g. surveillance systems. The objectives of the security systems differ i.e., detection of the plan before an attack, deny the access for carrying out an attack and mitigation measures after an attack.

16.7.3 Different Phases of Security

There are three different phases associated with the security system in metro. These phases are as under:

i. Prevention

These are the measures which can prevent a security breach from taking place. These can be identified by conducting risk assessment and gathering intelligence. Prevention begins with the daily operational security problems. Care has to be given in controlling unused, damaged properties which could otherwise prove to be a breeding ground for more serious crimes.

ii. Preparedness

Plans have to be prepared to respond to incidents and to mitigate the impacts. Staff have to be accordingly trained to carry out the exercises. The results of the risk assessment will give basis for such plans.

iii. Recovery

Urban transport system should have laid down procedures/instructions for quick recovery of normal service after an incident. Financial health is important for the recovery 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.

16.7.4 Responsibilities and Partnerships

The responsibility of the Security lies with the state. Security in public requires clear governance. Responsibility should be clearly defined. In the present scenario, this is the responsibility of the State Government to ensure secured travel in Kanpur Metro.

16.8 SECURITY SYSTEMS RECOMMENDED FOR KANPUR METRO

For providing an efficient security system in metro station areas the following provisions are suggested:

i. CCTV coverage of all metro stations with 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.
ii. 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.
iii. Multi-zone Door Frame Metal Detector (DFMD) minimum three per entry (2 per AFC array). The number can increase in view of the footfall at over crowed stations.
iv. 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.
v. 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.
vi. Bomb Blanket at least one per station and depot.
vii. Wireless sets (Static and Handheld) as per requirement of security agency.

viii. Dragon light at least one per metro station.
ix. Mobile phones, land lines and EPBX phone connections for senior security officers and control room etc.
x. Dog Squads (Sniffer Dog), at least one dog for 4 metro stations. Dog Kennels along with provision for dog handlers and MI room will also be provided by metro train depot administration including land at suitable places line wise.
xi. Bullet proof Morcha one per security check point (i.e. AFC array) and entry gate of metro train depot administration.
xii. Bullet proof jackets and helmets for Quick Response Team (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.
xiii. 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 & office and one steel top table with two chairs for checking point.
xiv. Ladies frisking booth - 1 per security check point (AFC) Wooden Ramp - 1 per DFMD for security check points.
xv. Wall mounted/ pedestal fan at security check point, ladies frisking booth and bullet proof morcha, as per requirement.
xvi. Physical barriers for anti-scaling at Ramp area, low height of via duct by providing iron grill of appropriate height & design/concertina wire.
xvii. Adequate number of ropes. Queue managers, cordoning tapes, dragon search lights for contingency.
xviii. Iron grill at station entrance staircases, proper segregation of paid and unpaid areas by providing appropriate design grills etc.
xix. Proper design of emergency staircase and fireman entry to prevent unauthorized entry.

The security model adopted for Lucknow Metro Rail Project will also be adopted for Kanpur Metro Rail Project. In Lucknow Metro Rail Project, a ‘Hybrid Model’ to make the security measures more effective has been adopted. In this ‘Hybrid Model’, Metro as well as U.P. Police both are giving security to metro. The roles of Metro and U.P. Police are as follows-

Role of Metro:

- Provision of Security related Infrastructure:

- Door Frame Metal Detectors, X-ray Baggage scanners and Hand-held Metal Detectors,
- CCTV Surveillance and Access Control to Technical Rooms
- Security Control Room at OCC,
- Effective lighting eliminating blind spots
- Deployment of Private Security Personnel:
- Watch and ward at Station areas, Security of assets at Stations, Depot, RSS etc. and Manning of Entry/Exit gates and Platforms.

Role of UP Police:

- Security checks of bags by X-BIS
- Regular patrolling of station area and Police Pickets at sensitive locations,
- Threat Assessment, Quick Response Team, Bomb Squad and Dog Squad,
- Respond to law & order and crime incidents as reported by LMRC, Anti Sabotage Check
- Monitoring the CCTV output at security control room.

17. DETAILED PROJECT COST ESTIMATES

Please refer Chapter 17 of Supplementary DPR.

Chapter – 18
TRANSIT ORIENTED DEVELOPMENT PLAN

18. TRANSIT ORIENTED DEVELOPMENT PLAN

18.1 BACKGROUND

18.1.1 National Transit Oriented Development (TOD Policy)

National Transit Oriented Development (TOD) Policy provides guidelines on development along transit corridors. TOD integrates land use and transport planning and aims to develop planned sustainable urban growth centers, having walkable and livable communes with high density mixed land-use. Citizens have access to open green and public spaces and at the same time transit facilities are efficiently utilized.

TOD focuses on creation of high density mixed land use development in the influence zone of transit stations, i.e. within the walking distance of (500-800 m) of transit station or along the corridor in case the station spacing is about 1 km. TOD advocates pedestrian trips to access various facilities such as shopping, entertainment and work.

TOD increases the accessibility of the transit stations by creating pedestrian and Non-Motorised Transport (NMT) friendly infrastructure that benefits large number of people, thereby increasing the ridership of the transit facility and improving the economic and financial viability of the system. Since the transit corridor has mixed land-use, where the transit stations are either origin (housing) or destination (work), the corridor experiencing peak hour traffic in both directions would optimize the use of the transit system.

18.1.2 Objectives of TOD

The objectives of TOD include:

- To promote the use of public transport by developing high density zones in the influence area, which would increase the share of transit and walk trips
- To provide all the basic needs of work/ job, shopping, public amenities, entertainment in the influence zone with mixed land-use development
- To establish a dense road network within the development area for safe and easy movement and connectivity of NMT and pedestrians between

various uses as well as to transit stations.

- To achieve reduction in the private vehicle ownership, traffic and associated parking demand.
- To provide all kinds of recreational/entertainment/ open spaces, required for a good quality of life in the influence area.
- To prevent urban sprawl by accommodating the growing population in a compact area with access to the transit corridor, this would also consolidate investments and bring down the infrastructure cost for development.
- To reduce carbon footprints by shifting towards environmentally friendly travel options for the line haul as well as for access and egress trips.

18.2 TOD POLICY AND GUIDELINES IN UTTAR PRADESH

Uttar Pradesh Government has approved property development for Lucknow Metro with 30% of the total area available with 5 (five) FAR to be used for commercial activity development and balance 70% for residential activity development (vide letter no. 2624/ Eight-1-13-09 LDA/13 dated 20.08.2013).

Further zoning regulations, planning norms and building classification for transit oriented development and mixed land use along mass rapid transit corridors have been notified by the Government of Uttar Pradesh vide letter no. 03/ Eight-3-15- 198 vividh/14 dated 04.03.2015 as attached in **Annexure 18.1**.

The definition of TOD Zone is stated in the notification as:

'It is the area falling within 500 meters distance on either side of the MRTS/ Transit/ Metro corridor'. This distance may be kept more than 500 m near the metro stations depending upon the development potential and local conditions. The external boundary of TOD zone may be defined based on physical features like Road, Railway line, River, Drain etc.

18.2.1 Planning Norms for Mixed Land use in TOD zone

- Mixed land use in TOD zone shall be permissible on maximum 20% of total area of the proposed developments. **Table 18.1** shows the type of land uses along with their permissible limit for mixed use:

TABLE 18.1: LAND USE TYPE IN MIXED USE WITH PERMISSIBLE %

S. No.	Land use Type	%
1	Residential	40-60
2	Office/ Institutional	15-30
3	Commercial	5-10
4	Industrial	5-10
5	Social/ Recreation	10-15

- The minimum areas of plot, maximum permissible FAR and Ground coverage for developed and new/ underdeveloped areas in mixed land use within TOD zone are given below in **Table 18.2.**
- The saleable factor for mixed land use shall be 0.5.

TABLE 18.2: MIXED LANDUSE IN TOD ZONE

Items	Developed Areas	New/Underdeveloped Areas
Minimum area of plot	0.5 Hectare	4 Hectare
Minimum Road width	18m	30m
Basic FAR	2	2.5
Saleable FAR	4	5
Ground coverage	50%	40%
Set Back	As per present building byelaws	
Parking Provision	• 1.5 ECS per 100 Sq. m. • 2 sq. m per cycle parking for each residential unit in vertical mixed use	

18.2.2 Demarcation of TOD Zones in Kanpur

Based on the definition of TOD zone as per the notification, the TOD influence zone have been demarcated and shown in **Figure 18.1.**

FIGURE 18.1: TOD INFLUENCE ZONE ALONG KANPUR METRO CORRIDORS

18.3 ASSESSMENT OF DEVELOPMENT POTENTIAL

18.3.1 List of Land Amenable for Change

Some land parcels along both the metro corridors have been identified after joint site visits with KDA for property development. Property development shall be taken up on the upper floors, depending upon the FAR (upto 4) and permitted ground coverage of 50% as notified by the government in the year 2015. A total of about 16 lakh Sqm of property development having Residential, Institutional and Commercial facilities has been proposed.

Apart from the property development of 8.16 Lakh Sqm floor space along both corridors, Samaj Kalyan Vibhag land has been considered for the balance 8 Lakh Sqm floor space requirement. In addition, some land has been reserved to take care of future requirements for the Kanpur Metro project. The details of the proposed development are presented in **Table 18.3.**

TABLE 18.3: DETAILS OF PROPERTY DEVELOPMENT FOR PHASE-I CORRIDORS

SN	Metro Station	Area in Sq. m	
		Property Development Area	Property Development Floor Space (with FAR of 4)
Corridor-1: IIT Kanpur to Naubasta			
1	IIT Kanpur	0	0
2	Kalyanpur	9100	36400
		8900	35600
3	SPM Hospital	0	0
4	CSJM University	18500	148000
		18000	144000
5	Gurudev Chauraha	0	0
6	Geeta Nagar	0	0
7	Rawatpur Rly Stn. (Interchange Station)	13350	106800
8	Lala Lajpat Rai Hospital	0	0
9	Moti Jheel	0	0
10	Chunniganj Bus Terminal	13050	104400
11	Navin Market	0	0
12	Bada Chauraha	2750	22000
13	Phoolbagh	0	0
14	Nayaganj	0	0
15	Kanpur Central Rly Stn.	0	0
16	Jhakarkati Bus Terminal	1750	14000
17	Transport Nagar	0	0
18	Baradevi	0	0

SN	Metro Station	Area in Sq. m	
		Property Development Area	Property Development Floor Space (with FAR of 4)
19	Kidwai Nagar	5800	46400
20	Vasant Vihar	0	0
21	Baudh Nagar	0	0
22	Naubasta	3950	31600
Corridor-2: Agriculture University to Barra-8			
23	Kakadeo	0	0
24	Double Pulia	0	0
25	VIjay Nagar	0	0
26	Govind Nagar	0	0
27	Shastri Chowk	850	6800
28	Barra 7	0	0
29	Barra 8	0	0
Depots & Samaj Kalyan Vibhag Land			
30	Polytechnic Depot	10000	40000
31	Agriculture Univ Depot	10000	40000
32	Naubasta Minor depot	10000	40000
33	Samaj Kalyan Vibagh Land	400000	800000
	Total	**526000**	**1616000**

With the construction of metro, the cost of property/ land along the corridor increases manifolds due to improved connectivity. It may be decided to capture the value of real estate along the corridor to fund the project.

On the basis of UP Government TOD guidelines, about 60% of total area available for property development has been used for commercial activity development and balance 40% has been used for residential activity development. Estimation of revenue generated from property development is based on following assumptions:

1. SPV will engage a developer for generating rental income. The developer will bring equity of 50% and balance amount shall be raised by SPV as market debt.
2. For estimating revenue from property development, rental and sale rates for commercial and residential properties have been worked out based on Circle Rates of Kanpur. The residential property sale rates are considered as Rs. 53,134/- per sqm. while the construction rate is calculated @ 27,125/- including construction of parking area and multiplying it by 1.2 to calculate total constructed area.

3. Residential properties will be for outright sale whereas commercial properties will be given on rental basis.
4. The return to Developer is assumed at 21% for development of both residential and commercial component of the real estate development envisaged at the available land of Metro at various locations.
5. Property development on 60% FAR area is for commercial to be leased out. The commercial property rent rates are considered based on average rentals in certain areas and further discounting it at 30%, as commercial development on floors above 1st floor will get much lower rentals as compared to ground floor rentals. Discounting for above ground floor is averaged out to arrive at 30% discounting of ground floor rentals.
6. The average rentals for 2017-18 are considered at Rs. 534/- per sqm and further escalated to arrive at operation year (2024-25) figure of Rs. 742/- per sqm. after escalating it by 5% each year.
7. Rate of interest on loan is assumed at 12% PA and Debt Equity ratio is assumed to be 50:50, as in real estate projects generally the banks are receptive to give loans and if give try to give around 50:50 ratio, as the developer also keep on getting booking and construction linked advances/receipts from the project buyers.

Based on above assumptions, it has been estimated that up to 16.0 Lakh Sqm of space would be required for property development. The total cost of the property development will be Rs 5,086 Crore. The developer will bring equity of Rs 2,543 Crore (50%) and balance Rs 2,543 Crore (50%) would be raised from market. the rental income will accrue from the year 2024-2025 which has been escalated @5% every year. Out of the estimated rental income, the developer will bear the maintenance expenditure; will repay the loan and interest. After meeting these obligations and retaining 21% return on this equity the residual rental earning will accrue to SPV. Escalation of 5% has been assumed on these calculations.

The detailed estimation of total income from property development is given in **Table 18.4**. This total income includes the revenue from sale of developed residential units and rent of commercial units.

TABLE 18.4: DETAILS OF TOTAL INCOME FROM PROPERTY DEVELOPMENT (Rs. in Crore)

Year	Construction Costs	Total Income	Maintenance Expenditure	Debt	IDC	Total Loan Payment	Loan Repayment	Balance Loan Amount	Interest @12%	Return @ 21%	Residual Income to SPV
19 - 20	921			460		460				-509	
20 - 21	967			483	55	539				-509	
21 - 22	1015			507	113	621				-509	
22 - 23	1066			533	174	707				-509	
23 - 24	1119			559	238	798				-509	
24 - 25		2581	258		305	305	343	3086	411	534	1034
25 - 26		2624	262			3429	343	2743	370	561	1088
26 - 27		952	95				343	2400	329	589	-404
27 - 28		1000	100				343	2057	288	618	-350
28 - 29		1050	105				343	1715	247	649	-294
29 - 30		1102	110				343	1372	206	682	-238
30 - 31		1157	116				343	1029	165	716	-182
31 - 32		1215	122				343	686	123	752	-124
32 - 33		1276	128				343	343	82	789	-66
33 - 34		1340	134				343	0	41	829	-7
34 - 35		1407	141							870	396
35 - 36		1477	148							913	416
36 - 37		1551	155							959	437
37 - 38		1628	163							1007	458
38 - 39		1710	171							1057	481
39 - 40		1795	180							1110	505
40 - 41		1885	188							1166	531
41 - 42		1979	198							1224	557
42 - 43		2078	208							1285	585
43 - 44		2182	218							1350	614
44 - 45		2291	229							1417	645
45 - 46		2406	241							1488	677
46 - 47		2526	253							1562	711
47 - 48		2652	265							1640	747
48 - 49		2785	278							1722	784
49 - 50		2924	292							1809	823

The total revenue generated from property development for SPV is summarised in **Table 18.5** for years 2024-25, 2034-35 and 2041-42.

TABLE 18.5: TOTAL REVENUE FROM PROPERTY DEVELOPMENT TO SPV

	2024-25	2034-35	2041-42
Net Revenue from Property Development (Rs. in crore)	1034	396	557

18.3.2 Land Value Capture - Overview

Value capture is based on the principle that private land and other structures in the influence area benefit from public investments in infrastructure and policy decisions of Governments considering change of landuse or Floor Space Index. Appropriate value capture tools can be adopted to capture a part of the appreciation in value of land and buildings to be used in project investment. As this additional value is generated by actions other than land owner's direct investment, value capture is distinct from user charges or fees that agencies collect for provision of services.

As per the Value Capture Finance Policy Framework issued by MoHUA, the main types of Value Capture Finance (VCF) methods are given below.

i. **Land Value Tax:** It is considered the most ideal Value Capture tool which apart from capturing any value increment, helps stabilize property prices, discourage speculative investments.

ii. **Fees for changing land use (agriculture to non-agriculture)**: Land revenue codes provide for procedures to obtain permission for conversion of land use from agricultural to non-agricultural use.

iii. **Betterment Levy**: One time upfront charge on the land value gain caused by public infrastructure investment. This occurs in two forms - revenue source for improvement schemes and for specific projects.

iv. **Development Charges (Impact Fees)**: These are area based and link the development charge to the market value of land by carrying out periodic revisions.

v. **Transfer of Development Rights (TDR)**: It is used for trading development rights. Many states have enabling laws for using TDRs for developing open spaces, promoting affordable housing etc.

vi. **Premium on additional FSI/FAR**: It is widely used in many states to allow for additional development rights beyond the permissible limits in the State Town Planning Laws and Regulations.

vii. **Vacant Land Tax**: It is applicable on those landowners who have not yet initiated construction on their lands

viii. **Tax Increment Financing**: Tax Increment Financing (TIF) tools are especially useful to finance new investments in existing habitations. In TIF, the incremental revenues from future increases in property tax or a surcharge on the existing property tax rate is ring-fenced for a defined period to finance some new investment in the designated area.

ix. **Land Acquisition and Development**: Acquiring and developing land could be adopted as a useful Value Capture method to mobilize resources.

x. **Land Pooling System**: It is a form of land procurement where all land parcels in an area are pooled, converted into a layout, infrastructure developed, and a share of the land, in proportion to original ownership, returned as reconstituted parcels.

The Government of Uttar Pradesh has the following practices:

i. Tax on conversion of Land – As per Zamindari Abolition and Land Reforms Act; Consolidation of Holdings Act
ii. Betterment Levy - As per Section 35 of Uttar Pradesh Urban Planning and Development (UPUPD) Act 1973
iii. Development Charge/Impact Fees – As per sections 14 and 15 of UPUPD Act 1973
iv. TDR and incentive FSI – As per sub-section-(2) (i) of section-56 of the UPUPD Act, 1973
v. Premium on Relaxation of Rules or Additional FSI – Policy for regulation of FAR-Housing Department, Govt. of UP
vi. Charge for regularization of Unauthorised Development – No specific provision
vii. Vacant Land Tax – No specific provision
viii. Town Planning Scheme – No specific provision

18.3.3 Land Value Capture in Kanpur

After discussion with LMRC, few of above mentioned Value Capture Finance (VCF) tools have been finalised to be used in Kanpur Metro. The type of VCF tools taken in the study and the total revenue generated from each of the tools have been given in subsequent sections. It is proposed that 35% of yearly projected revenue collection will accrue to Kanpur Metro (in same lines with Lucknow Metro).

a. Premium on Sale of Additional FAR

For the purpose of estimation of revenue from this component, sale of additional FAR of 1 has been considered with following assumptions:

- Sale of FAR will be possible only in the belt of 500 m on either side of the Metro corridor as laid down in TOD guidelines issued by UP govt.
- Sale of FAR will be possible in 50% of the length of the corridor due to other lengths not having habitation due to falling in undeveloped zone like approach of rivers etc.
- Only 25% of the occupants in this influence zone will opt purchase of FAR
- Out of the total influence zone area calculated as above, 20% is excluded for roads
- Rate of land for sale of additional FAR has been taken as 5000/ sq. m based on Circle Rates of Kanpur
- From the above, total FAR available for sale = 0.5 (50% of the length of corridor) x 1000 (width of influence belt) x length of corridor x 0.8 (20% deduction for road area) x 0.25 (only 25% occupants purchasing FAR) x 1 (additional FAR)

Based on the above assumptions and method, total FAR available for sale and total revenue inflow along the metro corridors has been given in **Table 18.6.**

TABLE 18.6: REVENUE ASSESSMENT FROM PREMIUM ON ADDITIONAL FAR

Items	**2024-25**	**2031-32**	**2041-42**
Corridor Area (Considered) in Sq. m	3,239,000	3,239,000	3,239,000
Additional 1 FAR Usage Rate (Rs. Per sq. m)	7,036	9,900	16,125
Additional 1 FAR Usage Charges (Total) (Rs. in crore)	228	321	522
Metro Share @ 35% (in crore)	**80**	**112**	**183**

This recovery is calculated at 10% for each year to be recovered in next 10 years.

b. External Development Charges

For the purpose of determining revenue from external development charges, the following assumptions have been taken:

- The area for external development charges is assumed to be same as of the corridor area

- The external development charges are assumed to be 15% of Rs. 5000 (Rate of purchase of additional FAR)

Based on the above assumptions, the area for external development charges and total revenue inflow along the metro corridors has been given in **Table 18.7.**

TABLE 18.7: REVENUE ASSESSMENT FROM EXTERNAL DEVELOPMENT CHARGES

Items	2024-25	2031-32	2041-42
Area for External Development Charges (Sqm)	3,239,000	3,239,000	3,239,000
External Development Charges @ (Rs. Per sqm)	1,055	1,485	2,419
External Development Charges (Total) (Rs. in Crore)	342	481	783
SPV Share for Metro @ 35% (Rs. in Crore)	**120**	**168**	**274**

c. Change in Land use

For the purpose of determining revenue from change in land use, the following assumptions have been taken:

- The area for change in land use is assumed to be 5% of the corridor area
- The fees for change in land use is considered to be 50% of Rs. 5000 (Rate of purchase of additional FAR)
- The sector rates are lower by 30-40% of circle rates and conversion charges are around 50% of sector rates. Hence in our case if we assume Rs. 5000 as the circle rate, the sector rate would be Rs. 3500/- (at 30% discount) and Rs. 1750/- (at another 50% discount on 3500/-) to arrive at land conversion charges.

Based on the above assumptions, the area for change in land use and total revenue inflow along the metro corridors has been given in **Table 18.8.**

TABLE 18.8: REVENUE ASSESSMENT FROM CHANGE IN LAND USE

Items	2024-25	2031-32	2041-42
Area for Change in Land use (Sq. m)	647,800	647,800	647,800
Change in Land use @ (Rs. Per sq. m)	2,462	3,465	5,644
Fees for change in land use (total) (Rs. In crore)	160	224	366
Metro Share @ 35% (in crore)	**56**	**79**	**128**

The total revenue share to Kanpur Metro from all the above land value capture tools in different years is given below in **Table 18.9.**

TABLE 18.9: TOTAL REVENUE SHARE TO METRO FROM LAND VALUE CAPTURE

SN	Items	Total Revenue (Rs. in crore)		
		2024-25	**2031-32**	**2041-42**
1	Premium on Additional FAR	80	112	183
2	External Development Charges	120	168	274
3	Change in Land use	56	79	128
	Total	**255**	**359**	**585**

d. Dedicated Fund for Metro Project

The entire revenue collection from the VCF tools taken is proposed to be shared among various stakeholders, namely Development Authority, Metro and any other agency to be identified by UP Govt. It is proposed that 35% of yearly projected revenue collection from above VCF tools will accrue to Kanpur Metro SPV (in same lines with Lucknow Metro). Remaining 65% may be used as allied investments in expanding utility capacity to densify areas around metro stations.

ANNEXURE 18.1: TOD POLICY AS NOTIFIED BY GOVERNMENT OF UTTAR PRADESH

संख्या– 03 /8–3–15–198 विविध/14

प्रेषक,

सदा कान्त,
प्रमुख सचिव,
उत्तर प्रदेश शासन।

सेवा में,

1. उपाध्यक्ष,
समस्त विकास प्राधिकरण,
उत्तर प्रदेश।

2. आयुक्त,
आवास एवं विकास परिषद्,
लखनऊ।

आवास एवं शहरी नियोजन अनुभाग–3 लखनऊः दिनांकः 04 मार्च, 2015

विषयः– राज्य शहरी आवास एवं पर्यावास नीति–2014 के क्रम में नए विकास में मिश्रित उपयोग तथा 'ट्रान्जिट ओरिएन्टेड डेवल्पमेन्ट' (टी.ओ.डी.) के लिए जोनिंग रेगुलेशन्स, 'प्लानिंग नॉर्म्स' एवं भवन उपविधि का निर्धारण किए जाने के सम्बन्ध में।

महोदय,

मुझे यह कहने का निदेश हुआ है कि राज्य शहरी आवास एवं पर्यावास नीति–2014 में नियोजित एवं सुस्थिर शहरों के विकास हेतु प्राविधानित रणनीति के अन्तर्गत नए विकास में मिश्रित उपयोग की अनुमति तथा 'मास रैपिड ट्रान्जिट सिस्टम' (एम.आर.टी.एस.) कॉरीडोर्स के साथ 'ट्रान्जिट ओरिएन्टेड डेवल्पमेन्ट' (टी.ओ.डी.) को प्रोत्साहित किए जाने की व्यवस्था है। इस सम्बन्ध में उक्त नीति के प्रस्तर–6.1.2 एवं प्रस्तर–6.1.3 में निहित प्राविधानों के क्रम में नए विकास में मिश्रित उपयोग तथा 'ट्रान्जिट ओरिएन्टेड डेवल्पमेन्ट'(टी.ओ.डी.) के लिए जोनिंग रेगुलेशन्स, प्लानिंग नॉर्म्स एवं भवन उपविधि का निम्नवत् निर्धारण किया जाता हैः–

1. नए विकास में मिश्रित उपयोग

1.1 मिश्रित उपयोग की परिभाषा

'मिश्रित उपयोग' का तात्पर्य दो अथवा अधिक भू–उपयोगों का मिश्रण एक ही भवन में ('हॉरीजन्टली' अथवा 'वर्टीकली') अथवा एक ही स्थल पर विभिन्न उपयोगों के एक से अधिक भवनों में अनुमन्य किये जाने से है। 'वर्टिकल' मिश्रित उपयोग के अन्तर्गत एक भवन में सामान्यतः विभिन्न तलों पर अलग–अलग भू–उपयोग अनुमन्य होंगे और विशेषकर भू–तल पर अधिक सक्रिय उपयोग (यथा–वाणिज्यिक/फुटकर दुकानें) तथा अनुवर्ती तलों पर औद्योगिक (प्रदूषणरहित सेवा उद्योग), कार्यालय/संस्थागत, सामुदायिक सुविधाएं एवं मनोरंजन तथा आवासीय उपयोग, आदि। जबकि 'हॉरीजन्टल' मिश्रित उपयोग के अन्तर्गत एक ही परियोजना स्थल पर आस–पास स्थित भवनों के समूह में प्रत्येक भवन में अलग–अलग भू–उपयोग होंगे।

1.2 मिश्रित उपयोग की अनुमन्यता

मिश्रित उपयोग निम्न परिस्थितियों में केवल नए विकास में अनुमन्य होगा:–

(क) एक्सप्रेसवेज़/प्रमुख हाईवेज़ के साथ चिन्हित 'डेवल्पमेन्ट नोड्स' में।

(ख) 'मास रैपिड ट्रान्जिट सिस्टम (एम.आर.टी.एस.) कॉरीडोर्स' के साथ 'ट्रॉज़िट ओरिएन्टेड डेवल्पमेन्ट (टी.ओ.डी.) ज़ोन्स' में।

(ग) नए टाउनषिप/इन्टीग्रेटेड टाउनषिप योजनाओं में।

(घ) शहरी पुनर्विकास योजनाओं में।

(ड.) महायोजना/ज़ोनल डेवल्पमेन्ट प्लान के अन्तर्गत 'पोटेन्शियल लोकेशन्स' में चिन्हित क्षेत्रों में।

1.3 मिश्रित उपयोग हेतु जोनिंग रेगुलेशन्स

मिश्रित उपयोग ('वर्टीकल' अथवा 'हॉरीजन्टल मिक्सिंग') के अन्तर्गत विभिन्न उपयोगों का मिश्रण उनकी अनुषांगिकता, परस्पर आर्थिक निर्भरता तथा प्रदूषण एवं पर्यावरण के दृष्टिकोण से अनुकूलता के आधार पर अनुमन्य होगा, जबकि 'नॉन–कम्पैटिबल', संकटकारक, खतरनाक, ज्वलनशील एवं प्रदूषणकारी प्रक्रिया और उत्सर्जन से युक्त क्रियाएं/उपयोग अनुमन्य नहीं होंगे। मिश्रित उपयोग के अन्तर्गत विभिन्न क्रियाओं/उपयोगों की अनुमति मिश्रित उपयोग से सम्बन्धित 'जोनिंग रेगुलेशन्स मैट्रिक्स' (परिशिष्ट–1) के अनुसार देय होगी।

1.4 मिश्रित उपयोग हेतु प्लानिंग नॉर्म्स

नए टाउनशिप/इन्टीग्रेटेड टाउनशिप, एक्सप्रेसवेज़/प्रमुख हाईवेज़ के साथ चिन्हित डेवल्पमेन्ट नोड्स तथा महायोजना/ज़ोनल डेवल्पमेन्ट प्लान में टाउनशिप/योजना के अधिकतम 20 प्रतिषत क्षेत्रफल पर मिश्रित उपयोग अनुमन्य होगा तथा इस प्रयोजनार्थ चिन्हित क्षेत्रों/स्थलों के अन्तर्गत प्रस्तावित योजनाओं के सम्पूर्ण क्षेत्रफल पर मिश्रित उपयोग अनुमन्य होगा। शहरी पुनर्विकास योजनाओं में भी मिश्रित उपयोग योजना के सम्पूर्ण क्षेत्रफल पर अनुमन्य होगा। महायोजना/जोनल डेवल्पमेन्ट प्लान में मिश्रित उपयोग चिन्हित न होने की दशा में आवेदक द्वारा मिश्रित उपयोग की अनुमति के लिए नियमानुसार भू–उपयोग परिवर्तन कराना आवश्यक होगा। मिश्रित उपयोग के अन्तर्गत विभिन्न उपयोगों के नियोजन हेतु मानक निम्नवत् होंगे:–

क्र.सं.	भू–उपयोग श्रेणी	प्रतिशत
(1)	आवासीय	40–60
(2)	कार्यालय/संस्थागत्	15–30
(3)	व्यवसायिक	5–10
(4)	औद्योगिक (प्रदूषणमुक्त सेवा उद्योग)	5–10
(5)	सामुदायिक सुविधाएं, सेवाएं एवं मनोरंजन	10–15

स्पष्टीकरणः—

(I) 'वर्टिकल' मिश्रण में विभिन्न उपयोगों/क्रियाओं का अनुपात सम्बन्धित भवन के कुल एफ.ए.आर. के उपरोक्त तालिका में दिये गए प्रतिशत की न्यूनतम एवं अधिकतम सीमान्तर्गत् होगा।

(II) 'हॉरीजन्टल' मिश्रण में विभिन्न उपयोगों/क्रियाओं का अनुपात/भू–आच्छादन सम्बन्धित भूखण्ड/स्थल हेतु अनुमन्य कुल भू–आच्छादन के अन्तर्गत उपरोक्त तालिका में दिये गए प्रतिशत के अनुसार होगा तथा प्रत्येक उपयोग के भवन का अधिकतम एफ.ए.आर. भी उपरोक्त तालिका में दिये गए प्रतिशत की न्यूनतम एवं अधिकतम सीमान्तर्गत होगा।

(III) स्थल विशेष की 'पोटेन्शियलिटी' के दृष्टिगत् विभिन्न उपयोगों हेतु निर्धारित न्यूनतम् एवं अधिकतम एफ.ए.आर. के उपयोग में इस प्रतिबन्ध के अधीन 'फ्लेक्सिबिलिटी' अनुमन्य होगी कि समस्त उपयोगों का कुल प्रतिशत 100 के अन्तर्गत रहे।

1.5 मिश्रित उपयोग हेतु भवन उपविधि

मिश्रित उपयोग के लिए एक्सप्रेसवेज़/प्रमुख हाईवेज़ के साथ चिन्हित डेवल्पमेन्ट नोड्स, नए/इन्टीग्रेटेड टाउनशिप, शहरी पुनर्विकास योजनाओं तथा महायोजना/ज़ोनल डेवल्पमेन्ट प्लान के अन्तर्गत चिन्हित क्षेत्रों में भूखण्ड का न्यूनतम क्षेत्रफल, पहुंच मार्ग की चौड़ाई, भू–आच्छादन, एफ.ए.आर., पार्किंग तथा भवन निर्माण सम्बन्धी अन्य अपेक्षाएं निम्नवत् होंगीः—

विकास/निर्माण सम्बन्धी अपेक्षाएं	निर्मित एवं विकसित क्षेत्र (केवल पुनर्विकास योजना में)	नए/अविकसित क्षेत्र में
• भूखण्ड का न्यूनतम् क्षेत्रफल	4.0 हेक्टेयर	4.0 हेक्टेयर
• पहुंच मार्ग की न्यूनतम् चौड़ाई	30 मीटर	30 मीटर
• भू–आच्छादन	50 प्रतिशत	40 प्रतिशत
• बेसिक एफ.ए.आर.	1.5	2.0
• क्रय–योग्य सहित एफ.ए.आर.	3.0	4.0
• सेट–बैक	प्रचलित भवन उपविधि के अनुसार	
• पार्किंग व्यवस्था	• प्रत्येक 100 वर्गमीटर तल क्षेत्रफल पर 1.5 'समान कार स्थल' (इक्वीवेलेन्ट कार स्पेस) • 'वर्टिकल मिश्रित' उपयोग में प्रत्येक आवासीय इकाई पर 01 साईकल पार्किंग हेतु 2.0 वर्गमीटर अतिरिक्त क्षेत्रफल की व्यवस्था	

टिप्पणीः—

(I) मिश्रित उपयोग के लिए 'क्रय—योग्य फैक्टर' (गुणांक) 0.5 होगा तथा क्रय—योग्य एफ.ए.आर. शुल्क की गणना अधिसूचना संख्या—3589/8—3—2011—11 विविध/08, दिनांक 04.08.2011 में निर्धारित फार्मूले के अनुसार की जाएगी।

(II) ग्रुप हाउसिंग के लिए क्रय—योग्य एफ.ए.आर. के सापेक्ष समानुपातिक आधार पर अतिरिक्त आवासीय इकाईयां अनुमन्य होंगी, जो महायोजना/जोनल डेवल्पमेन्ट प्लान/भवन निर्माण एवं विकास उपविधि में निर्धारित घनत्व के अतिरिक्त होंगी।

1.6 मिश्रित उपयोग हेतु विकास एवं निर्माण सम्बन्धी अन्य अपेक्षाएं

(I) बेसिक एफ.ए.आर. के ऊपर अतिरिक्त एफ.ए.आर. क्रय—योग्य आधार पर इस प्रतिबन्ध के अधीन अनुमन्य होगा कि भौतिक एवं सामाजिक अवस्थापना सुविधाओं (यथा—ड्रेनेज, सीवरेज़, जलापूर्ति, विद्युत—आपूर्ति, सालिड वेस्ट मैनेजमेन्ट, पार्क एवं खुले क्षेत्र, शैक्षिक, चिकित्सा एवं सामुदायिक सुविधाओं) का मानकों के अनुसार प्राविधान अनुमन्य एफ.ए.आर. के सापेक्ष प्राप्त होने वाली डेन्सिटी/जनसंख्या के आधार पर किया जाएगा।

(II) आवासीय अपार्टमेन्ट्स के लिए प्रवेश की व्यवस्था व्यवसायिक/अन्य उपयोगों से पृथक करनी होगी तथा मिश्रित उपयोग का नियोजन एवं अभिकल्पन इस प्रकार किया जाएगा, जिससे बिजनेस/औद्योगिक क्रियाओं से उत्पन्न होने वाली गन्ध (Odour) आवासीय अपार्टमेन्ट्स को प्रभावित न करें। इसी प्रकार आवासीय उपयोग की पार्किंग के लिए अन्य उपयोगों/पब्लिक पार्किंग से पृथक व्यवस्था करनी होगी।

(III) क्रय—योग्य एफ.ए.आर. से सम्बन्धित शासनादेश संख्या—1982/आठ—3—14—155 विविध/14,दिनांक 27.10.2014 तथा शासनादेश संख्या—1981/आठ—3—14—155 विविध/14, दिनांक 27.10.2014 के प्राविधान नए विकास में मिश्रित उपयोग की अनुमति के सम्बन्ध में लागू नहीं होंगे।

(IV) क्रय—योग्य एफ.ए.आर. की अनुमति शासनादेश संख्या—4823/8—3—09—11 विविध/08, दिनांक 10.11.2009 के अधीन गठित समिति की संस्तुति के आधार पर प्राधिकरण द्वारा प्रदान की जाएगी।

(V) क्रय—योग्य आधार पर अतिरिक्त एफ.ए.आर. की अनुमति हेतु विकास प्राधिकरण भवन निर्माण एवं विकास उपविधि में शासनादेश संख्या—4384/आठ—3—11—181 विविध/2008, दिनांक 27.9.2011 के अधीन जारी संशोधनों में निहित प्राविधानों एवं प्रक्रिया तथा भवन निर्माण एवं विकास उपविधि व अन्य सुसंगत शासकीय नीतियों/शासनादेशों का अनुपालन करना अनिवार्य होगा।

2. ट्रान्जिट ओरिएन्टेड डेवल्पमेन्ट (टी.ओ.डी.)

2.1 ट्रान्जिट ओरिएन्टेड डेवल्पमेन्ट (टी.ओ.डी.) की परिभाषा

'ट्रान्जिट ओरिएन्टेड डेवल्पमेन्ट' का तात्पर्य ट्रान्जिट सुविधा/स्टेशन के आस—पास ऐसे विकास से है, जो सघन, काम्पैक्ट एवं मिश्रित उपयोग के रूप में हो, ट्रान्जिट

स्टॉप/स्टेशन से पैदल दूरी पर स्थित हो तथा जो निजी वाहनों के उपयोग के स्थान पर पैदल चलने एवं सार्वजनिक परिवहन के उपयोग को प्रोत्साहित करता हो।

2.2 'टी.ओ.डी. जोन' का चिन्हीकरण

मास रैपिड ट्रान्जिट सिस्टम (एम.आर.टी.एस.)/ट्रान्जिट/मेट्रो कॉरीडोर के प्रभाव क्षेत्र को विकास प्राधिकरण द्वारा महायोजना/ज़ोनल डेवल्पमेन्ट प्लान के अन्तर्गत 'टी.ओ.डी. ज़ोन' के रूप में चिन्हित किया जाएगा। 'टी.ओ.डी. ज़ोन' की बाह्य सीमा एम.आर.टी.एस./ट्रान्जिट/मेट्रो कॉरीडोर के दोनों ओर लगभग 500 मीटर की दूरी तक होगी, जबकि मेट्रो स्टेशन्स के पास स्थानीय परिस्थितियों एवं 'डेवल्पमेन्ट पोटेन्शियल' को दृष्टिगत् रखते हुए उक्त दूरी 500 मीटर से अधिक रखी जा सकती है। 'टी.ओ.डी. ज़ोन' की बाह्य सीमा भौतिक फीचर्स जैसे कि सड़क, रेलवे लाईन, नदी/नाला/ड्रेन, इत्यादि से निर्धारित की जाएगी।

2.3 ज़ोनिंग रेगुलेशन्स एवं प्लानिंग नॉर्म्स

'टी.ओ.डी. ज़ोन' के अन्तर्गत मिश्रित उपयोग हेतु ज़ोनिंग रेगुलेशन्स एवं प्लानिंग नॉर्म्स 'नए विकास में मिश्रित उपयोग' के प्रस्तर क्रमशः 1.3 एवं 1.4 के अनुसार होंगे।

2.4 'टी.ओ.डी. ज़ोन' के लिए भवन उपविधि

(क) मिश्रित उपयोग हेतु भवन उपविधि

'टी.ओ.डी. ज़ोन' के अन्तर्गत 'निर्मित', 'विकसित क्षेत्र' तथा 'नए/अविकसित क्षेत्र' में मिश्रित उपयोग हेतु भूखण्ड का न्यूनतम क्षेत्रफल, अधिकतम एफ.ए.आर. एवं भू–आच्छादन तथा अन्य अपेक्षाएं निम्नवत् होंगी:–

विकास/निर्माण सम्बन्धी अपेक्षाएं	निर्मित एवं विकसित क्षेत्र	नए/अविकसित क्षेत्र
• भूखण्ड का न्यूनतम् क्षेत्रफल	0.5 हेक्टेयर	4.0 हेक्टेयर
• पहुंच मार्ग की न्यूनतम् चौड़ाई	18 मीटर	30 मीटर
• बेसिक एफ.ए.आर.	2.0	2.5
• क्रय–योग्य सहित एफ.ए.आर.	4.0	5.0
• भू–आच्छादन	50 प्रतिशत	40 प्रतिशत
• सेट–बैक	प्रचलित भवन उपविधि के अनुसार	
• पार्किंग व्यवस्था	• प्रत्येक 100 व.मी. तल क्षेत्रफल पर 1.5 'समान कार स्थल' (इक्वीवेलेन्ट कार स्पेस) • वर्टिकल मिश्रित उपयोग में प्रत्येक आवासीय इकाई पर 01 साईकल पार्किंग हेतु 2.0 व.मी. अतिरिक्त क्षेत्रफल की व्यवस्था	

(ख) मिश्रित उपयोग के अतिरिक्त अन्य भू–उपयोगों हेतु भवन उपविधि

'निर्मित', विकसित क्षेत्र' में 'टी.ओ.डी. जोन' के अन्तर्गत आवासीय (ग्रुप हाउसिंग), व्यवसायिक, औद्योगिक (प्रदूषणरहित सेवा उद्योग), कार्यालय/

संस्थागत, आदि भू–उपयोगों के लिए क्रय–योग्य सहित अधिकतम् एफ.ए.आर. 4.0 और 'नए/अविकसित क्षेत्र' में क्रय–योग्य सहित अधिकतम् एफ.ए.आर. 5.0 अनुमन्य होगा, जिसके लिए भूखण्ड का न्यूनतम् आकार, पहुंच मार्ग तथा भवन निर्माण सम्बन्धी अन्य अपेक्षाएं प्रचलित भवन उपविधि के अनुसार होंगी।

स्पष्टीकरणः

(I) 'टी.ओ.डी. ज़ोन' के अन्तर्गत विभिन्न भू–उपयोगों हेतु बेसिक एफ.ए.आर. प्रचलित भवन निर्माण एवं विकास उपविधि के अनुसार ही रहेगा, जबकि उसके ऊपर अतिरिक्त एफ.ए.आर. क्रय–योग्य आधार पर अनुमन्य होगा।

(II) मिश्रित उपयोग के लिए 'क्रय–योग्य फैक्टर' (गुणांक) 0.5 होगा तथा क्रय–योग्य एफ.ए.आर. शुल्क की गणना अधिसूचना संख्या–3589/8–3–2011–11 विविध/08, दिनांक 04.08.2011 में निर्धारित फार्मूले के अनुसार की जाएगी।

(III) ग्रुप हाउसिंग के लिए क्रय–योग्य एफ.ए.आर. के सापेक्ष समानुपातिक आधार पर अतिरिक्त आवासीय इकाईयां अनुमन्य होंगी, जो महायोजना/ज़ोनल डेवल्पमेन्ट प्लान/भवन निर्माण एवं विकास उपविधि में निर्धारित घनत्व के अतिरिक्त होंगी।

2.5 'टी.ओ.डी. ज़ोन' के अन्तर्गत विकास एवं निर्माण सम्बन्धी अन्य अपेक्षाएं

'टी.ओ.डी. ज़ोन' के अन्तर्गत मिश्रित उपयोग तथा विभिन्न भू–उपयोगों के लिए विकास एवं निर्माण सम्बन्धी अन्य अपेक्षाएं निम्नवत् होंगीः–

(I) मिश्रित उपयोग के अन्तर्गत आवासीय अपार्टमेन्ट्स के लिए प्रवेश की व्यवस्था व्यवसायिक/अन्य उपयोगों से पृथक करनी होगी तथा मिश्रित उपयोग का नियोजन एवं अभिकल्पन इस प्रकार किया जाएगा, जिससे बिजनेस/औद्योगिक क्रियाओं से उत्पन्न होने वाली गन्ध (Odour) आवासीय अपार्टमेन्ट्स को प्रभावित न करें। इसी प्रकार आवासीय उपयोग की पार्किंग के लिए अन्य उपयोगों/पब्लिक पार्किंग से पृथक व्यवस्था करनी होगी।

(II) 'निर्मित एवं विकसित क्षेत्र' में मिश्रित तथा विभिन्न भू–उपयोगों के लिए बेसिक एफ.ए.आर. के ऊपर अतिरिक्त एफ.ए.आर. (अधिकतम 4.0) सम्बन्धित स्थल पर अवस्थापना सुविधाओं (यथा–ड्रेनेज, सीवरेज, जलापूर्ति, सॉलिड वेस्ट मैनेजमेन्ट, आदि) की उपलब्धता/सुदृढ़ीकरण की व्यवहारिकता तथा भवन निर्माण की अन्य अपेक्षाओं यथा–सेटबैक, पार्किंग, फायर एवं स्ट्रक्चरल सेफ्टी, इत्यादि मानकों की पूर्ति सुनिश्चित होने की दशा में अनुमन्य होगा।

(III) 'नए/अविकसित क्षेत्र' में क्रय–योग्य सहित अनुमन्य अधिकतम 5.0 एफ.ए.आर. की अनुमति इस प्रतिबन्ध के अधीन देय होगी कि अवस्थापना सुविधाओं यथा–ड्रेनेज, सीवरेज, जलापूर्ति, सॉलिड वेस्ट मैनेजमेन्ट तथा अन्य सामुदायिक सुविधाओं का मानकों के अनुसार प्राविधान अनुमन्य एफ.ए.आर./उसके सापेक्ष प्राप्त होने वाली डेन्सिटी के आधार पर किया जाएगा।

(IV) शासनादेश संख्या–1982/आठ–3–14–155 विविध/14, दिनांक 27.10.2014 द्वारा 'निर्मित', 'विकसित' तथा 'नए/अविकसित क्षेत्रों' में 18 मीटर एवं अधिक चौड़ी सड़क पर क्रय–योग्य एफ.ए.आर. की अनुमति से सम्बन्धित प्राविधान टी.ओ.डी. जोन के अन्तर्गत भी लागू होगा। परन्तु उक्त शासनादेश के अनुसार विकसित क्षेत्र में 24.0 मीटर से अधिक चौड़ी सड़क पर बेसिक एफ.ए.आर. का अधिकतम 50 प्रतिशत क्रय–योग्य एफ.ए.आर. की सीमा का प्रतिबन्ध टी.ओ.डी. ज़ोन में लागू नहीं होगा अर्थात् क्रय–योग्य सहित अधिकतम एफ.ए.आर. 4.0 अनुमन्य होगा। इसी प्रकार शासनादेश संख्या–1981/आठ–3–14–155 विविध/2014, दिनांक 27.10.2014 के अनुसार 'निर्मित/विकसित क्षेत्र' में स्थित ऐसे भूखण्ड जिनका न्यूनतम् क्षेत्रफल 4.0 हेक्टेयर हो और जिन्हें न्यूनतम 30.0 मीटर चौड़ी विद्यमान सड़क से पहुंच की सुविधा उपलब्ध हो, के लिए क्रय–योग्य सहित अधिकतम 3.0 एफ.ए.आर. की अनुमन्यता का प्रतिबन्ध भी टी.ओ.डी. ज़ोन के अन्तर्गत लागू नहीं होगा अर्थात टी.ओ.डी. जोन में क्रय–योग्य सहित अधिकतम 4.0 एफ.ए.आर. अनुमन्य होगा।

(V) 'टी.ओ.डी. ज़ोन' के अन्तर्गत विकास/निर्माण की अनुमति के समय उ.प्र. नगर योजना और विकास (विकास शुल्क का निर्धारण, उद्ग्रहण एवं संग्रहण) नियमावली, 2014 के नियम–5 की व्यवस्थानुसार उक्त नियमावली की अनुसूची में विहित विकास शुल्क का 25 प्रतिशत से अनाधिक विकास शुल्क उद्ग्रहीत किया जा सकेगा।

(VI) क्रय–योग्य एफ.ए.आर. की अनुमति शासनादेश संख्या–4823/8–3–09–11 विविध/08, दिनांक 10.11.2009 के अधीन गठित समिति की संस्तुति के आधार पर प्राधिकरण द्वारा प्रदान की जाएगी।

(VII) 'टी.ओ.डी. ज़ोन' के अन्तर्गत क्रय–योग्य आधार पर अतिरिक्त एफ.ए.आर. की अनुमति हेतु विकास प्राधिकरण भवन निर्माण एवं विकास उपविधि में शासनादेश संख्या–4384/आठ–3–11–181 विविध/2008, दिनांक 27.9.2011 के अधीन जारी संशोधनों में निहित प्राविधानों एवं प्रक्रिया तथा भवन निर्माण एवं विकास उपविधि व अन्य सुसंगत शासकीय नीतियों/शासनादेशों का अनुपालन करना अनिवार्य होगा।

2.6 'टी.ओ.डी. ज़ोन' के अन्तर्गत सम्पत्तियों के आमेलन हेतु प्रक्रिया

'निर्मित/विकसित क्षेत्र' में विद्यमान भूखण्डों का आकार छोटा होने के कारण अनुमन्य एफ.ए.आर. के उपयोग में व्यवहारिक कठिनाई हो सकती है, अतः टी.ओ.डी. ज़ोन के अन्तर्गत एक से अधिक भूखण्डों/सम्पत्तियों का आमेलन अनुमन्य होगा, ताकि भूखण्ड के बढ़े हुए क्षेत्रफल के आधार पर अनुमन्य भू–आच्छादन एवं एफ.ए.आर. के अनुसार निर्माण होने से भूमि का समुचित/इष्टतम् उपयोग सम्भव हो सके। एक से अधिक भूखण्डों के आमेलन की अनुज्ञा निम्न शर्तों एवं प्रतिबन्धों के अधीन देय होगी:–

(I) आमेलन हेतु प्रस्तावित समस्त भूखण्डों का महायोजना/ज़ोनल डेवल्पमेन्ट प्लान में एक ही भू–उपयोग होना चाहिए। भिन्न प्रकृति के भू–उपयोगों के भूखण्ड

होने की दशा में एक ही भू–उपयोग में नियमानुसार भू–उपयोग परिवर्तन कराना आवश्यक होगा, जिसके उपरान्त ही आमेलन की अनुमति देय होगी।

(II) आमेलन हेतु प्रस्तावित भूखण्डों का स्वामित्व एक व्यक्ति/फर्म/कम्पनी के पक्ष में होना चाहिए।

(III) आमेलन हेतु प्रस्तावित भूखण्ड को न्यूनतम 18 मीटर चौड़ी विद्यमान सड़क से पहुँच की सुविधा उपलब्ध होनी चाहिए।

(IV) सक्षम प्राधिकारी द्वारा स्वीकृत योजना/ले–आउट प्लान के अन्तर्गत आमेलन अनुमन्य किये जाने की दशा में विकास प्राधिकरण द्वारा ले–आउट प्लान में तत्सीमा तक नियमानुसार संशोधन किया जाएगा।

(V) आमेलन की सुविधा हेतु आवेदक द्वारा आमेलित भूखण्ड के कुल क्षेत्रफल पर उसके वर्तमान सर्किल रेट के 10 प्रतिशत मूल्य के बराबर धनराशि विकास प्राधिकरण को देय होगी।

(VI) आमेलन के उपरान्त समेकित भूखण्ड के कुल क्षेत्रफल के आधार पर सेट–बैक, भू–आच्छादन, एफ.ए.आर., पार्किंग, आदि की अपेक्षाएं इस नीति में निर्धारित मानकों/प्रचलित भवन निर्माण एवं विकास उपविधि के अनुसार होंगी।

संलग्नकः–परिशिष्ट–1
(मिश्रित उपयोग हेतु 'ज़ोनिंग रेगुलेशन्स मैट्रिक्स')

भवदीय,

सदा कान्त
प्रमुख सचिव

संख्या एवं दिनांक तदैव

प्रतिलिपि निम्नलिखित को सूचनार्थ एवं आवश्यक कार्यवाही हेतु प्रेषितः–

1. मुख्य नगर एवं ग्राम नियोजक, उ0प्र0।
2. निदेशक, आवास बन्धु, उ0प्र0 को इस आशय से प्रेषित कि उक्त शासनादेश आवास बन्धु की वेबसाइड पर अपलोड करने का कष्ट करें।
3. गार्ड फाइल।

(शिव जनम चौधरी)
संयुक्त सचिव

19. FINANCIAL ANALYSIS & NON FARE BOX REVENUE ASSESSMENT

Please refer Chapter 19 of Supplementary DPR.

20. ECONOMIC ANALYSIS

Please refer Chapter 20 of Supplementary DPR.

Chapter – 21
IMPLEMENTATION PLAN

21. Implementation plan

21.1 PROJECT IMPLEMENTATION PLAN

The appointment of Interim and General Consultants may be initiated for project management including preparation of tender documents – as soon as DPR is approved by GoUP and formation of SPV. The possible dates of important milestones are given in **Table 21.1** and **Figure 21.1**.

TABLE 21.1: PROJECT IMPLEMENTATION SCHEDULE

S.N.	Tasks	Timelines
1	Final DPR	December, 2017
2	State Government Approval of DPR	January, 2018
3	Appointment of Interim Consultant	April, 2018
4	Appointment of DDC for Civil Works	April, 2018
5	Final Approval by GoI	May, 2018
6	Packaging and Invitation of Bids for Priority Section*	June, 2018
7	Appointment of General Consultants	August, 2018
8	Commencement of Civil Works on Priority Section*	January, 2019
9	Commencement of Operation	January, 2024

* IIT Kanpur to Moti Jheel of about 9.0 km may be taken as priority section

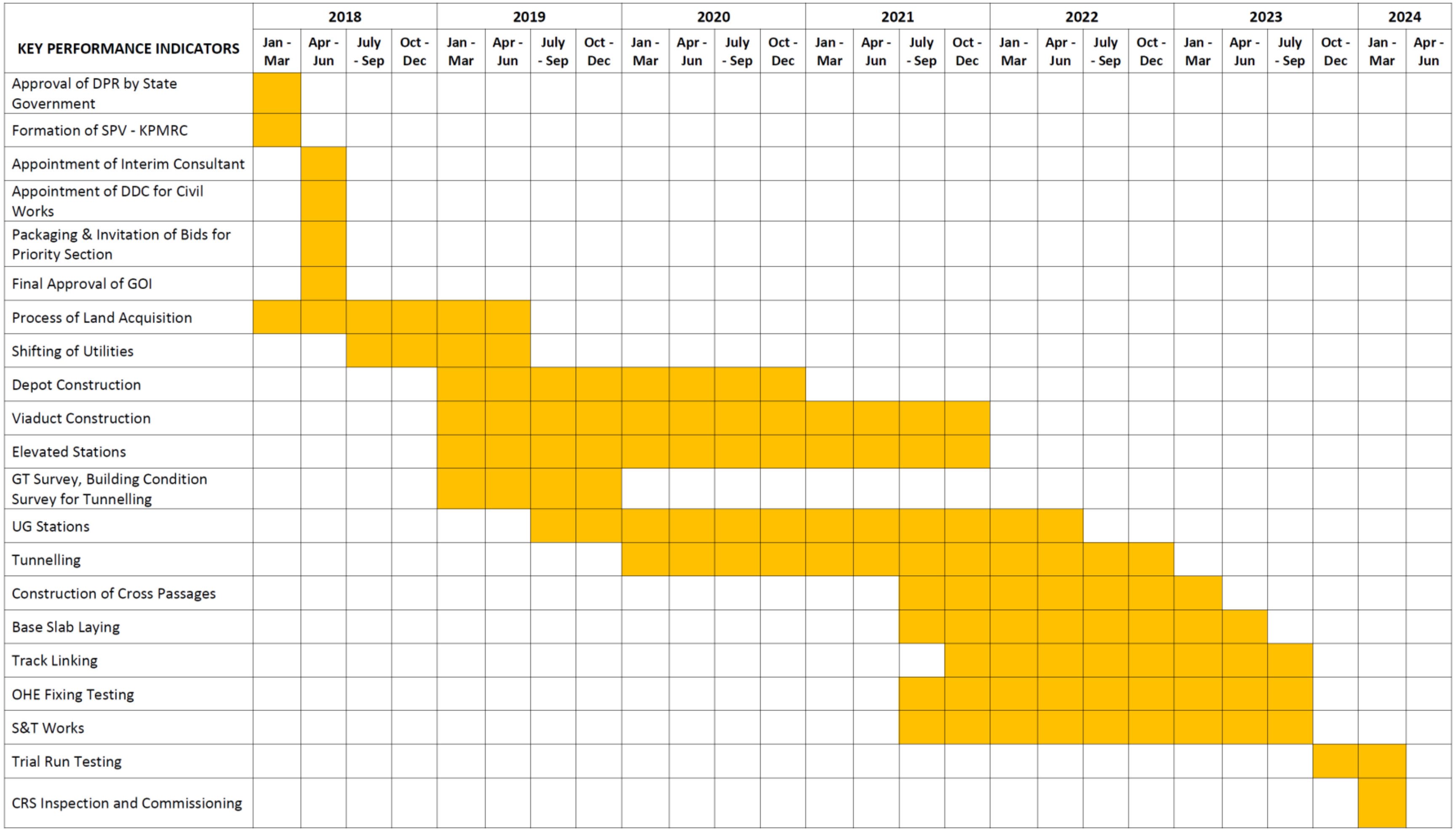
IIT Kanpur to Moti Jheel of about 9.0 km may be taken up on priority. The commercial operation on Phase-I corridors may start from January 2024 after providing about 5 years for construction and 3 months for safety audit and certification.

21.2 IMPLEMENTATION STRUCTURE

Uttar Pradesh has a successful example of metro operation in Lucknow on SPV model by Lucknow Metro Rail Corporation (LMRC). Kanpur metro project may also be implemented on SPV model. However, some subcomponents of operations & maintenance may be taken up with private sector participation (PPP) model.

The PPP model to be adopted and implementation structure shall be decided at the time of implementation.

FIGURE 21.1: IMPLEMENTATION SCHEDULE FOR MONITORING OF PROJECT



IIT Kanpur to Moti Jheel of about 9.0 km may be taken as priority section

21.3 LEGAL AND INSTITUTIONAL FRAMEWORK FOR IMPLEMENTING THE PROJECT

21.3.1 Legal Framework

Construction of Kanpur Metro should commence soon. Thus, there is immediate need to have a legislation to provide legal cover to the construction stage of Kanpur Metro. The implementation of proposed Kanpur Metro can, now, be done under 'The Metro Railways (Construction of Works) Act, 1978 (33 of 1978)-S.O. 1769 (E) and the Metro Railways (Operation and Maintenance) Act, 2002 (60 of 2002)-S.O. 1770 (E).' The copies of the Gazette notification dated 13.05.2016 is annexed at A**nnexure 21.1.**

21.3.2 Institutional Arrangements

Metro construction is a very specialized and multi-disciplinary job. It is therefore, impossible to have a single organizational set up which can be responsible for all aspects of metro implementation, namely investigation, planning, design, drawing up of specifications, preparation of tender documents, fixing of contractors, supervising the contractors' works, ensuring interface fusion between different contractors, ensuring quality and safety during constructions, planning and supervising integration system trials and getting the project commissioned in time.

Effective institutional arrangement is needed to enable the Metro project to be implemented without any loss of time and cost over-run. The details of possible arrangements are discussed in following sections. Experience of implementing Delhi and Lucknow metro projects has shown that a Special Purpose Vehicle (SPV), vested with adequate powers, is an effective organizational arrangement to implement and subsequently operate and maintain a metro rail project.

21.3.2.1 Lucknow Metro Rail Corporation, a 50:50 jointly owned company of the Government of India and the Government of Uttar Pradesh, which is being reconstituted under the Company Act, 2013 as a single SPV namely 'Uttar Pradesh Metro Rail Corporation,' will implement this project.

The Promoters, the Government of India and the Government of Uttar Pradesh may nominate 5 Directors each to the Board of Directors (BoD), totaling to 10 nominee Directors. The ex-officio Chairman of the Board may be the nominee of Government of India. The full time Managing Director with adequate technical experience may be nominee of Government of Uttar Pradesh. He may be appointed or removed only with prior written permission of Government of India. The Managing Director shall not be given any additional assignment by the Government of Uttar Pradesh without prior written permission of Government of India. The BoD will also have Functional Directors in addition to the 10 nominee Directors.

It is suggested to have a two tier organization with well defined responsibilities for implementation of this project. At the apex will be the UPMRC, a lean but effective organization with full mandate and total power with accountability. The second level will be project management team called the 'General Consultant', who will be engaged by the UPMRC on contract basis. They will be fully responsible for planning, designing and project management. In fact, they will be 'Engineers' for the UPMRC, who will be the 'Client'. The Detailed Design Consultants as required may be engaged by the General Consultants as their sub-consultants within their own contractual responsibilities. Since most of the alignment length is elevated, it is recommended that the contracts may be made on 'design and build' basis based on broad technical specifications and performance requirements drawn up by the general consultants.

21.3.2.2 **High Power Committee**

During the implementation of the project several problems with regard to acquisition of land, diversion of utilities, shifting of structures falling on the project alignment, rehabilitation of project affected persons, etc. are likely to arise. For expeditious resolution of these problems, an institutional mechanism needs to be set up at the State Government level. Towards this end, it is recommended that a High Power Committee under the chairmanship of Chief Secretary, Uttar Pradesh may be set up. Other members of this Committee may be the Secretaries of concerned Departments of State Government and Heads of civic bodies who are connected in one way or the other with the implementation of the project. Commissioner, Kanpur and Municipal Commissioner, Kanpur Nagar Nigam may also be the member of this committee.

21.3.2.3 **Empowered Committee**

At the Central Government level an Empowered Committee, under the chairmanship of Cabinet Secretary, is presently functioning for Delhi Metro project. Other members of this Committee are Secretaries of Planning Commission, Ministry of Home Affairs, Ministry of Housing and Urban Affairs, Ministry of Road Transport and Highways, Ministry of Environment and Forests, Department of Expenditure, Chief Secretary of Delhi and a representative from the PMO. The Empowered Committee meets regularly and takes decisions on matters connected with inter-departmental coordination and overall planning, financing and implementation of the Delhi Metro project.

It is suggested that the role of this Empowered Committee is enlarged to include Kanpur Metro project also and the Chief Secretary, Uttar Pradesh is inducted as a member of this Committee.

21.4 ROLE, RESPONSIBILITY AND INVOLVEMENT OF CITY GOVERNMENT

21.4.1 Unified Metropolitan Transport Authority (UMTA)

The National Urban Transport Policy 2014 has recommended setting up of Unified Metropolitan Transport Authorities (UMTA's) in million plus cities. The policy document stipulates following on UMTA.

"The current structure of governance for the transport sector is not equipped to deal with the problems of urban transport. These structures were put in place well before the problems of urban transport began to surface in India and hence do not provide for the right coordination mechanisms to deal with urban transport. The central government will, therefore, recommend the setting up of Unified Metropolitan Transport Authorities (UMTA's) in all million cities to facilitate more coordinated planning and implementation of urban transport programs & projects and integrated management of urban transport systems. Such Metropolitan Transport Authorities would need statutory backing in order to be meaningful."

The metro rail policy - 2017 makes it mandatory for the cities which are planning to have MRTS to address their mass transport requirements to have city level UMTA.

For integrated approach in planning and management of urban transport in the city, State Government shall constitute Unified Metropolitan Transport Authority (UMTA) as a statutory body. This Authority would implement various proposals as per CMP for the city, organize investments in urban transport infrastructure, establish effective coordination among various urban transport agencies, manage the Urban Transport Fund (UTF) etc. UMTA will have to play active role in the implementation of Kanpur Metro being a city government authority.

21.4.2 Steering Committee

Apart from a High Power Committee under the chairmanship of Chief Secretary, Uttar Pradesh, a 'Steering Committee' may be set up under the chairmanship of Commissioner Kanpur Mandal. Other members of this Committee may be District Magistrate, Municipal Commissioner, Kanpur Nagar Nigam and other heads of civic bodies who will be connected in one way or the other with the implementation of the project.

During the implementation of the project several problems with regard to acquisition of land, diversion of utilities, shifting of structures falling on the project alignment, rehabilitation of project affected persons, etc. are likely to arise. The steering committee will work for expeditious resolution of these problems at local level. This Committee may meet regularly to sort out all problems brought before it by UPMRC.

21.4.3 Performance Monitoring During Construction and Implementation

The efficiency in standards during construction and implementation will be monitored in following manner:

1. Constant monitoring in the meeting of the Board of Directors (BoD) of the company.

2. Monitoring by High Powered Committee (HPC) of the State Government: During implementation of the project, a High Powered Committee under the chairmanship of the Chief Secretary of the State Government will be set up by the State Government to take expeditious decisions on land acquisition matters, diversion of utilities, shifting of structures in the project alignment, rehabilitation of Project Affected Persons, multimodal integration and such other matters where the State Government has to facilitate quick action including various conditions of sanction of this project.

3. Audit of the projects accounts to be monitored in the Audit Committee of BoD.

21.4.4 Way Forward

On acceptance of the Detailed Project Report, following actions may be initiated for implementing the priority corridors of Kanpur Metro:

- Approval of State Government (Cabinet Approval) to the Detailed Project Report
- Set up the Special Purpose Vehicle (SPV) UPMRC (Uttar Pradesh Metro Rail Corporation Ltd.) for implementing the project and for its subsequent Operation and Maintenance
- Issue of notifications for the project, alignment and setting up of UMTA
- DPR to be forwarded to the Ministry of Housing and Urban Affairs, Niti Aayog and Finance Ministry with request for approving the Metro project and for financial participation through equity contribution to the SPV
- Appointment of Interim Consultants (IC)
- Appointment of Detailed Design Consultants (DDC)
- Packaging and invitation of bids for various contracts
- Final Approval from Government of India
- Appointment of General Consultants (GC)
- Land acquisition related issues
- Examination and appraisal of DPR by bilateral/multilateral funding agencies for possible funding
- Stakeholder consultation on environmental and social impact of the project
- Signing of an MOU between Uttar Pradesh State Government and Government of India giving all details of the Joint Venture bringing out the financial involvement of each party, liability for the loans raised, the administrative control in the SPV, policy in regard to fare structure etc.
- Agreement between the State and Central Government for financing the debt portion of the project along with the setting up of time frame for completing the Project
- Loan approval
- Providing legal cover for construction as well as O&M stages of the Project
- Memorandum of Understanding between various service providers to provide seamless integration between various transport modes

Annexure 21.1: Gazette of India Notification dated 13.05.2016

रजिस्ट्री सं० डी० एल०-33004/99 REGD. NO. D. L.-33004/99

भारत का राजपत्र
The Gazette of India

असाधारण
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शहरी विकास मंत्रालय

(एमआरटीएस–II)

अधिसूचना

नई दिल्ली, 13 मई, 2016

का.आ. 1769(अ).–केंद्रीय सरकार मेट्रो रेल (संकार्यो का निर्माण) अधिनियम, 1978 (1978 का 33) की धारा 1 की प्रदत्त उपधारा (3) द्वारा प्रदत्त शक्तियों का प्रयोग करते हुए, उत्तर प्रदेश सरकार से परामर्श करने के पश्चात, यह घोषणा करती है कि उक्त अधिनियम के उपबंधों का इस अधिसूचना के भारत के राजपत्र में प्रकाशन की तारीख से नीचे दी गई सारणी में विनिर्दिष्ट अनुसार महानगर क्षेत्रों तक विस्तार किया जाएगा:–

सारणी

महानगर क्षेत्र का नाम	राज्य का नाम
(1)	(2)
कानपुर	उत्तर प्रदेश
वाराणसी	उत्तर प्रदेश

[फा. सं. के–14011/4/2016–एमआरटीएस–II]

अम्बुज बाजपेयी, अवर सचिव

2243 GI/2016 (1)

MINISTRY OF URBAN DEVELOPMENT

(MRTS-II)

NOTIFICATION

New Delhi, the 13th May, 2016

S.O. 1769(E).—In exercise of the powers conferred by sub- section (3) of section1 of the Metro Railways (Construction of Works) Act, 1978 (33 of 1978), the Central Government after consultation with the Government of Uttar Pradesh, hereby declare that the provisions of the said Act shall extend to the metropolitan areas as specified in the Table below with effect from the date of publication of this the Official Gazette of India, namely:—

TABLE

Name of metropolitan area	**Name of State**
(1)	**(2)**
Kanpur	Uttar Pradesh
Varanasi	Uttar Pradesh

[F. No. K-14011/4/2016-MRTS-II]

AMBUJ BAJPAI, Under Secy.

अधिसूचना

नई दिल्ली, 13 मई, 2016

का.आ. 1770(अ).—केंद्रीय सरकार मेट्रो रेल (प्रचालन और अनुरक्षण) अधिनियम, 2002 (2002 का 60) की धारा 1 की उप-धारा (2) द्वारा प्रदत्त शक्तियों का प्रयोग करते हुए, उत्तर प्रदेश सरकार से परामर्श करने के पश्चात, यह घोषणा करती है कि उक्त अधिनियम के उपबंधों का इस अधिसूचना के भारत के राजपत्र में प्रकाशन की तारीख से नीचे दी गई सारणी में विनिर्दिष्ट अनुसार महानगर क्षेत्रों तक विस्तार किया जाएगा:—

सारणी

महानगर क्षेत्र का नाम	**राज्य का नाम**
(1)	(2)
कानपुर	उत्तर प्रदेश
वाराणसी	उत्तर प्रदेश

[फा. सं. के-14011/4/2016-एमआरटीएस-II]

अम्बुज बाजपेयी, अवर सचिव

NOTIFICATION

New Delhi, the 13th May, 2016

S.O. 1770(E).—In exercise of the powers conferred by sub-section (2) of section1 of the Metro Railways (Operation and Maintenance) Act, 2002 (60 of 2002), the Central Government after consultation with the Government of Uttar Pradesh, hereby declare that the provisions of the said Act shall extend to the metropolitan areas as specified in the Table below with effect from the date of publication of this the Official Gazette of India, namely:—

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(1)	(2)
Kanpur	Uttar Pradesh
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[F. No. K-14011/4/2016-MRTS-II]

AMBUJ BAJPAI, Under Secy.

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