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Government of Uttar Pradesh

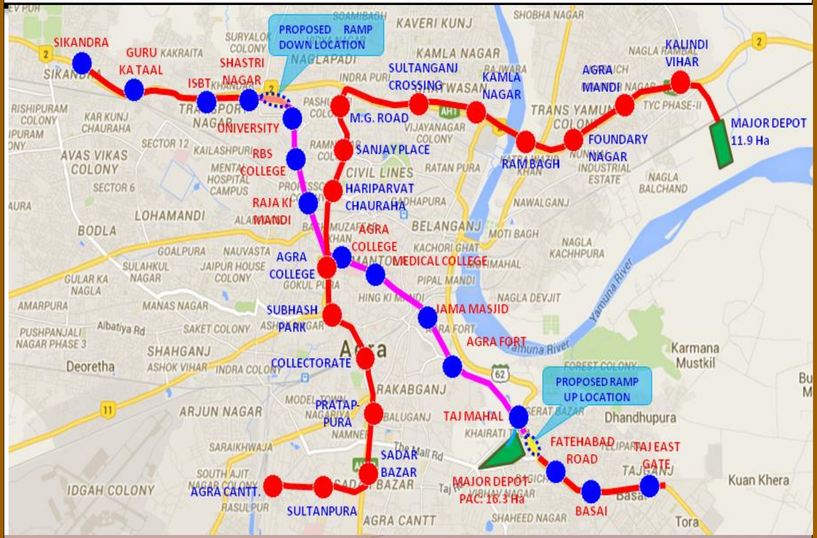
through

Agra Development Authority

Coordinated by

Lucknow Metro Rail Corporation

DPR FOR RAIL BASED MASS RAPID TRANSIT SYSTEM IN AGRA



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

Agra, the city of Taj Mahal is the 3rd most populous city in Uttar Pradesh and is administrative headquarters of the Agra district. Agra was the capital city of Mughals during their rule. The City is a major tourist hub with number of monuments like Agra Fort, Tomb of Akbar and Fatehpur Sikri besides the Taj Mahal, which have been listed as the UNESCO World Heritage sites.

In the past few decades Agra Development Authority Area has experienced an unprecedented spatial expansion from 61.8 sq km in 1971 to 520.2 sq km in 2008. The city's population grew from 5.9 lakh in 1971 to 9.8 lakh in 1991, 12.7 lakh in 2001 and 15.9 lakh in 2011.

The administrative limits of the Agra Nagar Nigam encompass an area of 141.0 sq. km with a population density of about 9,043 persons per sq. km. The highest density lies in the old city areas like Lohamandi and Shahganj, etc. where the settlements started flourishing from the Mughal period.

Unequal spatial development has led to pockets of high density in terms of employment and population, putting pressure on the infrastructure. A major challenge is to provide connectivity and promote growth by providing adequate inputs to the infrastructure which would improve the quality of life of the residents.

Large-scale urbanization and rapid growth of vehicles population has laid severe stress on the urban transport system in Agra 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 that the people have to make is also quite varied and they use private means of transport for most of these trips given the convenience of accessibility. The usage of private modes is growing unabated mainly due to inadequate and inconvenient public transport facilities with poor level of service. The augmentation in the 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 Agra. The Government of Uttar Pradesh has engaged RITES Ltd. to prepare a 'Detailed Project Report (DPR) for Metro Rail System in Agra'.

1.2. LOCATION, CLIMATE, PHYSICAL SETTING AND REGIONAL LINKAGES

1.2.1. Location, Climate and Physical Setting

Agra is geographically located at 27°12' North latitudes and 78°12' East longitudes. It has an extremely strategic location on the confluence of three distinct geo-physical regions namely the plain of Uttar Pradesh, the plateau of Madhya Pradesh and the desert of Rajasthan. The city also falls in the center of the four-culture areas- Braj, Bundelkhand, Rajputana and western U.P. Both these factors have played significant roles in shaping the life and history of the city. It lies in the Indo-Gangetic Plain on the Yamuna River about 200 km southeast of Delhi.

Agra is characterized by a semiarid climate that borders on a humid subtropical climate. The city features mild winters, hot and dry summers and a monsoon season. However the monsoons, though substantial in Agra, are not quite as heavy as the monsoon in other parts of India. This is a primary factor in Agra featuring a semiarid climate as opposed to a humid subtropical climate.

The physical setting of the city are such that the urban sprawl in Agra has taken place more or less in a unidirectional manner, a greater thrust of residential areas has been observed in north-west and south-east directions and development of transport facilities has not kept pace. Natural barriers such as River Yamuna, manmade barriers like the presence of the cantonment area near the city's CBD area have guided the city's growth.

The river Yamuna enters the city from the north-east corner, flows towards south for some distance and then turns towards east. The general slope is from west to east in CIS-Yamuna area on the right bank of the river Yamuna. The strata consist of mainly sandy soil. The city stretches for about 9.0 km along the Yamuna river. The major part of the city is on the Western side of Yamuna and has grown beyond the river on the eastern side and is called the Trans Yamuna.

1.2.2. Regional Linkages

Agra forms an important regional urban center. All traffic weather by rail or road going south invariably passes through Agra thus making it a major transport node at the regional level as well as at the national level. This has also led to an extremely rapid and haphazard growth pattern .

Agra has a radial pattern of road network, which includes one expressway, four national highways and other major roads namely, Mathura- Kanpur Road (NH-2), Yamuna expressway, Aligarh Road (NH-93), Gwalior Road (NH-3), Jaipur Road (NH-11), Fatehabad Road and M.G. Road etc.

Mall Road, M.G. Road-2 and Bodla Road are some of the major sub-arterial roads within the city. The old part of Agra, being a historical city has network of narrow roads. The road infrastructure facilities such as signages, traffic signals, etc. have not expanded in accordance with the increase of population and vehicles. The regional transport connectivity of Agra is shown in **Figure 1.1**.

Agra is served majorly by 2 railway stations, namely, Agra Cantt and Raja Ki Mandi which provide connectivity to major cities viz. Delhi, Mumbai, Kolkata, Chennai, Hyderabad, Bangalore, Ahmedabad, Bhopal, Srinagar, Jaipur, Guwahati, etc.

Aiport at Kheria Airforce station is used to serve the domestic air traffic along with defence and presently has very small numbers of domestic flyers using it. However, the Master Plan 2021 for Agra proposes Kheria to be retained as the site for airport operations.

1.3. DEMOGRAPHIC AND SOCIO ECONOMIC PROFILE

Study Area for the current assignment is the administrative boundary of Agra Development Authority (ADA) as shown in **Figure 1.2**. It includes Agra Municipal Corporation (AMC), Agra Cantonment, urban spillover and rural areas. The majority of population of the study area resides in the AMC area which comprise of 141 sq km out of total 520 sq km of ADA area. As per Agra Master Plan, the proposed population for ADA area in 2021 will be 25.5 lakh.

1.3.1. Population Growth

As per Census 2011, the population of Agra city is about 15.9 lakh. The average decadal growth from the year 1921 to 2011 stands at about 27.0% while average annual growth rate is 2.4%.The decadal population growth of Agra city is shown in **Table 1.1.**

TABLE 1.1: DECADAL POPULATION GROWTH TRENDS IN AGRA CITY

S. No.	Year	Population	Average Annual Growth Rate (%)	Decadal Growth %
1	1921	185532	-	-
2	1931	229764	2.2	23.8
3	1941	284149	2.1	23.7
4	1951	375665	2.8	32.2
5	1961	508680	3.1	35.4
6	1971	634622	2.2	24.8
7	1981	747318	1.6	17.8
8	1991	948063	2.4	26.9
9	2001*	1275000	3.0	34.5
10	2011*	1585704	2.2	24.4

*Source: Agra Master Plan, 2021, * Census figures*

FIGURE 1.1: REGIONAL TRANSPORT CONNECTIVITY

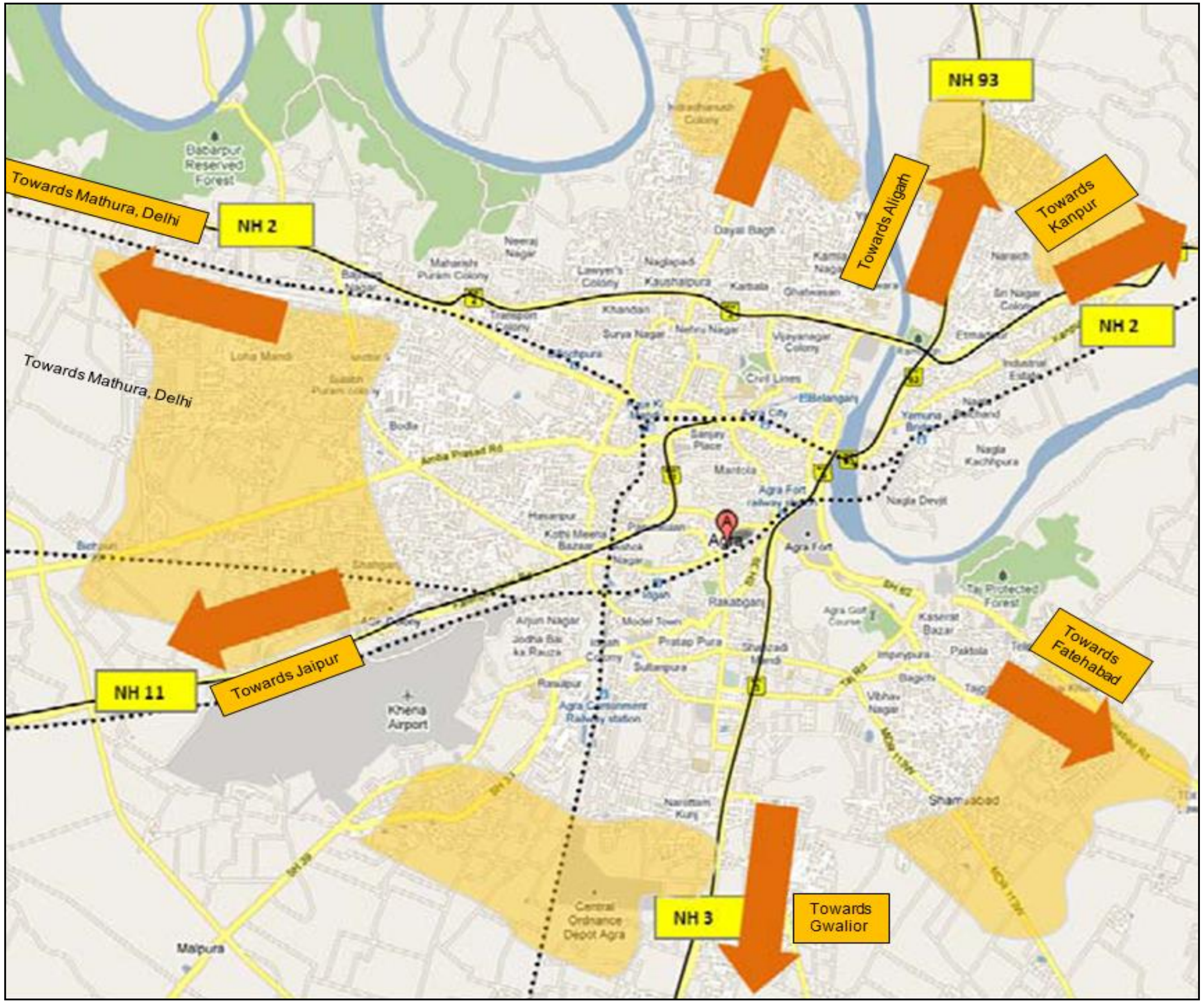
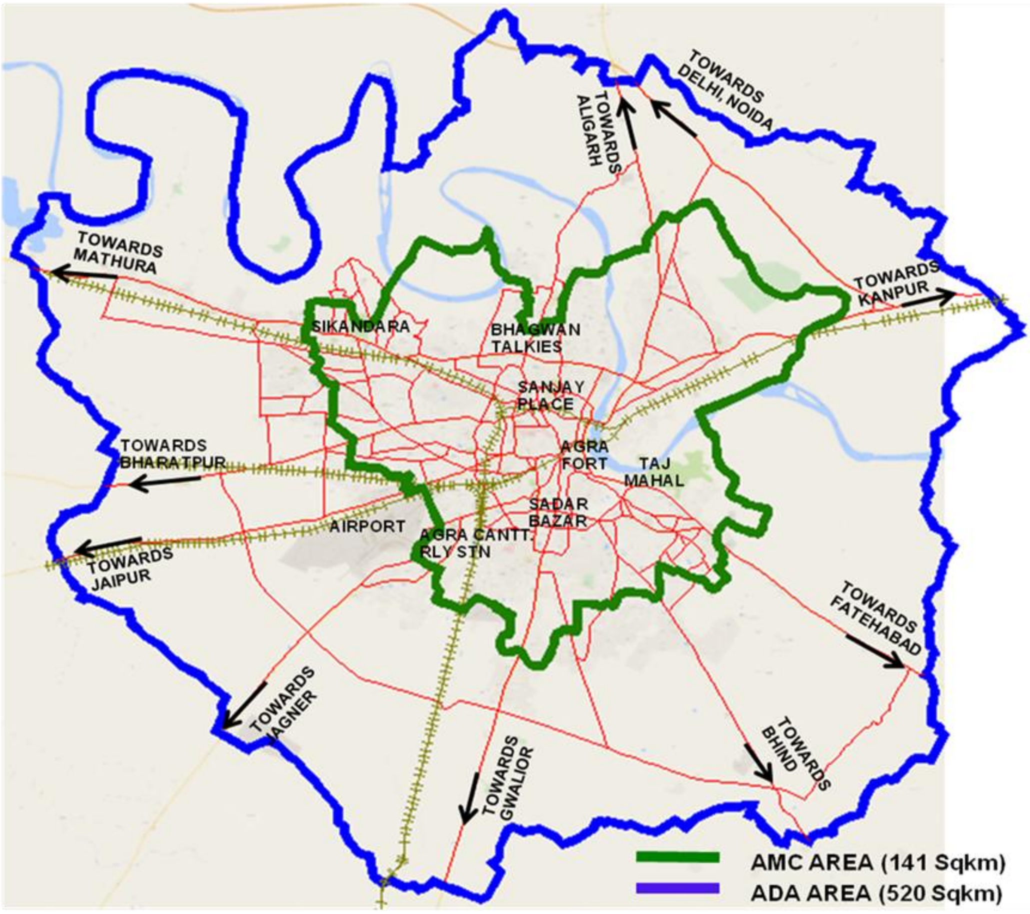


FIGURE 1.2: STUDY AREA - AGRA DEVELOPMENT AUTHORITY AREA



1.3.1 Population Density, Migration and Spatial Pattern

Agra is the second most self-employed in India in 2007. Agra has many industries. There are about 7,000 small scale industrial units. Being industrial and tourism centre has laid population increase from migrant workers over the years. It has been observed that the average annual growth in population had increased to 3% during 1991-2001 from average annual growth 2.4% previous decade (1981-91).

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 2017 is 23.7 Lakh. Accordingly, the population in the study area for the horizon years 2017, 2021, 2031 and 2041 is presented in **Table 1.2**

TABLE 1.2: PROJECTED POPULATION IN ADA FOR HORIZON YEARS

Year	Population (lakh)
2017	23.7
2021	25.5
2031	31.3
2041	36.2

1.4. Urban Land Use Structure

1.4.1. Land use Characteristics as per Agra Master Plan 2021

Agra has predominantly mixed landuse, especially in the housing, commercial and industrial sectors. The central part of the city is extremely crowded. High density is observed near Sanjay Place, M.G. Road, SadarBatti Road, Kinari Bazar Road and Daresi Areas. The density pattern in the peripheral areas exhibits a scattered development concentrated along major roads. The industrial policy in the state encourages industries to establish themselves outside urban areas and therefore, no new industries are developing in the city limits. High concentration of activities is observed on major arterial road system in the city. Acute traffic congestion is witnessed on these arteries throughout the day.

About 62% of area is categorized as residential and a significant 11% is assigned towards Traffic and Transportation. On the other hand the proportion of commercial and industrial land-use constitutes 2.6% and 7% respectively. The land use distribution (2001) is presented at **Table 1.3.**

TABLE 1.3: EXISTING LANDUSE – 2001

S. No	Landuse	Area (in Ha.)	%
1	Residential	48.9	61.8
2	Commercial	2.1	2.6
3	Industrial	5.4	6.9
4	Public Utilities and Services	8.4	10.7
5	Public/ Semi-Public Insituitions	1.8	2.3
6	Traffic and Transportation	8.6	10.9
7	Cremation ground	0.3	0.4
8	Parks and Playgrounds/ Recreational Areas	1.1	1.3
9	Historical/ Archeological areas	1.2	1.5
10	Nursery	0.3	0.3
11	Garden/ Green land areas	0.7	0.9
12	Sewage Plant	0.4	0.5
Sub - Total		79.0	100.0
13	Remaining Land (includes Agriculture land, forest land, Rural areas, River, Drains, Open land etc)	441.2	
Grand Total		520.2	

Source: Agra Master Plan 2021

The proposed allocation for land under various uses for year 2021 is given in **Table 1.4** and **Figure 1.3.** About 50% of area is categorized as residential and 11% of area has been reserved under Traffic and Transportation.

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.

TABLE 1.4: PROPOSED LANDUSE – 2021

S. No	Landuse	Area (in Ha.)	%
1	Residential	99.2	49.5
2	Commercial	5.4	2.7
3	Industrial	16.1	8.0
4	Public Utilities and Services	17.6	8.8
5	Public/ Semi-Public Insituitions	5.1	2.5
6	Traffic and Transportation	21.6	10.8
7	Tourism	1.8	0.9
8	Parks and Playgrounds/ Recreational Areas	8.8	4.4
9	Other open Green lands	4.2	2.1
10	Other areas	20.5	10.3
Sub- Total		**200.4**	**100.0**
11	Remaining Land (includes Agriculture land, forest land, Rural areas, River, Drains, Open land etc)	319.8	
Grand Total		**520.2**	

Source: Agra Master Plan 2021

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 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 .

1.4.3. Major Activity Centres in Agra

The major Landuse in Agra are Industrial, Institutional and mixed Residential cum Commercial activities. A brief of these activities along with prominent locations are presented in **Figure 1.4.**

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 32 % has been assumed from Agra Master Plan for the Horizon years. Thus, it has been estimated that 11.6 lakh workers would comprise the workforce in the study area by 2041. **Table 1.5** shows the growth trend in employment in the study area.

The total workers in the Study Area has been estimated at 6.7 lakh for the year 2017 with a Work Force Participation based on Master Plan, Economic and Landuse profiles.

FIGURE 1-3: PROPOSED LANDUSE DISTRIBUTION FOR AGRA – 2021

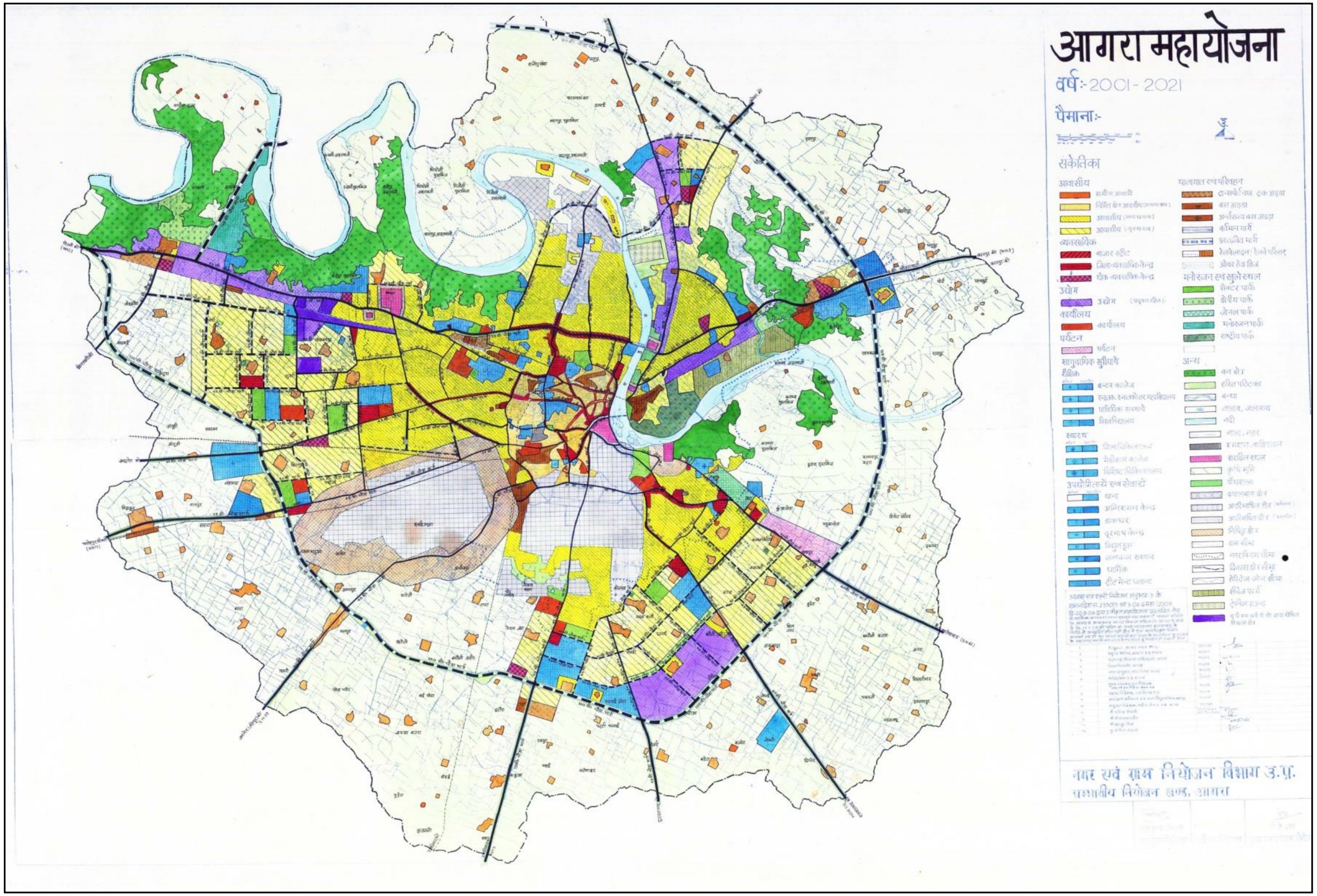


FIGURE 1.4: MAJOR AREAS AND LANDUSE ACTIVITIES

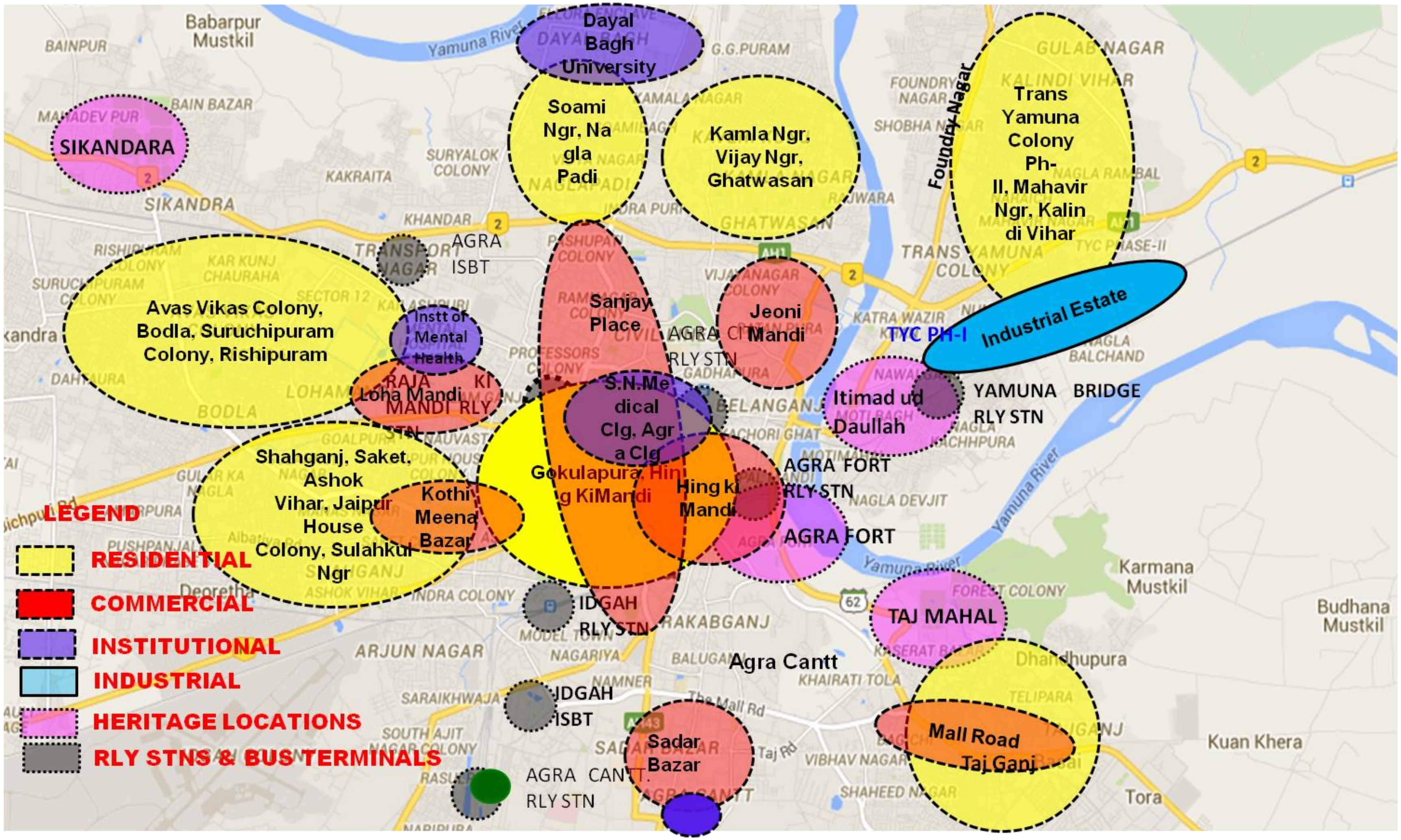


TABLE 1.5: WORK FORCE PARTICIPATION IN STUDY AREA FOR BASE AND HORIZON YEARS

Year	Workers (Lakh)	WFPR (%)
2017	7.0	29.6
2021*	7.6	30
2031	9.7	31
2041	11.6	32

* Source: Census 2011& Agra Master Plan 2021

1.4.4. Landuse Plan (Master Plan 2021) Proposals

A detailed Master Plan- 2021 for ADA area was prepared in 2001 for an area of about 520 sq km to accommodate population of 25.5 Lakh. In spite of the demand for transportation infrastructure, the proposed land under traffic & transportation use has remained constrained at 10.8%. Master Plan 2021 for Agra proposals for transport sector are as follows:

- A 100 m wide ring road has been proposed in order to by-pass the Agra city and avoid congestion in the city area
- Widening of radial roads have also been proposed to 75 m for Mathura Road, Kanpur Road, Aligarh Road, Gwalior Road, Fatehpur Sikri Road to 60 m for Jagner Road, Bharatpur Achhnera Road, Shamshabad Road, Fatehabad Road and to 45 m for Iradat Road.
- Parking facilities have been proposed on area from Civil Court to Hari Parvat Chowk on M.G. Road, Bhagwan Talkies Junction, Khandari Chowk to Water Works Chowk, Madiya Katra to Loha Mandi Chowk area and New Agra Area near Dayalbagh.
- Rail Over Bridges are proposed in Shastripuram, above Achhnera railway line and near Guru Ka Taal Fly-over

1.5. SCOPE OF WORK

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

1.5.1. Assessment of Existing 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 detail 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, 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. Detail of lands/areas amenable for change in near future e.g. vacant land, low rise development relocation etc.

1.5.18. 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. The State Governments will have to ensure the financial sustainability of the project through financial assistance.

1.5.19. 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.

1.5.20. 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.

1.5.21. 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 covering:

Chapter 1: Profile of the City covers background, demographic characteristics and urban land use 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 Agra. 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 AND TOURIST GROWTH AND COMPOSITION

The city is a major tourist hub with number of monuments like Taj Mahal, Agra Fort, Tomb of I'timād-ud-Daulah , MehtabBagh, PanchMahal, Jama Masjid, Tomb of Akbar (Sikandara), Moti Masjid, Guru KaTaalGurudwara, Ram Bagh, Mankameshwar Temple, etc. Tourists from all over the world visit the city round the year. **Table 2.1** shows the number of tourists visited at various heritage monuments.

The registered vehicles in Agra have increased significantly over the years. The year wise vehicle registered in Agra is presented in **Table 2.2**. This high density and rapid growth of vehicles have worsened the transport situation to a significant extent. The phenomenal increase of cars - demand more road space and has resulted in dense concentration of traffic on roads.

TABLE 2.1: TOURIST AT VARIOUS HERITAGE MONUMENTS

Heritage Monument	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017
TajMahal	4813006	5381946	7036050	5689743	6145307	6641590	7182244
Agra Fort	1366966	1474752	1563020	1593417	1679309	1770041	1865888
Tomb of Akbar (Sikandara)	441677	434343	459486	430095	430881	432915	435910
I'timād-ud-Daulah	84166	117315	142357	143674	173258	208933	251955
FatehpurSikri	448953	554809	577709	601263	670898	751496	844792

*Source: Agra Development Authority, * Estimation based on average growth rates*

TABLE 2.2: YEARWISE VEHICLE REGISTERED IN AGRA ROAD TRANSPORT OFFICE

Vehicle Category	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Two Wheeler	31860	31615	38675	42294	52268	57118	62828	75654	76172	74875	73026
Car	4398	3827	4958	5744	6958	7438	7230	8592	9371	9546	10122
Jeep	208	230	414	402	474	959	1332	1416	1431	1232	1140
Van	317	222	341	267	371	400	426	831	1218	983	555
Taxi	131	166	276	425	400	448	435	361	547	630	682
Ambulance	15	13	24	29	20	33	26	65	35	54	28
Auto (3-Wh)	3431	379	570	431	565	748	449	504	297	3698	1144
E-Rickshaw	0	0	0	0	0	0	0	0	1	167	364
Bus	96	88	98	101	41	43	17	7	13	11	25
Mini Bus	55	34	34	94	25	38	17	12	11	19	21
School Bus	13	9	12	30	39	30	58	50	53	61	129
Goods 3-Wheeler	384	691	800	948	1477	1307	1164	971	548	931	637
Light Comm. Vehicle	247	263	233	324	465	482	506	471	302	214	261
Truck	72	82	84	49	62	22	15	13	12	24	30
Multi-Axle Vehicle	101	77	78	83	178	195	144	125	155	147	246
Heavy Machinery Equipment/Vehicle	0	0	4	1	0	0	0	0	0	0	4
Fire Brigade	0	0	0	2	0	0	0	0	1	0	0
Tractor	955	575	1193	1055	2331	2007	1900	2731	1677	1507	1569
Tractor with Trailer	27	21	12	8	16	11	2	1	4	1	1
Other Vehicles	1	0	3	5	4	4	2	4	6	2	2

Source: Regional Transport Office, Agra

2.3 ROAD NETWORK CHARACTERITICS

2.3.1 Network Inventory

The road network inventory was carried out in 2015 along all arterial and major roads in the study area. About 63% of the road network has less than 20m ROW, 27% has ROW between 20-30m and merely 10% of the road has ROW more than 30m. The distribution of the road network as per right of way (ROW) is presented in **Table 2.3.**

TABLE 2.3: DISTRIBUTION OF ROAD NETWORK AS PER RIGHT OF WAY

SN	Right Of Way (m)	Road Length (km)	Percentage (%)
1	≤10	33.2	8.0
2	10 - 20	229.6	55.4
3	20-30	111.1	26.8
4	30-40	37.7	9.1
5	> 40	2.8	0.7
	TOTAL	**414.4**	**100.0**

About 24% of the road network has footpath available along the road, thus the majority length of road network is without footpath as presented in **Table 2.4.**

TABLE 2.4: AVAILABILITY OF FOOTPATH

SN	Footpath	Road Length (km)	Percentage (%)
1	Present	98.6	23.8
	One-side	*2.50*	*0.6*
	Both-sides	*96.2*	*23.2*
2	Absent	315.8	76.2
	Total	**414.4**	**100.0**

Agra has multiple ROBs/Flyovers in the City like at Mau, Sultanganj, and Water Works Crossing and Bijli Ghar Crossing etc.

2.4 MAJOR TRANSPORT NODES

The major bus terminals in the City include ISBT Near Transport Nagar, Idgah Bus Terminal, Bijlighar and Water Works. The daily boarding and alighting figures are observed to be 9064 (ISBT Near Transport Nagar), 20446 (Idgah), 10765 (Bijlighar) and 7161 (Water Works).

Agra is served majorly by 2 railway stations, namely, Agra Fort and Raja Ki Mandi which provide connectivity to major cities viz. Delhi, Mumbai, Kolkata, Chennai, Hyderabad, Bangalore, Ahmedabad, Bhopal, Srinagar, Jaipur, Guwahati, etc. Other influential railway stations include Agra Cantt and Idgah. The daily boarding and alighting figures are observed to be 19626 (Agra Fort), 14418 (Raja kiMandi), 29045 (Agra Cantt) and 9952 (Idgah).

Airport at Kheria Airforce station is used to serve the domestic air traffic along with defense and presently has very small numbers of domestic flyers using it. However, the Master Plan 2021 for Agra proposes Kheria to be retained as the site for airport operations.

2.5 PEDESTRIAN AND NMV FACILITIES

2.5.1 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 Bhagwan Talkies.

2.5.2 From primary surveys it is observed that only about 23% of the surveyed road network has footpath facility available along both sides of road. However, high share of pedestrian and Non-Motorised Vehicles require provision of continuous, encroachment free pedestrian and NMT facilities.

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

SN	Name of Location	Approach	Daily Pedestrian Vol. (12 hours)		Peak Hour Pedestrian Volume	
			Across	Along	Across	Along
1	Bhagwan Talkies	Delhi/ Mathura	1488	9296	106	1108
		Dayalbagh	2938	4978	510	386
		Kanpur	3090	3478	344	293
		AgraCantt.	1852	7367	190	646
2	Water Works	Delhi	1708	4145	223	428
		Balkeshwar	1501	3174	74	468
		Kanpur	1508	3555	120	300
		Shamsabad	1054	2905	101	273
3	Rambagh Choraha	Delhi/ Mathura	2884	4785	321	447
		Hathras	2518	3996	149	400
		Kanpur	2183	4067	191	457
		MehtabBagh	1905	4891	193	544
4	GhatiaAzam Khan Chowk	JeoniMandi	1583	3631	102	387
		Kinari Bazaar	1446	3931	142	460
		St. John's Clg	2127	2982	130	292
		Paliwal	1779	2463	211	210
5	Partapura Chowk-M.G.Road	Bhagwan Talkies	1544	4474	117	401
		Gwalior Road	1844	4054	144	372
		Agra Cant	1962	3873	158	410
		Idgah	1601	3205	195	375
6	Chhipitola Chowk M.G. Road	Bhagwan Talkies	1127	4023	84	371
		BijliGhar	2020	3527	146	364
		Agra Cant	1625	3740	183	402
		DholPur House	1736	4016	168	455

SN	Name of Location	Approach	Daily Pedestrian Vol. (12 hours)		Peak Hour Pedestrian Volume	
			Across	Along	Across	Along
7	Bodla Choraha	Sikandra	1032	5959	154	805
		LohaMandi	924	4734	100	443
		Shanganj	784	4634	100	403
		Vishpuri	863	2673	96	238
8	Bhogipura	Sikandra	900	4924	45	589
		PanchKhuia Road	1236	4803	103	428
		Shah Ganj	689	5938	54	834
		FatehpurSikri	315	6579	30	820
9	Khatipara (Amba Prasad Road)	MariyaKatra	1021	2932	116	296
		St. John's Clg	1025	3376	140	221
		Shaganj	842	3064	104	389
		Bodla	1240	3953	141	412
10	SoorSadan Chowk	Bhagwan Talkies	1899	3438	141	326
		Sanjay Place	946	3705	112	379
		Agra Cantt.	1536	3132	199	214
		Church Road	1901	3389	239	313

The CMP has also recommended some proposals such as installation of Foot paths and Cycle tracks on the major travel corridors, and also the secondary arterials, as a minimum requirement. Additionally, Footpaths should also 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. CMP has also suggested provision of grade separated facilities for the convenience of pedestrians at appropriate locations. As part of NMV proposals, cycle rickshaw management at the important congested areas have also been proposed .

2.6 TRAFFIC MANEGEMENT INCLUDING PARKING MANAGEMENT

Traffic management proposals in CMP consist of improvement of some important intersections, signalizing plans, pavement marking and signages. 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 include junction improvements, traffic management measures and safety measures as follows:

- Junctions that need improvements are Bhagwan alkies, Water Works Junction- NH-2, Hari Parvat Chowk - M.G. Road, Ram Bagh Choraha - NH-2, Sultan Ganj Ki Puliya (Vijay Nagar crossing on NH-2), Solanki Market Chowk, Sur Sadan Chowk (Sanjay Place) - M.G. Road, Kargil Chowk (on Badia Road), 100 Feet Rd Junction - NH-2, St. Joh n's College Chowk - M.G. Road.

- Signage and road markings are proposed to increase the safety and discipline in driving conditions.

Off-street parking locations are proposed at Agra Cant Station, Gura Ka Taal , Sadar Bazar, Taj Parking West, Truk Garage, Sn Medical College, District Court, Shahdra Chungi, District Collectorate, Guru Ka Taal, Raja Ki Mandi Station etc.

2.7 TRAFFIC CHARACTERITICS

2.7.1 Traffic Volumes and Composition

The daily traffic volumes total vehicles (PCUs) at major midblock locations observed are Trans Yamuna Colony, Phase 2 along NH-2 (76593 Vehicles, 80994 PCUs), Trans Yamuna Colony, Phase 1 along NH-2 (71173 Vehicles, 75732 PCUs), at Kamla Nagar T Point along NH-2 (73812 Vehicles, 76992 PCUs) and Diwani Chowk, MG Road (58593 Vehicles, 51053 PCUs).

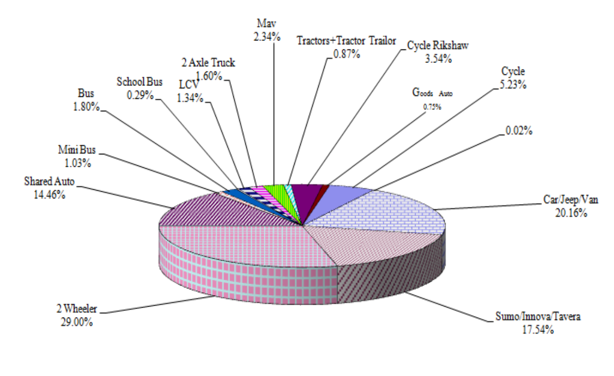
The daily traffic composition along these midblock locations is presented in **Figure 2.1.**

2.7.2 Speed and Delay Characteristics

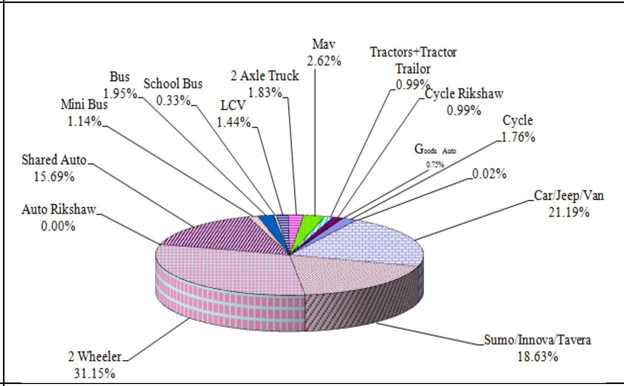
about 14% of the road network has journey speeds less than 20 kmph during peak hours and only 9% of network has more than 40 kmph. Average Journey Speed in the network is observed to be 25.3 kmph. The running speed of about 45% of the road network has between 21-30 kmph during peak hours. The delays are majorly caused by traffic signal and congestion.

FIGURE 2.1: DAILY TRAFFIC COMPOSITION ON MAJOR MIDBLOCK LOCATIONS

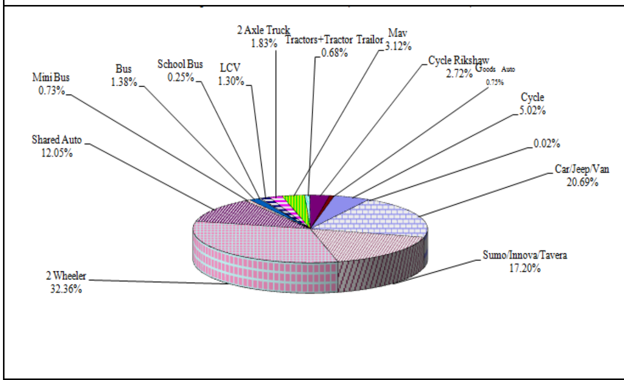
Trans Yamuna Colony, Phase 2



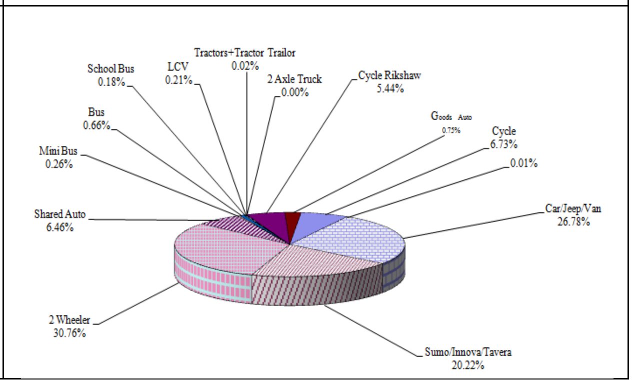
Trans Yamuna Colony, Phase 1



Kamla Nagar T Point



Diwani Chowk, MG Road



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 include: pedestrians, cyclists, motorists, vehicle passengers and passengers of on-road public transport (mainly buses and autos).

Agra has witnessed a steady rise in number of people injured in road accidents over the past few years (*Source: Road accidents data compiled by the Ministry of Road Transport and Highways, Nov 2017*). In fact in 2016, Agra reported more than 15% increase in the number of people sustaining injuries due to road accidents as against 2015. Agra recorded 811 injured persons in 2016 whereas there were 687 in 2015 and 803 in 2014. It is also revealed that there was about 5% increase in road accidents. In 2016, 1,062 road accidents were reported in Agra in comparison to 1,007 in 2015 and 971 in 2014. However, the number of casualties dropped by nearly two per cent in 2016. As many as 492 deaths due to road accidents were reported in 2016, which was 532 in 2015 and 522 in 2014.

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 2.6.**

TABLE 2.6: ROAD ACCIDENTS IN AGRA

Year	Total Accidents	Serious/Minor Injuries	Fatality/Deaths
2010	1120	818	559
2011	1207	967	607
2012	951	649	426
2013	1021	698	500
2014	971	811	522
2015	1007	687	532
2016	1062	803	492

Source: Traffic Police Agra

2.9 INTERMEDIATE PUBLIC TRANSPORT SYSTEM

Private auto, shared auto, cycle rickshaw and e-rickshaws supplement the main-line haul transportation service modes. IPT modes play a vital role in bridging the gap between the Public transport terminals of the city to the ultimate destination of the passenger trip. This gap is filled by two types of IPT Modes – Motorized and Non-motorized. Motorized modes are registered as per Motor vehicle Act. The major motorized IPT modes are Piaggio Ape shared auto, Bajaj Shared Auto, Tata Magic, Battery Operated Rickshaw and 6-seater battery operated Golf cart seen near Taj Mahal, Red Fort area which is a shuttle service between Taj Mahal and Red Fort. There are 15 routes on which IPT modes run on shared carriage and are listed in **Table 2.7.**

TABLE 2.7: INTERMEDIATE PUBLIC TRANSPORT ROUTES IN AGRA

S. No	IPT Routes	Length (km)
1	Dayalbagh- Bhagwan Talkies- Kamla Nagar	11.0
2	Dayalbagh- collectorate- Bijlighar	9.0
3	Kamla Nagar- Water Works Chauraha-Bijlighar	12.0
4	Bhagwan talkies- Madiakatra- Shahganj- Agra Cantt	13.0
5	Bhagwan talkies- Madiakatra- Shahganj- Agra Cantt	10.0
6	Trans Yamuna- Water Works- Bhagwan Talkies- ISBT- Sikandra	12.0
7	Dhanauli- Kheria Moad – Idgah- Sai Ka Takia- Bijlighar	11.0
8	Sikandara- Bodla- Shahganj	8.0
9	Shahganj- Collectorate- Bijligarh	7.0
10	Bijlighar- Purani Mandi- Taj Ganj	7.0
11	Bijlighar- Baluganj- Naulakha- Bundukatra	8.0
12	Bijlighar- Rajpur Chungi	8.0
13	Bijlighar- Water Works- Trans Yamuna/Rambagh	8.0
14	Agra Cantt.-Idgah- Saika Takia- Bhagwan Talkies	11.0
15	Shaihd Nagar-Bijlighar- I'timād-ud-Daulah -Trans Yamuna Colony-Chhalesar	10.0

The fare structure of the IPT modes is shown in **Table2.8**, which shows that the first stage is priced at 3 km for Rs.5.

TABLE 2.8: FARE STRUCTURE OF IPT MODES IN AGRA

Fare details	Fare in Rs.
upto 3 km	5.0
3 to 6 km	10.0
6 to 10 km	15.0
more than 10 km	20.0

2.10 PUBLIC TRANSPORTATION SYSTEM

2.10.1 Public Transport Services in Agra

Public transport plays a crucial role in the commuter transportation in any city. It offers economies of scale with minimized road congestion and low per capita road usage. Cheaper and affordable public transport systems world over have proved to promote mobility – move people more efficiently and safely with increased opportunities for education, employment, social development etc.

At present the public transport services are rather limited and bus is the only mass transport system in the Agra. Agra Mathura City Transport Services Limited (AMCTSL) operates the city bus services consisting of mainly normal buses and few low floor buses & mini buses. The fleet size of about 170 buses is a noticeable feature of poor supply public transport.

The present supply of buses per lakh populations works out to only nine buses, which cannot be compared with any standards. The benchmark for assessing the supply of buses should be about 60 to 70 buses per lakh population for city like size of Agra. Private auto, shared auto, cycle rickshaw and e-rickshaws supplement these transportation services.

2.10.2 Existing Bus Routes

The route structure in Agra has been designed by Agra Mathura City Transport Services Limited based on major boarding/alighting demand locations. The existing route structure is presented in **Table 2.9.**

TABLE 2.9: CITY BUS ROUTE STRUCTURE

S. No.	Route Name
Government Bus Routes	
1	Agra Cantt to Shastripuram
2	Bijlighar to Kheragarh
3	Bijilighar to Pinahat
4	Bijighar to Tundla
5	Dayalbagh to Agra Cantt.
6	Dayalbagh to Sainya Rohta
7	Idigah to Fatehpursikri

Source: Comprehensive Mobility Plan, Agra

2.10.3 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. In case of Agra, Public Transport requirements are catered by Agra Mathura City Transport Services Limited.

2.10.4 Constraints

The routes on which buses Agra Mathura City Transport Services Limited presently operate have less patronage and thus are incurring losses.

High growth of private modes over the years has resulted in declining trend of public transport system share. This has resulted in increased traffic congestion on road because of limited improvement in road transport infrastructure facilities. The challenge is to reverse this trend and ensure that public transport system is augmented to cater to the significant daily travel demand.

Private auto, shared auto, cycle rickshaw and e-rickshaws supplement these transportation services. The void created by public transport modes has been filled by IPT modes in form of auto rickshaws and 6 seater Vikrams.

2.11 PAST PROPOSALS FROM PREVIOUS STUDIES

Various past studies including City Development Plan, Comprehensive Mobility Plan and Master Plan for Agra 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 Agra - 2021

A detailed Master Plan- 2021 for ADA area was prepared in 2001 for an area of about 520 sq km to accommodate population of 25.5 Lakh. In spite of the demand for transportation infrastructure, the proposed land under traffic & transportation use has remained constrained at 10.8% (as compared to present 10.9). Master Plan 2021 for Agra proposals for transport sector are as follows:

- A 100 m wide ring road has been proposed in order to by-pass the Agra city and avoid congestion in the city area
- Widening of radial roads have also been proposed to 75 m for Mathura Road, Kanpur Road, Aligarh Road, Gwalior Road, Fatehpur Sikri Road to 60 m for Jagner Road, Bharatpur Achhnera Road, Shamshabad Road, Fatehabad Road and to 45 m for Iradat Road.

- Parking facilities have been proposed on area from Civil Court to Hari Parvat Chowk on M.G. Road, Bhagwan Talkies Junction, Khandari Chowk to Water Works Chowk, Madiya Katra to Loha Mandi Chowk area and New Agra Area near Dayalbagh.

- Rail Over Bridges are proposed in Shastripuram, above Achhnera railway line and near Guru Ka Taal Fly-over

2.11.2 City Development Plan for Agra - 2006

In order to adopt a holistic and all round plan for development for Agra, 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 141.0 sq km of Agra Municipal Corporation (AMC) comprising of 80 wards with a population of about 12.2 Lakh in 2001.

Proposed Transport Sector Strategies:

- Listing of protected/ un-protected monuments of the city shall be done along with improving the accessibility and connectivity to tourist places, so as to increase the tourist inflow of the city.
- Improvement of streetlights
- High mask lights at entry points of the city
- Parking requirement/ multi storeyed parking at various congested places like Phagwara Chauraha, Kinari Bazaar, Shahganj, Raja Mandi
- Flyovers to be proposed at various problematic junctions
- Traffic management for internal roads

2.11.3 Comprehensive Mobility Plan for Agra

Comprehensive Mobility Plan (CMP) for Agra has been updated in 2017. The study area for CMP extends over 520 sqkm of Agra Development Authority (ADA) area.

Comprehensive Mobility Plan has been prepared for long term with a vision for transport in Agra to ensure that the city has a planned, best performing transport system 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.

Important CMP Proposals were as follows:

a. **Mass Rapid Transport Proposals:**
The CMP proposes three mass transit corridors for length of 62 km and four feeder routes for length of 32.5 km. The city bus system improvement plan and bus fleet augmentation is also proposed for Agra. To carry out daily maintenance for

development of the city bus infrastructure/depot in line with the fleet augmentation plan is proposed.

CMP suggests route rationalization and expansion to be carried out in future years for catering to projected demand in future years.

A total of 8 Multi Modal Integration Hubs at Airport, Agra Cant & Fort Railway Station, Raja Ki Mandi Railway Station, Challesar Railway Station, Bichpuri Railway Station, Transport Nagar ISBT and Sadar Market MRTS station are proposed. These hubs will act as transfer station for all PT modes in addition to parking facility and NMT docking.

b. Road Network Proposals

To ensure proper distribution of traffic, ring and radial road network has been proposed in CMP. The missing links need to be created so as to complete the inner ring road. Outer ring road has been proposed for future scenarios when the inner ring roads get saturated. Further, to supplement the missing links, the present capacities of various existing links on the proposed mobility corridors shall be enhanced through removal of encroachment and repossession of ROW besides creation of grade separated roads wherever necessary.

c. Intermediate Public Transport Plan

To improve the efficiency of the public transport system it is proposed to have an integrated on demand IPT service in the city. As a part of sustainable transport scenario, it is also proposed to have electric vehicles to reduce the pollution. Each of the bus, MRTS stop/terminal shall have dedicated parking space and charging facilities for IPT vehicles.

The aim of the IPT service is to compliment the public transport system, rather than conflicting with the parallel routes. It is also proposed to have strict regulatory and enforcement mechanism to check the overlap.

d. Non-Motorized Transport Proposal

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, grade-separated pedestrian facilities, pedestrian phase at intersections, road markings, cycle rickshaw management plan along with a linked network at local area level.

Considering the high flow of the pedestrians, junctions such as Bhagwan Talkies Rambagh Choraha, Fawara Chowk (Kinari Bazaar Road), Ghatia Azam Khan Chowk, 100 Footi Road NH-2, Partapura Chowk-M.G.Road, Bhogipura have been be considered for pedestrian friendly junction improvements.

Construction of Cycle Track have been proposed in 146 km primary road network. Some of the secondary and tertiary roads are also proposed for cycle track provision for 120 km network length. It is also proposed to have bike sharing station at tourist places like Taj Mahal, Agra fort, Sikendra, Guru Ki Taal etc.

e. **Parking Proposal**

Off-street parking locations are proposed at Agra Cant Station, Gura Ka Taal , Sadar Bazar, Taj Parking West, Truk Garage, Sn Medical College, District Court, Shahdra Chungi, District Collectorate, Guru Ka Taal, Raja Ki Mandi Station etc.

f. **Traffic Engineering and Management Proposals:**

- A number of traffic management plan including junction improvements, traffic management measures and safety measures are proposed in CMP.
- Some of the junctions that need improvements as identified by the CMP are: Bhagwan Talkies, Water Works Junction- NH-2, Hari Parvat Chowk - M.G. Road, Ram Bagh Choraha - NH-2, Sultan Ganj Ki Puliya (Vijay Nagar crossing on NH-2), Solanki Market Chowk, Sur Sadan Chowk (Sanjay Place) - M.G. Road, Kargil Chowk (on Badia Road), 100 Feet Rd Junction - NH-2, St. Joh n's College Chowk - M.G. Road.
- Signage and road markings are proposed to increase the safety and discipline in driving conditions.

g. **Tourist Management Plan:**

- Visitor pass, allowing tourist to hop on – hop off in any mode of public transport has been proposed.
- Cycle Sharing Scheme/Creation of walkways connecting nearby destinations has been proposed.

2.11.4 Alternatives Analysis Report for Agra MRTS

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

- 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 Agra 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 Agra city.

2.12 INTERCONNECTIONS AMONG VARIOUS STUDIES/PROPOSALS

The past studies carried out earlier has analysed the existing conditions in detail and have come up with possible improvement proposals in Agra. 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-motorised transport facilities and road improvements have also been part of proposals from Master Plan and CMP.

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

2.13 ISSUES AND PROSPECTS

2.13.1 Existing Traffic Characteristics and Related issues

The sharing of limited right of way by a various of modes has resulted in traffic congestion, accidents, inadequate parking area and environment deterioration. These are presented in **Figure 2.2.**

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 2.10.**

As per available data Agra from November 2015 to March 2016 as presented in **Table 2.11**, 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 effective and 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 Agra and compliment with other sustainable transport initiatives and transport infrastructure improvement measures.

FIGURE 2.2: EXISTING CHARACTERISTICS ALONG MAJOR ARTERIAL ROADS

	
On-street parking and Encroachments on both sides of the road is observed near Jama Masjid	Uncontrolled movement of animals on road near university area
	
The photograph is Raja Ki Mandi where Parking of 2-wheeler on carriageway is observed	The photograph is Raja Ki Mandi encroachment due to temporary vendors on carriageway is observed
	
Shastri Nagar - damaged road infrastructure	Agra Mandi - Pedestrian moving on the carriageway due to absence of footpath.

FIGURE 2.3 CONGESTED ROAD SECTIONS

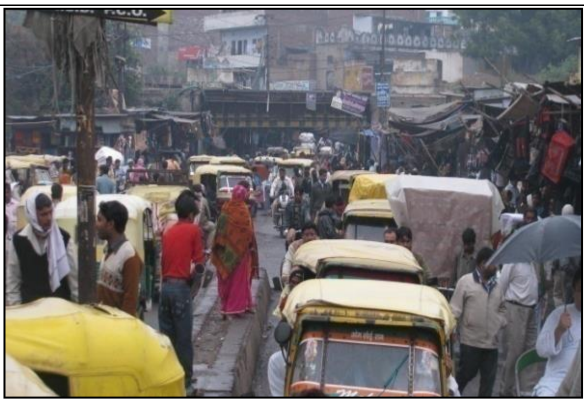
	
National Highway -2	Bhagwan Talkies Junction
	
Near Agra Fort	Near Pratapura Chowk
	
Market near Agra Fort	Near Bijli Ghar

TABLE 2.10: 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+

TABLE 2.11: MEASURED POLLUTION LEVELS FOR AGRA

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	259	384	417	No Data	No Data
2	260	308	421	234	No Data
3	274	No Data	403	188	No Data
4	292	333	418	191	No Data
5	255	369	442	276	No Data
6	183	No Data	414	No Data	No Data
7	279	390	407	No Data	144
8	304	No Data	449	No Data	No Data
9	287	359	298	259	No Data
10	309	360	262	309	No Data
11	354	309	323	286	174
12	288	352	274	290	85
13	367	278	315	237	61
14	412	279	400	No Data	166
15	377	207	389	No Data	149
16	347	287	329	No Data	143
17	293	341	399	No Data	174
18	265	370	No Data	263	110
19	363	379	397	293	210
20	360	401	385	299	196
21	377	403	372	180	153
22	382	427	403	76	57
23	413	431	360	159	73
24	392	420	383	202	194
25	336	253	346	224	220
26	294	320	400	227	164
27	320	317	No Data	No Data	82
28	359	287	387	No Data	156
29	423	314	389	No Data	150
30	398	273	371		No Data
31		412	391		No Data
MAX	423	431	449	309	220
MIN	183	207	262	76	57
AVG	327	342	377	233	143

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

Chapter – 3

TRAVEL CHARACTERISTICS AND DEMAND ESTIMATES

3. TRAVEL CHARACTERISTICS AND DEMAND ESTIMATES

3.1 VARIOUS TRAFFIC AND TRANSPORTATION STUDIES UNDERTAKEN

3.1.1 Study Area and Zoning

The geographic area within the jurisdiction Agra Development Authority (ADA) is taken as the study area for this study. To understand the travel pattern of the city, a total of 108 zones called traffic analysis zones have been identified. Considering the ease of getting required zonal information, administrative wards were considered as zones within the Municipal Area. A total of 108 internal zones inside ADA area and 10 external zones have been considered for the study. The zoning system of the study area are 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: ZONING SYSTEM

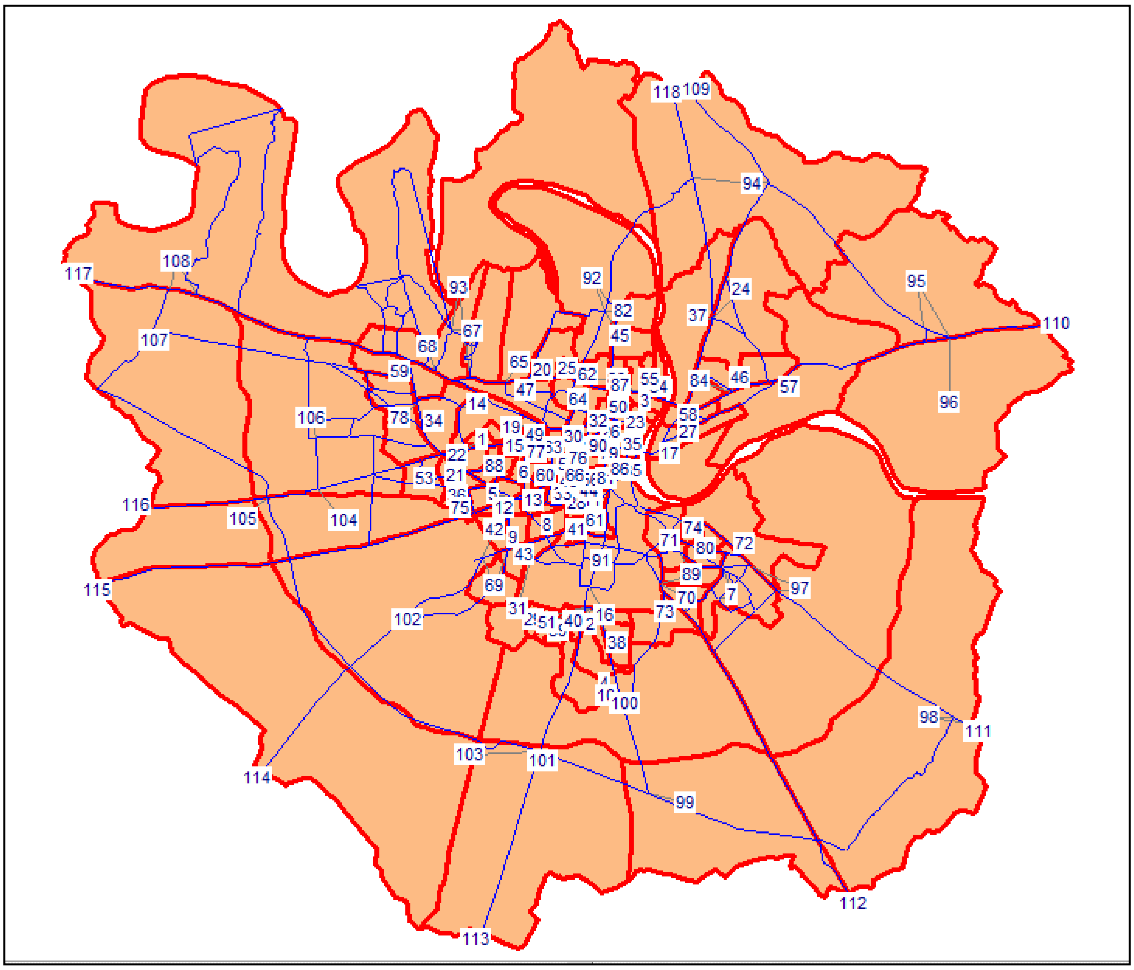
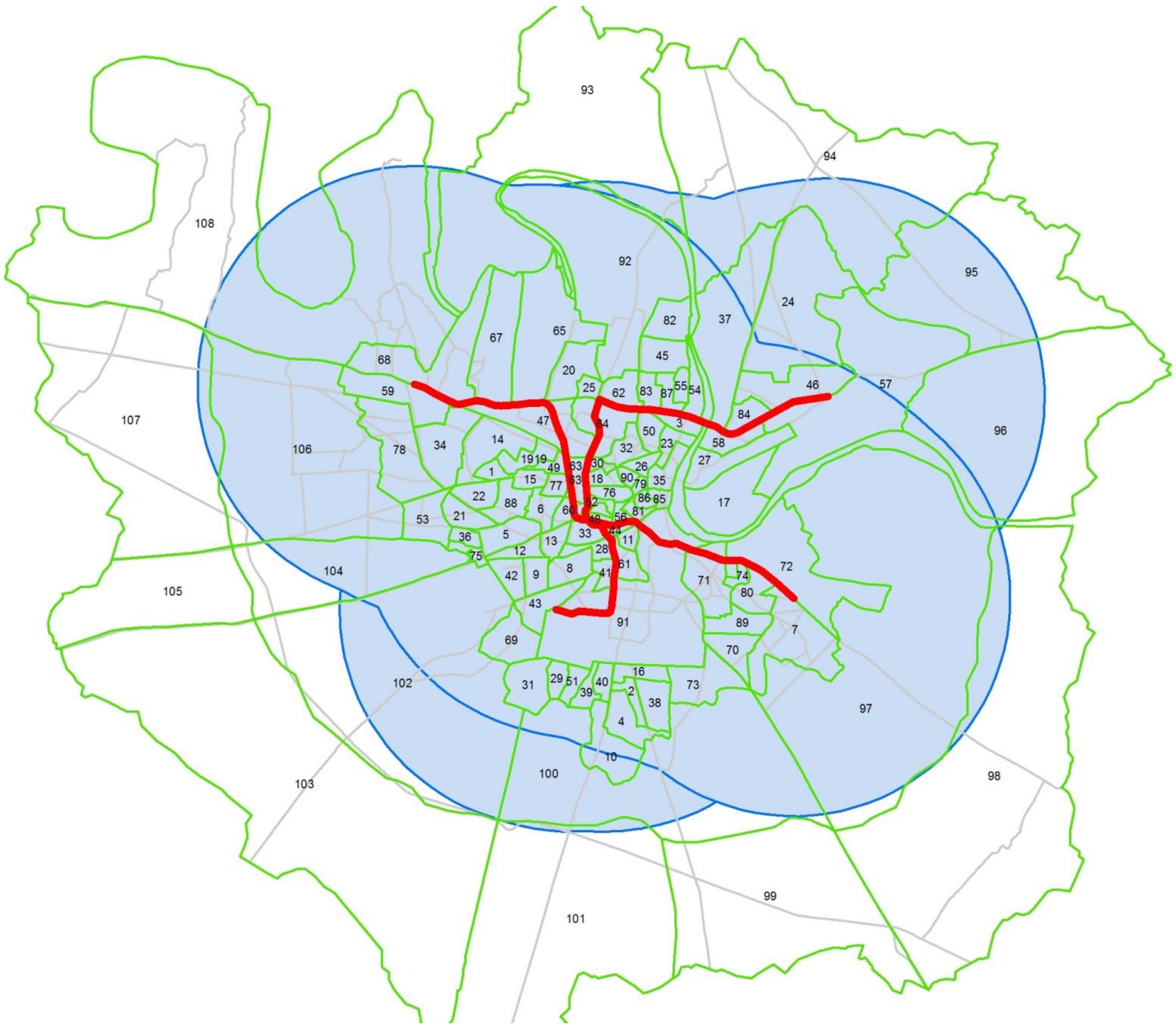


FIGURE 3.2: INFLUENCE AREA OF PROPOSED METRO CORRIDORS



3.1.2 Landuse Surveys

Landuse surveys have been carried out to understand the pattern along existing road network of about 415 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 19% and commercial about 38%.

TABLE 3.1: DISTRIBUTION OF ABUTTING LANDUSE ALONG MAJOR ROADS

SN	Landuse	Percentage %
1	Residential	18.5
2	Commercial	38.1
3	Institutional /Educational	0.3
4	Agriculture	30.7
5	Army	1.9
6	Other (Historical Place/Park/Court/Jail)	1.5
7	Waste land /Vacant	2.5
8	Industrial	6.5
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.

Average Daily 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 1,977 Vehicles (1,546 PCU’s) at Nagla Kachhan Railway Fatak to 76,593 Vehicles (80,994 PCU’s) along NH-2 near Trans Yamuna Colony Phase-II.

The morning peak hour volume varies from 246 PCUs (294vehicles) on Nagla Kachhan Railway Fatak to 8,323 PCUs (8,377 vehicles) Along NH-2 at Trans Yamuna Colony Phase-II.

ii. Turning Movement Counts at Intersections

Direction-wise classified traffic volume surveys were carried out at 50 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 3.4.**

Traffic Volume (Average Daily Traffic – 16 hours)

The daily and peak hour traffic characteristics at intersection locations is given in **Table 3.3**. It can be seen that Bhagwan Talkies junction handles the maximum daily traffic at 1,34,356 vehicles (1,30,479 PCUs) followed by Ram Bagh Choraha (NH-2) with 1,22,692 vehicles (1,24,837 PCUs) while the least daily traffic is observed on TDI Mall Chowk (near Hotel Trident - Fatehabad road) with 23,533 vehicles (19,812 PCUs). The survey involved 15 minutes interval direction wise classified traffic volume counts for each movement at the intersection-continuously for 16 hours (0600 hours to 2200 hours) on a typical working day.

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.

Average Daily (24 hours) and Peak Hour Traffic Characteristics

Outer Cordon survey locations are shown in **Figure 3.5**. Total daily and peak hour traffic at 10 locations is presented in **Table 3.4**. It is observed that the traffic varies from 3,075 Vehicle (4,140PCUs) at Yamuna Expressway (towards Delhi) to 39,955 Vehicle (52,585 PCU's) at NH-2 (towards Kanpur) on a normal working day. The morning peak hour volume varies from 227 vehicles (277 PCUs) to 3,601 vehicles (4,690 PCUs).

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

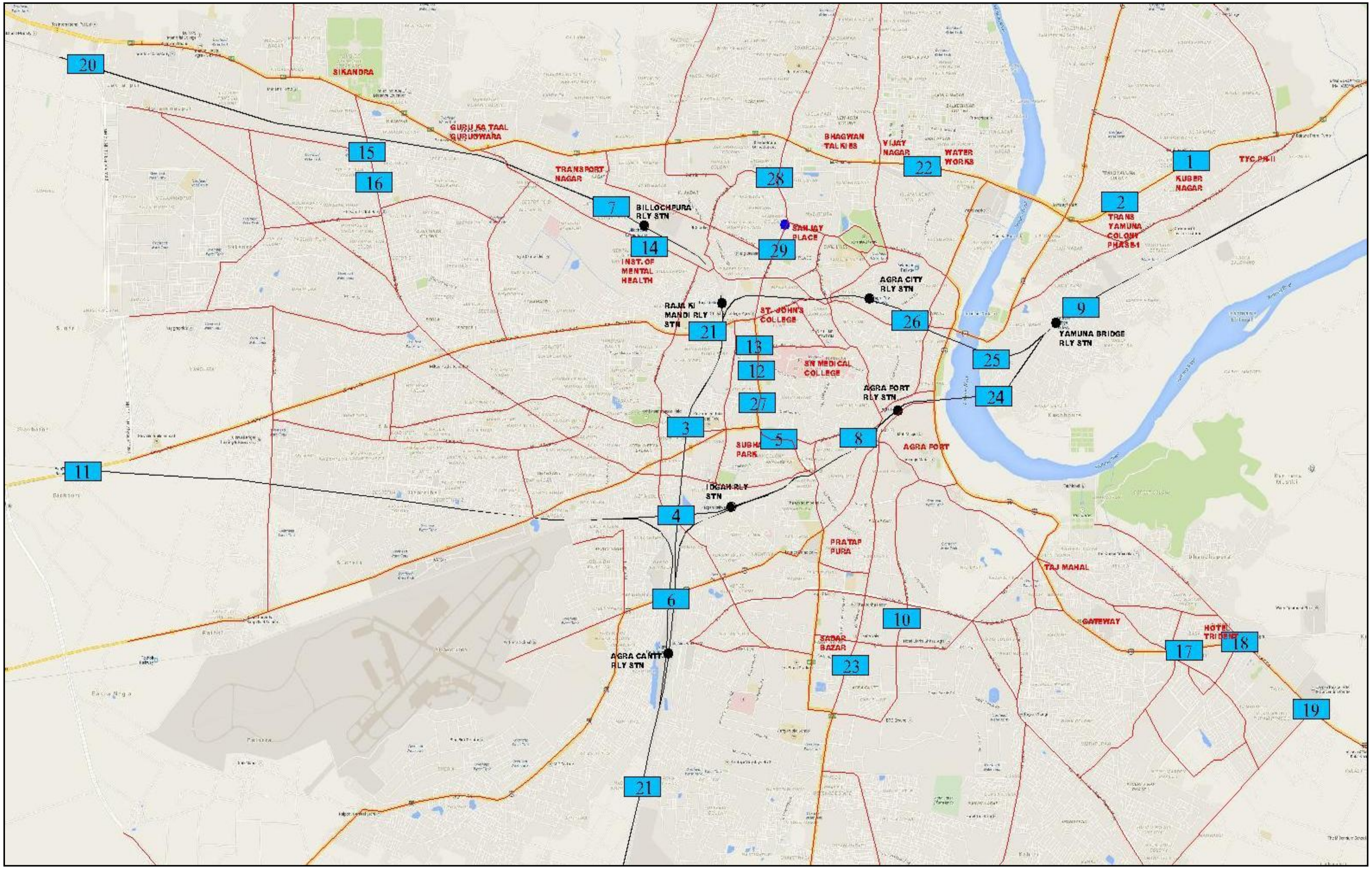


TABLE 3.2: INTENSITY AND DIRECTIONAL DISTRIBUTION OF TRAFFIC AT MID-BLOCK/SCREEN LINE LOCATIONS

SN	Name of Mid-Block/Screen Line 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	NH-2, Near Trans Yamuna Colony- Phase 1	71173	75732	5312	7.5	5382	7.1	7178	10.1	7165	9.5	3899	54.4	3266.0	45.6
2	NH-2, Near Trans Yamuna Colony- Phase 2	82898	86985	8377	10.1	8323	9.6	11010	13.3	10517	12.1	5945	71.4	2378.5	28.6
3	Near GIC Ground (M.G. Road-2)	28261	26116	2177	7.7	2280	8.7	1837	6.5	1650	6.3	1512	66.3	768	33.7
4	Near Idgah Railway station	11973	7849	1378	11.5	878	11.2	566	4.7	413	5.3	476	54.2	401.5	45.8
5	Dhakran (M.G.Road)	47084	39733	4065	8.6	3750	9.4	4285	9.1	3462	8.7	1942	51.8	1808	48.2
6	ROB at NH-39 (near Overhead Water Tank)	19654	15183	2154	11.0	1630	10.7	1755	8.9	1312	8.6	840	51.5	790	48.5
7	Near Bilochpura Railway Station	6321	4050	829	13.1	535	13.2	409	6.5	235	5.80	299	55.9	236	44.1
8	Near Bijli Ghar Crossing	25766	21563	4056	15.7	3324	15.4	1708	6.6	1386	6.4	1670	50.2	1654.5	49.8
9	Near Yamuna Bridge Railway station	16419	12200	1507	9.2	1171	9.6	1200	7.3	907	7.4	775	66.2	395.5	33.8
10	General Cariappa Road (near B.D.Jain Girls College)	7667	7040	701	9.1	779	11.1	799	10.4	690	9.8	422	54.2	357	45.8
11	Bichpuri Fatak	10661	22261	1554	14.6	3289	14.8	748	7.0	1561	7.0	1809	55.0	1479.5	45.0
12	Agra College (near S.N.Medical College)	15137	11469	1436	9.5	1150	10.0	1110	7.3	799	7.0	595	51.8	554.5	48.2
13	Kinari Bazaar Chowk towards Raja Ki Mandi	4565	3127	504	11.0	318	10.2	872	19.1	652	20.9	349	53.5	304	46.5
14	Institute of Mental Health (near Entry Gate)	13748	9101	1067	7.8	698	7.7	1370	10.0	885	9.7	499	56.3	387	43.7
15	UPSIIDC (ROB near Sikandara)	20407	17100	1995	9.8	1671	9.8	1813	8.9	1586	9.3	1155	69.1	516	30.9
16	Hans Chowk towards Bodla	16208	13502	1202	7.4	1023	7.6	1527	9.4	1339	9.9	793	59.2	546	40.8
17	Hilton chowk (Staggered- Fatehabad road)	18907	15911	1850	9.8	1503	9.4	1548	8.2	1371	8.6	766	51.0	736.5	49.0

SN	Name of Mid-Block/Screen Line 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)	%
18	Hyundai Factory Chowk - Fatehabad Road	10028	8123	1481	14.8	1214	14.9	798	8.0	688	8.5	638	52.6	575.5	47.4
19	Tora Police Chowki (near Jaypee Palace hotel - Fatehabad road)	22222	23026	3085	13.9	3202	13.9	2442	11.0	2471	10.7	1678	52.4	1523.5	47.6
20	Runkata (Near ROB)	7933	8454	868	10.9	903	10.7	692	8.7	889	10.5	512	56.7	391	43.3
21	Loha Mandi Pul (between Raja Ki Mandi and St. John's College chowk)	17918	16718	1893	10.6	1582	9.5	1425	8.0	1362	8.1	957	60.5	625	39.5
22	Kamla Nagar (T- Point along NH-2)	73812	76992	4622	6.3	4856	6.3	8741	11.8	8759	11.4	4898	55.9	3862	44.1
23	Naulakha	25053	23928	2948	11.8	2607	10.9	3954	15.8	3516	14.7	1795	51	1721	49
24	Rail Bridge (Itimad-Ud- Daullah to NH-3)	6936	7335	1063	15.3	1007	13.7	479	6.9	664	9.1	618	61.4	389	38.6
25	Moti Mahal	3001	2329	397	13.2	305	13.1	366	12.2	310	13.3	153	50.1	152	49.9
26	Near Corporation Bank, Belanganj	16463	13616	1426	8.7	1121	8.2	1466	8.9	1219	8.9	623	51.1	596	48.9
27	Naal Band Choraha - M.G. Road	60452	49280	8335	13.8	7623	15.5	4381	7.2	3496	7.1	3836	50.3	3787.5	49.7
28	Diwani Chowk - M.G. Road	58593	51053	7985	13.6	6996	13.7	3841	6.6	3458	6.8	4123	58.9	2873	41.1
29	Khandori Mod (near Shri Ram Hospital - M.G.Road)	19911	14812	1835	9.2	1358	9.2	2544	12.8	1863	12.6	1018	54.6	845	45.4
30	Nagla Kachhan Railway Fatak	1977	1546	294	14.9	246	15.9	133	6.7	114	7.3	133	54.0	113	46.0
31	Ramratan Road	4004	2567	344	8.6	205	8.0	384	9.6	239	9.3	138	67.1	67.5	32.9

FIGURE 3.4: TURNING MOVEMENT COUNT SURVEY LOCATIONS

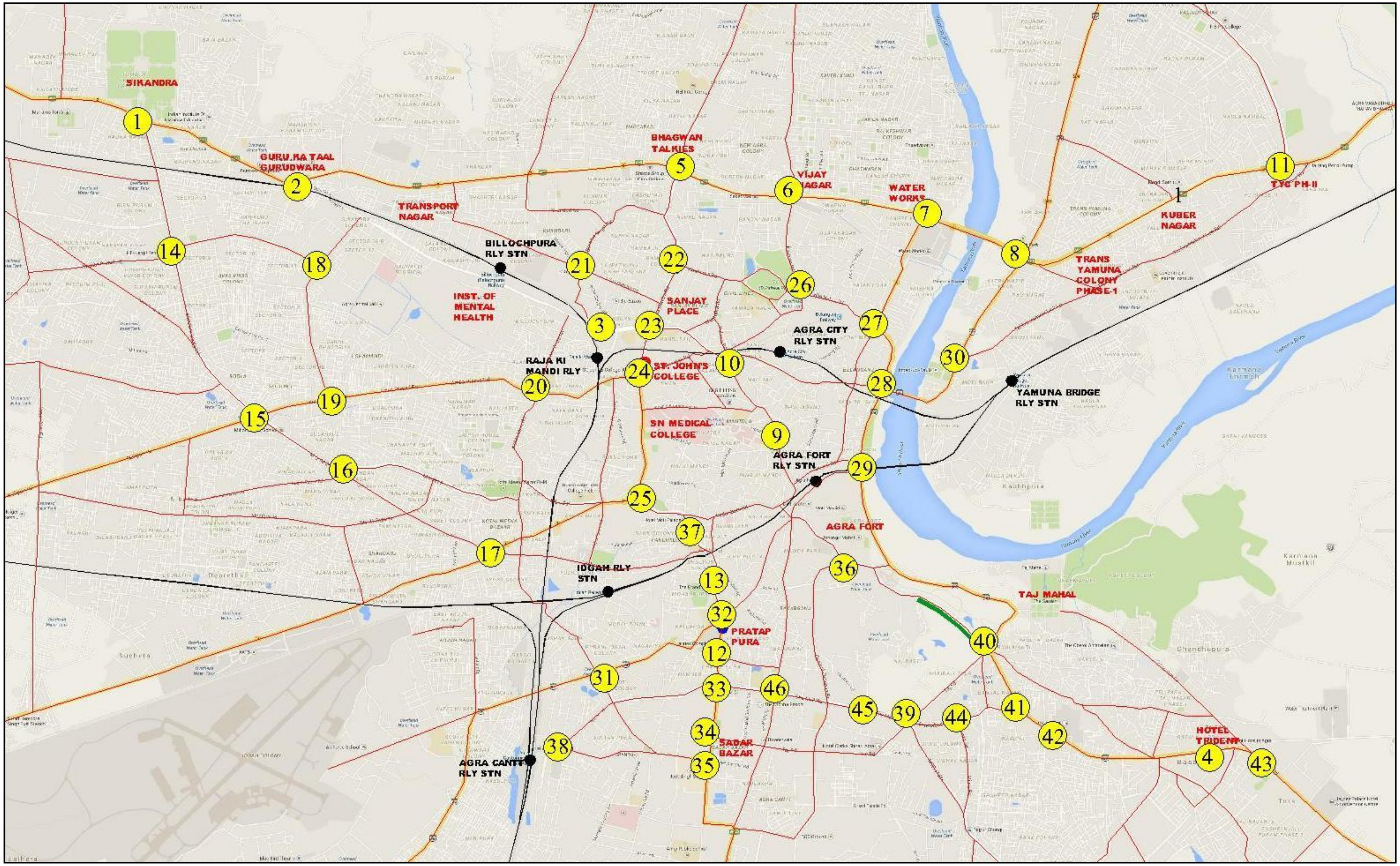


TABLE 3.3: DAILY AND PEAK HOUR TRAFFIC AT INTERSECTIONS

SN	Name of Intersection	Total Traffic		Morning Peak				Evening Peak			
		(Veh.)	(PCU's)	(Veh.)	% of Total Traffic	(PCU's)	% of Total Traffic	(Veh.)	% of Total Traffic	(PCU's)	% of Total Traffic
1	Sikandara	57311	75833	4639	8.1	6888	9.1	4714	8.2	5834	7.7
2	Guru Ka Taal	60158	66408	8038	13.4	8198	12.3	4712	7.8	6029	9.1
3	Guru agrasen Chowk (near Raja Ki Mandi Rly. Station)	49183	36530	3954	8.0	2988	8.2	6147	12.5	4461	12.2
4	TDI Mall Chowk (near Hotel Trident - Fatehabad road)	23533	19812	2254	9.6	1855	9.4	1962	8.3	1716	8.7
5	Bhagwan Talkies	134356	130479	16522	12.3	15927	12.2	18195	13.5	17443	13.4
6	Sultan Ganj Ki Puliya (Vijay Nagar crossing on NH-2)	97320	96076	6808	7.0	6568	6.8	11257	11.6	10601	11.0
7	Water Works Junction- NH-2	109407	109105	6963	6.4	6891	6.3	16955	15.5	16262	14.9
8	Ram Bagh Choraha - NH-2	122692	124837	9915	8.1	8970	7.2	10998	9.0	10765	8.6
9	Fuwara Chowk (Kinari Bazaar Road)	27725	19618	2231	8.0	1601	8.2	2053	7.4	1418	7.2
10	Ghatia Azam Khan Chowk (near Agra City Railway Station - Kinari Bazaar Chowk)	45327	30542	3821	8.4	2527	8.3	4051	8.9	2733	8.9
11	100 Feet Rd Junction - NH-2	74135	78401	5574	7.5	5600	7.1	7383	10.0	7329	9.3
12	Pratapura chowk - M.G. Road	65493	56888	9143	14.0	8127	14.3	5479	8.4	4582	8.1
13	Chhipitola chowk - M.G. Road	67691	55861	7375	10.9	5652	10.1	5871	8.7	4791	8.6
14	Kargil Choraha (Staggered) (on Bodla Road)	74650	59734	4389	5.9	3380	5.7	9314	12.5	7337	12.3
15	Bodla Choraha	86628	65008	6789	7.8	5262	8.1	7411	8.6	5624	8.7
16	Maruti Estate Choraha (M.G. Road -2)	60525	45279	4392	7.3	3172	7.0	4812	8.0	3492	7.7
17	Bhogipura Choraha	51946	39360	4772	9.2	3523	8.9	4111	7.9	3044	7.7
18	Sector- 12C Chowk	41107	32982	3393	8.3	2598	7.9	3639	8.9	2909	8.8
19	Sector- 4 - T Junction (near Hanuman Mandir)	35555	26827	3244	9.1	2674	10.0	2695	7.6	1829	6.8
20	Khatipara (Amba Prasad Road)	49012	37946	4270	8.7	3334	8.8	3610	7.4	2853	7.5
21	RBS College Chowk	54650	43012	5110	9.4	4075	9.5	6891	12.6	5642	13.1
22	Soor Sadan Chowk (Sanjay Place) - M.G. Road	117140	100557	15763	13.5	13515	13.4	8388	7.2	7439	7.4
23	Hari Parvat Chowk - M.G. Road	111431	88839	7570	6.8	5936	6.7	17406	15.6	14075	15.8
24	St. John's College Chowk - M.G. Road	116883	85622	15865	13.6	11561	13.5	9454	8.1	6753	7.9

SN	Name of Intersection	Total Traffic		Morning Peak				Evening Peak			
		(Veh.)	(PCU's)	(Veh.)	% of Total Traffic	(PCU's)	% of Total Traffic	(Veh.)	% of Total Traffic	(PCU's)	% of Total Traffic
25	Subhash Park - M.G. Road	76856	58742	13755	17.9	10654	18.1	5468	7.1	4028	6.9
26	Paliwal Chowk (near Paliwal Park)	29892	22771	3940	13.2	2963	13.0	2140	7.2	1615	7.1
27	Jeoni Mandi Chowk	38562	33923	3744	9.7	3223	9.5	5436	14.1	4883	14.4
28	New Yamuna Park Chowk	31056	28307	3499	11.3	3312	11.7	2483	8.0	2263	8.0
29	Haathi Ghat Chowk	50404	41292	3987	7.9	3295	8.0	4080	8.1	3181	7.7
30	Itimad- ud - Daullah Chowk	24603	21804	2391	9.7	2084	9.6	1961	8.0	1713	7.9
31	Idgah Chowk	53973	41452	4296	8.0	3221	7.8	4958	9.2	3701	8.9
32	Sai Ki takia Chowk - M.G. Road	87000	74145	6195	7.1	5208	7.0	8277	9.5	6887	9.3
33	Avanti Bai Chowk - M.G. Road	75470	67876	9819	13.0	8956	13.2	5779	7.7	5143	7.6
34	Sadar Bazaar Chowk - M.G. Road	49245	43243	3935	8.0	3526	8.2	4434	9.0	3983	9.2
35	Solanki Market Chowk	57527	54195	5009	8.7	4434	8.2	8310	14.4	7468	13.8
36	Agra Fort	32842	27163	3162	9.6	2650	9.8	2332	7.1	1804	6.6
37	Collectorate chowk - M.G. Road	63515	52447	4578	7.2	3841	7.3	6155	9.7	4985	9.5
38	Agra Cantt. Railway Station Chowk	34791	30722	4517	13.0	3858	12.6	3053	8.8	2574	8.4
39	Phool Sayyed Ka Choraha	28493	23290	2095	7.4	1670	7.2	2547	8.9	2016	8.7
40	Purani Mandi Chowk (Taj Mahal West Gate entry)	32341	26846	2359	7.3	1950	7.3	2755	8.5	2271	8.5
41	Dikshit Chowk (near Hotel Gateway)	55345	53990	4612	8.3	4740	8.8	5547	10.0	5368	9.9
42	Sabha Kalyan Chowk (Fatehabad Road)	23810	20289	2802	11.8	2330	11.5	2221	9.3	1836	9.0
43	Poorvi Gate Chowk (Taj Mahal East Gate entry road near Hotel Trident)	33750	31623	5031	14.9	4658	14.7	2180	6.5	2041	6.5
44	Shamsabad Chowk (Mall Road - Minto Road Crossing near Hotel Amar Inn)	41672	32772	3528	8.5	2734	8.3	3965	9.5	3016	9.2
45	Commissioner Agra Mandal Residence choraha (Mall road)	54079	44763	6904	12.8	5639	12.6	4314	8.0	3587	8.0
46	Mahal Talkies Chowk (Mall Road)	77087	65349	9051	11.7	7333	11.2	7039	9.1	5804	8.9
47	After Kargil chowk (near eat mandi)	40635	36467	2833	7.0	2501	6.9	3590	8.8	3091	8.5
48	Nand chowk	48157	41822	3941	8.2	3358	8.0	5061	10.5	4308	10.3
49	Victoria Chowk	31835	27785	3347	10.5	2822	10.2	2947	9.3	2525	9.1
50	Ram Nagar Puliya	63574	49757	5721	9.0	4368	8.8	4923	7.7	3820	7.7

FIGURE 3.5: OUTER CORDON LOCATIONS

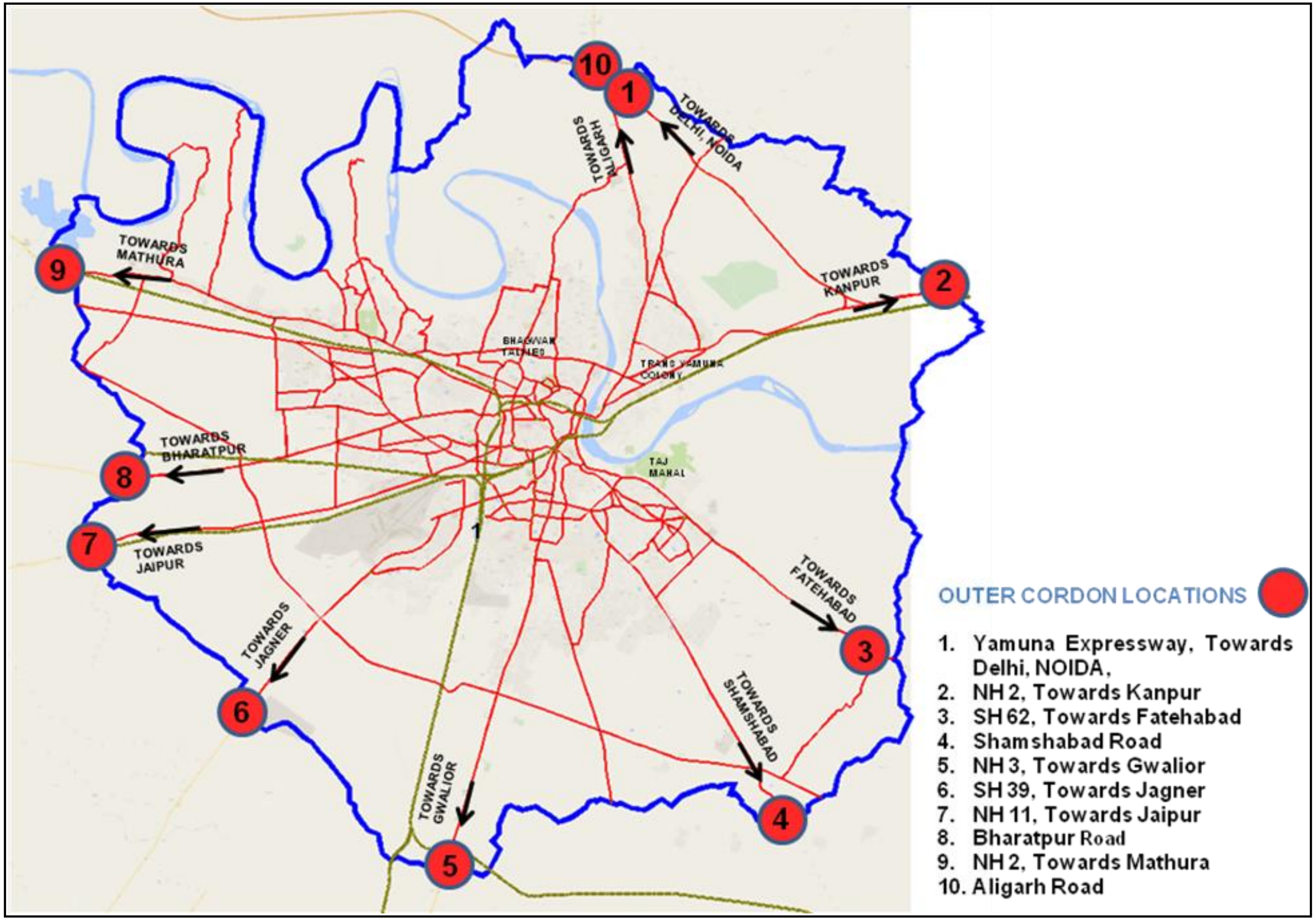


TABLE 3.4: INTENSITY AND DIRECTIONAL DISTRIBUTION OF TRAFFIC AT OUTER CORDON LOCATIONS

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	Yamuna Expressway (towards Delhi)	3075	4140	227	7.4	277	6.7	218	7.2	260	6.3	157	56.6	120	43.3
2	NH-2 (towards Kanpur)	39955	52585	3601	9.0	4690	8.9	2786	6.9	3720	7.1	2352	50.1	2338	49.9
3	SH-62 (towards Fatehabad)	13503	13573	930	6.9	783	5.8	1152	8.5	1185	8.7	413	52.7	573	73.2
4	Shamshabad road	10348	10669	867	8.4	914	8.6	780	7.5	870	8.2	499	54.6	415	45.4
5	NH-3 (towards Gwalior)	20471	33083	1842	9	2746	8.3	1336	6.5	2205	6.7	2033	74.0	713	25.9
6	SH-39 (towards Jagner)	15057	12828	1377	9.2	1178	9.2	1292	8.6	1073	8.4	789	67.0	389	32.9
7	NH-11 (towards Jaipur)	11160	11236	1058	9.5	908	8.1	1080	9.7	1020	9.1	683	75.2	225	24.8
8	Bharatpur road	12690	29612	835	6.6	1766	5.9	748	5.9	1556	5.3	1025	58.0	741	41.9
9	NH-2 (towards Mathura)	26204	42520	1603	6.1	2047	4.8	1059	4.0	2002	4.7	1145	55.9	902	44.1
10	Aligarh road	16508	25758	1256	7.6	1861	7.2	920	5.6	1684	6.5	935	50.2	926	49.8

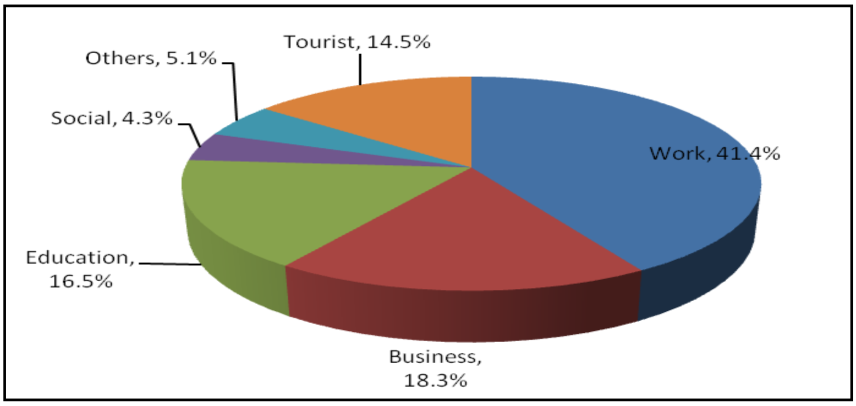
3.1.3.2 Road Side Origin and Destination Interviews at Outer Cordon Locations

Purpose wise distribution of passengers at outer cordon locations is given in **Table 3.5** and **Figure 3.6.** It is observed that the share of work and business purpose trips is about 60%. The educational purpose trips contribute to about 17% at outer cordon location.

TABLE 3.5: DISTRIBUTION OF OUTER CORDON PASSENGERS BY TRIP PURPOSE AND MODE

SN	Mode	Work	Business	Education	Social	Others	Tourist	Total
1	Car	24535	3775	2918	1171	1380	5240	39019
2	2-Wheeler	41456	2074	24093	2944	6282	23157	100007
3	Auto	39666	48911	10533	8207	4543	18214	130074
4	Bus	19973	1180	14884	1537	4758	4932	47264
5	Mini Bus	36866	15806	12489	2972	2998	5366	76496
Total		**162495**	**71745**	**64917**	**16832**	**19962**	**56909**	**392860**
Composition (%)		**41.4**	**18.3**	**16.5**	**4.3**	**5.1**	**14.5**	**100.0**

FIGURE 3.6: DISTRIBUTION OF OUTER CORDON PASSENGERS BY TRIP PURPOSE

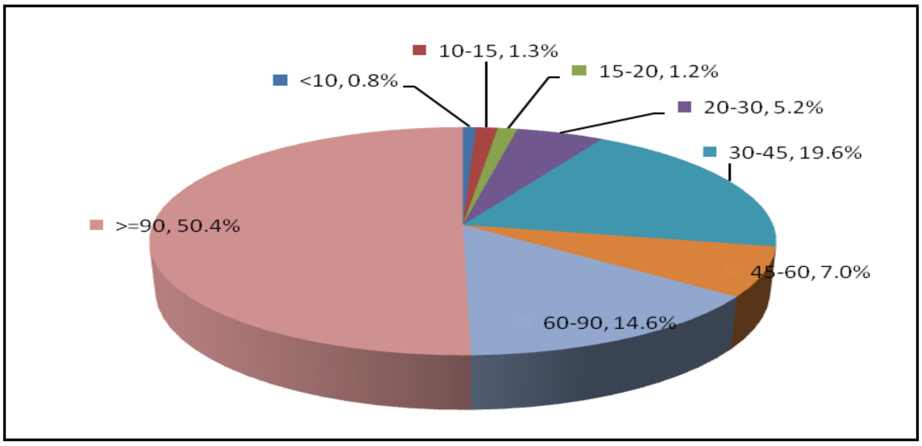


It is observed from **Table 3.6** and **Figure 3.7** that travel time of about 9% of total passengers is upto 30 minutes. About 41% of total passengers' travel time ranges between 30-90 minutes and about 50% of total passengers' travel time is found to be more than 90 minutes at outer cordon locations.

TABLE 3.6: DISTRIBUTION OF OUTER CORDON PASSENGERS BY TRAVEL TIME

S. No	Mode	Distribution of Trips by their Travel Time (In Mins.)								Total
		<10	10-15	15-20	20-30	30-45	45-60	60-90	>90	
1	Car	141	269	876	6098	20996	6184	4455	-	39019
2	2-Wheeler	-	-	176	1400	7511	6383	17096	67441	100007
3	Auto	645	1220	1617	6954	21396	6393	8890	82959	130074
4	Bus	-	-	216	786	5126	2751	11371	27014	47264
5	Mini Bus	2243	3572	1702	5115	21994	5848	15553	20469	76496
Total		**3028**	**5061**	**4586**	**20353**	**77023**	**27558**	**57366**	**197884**	**392860**
Composition (%)		**0.8**	**1.3**	**1.2**	**5.2**	**19.6**	**7.0**	**14.6**	**50.4**	**100.0**

FIGURE 3.7: DISTRIBUTION OF OUTER CORDON PASSENGERS BY TRAVEL TIME



Distribution of Passengers by trip length is presented in **Table 3.7**. It is observed that about 65% of passengers have trip length more than 30 Km.

TABLE 3.7: DISTRIBUTION OF OUTER CORDON PASSENGERS BY TRIP LENGTH

SN	Mode	Distribution of Trips by Travel Distance (In Km)								Total
		<5	5-8	8-10	10-15	15-20	20-25	25-30	>=30	
1	Car	2282	3431	1558	4162	5107	6439	5813	101283	130074
2	2-Wheeler	5881	6267	3397	6939	7840	7666	5216	33291	76496
3	Auto	1320	4424	3829	11407	7364	4954	3181	2540	39019
4	Bus	-	-	-	1753	1934	8251	4556	83513	100007
5	Mini Bus	-	659	326	1112	725	5866	3606	34969	47264
Total		9483	14781	9110	25373	22970	33176	22372	255596	392860
Composition %		2.4%	3.8%	2.3%	6.5%	5.8%	8.4%	5.7%	65.1%	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 Agra. 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.

Willingness to Pay Survey at Bus Terminals

It is observed that about 44650 (94.1%) 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 28% respondents want the existing fare for new public transport as same as existing fare. Only 5% of respondents are showing their willingness to pay more than Rs.15 as extra fare for MRTS in comparison to existing fare.

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

Parameters	Extra as compared to Existing Mode Fare (Rs.)									Total
	Same as Existing Mode Fare	2	5	10	12	15	20	25	>25	
Bus Passengers	12593	7368	9467	7770	3885	1384	715	402	1072	44657
Composition (%)	28.2	16.5	21.2	17.4	8.7	3.1	1.6	0.9	2.4	100.0

Willingness to Pay Survey at Rail Terminals

It is observed that about 68900 (94.3%) of rail passengers have willingness to shift to MRTS. The willingness to pay extra fare to reach rail terminal by MRTS is presented in **Table 3.9**. The result indicates that about 24% respondents want the existing fare for new public transport as same as existing fare. Only 8% of respondents are showing their willingness to pay more than Rs.15 as extra fare for good MRTS system in comparison to existing fare.

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

Parameters	Extra as compared to Existing Mode Fare (Rs.)									Total
	Same as Existing Mode Fare	2	5	10	12	15	20	25	>25	
Rail Passengers	16813	12334	13850	11370	8889	2687	1378	758	827	68907
Composition(%)	24.4	17.9	20.1	16.5	12.9	3.9	2	1.1	1.2	100.0

Willingness to Pay Survey at PT/IPT Stops

It is observed that 159590 (93%) of surveyed passengers have willingness to shift to MRTS. The willingness to pay extra fare for MRTS System is presented in **Table 3.10**. The result indicates that 26% respondents want the existing fare for new public transport as same as existing fare. About 29% of respondents are showing their willingness to pay more than Rs.10 as extra fare for MRTS system in comparison to existing fare.

TABLE 3.10: WILLINGNESS TO PAY EXTRA FARE FOR REACHING PT/IPT STOPS

Parameters	Extra as compared to Existing Mode Fare (Rs.)									Total
	Same as Existing PT/IPT Fare	2	5	10	12	15	20	25	>25	
PT/IPT Passengers	40698	20647	27113	24907	26011	5470	2236	7914	4593	159590
Composition(%)	25.5	12.9	17.0	15.6	16.3	3.4	1.4	5.0	2.9	100.0

3.1.3.4 Speed-Delay Surveys

The Speed and delay survey was conducted along the road 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 is observed that about 18% of the total road network has journey speeds less than 20 kmph during peak hours inside the core city. Average Journey Speed during peak period for a city as a whole is observed to be 25.3 kmph.

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

SN	Journey Speed (Kmph)	Road Length (Km)	Percentage (%)
1	<10	16.4	3.9
2	10-20	57.7	13.9
3	21-30	174.9	42.2
4	31-40	129.9	31.3
5	**>40**	**35.5**	**8.7**
	Total	**414.4**	**100.0**

ii. Running Speed

The distribution of road length by Peak hour running speed is given in **Table 3.12**. It can be observed that about 45% of the road network has running speeds between 21-30 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	11.1	2.7
2	10-20	50.7	12.2
3	21-30	185.6	44.8
4	31-40	129.3	31.2
5	>40	37.7	9.1
	Total	**414.4**	**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 signal which account for about 64% in the peak hour. Whereas in the off peak period, traffic signal accounts for 68%.

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

SN	Causes of Delays	Peak Hour		Off Peak Hour	
		No. of Points	%	No. of Points	%
1	Traffic Signals	25	64.1	13	68.4
2	Traffic Congestion	2	5.1	2	10.5
3	Traffic Signal+ Congestion	10	25.6	2	10.5
4	Railway Crossing	2	5.1	2	10.5
Total		**185**	**100.0**	**85**	**100.0**

3.1.3.5 Parking Surveys

The parking surveys have been conducted at 63 locations at identified on-street parking stretches 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 with maximum concentration is observed to be at Agra Cantt. Railway station (265 E.C.S.). The total parking demand over the day at the main parking stretches was observed to be about 5214 E.C.S. with maximum demand being observed at Agra Cantt. Railway station.

ii. Parking Demand

Table 3.15 indicates that parking demand is high at many locations and parking demand outstrips parking supply. Many locations have on street parking provisions which in turn reduces the effective carriageway width and affects the smooth movement of the traffic.

TABLE 3.14: PEAK HOUR PARKING ACCUMULATION

	Name of Location	Time	Side	Peak Accumulation				Equivalent Car Spaces (ECS)	Parking Type
				Car	2-Whlr.	Auto	Cycle		
1	Sikandra	04.00-04.30	-	19	38	0	1	29	Off Street
2	Transport Nagar ISBT (Bus Stand)	10.00-10.30	-	6	8	5	3	14	Off Street
3	Raja Ki Mandi Railway Station (Jwala Devi Mandir)	05.30-06.00	-	6	87	19	0	47	Off Street
4	St. John’s College	04.00-04.30	-	17	200	0	7	69	Off Street
5	S.N. Medical College	08.00-08.30	-	60	298	10	36	154	Off Street
6	Subhash Park	09.30-10.00	-	11	9	0	3	14	Off Street
7	Agra Fort Railway Station	01.30-02.00	-	9	136	0	12	46	Off Street
8	Agra Fort	10.00-10.30	-	52	16	0	7	58	Off Street
9	Taj Mahal Parking - West	12.30-01.00	-	141	44	7	0	159	Off Street
10	Agra Cantt. Railway Station (Bus Stop Parking)	05.30-06.00	-	17	43	0	2	28	Off Street
11	Nagar Nigam	12.30-01.00	-	26	131	2	0	61	Off Street
12	Sadar Bazar	07.30-08.00	Both	137	171	0	14	183	On Street
13	Taj Mahal - East Gate	01.30-02.00	-	35	67	10	0	62	Off Street
14	I'timād-ud-Daulah	01.30-02.00	LHS	16	10	0	0	19	On Street
15	Shahdra Chungi (NH-2,LHS Side)	10.00-10.30	RHS	6	38	5	9	23	On Street
16	Truck Garage (Transport Nagar)	10.00-10.30	Both	4	7	14	0	20	On Street
17	Idgah Railway Station (Police Lines Side)	11.30-12.00	-	21	40	16	0	47	Off Street
18	Thomsan Hostel (MG Road,Near S.N Medical College)	07.30-08.00	RHS	14	34	0	3	23	On Street
19	TDI Mall (Hotels) Fatehabad Road	04.00-04.30	RHS	12	27	0	0	19	On Street
20	Gura Ka Taal (NH-2,Gurudwara)	03.30-04.00	-	6	30	0	2	14	Off Street
21	Bhagwan Talkies (Towards Dayalbagh)	06.30-07.00	Both	35	65	27	30	86	On Street
22	Bailghar Radha Swami Satsang(Dayalbagh Road)	07.00-07.30	-	15	15	0	0	19	Off Street

	Name of Location	Time	Side	Peak Accumulation				Equivalent Car Spaces (ECS)	Parking Type
				Car	2-Whlr.	Auto	Cycle		
23	Bodla Chowk (Bodla Road)	12.00-12.30	RHS	13	29	16	16	40	On Street
24	Nehru Nagar (near Woodland Showroom)	06.30-07.00	RHS	18	28	0	7	27	On Street
25	Nehru Nagar Market	01.00-01.30	LHS	30	40	4	15	48	On Street
26	Nehru Nagar (near Anjana Cinema)	04.30-05.00	LHS	9	50	0	30	29	On Street
27	Shah Market - M.G Road (LHS)	04.00-04.30	LHS	8	90	0	30	38	On Street
28	Shah Market - M.G Road (RHS)	04.30-05.00	RHS	10	95	0	25	40	On Street
29	Collectorate	01.30-02.00	-	30	258	1	0	96	Off Street
30	Court	12.30-01.00	-	56	235	1	0	116	Off Street
31	RTO Office	02.30-03.00	-	18	197	2	2	70	Off Street
32	Shahjahan Garden	03.00-03.30	-	15	27	5	0	27	Off Street
33	Agra Cantt. Railway Station (Main Gate Parking)	12.30-01.00	-	178	97	55	30	265	Off Street
34	Sadar Bazar (near Café Coffe Day)	07.30-08.00	-	119	223	0	17	179	Off Street
35	Shahdra Chungi (NH-2,LHS Side)	04.30-05.00	RHS	2	11	2	3	8	On Street
36	Truck Garage (Transport Nagar)	10.30-11.00	-	7	4	6	0	14	Off Street
37	Idgah Railway Station (Ajmer Road Side)	11.00-11.30	-	20	40	25	0	55	Off Street
38	Guru Ka Taal (NH-2,Gurudwara)	10.00-10.30	Both	2	3	4	0	7	On Street
39	Canara Bank Head Office (Sanjay Palace)	12.00-12.30	-	22	98	0	5	48	Off Street
40	LIC (Sanjay Palace)	12.30-01.00	-	3	209	0	6	57	Off Street
41	Vikas Bhawan (Sanjay Palace)	10.30-11.00	-	25	70	0	5	44	Off Street
42	Aaykar Bhavan (Sanjay Palace)	05.00-05.30	-	29	15	2	0	35	Off Street
43	Market Parking (near Titan Showroom,Sanjay Palace)	12.00-12.30	-	22	54	0	2	36	Off Street
44	Market Parking (near Tirupati Cloths,Sanjay Palace)	12.30-01.00	-	18	54	0	6	33	Off Street
45	Market Parking (near Bachoomal Gallery,Sanjay	04.30-05.00	-	39	35	4	0	52	Off Street

	Name of Location	Time	Side	Peak Accumulation				Equivalent Car Spaces (ECS)	Parking Type
				Car	2-Whlr.	Auto	Cycle		
	Palace)								
46	Market t Parking (near State Bank Atm,Sanjay Palace)	06.30-07.00	-	35	50	0	0	48	Off Street
47	Market Parking (near Nigam Communication Chinese Soup Center Sanjay Palace)	03.00-03.30	-	35	50	0	1	48	Off Street
48	Market Parking (near Syndicate Bank,Sanjay Palace)	02.30-03.00	-	43	50	0	0	56	Off Street
49	Indus Bank (Sanjay Palace)	03.00-03.30	-	45	50	0	0	58	Off Street
50	Market Parking (near BSNL Office)	03.00-03.30	-	53	70	0	0	71	Off Street
51	SBI Bank (Sanjay Palace)	02.30-03.00	-	65	102	0	0	91	Off Street
52	BOB Bank (Sanjay Palace)	05.00-05.30	-	52	70	0	0	70	Off Street
53	Amway Parking (Sanjay Palace)	11.30-12.00	-	39	46	0	0	51	Off Street
54	ICICI Bank (Sanjay Palace)	04.00-04.30	-	49	80	0	0	69	Off Street
55	Max (Sanjay Palace)	05.00-05.30	-	33	80	0	0	53	Off Street
56	BOB Bank (Sanjay Palace)	05.00-05.30	-	45	60	0	0	60	Off Street
57	Market Parking (Euro-7 Showroom, Girraj Finance, Sanjay Palace)	01.30-02.00	-	30	71	0	0	48	Off Street
58	Sanjay Talkies (Sanjay Palace)	03.30-04.00		32	65	0	0	48	Off Street
59	Sanjay Palace (On Street Road No.-2)	02.00-02.30	Both	60	75	0	0	79	On Street
60	Pizza Hut (Sanjay Palace)	10.00-10.30	-	8	12	4	2	16	Off Street
61	Easy Day (Comissioner Office)	06.00-06.30	-	37	20	8	0	50	Off Street
62	Sanjay Palace (On Street Road No.-1)	05.30-06.00	Both	32	38	7	0	49	On Street
63	Raja Ki Mandi Station (RHS near Hospitals)	10.30-11.00	-	16	220	20	0	91	Off Street
	GRAND TOTAL			**2067**	**4685**	**281**	**331**	**3602**	

TABLE 3.15: PARKING DEMAND

SN	Name of Location	Car	2-Whlr	Auto	Parking Demand (ECS)
1	Sikandra	231	767	0	423
2	Transport Nagar ISBT (Bus Stand)	94	97	52	170
3	Raja Ki Mandi Railway Station (Jwala Devi Mandir)	63	1806	265	780
4	St. John's College	268	2643	0	929
5	S.N. Medical College	563	2350	103	1254
6	Subhash Park	21	259	0	86
7	Agra Fort Railway Station	142	2427	0	749
8	Agra Fort	700	442	0	811
9	Taj Mahal Parking - West	2162	887	128	2459
10	Agra Cantt. Railway Station (Bus Stop Parking)	331	1034	0	590
11	Nagar Nigam	255	1084	34	560
12	Sadar Bazar	1696	2789	0	2393
13	Taj Mahal - East Gate	749	1352	27	1114
14	I'timād-ud-Daulah	205	273	0	273
15	Shahdra Chungi (NH-2,LHS Side)	68	551	100	306
16	Truck Garage (Transport Nagar)	118	108	161	306
17	Idgah Railway Station (Police Lines Side)	297	799	191	688
18	Thomsan Hostel (MG Road,Near S.N Medical College)	150	505	1	277
19	TDI Mall (Hotels) Fatehabad Road	196	391	0	294
20	Gura Ka Taal (NH-2,Gurudwara)	180	710	29	387
21	Bhagwan Talkies(Towards Dayalbagh)	355	614	332	841
22	Bailghar Radha Swami Satsang(Dayalbagh Road)	40	85	0	61
23	Bodla Chowk (Bodla Road)	246	559	269	655
24	Nehru Nagar (near Woodland Showroom)	214	453	0	327
25	Nehru Nagar Market	522	514	18	669
26	Nehru Nagar (near Anjana Cinema)	84	653	14	261
27	Shah Market - M.G Road (LHS)	146	1325	22	499
28	Shah Market - M.G Road (RHS)	128	1319	56	514
29	Collectorate	407	2879	6	1133
30	Court	929	3255	14	1757
31	RTO Office	235	2251	69	867
32	Shahjahan Garden	183	546	122	442
33	Agra Cantt. Railway Station (Main Gate Parking)	3685	1828	1072	5214
34	Sadar Bazar (near Café Coffe Day)	1136	2769	0	1828
35	Shahdra Chungi (NH-2,RHS Side)	64	192	53	165
36	Truck Garage (Transport Nagar)	132	138	96	263
37	Idgah Railway Station (Ajmer Road Side)	350	838	198	758
38	Guru Ka Taal (NH-2,Gurudwara)	6	13	51	60
39	Canara Bank Head Office (Sanjay Palace)	312	1122	0	593

SN	Name of Location	Car	2-Whlr	Auto	Parking Demand (ECS)
40	LIC (Sanjay Palace)	45	2855	0	759
41	Vikas Bhawan (Sanjay Palace)	290	832	0	498
42	Aaykar Bhavan (Sanjay Palace)	304	324	21	406
43	Market Parking (near Titan Showroom,Sanjay Palace)	342	877	0	561
44	Market Parking (near Tirupati Cloths,Sanjay Palace)	269	825	0	475
45	Market Parking (near Bachoomal Gallery,Sanjay Palace)	560	632	28	746
46	Market t Parking (near State Bank Atm,Sanjay Palace)	441	729	0	623
47	Market Parking (near Nigam Communication Chinese Soup Center Sanjay Palace)	447	722	0	628
48	Market Parking (near Syndicate Bank,Sanjay Palace)	546	853	0	759
49	Indus Bank (Sanjay Palace)	625	724	0	806
50	Market Parking (near BSNL Office)	857	796	0	1056
51	SBI Bank (Sanjay Palace)	804	1373	0	1147
52	BOB Bank (Sanjay Palace)	728	1054	0	992
53	Amway Parking (Sanjay Palace)	618	1181	0	913
54	ICICI Bank (Sanjay Palace)	88	75	54	161
55	Max (Sanjay Palace)	476	1068	0	743
56	BOB Bank (Sanjay Palace)	493	995	0	742
57	Market Parking (Euro-7 Showroom, Girraj Finance, Sanjay Palace)	387	999	1	638
58	Sanjay Talkies (Sanjay Palace)	412	1095	0	686
59	Sanjay Palace (On Street Road No.-2)	816	1309	0	1143
60	Pizza Hut (Sanjay Palace)	61	357	35	185
61	Easy Day (Comissioner Office)	396	300	32	503
62	Sanjay Palace (On Street Road No.-1)	457	590	82	687
63	Raja Ki Mandi Station (RHS near Hospitals)	282	4096	307	1613

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
- PT/IPT Stop Surveys

i. Bus Terminal Surveys

A total of 4 Bus terminals were selected to conduct terminal survey within study area. It is observed from **Table 3.16** that Idgah Bus Terminal caters to the maximum number of passengers with 12,198 Boarding & 8,248 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	ISBT Transport Nagar	4600	4464	9064	1130 - 1230	308	309	617
2	Idgah Bus Terminal	12198	8248	20446	1745 - 1845	1037	587	1624
3	Bijlighar Bus Terminal	5710	5055	10765	0845 - 0945	407	430	837
4	Water Works	4652	2509	7161	1000 - 1100	554	218	772
Total		**27160**	**20276**	**47436**		**2306**	**1544**	**3850**

Origin Destination Survey at Bus Terminals

It is observed from **Table 3.17** that work trips contribute about 49% of total trips. Distribution of passenger trips by purpose is presented in **Figure 3.8**.

TABLE 3.17: DISTRIBUTION OF BUS PASSENGERS BY TRIP PURPOSE

Trip Purpose	Service	Business	Education	Social	Others	Total
Bus Passengers	7942	15140	5030	6478	12845	47436
Composition (%)	16.7	31.9	10.6	13.7	27.1	100.0

FIGURE 3.8: DISTRIBUTION OF BUS PASSENGERS BY TRIP PURPOSE

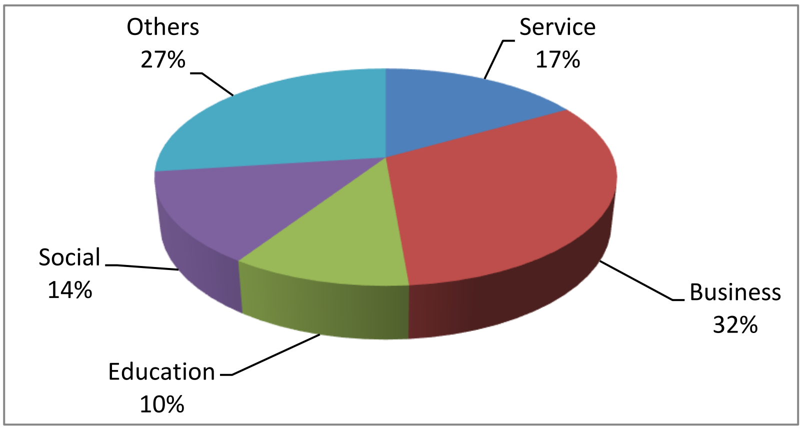


Table 3.18 shows that about 21% of passengers used auto to reach bus terminal. The share of 2-Wheeler and Car is about 37% and 29% respectively.

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

Mode	Car	2 Wlr	Auto	Bus	Mini Bus	School Bus	Chartered Bus	Cycle	Cycle Rikshaw	Walk	E-Rikshaw	Total
Bus Passengers	13610	17459	9767	2967	1385	565	1338	158	57	19	89	47436
Composition (%)	28.7	36.8	20.6	6.3	2.9	1.2	2.8	0.3	0.1	22.0	0.2	100.0

ii. Rail Terminal Surveys

A total of 4 Rail terminals were selected to conduct terminal survey spread over the entire study area. It is observed from **Table 3.19** that Agra Cantt. railway station caters to the maximum number of passengers with 18,221 boarding & 10,824 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	Agra Fort Railway Station	8655	10971	19626	1730 - 1830	654	679	1333
2	Raja Ki Mandi Railway Station	7434	6984	14418	1900 - 2000	732	582	1314
3	Idgah Railway Station	4881	5071	9952	0930 - 1030	677	803	1480
4	Agra Cant Railway Station	18221	10824	29045	1930-2030	890	874	1764
	Total	**39191**	**33850**	**73041**		**2953**	**2938**	**5891**

Origin Destination Survey at Rail Terminals

It is observed from **Table 3.20** that trips purpose for service and business together contributes to about 40%. Distribution of passenger trips by purpose is presented in **Figure 3.9**.

TABLE 3.20: DISTRIBUTION OF RAIL PASSENGERS BY TRIP PURPOSE

Trip Purpose	Service	Business	Education	Social	Others	Total
Rail Passengers	14308	14926	12405	9082	22319	73041
Composition (%)	19.6	20.4	17.0	12.4	30.6	100.0

FIGURE 3.9: DISTRIBUTION OF RAIL PASSENGERS BY TRIP PURPOSE

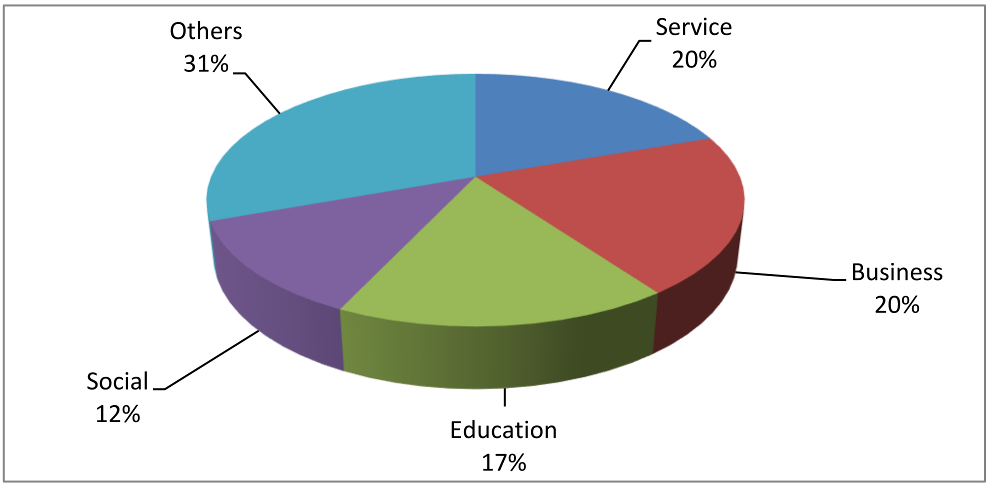


Table 3.21 shows that about 29% of passengers used auto to reach rail terminal. 2-Wheeler and Bus contributes about 34% and 10% respectively.

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

Mode	Car	2-Whlr	Auto	Bus	Mini Bus	School Bus	Chartered Bus	Cycle	Cycle Rickshaw	Train	Walk	E-Rickshaw	Total
Rail Passengers	6816	24577	21134	7319	8444	205	569	245	113	3322	136	162	73041
Composition (%)	9.3	33.6	28.9	10.0	11.6	0.3	0.8	0.3	0.2	4.5	0.2	0.2	100.0

iii. PT/ IPT Stop Survey

A total of 73 stops were selected in the entire study area. It is observed from **Table 3.22** that IPT stop at Water Works (Rambagh to Bhagwan Talkies) caters to the maximum number of passengers viz. 2,394 boarding & 2,481 alighting.

Origin Destination Survey at PT/IPT Stops

It is observed from **Table 3.23** that the share of service purpose trips is about 28%, followed by educational trips which contribute to 17%. Distribution of passenger trips by purpose is presented in **Figure 3.10**.

TABLE 3.22: DISTRIBUTION OF PT/IPT PASSENGERS BY TRIP PURPOSE

Trip Purpose	Service	Business	Education	Social	Others	Total
PT/IPT Passengers	48424	27501	28184	14686	52467	171263
Composition (%)	28.3	16.1	16.5	8.6	30.6	100.0

FIGURE 3.10: DISTRIBUTION OF PT/IPT PASSENGERS BY TRIP PURPOSE

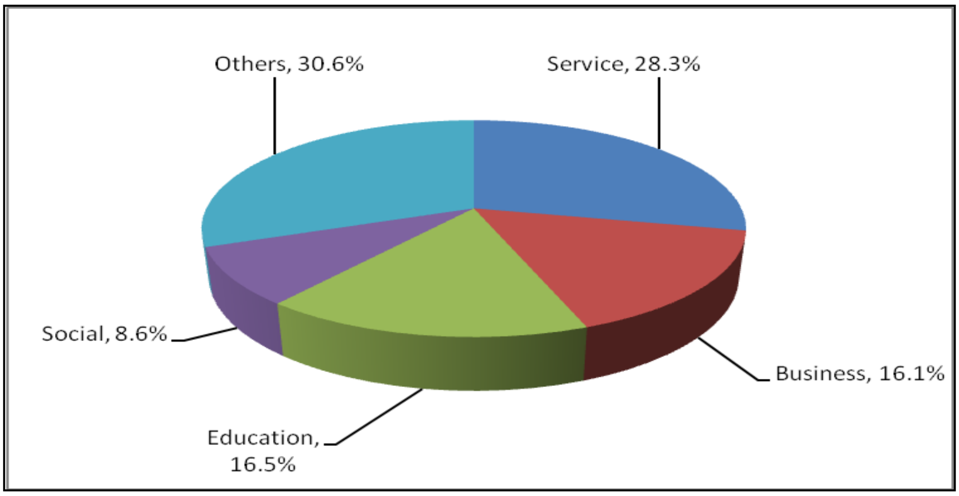


TABLE 3.23: DISTRIBUTION OF PASSENGER AT PT / IPT STOPS

SN	Mode	Name of Location	Total Boarding	Total Alighting	Total (B+A)	Peak Time	Peak Hour Boarding	Peak Hour Alighting	Peak Hour (B+A)
1	Bus	Bhagwan Talkies	2358	1335	3693	0915 - 1015	280	107	387
2	Bus	Water Works (Bhagwan Talkies - Rambagh)	2017	1771	3788	1745 - 1845	217	183	400
3	Bus	Sikandara	1451	1614	3065	1815 - 1915	182	173	355
4	Bus	Nalband Chowk	1273	1233	2506	1745 - 1845	137	157	294
5	Bus	Agra Cantt. Railway Station	958	1015	1973	1730 - 1830	155	124	279
6	Bus	Sai Ki Takiya	1249	1088	2337	1900 - 2000	178	49	227
7	Bus	Pratap Pura Chowk	812	389	1201	1745 - 1845	107	30	137
8	Bus	Guru Ka Taal	1141	701	1842	0915 - 1015	110	93	203
9	Bus	Raja Ki Mandi	1176	917	2093	1700 - 1800	144	102	246
10	Bus	St. John's Clg.	1384	1306	2690	0945 - 1045	382	224	606
11	Bus	Hari Parwat	1247	996	2243	1630 - 1730	145	112	257
12	Bus	Sanjay Place	818	789	1607	1745 - 1845	85	65	150
13	Bus	Sultan Ganj Ki Puliya	1191	865	2056	1715 - 1815	158	111	269
14	Bus	I'timād-ud-Daulah	1150	998	2148	1715 - 1815	157	128	285
15	Bus	Transport Nagar	1459	1825	3284	1715 - 1815	248	194	442
16	Bus	Purani Mandi	1344	1066	2410	0830 - 0930	181	154	335
17	Bus	Idgah	1861	1259	3120	1730 - 1830	201	173	374
18	Bus	Collectorate Chowk	1849	1066	2915	1715 - 1815	263	132	395
19	Bus	Diwani Chowk	1307	957	2264	1700 - 1800	207	68	275
20	Bus	Sur Sadan	1743	914	2657	1730 - 1830	250	131	381
21	Bus	Shah Market	1222	820	2042	1715 - 1815	114	96	210
22	Bus	Vijay Nagar	1208	944	2152	1745 - 1845	146	135	281
23	Bus	Dhakran Chowraha	1476	1513	2989	0900 - 1000	240	82	322
24	Bus	Agra College	1903	1253	3156	1730 - 1830	199	158	357
25	Bus	Chhalesar	1119	890	2009	0900 - 1000	142	150	292
26	Bus	Bichpuri	851	732	1583	1730 - 1830	220	168	388
27	Bus	Yamuna Park	1124	792	1916	1730 - 1830	269	235	504

SN	Mode	Name of Location	Total Boarding	Total Alighting	Total (B+A)	Peak Time	Peak Hour Boarding	Peak Hour Alighting	Peak Hour (B+A)
28	Auto	Bhagwan Talkies (Water Works to Sikandara)	1493	1514	3007	0830 - 0930	310	204	514
29	Auto	Bhagwan Talkies (Sikandara to Water Works)	1149	531	1680	1745 - 1845	177	58	235
30	Auto	Water Works (Rambagh to Bhagwan Talkies)	2394	2481	4875	1745 - 1845	227	344	571
31	Auto	Water Works(Bhagwan Talkies to Rambagh)	2297	1641	3938	1745 - 1845	229	220	449
32	Auto	Bijli Ghar (towards Agra fort	1975	861	2836	1715 - 1815	260	83	343
33	Auto	Bijli Ghar (towards Water Works)	1952	668	2620	1745 - 1845	217	77	294
34	Auto	Bijli Ghar (Bus terminal)	769	1534	2303	1715 - 1815	121	175	296
35	Auto	Sikandara	1484	1356	2840	1730 - 1830	470	312	782
36	Auto	Agra Cant Railway Station (towards Sadar Bazar)	1541	1643	3184	1745 - 1845	262	157	419
37	Auto	Agra Cant Railway Station – (Sadar bazar to Agra Cantt.)	1263	1111	2374	1800 - 1900	143	89	232
38	Auto	Sadar Bazar	766	618	1384	1715 - 1815	116	117	233
39	Auto	Shah Ganj	1970	1134	3104	0900 - 1000	171	180	351
40	Auto	Sai Ki Takiya	1717	1197	2914	1745 - 1845	197	108	305
41	Auto	Pratap Pura Chowk	901	616	1517	1715 - 1815	143	90	233
42	Auto	Madhu Nagar	1556	1380	2936	1745 - 1845	240	128	368
43	Auto	Hari Parwat	1115	709	1824	1745 - 1845	204	103	307
44	Auto	Shamshabad Road	1417	887	2304	1730 - 1830	226	131	357
45	Auto	Sultan Ganj Ki Puliya	1350	924	2274	1730 - 1830	187	165	352
46	Auto	Tadi Bagiya	1599	948	2547	1800 - 1900	253	115	368
47	Auto	Langre Ki Chungi	1557	1066	2623	1800 - 1900	283	171	454
48	Auto	I'timād-ud-Daulah	1775	999	2774	1730 - 1830	235	101	336
49	Auto	Nanhai	669	375	1044	1730 - 1830	126	31	157
50	Auto	Transport Nagar	991	536	1527	1815 - 1915	144	47	191
51	Auto	Purani Mandi	1137	951	2088	1800 - 1900	138	149	287
52	Auto	Yamuna Colony	1032	800	1832	1730 - 1830	145	113	258
53	Auto	Idgah	1225	879	2104	1715 - 1815	196	148	344
54	Auto	Diwani Chowk	1190	974	2164	1745 - 1845	160	88	248
55	Auto	Sur Sadan	1107	581	1688	1745 - 1845	132	74	206
56	Auto	Hotal Trident	1036	642	1678	1745 - 1845	161	91	252

SN	Mode	Name of Location	Total Boarding	Total Alighting	Total (B+A)	Peak Time	Peak Hour Boarding	Peak Hour Alighting	Peak Hour (B+A)
57	Auto	Hotal Taj View	1076	696	1772	1745 - 1845	180	123	303
58	Auto	Hotal Amar Inn	1040	586	1626	1745 - 1845	164	89	253
59	Auto	Vijay Nagar	1117	648	1765	1730 - 1830	183	68	251
60	Auto	Dhakran Chowraha	1045	741	1786	1715 - 1815	168	143	311
61	Auto	Institute of Mental Health	1435	837	2272	1730 - 1830	220	127	347
62	Auto	Taj Mahal East	1495	1042	2537	1745 - 1845	247	113	360
63	Auto	Taj Mahal West	1255	916	2171	1745 - 1845	153	140	293
64	Auto	Rambagh Chowk	1746	1972	3718	1715 - 1815	160	162	322
65	Auto	Bichpuri	1063	617	1680	1745 - 1845	172	73	245
66	Auto	Agra City Station	1443	1006	2449	1715 - 1815	248	176	424
67	Auto	TDI Mall	940	586	1526	1745 - 1845	166	87	253
68	Auto	Delhi Gate	1340	967	2307	1730 - 1830	229	108	337
69	Auto	Gatway PAC Land	1126	677	1803	1745 - 1845	224	76	300
70	Auto	Red Fort	1640	1100	2740	1700 - 1800	236	103	339
71	Auto	Dayal Bagh	1259	904	2163	1715 - 1815	128	106	234
72	Auto	Billochpura Railway Station	352	215	567	1900 - 2000	41	14	55
73	Auto	Kinari Bazar	1699	960	2659	1745 - 1845	232	153	385
	TOTAL		**98189**	**73074**	**171263**		**14141**	**9264**	**23405**

3.2 SOCIO-ECONOMIC CHARACTERISTICS

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

A total of 7,500 households (i.e. about 1.5% sample size) were interviewed in the study area consisting of 108 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 household to be survey 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

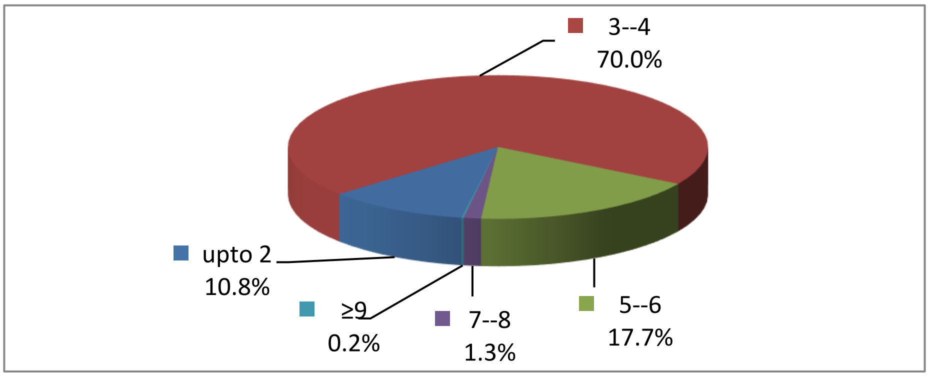
i. Household Size

The distribution of households by size is presented in **Table 3.24** and **Figure 3.11**. A total of 7500 households consisting of 27,232 members were interviewed in the survey. It can be observed that majorly i.e. 70% of the households fall under the category of 3-4 persons per household and about 18% of household's falls under category of 5-6 persons group.

TABLE 3.24: DISTRIBUTION OF HOUSEHOLDS BY SIZE

SN	Household by Size	Percentage (%)
1	Upto 2	10.8
2	3-4	70.0
3	5-6	17.7
4	7-8	1.3
5	≥9	0.2
Total		**100.0**

FIGURE 3.11: 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 27% of individuals are up to age of 14 to 35 years. About 2% of the surveyed individuals are senior citizen.

TABLE 3.25: DISTRIBUTION OF HOUSEHOLD MEMBERS BY AGE

SN	Age (in years)	% age
1	0-14	10.3
2	14-28	17.9
3	28-35	9.0
4	35-45	9.2
5	45-60	5.5
6	60+	1.8
Total		**100.0**

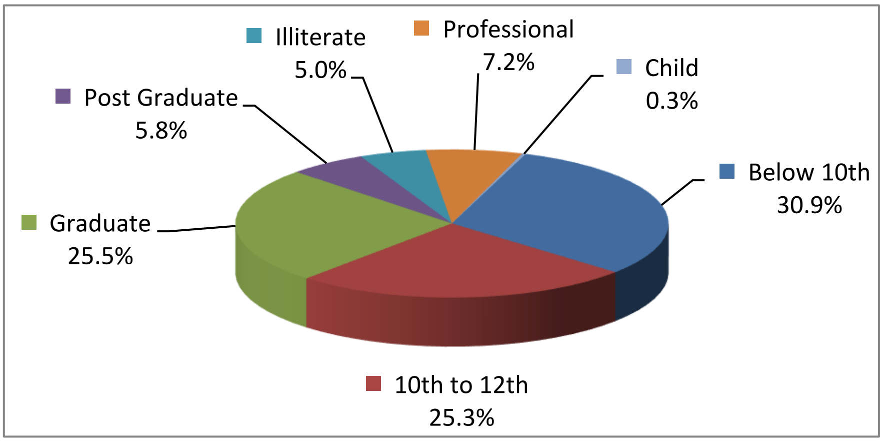
iii. Education Level

The distribution of individuals by educational qualifications is presented in **Table 3.26** and **Figure 3.12**. The members of household, below four years of age are considered as child. It is observed that about 56% of individuals are non-matriculates, matriculated or intermediate (12^{th}) pass. Graduates and Post Graduates account for nearly 31% of the surveyed sample. About 5% of the surveyed sample is illiterate.

TABLE 3.26: DISTRIBUTION OF HOUSEHOLD MEMBERS BY EDUCATION LEVEL

SN	Education	Percentage(%)
1	Below 10^{th}	30.9
2	10^{th} to 12^{th}	25.3
3	Graduate	25.5
4	Post Graduate	5.8
5	Professional	7.2
6	Illiterate	5.0
7	Child	0.3
Total		**100.0**

FIGURE 3.12: DISTRIBUTION OF HOUSEHOLD MEMBERS BY EDUCATION LEVEL



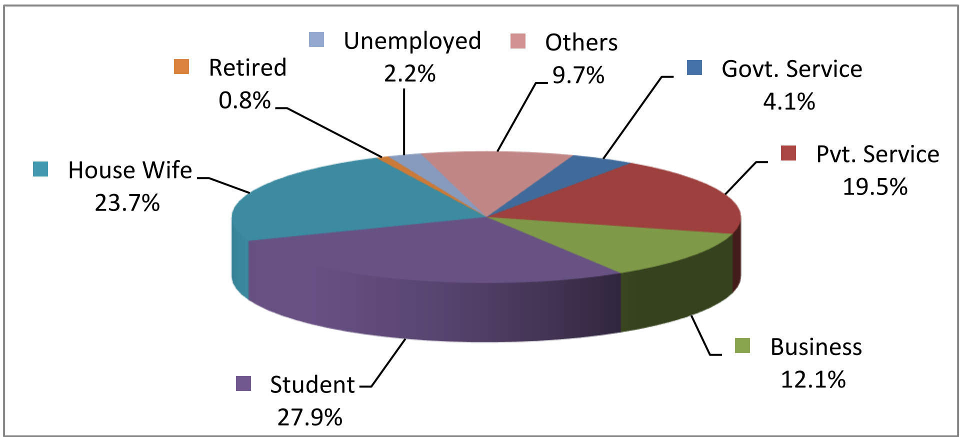
iv. Activity Status/Occupation

The Activity Status/ occupational structure of the surveyed household members is presented in **Table 3.27** and **Figure 3.13.** It is observed that about 36% of individuals are engaged in occupations like Government service, Private service and Business. 55% samples are non-workers comprising of students, housewives, retired and unemployed people.

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

SN	Occupation	Percentage (%)
1	Govt. Service	4.1
2	Pvt. Service	19.5
3	Business	12.1
4	Student	27.9
5	House Wife	23.7
6	Retired	0.8
7	Unemployed	2.2
8	Others	9.7
Total		**100**

FIGURE 3.13: DISTRIBUTION OF HOUSEHOLD MEMBERS BY ACTIVITY STATUS/OCCUPATION



v. Number of Earning Members per Household

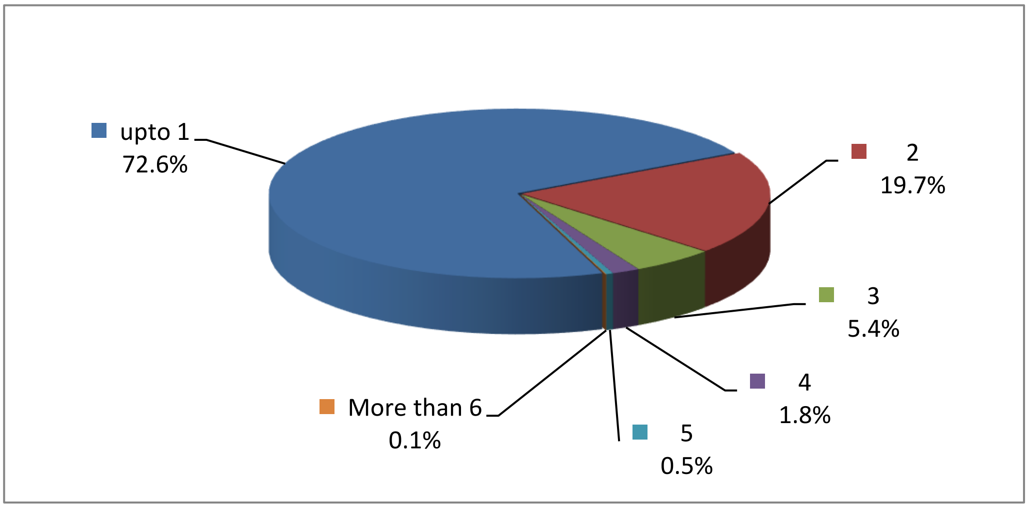
The distribution of earning members per household in the study area is presented in **Table 3.28** and **Figure 3.14**. It is observed that about 73% of the households have only 1 earning member, 20% have 2 earning members, while nearly 5% have 3 earning members.

TABLE 3.28: DISTRIBUTION OF HOUSEHOLDS BY NUMBER OF EARNING MEMBERS

SN	Number of workers	Percentage (%)
1	1	72.6
2	2	19.7
3	3	5.3
4	4	1.8

SN	Number of workers	Percentage (%)
5	5	0.5
6	More than 6	0.1
Total		100.0

FIGURE 3.14: DISTRIBUTION OF HOUSEHOLDS BY NUMBER OF EARNING MEMBERS



vi. Income Distribution

The average monthly household income in the study area is Rs.22,491. **Table 3.29** and **Figure 3.15** presents the distribution of Households by monthly income. It is observed that about 50% of the households earn Rs.5000 to Rs.20,000. About 43% between Rs.20,00 to Rs. 50,000. A small percentage of about 0.2% households are earning even less than or equal to Rs.5000 per month. Only, about 7% of the households has monthly income more than Rs.50,000.

TABLE 3.29: DISTRIBUTION OF HOUSEHOLDS BY MONTHLY INCOME

SN	Income Group	Percentage (%)
1	≤Rs 5000	0.2
2	Rs 5000 - Rs 10000	16.9
3	Rs 10000 - Rs 15000	15.3
4	Rs 15000 - 20000	17.4
5	Rs 20000-25000	14.4
6	Rs 25000-50000	28.5
7	>Rs 50000	7.3
Total		100.0

vii. Vehicle Ownership per Household

Distribution of households owning vehicles is presented in **Table 3.30.** It is observed that about 10% of households have no vehicle.

FIGURE 3.15: DISTRIBUTION OF HOUSEHOLDS BY MONTHLY INCOME

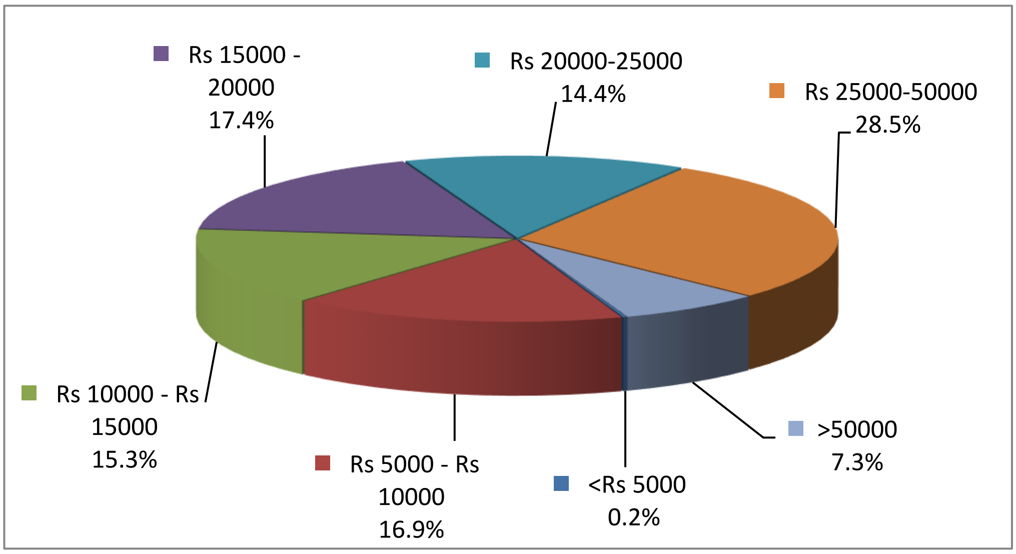


TABLE 3.30: DISTRIBUTION OF HOUSEHOLDS BY VEHICLE OWNERSHIP

S N	Type of Vehicle	Percentage (%)
1	No Vehicle	9.5
2	Only Car	0.7
3	Only 2-Wheeler	38.9
4	Only Cycle	6.5
5	Only Auto Rickshaw	0.1
6	Car & 2-Wheeler	13.1
7	Car & Cycle	0.1
8	2-Wheeler & Cycle	26.4
9	2-Wheeler & Auto Rickshaw	0.3
10	Cycle & Auto Rickshaw	0.1
11	Car, 2-Wheeler & Cycle	3.7
12	2-Wheeler, Cycle and Auto Rikshaw	0.5
13	Car,2-Wheeler,Cycle & Auto Rickshaw	0.1
Total		**100.0**

3.2.2 Travel Characteristics

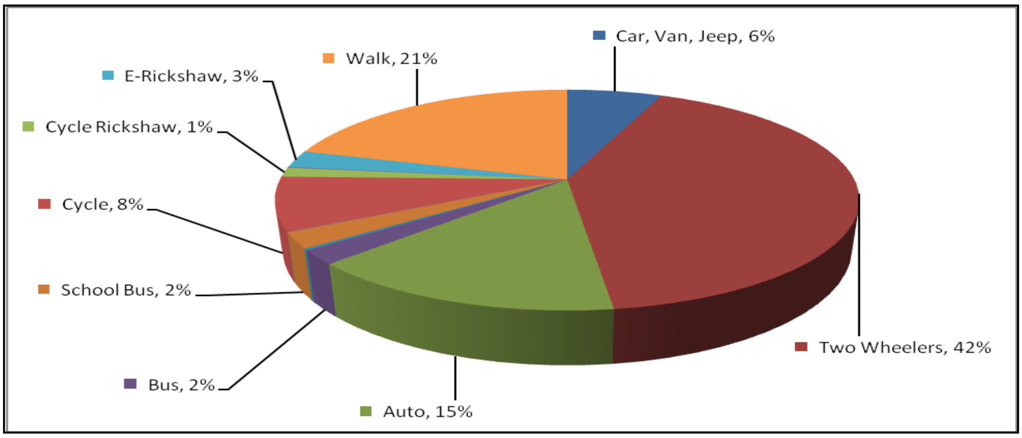
i. Trip Rate

The total daily trips, as derived from the household survey, in the study area is about 30.9 lakh. Distribution of trips according to mode of travel is given in **Table 3.31** and **Figure 3.16.** It is observed that about 21% of the trips are walk trips. However, the trips performed by 2 wheelers are about 42%. It is observed from the table that auto is the major public transport mode catering to about 15% of the total trips. Whereas trips performed by cars/Taxi are nearly 6%. Per capita trip rate including walk is 1.36, excluding walk is 1.08 and for motorised trips is 0.95.

TABLE 3.31: DISTRIBUTION OF DAILY PASSENGER TRIPS BY MODE (INCLUDING WALK)

Trip Type	Type of Vehicle	Number of Trips	Percentage (%)
Vehicular Trips	Car, Van, Jeep	194399	6.3
	Two Wheelers	1285326	41.6
	Auto + Shared Auto	461685	14.9
	Bus	64493	2.1
	Mini Bus	7898	0.3
	School Bus	71678	2.3
	Chartered Bus	1486	0.0
	Cycle	243514	7.9
	Cycle Rickshaw	42488	1.4
	Train	3342	0.1
	E-Rickshaw	78581	2.5
Walk Trips	Walk	635483	20.6
Total Trips		**3090373**	**100.0**
PCTR including walk		**1.36**	

FIGURE 3.16: DISTRIBUTION OF DAILY PASSENGER TRIPS BY MODE (INCLUDING WALK)



ii. Trip Purpose

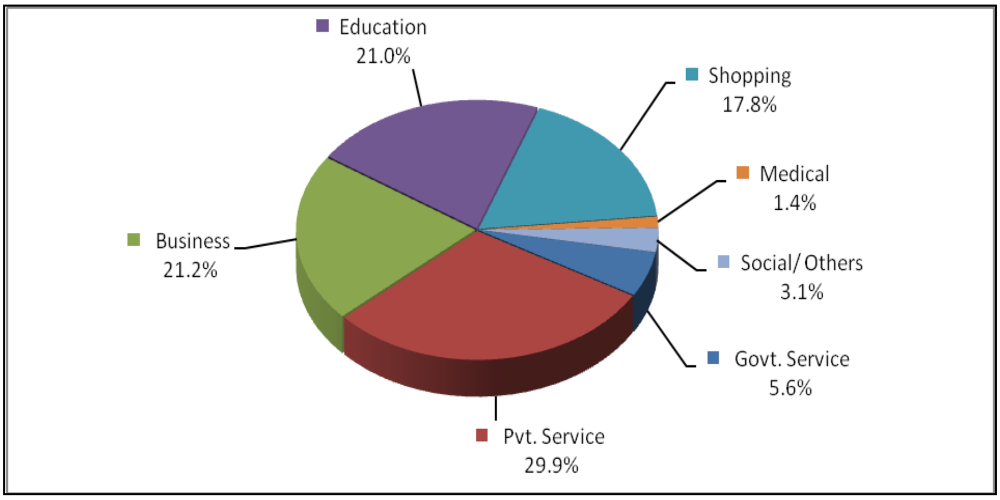
The purpose wise distribution of trips is presented in **Table 3.32** and is pictorially represented in **Figure 3.17.** Among the total trips, government and private work trips account for about 36% and business trips of about 21%.

TABLE 3.32: DISTRIBUTION OF TRIPS BY PURPOSE

SN	Trip Purpose	Total Trips	Percentage %
1	Govt. Service	173390	5.6
2	Pvt. Service	924084	29.9
3	Business	654593	21.2
4	Education	650296	21.0

SN	Trip Purpose	Total Trips	Percentage %
5	Shopping	551294	17.8
6	Medical	42434	1.4
7	Social/ Others	94283	3.1
	Total	**3090373**	**100.0**

FIGURE 3.17: DISTRIBUTION OF PASSENGER TRIPS BY PURPOSE



iii. Trip Length

Average trip length of 4.8 km (including walk) and 5.2 km (excluding walk) is observed in the study area as presented in **Table 3.33**. It is observed that an average trip length of 0.6 km is being covered up by walk.

TABLE 3.33: DISTRIBUTION OF AVERAGE TRIP LENGTH BY MODE

SN	Type of Vehicle	Total Trips	Avg.Trip Length (Km)
1	Car, Van, Jeep	194398	7.8
2	Two Wheelers	1285327	5.7
3	Auto	461686	3.5
4	Bus	64493	8.4
5	Mini Bus	7898	6.1
6	School Bus	71678	5
7	Chartered Bus	1486	7.3
8	Cycle	243513	3.2
9	Cycle Rickshaw	42488	2.6
10	Train	3342	105.4
11	Walk	635482	0.6
12	E-Rickshaw	78581	2.4
	Total Including Walk	**3090373**	4.8
	Total Excluding Walk	**2454890**	5.2

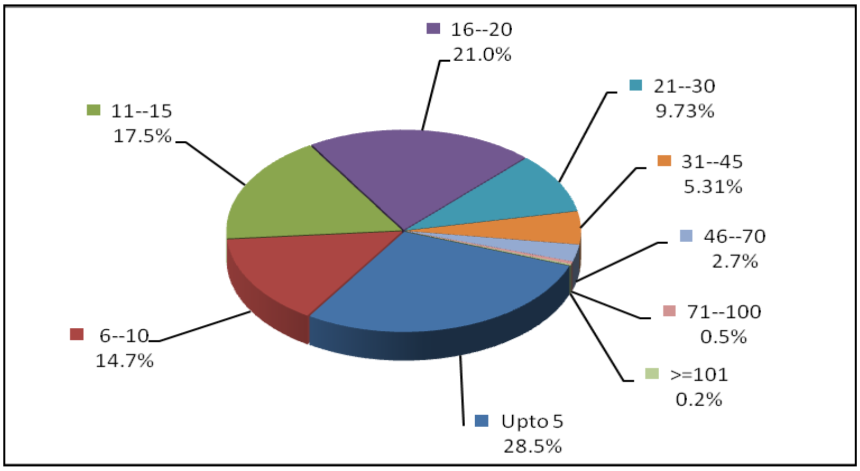
i. Expenditure on Travel

The distribution of passenger trips by expenditure on travel in the study area is presented in **Table 3.34** and **Figure 3.18**. It is seen that travel cost for about 54% of trips are between Rs 11 to Rs 20. About 12% of the trips have travel cost more than Rs 30.

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

SN	Particulars	Travel Cost (Rs.)									Total Trips
		Upto 5	6--10	11--15	16--20	21--30	31--45	46--70	71--100	>=101	
1	Number of Trips	1456	438717	523112	627162	291061	158816	81811	13771	5677	**2141584**
2	Percentage (%)	0.1	20.5	24.4	29.3	13.6	7.4	3.8	0.6	0.3	**100.0**

FIGURE 3.18: DISTRIBUTION OF PASSENGER TRIPS BY TRAVEL COST COST (EXCLUDING WALK AND CYCLE)



ii. 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, government and private work trips account for about 23% and business trips of about 9%.

TABLE 3.35: DISTRIBUTION OF WOMEN TRIPS BY PURPOSE

SN	Trip Purpose	% age
1	Govt. Service	2.1
2	Pvt. Service	20.9
3	Business	9.4
4	Education	13.7
5	Shopping/Recreation	46.4
6	Medical	2.8
7	Social/Others	4.6
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 3.19.**

3.3.2 Model Structure

The model (**Figure 3.20**) is based on motorized trip productions / attractions and internal trips of Agra 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 21.05 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.

A total of about 18 thousand daily tourists (Total 57 Lakh per annum) are expected to use the existing transport facilities. It is assumed that each tourist will make average 3 trips per day. Thus total 54 thousand passenger trips are added to total trips.

FIGURE 3.19: FOUR STAGE TRAVEL DEMAND MODEL

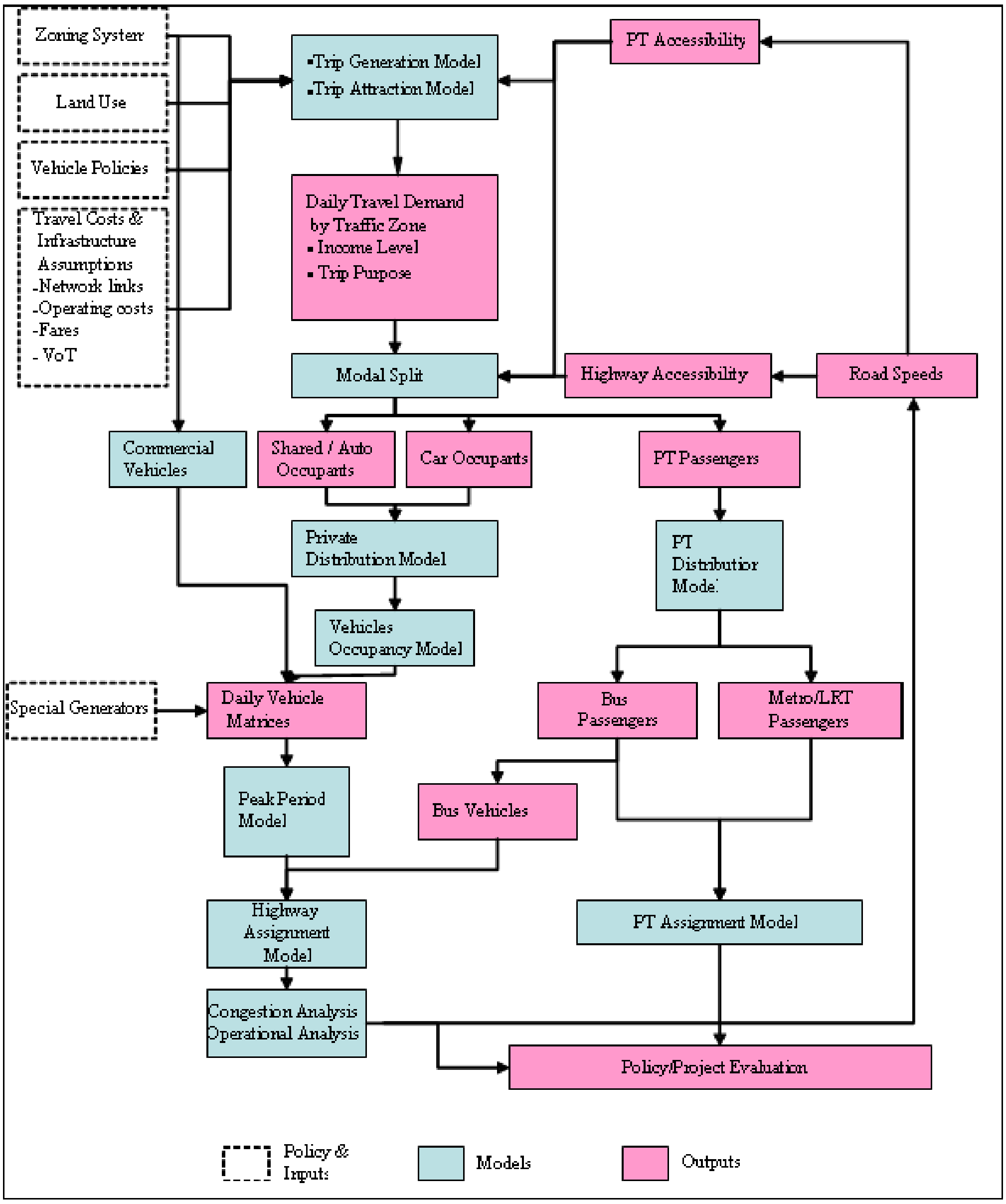
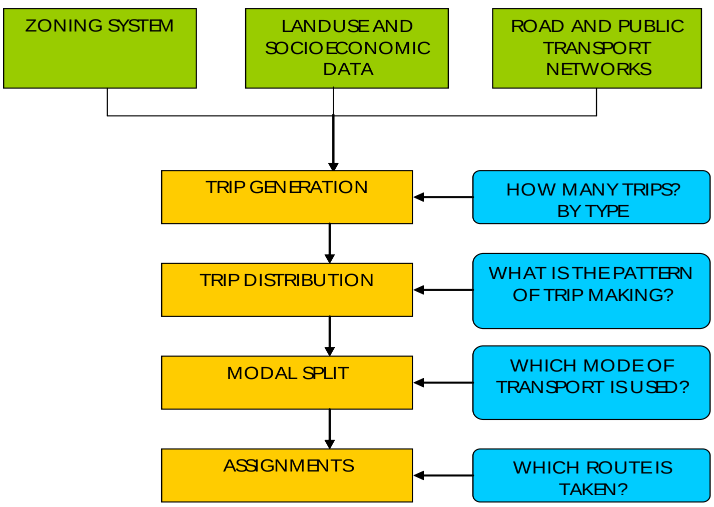


FIGURE 3.20: FOUR STAGE MODEL STRUCTURE



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.

3.3.3.1 Factors Affecting Trip Generation

The factors that affect Trip Generation can be categorized into following categories:

- 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.

3.3.3.2 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.

3.3.3.3 Mathematical Forms

- **Trip Production Equations**
  The general form of the work trip production equation developed is

  $\mathbf{T_i} = a + b*(IVi)$

Where,

$\mathbf{T_i}$ = 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

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

Where,

$\mathbf{T_j}$ = Trips attracted to zone j

a = constant (unexplained part of the relationship)
b = parameter explaining the dependency on the independent variable
IVj = Independent Variable in zone j

3.3.3.4 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

Dependent Variable	Independent Variable	Regression Coefficient (Trip Rate)	(R2) Co-efficient of Determination
(Y)	(X)	(b)	
Trip Production			
All Modes	Population	0.8866	0.71

- **Independent Variable: Zonal Population**

Figure 3.21 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 Agra is stated below:

Trips Produced = 0.886605* (Population), **R^2 = 0.71**

Where,

P = Population
R^2 = Coefficient of Determination

FIGURE 3.21: SCATTER PLOT: POPULATION VS TRIP PRODUCTION

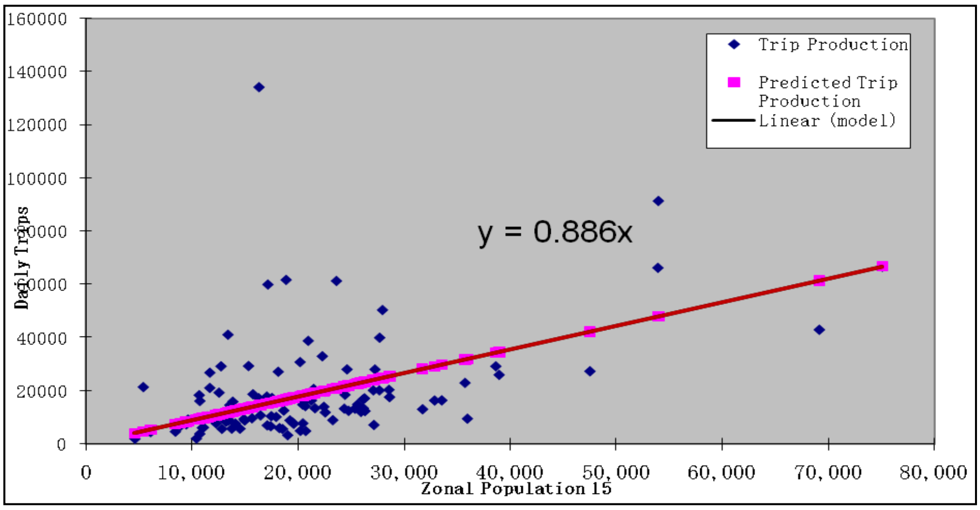


TABLE 3.37: SUMMARY OF OUTPUT OF TRIP PRODUCTION MODEL

SUMMARY OUTPUT								
Regression Statistics								
Multiple R	0.77							
R Square	0.7076							
Adjusted R Square	0.5983							
Std. Error	17105.7							
Observations	108.0							
ANOVA								
	df	***SS***	***MS***	***F***	***Significance F***			
Regression	1	48482638300	48482638300	165.6913	2.12963E-23			
Residual	107	31309064064	292608075.4					
Total	108	79791702364						
	Coeff	***Std. Error***	***t Stat***	***P-value***	***Lower 95%***	***Upper 95%***	***Lower 95.0%***	***Upper 95.0%***
Intercept	0	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
X Variable 1	0.88661	0.06888	12.87212	0.00000	0.75006	1.02315	0.75006	1.02315

3.3.3.5 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 & HBO and school enrolments for HBE. To be consistent with the generation model, the attraction model is based on PA.

The coefficient of Determination R2 is the deciding factor for linear regression analysis. The more R2 is near to 1, more the linear regression is reliable. For instance, **Figure 3.22** presents the linear regression of HBW trips with R-square value equal to 0.92 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 3.22: ATTRACTION MODEL (HBW – LINEAR REGRESSION)

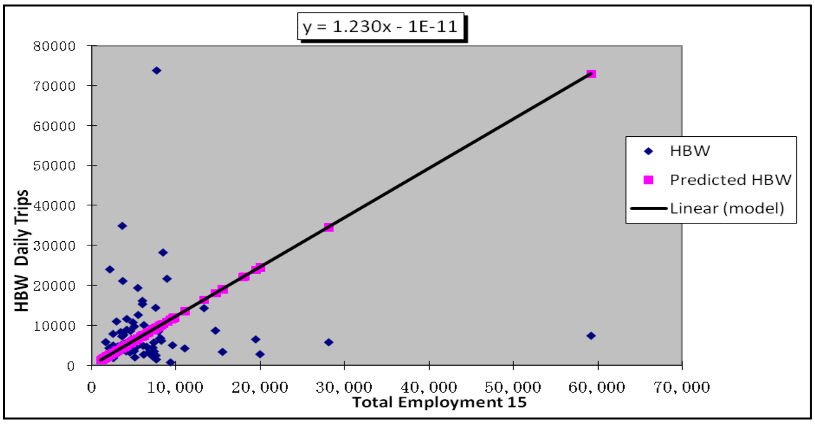


TABLE 3.38: SUMMARY OF OUTPUT OF TRIP ATTRACTION FOR HBW TRIPS

SUMMARY OUTPUT								
Regression Statistics								
Multiple R	0.9606							
R Square	0.9227							
Adjusted R Square	0.9134							
Standard Error	3281.49							
Observations	108							
ANOVA								
	df	***SS***	***MS***	***F***	***Significance F***			
Regression	1	1.38E+10	1.38E+10	1277.427	5.97E-61			
Residual	107	1.15E+09	10768207					
Total	108	1.49E+10						
	Coefficients	***Standard Error***	***t Stat***	***P-value***	***Lower 95%***	***Upper 95%***	***Lower 95.0%***	***Upper 95.0%***
Intercept	0	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
X Variable 1	1.2307	0.0344	35.7411	2.61E-61	1.1624	1.2989	1.1624	1.2989

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	8,36,436	8,39,133	0.3%
HBB	4,22,717	4,21,360	-0.3%
HBE	5,23,192	5,25,176	0.4%
HBO	3,22,733	3,22,980	0.1%
Total	21,05,078	21,08,649	0.2%

3.3.4 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

3.3.4.1 Gravity Model Development and Calibration

For the practical purpose of gravity model application in the study area and distribution of the observed T_{ij} 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 private and public transport cost models implemented in Cube Voyager software. 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 **Figure 3.23**

FIGURE 3.23: 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 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 centroid link)
- Waiting time at bus stop
- Travelling time on bus
- Interchange waiting time – where appropriate
- Walking time from bus stop to destination (by notional centroid 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;

3.3.4.2 Gravity Model – Calibration Results

The sequence of activities involved in the calibration of Gravity Model is shown in **Figure 3.23.** 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	21,05,078	-0.39406	-0.03439	7.48	21,08,664	-0.17%

Calibration process included comparison of observed and simulated mean trip time (minutes) as well as shapes of the trip time frequency distribution.

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’.

3.3.5 Modal Split Model

The modal split model is developed based on the HIS database and the Generalized Costs (GC) produced from the private 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 Road 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 3.29**, where P means Probability and C is the Generalized Cost);

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. As shown by **Figure 3.24** for illustrative purpose only (example with Private versus Public Travel modes), when λ increases, the model becomes more responsive to the difference in cost.

FIGURE 3.24: MULTI-LOGIT FORMULAS (COMBINED SPLIT)

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

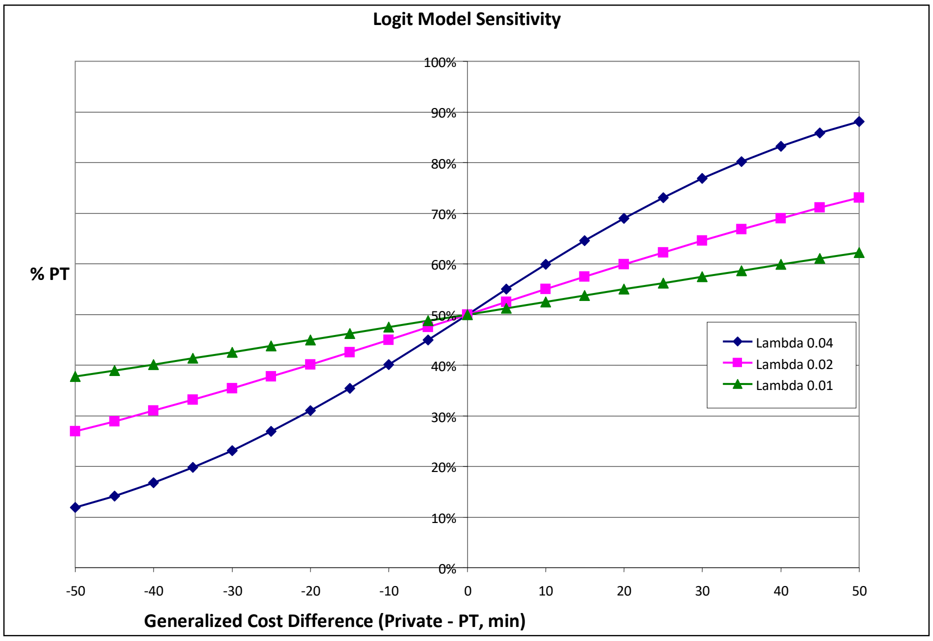
$$P_{2W} = \frac{e^{(-\lambda C_{2W})}}{e^{(-\lambda C_{Car})} + e^{(-\lambda C_{2W})} + e^{(-\lambda C_{Auto})} + e^{(-\lambda C_{PT})}}$$

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

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

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. The sensitivity of Logit Model is presented in **Figure 3.25.**

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

3.3.5.1 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 (-) 0.0589 and further between buses and shared autos as (-) 0.0789.

TABLE 3.41: MODAL SPLIT MODEL CALIBRATION RESULTS

Modes	HIS	Model
Car	1,84,216	1,84,823
2W	12,52,958	12,52,018
Auto	52,955	53,659
PT including Shared Auto	6,14,949	6,18,164
Total	**21,05,078**	**21,08,664**

3.3.6 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 Road 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 Road network following the Road 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 148 “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 private and public transport assignments. Peak hour model assignment is done separately to exhibit the constrained level of services during the peak hour.

3.3.7 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.

3.3.7.1 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.**

The formula for the "GEH Statistic" is:

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

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.

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

SN	Location	Survey Peak Hour PCU	Modeled Peak Hour PCU	% Difference	GEH Value
Mid-Block / Screenline Locations					
1	Bichpuri Road (near Bichpuri Fatak)	1163	1297	10.3%	3.8
2	Sikandara - Bodla Road (UPSIIDC ROB near Sikandara)	1497	1665	10.1%	4.2
3	NH-2 (Runkata Near ROB)	524	575	8.9%	2.2
4	Ghatia Azam Khan Road (Near Corporation Bank, Belanganj)	843	981	14.1%	4.6
5	Fatehpur Sikri Road (Bhogipura Chauraha)	1113	995	-11.9%	3.6
6	Bichpuri Road (Bhogipura Chauraha)	695	652	-6.6%	1.7
7	Madia Katra Road (Guru Agrasen Chowk near Raja Ki Mandi RS)	3243	3412	5.0%	2.9
8	Bichpuri Road (Bhogipura Chauraha)	829	965	14.1%	4.5
9	Ghatia Azam Khan Road (near Agra City RS)	730	757	3.6%	1.0
	Outer Cordon Locations				
10	Yamuna Expressway (towards Delhi)	261	219	-19.2%	2.7
11	NH-2 (towards Kanpur)	3087	3543	12.9%	7.9
12	SH-62 (towards Fatehabad)	1079	1192	9.5%	3.4
13	Shamshabad Road	530	586	9.6%	2.4
14	NH-3 (towards Gwalior)	2073	1905	-8.8%	3.8
15	SH-39 (towards Jagner)	830	787	-5.5%	1.5
16	NH-11 (towards Jaipur)	804	757	-6.2%	1.7
17	Bharatpur Road	1164	1072	-8.6%	2.8
18	NH-2 (towards Mathura)	1953	2238	12.7%	6.2
19	Aligarh- Hathras Road	1096	1236	11.3%	4.1

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.

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

3.4 FUTURE TRAVEL DEMAND SCENARIOS

3.4.1 Forecast of Planning Parameters

3.4.1.1 Future Growth Scenario

Master Plan for Agra 2021 gives the likely growth to take place within the various areas of study area. The development plan also gives locations of various land uses such as residential, commercial, industrial uses etc.

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

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 finalized in consultation with ADA and a technical note on 'Land-use Parameters Estimation and Traffic Zone Wise Distribution of Population, Employment and School Enrolment' was submitted on 22nd May, 2015.

3.4.1.2 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 study area population in the base year 2015 is 22.7 Lakh.
The employment for year 2011 has been worked out from the census data figures and has been extrapolated to obtain base year 2015 employment figures. WFPR as observed in the base year 2015 is 29.4% (total 6.7 lakh workers). Keeping in view the economic profile of the study area, development prospects and transport intervention policies, WFPR of 30%, 31% and 32% has been assumed from Agra Master Plan for the Horizon years 2021, 2031 and 2041 respectively. Thus, it has been estimated that 11.6 lakh workers would comprise the workforce in the study area by 2041.

Accordingly, population and employment for the horizon years 2021, 2031 and 2041 including TOD and other growth parameters are presented in **Table 3.43.** The distribution of population and employment in horizon years amongst various traffic zones is 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 M.G. Road, Sanjay Place, Foundry Nagar, Idgah, Shamsabad, Rui ki Mandi, Nai ki Mandi, Taj Gunj etc. have been considered.

TABLE 3.43: FORECASTED POPULATION AND EMPLOYMENT IN THE STUDY AREA FOR HORIZON YEARS

Year	Population (lakh)	Workers (Lakh)	WFPR (%)
2021	25.5	7.6*	30*
2031	31.3	9.7	31
2041	36.2	11.6	32

* Source: Census 2011& Agra Master Plan 2021

TABLE 3.44: ZONEWISE FORECASTED POPULATION AND EMPLOYMENT FOR HORIZON YEARS

Zone No.	2021		2031		2041	
	Population	Employment	Population	Employment	Population	Employment
1	31154	1705	36155	2183	38004	2534
2	21877	4293	25389	5496	26688	6378
3	17697	5463	20539	6994	21589	8116
4	29600	4181	34352	5352	36108	6211
5	32389	6798	39482	8492	45820	10871
6	15387	6544	15697	7977	15855	8384
7	27361	5677	38596	7267	48450	9766
8	19188	10110	19575	12324	19771	12955
9	23410	8833	28537	11034	33118	14124
10	17817	7354	25133	9414	31550	12652
11	21285	8825	21714	10758	21932	11308
12	24612	8925	30002	11150	34819	14273
13	14130	10095	14416	12306	14560	12936
14	22030	13373	25566	17119	26874	19867
15	26180	4534	30383	5804	31937	6736
16	19584	3404	22728	4357	23891	5057
17	30547	10549	35451	13504	37264	15672
18	14476	9649	14768	11762	14917	12364
19	23304	15175	27045	19426	28428	22544
20	40222	7171	46679	9180	49066	10653
21	32205	5865	37375	7508	39286	8714
22	24292	6062	28192	7760	29634	9006
23	20842	9544	24188	12218	25425	14179
24	23676	8139	28861	10168	33495	13015
25	37750	8432	43810	10794	46051	12526
26	13092	13200	13356	16091	13490	16914
27	20518	15470	23812	19803	25030	22982
28	11392	9218	11622	11237	11739	11811
29	5648	6151	7967	7874	10001	10582
30	18648	11189	19025	13640	19216	14337
31	14823	4700	18070	5872	20971	7516
32	17642	11911	17998	14520	18179	15262
33	9708	10688	9904	13029	10004	13695
34	60760	8268	70514	10584	74120	12283
35	13194	11509	13460	14030	13595	14747
36	17245	8031	21022	10032	24397	12842
37	29675	15501	36174	19364	41981	25787

Zone No.	2021		2031		2041	
	Population	Employment	Population	Employment	Population	Employment
38	21502	4295	30330	5497	38074	7388
39	10328	4700	14569	6017	18289	8086
40	9995	5964	11599	7634	12192	8860
41	11786	8860	12024	10801	12145	11353
42	31571	6862	38485	8572	44663	10972
43	44788	9107	54596	11376	63361	14562
44	17974	3535	18337	4309	18521	4529
45	23167	7023	26886	8989	28261	10433
46	29420	11637	34144	14896	35890	17287
47	26566	10081	30830	12905	32407	14977
48	14238	10122	14525	12339	14671	12970
49	13768	9747	14046	11882	14187	12490
50	18304	6993	21243	8952	22329	10389
51	12405	2883	15122	3601	17550	4610
52	15763	9168	16081	11176	16243	11748
53	16639	3984	23472	5099	29464	6853
54	18497	5878	21467	7525	22564	8733
55	19221	5277	22307	6754	23448	7839
56	10971	3412	11192	4159	11305	4372
57	25977	11960	31666	14940	36749	19124
58	23569	6411	27353	8206	28752	9523
59	23162	10813	32672	13842	41014	18602
60	13564	9751	13838	11887	13977	12495
61	20771	9118	21190	11115	21403	11684
62	19166	7203	22243	9220	23381	10701
63	12006	9886	12248	12051	12371	12667
64	18342	17092	21287	21879	22375	25391
65	31385	2890	38258	3611	44400	4622
66	12000	9075	12242	11063	12365	11629
67	15294	5514	18644	6887	21637	8817
68	22008	3434	31045	4396	38971	5907
69	38091	1891	46433	2362	53888	3024
70	29989	2871	42303	3675	53104	4939
71	21570	13772	25033	17629	26313	20459
72	11116	6622	13551	8272	15726	10588
73	44177	4655	62316	5958	78227	8007
74	31121	1704	36117	2181	37964	2531
75	22270	2111	27147	2637	31505	3376
76	11034	9058	11256	11042	11370	11607
77	13793	1409	14071	1717	14213	1805
78	34502	7549	48668	9664	61094	12987
79	12619	2520	12874	3072	13003	3229
80	31837	3877	44910	4962	56376	6669
81	6252	2064	6378	2516	6442	2645
82	27673	1247	39036	1596	49002	2145
83	11695	5448	13573	6974	14267	8094
84	28528	6339	33108	8115	34801	9418
85	15495	5434	15808	6624	15966	6963

Zone No.	2021		2031		2041	
	Population	Employment	Population	Employment	Population	Employment
86	12899	2626	13159	3201	13291	3365
87	17597	2162	20423	2768	21467	3212
88	19720	1859	22885	2379	24056	2761
89	32255	3564	45499	4563	57115	6132
90	13733	4787	14010	5835	14151	6134
91	55214	14569	57462	17760	59803	20611
92	6233	6650	7598	8106	8817	10376
93	11965	1384	16080	1687	22141	2267
94	22330	9466	30010	13538	41320	19194
95	14639	1501	19674	1830	27089	2459
96	24639	7577	33113	9236	45594	12412
97	42572	4326	57213	5273	78777	7086
98	34677	1943	46603	2369	64167	3183
99	26885	9558	36131	12652	49749	18003
100	92277	14815	130166	20059	163401	27958
101	27043	3780	36343	4608	50041	6193
102	80170	2749	97727	3351	113417	4503
103	31213	1549	41947	1888	57757	2537
104	32087	10993	45262	13401	56818	18009
105	26600	1320	35748	1609	49221	2162
106	26356	6870	37177	8375	46670	11255
107	20762	12391	27902	17104	38419	24486
108	51938	13978	69800	19039	96107	27587
Total	**2563075**	**768202**	**3126013**	**967626**	**3622864**	**1159586**

3.4.2 Assumptions for Transport Demand Forecasting

The following assumptions have been made for forecasting transport demand for the 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% in various adjoining towns.

vi. The special generator passenger traffic of bus terminals and railway stations in Agra 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.

The Phase-I metro system is expected to be operational by 2024. Desired shifting of passengers from other modes of transport to proposed metro system is a slow & continuous process. Metro ridership gradually increases over a period of time and initially 2024 ridership can be assumed same as that of the year 2021.

3.4.3 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. Daily inter and intra city trips by various modes in BAU 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 about 30% same as existing modal share. The total no. of PT trips (including shared auto trips) will increase from 6.2 Lakh to about 10.9 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. Traffic assignment for peak hour traffic (in PCU'S) on road network in bau scenario 2041 is given in **Figure 3.27.**

TABLE 3.45: DAILY INTER & INTRA CITY TRIPS BY VARIOUS MODES IN BAU SCENARIO, 2041

SN	Mode	2015		2041 BAU	
		Trips	Modal Share	Trips	Modal Share
1	Car	1,84,823	8.8%	282672	8.0%
2	Two Wheeler	12,52,018	59.4%	2091967	59.1%
3	Auto	53,659	2.5%	83228	2.4%
4	PT + Share Auto	6,18,164	29.3%	1083065	30.6%
	Total	**21,08,664**	**100.0%**	**3540932**	**100.0%**

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 2021, 2031 and 2041. The maximum peak hour peak direction trips for proposed metro corridors are given in **Table 3.46**. Total proposed Metro length in Phase-I is about 30 Km.

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

Corridor No.	Corridor details	Maximum PHPDT				Length (Km)
		2024	2031	2041	Design	
1	Sikandara to Taj East Gate	10200	15300	19400	24000	14.0
2	Agra Cantt. to Kalindi Vihar	14100	18700	23300	27000	16.0
Total Length of Phase I						**30.0**

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

FIGURE 3.28: ASSIGNED PEAK HOUR TRAFFIC ON NETWORK IN PCU – 2041

3.5.1.1 Horizon Year Trip Assignment

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

3.5.1.2 Ridership on Phase I Metro for 2024, 2031 & 2041

Daily ridership on the entire metro system for the years 2024, 2031 and 2041 is expected to be 5.7 Lakh, 7.4 Lakh and 8.7 Lakh passengers respectively. Line wise daily passenger boarding (including the interchanges between metro stations) and trips for 2024, 2031 and 2041 are shown in **Table 3.47**.

TABLE 3.47: DAILY RIDESHIP ON METRO SYSTEM IN YEAR 2021, 2031 & 2041

S No.	Corridor Name	Daily Boardings (Lakh)			Daily Trips (Lakh)		
		2024	2031	2041	2024	2031	2041
1	Sikandara to Taj East Gate	3.57	4.81	5.5	2.70	3.42	4.2
2	Agra Cantt. to Kalindi Vihar	3.72	5.53	6.5	3.00	3.94	5.0
	Total Daily Boardings / Trips	**7.29**	**10.34**	**12.0**	**5.70**	**7.36**	**9.2**

3.5.1.3 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.**

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: Sikandara to Taj East gate							
Sikandara	Guru Ka Taal	4,100	4,100	4,500	4,800	6,000	6,400
Guru Ka Taal	ISBT	6,100	7,000	6,600	7,200	8,600	9,400
ISBT	Shastri Nagar	7,500	7,600	7,700	7,800	9,700	10,600
Shastri Nagar	University	7,500	7,800	7,900	8,100	9,800	10,500
University	RBS College	8,600	9,400	9,000	10,500	11,200	13,300
RBS College	Raja Ki Mandi	8,700	9,600	8,900	10,500	11,100	13,300
Raja Ki Mandi	Agra College	9,300	10,200	15,300	15,300	18,500	19,400
Agra College	Medical College	6,600	9,600	8,400	10,100	10,000	13,000
Medical College	Jama Masjid	5,500	9,400	6,700	9,900	8,300	12,500
Jama Masjid	Agra Fort	5,600	9,200	6,200	9,700	7,800	12,400
Agra Fort	Taj Mahal	5,700	9,300	5,900	9,700	7,600	12,400
Taj Mahal	Fatehabad Road	4,800	8,200	4,800	8,400	6,300	10,900
Fatehabad Road	Basai	3,500	4,900	4,300	6,600	6,200	10,000

From	To	2024		2031		2041	
		Dir1	Dir2	Dir1	Dir2	Dir1	Dir2
Basai	Taj East Gate	1,800	3,300	2,200	4,300	4,100	5,950
Corridor 2: Agra Cantt. to Kalindi Vihar							
Agra Cantt.	Sadar Bazar	3,100	2,000	3,300	2,900	4,000	3,600
Sadar Bazar	Partap-Pura	6,100	4,100	12,100	8,800	15,300	10,700
Partap-Pura	Collectorate	10,700	7,300	18,300	11,900	22,800	14,700
Collectorate	Subhash Park	11,900	7,900	18,700	12,200	23,300	15,300
Subhash Park	Agra College	11,900	9,000	18,200	13,500	22,500	16,600
Agra College	Hariparvat Chauraha	14,200	9,800	17,200	12,000	21,600	14,900
Hariparvat Chauraha	Sanjay Place	13,100	10,000	15,800	12,200	20,100	15,100
Sanjay Place	M.G.Road	10,500	10,200	13,400	12,600	17,200	15,600
M.G.Road	Sultan Ganj Crossing	10,300	10,000	13,200	12,400	17,000	15,400
Sultan Ganj Crossing	Kamla Nagar	9,900	9,800	12,600	12,100	16,400	15,200
Kamla Nagar	Ram Bagh	8,900	8,500	11,400	10,600	15,100	13,600
Ram Bagh	Foundary Nagar	5,800	5,900	7,500	7,600	12,000	13,800
Foundary Nagar	Agra Mandi	5,800	5,900	7,500	7,600	12,000	13,800
Agra Mandi	Kalindi Vihar	4,100	3,700	5,300	4,900	5,800	6,200

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: Sikandara to Taj East gate						
Sikandara	4120	4080	4530	4800	5960	6410
Guru Ka Taal	3090	3960	4010	4260	4240	4620
ISBT	760	700	950	940	1130	1150
Shastri Nagar	680	500	880	740	1130	930
University	1250	1280	1800	2810	1820	3120
RBS College	1400	1440	2030	2090	2530	2590
Raja Ki Mandi	2340	2400	7570	5960	8420	7160
Agra College	7010	9170	10380	12170	12070	14080
Medical College	2140	3030	4560	6010	5190	6440
Jama Masjid	4620	4270	7520	7830	10060	10450
Agra Fort	1480	1540	2450	2690	3110	3350
Taj Mahal	1590	1370	1840	1580	2130	1900
Fatehabad Road	3700	1730	4180	2930	4320	3490
Basai	1680	1700	2300	2120	2890	2950
Taj East Gate	3260	1770	4310	2220	5950	4100
Corridor 2: Agra Cantt. to Kalindi Vihar						
Agra Cantt.	3060	2040	3270	2880	4030	3610
Sadar Bazar	3540	2560	8970	6020	12870	8730
Partap-Pura	5180	3840	7690	4640	8740	5210

Station	Peak Hour 2024*		Peak Hour 2031*		Peak Hour 2041*	
	Boarding	Alighting	Boarding	Alighting	Boarding	Alighting
Collectorate	1510	880	1560	1500	1580	1730
Subhash Park	2190	3200	2510	4250	2840	4890
Agra College	8970	7520	12190	11650	17710	16870
Hariparvat Chauraha	2170	3420	2710	4350	3370	5070
Sanjay Place	1270	4060	1500	4250	1770	5100
M.G.Road	1370	1420	1690	1710	1960	2020
Sultan Ganj Crossing	830	1050	990	1340	1130	1630
Kamla Nagar	1910	1560	2410	2110	2830	2500
Ram Bagh	2980	3530	3650	4530	4330	7500
Foundary Nagar	1990	2460	2350	3020	3010	3640
Agra Mandi	2320	1840	2890	2300	3960	2640
Kalindi Vihar	3750	4130	4850	5350	6240	5820

* Peak Hour Both Direction boardings/alightings

3.5.1.4 Design Ridership

In view of the estimated section loads and the changes in the traffic along the corridors, the MRTS Corridor from Sikandara to Taj East Gate is being designed for 10200 PHPDT in 2024, 15300 in 2031, 19400 in 2041 whereas Agra Cantt. to Kalindi Vihar Corridor is being designed for 14,200 PHPDT in 2024, 18,700 in 2031, 23,300 in 2041.

MRTS system however, will serve the city much beyond 2041. The design ridership for the two corridors have been taken as 24,000 PHPDT (Sikandara to Taj East Gate to Budhera) and 27,000 PHPDT (Agra Cantt. to Kalindi Vihar to Kuberpur) to take care of traffic growth beyond 2041.

The materialization of these PHPDT figures will depend on the proposed developments as envisaged in Master Plan of Agra and realization of other planned transport infrastructure projects. The system will start operating with initial ridership estimated and the capacity will be increased depending on the ridership growth.

Chapter – 4
SYSTEM AND TECHNOLOGY SELECTION

4. SYSTEM AND 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 Agra City have been evaluated based on projected traffic demand. Various road and rail based systems have been screened based on qualitative and quantitative parameters in the Alternatives Analysis Report for Agra MRTS. Considering the city specific characteristics, traffic demand, availability of right of way, Medium Capacity Metro rail system, which can cater to design capacity of 27800 PHPDT, is proposed to be adopted for Agra Metro corridors.

Metro Rail system is most prevalent mass transit system adopted worldwide. In India, MRTS is operational in various cities viz. Lucknow, Delhi, Chennai, Kolkata, Mumbai, Bangalore, Kochi, Jaipur, Hyderabad 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 above, Metro rail system with 3 car train composition can be adopted for the proposed corridors of Agra. The capacities indicated for 3 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 Agra 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)		30000 with 3 coach trains at 2 min headway
Alignment and Gauge	Minimum radius of curvature	Min. for elevated = 120m Min. for UG = 200m
	Gradient	4%
	Gauge	Standard gauge (1435 mm)
Traction System		750 V DC Third Rail traction system
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	3 car basic unit DMC-TC-DMC
	Train Composition	3 car – DMC-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 :1.0 m/s^2 Max. Deceleration : 1.1 m/s^2 (Normal brake) More than 1.3 m/s^2 (Emergency brake

Chapter – 5

CIVIL ENGINEERING & ALIGNMENT DETAILS

5. CIVIL ENGINEERING

5.1 ALIGNMENT DESCRIPTION OF APPROVED ALIGNMENT, AVAILABILITY OF ROAD SPACE

5.1.1 Engineering Survey and Alignment Design

5.1.1.1 Introduction

Two corridors were agreed upon for the study. Corridor 1 starts from Sikandara and ends at Taj East Gate (Hotel Trident) whereas corridor 2 starts from Agra Cantt. Railway Station and ends at Kalindi Vihar (Trans Yamuna Colony Phase-II) which traverses through city from west to east and South to North respectively. An interchange station between the corridors has been proposed near St. John's College.

Metro Route of both the corridors was initially planned on Google Map. For detailed planning of the proposed metro route, ground survey was carried out with the help of GPS, Total Station and Auto levels. Details of all the existing features falling in the proposed corridor were collected for proper planning of the alignment and Depot. Detailed Methodology of the Survey and other descriptions are given in subsequent paragraphs.

5.1.1.2 Survey Methodology

i. 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.

ii. Topographical survey of the Corridor 1- (Sikandara to Taj East Gate) and Coridor-2 (Agra Cantt. to Kalindi Vihar) 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.

iii. 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.

iv. Topographical survey and alignment design has been carried out in following steps:

a. Establishment of Horizontal Control Points using DGPS
b. Densification of Horizontal Control Points using Total station
c. Establishment of Vertical Control Points

d. Detailed survey of corridor
e. Preparation of drawings.
f. Site verification of features and finalization of drawings.
g. Alignment design on basis of verified drawings.

A. Establishment of Horizontal Control Points 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 GPS work, first control point (base point) was set-up at Kalindi Vihar, along NH-2. At this point, 24hrs GPS observation was done to achieve higher degree of accuracy and for other points, sufficiently long hours common period observation was carried out. Common period observation at three points have been carried out to form the triangle and to calculate the 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 (GPS) established are provided given in **Table 5.1.**

TABLE 5.1: LIST OF GPS CONTROL POINTS

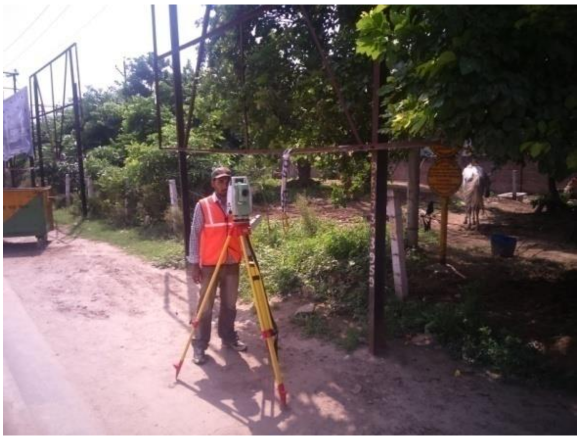
S. No.	Point Id	Ground Coordinate		Msl Level (M)	Description
		Easting	Northing		
1	GPS1	210156.095	3013528.759	158.805	LHS OF THE ROAD ON THE SHOULDER STARTING OF THE ALIGNMENT 30M FROM THE CULVERT
2	GPS1A	210244.198	3013439.617	148.564	ON BANK OF NALLA NEAR TYC DEPOT
3	GPS2	209048.821	3013210.699	158.810	ON MEDIAN IN FRONT OF UP RAJYA BHANDARAN NIGAM
4	GPS2A	209021.000	3013132.977	155.250	LHS OF A CROSS ROAD NEAR GITANJALI HOSPITAL
5	GPS3	207946.240	3012770.441	159.158	ON MEDIAN IN FRONT CHINU THE RESTAURANT & PANSHI PETHA STORE
6	GPS3A	207835.061	3012678.297	158.802	RHS SIDE OF THE ALIGNMENT & RHS OF THE CROSS ROAD NEAR CHAHAK CHILD CARE NEAR A TELEPHONE POLE
7	GPS4	206600.046	3012517.701	158.594	RHS OF THE ALIGNMENT & RHS OF THE SERVICE ROAD FOOTPATH 100M FROM YAMUNA BRIDGE TOWORDS RAM BAGH CHAURAHA
8	GPS4A	206505.858	3012543.180	159.990	ON MEDIAN AT THE YAMUNA BRIDGE END OF THE RAM BAGH FLYOVER
9	GPS5	205807.984	3012792.181	155.601	LHS SIDE OF THE CROSS ROAD BEHIND THE WATER WORKS TRAFFIC OUT POST
10	GPS5A	205736.914	3012762.293	155.042	RHS SIDE OF THE CROSS ROAD, BELOW THE HOARDING IN FRONT OF A GATE, 150 M FROM WATER WORKS CHAURAHA
11	GPS6	204713.263	3013059.846	159.238	RHS OF THE NH-2 NEAR A CROSS ROAD TO KAMLA NAGAR NEAR SHRI RAM PICTURE PALACE
12	GPS6A	204529.198	3013068.465	159.056	RHS OF THE NH 10 M BEFORE HANUMAN TEMPLR IN FRONT OF RASHMI PALACE
13	GPS7	204032.393	3013059.320	161.674	LHS OF THE NH NEAR MANOJ BANSAL BOUNDARY
14	GPS7A	203958.149	3013124.189	163.107	RHS OF THE NH-2 NEAR G.S MOTORS & CAR BAZAR
15	GPS8	203187.003	3012911.928	165.804	RHS OF THE CROSS ROAD TO NEHRU NAGAR AT BOUNDARY CORNER OF CANARA BANK

S. No.	Point Id	Ground Coordinate		Msl Level (M)	Description
		Easting	Northing		
16	GPS8A	203292.950	3012908.440	165.912	RHS SIDE OF THE CROSS ROAD TO NEHERU NAGAR IN FRONT OF HARI CHATNI RESTAURANT
17	GPS9	203044.199	3011889.380	166.165	LHS OF THE ALIGNMENT NEAR THE SIGN BOARD OF EMPLOY PROVIDENT FUND
18	GPS9A	203135.967	3011863.429	166.265	LHS OF THE CROSS ROAD IN FRONT OF HDFC BANK
19	GPS10	202861.154	3011078.286	165.786	IN SIDE A OPEN PLOT SIDE OF THE HOTEL BRINDABAN
20	GPS10A	202815.783	3011052.950	165.734	IN SIDE A OPEN PLOT SIDE OF THE HOTEL BRINDABAN
21	GPS11	202924.441	3010371.102	165.250	LHS OF THE ALIGNMENT IN FRONT OF AN OPEN PLOT GATE
22	GPS11A	202974.048	3010363.305	165.864	LHS OF THE ALIGNMENT INSIDE AN OPEN PLOT
23	GPS12	203380.904	3009745.499	160.134	LHS OF THE ROAD, SIDE OF THE DRAIN NEAR MADRASH MOHAMMADIYA PRIMARI SCHOOL
24	GPS12A	203476.171	3009778.454	159.422	LHS OF THE ROAD, SIDE OF THE DRAIN NEAR MADRASH MOHAMMADIYA PRIMARY SCHOOL
25	GPS13	203669.155	3008797.584	167.731	LHS OF ROAD NEAR PASSENGER SHED 40M FROM SAIKA TAKIYA CHAURAHA
26	GPS13A	203611.022	3008654.930	168.037	RHS OF ROAD ON FOOTPATH SIDE OF HOTEL LAURIES BOUNDARY OPPOSITE OF EKTA MOTORS
27	GPS14	203342.725	3007468.642	166.780	RHS OF ROAD NEAR CROSS ROAD AT SIDE OF ASHOK BECKAYA BUILDING BOUNDARY
28	GPS14A	203369.162	3007559.816	166.524	RHS OF THE CROSS ROAD SIDE OF THE BOUNDARY 90M FROM GPS 14
29	GPS15	202602.749	3007536.485	167.540	LHS OF THE ROAD IN FRONT OF MASJID & OPPOSITE OF MAHATMA GANDHI STATUE NEAR DAYANDA BAL MANDIR SR. SEC. SCHOOL
30	GPS15A	202514.467	3007494.420	167.395	LHS OF ROAD IN FRONT OF NC WADIK INTER COLLEGE GATE
31	GPS16	201868.855	3007619.306	166.843	LHS CORNER OF ROAD JUNCTION , STARTING OF RLY STAFF QTR. BOUNDARY AT AGRA CANTT.
32	GPS16A	201826.663	3007519.286	166.820	RHS OF ROAD IN SIDE RLY BUS STAND NEAR HIGH MAST LAMP POST
33	GPS17	208775.620	3007314.898	167.792	RHS OF THE MEWATI NAGAR CROSS ROAD AT TRIDENT HOTEL

S. No.	Point Id	Ground Coordinate		Msl Level (M)	Description
		Easting	Northing		
34	GPS17A	208721.788	3007401.217	168.197	LHS OF THE ROAD ,SIDE OF BOUNDARY OPPOSITE OF TRIDENT HOTEL
35	GPS18	207930.778	3007317.248	167.609	LHS OF ROAD JUST WALL SIDE OF ORCHID FARM
36	GPS18A	207866.172	3007364.101	167.327	RHS OF ROAD AT BOUNDARY SIDE OF DIAMOND CARPET
37	GPS19	207061.543	3007520.554	167.101	LHS OF THE ROAD NEAR A HAIR SALOON & KM STONE OPPOSITE SIDE OF ITC HOTEL BOUNDARY
38	GPS19A	207021.010	3007520.293	164.838	LHS OF ROAD SIDE OF THE BOUNDARY WALL BEHIND THE SHIV TEMPLE
39	GPS20	206323.093	3008438.953	168.230	LHS OF ROAD IN FRONT OF WARE HOUSE AT PURANI MANDI
40	GPS20A	206279.966	3008505.366	167.496	RHS OF ROAD ON FOOTPATH BESIDE SHAHJAHAN PARK BOUNDARY
41	GPS21	205618.943	3009033.355	153.082	RHS OF THE ROAD ON FOOTPATH AT KHERITOLA AREA BESIDE SHAHJAHAN PARK BOUNDARY
42	GPS21A	205430.580	3009047.011	154.550	LHS OF ROAD IN FRONT OF ARMY GATE & HANUMAN TEMPLE
43	GPS22	204639.807	3009634.151	154.116	LHS OF ROAD ON FOOTPATH NEAR HANUMAN GATE OF RAMLELLA MAIDAN
44	GPS22A	204560.882	3009605.573	154.532	IN SIDE RAM LILA MAIDAN & CORNER OF THE GROUND
45	GPS23	203393.430	3010640.000	162.916	ON SOUTH WEST CORNER OF THE SN MEDICAL PLAYGROUND VERY NEAR TO COMPOUND WALL
46	GPS23A	203478.128	3010795.573	162.796	ON NORTH WEST CORNER OF THE SN MEDICAL COLLEGE PLAYGROUND NEAR TO NEW BOY'S HOSTEL
47	GPS24	202564.856	3011261.098	167.945	LHS OF ROAD MARK INSIDE KIDWAI PARK ON CEMENT SURFACE
48	GPS24A	202510.541	3011231.865	166.657	LHS OF ROAD INSIDE KIDWAI PARK AT NORTH EAST CORNER
49	GPS25	202260.975	3013029.805	167.375	INSIDE AMBEDKAR UNIVERCITY GROUND BESIDE BOUNDARY WALL
50	GPS25A	202239.099	3013313.458	167.623	INSIDE AMBEDKAR UNIVERCITY GROUND END OF THE BOUNDARY WALL AT NH2 END
51	GPS26	201299.556	3012946.227	167.631	LHS OF THE ROAD NEAR A CORNER OF PRIVATE BUILDING INSIDE TRANSPORT NAGAR

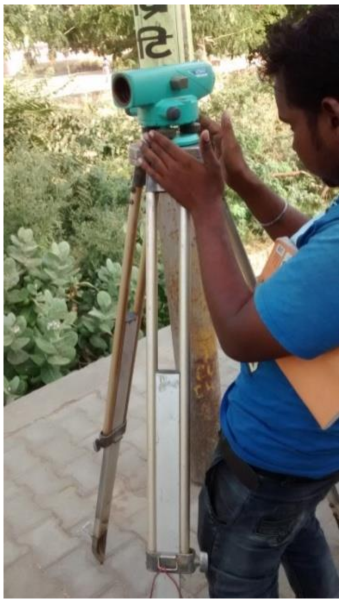
S. No.	Point Id	Ground Coordinate		Msl Level (M)	Description
		Easting	Northing		
52	GPS26A	201188.861	3012969.125	167.546	LHS OF ROAD INSIDE TRANSPORT NAGAR NEAR ELECTRIC POLE & IN FRONT OF SHOE FACTORY
53	GPS27	200585.314	3013163.828	168.760	RHS OF ROAD IN FRONT OF GARAGE & IN FRONT OF ISBT BUS STAND GATE
54	GPS27A	200547.906	3013120.937	169.360	MARKED INSIDE ISBT BUS STAND WHERE BUS ARE KEPT FOR TEMPORARY
55	GPS28	198767.308	3013611.707	169.490	LHS OF NH2 IN FRONT OF RATAN COMPLEX AND OPPOSITE OF SHANTI CHAUDHURY COMPLEX
56	GPS28A	198687.002	3013650.121	169.919	LHS OF NH2 IN FRONT OF POST OFFICE & OPPOSITE OF CROSS ROAD

B. Densification of Horizontal Control Points using Total Station



For densification of Horizontal Control Points, five to six additional pillars of same size on traverse points have been fixed between GPS control points which were used during the detailed topographical survey of the corridors

For densification of horizontal points, traversing was 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. Total linear error in traverse after angular adjustment was permitted as 1 in 50,000 whereas angular error of traverse was permitted as 15"√n where n is the number of angle measured in the traverse network.



C. Establishment of Vertical Control

Establishment of vertical control was started from a known GTS benchmark situated in Nehru Park near Agra Fort Railway Station. The value of this benchmark is 525.00 ft (160.02m). 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 TBM'S

S. No.	TBM NO	EASTING	NORTHING	RL	DESCRIPTION
1	TBM1/1	210019.801	3013413.619	160.443	ON TOP OF THE PILLAR LHS OF THE ALIGNMENT INFRONT OF HARSH TRADERS
2	TBM1/2	209505.329	3013290.712	161.604	ON TOP OF THE PILLAR RHS OF THE ALIGNMENT INFRONT OF INDIANOIL PETROL PUMP
3	TBM2/1	208428.944	3013001.832	157.011	ON LHS PARAPET OF THE CULVERT BEFORE 40 M FROM JMD NATHAN MEDICAL
4	TBM2/2	208402.444	3013006.277	156.882	ON TOP OF THE PILLAR 10 M AHEAD LIGHT POST NO 599
5	TBM2/3	208005.084	3012801.153	158.379	ON TOP OF EDGE OF THE MEDIAN INFRONT OF SINGHAL IRON STORE
6	TBM 3/1	207362.099	3012452.797	161.048	ON TOP OF EDGE OF THE DRAIN ON SERVICE ROAD INFRONT OF GOYAL HOSPITAL
7	TBM3/2	206764.185	3012365.827	156.639	ON BASE OF THE ISLAND AT RAMBAGH CHAURAHA LHS OF THE ALIGNMENT
8	TBM4/1	206414.016	3012573.710	160.999	ON MIDDLE PARAPET OF YAMUNA BRIDGE AT RAMBAGH END NEAER GCP4/1
9	TBM5/1	205315.917	3012938.216	157.620	ON TOP OF THE PILLAR LHS OF THE ALIGNMENT INFRONT OF DR TILES SHOWROOM AND LIGHT POST NO 527
10	TBM5/2	205199.749	3012958.927	158.446	ON TOP OF THE PILOR LHS OF THE ALIGNMENT INFRONT OF GYANA JOTI VIDYAMANDIR
11	TBM5/3	204787.332	3013042.642	159.428	ON TOP OF THE MEDIAN INFRONT OF K N HOSPITAL

S. No.	TBM NO	EASTING	NORTHING	RL	DESCRIPTION
12	TBM6/1	204604.137	3013078.205	159.796	ON TOP OF THE RHS PARAPET OF THE CULVERT INFRONT OF YES BANK
13	TBM 6/2	204389.568	3013041.475	160.200	ON TOP OF THE PILLAR LHS OF THE NH2 SERVICE ROAD NEAR A TRANSFORMER 10M BEFORE GATE OF SABARWALA & SONS BUILDING
14	TBM7/1	203607.475	3013192.598	167.400	ON TOP OF THE PILLAR LHS OF THE NH2 SERVICE ROAD INFRONT OF JAY HOSPITAL
15	TBM7/2	203276.163	3013263.365	168.256	ON TOP OF THE MEDIAN INFRONT OF KESAV GAS SERVICE
16	TBM7/3	203262.418	3013189.120	167.115	ON TOP OF THE PILLAR LHS OF THE ALIGNMENT ON FOOTPATH INFRONT OF NATHAN HOSPITAL
17	TBM8/1	203292.481	3012623.597	164.442	ON TOP OF THE PILLAR LHS OF THE ALIGNMENT , CORNER OF THE CROSS ROAD IN FRONT OF SHAH MARKET
18	TBM8/2	203287.645	3012519.752	164.136	ON TOP OF THE MEDIAN BELOW THE LIGHT POST INFRONT OF HINDUSTAN MEDIA SOLUTION
19	TBM8/3	203301.015	3012399.428	164.078	ON BASE OF THE ISLAND BELOW THE VIVEKANADA STATUE AT HARIPARWAT CHARURAHA
20	TBM9/1	202965.148	3011755.582	166.751	ON BASE OF THE ISLAND NEAR HARIPARWAT POLICE STATION
21	TBM9/2	202930.074	3011631.885	167.696	ON TOP OF THE PILLAR RHS OF THE ALIGNMENT SIDE OF INDOOR COLLEGE BOUNDARY & 20 M AHEAD THE ROAD FOB
22	TBM10/1	202882.111	3010729.369	166.696	ON TOP OF THE MEDIAN BELOW THE LIGHT POST INFRONT OF AGRA COLLEGE GATE
23	TBM10/2	202871.733	3010598.905	166.024	ON TOP OF THE PILLAR SIDE OF THE KD HOSTEL BOUNDARY NEAR A PASSENGER SHED
24	TBM11/1	202862.968	3010123.790	165.927	ON TOP OF THE MEDIAN BELOW THE HOARDING IN FRONT OF PEOPLES HONDA SHOWROOM
25	TBM11/2	203303.679	3009863.985	167.189	ON TOP OF THE MEDIAN BELOW THE LIGHT POST IN FRONT OF HOTEL VIMAL
26	TBM12/1	203442.273	3009591.146	167.707	ON TOP OF THE MEDIAN BELOW THE LIGHT POST IN FRONT OF THE CHURCH
27	TBM12/2	203472.187	3009532.231	167.768	ON TOP OF THE TRAFFIC POST AT COLECTOR CHAURAHA

S. No.	TBM NO	EASTING	NORTHING	RL	DESCRIPTION
28	TBM12/3	203643.218	3008970.327	167.929	ON THE BASE OF THE HOARDING IN FRONT OF THE MATHUR BUILDING
29	TBM13/1	203589.006	3008437.552	168.130	ON TOP OF THE MEDIAN BELOW THE LIGHT POST IN FRONT OF DEVI RAM SWEET
30	TBM13/2	203611.926	3008191.779	167.745	ON TOP OF THE PILLAR SIDE OF THE IRRIGATION BOUNDARY NEAR LIGHT POST
31	TBM13/3	203448.450	3007432.186	167.881	ON BASE OF THE TRANSFORMER BOUNDARY NEAR THE GCP 13/5
32	TBM14/1	202909.080	3007518.513	167.546	ON TOP OF THE LHS PARAPET OF THE CULVERT NEAR A CROSS ROAD TO ARMY HQ
33	TBM14/2	202564.218	3007531.776	168.351	ON TOP OF THE MEDIAN BELOW THE LIGHT POST IN FRONT OF THE NC WADIN INTER COLLEGE
34	TBM15/1	202112.836	3007547.794	167.518	ON BASE OF THE GREEN BELT ,SIDE OF THE DRM RESIDENCIAL BOUNDARY
35	TBM15/2	201863.797	3007632.053	167.513	ON TOP OF THE TRAFIC POST IN FRONT OF THE AGRA CANTT. RLY STATION
36	TBM17/1	208445.176	3007400.531	167.923	ON TOP OF THE MEDIAN BELOW THE 1ST LIGHT POST OF MEDIAN INFRONT OF TDI MALL
37	TBM17/2	208101.564	3007350.351	167.381	ON TOP OF THE PILLAR LHS OF THE ALIGNMENT IN FRONT OF VISHAL MEGA MART
38	TBM17/3	207914.105	3007346.384	168.028	ON TOP OF THE MEDIAN BELOW THE LIGHT POST IN FRONT OF VIRENDRA GENERAL STORE
39	TBM18/1	207523.279	3007358.129	167.992	ON TOP OF THE MEDIAN ON IN FRONT OF THE CROSS ROAD TO BASAI & ALSO INFRONT OF A TRANSFORMER
40	TBM18/2	207170.341	3007463.457	168.200	ON TOP OF THE MEDIAN BELOW THE LIGHT POST INFRONT OF BHARAT GUEST HOUSE
41	TBM 19/1	206613.994	3007862.820	168.070	ON BASE OF THE STATUE OF UGRESAN AT UGRESEN CHAURAHA
42	TBM 21/1	204717.868	3009611.962	154.165	ON TOP OF THE PILLAR ON FOOTPATH 50 M AHED FROM GCP 21/3
43	TBM22/1	203591.681	3009867.846	166.190	ON BASE OF THE TRAFIC POST ON HINGH MANDI CHARURAH A
44	TBM23/1	202910.239	3010960.498	166.302	ON BASE OF THE HORDING CROSS ROAD TO MEDICAL NEAR DURGA TEMPLE

S. No.	TBM NO	EASTING	NORTHING	RL	DESCRIPTION
45	TBM23/2	202542.431	3011208.799	168.128	ON TOP OF THE MANDAP NEAR GPS24
46	TBM24/1	202435.502	3012709.227	167.445	ON TOP OF THE PILLAR LHS OF THE ROAD BELOW THE HORDING 200M BEFORE THE LOHAI MANDI
47	TBM24/3	202554.467	3012852.705	168.121	ON TOP OF STEP OF THE TEMPLE AT LOHAI MANDI
48	TBM 27/1	199525.042	3013336.390	170.069	ON EDGE OF THE ISLAND LHS OF THE ALIGNMENT IN FRONT OF AKBAR GHODA
49	TBM27/2	198801.669	3013630.839	169.669	ON BASE OF THE LIGHT POST ON CROSS ROAD IN FRONT OF GPS 28

D. Detailed Survey of the Corridor

Based on Easting & Northing co-ordinates arrived by the traversing and Elevation by Precise Leveling, Detailed 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 up line 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 picking up of relevant details like roads, footpaths, dividers/central verges, railway tracks, trees, manholes and other structures, H.T., L.T., Transmission lines, bridges, ROBs / RUBs, ponds, streams, major drains, level crossing, religious structures such as Temples, Gurudwaras, Mosques, Churches, Monuments, tombs etc. Spot/ Ground levels were taken at 25 m intervals in longitudinal as well as traverse direction and at sudden change of levels.

E. 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.

F. 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.

G. Preparation of Alignment Drawing

Based on the finalized topographical survey drawing, the alignment design was done using Mx-Rail software.

5.1.2 Route Alignment

Two corridors have been finalized for implementation in Phase – I of Agra Metro Rail Project network as per details given under:

- **i.** Corridor-1: Sikandara to Taj East Gate
- **ii.** Corridor-2: Agra Cantt. to Kalindi Vihar

5.1.2.1 Corridor – 1: Sikandara to Taj East Gate

A. Alignment Description

Considering centre line of Sikandara station as 0.00m, this corridor is 14000m long starting from -50m and running upto 13950m. This corridor consists of elevated and Underground stretches along with Switch over Ramps (SOR) as detailed in **Figure 5.1.** The corridor is summarised as under in **Table 5.3.**

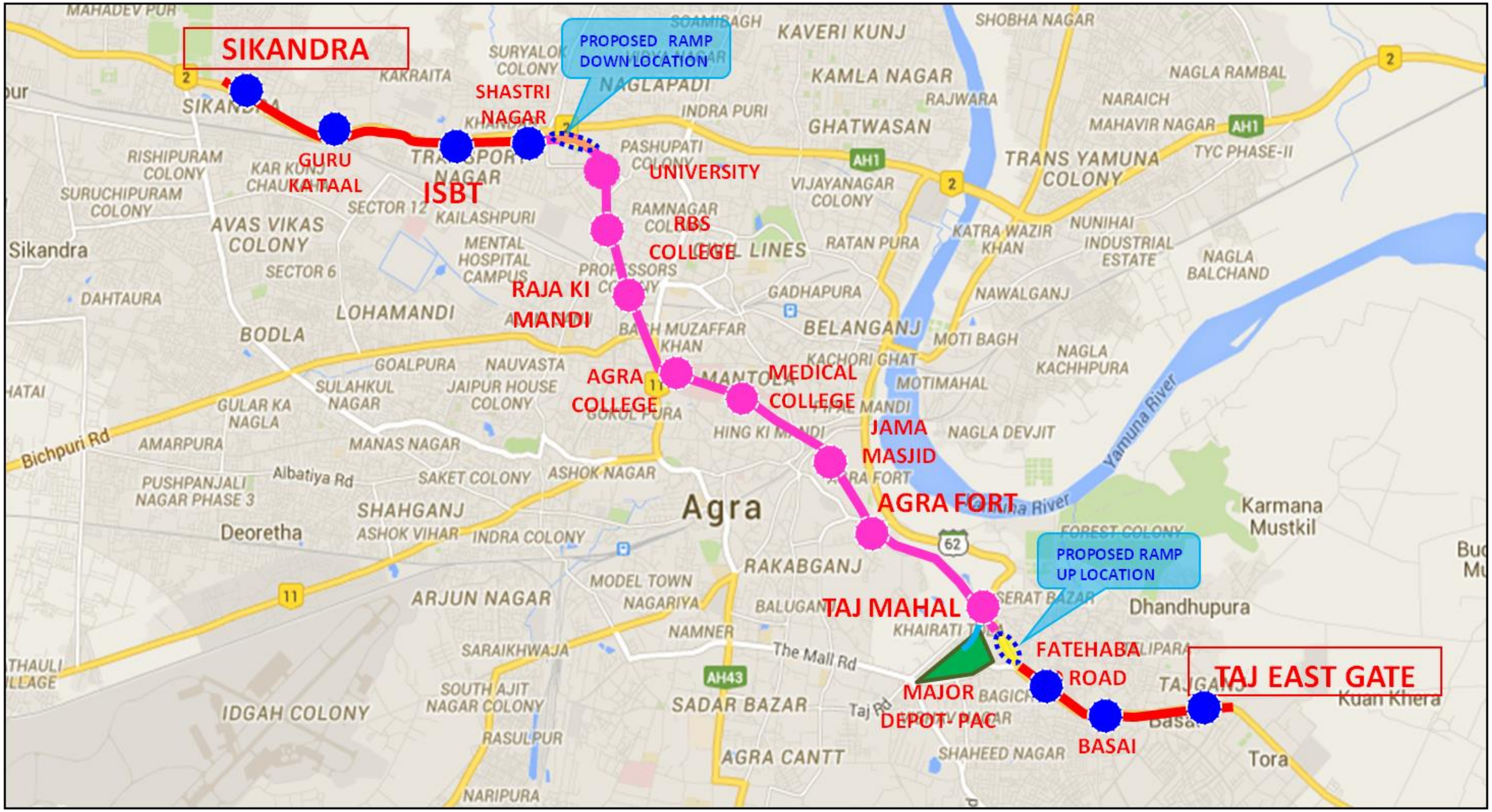
TABLE 5.3: ALIGNMENT DESCRIPTION

Alignment Type	From (m)	To (m)	Length (m)
Elevated	-50	3551	3601
Switch over Ramp (+)8.0m to (-)8.0m	3551	4010	459
Underground	4010	11175	7165
Switch over Ramp (-)8.0m to (+)8.0m	11175	11600	425
Elevated	11600	13950	2350
Total			**14,000**

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

i. Sikandara to Shastri Nagar Section
ii. Switch Over Ramp from Elevated to Underground
iii. University to Taj Mahal
iv. Switch Over Ramp from Underground to Elevated
V. Fatehabad Road to Taj East Gate

FIGURE 5.1: PROPOSED AGRA METRO CORRIDOR-1



i. Sikandara to Shastri Nagar Section

- In accordance with the provision of the Ancient Monuments and Archaeological Sites and Remains Act, 1958, as amended by the Ancient Monuments and Archaeological Sites and Remains (Amendment and Validation) Act, 2010, the area falling within 100m of the limits of the Akbar's Tomb (protected monument) has been declared to be the Prohibited area for the purpose of construction. Accordingly, the proposed alignment of Corridor-1 starts about 105m before Akbar's Tomb, Sikandara along NH-2 as elevated and heads in East direction.
- Total length of the section is about 3.60 Km and is completely elevated.
- 4 elevated stations namely Sikandara, Guru Ka Taal, ISBT and Shastri Nagar have been proposed in this section.
- Sikandara Station, first elevated station has been proposed along NH-2 with island platform and is about 105 m from the Akbar's Tomb, Sikandara.
- Guru ka Taal, second elevated station on the alignment, has been proposed along NH-2 in front of Guru ka Taal Gurudwara. Alignment and proposed Metro station falls in the prohibited zone of two ASI Monuments i.e. Guru Ka Taal Gurudwara and Kafur's Mosque with Pathar ka Ghoda. Permission of Competent Authority will be required before undertaking Metro construction in the prohibitive zone. This subject is dealt with in detail in subsequent paras.
- The alignment runs along NH-2 upto Ch: 1825m, thereafter, it goes off the road and passes through open land of Irrigation Department.
- Next elevated station on the alignment is ISBT which has been proposed near Agra ISBT and has been proposed in open land of State Government (Irrigation Department). Integration with existing Agra ISBT has also been planned with proposed Metro station. This station will serve as Terminal Station in case permission from Competent Authority is not granted for construction of Metro corridor in the Prohibited limits of Pathar Ka Ghoda and Guru Ka Taal ASI Monuments. Necessary provisions have been kept in the planning of ISBT Metro station. Reversal Facilities has also been planned beyond ISBT station. Two additional stabling lines for 3 rakes each has been proposed near ISBT station.

ii. Ramp From At-grade to Underground

- In this stretch, ramp is required to provide transition from elevated to underground alignment after Shastri Nagar station. Horizontal and vertical alignment in this stretch has been designed in such fashion so that minimum land is required.
- The alignment runs elevated till Ch: 3551m, thereafter, from Ch: 3551m to Ch: 4010m ramp (to become underground) has been proposed with a gradient of 4.0% and 3.87% in open land of State Government (Irrigation Department) and Private land of RBS College. About 4550 sqm of Govt. land and about 1177sqm of Pvt. land has been proposed for locating ramp.

iii. University to Taj Mahal Section

- This section is completely underground consisting of total 8 nos. underground stations namely, University, RBS College, Raja Ki Mandi, Agra College, Medical College, Jama Masjid, Agra Fort and Taj Mahal Station. All the stations have been proposed by Cut & Cover method.
- All the underground stations are off the road and are proposed in open land leading to ease in construction and avoidance to disruption in road traffic.
- University and RBS College stations have been proposed inside open land of Raja Balwant Singh (RBS) College. It will require 5693 sqm private land on permanent basis for construction of Entry/exits and station facilities in open land of RBS College. An area of about 9300 sqm will be required on temporary basis for about 4 years period for construction of tunnels by Cut & Cover method.
- Raja Ki Mandi Station has been proposed inside the parking/circulating area of Raja Ki Mandi Railway Station for better integration with existing Railway station. It will require 591 sqm land on permanent basis for construction of Entry/exits in the circulatory area of Railway station. Besides this, around 4500 sqm of Railway land will be required on temporary basis for about 4 years period for construction of station by Cut & Cover method.
- Agra College station has been proposed in the open ground of Agra College and has been proposed by cut & cover method. This station will serve as the interchange station with proposed Agra College elevated station of Corridor-2.
- Medical College station has been proposed in ground of SN Medical College and has been proposed by cut & cover method. This station will serve Medical College and Hing Ki Mandi area.
- The area between Medical College and Jama Masjid i.e. Hing Ki Mandi is densely populated with very narrow lanes and bye lanes leading to no path for movement of construction equipments and machinery as well as any open space for initiating underground station construction by cut & cover/NATM. Hence, next station is proposed near Jama Masjid at inter station distance of 1.40 Km.
- Jama Masjid station has been proposed by cut & cover in abandoned Electricity board land (Bijli Ghar land, now belonging to Torrent Power). This station will primarily serve Jama Masjid, Agra Fort Railway Station and Mantola.
- Agra Fort Station has been proposed in the open land of the Agra Cantonment (Central Govt.) in front of Agra Fort. This station has been proposed by cut & cover method. As Agra Fort is a Protected Monument with 100m Prohibited area, the alignment and station has been kept about 105m away from the outer boundary of Agra Fort so as to clear the designated Prohibited area. An area of about 4901 sqm of Agra Cantonment (Central Govt.) will be required on permanent basis for construction of Entry/exits and station facilities.
- After Agra Fort station, the alignment passes through Shahjahan Park (State Govt. land). The underground alignment has been proposed to be done by cut & cover. Accordingly, depth of the tunnels and track centre has been reduced. Also, to avoid

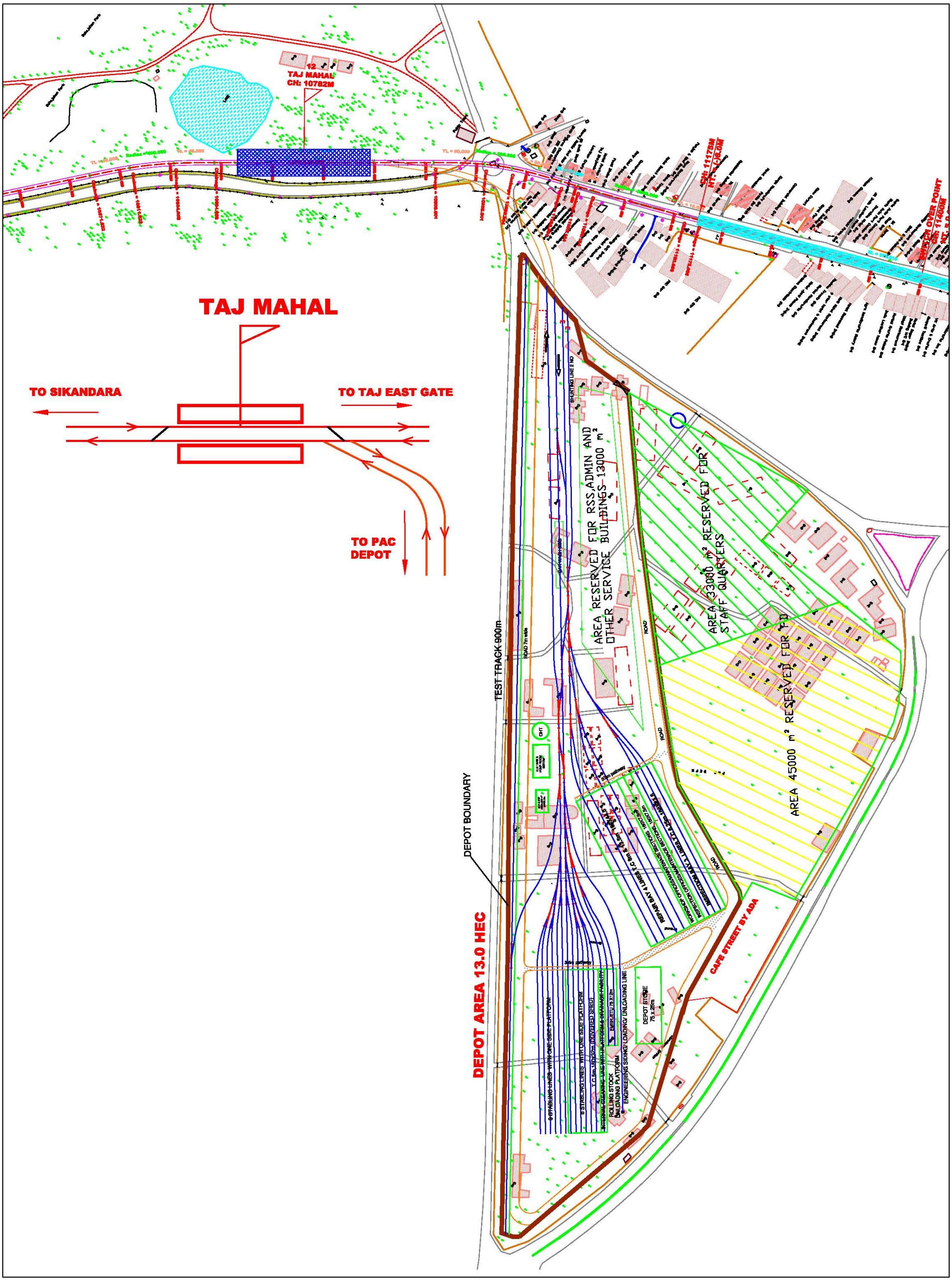
infringement /obstruction to the view of Taj Mahal, Taj Mahal station has been proposed as underground.

- About 16500 sqm of State Govt. land will be required on temporary basis during construction of tunnels by cut & cover method and about 5818 sqm on permanent basis for construction of station facilities.
- Entry to PAC depot (State Govt. land) has been planned from Taj Mahal station. Separate entry to the Maintenance Depot at PAC has been proposed from Taj Mahal station. An area of 20.80 Ha of Govt. land has been proposed for depot facilities. Out of the total of 20.80 Ha, depot has been planned in 16.30 Ha land and 4.5 Ha land has been proposed for Property development.
- Depot land for corridor-1 was identified by ADA in PAC land with the planning that PAC staff quarters shall be relocated at some other suitable location. With this objective, entire 20.80 Ha land of PAC is proposed to be acquired for construction of depot, staff quarters, parking & property development. 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 Taj Mahal Station towards Sikandara directly and towards Taj East Gate with reversal. Since, in the morning the train frequency is about 15 minutes, reversal will not cause any constraint to train movement.
  - Further, to avoid the reversal in morning, the four rakes stabled at Taj East Gate Terminal station can be utilized to initiate morning services from Taj East Gate to Sikandara. As during off peak morning period the frequency of train operation is about 15 minutes, the four rakes will adequately cover the initial requirement of train operations from Taj East Gate to Sikandara. In the mean while four rakes stabled at other Terminal station i.e. Sikandara and six rakes stabled at ISBT will reach Taj East Gate and normal traffic flow may be restored. Hence, the trains initiating from the depot in the morning may be directly operated towards Sikandara without any reversal.
  - At the end of services, rakes from Sikandara end can enter the depot directly but passengers boarding the train from Sikandara end will have to be deboarded at Agra Fort/Taj Mahal Station and thereafter, empty rake will be placed to depot directly. However, it may cause inconvenience to public and hence, the trains from Sikandara may be run upto Terminal station i.e. Taj East Gate and after deboarding the passengers, the empty rake shall be run for short length of 3.0 Km upto Taj Mahal station and after reversal shall be placed in the depot. Since in the night, the train frequency will be about 15 minutes, reversal will not affect the train operation.

FIGURE 5.2: PAC DEPOT CONNECTIVITY FROM TAJ MAHAL STATION



iv. Switchover Ramp From Underground to Elevated

Further, the alignment after Taj Mahal station heads in east direction along Fatehabad Road and terminates at Taj East Gate.

To become elevated from underground, ramp has been provided along Fatehabad Road after Taj Mahal Station. The switch over ramp has been proposed from Ch: 11175m to Ch: 11600m at limiting gradient of 3.5% (compensated). About 4250 sqm State Govt. land will be required permanently for locating the ramp.

v. Fatehabad Road to Taj East Gate

- The proposed section is completely elevated with total length of 2.30 Km and consists of total 3 elevated stations namely, Fatehabad Road, Basai and Taj East Gate.
- Taj East Gate station has been proposed in front of Pacific Mall. Reversal/stabling facility has also been planned beyond Taj East Gate Metro station. Two nos. elevated stabling lines for two rakes each has also been proposed beyond station to provide stabling space for total four rakes. Provision for future extension of the corridor along Fatehabad Road has also been made in the alignment.

A. Reference Point

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

B. Terminal stations of Corridor-1

- **Sikandara Metro Station (Western side terminal station)**

The Western terminal station on the Metro corridor is Sikandara Metro Station. The station is proposed elevated and rail level has been kept 12.00 m (minimum) above the ground level. Station has been planned with island platform. Proposed metro station will provide connectivity to heritage Monument Sikandara and nearby areas. As per the ASI guidelines, the station has been proposed about 100m away from Sikandara's Boundary wall.

- **Taj East Gate Metro Station (Eastern side terminal station)**

Eastern Terminal of the corridor will be Taj East Gate Metro Station. The station is proposed elevated and rail level has been kept 12.00 m (minimum) above the ground level. This station has been proposed in-front of Pacific Mall.

Reversal/stabling facility has also been planned beyond Taj East Gate Metro station. Two nos. elevated stabling lines for two rakes each has also been proposed beyond station to provide stabling space for total four rakes. In addition to this, one rake can be stabled at each platform of Taj East Gate Station. Provision for further extension of the corridor along Fatehabad Road has also been made in the alignment.

C. 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 5.4.**

TABLE 5.4: INTERCHANGE STATIONS OF CORRIDOR-1

S. No.	Name of Metro station	Mode	Interchange with
1	ISBT Metro Station	Bus System	Agra Inter-State Bus Terminal
2	Raja Ki Mandi Metro Station	IR Broad Gauge Railway network	Delhi - Agra Railway line
3	Agra College Metro Station	Metro	Proposed St. John's College Metro Station of Corridor-2 of Phase-I Agra Metro
4	Jama Masjid Metro Station	Bus System	Bijli Ghar Bus Stand

D. Major Roads along Corridor-1

The major roads along and across the alignment are given in **Table 5.5** and **5.6** respectively.

TABLE 5.5: MAJOR ROADS ALONG CORRIDOR-1

S. No.	Name of the Road	Chainage	
		From (m)	To (m)
1	NH-2	(-) 300	1850
2	Raja Balwant Singh Road	4500	5150
3	Fatehabad Road	10750	13700

TABLE 5.6: MAJOR ROADS ACROSS CORRIDOR-1

S. No.	Description	Chainage
1	Khandar Road	4200
2	MG Road	6270
3	Shaheed Bhagat Singh Road	6650
4	Hing Ki Mandi Road	7595
5	Mantola Road	8100

5.1.2.2 Corridor - 2: Agra Cantt. To Kalindi Vihar

A. Alignment Description

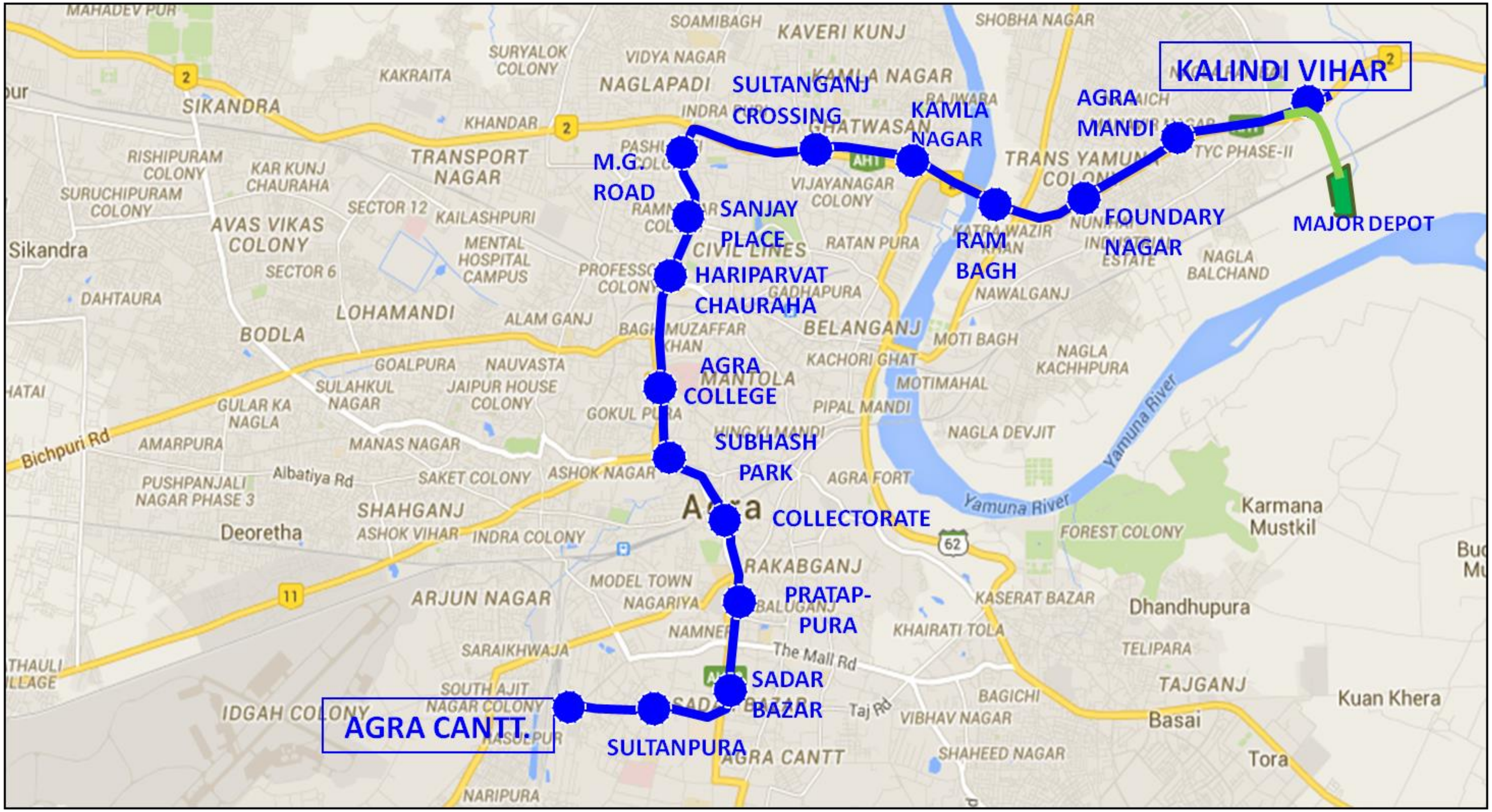
Considering centre line of Agra Cantt. Metro Station as 0.00m, this corridor is 15400m long starting from (-)50m and running upto 15350m. This corridor is proposed as completely elevated. Depot entry having a length of about 800m has been proposed after Kalindi Vihar Station. The corridor is summarised in **Table 5.7**.

TABLE 5.7: ALIGNMENT DESCRIPTION OF CORRIDOR - II

Alignment Type	From (m)	To (m)	Length (m)
Elevated	(-)50	15350	15400
Depot Entry	15350	16150	800

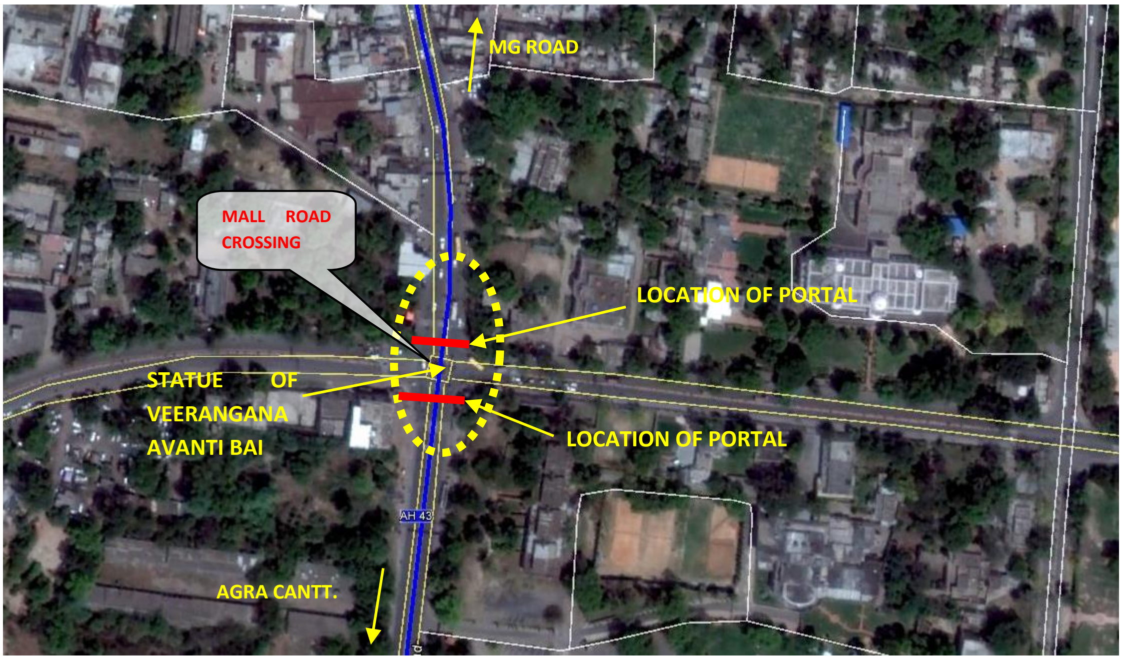
- The proposed MRTS alignment of Corridor-2 starts from Agra Cantt. Railway station. The alignment heads in North direction along Station road, MG Road and NH-2. The corridor integrates with Corridor-1 at Agra College station. **Figure 5.3** shows the proposed corridor-2.
- After Agra Cantt. station, alignment runs along station road and takes left turn and passes through private Property and aligns along MG Road. The alignment near DRDO has been kept off the road to avoid DRDO guest house and minimise other private property acquisition. Further, alignment runs along MG Road upto Bhagwan talkies, thereafter, it takes right turn and aligns along NH-2 and runs along it till end i.e. Kalindi Vihar.
- Total of 15 elevated stations have been proposed for the corridor namely, Agra Cantt., Sadar Bazar, Partap-pura, Collectorate, Subhash park, Agra College, Hariparvat Chauraha, Sanjay Place, MG Road, Sultanganj Crossing, Kamla Nagar, Ram Bagh, Foundary Nagar, Agra Mandi and Kalindi Vihar. Sultanpura Station has been proposed as future Station.
- In view of construction ease and to avoid disruption to running road traffic, efforts have been made to locate the elevated stations off the road. However, due to alignment passing through heavily habitated area and narrow roads, only three stations i.e. Subhash Park, Sultanganj Crossing and Ram Bagh could be planned off the road in open land. At other station locations, open land is not available to provide off the road stations.
- Sultanganj Crossing station has been proposed as Mid Terminal. Reversal facilities have been planned at this station. Two separate stabling lines has been proposed for total of 5 rakes.

FIGURE 5.3: CORRIDOR 2: AGRA CANTT. TO KALINDI VIHAR



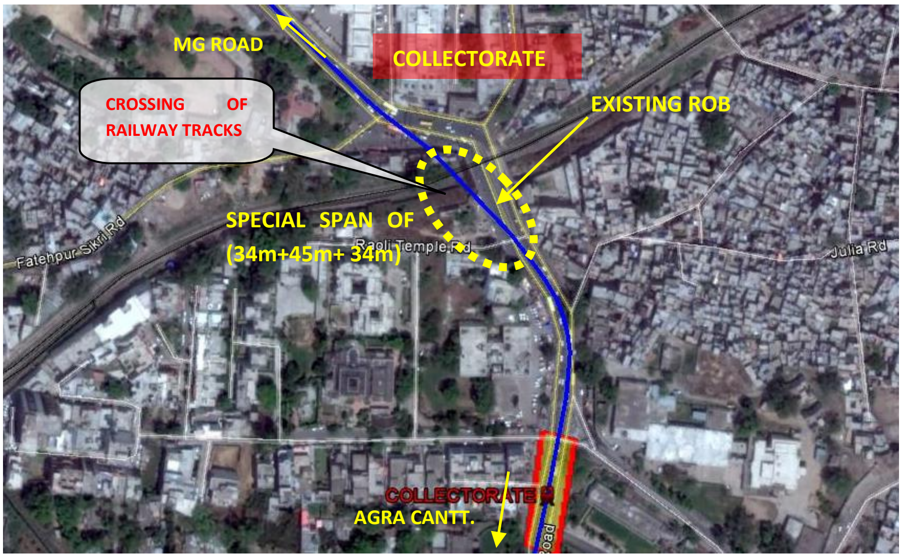
- The alignment will cross Mall road Crossing having important statue of Veerangana Avanti Bai located at the centre of crossing in a circular perimeter of 10m diameter. To avoid interference to road traffic, portal has been proposed for elevated span crossing the junction.

FIGURE 5.4: LOCATION OF PORTAL AT MALL ROAD CROSSING



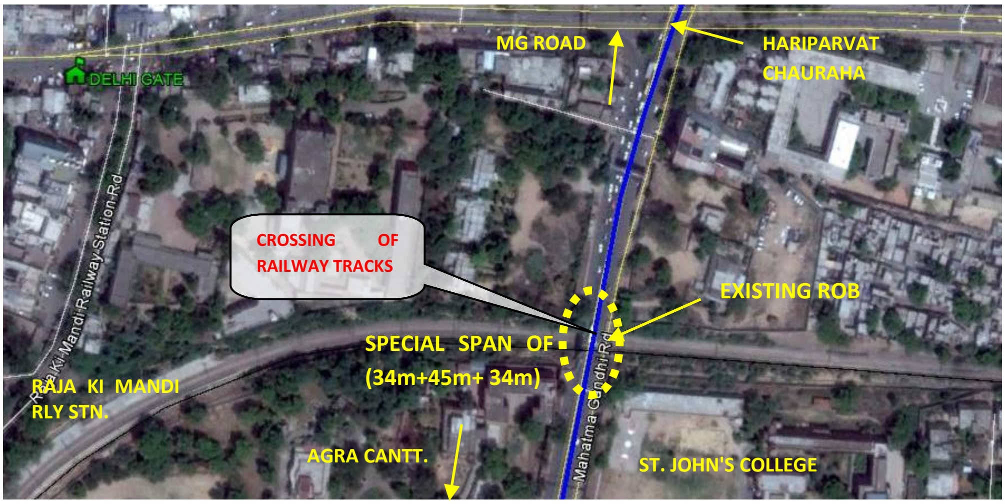
- The alignment near Collectorate has to be taken off the road due to road geometry and exiting ROB across the railway tracks between Eidgah and Agra Fort railway Stations. To cross the Railway tracks at Collectorate, special span of (34m + 45m + 34m) has been proposed.

FIGURE 5.5: LOCATION OF SPECIAL SPAN AT COLLECTORATE



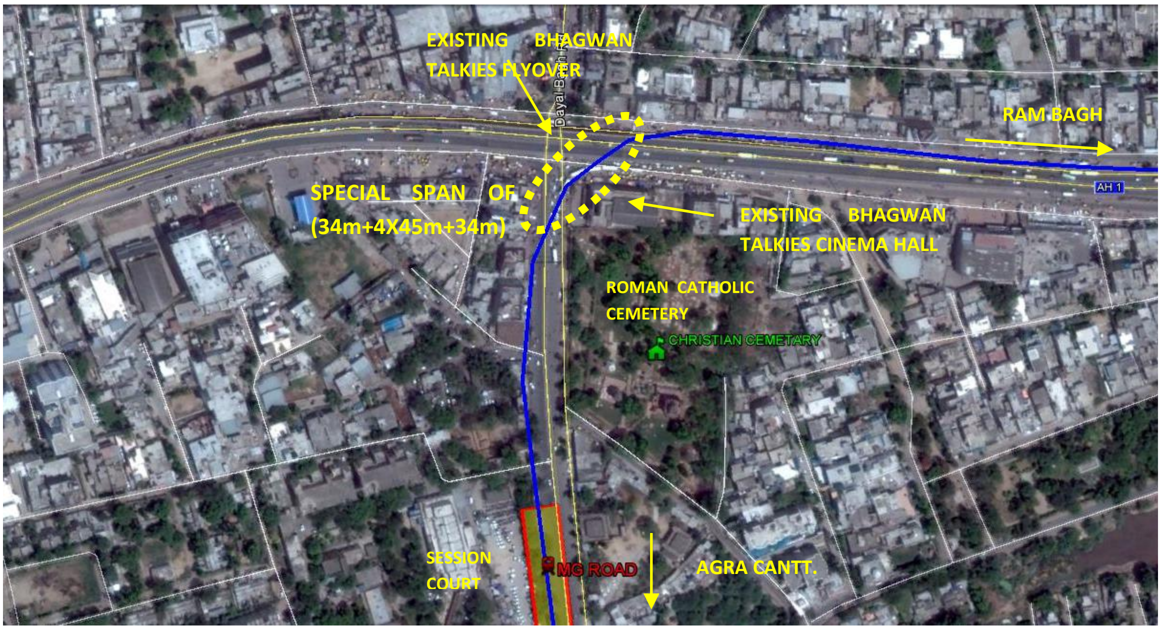
- Near St. John's College, alignment again crosses Railway tracks between Raja Ki Mandi and Agra City/Belanganj Railway Stations. There is an existing ROB over the railway tracks. The proposed Metro alignment is following the MG Road median and to cross the Railway tracks one option is to provide portal arrangement to become off the road and then again come back to the median. However, this arrangement will traverse through private land and also introduce additional curves in the alignment. To avoid this, special span is proposed with span configuration of (34m + 45m + 34m).

FIGURE 5.6: LOCATION OF SPECIAL SPAN NEAR ST. JOHN'S COLLEGE



- The alignment crosses NH-2 flyover at Bhagwan Talkies at double height and it will require special span arrangement of (34m + 4x45m + 34m).

FIGURE 5.7: LOCATION OF SPECIAL SPAN AT BHAGWAN TALKIES



- The proposed alignment is required to cross Yamuna River between Water Works and Ram Bagh. At this location, there are two existing Road bridges having 20m edge to edge distance with other relevant details as under:

S. No.	Direction	Year of Construction	Type of Structure	Span
1	Water Works to Ram Bagh	1993	Simply Supported Box Girder	4x20m (viaduct) +1x47.32m + 6x45.72m + 1x18.40 + 4x20m (viaduct) (on well foundation)
2	Ram Bagh to Water Works	1963	Continuous Spans	End span + 7x45.72m + End span (on well foundation)

Due to less clear space of 20m between the two existing road bridges, it was not possible to place the new Metro Bridge in between the existing road bridges and hence, two options of placing the new Metro Bridge were considered on upstream and downstream side of road bridges. Option of providing Metro Bridge on Upstream side was dropped due to presence of ASI structure/site i.e. Ram Bagh. Accordingly, new Metro Bridge is proposed on downstream side of the existing road bridges. Span arrangement for the new Metro Bridge is proposed as (34m + 7x45m + 34m).

FIGURE 5.8: NEW METRO BRIDGE ACROSS YAMUNA RIVER

- **Alignment Options near Roman Catholic Cemetery**

Roman Catholic Cemetery is protected ASI Monument located adjacent to MG Road near Bhagwan Talkies. Three alignment options have been studied and are shown in **Figure 5.9.** All the three alignment options are detailed below:

a. Option 1: Elevated alignment along MG Road

In this option, the alignment continues to run elevated along MG Road and turns right from Bhagwan Talkies flyover and thereafter runs along NH-2 till end i.e. Kalindi Vihar. The alignment in this option passes through the prohibited area of Roman Catholic Cemetery. Permission from the competent Authority for passing through the prohibited area of ASI Monument will be required. Grounds for requesting permission are detailed in subsequent paras.

b. Option 2: Elevated alignment through Nehru Nagar

This is an alternate option, to be used in case permission from Competent Authority for passing through prohibited area of Roman Catholic Cemetery is refused. In this option, the alignment continues to run elevated along MG Road and turns right from Diwani Chauraha and passes through Government land and thereafter, with the help of reverse curve joins into the original alignment before Sultanganj Crossing station. The alignment in this option is in the Regulated area of Roman Catholic Cemetery. An area of about 10811 sqm of Government land and about 4654 sqm will be required permanently for running section. Number of government as well as private structures will require acquisition for the alignment, details are given below.

S. No.	Properties Affected	Ownership	No's of Properties	Plot Area (SQM)	Floor Area (SQM)
1	Canara Bank (G+2)	Private	1	964	2892
2	Building (G+0)	Private	1	57	57
3	Building (G+0)	Govt.	1	284	284
4	Res. Building (G+0)	Govt.	1	96	96
5	Res. Building (G+0)	Govt.	5	626	626
6	Res. Building (G+0)	Govt.	3	825	825
7	RES. BUILDING (G+1)	Private	1	227	454
8	Udupi Restaurant (B+G+2)	Private	1	370	1480
9	Res. Building (G+0)	Private	1	219	219
10	Comm. Building (G+1)	Private	1	382	764
				Total	**7697**

Acquisition of properties and land will have implication of about Rs. 150 Crore on the project. This option will also have the drawback of leaving potential traffic point at Bhagwan talkies chauraha.

c. Option 3: Underground alignment through Nehru Nagar

In this option, the alignment runs elevated upto Diwani Chowk, thereafter it turns right and goes underground through ramp down proposed within the Government land. As there is no location for ramp up (to become elevated from underground), the alignment will be underground till end i.e. Kalindi Vihar. 6 Station namely Sultanganj crossing, Kamla Nagar, Ram Bagh, Foundary Nagar, Agra Mandi and Kalindi Vihar will be underground. Kamla Nagar and Foundary Nagar stations will have to be constructed by NATM as there is no space for cut & cover construction. The alignment in this option is in the Regulated area of Roman Catholic Cemetery. An area of about 10811 sqm of Government land and about 2264 sqm will be required permanently for running section. For locating ramp, number of government as well as private structures will require acquisition, details are given below:

S. No.	Properties Affected	Ownership	No's of Properties	Plot Area (SQM)	Floor Area (SQM)
1	Canara Bank (G+2)	Private	1	964	2892
2	Building (G+0)	Private	1	57	57
3	Building (G+0)	Govt.	1	284	284
4	Res. Building (G+0)	Govt.	1	96	96
5	Res. Building (G+0)	Govt.	5	626	626
6	Res. Building (G+0)	Govt.	3	825	825
				Total	**4780**

The underground alignment and stations will have implication of about Rs. 2000 Crore on the project. Hence this option is not recommended by the consultant.

- **Comparison of three options near Roman Catholic Cemetery**

  Brief comparison among the three alignment options near Roman Catholic Cemetery is given in **Table 5.8**.

FIGURE 5.9: ALIGNMENT OPTIONS NEAR ROMAN CATHOLIC CEMETERY

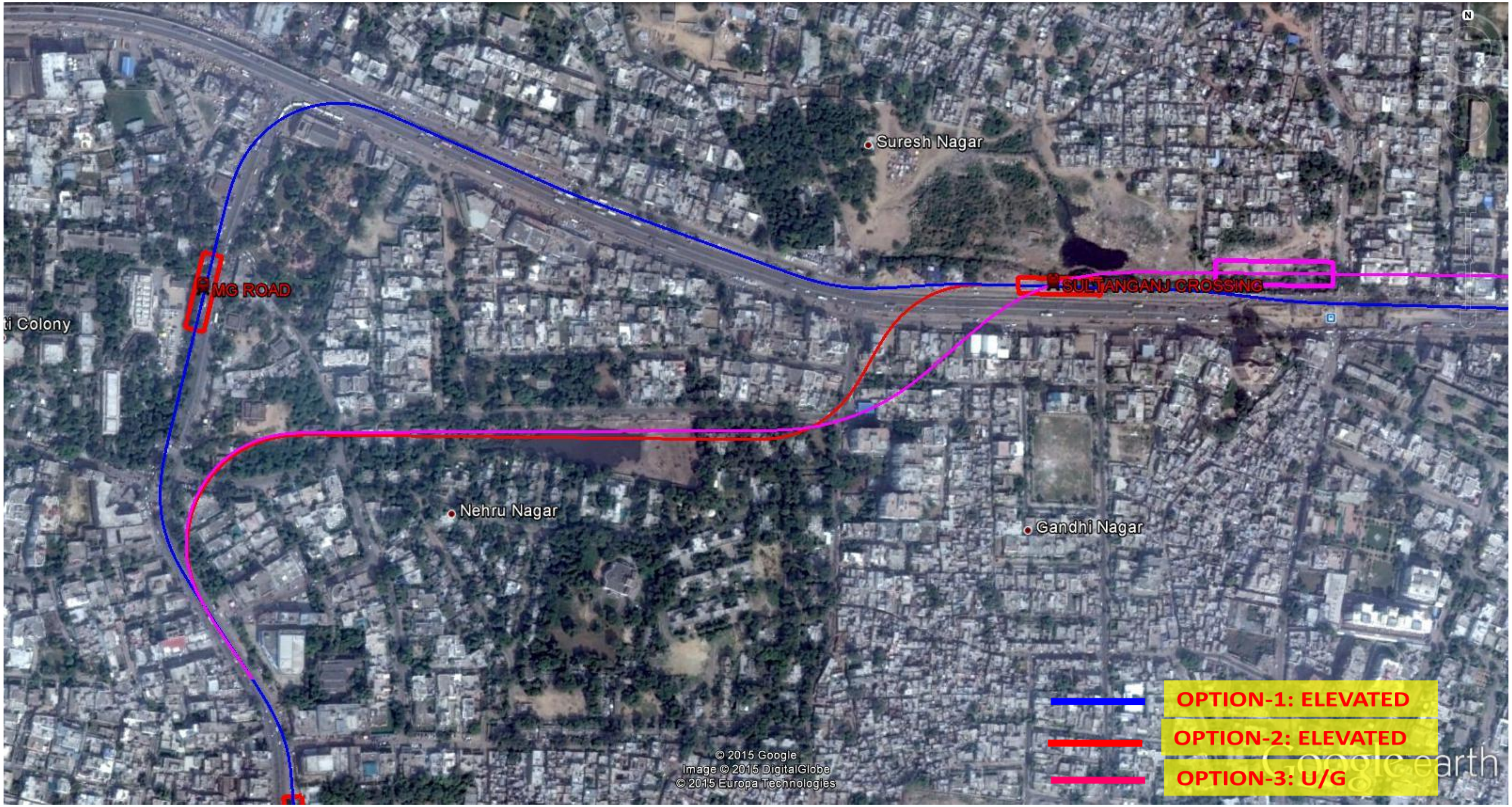


TABLE 5.8: ALIGNMENT OPTIONS NEAR ROMAN CATHOLIC CEMETERY

Details	Option-1: Elevated alignment along MG Road	Option-2: Elevated alignment through Nehru Nagar	Option-3: Underground alignment through Nehru Nagar
Alignment	Alignment is elevated passing along MG Road.	Alignment is elevated passing through Govt. land	Alignment is underground after Diwani Chauraha with ramp in Govt. land
ASI Monument	Through prohibited area of Roman Catholic Cemetery	Through regulated area of Roman Catholic Cemetery	Through regulated area of Roman Catholic Cemetery
Elevated/ Underground	Completely Elevated	Completely Elevated	Underground after Diwani Chauraha
Minimum Distance from Roman Catholic Cemetery (m)	14.0	105.0	105.0
Land Acquisition between Diwani Chauraha and Sultan-ganj Crossing	390 sqm Pvt. Land with 4 structures near MG Road station	5866 sqm floor area of Pvt. Land with 6 structures	2949 sqm floor area of Pvt. Land near Diwani Chauraha with one structure
		1831 sqm floor area of Govt. land with 10 residential structures	1831 sqm floor area of Govt. land with 10 residential structures
Stations	MG Road station Feasible	MG Road station not Feasible	MG Road station not Feasible.
Elevated Length (Km)	15.4	15.1	8
U/G Length (Km)	0	0	7.4
Elevated Stations	15	14	8
U/G Stations	0	0	6
Broad Cost (Crore)	3850	3950	5850
Recommendations	**Recommended subject to ASI permission**	**Recommended if ASI permission is not given**	**Not Recommended**

- NHAI is constructing three flyovers along NH-2 namely at Khandari Chauraha, Sultanganj Crossing and Water Works Chauraha. Consultant has made repeated requests to NHAI through letters dated 29.09.2015 and 20.11.2015 (Annexure – 5.1 & 5.2), followed by several telephonic requests and personal visits, to provide details of the flyovers. Vide email dated 07.12.2015, partial details of flyover at Khandari Chauraha (Annexure – 5.3 & 5.4) and Sultanganj Crossing (Annexure – 5.5 & 5.6) have been received. Details of ramp for the above two flyovers are still awaited from NHAI. For flyover at Water Works Chauraha, no details have been communicated by NHAI till date.

As per the details received so far and interaction with NHAI, the flyovers at Khandari Chauraha and Sultanganj Crossing are of 6-lanes (3-lanes on either side) with total width of 25.0m (12.50m on either side from the existing median of NH-2). Flyover at Water works chauraha is of 4-lanes (2-lanes on either side).

Flyovers at Sultanganj Crossing and Water Works Chauraha are coming within the proposed alignment of Metro Corridor-2 i.e. Agra Cantt. to Kalindi Vihar. Accordingly, the centre line of Metro alignment has been kept at a distance of 4.50m from the face of RE wall of road flyover. This will facilitate drilling of piles for Metro substructure. After construction of Metro piers, around 3.0-3.25m space will be left between edge of Metro piers (including protection) and face of RE wall of road flyover. This space will not be useful for vehicular traffic, however, this portion may be raised and used as pedestrian footpath/cycle tracks. On other side, about 6.0-7.0m space will be left between Metro piers (including protection) and property line and same may be used as single lane service road plus footpath.

Part of the Metro viaduct will overhang on flyover. Accordingly, the height of Metro alignment has been kept maintaining a clear height of 5.50m above the finished road level of the proposed flyover.

- **Major Depot at Kalindi Vihar**

  Separate depot with an area of 11.90 Ha is proposed at Kalindi Vihar in the Govt. land (Rajkiya Asthan Land) piece identified by District Administration. The said land piece is identified by avoiding the adjoining forest land and is about 800m away from the road. As shown in **Figure 5.10**, separate entry of approximately 800m length (upto zero point) to depot has been provided from Kalindi Vihar Terminal Station.

  For smooth operation and placement/withdrawal of rakes to/from depot, double line connectivity from Kalindi Vihar station is proposed through two elevated lines of about 800 m. The depot connecting lines are planned through available open land for ease of construction and to avoid acquisition of properties.

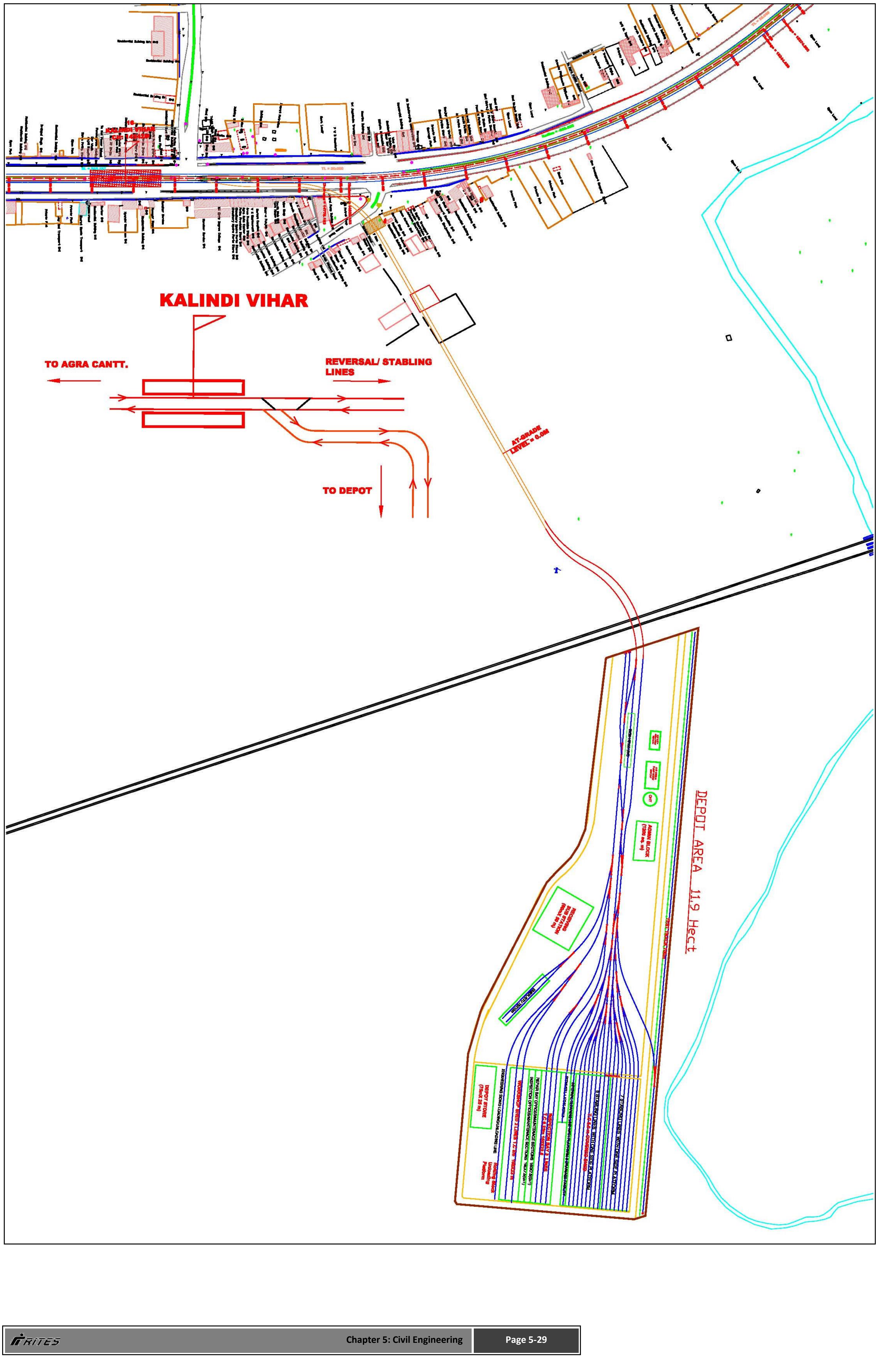
  This option will have following bearings over train operation:-

  - After washing/servicing at depot, the morning services can be initiated from Terminal station i.e. Kalindi Vihar towards Agra Cantt. Station directly.
  - During night, terminating rakes coming from Agra Cantt. may be terminated at Kalindi Vihar station and empty rakes can be placed inside the depot directly.

A. Reference Point for Corridor-2

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

FIGURE 5.10: CONNECTIVITY TO DEPOT FROM KALINDI VIHAR



B. Terminals of Corridor-2

i. Agra Cantt. Metro Station (Southern terminal station)

The Southernmost station on the Metro corridor - 2 is Agra Cantt. Station. The station is proposed elevated in Railway land near the Parking area of Agra Cantt. Railway Station and rail level has been kept 12.00m (minimum) above the ground level. Station has been proposed with Island platform. Proposed metro station will have direct integration with Agra Cantt. Railway Station of Northern – Central Railway.

ii. Kalindi Vihar Metro Station (Northern terminal station)

Northern Terminal of the corridor will be Kalindi Vihar 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 area of Kalindi Vihar and Trans Yamuna Colony Phase-II. Provision for further extension of the corridor along NH-2 has also been kept in the alignment.

Reversal/stabling facility has also been planned beyond Kalindi Vihar Station. Two elevated stabling lines for two Rakes each (total stabling facility for 4 rakes) has been proposed beyond station. The said corridor can be extended in future towards Etmadpur.

Entry to proposed Depot has also been planned from Kalindi Vihar Station. Two separate tracks have been proposed for entry & exit to the depot.

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 5.9.**

TABLE 5.9: INTERCHANGE STATIONS OF CORRIDOR-2

S. No.	Name of station	Mode	Interchange with
1	Agra Cantt. Metro Station	Railway	Agra Cantt. Railway Station of North Central Railway
2	Agra College Metro Station	Metro	Proposed Agra College Metro Station of Corridor-1 of Phase-I Agra Metro

C. Major Roads along Corridor-2

The major roads along and across the alignment are given in **Table 5.10** and **5.11** respectively.

TABLE 5.10: MAJOR ROADS ALONG CORRIDOR-2

S. No.	Name of the Road	Chainage	
		From (m)	To (m)
1	MG Road	1750	8100
2	NH-2	8150	15350

TABLE 5.11: MAJOR ROADS ACROSS CORRIDOR-2

S. No.	Description	Chainage
1	Station Road	130
2	Saudagar Lines	1870
3	Mall Road	2400
4	MG Road-2	4700
5	Shaheed Bhagat Singh Road	5610
7	SN Yadav Road	5610
8	Raja Balwant Singh Road	7675
9	Karbala Road	9320
10	NH-93	11740

5.1.3 ASI Monuments in Agra

5.1.3.1 Legal Provisions

Agra, being a capital city of Mughal Empire followed by being an important civil and military city during the British period, is having very rich Historical and Cultural Heritage and is endowed with numerous Ancient Monuments. Some of these Monuments are located in the close vicinity of proposed Metro alignment and will require necessary approval by competent authority. The applicable Act will be "The Ancient Monuments and Archaeological Sites and Remains Act, 1958, as updated by the Ancient Monuments and Archaeological Sites and Remains (Amendment and Validation) Act, 2010". The relevant provisions of the said Act are summarized as under:-

- In terms of Section - 4 of said Act, Central Government is empowered to declare an Ancient Monument or Archaeological Site and Remains to be of National importance. As per Section-4 (4) of said Act, "*A notification published under sub-section (3) shall, unless and until it is withdrawn, be conclusive evidence of the fact that the Ancient Monument or the Archaeological Site and Remains to which it relates is of National importance for the purposes of this Act*".
- In terms of Section-20A of the said Act, "*Every area, beginning at the limit of the protected area or the protected Monument, as the case may be, and extending to a distance of one hundred metres in all directions shall be the prohibited area in respect of such protected area or protected Monument*". Further, Central Government is empowered to increase the limit of Prohibited area beyond one hundred metres.

- In terms of Section-20(3)(a) & 20(3)(b) of the said Act, Central Government or the Director General is empowered to permit construction in Prohibited area, in case of Public work or any project essential to the Public or such other works or Projects which shall not have any substantial adverse impact on the preservation, safety, security of, or, access to, the monument or its immediate surroundings.
- However, the above power has been withdrawn by way of Amendment to Section-20A, inserted by sub clause 20(4), which stipulates, "*No permission, referred to in sub-section (3), including carrying out any public work or project essential to the public or other constructions, shall be granted in any prohibited area on and after the date on which the Ancient Monuments and Archaeological Sites and Remains (Amendment and Validation) Bill, 2010 receives the assent of the President*".
- In terms of Section-20B of the said Act, "*Every area, beginning at the limit of the prohibited area in respect of every ancient monument and archaeological site and remains, declared as of National importance under Section-3 & 4 and extending to a distance of two hundred metres in all directions shall be the regulated area in respect of every ancient monument and archaeological site and remains*". Further, Central Government is empowered to increase the limit of regulated area beyond two hundred metres.
- Clause 20D of the said Act, deals with the grant of permission by Competent Authority within Regulated area through National Monument Authority. While considering permission, impact of such construction (including the impact of large scale development project, public project and project essential to the public) along with Heritage bye-laws are to be taken into account by the Competent Authority. As per sub-clause 20D(5) of the said Act, "*The recommendation of the Authority shall be final*".
- Section-20E of the said Act, directs the Competent Authority to frame Heritage bye-laws in respect of each protected monument and protected area.
- Section-20F of the said Act, empowers the Central Government to constitute National Monument Authority and Section-20-I of the said Act stipulates functions and power of Authority. Sub-section 20-I(1)(a) & (b) deals with functions of Authority for making recommendations to the Central Government for grading and classifying protected monuments and protected areas. Sub-section 20-I(1)(f) stipulates, "To make recommendations to the Competent Authority for grant of permission", as one of the important function of National Monument Authority.
- Section-20N of the said Act, deals with the power of Central Government to supersede National Monument Authority. Sub-clause 20-N(c) empowers Central Government to supersede National Monument Authority in circumstances which render it necessary to do so in the public interest.
- As per Section-20-O of the said Act, jurisdiction of civil court is barred in respect to matter coming under the jurisdiction of National Monument Authority.
- Section-30 of the said Act, deals with the penalty for violation of provisions of the Act.

- Section-38 of the said Act, empowers the Central Government for making rules for carrying out the purposes of this Act.

5.1.3.2 Categorization of Monuments

In terms of "The Ancient Monuments and Archaeological Sites and Remains Act, 1958, as updated by the Ancient Monuments and Archaeological Sites and Remains (Amendment and Validation) Act, 2010", various Monuments are to categorized on basis of its importance. As per performance audit of Preservation and Conservation of Monuments and Antiquities (Report No. 18 of 2013), in 2011, ASI headquarter notified that all the monuments are to be categorized in following manner (**Figure 5.11**):-

FIGURE 5.11: CATEGORIZATION OF MONUMENTS

Category I	World Heritage Sites
Category II	Tentative list of World Heritage Sites
Category III	Identified for inclusion in the World Heritage tentative list
Category IV	Ticketed monuments (other than mentioned above)
Category V	Identified for categorisation as ticketed monuments
Category VI	Living monuments which receive large number of visitors/pilgrims
Category VII	Other monuments located in the Urban/semi urban limits and in the remote villages
Category VIII	Other category as the Authority may deem fit

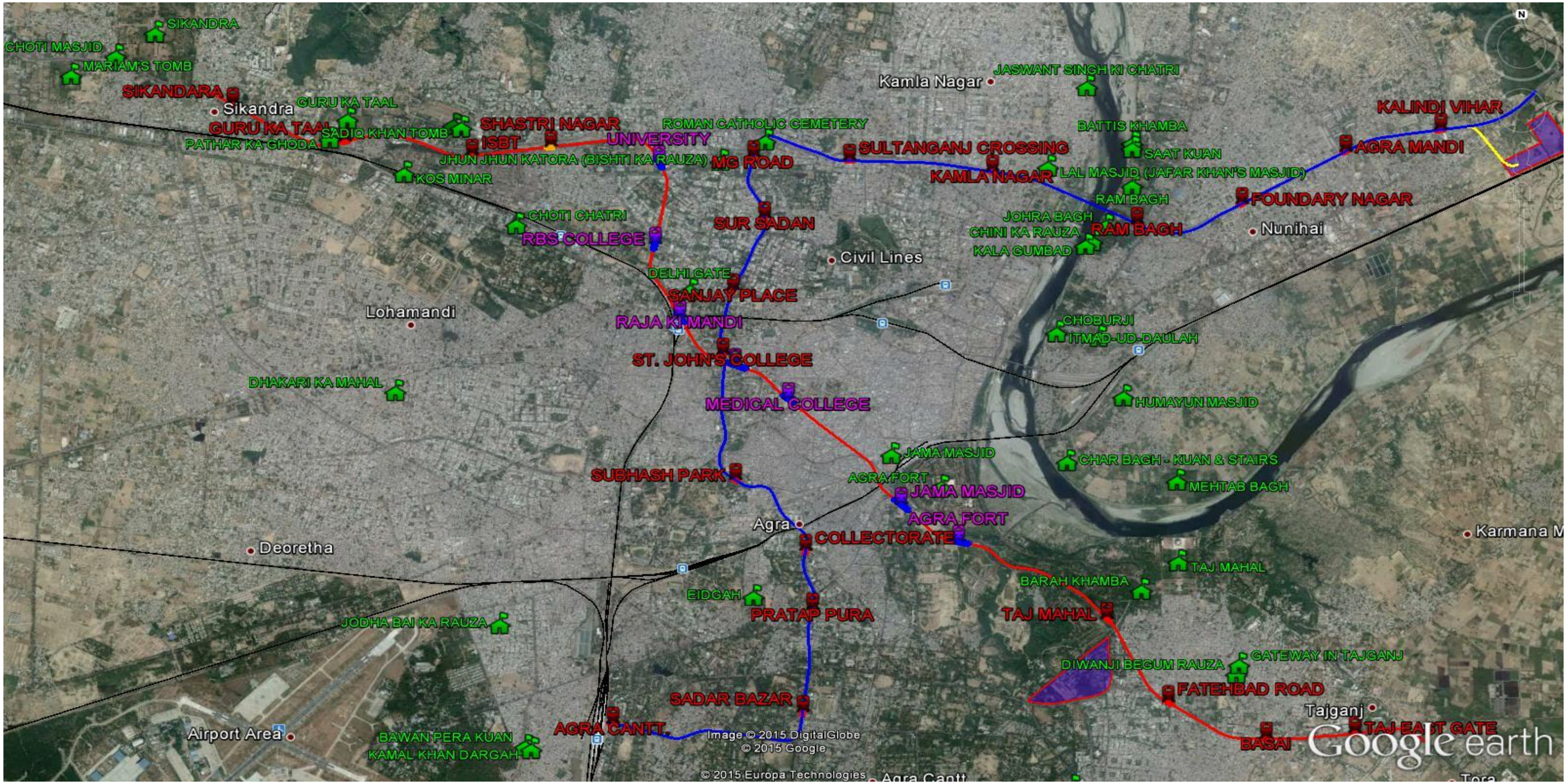
5.1.3.3 Ancient Monuments along Metro Corridors

List of ancient monuments along Metro corridors is shown in **Table 5.12** and **Figure 5.12**.

TABLE 5.12: LIST OF ANCIENT MONUMENTS ALONG METRO CORRIDORS

S. No.	Name of Monuments	Nearest Station	Prohibited Distance as per ASI (m)	Distance from Monument's boundary wall (m)	Beyond Prohibited Area (Y/N)	Beyond Regulated Area (Y/N)
Corridor-1: Sikandara to Taj East Gate						
1	Akbar's Tomb, Sikandara	Sikandara	100	105	Y	N
2	Pathar ka Ghoda	Guru ka Taal	100	20	N	N
3	Guru Ka Taal	Guru ka Taal	100	12.5	N	N
4	Tomb of Salamat Khan	ISBT	100	160	Y	N
5	Sadiq Khan Tomb	ISBT	100	160	Y	N
6	Delhi Gate	Raja Ki Mandi	100	140	Y	N
7	Jama Masjid	Jama Masjid	100	170	Y	N
8	Agra Fort	Agra Fort	100	105	Y	N
9	Taj Mahal	Taj Mahal	500	505	Y	Y
Corridor-2: Agra Cantt. to Kalindi Vihar						
1	Delhi gate	Sanjay Place	100	355	Y	Y
2	Roman Catholic Cemetery	MG Road	100	14	N	N
3	Lal Masjid	Kamla Nagar	100	65	N	N
4	Ram Bagh	Ram Bagh	100	105	Y	N

FIGURE 5.12: ANCIENT MONUMENTS IN AGRA



5.1.3.4 ASI Monuments with Alignment through Prohibited Area

A. Pathar Ka Ghoda & Guru Ka Taal

Pathar Ka Ghoda & Guru Ka Taal ASI Monuments are located at the left and right side of NH-2 respectively as one traverse from Agra to Sikandara. Pathar ka Ghoda is listed in the category of "Some Other Monuments" and Guru ka Taal in "List of Monuments and Sites" maintained at website of ASI, Agra circle (http://www.asiagracircle.in/list-of.html).

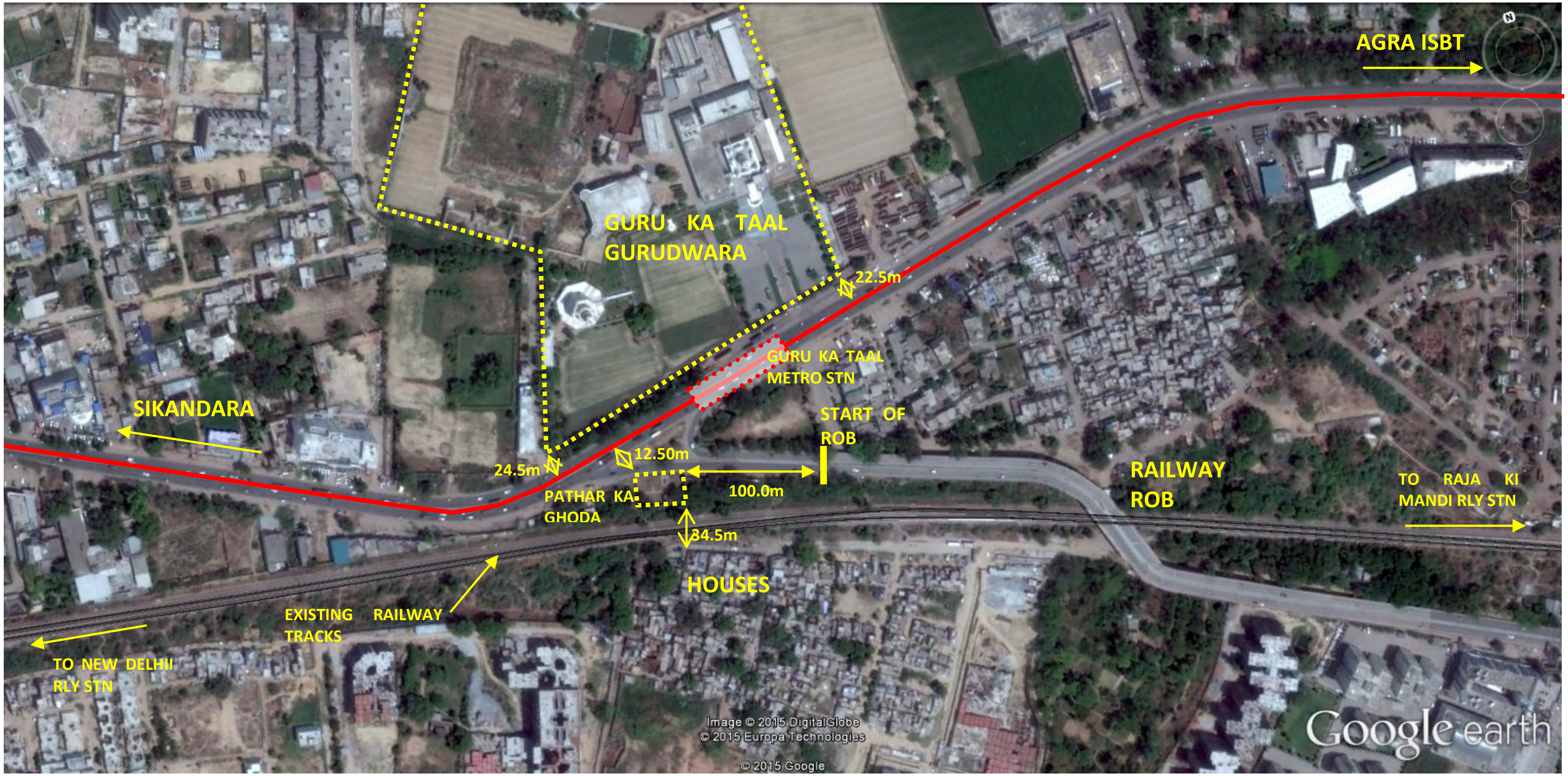
It is to be noted that construction of Railway ROB, National Highway-2 and residential houses have taken place during the course of time which is also falling within the 100m Prohibited area. The site description and photographs of these Monuments/sites are placed as **Figure 5.13** for better appreciation of site conditions.

As the alignment is passing through between the two monuments/sites, it is not possible to avoid the prohibitive area of the two monuments. Presence of Railway lines and dense habitation put the constraint of following NH-2 alignment for the Metro corridor.

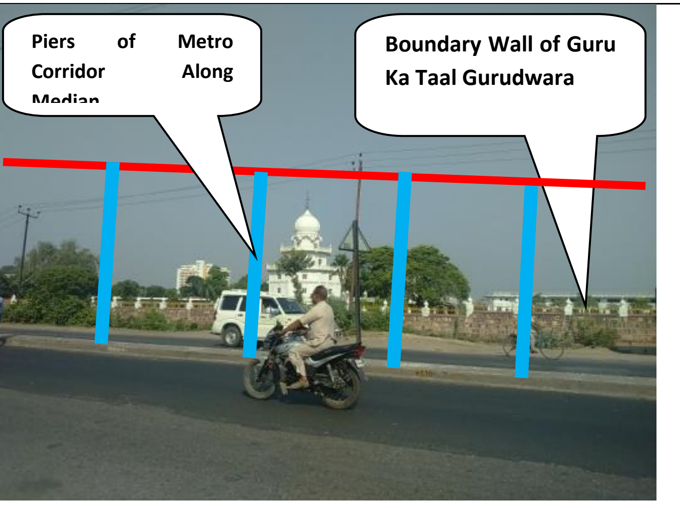
It is recommended to obtain dispensation of appropriate Authority/Central Government on following grounds:-

a. Elevated alignment proposed to pass in between the two monuments/sites on the central median of NH-2 will be the safest and least intrusive option with regard to these two monuments/sites.
b. The elevated alignment will require construction of piles and piers in the centre of the NH-2 on the median and the construction requirement will not cause any damage to these two monuments/sites. This aspect can be demonstrated to competent authority with complete description of detailed construction scheme.
c. Guru ka Taal is located in well defined boundary and there will be no requirement to enter into the premises of Guru ka Taal. Similarly, Pathar ka Ghoda is located in fenced enclosure and the said enclosure will not be required to relocate/disturb during construction and operation phase.
d. Metro being an environment and eco-friendly mode of transport and will reduce the burden on road traffic and consequent noise and air pollution caused by road traffic.
e. A lot of construction activities including Road over bridge has already under taken within the prohibitive limit of two monuments/sites.
f. The Metro project falls in the category of "Public Work" and "Project essential to Public" and it can be demonstrated in detail that the proposed elevated construction will not have any substantial adverse impact on the preservation, safety, security of, or, access to, the monument or its immediate surroundings.
g. In case, the permission for the proposed alignment near these two monuments/sites is not granted, the alignment will be required to be terminated at ISBT and it will deprive domestic and international tourist to reach Sikandara through Metro Corridor and may result into loss of tourist inflow to the monuments located in Sikandara.

FIGURE 5.13: ALIGNMENT NEAR PATHAR KA GHODA & GURU KA TAAL

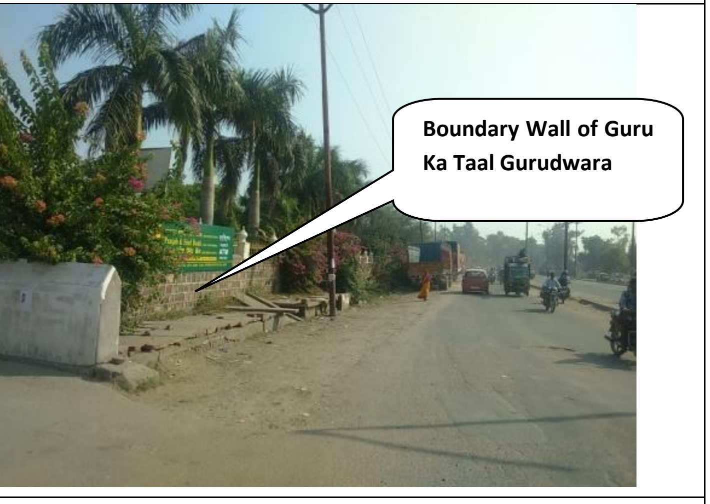


Guru Ka Taal Gurudwara, protected Monument



Boundary Wall Of Guru Ka Taal Gurudwara

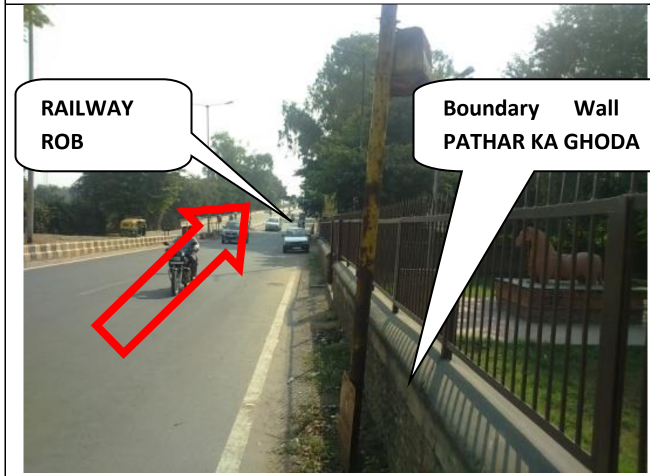
Boundary Wall Of Guru Ka Taal Gurudwara



Boundary Wall Of Guru Ka Taal Gurudwara

Pathar ka Ghoda, Protected Monument

Boundary Wall Pathar ka Ghoda



ROB near Pathar ka Ghoda Monument

NH-2 near Pathar Ka Ghoda

h. Alternative alignment options have also been studied and none has been found feasible.

i. The option of taking the alignment underground upto Sikandara was also studied but the underground alignment will come even much closer to the Monument boundary as compared to the elevated alignment. Moreover, underground construction can cause damage to the structure due to the vibrations coming through the underground tunnels. Hence, underground construction is not recommended for the section.

B. Roman Catholic Cemetery

Roman Catholic Cemetery is located at the right side of MG Road as one traverse from Agra Cantt. Railway station to Bhagwan Talkies. Roman Catholic Cemetery is listed in the category of "Some Other Monuments" maintained at website of ASI, Agra circle (http://www.asiagracircle.in/list-of.html). It is not even a ticketed monument.

It is to be noted that during the course of time, construction of NH-2 Flyover, Bhagwan Talkies Cinema Hall, Petrol Pump, multi-storey Commercial complex and mushrooming of residential houses have taken place within the 100m Prohibited area. The site description and photographs of Roman Catholic Cemetery is placed as **Figure 5.14** for better appreciation of site conditions.

As the alignment is passing along MG Road on west of the monument/site, it is not possible to avoid the prohibitive area of the Roman Catholic Cemetery. Presence of dense habitation on either side of MG Road put the constraint of following any detour in the alignment to avoid prohibitive area of Roman Catholic Cemetery. Elevated alignment is proposed to pass on the western edge of MG Road so as to keep it at maximum possible distance from the boundary of Roman Catholic Cemetery.

It is recommended to obtain dispensation of appropriate Authority/Central Government on following grounds:-

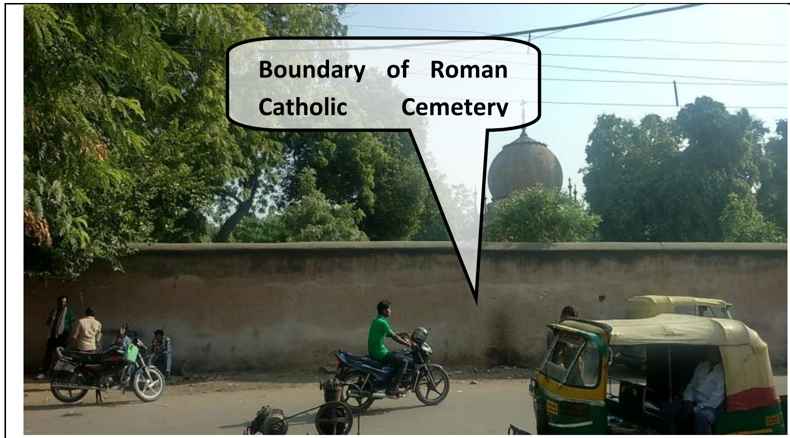
a. Proposed Elevated alignment pass on the western side of Roman Catholic Cemetery along the edge of MG Road will be the safest and least intrusive option with regard to Roman Catholic Cemetery.

b. The elevated alignment will require construction of piles and piers along the western edge of MG Road and the construction requirement will not cause any damage to the monument/site. This aspect can be demonstrated to competent authority with complete description of detailed construction scheme.

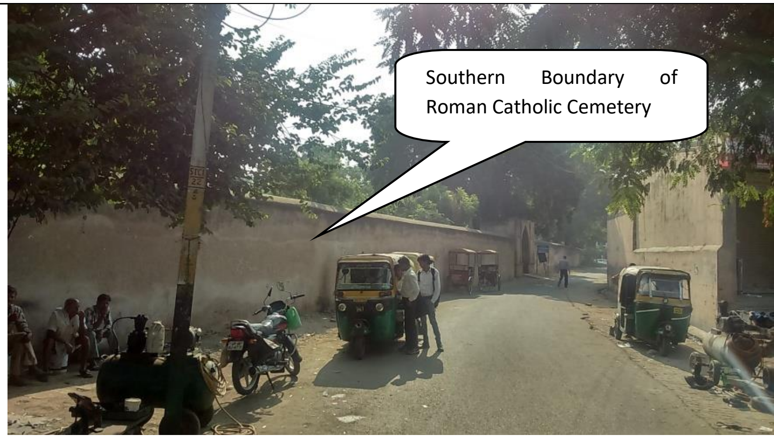
c. Roman Catholic Cemetery is located in well defined boundary and there will be no requirement to enter into the premises of Roman Catholic Cemetery and the said boundary will not be required to disturb during construction and operation phase.

d. Metro being an environment and eco-friendly mode of transport and will reduce the burden on road traffic and consequent noise and air pollution caused by road traffic.

FIGURE 5.14: ALIGNMENT NEAR ROMAN CATHOLIC CEMETERY

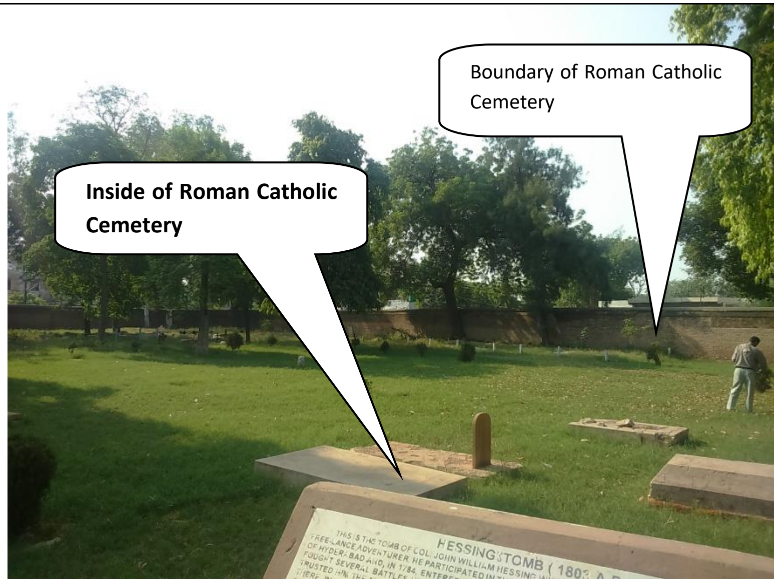


Boundary of Roman Catholic Cemetery facing MG Road

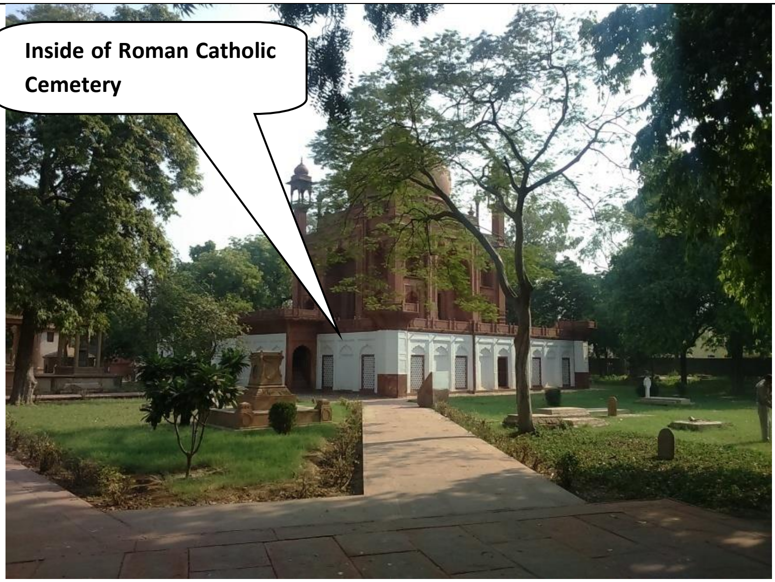
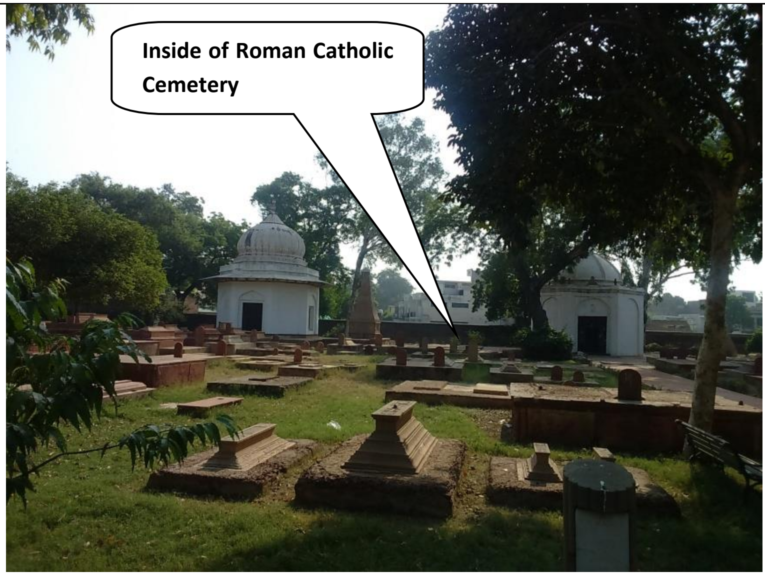
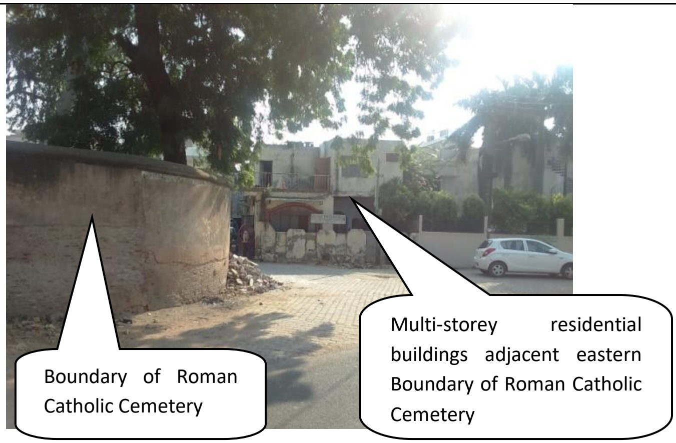
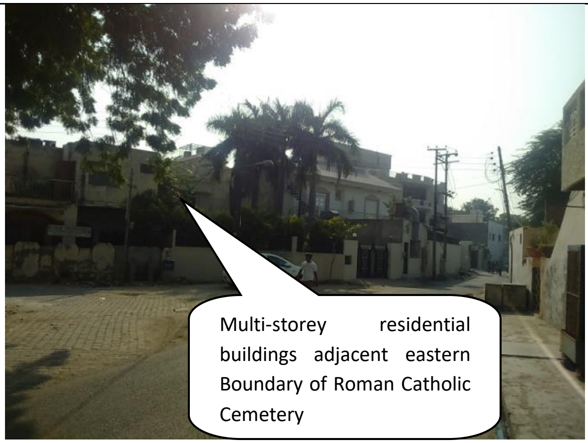


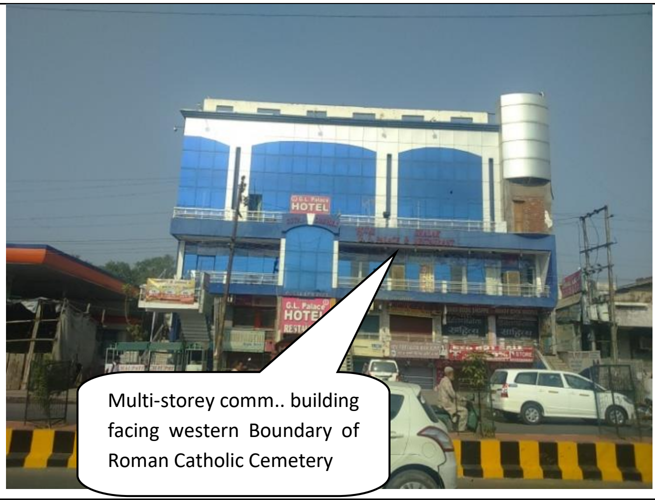
Boundary of Roman Catholic Cemetery perpendicular to MG Road

Entry of Roman Catholic Cemetery



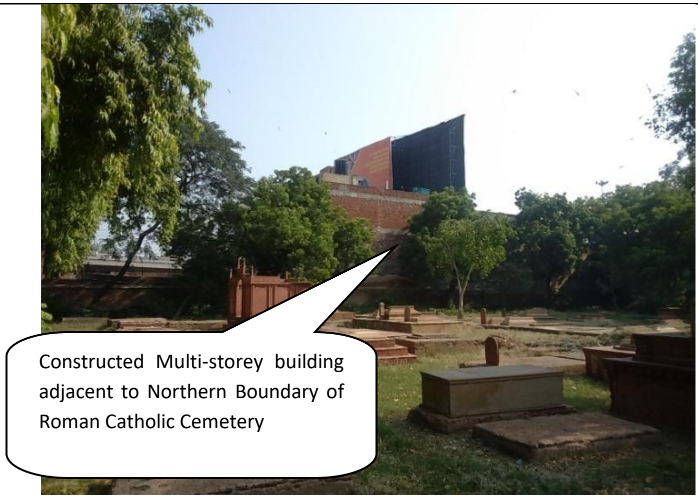
Roman Catholic Cemetery

	
	
Residential Building near Boundary of Roman Catholic Cemetery	**Residential Building near Boundary of Roman Catholic Cemetery**



Multi-storey building near Boundary of Roman Catholic Cemetery facing MG Road

Bhagwan Talkies Cinema Hall adjacent to Northern Boundary wall of Roman Catholic Cemetery



e. A lot of construction activities including Bhagwan Talkies Flyover along NH-2, Bhagwan Talkies Cinema Hall, Petrol Pump, multi-storey Commercial complex and mushrooming of residential houses has already under taken within the prohibitive limit of Roman Catholic Cemetery.

f. The Metro project falls in the category of "Public Work" and "Project essential to Public" and it can be demonstrated in detail that the proposed elevated construction will not have any substantial adverse impact on the preservation, safety, security of, or, access to, the monument or its immediate surroundings.

g. Proposed Elevated alignment is part of 16.0 Km fully elevated Corridor-2 from Agra Cantt. Railway Station to Kalindi Vihar and will serve the important area like Sadar Bazar, Partap-pura, Collectorate, Agra College, Sanjay Place, Sultanganj Crossing, Kamla Nagar, Foundary Nagar, Trans Yamuna Colony Phase-I & II and Kalindi Vihar. The only land parcel for depot for the said corridor is available in Kalindi Vihar. In case, the permission for the proposed alignment near Roman Catholic Cemetery is not granted, the whole corridor will have to be abandoned leading to lot of inconvenience to general public and huge financial and ecological loss to Nation.

h. In case underground alignment is considered, it is to be planned from starting of the corridor at Agra Cantt. Railway Station as there is no space available for ramping down. Moreover, in this case, due to proximity of alignment to the monument, likelihood of damage to the monuments is more in case of underground tunneling.

C. Lal Masjid (JAFAR KHAN'S TOMB)

Lal Majid is located on the north of Water works. Lal Majid is listed in the category of "Some Other Monuments" maintained at website of ASI, Agra circle (http://www.asiagracircle.in/list-of.html). As per ASI, 100 m is the prohibited area around Lal Majid. Due to private commercial buildings, the alignment falls within Prohibited area and has been planned at a distance of about 65m away from boundary wall of Lal Majid.

It is to be noted that during the course of time, multi-storey commercial buildings and mushrooming of residential houses have taken place within the 100m Prohibited area. The site description of Lal Majid is placed as **Figure 5.15** for better appreciation of site conditions.

As the alignment is passing through the open Government land on South of the monument/site, it is not possible to avoid the prohibitive area of the Lal Masjid. Presence of dense habitation on either side of NH-2 put the constraint of following any detour in the alignment to avoid prohibitive area of Lal Masjid. Elevated alignment is proposed to pass on the Southern end of NH-2 so as to keep it at maximum possible distance from the boundary of Lal Masjid.

FIGURE 5.15: ALIGNMENT NEAR LAL MASJID

	
Lal Masjid, protected Monument	**Lal Masjid, protected Monument**
	
Maintenance work of Lal Masjid is in progress	**Under construction flyover at Water Works Chauraha near Lal Masjid**

	
Under construction flyover at Water Works Chauraha near Lal Masjid	**Multi-storey building near Lal Masjid**
	
Multi-storey building near Lal Masjid	**Maintenance work of Lal Masjid is in progress**

Permission from Competent Authority/Central Government can be obtained on following grounds:-

a. The proposed alignment is located at about 65 m from boundary of Lal Masjid. Proposed elevated alignment pass on the Southern side of Lal Masjid from open Government land will be the safest and least intrusive option with regard to Lal Masjid.
b. NHAI is constructing flyover at water works chauraha which also falls in prohibited area of Lal Masjid at an approximate distance of 30m from the monument. It is understood that NHAI has obtained permission for construction of flyover within prohibited area of Lal Masjid. Accordingly, on same grounds permission can be requested for the proposed Metro corridor.
c. After construction of NHAI flyover across NH-2 at water works chauraha, it will serve as a physical barrier between Metro corridor and Lal Masjid.
d. The elevated alignment will require construction of piles and piers in open Government land on south of Lal Masjid and the construction requirement will not cause any damage to the monument/site.
e. Lal Masjid is located in well defined boundary and there will be no requirement to enter into the premises of Lal Masjid and the said boundary will not be required to disturb during construction and operation phase.

5.1.3.5 ASI Monuments with Alignment through Regulated Area

The alignment passes through the regulated area of ASI monuments namely, Akbar's Tomb (Sikandara), Salamat Khan's Tomb, Sadiq Khan's Tomb, Delhi Gate, Jama Masjid, Agra Fort, Taj Mahal and Ram Bagh. Permission from the Competent Authority/Central Government will be required to pass through the regulated area of these protected monuments.

As per ASI, 100 m is the prohibited area around these monuments. Permission from Competent Authority/Central Government can be obtained on following grounds:-

a. Proposed alignment is outside Prohibited area.
b. Proposed alignment is safest and least intrusive option with regard to the ASI Monuments.
c. ASI Monuments are located in well defined boundary and there will be no requirement to enter into their premises and the said boundary will not be required to disturb during construction and operation phase.
d. Metro being an environment and eco-friendly mode of transport and will reduce the burden on road traffic and consequent noise and air pollution caused by road traffic.
e. The Metro project falls in the category of "Public Work" and "Project essential to Public" and it can be demonstrated in detail that the proposed elevated construction will not have any substantial adverse impact on the preservation, safety, security of, or, access to, the monument or its immediate surroundings.

f. With proposed Metro stations near ASI Monuments, domestic and international tourist will be able to reach with ease and may result into increase of tourist inflow to the monument.

5.1.3.6 Few Precedence of Metro Alignment passing within Prohibitive/ Regulated Area of Ancient Monuments

- Vide letter No. CA (ASI)/Delhi/Permission(RA)/2013/UID: 86/362/3054, Dated 01.02.2013, Competent Authority NCT of Delhi, has granted permission for construction of Delhi Metro Phase-III corridor from Central Secretariat to Kashmere Gate via Janpath, Delhi Gate, Jama Masjid and Lal Qila which falls in the regulated area of Jantar Mantar, Delhi Gate, Sunehari Masjid, Red Fort and Kashmere Gate.
- For East West Metro corridor (Howrah Maidan to Salt Lake Sector-V), Kolkata, permission for passing alignment through prohibited area of following monuments is under active consideration of ASI:-
  - Currency Building (Alignment is 24.0m from boundary wall of protected Monument).
  - Beth-el-Synagogue (Alignment is 17.0m from boundary wall of protected Monument).
  - Magen David Synagogue (Alignment is 9.80m from boundary wall of protected Monument).
- Passing Jaipur Metro alignment near Chandpole.

5.1.4 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 ADA.
- 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 5.13 and 5.14** respectively**.** Wherever space and site condition permits, portal type arrangement is proposed for elevated stations. However, due to limited ROW and narrow roads, most of the elevated stations are proposed with Cantilever type arrangement, which is also used extensively in Jaipur Metro and for specific stations in LMRC as well as DMRC.
- Schematic diagram for Agra Metro corridors is shown in **Figure 5.16**.

TABLE 5.13: LIST OF STATIONS FOR CORRIDOR-1

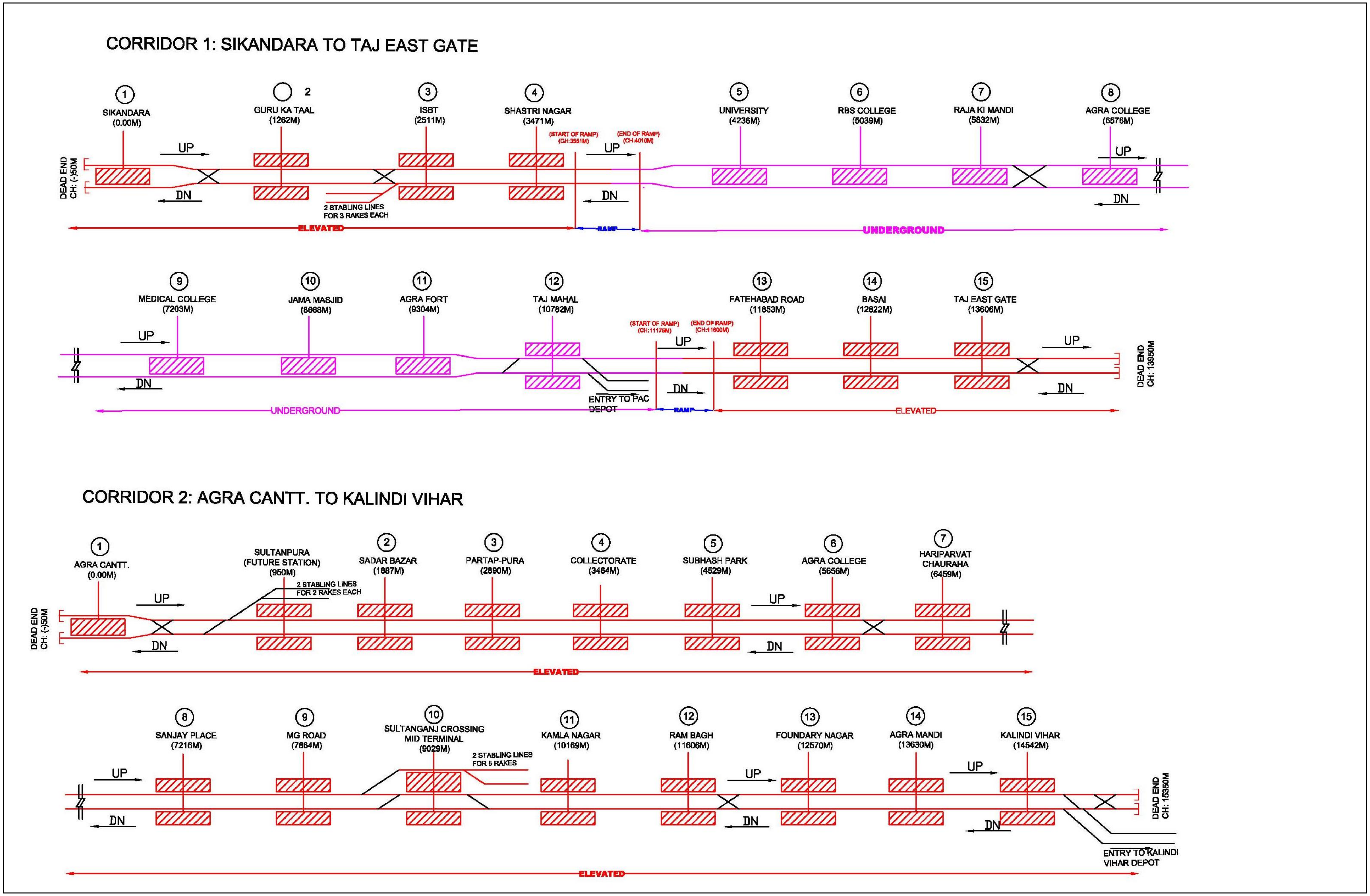
S. No.	Station Name	Chainage (Km)	Inter Station Distance	Ground level	Proposed Rail Level	Station Height/ Depth	Underground/ Elevated	TSS	Proposed Length	Proposed Width
1	Sikandra	0.00	-	169.992	181.500	11.508	Elevated	Yes	85	20.45
2	Guru Ka Taal	1262	1262	169.990	182.000	12.010	Elevated	No	75	20.5
3	ISBT	2511	1249	170.547	181.000	10.453	Elevated	Yes	85	19.2
4	Shastri Nagar	3471	960	168.707	177.500	8.793	Elevated	No	75	21.7
5	University	4236	765	167.858	155.000	-12.858	Underground	Yes	130	26.55
6	RBS College	5039	803	166.929	148.000	-18.929	Underground	No	130	26.55
7	Raja Ki Mandi	5832	793	167.140	148.000	-19.140	Underground	Yes	140	26.55
8	Agra College	6576	744	163.400	148.000	-15.400	Underground	No	180	26.55
9	Medical College	7203	627	162.593	144.000	-18.593	Underground	Yes	140	26.55
10	Jama Masjid	8668	1465	158.000	140.000	-18.000	Underground	No	170	24.6
11	Agra Fort	9304	636	153.547	144.000	-9.547	Underground	Yes	180	24.6
12	Taj Mahal	10782	1478	166.544	159.000	-7.544	Underground	No	130	26.55
13	Fatehabad Road	11853	1071	167.891	180.000	12.109	Elevated	Yes	85	21.7
14	Basai	12822	969	167.328	179.500	12.172	Elevated	No	75	19.2
15	Taj East Gate	13606	784	168.483	180.500	12.017	Elevated	Yes	85	21.7

TABLE 5.14: LIST OF STATIONS FOR CORRIDOR-2

S. No.	Station Name	Chainage (Km)	Inter Station Distance	Ground level	Proposed Rail Level	Station Height/ Depth	Underground/ Elevated	TSS	Proposed Length	Proposed Width
1	Agra Cantt.	0.00	-	167.040	179.100	12.060	Elevated	Yes	85	20.45
2	Sultanpura*	950	950	167.083	179.300	12.217	Elevated	Yes	85	19.2
3	Sadar Bazar	1887	937	167.155	179.200	12.045	Elevated	Yes	85	21.7
4	Partap-Pura	2890	1003	168.234	180.300	12.066	Elevated	Yes	85	21.7
5	Collectorate	3464	574	166.286	178.500	12.214	Elevated	No	75	21.7
6	Subhash Park	4529	1065	165.061	176.300	11.239	Elevated	Yes	85	21.7
7	Agra College	5656	1127	165.880	178.100	12.220	Elevated	No	80	27.15
8	Hariparvat Chauraha	6459	803	166.598	178.500	11.902	Elevated	Yes	85	19.2
9	Sanjay Place	7216	757	163.670	175.800	12.130	Elevated	No	75	20.5
10	M.G.Road	7864	648	167.065	181.000	13.935	Elevated	Yes	85	20.5
11	Sultan Ganj Crossing	9029	1165	160.396	175.000	14.604	Elevated	No	75	27.9
12	Kamla Nagar	10169	1140	157.848	170.200	12.352	Elevated	Yes	85	20.5
13	Ram Bagh	11606	1437	155.036	167.000	11.964	Elevated	No	75	20.5
14	Foundary Nagar	12570	964	161.093	173.300	12.207	Elevated	Yes	85	19.2
15	Agra Mandi	13630	1060	160.062	172.300	12.238	Elevated	No	75	19.2
16	Kalindi Vihar	14542	912	162.584	174.600	12.016	Elevated	Yes	85	20.5

*Future Station

FIGURE 5.16: SCHEMATIC DIAGRAM OF AGRA METRO



5.2 ANALYSIS OF CORRIDOR OPTIONS TO BE ELEVATED, UNDERGROUND OR AT GRADE

5.2.1 Corridor Selection

5.2.1.1 Comprehensive Mobility Plan (CMP)

The Comprehensive Mobility Plan (CMP) was prepared in 2011 for the Agra Development Authority (ADA) area and updated in January 2018.

The CMP proposes a total of 116 km length of mass rapid transit system (MRTS) network in Phase III of implementation of CMP proposals. A part of Ring corridor covering Nagla Basua, NH 11, NH3, Rohta, Dayal Bagh, M.G. Road, Sikandara, Kitham and NH2 proposed to be taken up for MRTS (about 19km) in Phase I.

5.2.1.2 Site Reconnaissance

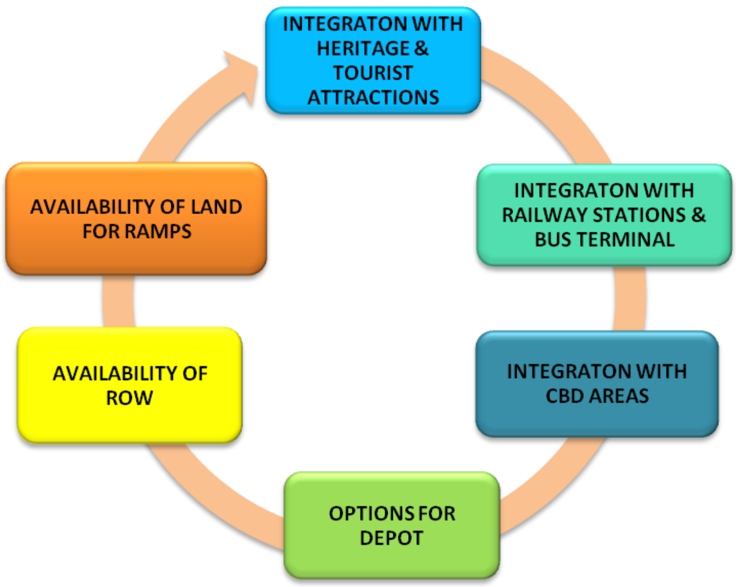
To select the high density corridor in 2015 as well as major industrial areas and upcoming developments, a site reconnaissance survey was carried out by RITES along with ADA and LMRC officials to finalise the priority MRTS corridors. Based on site reconnaissance, two corridors were agreed as priority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

- Corridor 1: Sikandara to Hotel Trident (approx. 14 Kms)
- Corridor 2: Agra Cantt. To TYC Phase-II (approx. 16 Kms)

5.2.1.3 Alignment Options Parameters

The consultant studied the various alignment options for the priority MRTS corridors based on the planning parameters shown in **Figure 5.17.**

FIGURE 5.17: ALIGNMENT OPTIONS PARAMETERS



MRTS corridors as recommended in Inception cum Options Report are presented in **Figure 5.18** and are briefly discussed as under.

5.2.1.4 Alignment Options for Corridor -1

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

A. Sikandara to Agra Fort Section

The corridor-1 starts from Sikandara and runs along NH-2 and heads in East direction. Following three options were presented in Inception cum options report:

- **Option - I**: **Alignment via Institute of Mental Health and SN Medical College** as partially elevated/ underground with ramp down near Institute of Mental Health.
- **Option - II**: **Alignment via Institute of Mental Health and MG Road** as partially elevated/ underground with ramp down near Institute of Mental Health.
- **Option - III**: **Alignment via Bodla Road and MG Road-2** as partially elevated/ underground with ramp down near Govind Nagar.

Major Depot for corridor-1 was proposed in the land parcel identified by Agra Development Authority (presently under possession of 15th Battalion of Provincial Armed Constabulary) near Fatehabad Road. An area of about 20 Hac has been identified for the Maintenance Depot.

B. Agra Fort to Hotel Trident Section

After Agra Fort, the corridor heads in east direction along Fatehabad Road and terminates at Hotel Trident. The alignment from Agra Fort to Golf course has been proposed as underground and from West gate of Taj Mahal till end as elevated with ramp down in Golf Course land.

5.2.1.5 Alignment Options for Corridor -2

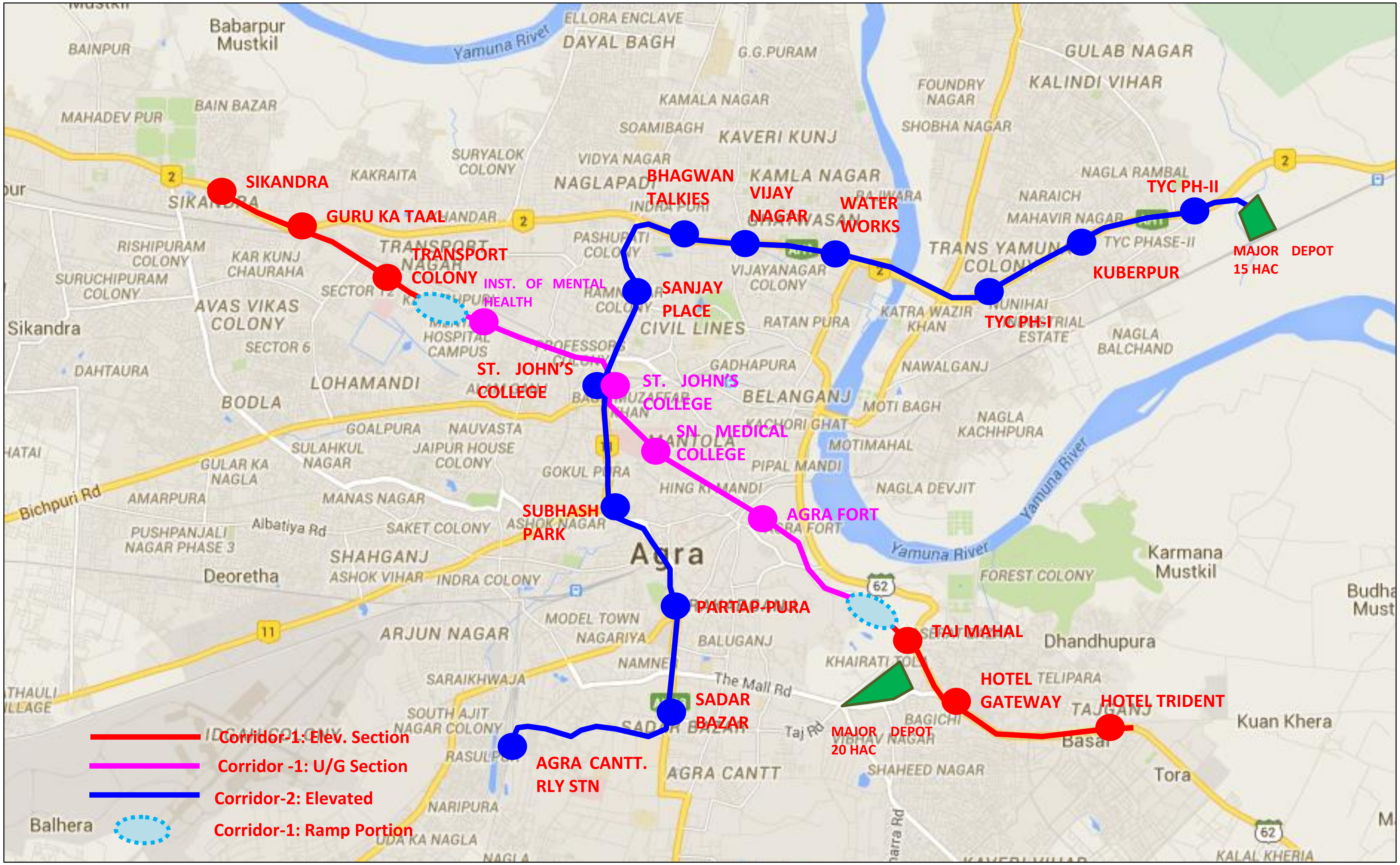
The consultant studied the following alignment options for Corridor-2:

A. Trans Yamuna Colony Ph-II to Water Works Section

Two options were presented in Inception cum options report is as under:

- **Option-2A**: **Trans Yamuna Colony Ph-II to Water Works** as elevated with new Metro Bridge over Yamuna River between existing Road bridges.
- **Option-2B**: **Trans Yamuna Colony Ph-II to Water Works** as elevated with new Metro Bridge over Yamuna River on extreme north of existing Road bridge.

FIGURE 5.18: METRO ALIGNMENT, STATION LOCATIONS & STATION NAMES AS PROPOSED IN INCEPTION CUM OPTIONS REPORT



Major Depot with an area of 15 Ha for Corridor-2 has been proposed in open private agricultural land parcel identified by Agra Development Authority.

B. Water Works to Agra Cantt. Railway Station Section

Two options were presented in Inception cum options report is as under:

- **Alignment Option-I: Alignment via NH-2 and MG Road** as completely elevated.
- **Alignment Option-II: Alignment along MG Road and Railway Tracks** as completely elevated with about 5 KM along Railway tracks.
- **Alignment Option-III: Alignment via Belanganj, SN Medical College, and MG Road** as underground till end.

5.2.1.6 Selection of Corridors

i. During the meeting chaired by Commissioner, Agra Mandal on 13.05.2015, considering the ASI issues at Sikandara and Guru Ka Taal, it was suggested that the alignment of proposed corridor -1 may be modified after Raja Ki Mandi and terminated at ISBT via RBS College and B.R. Ambedkar University. The land parcel near Fatehabad road (presently under possession of PAC) and identified by Agra Development Authority was also approved by District Administration.

It was also suggested that Corridor 2 may start from Agra Cantt. Railway Station and considering the ASI issues at Roman Catholic Cemetery near Bhagwan Talkies, it may be planned as elevated upto Diwani Chowk and from Diwani Chowk to NH-2 feasibility of underground alignment may be explored.

The option of crossing Yamuna River in between the two existing Road Bridges/South of existing Road Bridges was also discussed and it was decided that space between the two existing Road Bridges may be left for future widening of Highway/replacement of existing old Road Bridge and hence, new metro bridge across Yamuna bridge to be on South of the existing Road Bridges. It was also suggested during the meeting that corridor - 2 may be terminated at TYC Phase-II. The land parcel (Private Agricultural land with an area of 15-20 Ha) near TYC Phase-II and identified by Agra Development Authority for maintenance depot was also approved.

Integration of the both the corridors was also suggested near St. John’s College.

ii. During the meeting chaired by Commissioner, Agra Mandal on 03.07.2015, it was discussed that option of extending the Corridor-1 till Sikandara may be explored. In case, permission from ASI is not received, the corridor may be terminated at ISBT. Also, it was agreed that Jama Masjid station near Bijli Ghar bus stand shall be added to connect Jama Masjid and Agra Fort Railway Station.

Further, Commissioner, Agra Mandal had suggested to consider land parcel near Agra City Railway Station for Depot. RITES informed that the suggested land is away from the corridor and is only about 2.2 Hac and hence, is inadequate for construction of depot.

The alternate depot option for Corridor-2 in Dayal Bagh was discussed and it was confirmed by ADA that no land is likely to be available for depot.

iii. During the meeting chaired by Commissioner, Agra Mandal on 18.09.2015, RITES informed that Corridor-1 from University to Sikandara may be planned as elevated by realigning the earlier alignment. By the modified arrangement, about 3.0 Km length will be elevated and will reduce the cost of the project by approximately Rs. 700 Crore. For the above arrangement, ramp for transition from elevated to underground will be located in Irrigation Department open land parallel to NH-2.

Also, the location of ramp for transition from underground to elevated after Agra Fort was discussed and RITES suggested that locating the ramp in Shahjahan Park instead of earlier proposed location at Golf Course (presently under Agra Cantt. possession) shall be a better option. Moreover, the land of Shahjahan Park belongs to State Government and hence, can be easily made available to the project. The above modifications for Corridor-1 were approved.

iv. Further, RITES also informed that the alignment for Corridor-2 may be planned as completely elevated along MG Road and NH-2. It was informed by RITES that based upon detailed topographical survey, it was found that due to constraints of alignment and land availability, the transition from elevated to underground and then underground to elevated after Divani Chowk is not feasible and accordingly, it was approved that Corridor-2 may be planned as completely elevated along MG Road - Bhagwan Talkies - NH-2 till Kalindi Vihar.

v. During the meeting chaired by Commissioner, Agra Mandal on 21.01.2016, it was suggested that possibility of property development over Kalindi Vihar Depot may be explored.

LMRC suggested to shift the Sikandara station near to Akbar's Tomb, ASI Monument for better station planning. It was also suggested that necessary provision shall be kept in the cost estimate for shifting and relocation/construction of PAC and its structures.

vi. During the site visit with MD, LMRC on 22.01.2016, the following were suggested:

- In Corridor-1, Shastri Nagar station shall be shifted near Khandari Chauraha and shall be planned as elevated with con-course on the ground. Efforts shall be made to increase the elevated length in the section.
- In Corridor-1, on consideration that permission for elevated alignment near Taj Mahal will be difficult, it was suggested that alignment in Shahjahan Park may be kept as underground at shallow depth. Also Taj Mahal station shall be planned as

underground instead of elevated. Switch over ramp (underground to elevated) shall be planned along Fatehabad Road by keeping provision for 2-lanes on each side of ramp.

- In Corridor-2, based on the inter-station distance, it was suggested that provision for future station (Sultanpura) between Agra Cantt. And Sadar Bazar may be kept in alignment design.
- It was suggested that name of 3 station i.e. St. John' College, Sanjay Place and Sur Sadan may be renamed as Agra College, Hariparvat Chauraha and Sanjay Place respectively.
- Considering the acquisition of large number of private residential and commercial properties near Ram Bagh, it was suggested that alignment may be modified and be brought near to NH-2 to reduce land acquisition.

vii. During the meeting chaired by Commissioner, Agra Mandal on 20.04.2016, all the suggestions received from LMRC were approved. It was highlighted by RITES that during the site visit with Tehsildar, Etmadpur and ADA officials on 18.04.2016, additional Govt. land near Kalindi Vihar, across the railway line has been identified. It was proposed and agreed that the present depot at Kalindi Vihar planned in private land may be shifted to the adjoining Govt. land of Rajkiya Asthan.

5.3 DESIGN NORMS

5.3.1 Track Geometry

The geometric design norms presented in subsequent paragraphs 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.

5.3.1.1 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

5.3.1.2 Geometric Design Parameters

A. 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.

B. General Criteria

General Criteria used for the design purpose are given 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	750V DC, THIRD RAIL

C. 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.

i. 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.		

ii. 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.

iii. 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	

D. 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.

i. 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

ii. 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

E. Gradients

i. 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.

ii. 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.

iii. 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%

F. 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

5.3.1.3 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
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

5.3.2 Fixed Structure Clearance & 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.

5.3.2.1 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.

5.3.2.2 Structural System of Viaduct

A. 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.

B. 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.

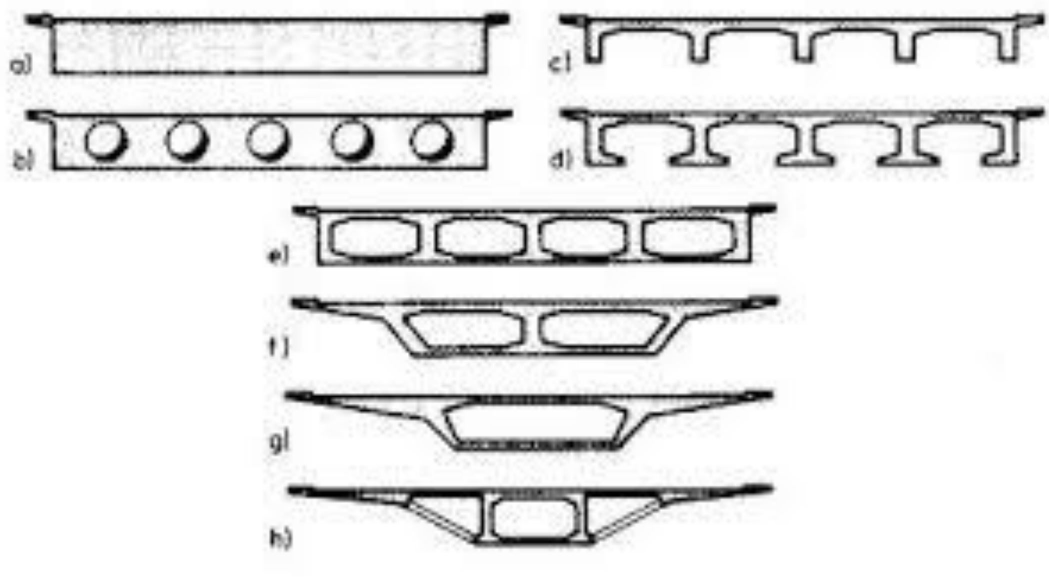
ii) Precast U-Channel superstructure with internal pre-stressing.

iii) Precast U-Channel segmental superstructure using external unbonded tendon.

iv) I-Girder with internal pre-stressing.

v) Special spans

FIGURE 5.19: TYPES OF SUPERSTRUCTURE



Three types of superstructures are further deliberated as under:-

C. 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 5.20: 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.

D. 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 5.21: 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 4.6m to accommodate the two inside walls of the two girders.

FIGURE 5.22: LAUNCHING OF U-CHANNEL GIRDER

E. 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.

F. 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 5.23: LAUNCHING OF I-GIRDER

G. 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, Rivers etc. Cantilever construction Method using PSC spans are used in such situation. Some of common span arrangements are suggested as under:-

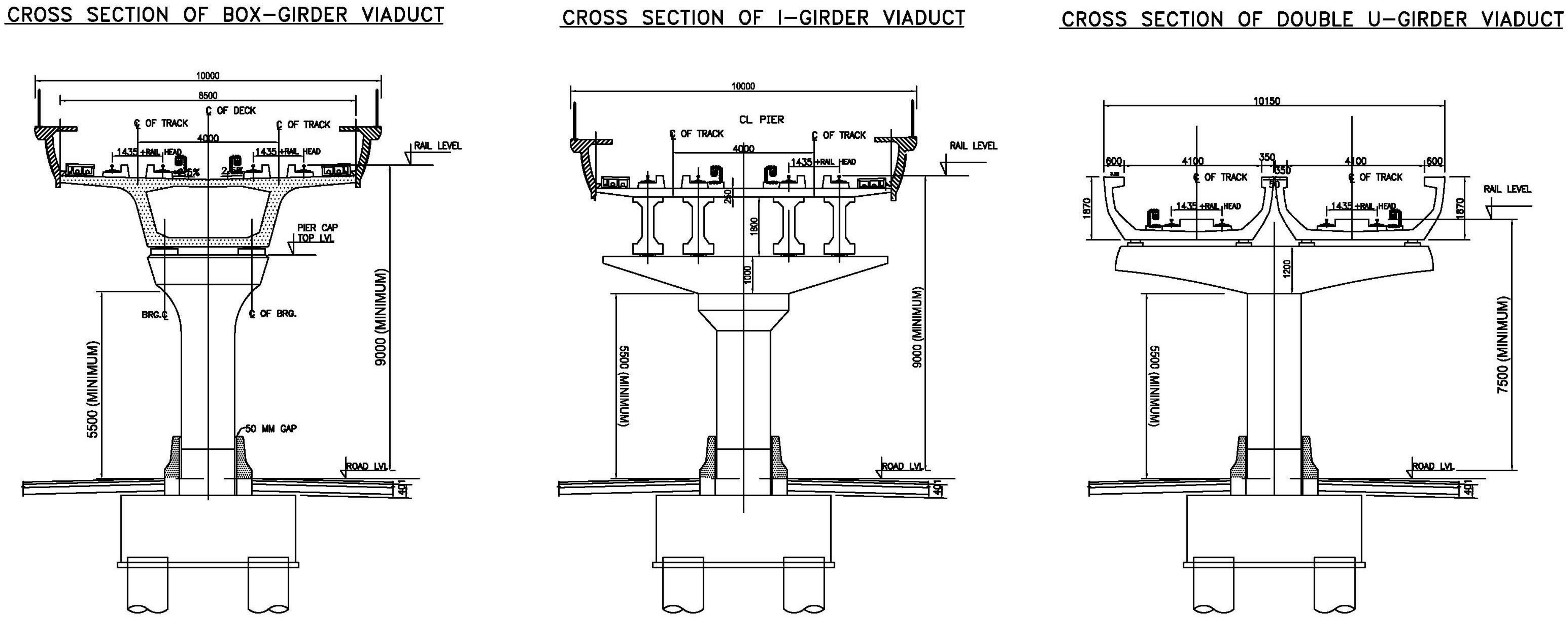
- 34m + 45m + 34m
- 34m + 60m + 34m
- 75m + 105m + 75m

Other span configurations may also be designed as per specific site requirement.

Other alternative is to use steel span. Steel span of upto 60m have been used in Metro systems in India.

FIGURE 5.24: CLC SPAN 75M + 105M + 75M AND STEEL SPAN 60M

FIGURE 5.25: TYPICAL BOX GIRDER VIADUCT SECTION



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.

5.3.2.3 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 5.23**.

TABLE 5.23: 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 and to accommodate the platform width (approx. 4m each), total 8m additional width of cantilever is required to support the comparatively lighter load of platform and passengers. 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.

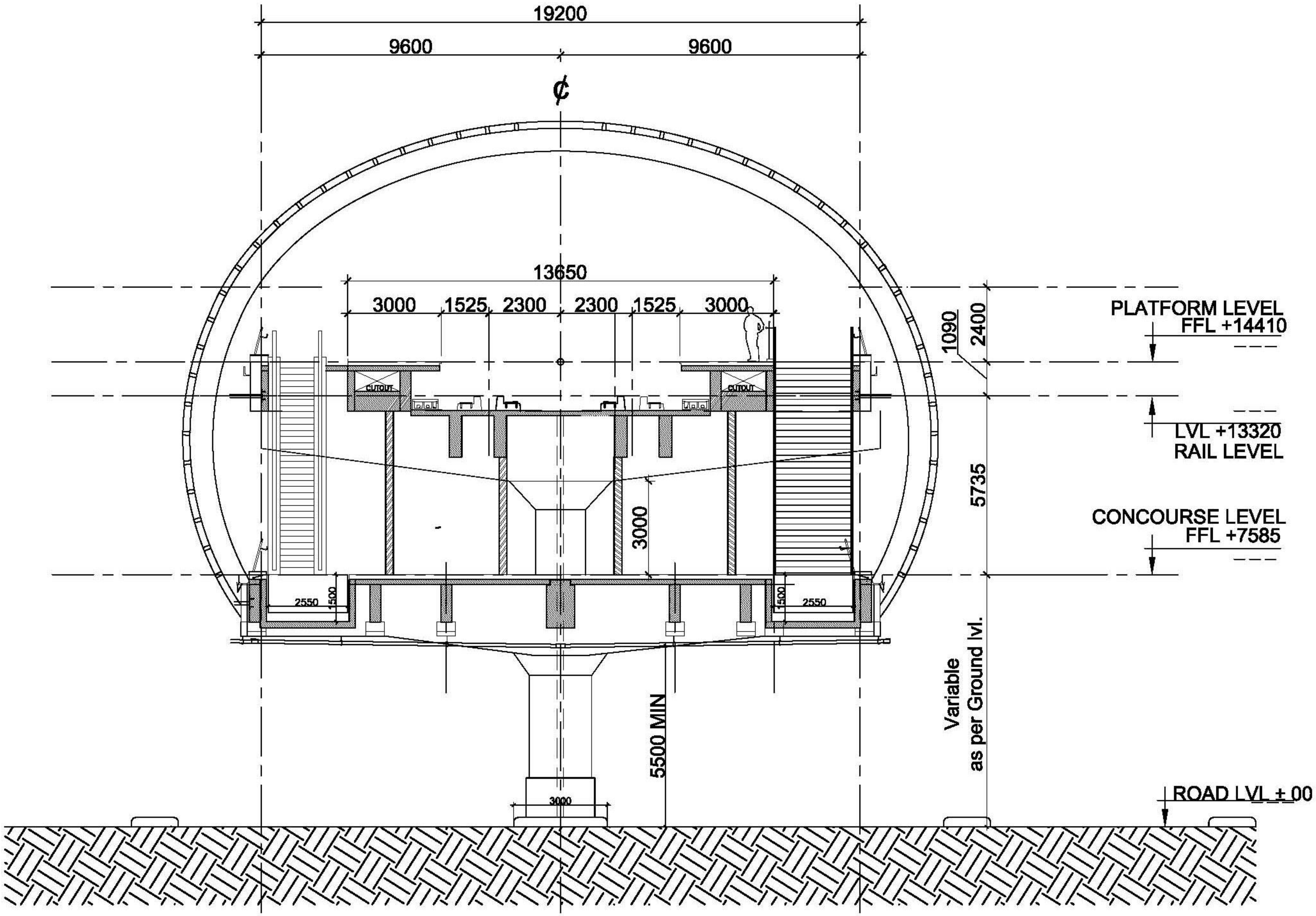
Item	Three legged portal structure	Cantilever Structure
Merit	• Three legged portal is a better structural arrangement with respect to vibration induced by the train loads, long term deflections of the concrete members etc., • The concentrated loads coming from escalators and stair cases connecting concourse 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. Cantilever arrangement may be properly designed to withstand all dead loads, live loads, seismic and wind loads as well as train induced vibrations. • 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 may be planned at Concourse level to use the available space. • Service lane need to be provided to ensure access to adjoining properties.	• There is need for Bus bays, drop/pick up points.

Typical Elevated Station

The elevated station is generally located on the road median 85 m long and 19.20 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 5.26** shows a typical cross section of elevated station.

FIGURE 5.26: TYPICAL ELEVATED STATION



5.3.2.4 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.

A. 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.

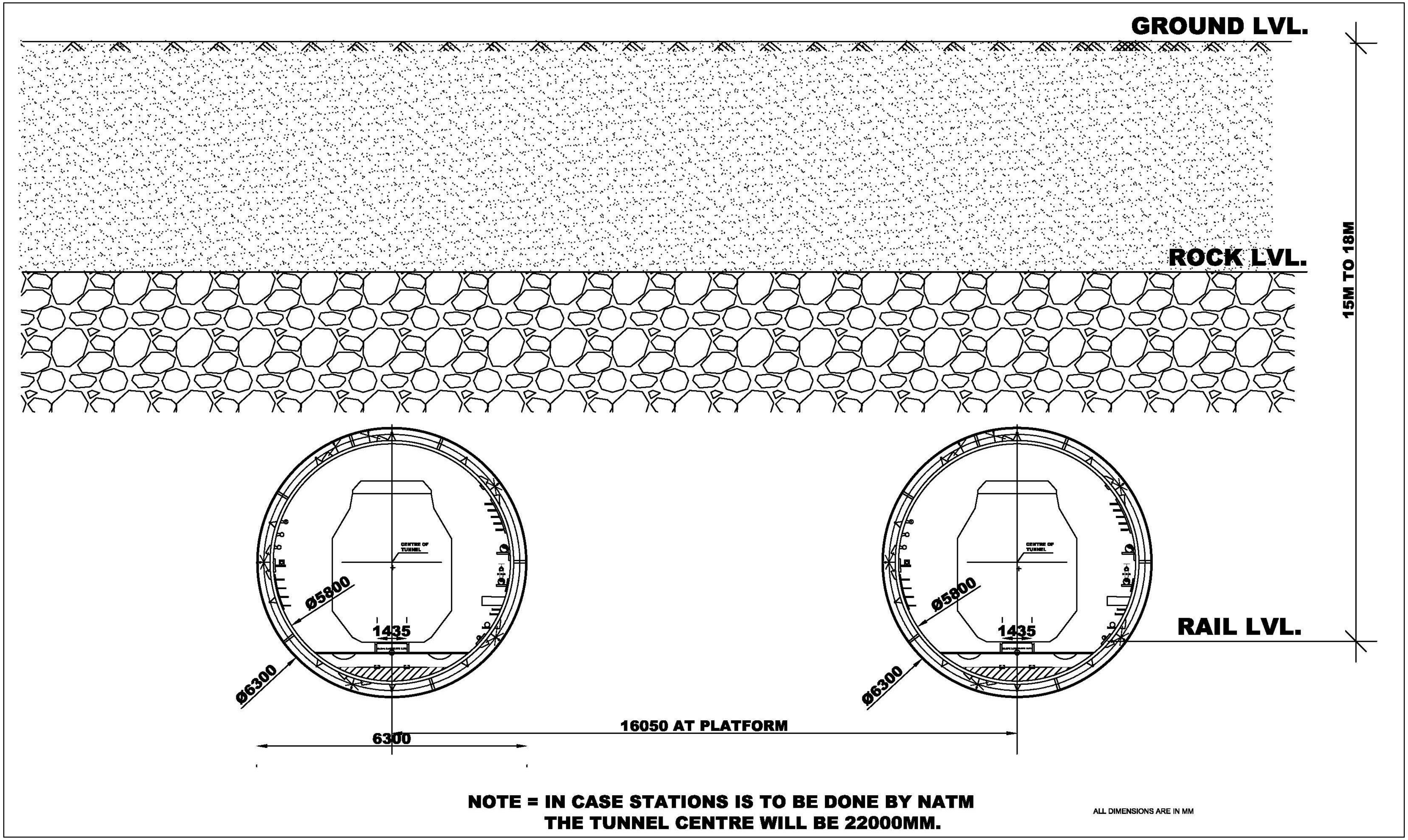
The most important issues to be addressed in selecting a Shield tunnelling method is face stability and minimum displacement/settlement of ground and structures confronting suitable TBM in this project will be the closed type. The Closed type TBM is further categorized as Earth- Pressure Balanced (EPB) 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 5.27: EARTH PRESSURE BALANCE TBM

FIGURE 5.28: 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.

B. Proposed Dimensions

TABLE 5.24: DIMENSIONS OF TBM

Parameter	Proposed dimension
Tunnel internal diameter	5200 mm (minimum)*
Tunnel external diameter	5800 mm
Tunnel excavation diameter	6200 mm
TBM cutter head diameter	6270
Number of segments/rings	5 + 1 Key
Width of segments	1.2m/1.4m/1.5m
Thickness of segments	300 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

*Wider Tunnel diameter may be adopted based upon detailed Geotech investigation at Detailed Design Stage.

C. 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:

i. 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.

ii. 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.

iii. Construction of Reaction Frame

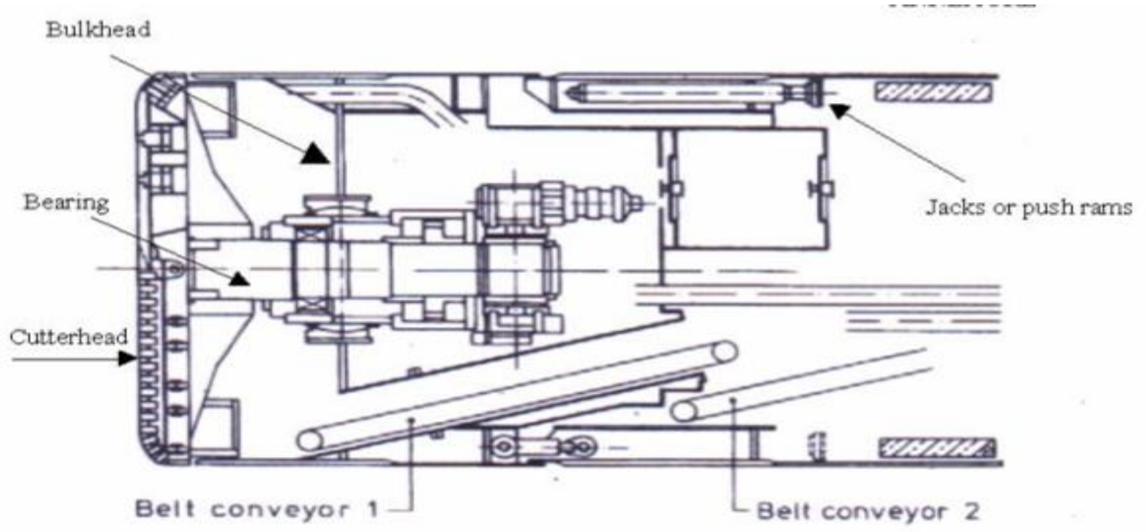
This is a steel Structure consisting of the Frame and supports which is fixed to the shaft floor and is designed to safely bear the thrust [a force of App. 1200 ton (30% of total thrust)] applied by the TBM during its working (force required by the cutting edge to cut the rock). The machine is to be 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 5.29: LAUNCHING CHAMBER

FIGURE 5.30: 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 5.31: MAIN SHIELD ERECTION

FIGURE 5.32: ERECTOR, SCREW CONVEYOR & BACKUP SYSTEM

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.

c. Excavation

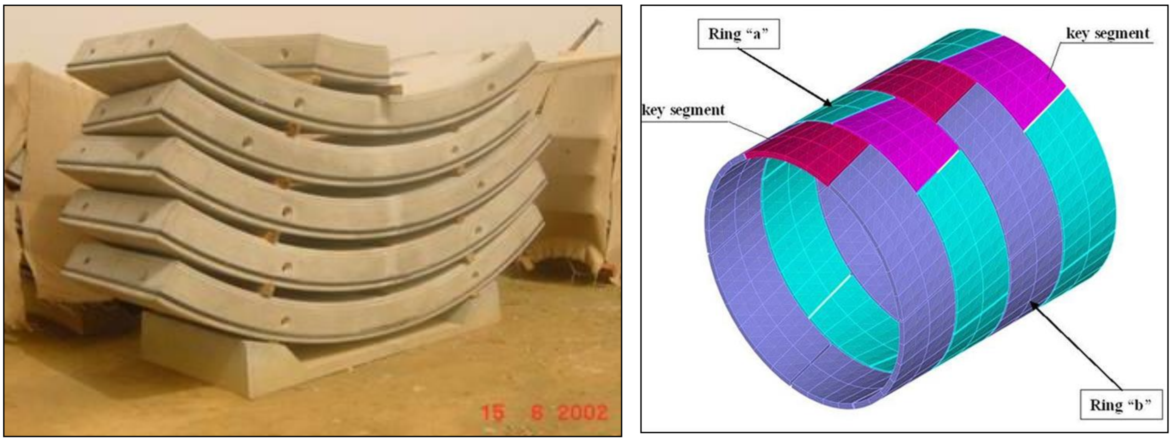
The TBM will operate at all times in enclosed mode. The pressure being maintained by balancing excavated material and foam introduced against material removed via the screw. A belt weighing device will be included on conveyor belt. This will measure the weight of the excavated material as it is transported on the conveyor belt.

FIGURE 5.33: 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 5.34: 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 5.35: TBM THROUGH THE DIAPHRAGM WALL

FIGURE 5.36: TBM PUSHED TO THE OTHER END OF THE STATION

5.3.2.5 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 5.37: CONSTRUCTION OF TUNNEL BY NATM

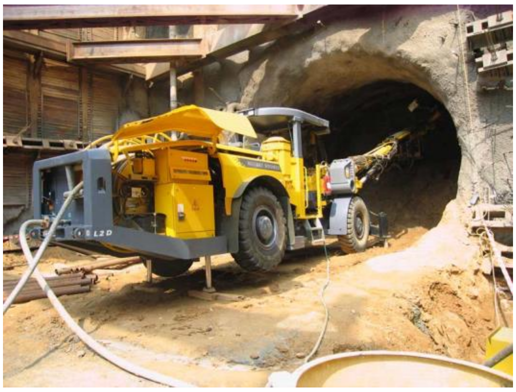
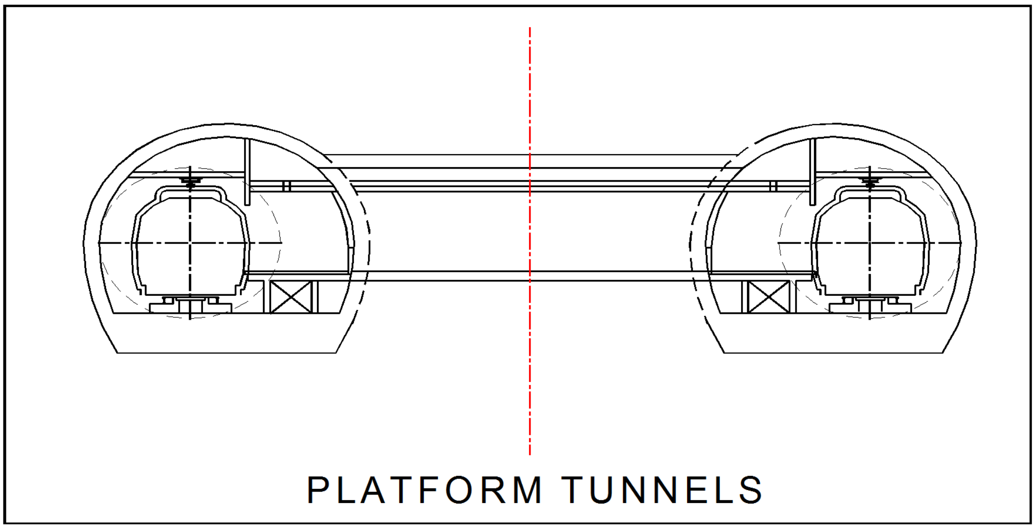


FIGURE 5.38: TYPICAL CROSS SECTION OF TWIN TUNNELS OF U/G STATION BY NATM



A. 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.

B. 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.

C. 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

D. 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.

FIGURE 5.39: LATTICE GIRDER

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.

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.

5.3.2.6 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).**

A. 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:-

a. Construct the retaining wall.
b. Construct piles. Place the steel columns where piles are constructed.
c. Proceed to the first stage excavation.
d. Cast the floor slab.
e. Begin to construct superstructure.
f. Proceed deeper to second stage of excavation. Cast the floor slab.
g. Repeat the same procedure till designed depth is achieved.
h. Cast bottom most slab.

The merits and de-merits of this method are shown in **Table 5.25.**

TABLE 5.25: 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.

B. New Austrian Tunneling Method (NATM)

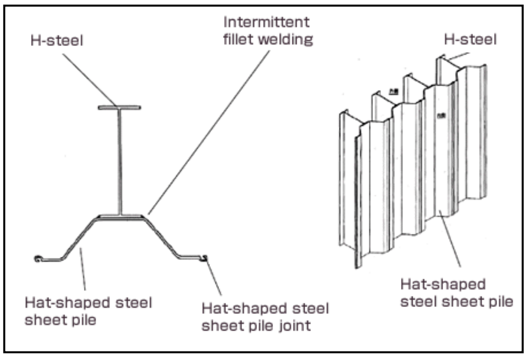
Where ROW is extremely restricted and it is not possible to adopt cut and cover method, stations are constructed by NATM. In this method, two separate tunnels consisting of one track and one platform are constructed by NATM method and are connected by means of cross passages. This method requires overburden 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.

C. 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.

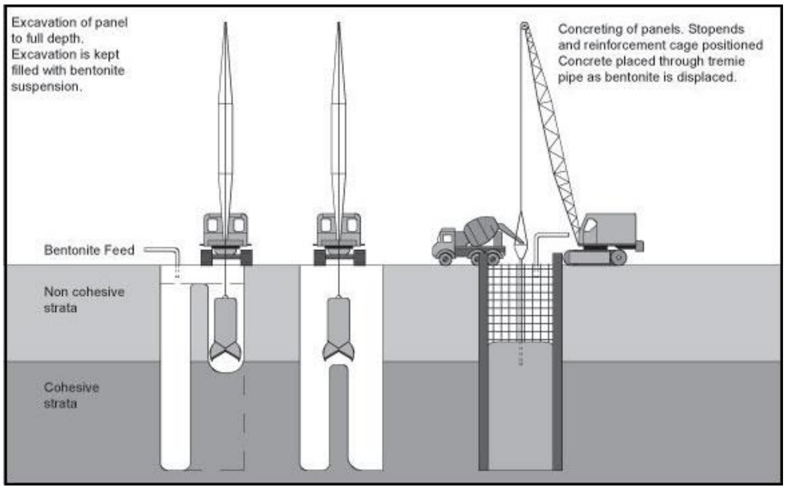
b. **Sheet Piles:** Sheet piles of 'Z' or 'U' shape are driven into soil by striking or static vibrating. The sheet pile is interconnected with adjoining piles to achieve interlocking and water sealing. Sheet piles can be used again and again and hence becomes economical. Driving of sheet piles require 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 5.40: DIAPHRAGM WALL



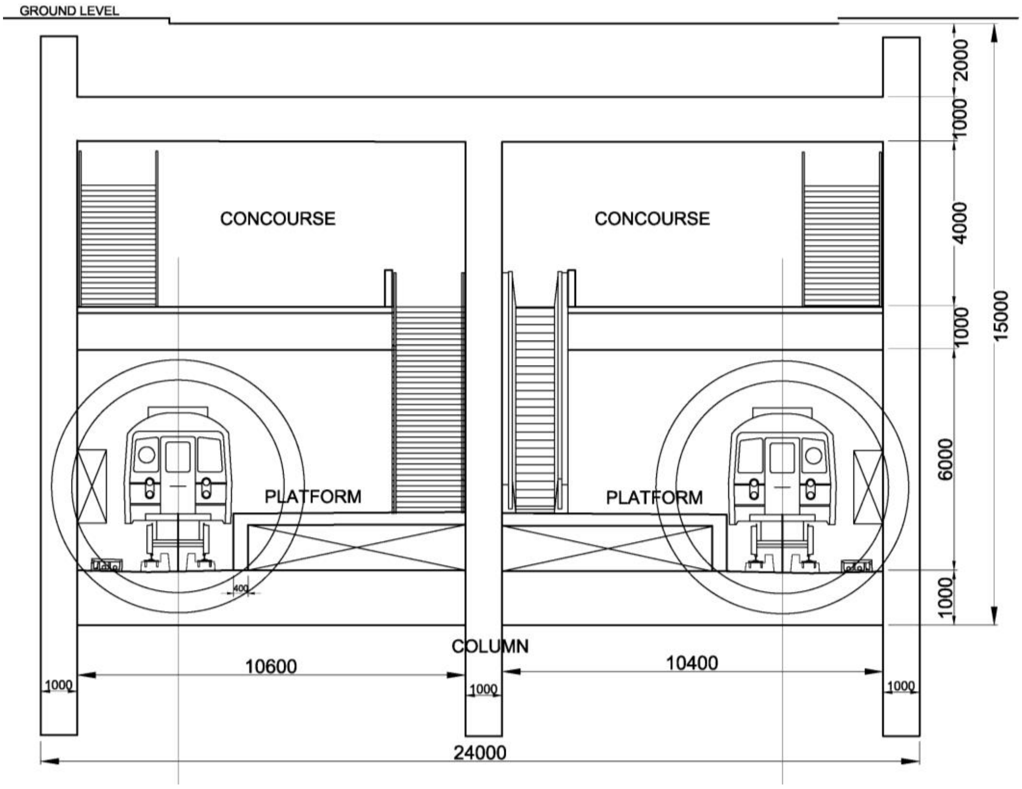
D. Typical Underground Station

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 5.41** 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.

FIGURE 5.41: TYPICAL UNDERGROUND STATION



5.3.2.7 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.

5.3.2.8 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.

5.3.2.9 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.

5.3.2.10 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.

5.3.2.11 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).

5.3.3 Geo-Technical Details with New Innovative Techniques to be used for Implementation in Civil Works, Track System

5.3.3.1 Introduction

The geotechnical investigation was carried out by RITES with the following objectives:

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

- To determine the subsurface profile of the underlying strata.

The present geotechnical report includes the field investigation, the laboratory test results of the soil samples to evaluate the soil parameters and recommendations with regard to competency of strata for the design of foundations of proposed structures.

5.3.3.2 Physiography & Climate

Agra Metropolis is one of the most populous cities in Uttar Pradesh and among the top 20 most populous cities in India. Situated on the banks of Yamuna River, Agra is 200 km away from the National Capital New Delhi. Agra District is situated in western Uttar Pradesh between 27.11' degree Latitude North and 78.0' degree to 78.2' degree Longitude East. Its mean Altitude is 169 meters above sea level. On the North it is bounded by Mathura District, on the South it is bounded by Dhaulpur District, on the East it is bounded by Firozabad District and on the West it is bounded by Bharatpur.

The climate of Agra features a semi-arid climate that borders on a humid subtropical climate. The city features mild winters, hot and dry summers and a monsoon season. The monsoon, though substantial in Agra, is not quite as heavy as the monsoon in other parts of India. The average monsoon rainfall during June to September is 628.6 millimeters. Agra has a reputation of being one of the hottest towns in India. In summers the city witnesses a sudden surge in temperature and at times, mercury goes beyond the 46°C mark in addition to a very high level of humidity. During summer, the daytime temperature hovers around 46-50°C. Nights are relatively cooler and temperature lowers to a comfortable 30°C. The minimum temperature sometimes goes as low as 2° or 3°C but usually hovers in the range of 6° to 8°C.

5.3.3.3 General Geology & Related Characteristics

The general geological sequence of Agra region can be classified broadly into three fold geological sequence viz. Algonkian- Delhi system, Cambrian (Upper Vindhyan) and Quaternary(Pleistocene, Recent to Upper Pleistocene) as given in Table-1. Coming to the geological environment of Agra district proper, the whole of the district is covered by Pleistocene to sub-recent alluvial deposits of the rivers of the Indo-Gangetic system which have traversed this area. In the southern part of the district it gets blended with the alluvial deposits of the peninsular block, carried by the rivers of the Vindhyan Foreland. The deposition of the alluvium commenced after the final upheaval of the Himalayas and has continued all through the Pleistocene age upto the present. The alluvium in the district consists of interbeded deposits of sand, silt and clays. At places calcareous concretions (locally known as kankar) are associated with this alluvium. Kankar is very commonly found in the alluvium and quarried economically where it is found within a depth of 3 mbelow land surface. Open-pit quarrying for kankar below that depth is generally not considered economical. Kankar is used as road metal and also for making lime. The thickness of the alluvium progressively decreases towards south and ultimately becoming zero over the peninsular block.

A narrow strip of easterly trending Vindhyan sandstone outcrop, running in a north-eastern to south-western direction, is exposed in the south-western part of the district near Fatehpur Sikri. The Vindhyan rock system of the district comprises of Upper Bhander sandstones. It comprises hard compact, reddish, fine grained sand stones characterized by white to fawn colored spots. The ripple marks and current bedding indicate deposition under shallow water conditions. The Vindhyan outcrops does not riser for more than 80 meters above the surrounding plains. The Vindhyan sandstones are traceable even beyond the boundaries of the district under the massive cover of alluvium.

Rocks of the older formations like the Vindhyan system and the Delhi system are highly folded and faulted. Heron (1922) has mentioned two main faults running parallel to each other in a NE-SW direction which is the direction of axis of folding in the region (Baweja 1980). The Great Boundary Fault, separating the two important formations, the Dharwarian represented by the Aravalis on the west and the Vindhyans on the east, is another remarkable geologic feature of the district. The eastern extremity of one of these, the Great Boundary Fault of Eastern Rajputana has been traced to about 5 km west of Agra district boundary in the Kheragarh tehsil. The north-western fault is not so well seen and much of its length can only be approximately laid down on the map as it lies below the veil of alluvium deposit in the district. The generalized geological succession is as shown in **Table 5.26.**

TABLE 5.26: GEOLOGICAL SUCCESSION IN AGRA

Period	Age	Land Form (Geomorphology)	Rock Type
Quaternary	Recent to Upper Pleistocene	Newer Alluvium	Sand and gravel
	Pleistocene Older Alluvium	Laterite and Clay	Sand, clay, silt and
Cambrian	Upper Vindhayan	Upper Bhander Sandstone Lower Rewa Sandstone	Sandstone, hard and compact Sandstone, hard and compact
Algonkian	Delhi system	Ajabgarh Series Alwar Series	Slates, phylites, quartzite and quartzite, impure, lime stones Quartzite, grits, conglomerates and impure limestone

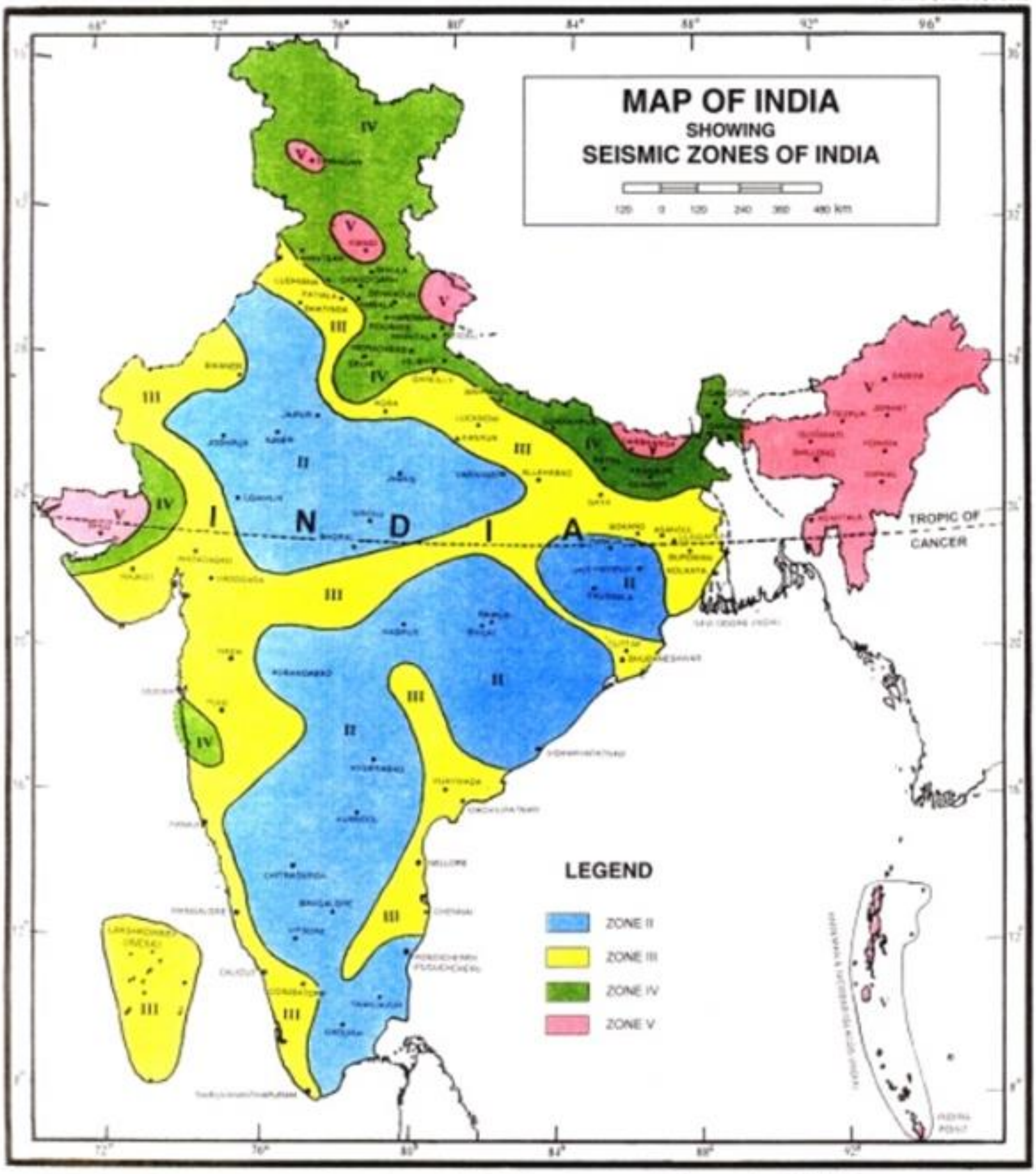
In simple language, the district is mostly covered by a thick pile of quaternary sediments with restricted patches of rocks of Vindhyan Super-group. Vindhyan Super group consists of rocks of Bhander Group, which includes white to purple arenite, medium to fine grained purplish to reddish spotted and laminated sandstone with intermittent partings of shale, shale-pebble-conglomerate, siltstone and greenish sand stone. Quaternary sediment has been classified into (1) Older Alluvium and 2) Newer Alluvium. The older Alluvium is represented by Alluvium of Middle to Later Pleistocene age. Newer Alluvium of Holocene age comprises of two units (1) Terrace Alluvium and (2) Channel Alluvium. The district is poor in minerals.

5.3.3.4 Seismicity

Agra falls in high risk seismic zone III and corresponds to MSK intensity VII. The existence of the Great Boundary Fault near Jalesar, causes Agra prone to seismic activities. Old and weak structures not designed for seismic forces are highly vulnerable to seismic hazards. Although no major earthquake has occurred in Agra in recent years, yet tremors have been felt from earthquakes in the adjoining National Capital Region (NCR). The NCR has fairly high seismicity with general occurrence of earthquakes of 5-6 magnitude, a few of magnitude 6-7 and occasional incident of 7.5-8.0 magnitude shocks.

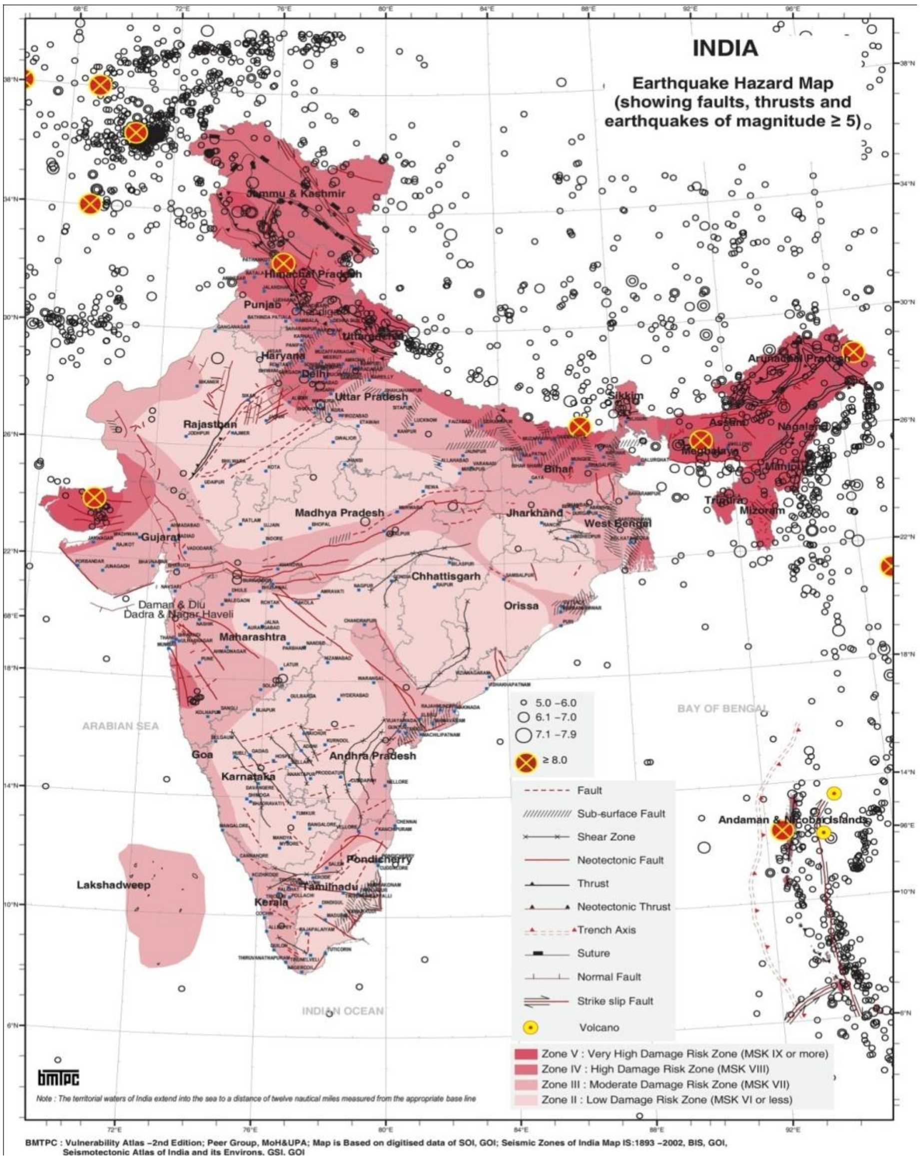
Though the earthquake risk for the district is moderate, most of the houses in Agra have not incorporated building by-laws, and do not have adequate structural strength to withstand even a moderate earthquake. So the earthquake will adversely affect large number of structures not designed for seismic forces. However, structures properly designed and constructed as per applicable standards can adequately withstand the Seismic forces without much concern. Seismic Zones in India and Earthquake Hazard map are shown in **Figure 5.42** and **Figure 5.43.**

FIGURE 5.42: SEISMIC ZONES OF INDIA



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

FIGURE 5.43: EARTHQAUKE HAZARD MAP



5.3.3.5 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 5.27: GEOLOGICAL SUCCESSION IN AGRA

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)		✓

5.3.3.6 Details of Geotechnical Investigation

A. General

In total, 42 BHs have been drilled of 30 m depth each, all along the length of proposed Metro alignment. 22 BHs have been drilled in Corridor-I (Sikandara to Hotel Trident-Taj East Gate), 18 BHs have been drilled in Corridor-II (Kalindi Vihar to Agra Cantt. Railway Station) & 2BHs have been drilled for depots. Details of Boreholes drilled are given in Table No. 2, 3 & 4 below.

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.

B. Details for Corridor-I

A total of 22 BHs having 30.0 m depth each have been drilled in the soil for corridor between Sikandara to Hotel Trident (Taj East Gate). Summary of the boreholes drilled in the corridor is given in **Table 5.28.**

TABLE 5.28: 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	1A	Near Sikandara	- 270.00	169.919	Not Met	Elevated
2	1B	Near Guru Ka Taal	1250.00	169.645	Not Met	Elevated
3	1	Near Agra ISBT	2100.00	169.360	28.00	Elevated
4	2	Near St. Conrad's Inter College	3050.00	168.492	28.00	Elevated
5	3	Near University on NH-2	3740.00	167.623	27.00	U/G
6	4	Near Defense Colony	4340.00	167.781	29.00	U/G
7	5	Near RBS College	4900.00	167.921	28.00	U/G
8	6	Near Delhi Gate	5300.00	167.214	Not Met	U/G
9	7	Near Raja ki Mandi Railway Station	5680.00	166.153	Not Met	U/G
10	8	Near Kidwai Park (Raja ki Mandi)	5850.00	166.153	Not Met	U/G
11	9	Near Agra College	6300.00	165.734	Not Met	U/G
12	10	Near Medical College	6775.00	163.989	Not Met	U/G
13	11	Medical College Ground	6980.00	162.796	Not Met	U/G
14	12	Near Jama Masjid	8100.00	157.070	Not Met	U/G
15	13	Near BijliGhar	8290.00	156.135	Not Met	U/G
16	14	Near Buddh Vihar	8485.00	154.532	Not Met	U/G
17	15	Near Agra Fort	8600.00	154.532	Not Met	U/G
18	16	Near Purani Mandi Chowk	10700.00	167.496	Not Met	U/G
19	17	Near Howards Plaza	11150.00	167.103	Not Met	Elevated
20	18	Near Hotel Mughal	11900.00	167.288	Not Met	Elevated
21	19	Near Basai Chowk on Fatehabad Road	12800.00	167.327	Not Met	Elevated
22	20	Near Hotel Trident (Taj East Gate)	13600.00	168.197	Not Met	Elevated

C. Details for Corridor-II

A total of 18 BHs having 30.0 m depth each have been drilled in soil for the corridor between Kalindi Vihar to Agra Cantt. Railway Station. Summary of the boreholes drilled in the corridor is given in **Table 5.29**.

TABLE 5.29: 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	21	Near Kalindi Vihar	14680.00	160.973	Not Met	Elevated
2	22	Near Agra Mandi	13680.00	155.087	Not Met	Elevated
3	23	Near Foundry Nagar	12620.00	161.546	Not Met	Elevated
4	24	Near Ram Bagh	11580.00	154.180	Not Met	Elevated
5	25	Near Kamla Nagar	9985.00	157.961	Not Met	Elevated
6	26	Near Sultanganj Crossing	9390.00	159.210	Not Met	Elevated
7	27	Near Nehru Nagar	7780.00	165.783	Not Met	Elevated
8	27A	Near Nehru Nagar Park	8600.00	166.863	Not Met	Elevated
9	28	Near Diwani Chowk	7540.00	165.930	Not Met	Elevated
10	28A	Near Bhagwan Talkies	8250.00	167.649	Not Met	Elevated
11	29	Near Sanjay Place	6880.00	167.241	Not Met	Elevated
12	30	Near ST. John's College	6010.00	165.773	Not Met	Elevated
13	31	Near Subhash Park	4600.00	166.345	Not Met	Elevated
14	32	Near Collectorate	3535.00	165.719	Not Met	Elevated
15	33	Near Pratap Pura	2670.00	166.403	Not Met	Elevated
16	34	Near Sadar Bazar	1900.00	166.360	Not Met	Elevated
17	35	Near Sultan Pura	940.00	167.397	Not Met	Elevated
18	36	Near Agra Cantt. Railway Station	120.00	167.439	Not Met	Elevated

D. Details for Depots

A total of 2 BHs having 30.0 m depth each have been drilled in soil for the 2 proposed depots. Summary of the boreholes drilled is given below in **Table 5.30.**

TABLE 5.30: 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 Trans Yamuna Colony Phase-II	15140.00	158.519	Not Met	At Ground Level
2	D-2	Near Provincial Armed Constabulary	10900.00	167.103	Not Met	

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)

The engineering parameters of each layer met along the corridor-1, Corridor-2 and depots are tabulated in **Table 5.31, 5.32 and 5.32** respectively.

The lithological sections of the strata met along the corridor-I are enclosed at **Figure 5.44 & 5.45.**The litho logical sections of the strata met along the corridor-II are enclosed at **Figure 5.46 & 5.47**.

5.3.3.8 Type of Foundation

A. Introduction

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.

B. 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.

TABLE 5.31: 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)		OBSERVED SPT N VALUES	Shear Parameters		Depth (m)		OBSERVED SPT N VALUES	Shear Parameters		Depth (m)		OBSERVED SPT N VALUES	Shear Parameters	
	From	TO		C (kg/sq. cm)	φ	From	TO		C (kg/sq. cm)	φ	From	TO		C (kg/sq. cm)	φ
1A	3.50	30.00	30 – 80	0.85 – 0.90	4 - 5	0.00	3.50	-	-	-	-	-	-	-	-
1B	12.50	21.50	33 - 55	-	-	0.00	2.00	9	-	-	2.00	3.50	-	0	31
	27.50	29.00	78	-	-	3.50	5.00	12	-	-	5.00	6.50	-	-	-
	-	-	-	-	-	6.50	8.00	22	-	-	8.00	9.50	-	-	-
	-	-	-	-	-	9.50	11.00	27	-	-	11.00	12.50	-	0	32
	-	-	-	-	-	23.00	27.50	63 - 73	-	-	21.50	23.00	58	-	-
	-	-	-	-	-	29.00	30.00	82	-	-	-	-	-	-	-
1	0.00	12.50	25	0.80	5	12.50	14.00	25	-	-	-	-	-	-	-
	14.00	27.50	31	0.90 – 1.75	0 - 4	27.50	30.00	42	-	-	-	-	-	-	-
2	0.00	30.00	15 – 100	0.70	6	-	-	-	-	-	-	-	-	-	-
3	0.00	30.00	10 – 96	0.66 – 0.85	4 - 5	-	-	-	-	-	-	-	-	-	-
4	0.00	30.00	13 – Refusal	0.65	6	-	-	-	-	-	-	-	-	-	-
5	0.00	23.00	13 – 72	0.9	4	23.00-	24.50	80	-	-	-	-	-	-	-
	24.50	30.00	107	-	-	-	-	-	-	-	-	-	-	-	-
6	0.00	2.00	18	-	-	2.00	3.50	-	-	-	-	-	-	-	-
	3.50	30.00	22 - 106	0.9	4	-	-	-	-	-	-	-	-	-	-
7	0.00	6.50	13 – 22	0.7	6	6.50	8.00	29	-	-	-	-	-	-	-
	8.00	30.00	29 – 76	-	-	-	-	-	-	-	-	-	-	-	-
8	0.00	30.00	15 – 70	0.75 – 0.88	4 - 5	-	-	-	-	-	-	-	-	-	-
9	0.00	30.00	13 – 64	0.9	4	-	-	-	-	-	-	-	-	-	-
10	5.00	12.50	26 – 34	0.8	5	0.00	5.00	15 – 21	0.18	19	-	-	-	-	

BH No.	LAYER-I (CL/CI,CL-CI)					LAYER-II (ML)					LAYER-III (SM)				
	Depth (m)		OBSERVED SPT N VALUES	Shear Parameters		Depth (m)		OBSERVED SPT N VALUES	Shear Parameters		Depth (m)		OBSERVED SPT N VALUES	Shear Parameters	
	From	TO		C (kg/sq. cm)	φ	From	TO		C (kg/sq. cm)	φ	From	TO		C (kg/sq. cm)	φ
	14.00	20.00	39 – 53	-	-	12.50	14.00	37	-	-	-	-	-	-	-
	24.50	30.00	70	-	-	20.00	24.50	61	-	-	-	-	-	-	-
11	0.00	17.00	15 – 33	0.80 – 1.00	5 – 6	17.00	30.00	45 – Refusal	-	-	-	-	-	-	-
12	0.00	30.00	10 – 84	0.80 – 0.95	4 – 5	-	-	-	-	-	-	-	-	-	-
13	0.00	30.00	14 – 100	0.90 – 1.00	4 – 5	-	-	-	-	-	-	-	-	-	-
14	0.00	8.00	15	0.80	5	8.00	9.50	-	-	-	-	-	-	-	-
	9.50	30.00	24 – 83	0.95	4	-	-	-	-	-	-	-	-	-	-
15	0.00	30.00	10 – 71	0.85 – 0.95	5 – 6	-	-	-	-	-	-	-	-	-	-
16	0.00	14.00	12 – 28	0.80 – 0.90	4 – 5	14.00	15.50	-	-	-	-	-	-	-	-
	15.50	30.00	32 – 76	-	-	-	-	-	-	-	-	-	-	-	-
17	5.00	6.50	16	-	-	8.00	9.50	20	-	-	0.00	5.00	-	0.04	27
	11.00	12.50	23	-	-	14.00	15.50	27	-	-	6.50	8.00	-	-	-
	15.50	18.50	37	-	-	18.50	21.50	48	-	-	9.50	11.00	-	0.04	26
	21.50	27.50	57 – 71	-	-	29.00	30.00	87	-	-	12.50	14.00	-	-	-
	-	-	-	-	-	-	-	-	-	-	27.50	29.00	80	-	-
18	3.50	30.00	10 – 83	0.65	4 - 5	-	-	-	-	-	0.00	3.50	-	-	-
19	5.00	6.50	15	-	-	3.50	5.00	-	0.18	19	0.00	3.50	-	-	-
	17.00	30.00	35 – 79	-	-	6.50	17.00	19 – 32	0.20	18	-	-	-	-	-
20	0.00	30.00	13 – 84	0.80 – 0.90	5 - 6	-	-	-	-	-	-	-	-	-	-

TABLE 5.32: 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)		SPT N VALUES	Shear Parameters		Depth (m)		SPT N VALUES	Shear Parameters		Depth (m)		SPT N VALUES	Shear Parameters	
	From	TO		C (kg/sq. cm)	φ	From	TO		C (kg/sq. cm)	φ	From	TO		C (kg/sq. cm)	φ
21	11.00	12.50	32	-	-	0.00	6.50	20	0.18	17	6.50	8.00	-	-	-
	14.00	15.50	38	-	-	8.00	9.50	27	-	-	9.50	11.00	-	0.00	32
	-	-	-	-	-	11.00	12.50	-	-	-	12.50	14.00	-	-	-
	-	-	-	-	-	-	-	-	-	-	15.50	30.00	44 – Refusal	-	-
22	0.00	6.50	-	0.90	4	8.00	9.50	-	-	-	6.50	8.00	13	-	-
	11.00	15.50	24 – 34	0.80	6	15.50	17.00	34	-	-	9.50	11.00	17	-	-
	17.00	21.50	42 – 54	-	-	-	-	-	-	-	21.50	23.00	60	-	-
	23.00	24.50	66	-	-	-	-	-	-	-	24.50	26.50	71	-	-
	26.50	30.00	78 – 91	-	-	-	-	-	-	-	-	-	-	-	-
23	0.00	9.50	17	0.9	5	9.50	11.00	-	-	-	24.50	27.50	81	-	-
	11.00	24.50	26 – 72	1.0	4	27.50	30.00	92	-	-	-	-	-	-	-
24	0.00	5.00	-	-	-	5.00	6.50	16	-	-	-	-	-	-	-
	6.50	12.50	19 – 28	0.90	4	12.50	23.00	34 – 67	0.20	19	-	-	-	-	-
	23.00	30.00	75 – 97	-	-	-	-	-	-	-	-	-	-	-	-
25	0.00	30.00	14 – 90	0.90 – 1.00	4 – 5	-	-	-	-	-	-	-	-	-	-
26	3.50	8.00	13	0.85	5	8.00	9.50	17	-	-	0.00	3.50	-	-	-
	11.00	20.00	23 – 50	-	-	20.00	21.50	56	-	-	9.50	11.00	-	0.95	4
	-	-	-	-	-	27.50	30.00	87	-	-	21.50	27.50	61 – 82	-	-
27	-	-	-	-	-	0.00	30.00	13 – 84	0.18	19	-	-	-	-	-
27 A	5.00	30.00	14 – 87	0.80	6	0.00	5.00	-	0.20	20					
28	0.00	2.00	-	-	-	2.00	3.50	-	-	-	-	-	-	-	-

BH No.	LAYER-I (CL/CI,CL-CI)					LAYER-II (ML)					LAYER-III (SM)				
	Depth (m)		SPT N VALUES	Shear Parameters		Depth (m)		SPT N VALUES	Shear Parameters		Depth (m)		SPT N VALUES	Shear Parameters	
	From	TO		C (kg/sq. cm)	φ	From	TO		C (kg/sq. cm)	φ	From	TO		C (kg/sq. cm)	φ
	3.50	5.00	16	-	-	5.00	15.50	21 – 34	0.18	19	-	-	-	-	-
	15.50	21.50	38 – 56	-	-	21.50	24.50	62	-	-	-	-	-	-	-
	24.50	27.50	71	-	-	27.50	30.00	80	-	-	-	-	-	-	-
28A	0.00	6.50	12	0.95	4	6.50	8.00	-	0.16	20	-	-	-	-	-
	8.00	9.50	18	-	-	9.50	11.00	-	-	-	-	-	-	-	-
	11.00	30.00	24 – 91	-	-	-	-	-	-	-	-	-	-	-	-
29	0.00	11.00	12 – 28	0.80 – 0.90	19 - 20	11.00	12.50	-	-	-	-	-	-	-	-
	12.50	20.00	32 – 46	-	-	20.00	21.50	49	-	-	-	-	-	-	-
	21.50	26.00	55	-	-	26.00	30.00	67	-	-	-	-	-	-	-
30	8.00	9.50	-	0.90	5	0.00	8.00	8 – 17	0.18	19	-	-	-	-	-
	11.00	12.50	-	-	-	9.50	11.00	21	-	-	-	-	-	-	-
	12.50	30.00	22 – 54	-	-	-	-	-	-	-	-	-	-	-	-
31	0.00	2.00	10	-	-	2.00	3.50	-	-	-	-	-	-	-	-
	3.50	5.00	13	-	-	5.00	6.50	-	0.18	19	-	-	-	-	-
	6.50	9.50	18	0.15	20	9.50	11.00	23	-	-	-	-	-	-	-
	11.00	15.50	27	-	-	15.50	30.00	30 – 75	-	-	-	-	-	-	-
32	2.00	3.50	12	-	-	0.00	2.00	-	-	-	-	-	-	-	-
	6.50	9.50	28	0.90	5	3.50	6.50	23	0.18	19	-	-	-	-	-
	11.00	15.50	34	-	-	9.50	11.00	-	-	-	-	-	-	-	-
	17.00	18.50	44	-	-	15.50	17.00	40	-	-	-	-	-	-	-
	20.00	23.00	52	-	-	18.50	20.00	47	-	-	-	-	-	-	-
	24.50	26.00	61	-	-	23.00	24.50	57	-	-	-	-	-	-	-

BH No.	LAYER-I (CL/CI,CL-CI)					LAYER-II (ML)					LAYER-III (SM)				
	Depth (m)		SPT N VALUES	Shear Parameters		Depth (m)		SPT N VALUES	Shear Parameters		Depth (m)		SPT N VALUES	Shear Parameters	
	From	TO		C (kg/sq. cm)	φ	From	TO		C (kg/sq. cm)	φ	From	TO		C (kg/sq. cm)	φ
	27.50	30.00	70	-	-	26.00	27.50	63	-	-	-	-	-	-	-
33	0.00	30.00	10 – 77	0.90 – 1.00	5	-	-	-	-	-	-	-	-	-	-
34	0.00	8.00	15	0.85	5	8.00	11.00	25	0.20	19	26.00	30.00	71 – 85	-	-
	11.00	26.00	29 – 68	0.90	4	-	-	-	-	-	-	-	-	-	-
35	0.00	3.50	11	-	-	3.50	5.00	-	-	-	-	-	-	-	-
	5.00	30.00	14 – 78	0.80 – 0.90	5 - 6	-	-	-	-	-	-	-	-	-	-
36	2.00	3.50	-	0.90	5	0.00	2.00	10	-	-					
	5.00	9.50	17	0.80	5	3.50	5.00	15	-	-					
	12.50	17.00	38	-	-	9.50	12.50	24	0.18	19					
	18.50	20.00	48	-	-	17.00	18.50	45	-	-					
	21.50	30.00	58 – 75	-	-	20.00	21.50	51	-	-					

TABLE 5.33: ENGINEERING PARAMETERS OF EACH LAYER MET ALONG DEPOT

BH No.	LAYER-I (CL/CI,CL-CI)					LAYER-II (ML)					LAYER-III (SM)				
	Depth (m)		SPT N VALUES	Shear Parameters		Depth (m)		SPT N VALUES	Shear Parameters		Depth (m)		SPT N VALUES	Shear Parameters	
	From	TO		C (kg/sq. cm)	φ	From	TO		C (kg/sq. cm)	φ	From	TO		C (kg/sq. cm)	φ
D-1	3.50	30.00	14 – 90	0.85 – 0.90	4 - 5	-	-	-	-	-	0.00	3.50	-	-	-
D-2	3.50	30.00	15 – 81	0.65 – 0.85	4 – 6	0.00	3.50	-	-	-	-	-	-	-	-

FIGURE 5.44: LITHOLOGICAL SECTION ALONG CORRIDOR - I (A)

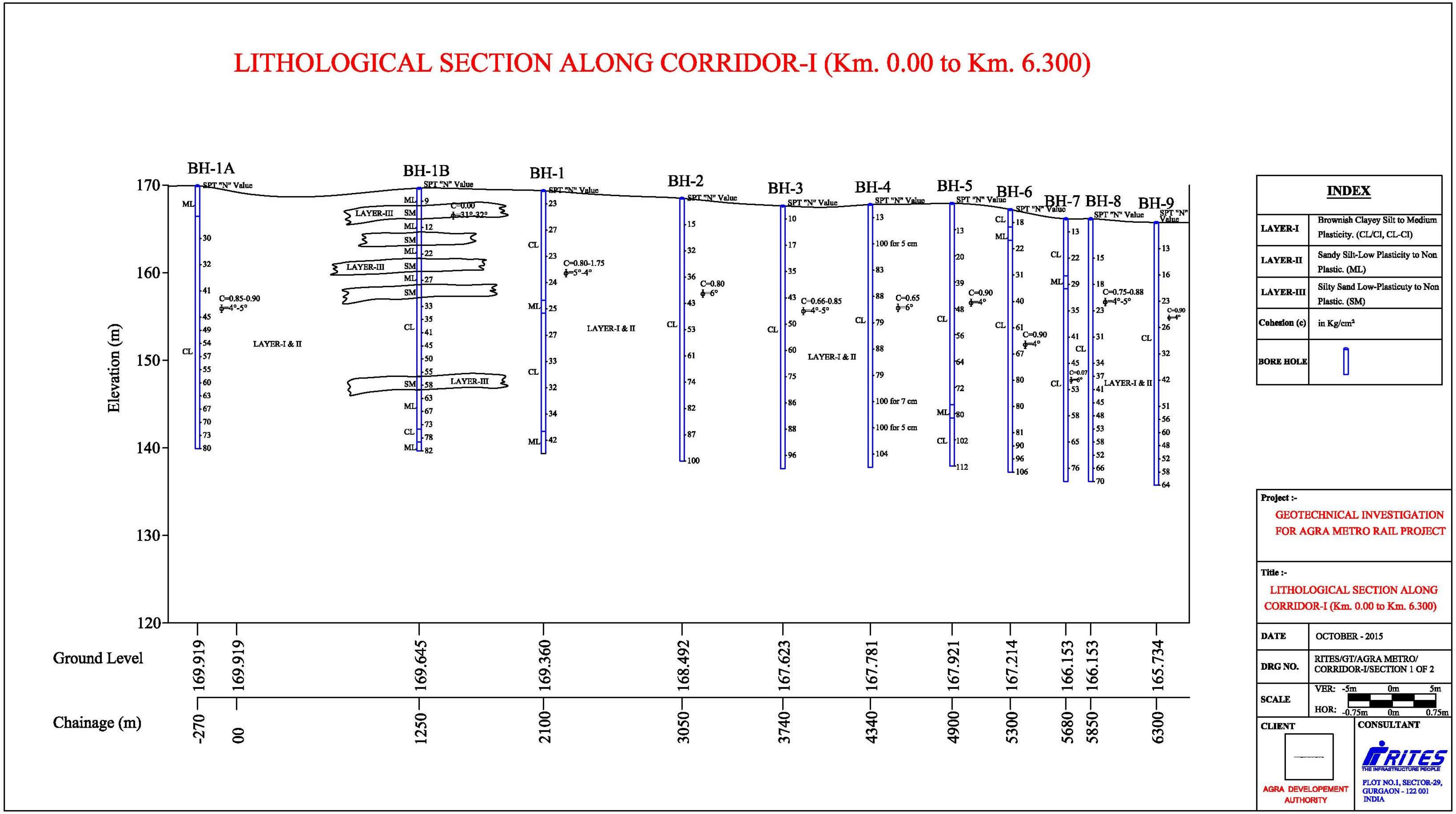


FIGURE 5.45: LITHOLOGICAL SECTION ALONG CORRIDOR - I (B)

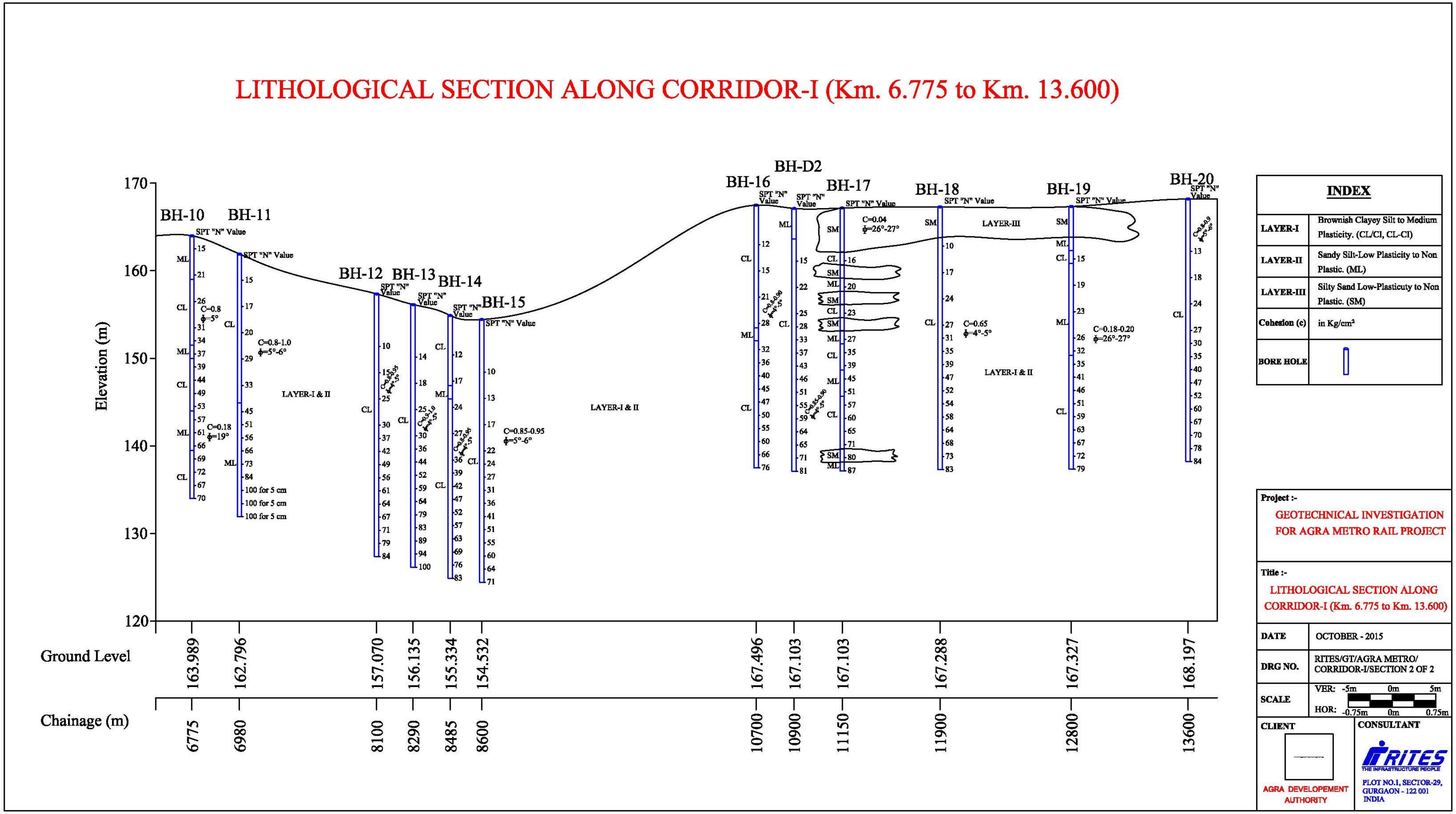


FIGURE 5.46: LITHOLOGICAL SECTION ALONG CORRIDOR - II (A)

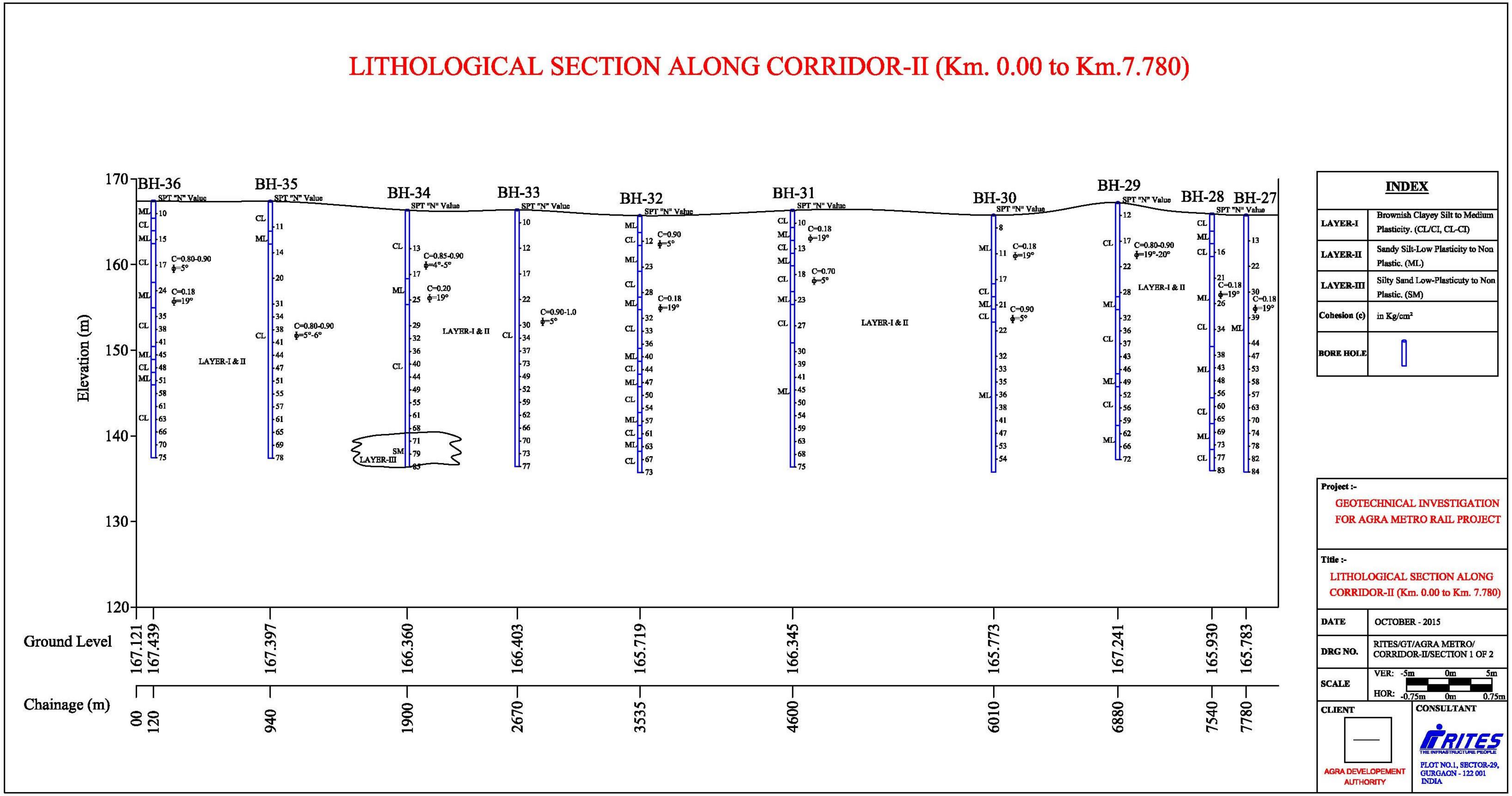
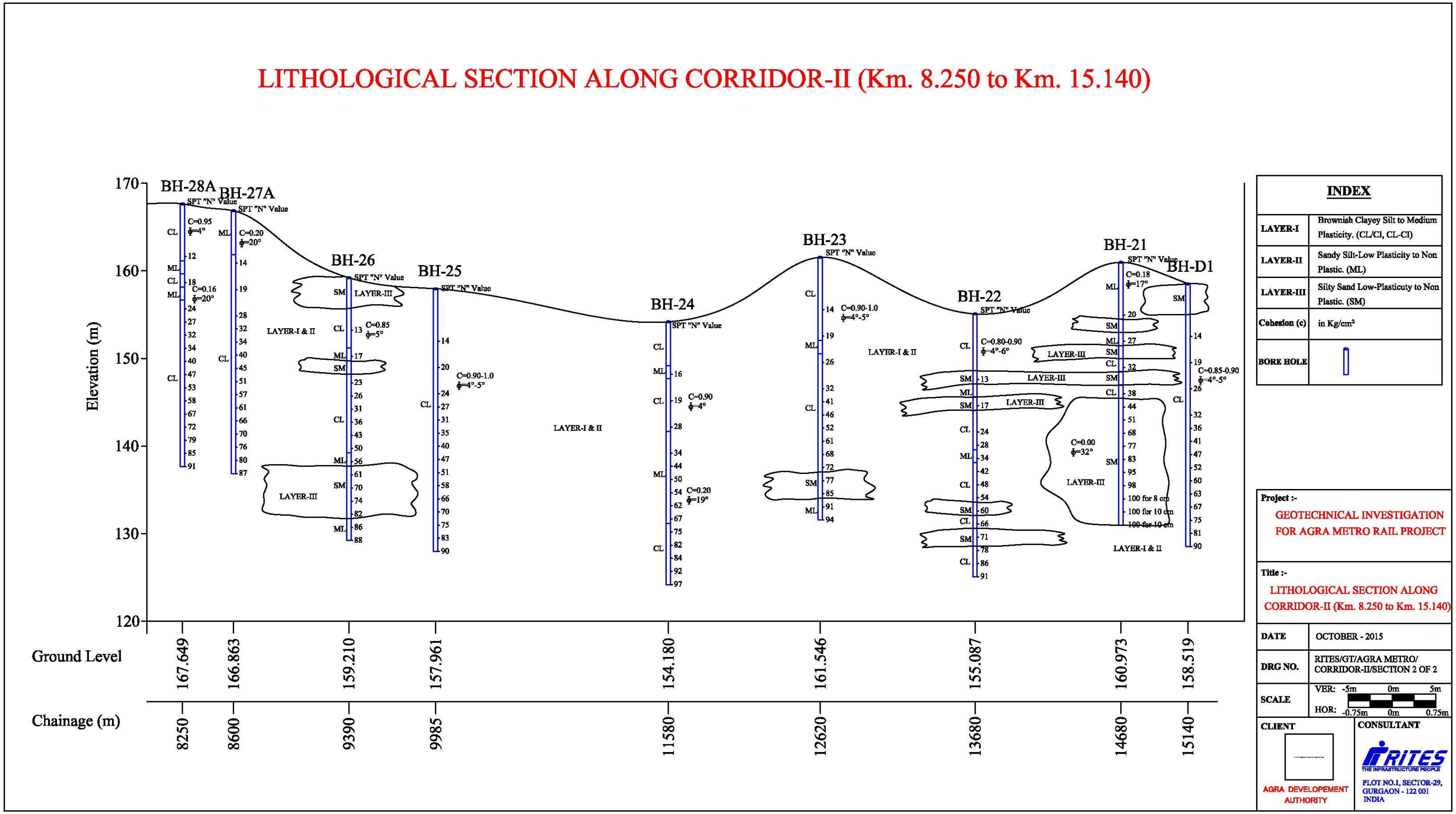


FIGURE 5.47: LITHOLOGICAL SECTION ALONG CORRIDOR – II (B)



5.3.3.9 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 5.34**.

TABLE 5.34: SBC OF CONTINUOUS STRIP FOUNDATION (DEPOT LOCATIONS)

Location	Depth (m)	Width (m)	Safe Bearing Capacity (T/m^2)		Recommended SBC (T/m^2)
			Based on settlement	Based on Shear Criterion	
Trans Yamuna Colony Phase-II **(D-1)**	2.0	1.0	13.65	18.10	13.50
		2.0	11.36	16.40	11.00
		3.0	10.61	18.30	10.50
	3.0	1.0	15.00	43.80	15.00
		2.0	13.65	35.80	13.50
		3.0	12.12	37.80	12.00
Provincial Armed Constabulary **(D-2)**	2.0	1.0	14.98	16.00	15.00
		2.0	12.50	13.00	12.50
		3.0	11.66	15.70	11.50
	3.0	1.0	15.60	35.50	15.50
		2.0	14.00	29.30	14.00
		3.0	13.33	27.80	13.00

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 5.35, Table 5.36** and **Table 5.37.**

TABLE 5.35: 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-1A	1.0	17.00	184.50	105.00
	1.2	17.00	237.2	128.00
BH-1B	1.0	19.00	182.20	77.00
	1.2	19.00	235.70	94.00
BH-1	1.0	21.00	185.70	99.00
	1.2	21.00	236.60	121.00
BH-2	1.0	16.00	182.90	111.00
	1.2	16.00	236.40	135.00
BH-16	1.0	20.00	181.40	101.00
	1.2	20.00	231.80	123.00
BH-17	1.0	22.00	179.90	81.00
	1.2	22.00	242.40	105.00
BH-18	1.0	19.00	183.20	91.00
	1.2	19.00	236.50	112.00
BH-19	1.0	23.00	178.50	81.00
	1.2	23.00	234.10	99.00
BH-20	1.0	18.00	194.00	91.00
	1.2	18.00	251.70	112.00

TABLE 5.36: 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-21	1.0	16.00	176.60	58.00
	1.2	16.00	248.70	71.00
BH-22	1.0	18.00	180.40	92.00
	1.2	18.00	232.80	113.00
BH-23	1.0	18.00	179.70	93.00
	1.2	18.00	230.50	114.00
BH-24	1.0	16.00	187.60	80.00
	1.2	16.00	253.30	98.00
BH-25	1.0	18.00	174.50	92.00
	1.2	18.00	223.70	113.00
BH-26	1.0	18.00	177.80	96.00
	1.2	18.00	227.20	117.00
BH-27	1.0	21.00	183.00	79.00
	1.2	21.00	280.00	105.00
BH-27A	1.0	20.00	182.60	97.00
	1.2	20.00	234.20	118.00
BH-28	1.0	21.00	174.50	75.00
	1.2	21.00	263.30	97.00
BH-28A	1.0	20.00	184.20	96.00
	1.2	20.00	236.90	117.00

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-29	1.0	16.00	181.10	87.00
	1.2	16.00	233.90	107.00
BH-30	1.0	20.00	174.40	85.00
	1.2	20.00	252.80	107.00
BH-31	1.0	20.00	182.30	86.00
	1.2	20.00	266.60	111.00
BH-32	1.0	20.00	175.50	91.00
	1.2	20.00	226.00	112.00
BH-33	1.0	18.00	181.20	95.00
	1.2	18.00	232.60	116.00
BH-34	1.0	19.00	184.20	77.00
	1.2	19.00	237.20	94.00
BH-35	1.0	20.00	186.4	104.00
	1.2	20.00	237.00	128.00
BH-36	1.0	20.00	191.70	98.00
	1.2	20.00	246.90	120.00

TABLE 5.37: 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	19.00	181.40	99.00
	1.2	19.00	231.50	121.00
BH-D-2	1.0	19.00	183.10	99.00
	1.2	19.00	234.10	121.00

5.3.3.10 Conclusions & Recommendations

- Forty two 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-1A to BH-2, BH-16 to BH-20, BH-21 to BH-36 & BH D-1 to BH D-2. Shallow foundation is also recommended at location of BH-D-1 & BH-D-2 for light weight structures. Since portion between BH-3 to BH-15 is proposed as underground section, parameters for tunnel construction.
- The load capacities of piles are based on empirical correlation's and should 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 zonation map of India, suitable seismic coefficient commensurate to seismic Zone III(IS: 1893) should be adopted in the design of the structures.

5.4 GEOMETRIC DESIGN OF CORRIDOR 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.
f. Traffic diversion will be required where elevated stations are proposed along the road.
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 Corridor – 1: Sikandara to Taj East Gate

A. Horizontal Curvature

The proposed alignment 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 33 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 58% alignment is on straight & about 42% of alignment is on curves. The abstract and details of curves are indicated in **Table 5.38** and **5.39** respectively.

TABLE 5.38: ABSTRACT OF HORIZONTAL CURVES OF CORRIDOR-1

S. No.	Curve Radius	No. of Occurrences	Length	Percentage
1	<200	0	0.00	0.00
2	200	2	496.07	8.40
3	>200 ≤ 300	12	2321.50	39.29
4	>300 ≤ 500	8	1889.69	31.98
5	>500 ≤ 800	7	840.81	14.23
6	>800 ≤ 1000	1	80.79	1.37
7	>1000	3	279.62	4.73
	Total	**33**	**5908.47**	**100.00**

TABLE 5.39: 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
	From	To			D	M	S	In	Out				
1	171.09	275.35	Left	-550	6	24	50.04	40	40	52.17	24.26	104.26	180.78
2	456.13	507.12	Left	-3500	0	21	7.56	15	15	25.49	20.99	50.99	434.67
3	941.79	1132.59	Left	-200	38	32	29.40	55	55	98.34	80.80	190.80	386.12
4	1518.71	1829.35	Right	360	40	24	38.88	55	55	161.10	200.64	310.64	35.87
5	1865.22	1997.75	Left	-500	10	21	39.60	40	40	66.41	52.53	132.53	184.36
6	2182.11	2377.95	Left	-350	23	1	55.56	55	55	98.95	85.84	195.84	1436.16
7	3814.11	4119.37	Right	200	71	24	51.84	55	55	172.44	195.27	305.27	216.40
8	4335.77	4542.50	Right	250	34	27	45.72	55	55	105.93	96.73	206.73	318.27
9	4860.77	4941.56	Right	1000	3	6	52.92	25	25	40.40	30.79	80.79	223.41
10	5164.96	5430.29	Left	-250	48	7	15.60	55	55	139.55	155.32	265.32	43.75
11	5474.04	5592.95	Right	700	6	31	14.52	35	35	59.51	48.91	118.91	394.07
12	5987.03	6116.83	Right	700	7	27	13.32	35	35	64.98	59.81	129.81	35.33
13	6152.17	6481.49	Left	-230	68	12	4.32	55	55	183.98	219.32	329.32	198.69
14	6680.17	6957.17	Right	220	57	29	9.24	55	55	149.29	167.00	277.00	21.54
15	6978.71	7126.02	Left	-300	17	22	30.00	55	55	74.08	37.31	147.31	383.75
16	7509.77	7615.90	Left	-2000	2	21	49.68	15	15	53.07	76.13	106.13	341.44
17	7957.34	8102.69	Right	250	20	25	20.28	55	55	73.25	35.35	145.35	222.82

Curve No	Chainage		Direction	Radius	Intersection Angle			Transition Length		Tangent Length	Curve Length	Total Curve Length	Straight Between
	From	To			D	M	S	In	Out				
18	8325.52	8505.25	Left	-450	15	31	31.44	55	55	90.31	69.73	179.73	497.58
19	9002.83	9194.32	Left	-250	31	9	55.44	55	55	97.62	81.49	191.49	230.86
20	9425.18	9615.79	Right	250	31	2	40.20	55	55	97.15	80.61	190.61	17.77
21	9633.56	9771.39	Left	-300	15	29	28.68	55	55	69.23	27.83	137.83	29.18
22	9800.57	9951.77	Left	-250	22	1	31.08	55	55	76.29	41.20	151.20	53.99
23	10005.76	10158.12	Right	250	22	11	6.36	55	55	76.90	42.36	152.36	44.90
24	10203.02	10331.12	Right	700	7	22	17.04	35	35	64.12	58.10	128.10	240.50
25	10571.62	10694.66	Right	400	11	32	2.04	40	40	61.68	43.04	123.04	214.24
26	10908.90	11035.86	Right	265	16	22	57.00	50	50	63.81	26.96	126.96	17.29
27	11053.15	11175.66	Left	-3000	2	1	52.32	15	15	61.26	92.51	122.51	372.01
28	11547.68	11808.61	Left	-400	29	17	43.08	55	55	132.88	150.94	260.94	537.78
29	12346.40	12645.60	Left	-430	32	19	19.20	55	55	153.07	189.20	299.20	406.45
30	13052.05	13195.01	Left	-800	8	3	9.00	30	30	71.58	82.96	142.96	83.75
31	13278.76	13384.44	Right	700	5	28	14.88	35	35	52.88	35.69	105.69	0.03
32	13384.48	13495.55	Left	-700	6	8	1.32	35	35	55.58	41.08	111.08	379.32
33	13874.87	14262.65	Left	380	50	6	11.88	55	55	205.56	277.78	387.78	

B. Gradients

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 41 number of change of gradients has been provided in the entire Corridor. Flattest gradient is level provided for 61% of the alignment. Steepest gradient is 4.0% provided for ramp at Shastri Nagar. The abstract and details of gradients are given in **Table 5.40 and 5.41** respectively.

TABLE 5.40: ABSTRACT OF GRADIENTS OF CORRIDOR-1

S. No.	Description	No's of Occurrences	Length (m)	Percentage
1	Level (0%)	19	8494	60.67
2	>0% to 1%	5	1150	8.21
3	>1% to 2%	12	2698	19.27
4	>2% to 3%	1	200	1.43
5	>3%	4	1458	10.41
	TOTAL	**41**	**14000**	**100.00**

TABLE 5.41: DETAILS OF GRADIENTS FOR CORRIDOR-1

S. No.	Chainage		Length	Rail Level		Gradient	Remarks
	From	To		From	To		
1	-50	150	200	181.50	181.50	0.00	Level
2	150	350	200	181.50	178.50	-1.50	Fall
3	350	925	575	178.50	178.50	0.00	Level
4	925	1175	250	178.50	182.00	1.40	Rise
5	1175	1334	159	182.00	182.00	0.00	Level
6	1334	1600	266	182.00	179.00	-1.13	Fall
7	1600	1750	150	179.00	179.00	0.00	Level
8	1750	1934	184	179.00	181.00	1.09	Rise
9	1934	2600	666	181.00	181.00	0.00	Level
10	2600	2800	200	181.00	178.00	-1.50	Fall
11	2800	2925	125	178.00	177.50	-0.40	Fall
12	2925	3551	626	177.50	177.50	0.00	Level
13	3551	3795	244	177.50	167.74	-4.00	Fall
14	3795	4150	355	167.74	154.00	-3.87	Fall
15	4150	4321	171	154.00	154.00	0.00	Level
16	4321	4575	254	154.00	150.00	-1.57	Fall
17	4575	4825	250	150.00	148.00	-0.80	Fall

S. No.	Chainage		Length	Rail Level		Gradient	Remarks
	From	To		From	To		
18	4825	6775	1950	148.00	148.00	0.00	Level
19	6775	7050	275	148.00	144.00	-1.45	Fall
20	7050	7325	275	144.00	144.00	0.00	Level
21	7325	7550	225	144.00	142.00	-0.89	Fall
22	7550	7925	375	142.00	142.00	0.00	Level
23	7925	8125	200	142.00	140.00	-1.00	Fall
24	8125	8850	725	140.00	140.00	0.00	Level
25	8850	9100	250	140.00	144.00	1.60	Rise
26	9100	9525	425	144.00	144.00	0.00	Level
27	9525	9875	350	144.00	145.00	0.29	Rise
28	9875	10266	391	145.00	145.00	0.00	Level
29	10266	10525	259	145.00	154.00	3.47	Rise
30	10525	10725	200	154.00	159.00	2.50	Rise
31	10725	11125	400	159.00	159.00	0.00	Level
32	11125	11725	600	159.00	180.00	3.50	Rise
33	11725	11925	200	180.00	180.00	0.00	Level
34	11925	12125	200	180.00	177.00	-1.50	Fall
35	12125	12550	425	177.00	177.00	0.00	Level
36	12550	12750	200	177.00	179.50	1.25	Rise
37	12750	12900	150	179.50	179.50	0.00	Level
38	12900	13125	225	179.50	177.00	-1.11	Fall
39	13125	13331	206	177.00	177.00	0.00	Level
40	13331	13525	194	177.00	180.50	1.80	Rise
41	13525	13950	425	180.50	180.50	0.00	Level

* Note : All the change points are provided with Vertical curves

C. Portals and Special Span

There is no requirement of special span and the elevated corridor can be served through regular spans of 25 - 31m. For diverting the elevated alignment from centre of road to off the road and vice-versa, portal arrangement will be required with details as per **Table 5.42**

TABLE 5.42: LOCATION OF PORTALS CORRIDOR - 1

S. No.	Location	Chainage		Length (m)	Purpose
		From	To		
1	ISBT	1650	1800	150	After Guru Ka Taal Station, the alignment is diverted off the road from median.

D. Break-up of Alignment Length

Break-up of alignment length for Corridor-1 is given in **Table 5.43**.

TABLE 5.43: BREAK-UP OF ALIGNMENT LENGTH FOR CORRIDOR-1

S. No.	Description	Chainage (m)		Length (m)	Method of Construction/ Structure Type
		From	To		
1	Elevated	-250	3410	3660	Box/I/U- Shape Girder
2	Ramp	3410	3885	475	Elevated to Underground Ramp
3	Underground	3885	11052	7167	TBM/ Cut & cover/NATM
4	Ramp	11052	11475	423	Underground to Elevated Ramp
5	Elevated	11475	13750	2275	Box/I/U- Shape Girder
			Total	**14000**	

5.4.3 Corridor - 2: Agra Cantt. To Kalindi Vihar

A. Horizontal Curvature

The proposed alignment 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.

A total of 49 curves have been provided on the entire length of the alignment. The minimum radius of curves is 120 m provided at 3 locations. About 53% of the length of the alignment is on curves. The abstract and details of curves are indicated in **Table 5.44** and **5.45** respectively.

TABLE 5.44: ABSTRACT OF HORIZONTAL CURVES OF CORRIDOR-2

S. No.	Curve Radius	No. of Occurrences	Length	Percentage
1	<120	0	0.00	0.00
2	=120	3	727.19	75.73
3	=150	2	336.84	35.08
4	=190	4	759.18	79.06
5	>190 ≤ 300	10	1750.06	182.26
6	>300 ≤ 500	9	1602.55	166.90
7	>500 ≤ 800	8	945.30	98.45
8	>800 ≤ 1000	4	1084.83	112.98
9	>1000	9	960.20	100.00
	Total	**49**	**8166.15**	**850.46**

Note:

1. Check rail will be provided for alignment sharper than 190m.
2. Being fully elevated corridor, it is largely dictated by road geometry. At locations having sharp road, less ROW and presence of structures, sharp curves are unavoidable.

TABLE 5.45: DETAILS OF HORIZONTAL CURVES OF CORRIDOR-2

Curve No	Chainage		Direction	Radius	Intersection Angle			Transition Length		Tangent Length	Curve Length	Total Curve Length	Straight Between
	From	To			D	M	S	In	Out				
1	175.00	259.42	Left	-800	3	32	6.72	30	30	42.22	24.42	84.42	0.90
2	260.32	336.48	Right	800	3	10	55.56	30	30	38.09	16.16	76.16	116.26
3	452.74	625.71	Left	-190	35	20	35.52	55	55	88.65	62.97	172.97	72.15
4	697.87	850.68	Right	200	28	0	42.48	55	55	77.55	42.81	152.81	235.64
5	1086.32	1283.50	Right	1200	8	16	24.96	20	20	98.75	157.18	197.18	179.62
6	1463.12	1719.49	Left	-120	96	5	6.72	55	55	162.24	146.37	256.37	27.06
7	1746.56	1811.23	Left	-5000	0	20	27.24	15	15	32.34	34.67	64.67	238.30
8	2049.53	2104.68	Left	-3500	0	23	33.36	15	15	27.58	25.15	55.15	252.54
9	2357.22	2496.37	Left	-250	19	10	15.96	55	55	70.05	29.15	139.15	0.11
10	2496.48	2632.81	Right	300	15	19	12.36	55	55	68.47	26.33	136.33	22.73
11	2655.55	2769.50	Right	500	8	16	57.72	40	40	57.05	33.95	113.95	201.43
12	2970.92	3154.37	Left	-200	36	28	28.92	55	55	94.22	73.44	183.44	93.55
13	3247.92	3422.95	Right	200	34	13	49.80	55	55	89.56	65.03	175.03	80.76
14	3503.71	3751.36	Left	-190	58	3	15.48	55	55	133.38	137.65	247.65	75.30
15	3826.65	4022.18	Right	300	26	30	7.20	55	55	99.17	85.53	195.53	95.58
16	4117.76	4325.48	Left	-120	72	33	0.72	55	55	116.89	97.72	207.72	0.47
17	4325.95	4484.63	Right	150	39	21	42.48	55	55	81.78	48.69	158.69	88.49
18	4573.13	4888.00	Right	195	76	12	44.28	55	55	181.32	204.87	314.87	37.19
19	4925.18	5091.59	Left	-200	31	32	43.80	55	55	84.85	56.41	166.41	80.53
20	5172.12	5320.82	Right	400	13	15	7.20	55	55	74.60	38.71	148.71	160.02
21	5480.84	5604.54	Left	-500	9	21	9.36	40	40	61.95	43.69	123.69	241.94
22	5846.48	5987.49	Right	250	19	25	27.48	55	55	71.01	31.01	141.01	297.29
23	6284.78	6410.80	Right	600	8	7	30.36	40	40	63.09	46.02	126.02	93.24

Curve No	Chainage		Direction	Radius	Intersection Angle			Transition Length		Tangent Length	Curve Length	Total Curve Length	Straight Between
	From	To			D	M	S	In	Out				
24	6504.03	6623.04	Right	500	9	1	52.32	40	40	59.60	39.01	119.01	1.18
25	6624.22	6753.65	Left	-600	8	19	20.28	40	40	64.81	49.43	129.43	80.75
26	6834.40	6990.65	Right	400	14	18	3.96	55	55	78.43	46.25	156.25	0.48
27	6991.13	7176.38	Left	-190	39	9	47.16	55	55	95.51	75.24	185.24	87.17
28	7263.55	7416.86	Left	-190	29	23	3.84	55	55	77.94	43.31	153.31	104.10
29	7520.96	7699.11	Right	150	47	1	21.72	55	55	93.12	68.15	178.15	256.69
30	7955.79	8218.90	Right	120	99	12	51.12	55	55	170.09	153.10	263.10	159.47
31	8378.37	8466.89	Left	-1000	3	22	55.92	25	25	44.27	38.52	88.52	180.34
32	8647.22	8792.70	Left	-230	22	19	18.48	55	55	73.43	35.48	145.48	0.45
33	8793.15	8886.44	Right	750	4	16	16.68	35	35	46.67	23.30	93.30	409.98
34	9296.42	9392.04	Right	600	5	28	18.84	35	35	47.84	25.62	95.62	0.22
35	9392.26	9491.76	Left	-600	6	5	36.24	35	35	49.79	29.50	99.50	26.73
36	9518.49	9752.64	Right	1500	8	13	17.40	15	15	117.27	204.15	234.15	43.36
37	9796.01	9916.90	Right	500	9	9	40.32	40	40	60.55	40.90	120.90	58.55
38	9975.45	10096.95	Left	-500	9	12	7.92	40	40	60.85	41.50	121.50	141.26
39	10238.22	10311.67	Right	1500	2	1	22.80	20	20	36.73	33.45	73.45	113.17
40	10424.84	10674.23	Right	1000	12	30	44.28	25	25	125.17	199.39	249.39	185.61
41	10859.84	10964.87	Left	-1200	3	29	30.12	25	25	52.53	55.03	105.03	341.36
42	11306.23	11457.66	Right	1000	7	8	37.68	25	25	75.80	101.43	151.43	188.18
43	11645.83	12239.43	Left	-500	63	15	41.04	40	40	329.11	513.59	593.59	0.42
44	12239.84	12344.80	Right	500	7	15	48.96	40	40	52.53	24.96	104.96	120.75
45	12465.55	12525.17	Left	-2000	1	9	50.76	15	15	29.81	29.62	59.62	101.12
46	12626.29	12710.34	Right	7000	0	20	7.80	15	15	42.03	54.06	84.06	1040.91
47	13751.26	13992.11	Right	600	19	23	33.72	35	35	121.46	170.85	240.85	155.07
48	14147.18	14234.06	Right	3500	1	6	12.96	15	15	43.44	56.88	86.88	545.11
49	14779.17	15374.66	Left	-830	39	1	16.68	30	30	309.24	535.50	595.50	25.34

B. Gradients

A total 57 number of change of gradients has been provided in the entire Corridor. Flattest gradient is level provided on 52% of alignment including the stations and steepest gradient is 2.24% (compensated) provided for a length of 250 m. The abstract and details of gradients are given in **Table 5.46 and 5.47** respectively.

TABLE 5.46: ABSTRACT OF GRADIENTS OF CORRIDOR-2

S. No.	Description	No.s of Occurrences	Length (m)	Percentage
1	Level (0%)	25	7978	51.81
2	>0% to 1%	7	2066	13.42
3	>1% to 2%	21	4261	27.67
4	>2% to 3%	4	1095	7.11
5	>3%	0	0	0.00
	TOTAL	**57**	**15400**	**100.00**

TABLE 5.47: DETAILS OF GRADIENTS OF CORRIDOR-2

S. No.	Chainage		Length (m)	Rail Level		Gradient	Remarks
	From (m)	To (m)		From (m)	To (m)		
1	-50	360	410	179.10	179.10	0.00	Level
2	360	535	175	179.10	177.00	-1.20	Fall
3	535	780	245	177.00	179.30	0.94	Rise
4	780	1050	270	179.30	179.30	0.00	Level
5	1050	1250	200	179.30	176.00	-1.65	Fall
6	1250	1575	325	176.00	176.00	0.00	Level
7	1575	1780	205	176.00	179.20	1.56	Rise
8	1780	1950	170	179.20	179.20	0.00	Level
9	1950	2150	200	179.20	176.00	-1.60	Fall
10	2150	2566	416	176.00	176.50	0.12	Rise
11	2566	2800	234	176.50	180.30	1.62	Rise
12	2800	3050	250	180.30	180.30	0.00	Level
13	3050	3225	175	180.30	177.00	-1.89	Fall
14	3225	3350	125	177.00	178.50	1.20	Rise
15	3350	3580	230	178.50	178.50	0.00	Level
16	3580	3800	220	178.50	176.30	-1.00	Fall
17	3800	4675	875	176.30	176.30	0.00	Level
18	4675	4907	232	176.30	173.30	-1.29	Fall
19	4907	5125	218	173.30	175.30	0.92	Rise
20	5125	5350	225	175.30	175.30	0.00	Level
21	5350	5543	193	175.30	178.10	1.45	Rise
22	5543	5800	257	178.10	178.10	0.00	Level
23	5800	6010	210	178.10	176.00	-1.00	Fall

S. No.	Chainage		Length	Rail Level		Gradient	Remarks
	From (m)	To (m)	(m)	From (m)	To (m)		
24	6010	6200	190	176.00	176.00	0.00	Level
25	6200	6348	148	176.00	178.50	1.69	Rise
26	6348	6565	217	178.50	178.50	0.00	Level
27	6565	6815	250	178.50	173.50	-2.00	Fall
28	6815	6915	100	173.50	173.50	0.00	Level
29	6915	7100	185	173.50	175.80	1.24	Rise
30	7100	7340	240	175.80	175.80	0.00	Level
31	7340	7500	160	175.80	176.00	0.12	Rise
32	7500	7775	275	176.00	181.00	1.82	Rise
33	7775	7925	150	181.00	181.00	0.00	Level
34	7925	8100	175	181.00	184.70	2.11	Rise
35	8100	8250	150	184.70	184.70	0.00	Level
36	8250	8720	470	184.70	175.00	-2.06	Fall
37	8720	9275	555	175.00	175.00	0.00	Level
38	9275	9600	325	175.00	170.00	-1.54	Fall
39	9600	9775	175	170.00	168.00	-1.14	Fall
40	9775	9950	175	168.00	168.00	0.00	Level
41	9950	10140	190	168.00	170.20	1.16	Rise
42	10140	10276	136	170.20	170.20	0.00	Level
43	10276	10475	199	170.20	167.00	-1.61	Fall
44	10475	11725	1250	167.00	167.00	0.00	Level
45	11725	11900	175	167.00	169.00	1.14	Rise
46	11900	12497	597	169.00	173.30	0.72	Rise
47	12497	12665	168	173.30	173.30	0.00	Level
48	12665	12865	200	173.30	169.00	-2.15	Fall
49	12865	13350	485	169.00	169.00	0.00	Level
50	13350	13550	200	169.00	172.30	1.65	Rise
51	13550	13725	175	172.30	172.30	0.00	Level
52	13725	13925	200	172.30	169.00	-1.65	Fall
53	13925	14200	275	169.00	169.00	0.00	Level
54	14200	14450	250	169.00	174.60	2.24	Rise
55	14450	15000	550	174.60	174.60	0.00	Level
56	15000	15200	200	174.60	172.20	-1.20	Fall
57	15200	15350	150	172.20	172.20	0.00	Level

C. Special Span & Portals

Details of locations having special spans and portal arrangement are given in **Table 5.48** and **Table 5.49** respectively.

TABLE 5.48: LOCATION OF SPECIAL SPANS CORRIDOR - 2

S. No	Location	Chainage		Configuration Special span
		From	To	
1	Railway Crossing, Collectorate	3750	3830	34m + 45m + 34m
2	Railway Crossing, St. John's College	6200	6290	34m + 45m + 34m
3	Bhagwan Talkies	8050	8250	34m + 4x45m + 34m
4	Yamuna River Bridge	11000	11350	34m +7x45m + 34m

TABLE 5.49: LOCATION OF PORTALS CORRIDOR - 2

S. No.	Location	Chainage		Length	Purpose
		From	To		
1	Partap-pura	2380	2450	70	To avoid Veerangana Avanti Bai Statue across MG Road and Mall Road crossing
2	Collectorate	3600	3700	100	Alignment runs from road median to off the road
3	Subhash Park	4200	4300	100	Alignment is on sharp curve of 120m
4	Sanjay Place	6550	6700	150	Alignment along the road but away from median
5	MG Road	7600	7750	150	Alignment takes sharp turn and passes over Diwani chauraha
6	Bhagwan Talkies Flyover	8700	8900	200	Alignment diverts from one end of NH-2 to other end.
7	Foundary Nagar	12250	12400	150	Alignment comes along median of Nh-2 from edge of service road

D. Break-up of Alignment Length

Break-up of alignment length for Corridor-2 is given in **Table 5.50**.

TABLE 5.50: BREAK-UP OF ALIGNMENT LENGTH FOR CORRIDOR-2

S. No.	Description	Chainage (KM)		Length (m)	Method of Construction/ Structure Type
		From	To		
1	Elevated	(-)50	15350	15400	Box/I/U- Shape Girder
2	Depot Entry	15350	16150	800	Box/I/U- Shape Girder
Total Length				**16200**	

5.5 IDENTIFICATION OF EXISTING SERVICES/ 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 utilities were identified during physical survey of corridor. Moreover, liaison with concerned utility owners was made for identification 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 and Corridor -2, liaison was made with following Organizations/Departments (**Table 5.51**):-

TABLE 5.51: UTILITY RESPONSIBILITY DEPARTMENTS

S. No.	ORGANIZATION/ DEPARTMENT	UTILITY SERVICES
1	NHAI, Agra	Road Construction and maintenance of State highways, Municipal Roads etc.
2	PWD	City Roads
3	Indian Railways	Railway crossings, subways, signals, railway bridges etc.
4	Agra MC-Jal Nigam	Water pipe lines.
5	Jal Kal Vibhag	Sewer lines and Water lines
6	Torrent Power	HT/other overhead Power lines.
7	Agra MC-Sewerage	Sewerage pipe lines.
8	Agra MC-Storm Water Drains	Storm water drainage.
9	Irrigation Department	Canal

S. No.	ORGANIZATION/ DEPARTMENT	UTILITY SERVICES
10	Gas Authority of India (GAIL)	Gas Pipelines
11	Green Gas Limited	Gas Pipelines
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 (Cables)	Telecommunications cables, junction boxes, telephone posts, O.H. Lines.
15	Idea (Cables)	Telecommunications cables, junction boxes, telephone posts, O.H. Lines.
16	Tata Tele Services (Cables)	Telecommunications cables, junction boxes, telephone posts, O.H. Lines.
17	Vodafone (Cables)	Telecommunications cables, junction boxes, telephone posts, O.H. Lines.
18	North Telecom Region (Long Distance Cables)	Telecommunications cables, junction boxes, telephone posts, O.H. Lines.

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. Details of sewer lines & storm water drains and water pipe lines affected are indicated in **Table 5.52 and 5.53**.

5.5.5 Gas Pipe Lines

Few gas pipe lines with varying diameters belonging to Green Gas Ltd. And GAIL 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 detailed in **Table 5.54** and **Table 5.55.**

5.5.6 Telecom Cables, OFC, Ducts and Trench

At several places, telecom cables and OFC of Vodafone, Idea, Rail Tel, NTR, Airtel and BSNL are also running along and across the proposed corridors and few of them are likely to be affected. The list of such cables along with their locations and diversion proposals are shown in **Table 5.56 to 5.65**.

TABLE 5.52: WATER & SEWER PIPES OF JAL KAL

S. No.	Corridor	Utility	Chainage From (M)	Chainage To (M)	Length (M)	LHS/ RHS	DIA/ SIZE (Inches)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Reqd
1	I	Water Pipe Line	5330	5380	50	Crossing	18	1.5	CI	Perpendicular	UG	No
2	I	Water Pipe Line	5330	5380	50	Crossing	30	2	CI	Perpendicular	UG	No
3	I	Water Pipe Line	5340	5750	410	LHS	18	1.5	CI	Parallel	UG	No
4	I	Water Pipe Line	5340	5750	410	LHS	30	2	CI	Parallel	UG	No
5	I	Water Pipe Line	8320	8320	50	RHS	8	1	CI	Perpendicular	UG	No
6	I	Water Pipe Line	8340	8340	50	LHS	8	2	CI	Perpendicular	UG	No
7	I	Water Pipe Line	8340	8340	50	RHS	8	1	CI	Perpendicular	UG	No
8	I	Water Pipe Line	8340	9350	1010	LHS	8	2	CI	Parallel	UG	No
9	I	Water Pipe Line	9350	10200	850	RHS	8	2	CI	Parallel	UG/Elevated	No
10	I	Water Pipe Line	9340	10200	860	LHS/RHS	8	1.5	CI	Parallel	UG/Elevated	No
11	I	Water Pipe Line	10200	10700	500	RHS	8	1.5	CI	Parallel	Elevated	No
12	I	Water Pipe Line	10700	10900	200	LHS	8	1.5	CI	Parallel	Elevated	Yes
13	I	Water Pipe Line	10200	10950	750	RHS	8	2	CI	Parallel	Elevated	No
14	I	Water Pipe Line	10900	11500	600	LHS	8	1.5	PVC	Parallel	Elevated	No
15	I	Water Pipe Line	10950	11550	600	RHS	8	1.5	PVC	Parallel	Elevated	No
16	I	Water Pipe Line	10950	11550	600	RHS	20	1	CI	Parallel	Elevated	No
17	I	Water Pipe Line	11550	12650	1100	RHS	8	1.5	PVC	Parallel	Elevated	Yes
18	I	Water Pipe Line	11550	12650	1100	RHS	20	1	CI	Parallel	Elevated	Yes
19	I	Water Pipe Line	11500	12650	1150	LHS	12	1.5	CI	Parallel	Elevated	Yes
20	I	Water Pipe Line	11500	12650	1150	LHS	20	1	PVC	Parallel	Elevated	Yes
21	I	Water Pipe Line	12650	13450	800	LHS	12	1.5	CI	Parallel	Elevated	No
22	I	Water Pipe Line	12650	13450	800	LHS	20	1	PVC	Parallel	Elevated	No
23	I	Water Pipe Line	12650	13350	700	RHS	8	1.5	PVC	Parallel	Elevated	No
24	I	Water Pipe Line	12650	13350	700	RHS	20	1	CI	Parallel	Elevated	No
25	I	Water Pipe Line	13350	13450	100	RHS	8	1.5	PVC	Parallel	Elevated	Yes

S. No.	Corridor	Utility	Chainage From (M)	Chainage To (M)	Length (M)	LHS/ RHS	DIA/ SIZE (Inches)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Reqd
26	I	Water Pipe Line	13450	13910	460	RHS	8	1.5	PVC	Parallel	Elevated	No
27	I	Water Pipe Line	12600	12600	50	Crossing	4	2	PVC	Perpendicular	Elevated	Yes
28	I	Water Pipe Line	13450	14050	600	LHS	8	2	CI	Parallel	Elevated	No
29	I	Water Pipe Line	13450	14050	600	LHS	12	1.5	CI	Parallel	Elevated	No
30	I	Water Pipe Line	13900	13900	50	Crossing	10	2	CI	Perpendicular	Elevated	Yes
31	I	Water Pipe Line	13900	13900	50	Crossing	14	1.5	CI	Perpendicular	Elevated	Yes
32	I	Sewer Pipe Line	10900	11500	600	LHS	48	2	CI	Parallel	Elevated	No
33	I	Sewer Pipe Line	11500	12650	1150	LHS	48	2	RCC	Parallel	Elevated	Yes
34	I	Sewer Pipe Line	12650	14050	1400	LHS	48	2	RCC	Parallel	Elevated	No
35	II	Water Pipe Line	-50	1250	1300	RHS	10	1.5	DI	Parallel	Elevated	No
36	II	Water Pipe Line	1250	1600	350	RHS	10	2	DI	Parallel	Elevated	No
37	II	Water Pipe Line	1600	2000	400	RHS	8	2	PVC	Parallel	Elevated	Yes
38	II	Water Pipe Line	1600	2000	400	RHS	8	2	PVC	Parallel	Elevated	Yes
39	II	Water Pipe Line	1600	2000	400	RHS	10	1	DI	Parallel	Elevated	Yes
40	II	Water Pipe Line	1600	2000	400	RHS	30	1	CI	Parallel	Elevated	Yes
41	II	Water Pipe Line	2000	2850	850	RHS	12	2	CI	Parallel	Elevated	Yes
42	II	Water Pipe Line	2000	2850	850	RHS	12	2	CI	Parallel	Elevated	Yes
43	II	Water Pipe Line	2000	2850	850	RHS	30	1	CI	Parallel	Elevated	Yes
44	II	Water Pipe Line	2850	3000	150	RHS	12	2	CI	Parallel	Elevated	Yes
45	II	Water Pipe Line	2850	3000	150	RHS	12	2	CI	Parallel	Elevated	Yes
46	II	Water Pipe Line	2850	3000	150	RHS	30	1	CI	Parallel	Elevated	Yes
47	II	Water Pipe Line	3000	3250	250	RHS	12	2	CI	Parallel	Elevated	No
48	II	Water Pipe Line	3000	3250	250	RHS	12	2	CI	Parallel	Elevated	No
49	II	Water Pipe Line	3000	3250	250	RHS	30	1	CI	Parallel	Elevated	No
50	II	Water Pipe Line	3250	4550	1300	RHS/LHS	10	1	DI	Parallel	Elevated	No
51	II	Water Pipe Line	3250	4550	1300	RHS/LHS	18	1.5	DI	Parallel	Elevated	No
52	II	Water Pipe Line	3080	3600	520	LHS	8	1.5	CI	Parallel	Elevated	Yes

S. No.	Corridor	Utility	Chainage From (M)	Chainage To (M)	Length (M)	LHS/ RHS	DIA/ SIZE (Inches)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Reqd
53	II	Water Pipe Line	3080	3600	520	LHS	10	1	CI	Parallel	Elevated	Yes
54	II	Water Pipe Line	3600	4700	1100	LHS	8	1.5	CI	Parallel	Elevated	No
55	II	Water Pipe Line	3600	4700	1100	LHS	10	1	CI	Parallel	Elevated	No
56	II	Water Pipe Line	3560	3560	50	Crossing	10	2	DI	Perpendicular	Elevated	Yes
57	II	Water Pipe Line	4550	4650	100	LHS	10	1	DI	Parallel	Elevated	No
58	II	Water Pipe Line	4550	4650	100	LHS	10	2	DI	Parallel	Elevated	No
59	II	Water Pipe Line	4550	4650	100	LHS	18	1.5	DI	Parallel	Elevated	No
60	II	Water Pipe Line	4650	4700	50	LHS	8	1.5	CI	Parallel	Elevated	No
61	II	Water Pipe Line	4650	4700	50	LHS	12	2	DI	Parallel	Elevated	No
62	II	Water Pipe Line	4700	5300	600	RHS	10	1	DI	Parallel	Elevated	No
63	II	Water Pipe Line	4700	5300	600	RHS	18	1.5	DI	Parallel	Elevated	No
64	II	Water Pipe Line	5300	5600	300	RHS	8	1.5	CI	Parallel	Elevated	No
65	II	Water Pipe Line	5300	5600	300	RHS	12	2	DI	Parallel	Elevated	No
66	II	Water Pipe Line	5600	5900	300	LHS	8	1.5	CI	Parallel	Elevated	No
67	II	Water Pipe Line	5600	5900	300	LHS	12	2	DI	Parallel	Elevated	No
68	II	Water Pipe Line	5900	6220	320	RHS/LHS	8	1.5	CI	Parallel	Elevated	Yes
69	II	Water Pipe Line	6450	6450	50	Crossing	5	1.5	RCC	Perpendicular	Elevated	No
70	II	Water Pipe Line	6450	6450	50	Crossing	18	1.5	CI	Perpendicular	Elevated	No
71	II	Water Pipe Line	6450	6450	50	Crossing	30	1	CI	Perpendicular	Elevated	No
72	II	Water Pipe Line	6450	7120	670	RHS	6	2	CI	Parallel	Elevated	No
73	II	Water Pipe Line	6450	7120	670	RHS	8	1	CI	Parallel	Elevated	No
74	II	Water Pipe Line	7240	7700	460	RHS/LHS	4	2	GI	Parallel	Elevated	Yes
75	II	Water Pipe Line	7240	7700	460	RHS/LHS	8	1.5	RCC	Parallel	Elevated	Yes
76	II	Water Pipe Line	7700	8150	450	RHS	4	2	GI	Parallel	Elevated	No
77	II	Water Pipe Line	7700	8150	450	RHS	8	1.5	RCC	Parallel	Elevated	No
78	II	Water Pipe Line	8150	9400	1250	LHS	6	1.5	RCC	Parallel	Elevated	No
79	II	Water Pipe Line	9400	10300	900	LHS	14	1.5	CI	Parallel	Elevated	No

S. No.	Corridor	Utility	Chainage From (M)	Chainage To (M)	Length (M)	LHS/ RHS	DIA/ SIZE (Inches)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Reqd
80	II	Water Pipe Line	9330	9330	50	Crossing	4	2	PVC	Perpendicular	Elevated	Yes
81	II	Water Pipe Line	9330	9330	50	Crossing	14	1.5	CI	Perpendicular	Elevated	Yes
82	II	Water Pipe Line	10300	11550	1250	LHS	30	1.5	CI	Parallel	Elevated	No
83	II	Water Pipe Line	10240	10670	430	RHS/LHS	14	2	CI	Parallel	Elevated	Yes
84	II	Water Pipe Line	10240	10670	430	RHS/LHS	30	1.5	CI	Parallel	Elevated	Yes
85	II	Water Pipe Line	10670	10670	50	Crossing	30	1.5	CI	Perpendicular	Elevated	Yes
86	II	Water Pipe Line	10700	11360	660	RHS	10	1.5	CI	Parallel	Elevated	Yes
87	II	Water Pipe Line	10700	11360	660	RHS	30	1	CI	Parallel	Elevated	Yes
88	II	Water Pipe Line	11550	12150	600	LHS	12	1.5	CI	Parallel	Elevated	No
89	II	Water Pipe Line	12150	12750	600	LHS	4	2	PVC	Parallel	Elevated	No
90	II	Sewer Pipe Line	7050	7700	650	LHS	12	4	CI	Parallel	Elevated	No
91	II	Sewer Pipe Line	7700	8150	450	LHS/RHS	12	4	CI	Parallel	Elevated	Yes
92	II	Sewer Pipe Line	11340	11340	50	Crossing	30	1	CI	Perpendicular	Elevated	Yes
93	II	Sewer Pipe Line	11360	11360	50	Crossing	30	4.5	CI	Perpendicular	Elevated	Yes
94	II	Sewer Pipe Line	11370	11370	50	Crossing	24	4	CI	Perpendicular	Elevated	Yes
95	II	Sewer Pipe Line	11390	11390	50	Crossing	12	1.5	CI	Perpendicular	Elevated	Yes
96	II	Sewer Pipe Line	12750	15530	2780	LHS	12	4	CI	Parallel	Elevated	No
97	II	Sewer Pipe Line	12750	15530	2780	LHS	12	4.5	DI	Parallel	Elevated	No

TABLE 5.53: SEWER LINES OF JAL NIGAM

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (M)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Reqd
1	I	2280	2900	620	RHS	0.15	4	CI	Parallel	Elevated	No
2	I	3100	3400	300	RHS	0.9	2	CI	Parallel	Elevated	No
3	I	3370	3370	50	Crossing	0.9	2.5	CI	Perpendicular	Elevated	No
4	I	3370	3850	480	LHS	0.2	2.5	CI	Parallel	Elevated	No
5	I	4250	4250	50	Crossing	0.2	1.5	RCC	Perpendicular	Elevated	Yes
6	I	4500	4500	50	Crossing	1	1.5	CI	Perpendicular	U/G	No
7	I	4530	4530	50	Crossing	1	4.5	CI	Perpendicular	U/G	No
8	I	4530	4800	270	RHS	1	1.5	CI	Parallel	U/G	No
9	I	4800	4800	50	Crossing	1	4.5	PVC	Perpendicular	U/G	No
10	I	8950	8950	50	Crossing	1.8	6	RCC	Perpendicular	U/G	Yes
11	I	8950	8950	50	LHS	1.6	6	RCC	Perpendicular	U/G	No
12	I	8950	9300	350	LHS	1.6	7	PVC	Parallel	U/G	No
13	I	9470	9470	50	Crossing	1.6	4	CI	Perpendicular	U/G	Yes
14	I	9650	11450	1800	RHS	0.9	2	PVC	Parallel	Elevated	No
15	I	10770	11450	680	LHS	0.25	3	RCC	Parallel	Elevated	No
16	I	10770	11450	680	LHS	0.9	1.5	RCC	Parallel	Elevated	No
17	I	11450	11450	50	Crossing	0.6	6	CI	Perpendicular	Elevated	Yes
18	I	11450	11850	400	LHS	0.25	3	CI	Parallel	Elevated	Yes
19	I	11550	12380	830	RHS	1.4	2	CI	Parallel	Elevated	No
20	I	12380	12380	50	Crossing	1.4	2	CI	Perpendicular	Elevated	Yes
21	I	12380	12650	270	LHS	1.4	2	CI	Parallel	Elevated	Yes
22	I	12650	13900	1250	LHS	1.4	2	CI	Parallel	Elevated	No
23	II	6450	6450	50	Crossing	0.6	6.5	DI	Perpendicular	Elevated	No
24	II	6450	6550	100	RHS	0.6	6.5	DI	Parallel	Elevated	Yes
25	II	6550	6740	190	RHS	0.6	6.5	DI	Parallel	Elevated	No
26	II	6740	6740	50	Crossing	0.6	6.5	DI	Perpendicular	Elevated	Yes
27	II	7060	7060	50	Crossing	0.9	4	DI	Perpendicular	Elevated	Yes
28	II	7060	7150	90	RHS	0.9	4	PVC	Parallel	Elevated	No

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (M)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Reqd
29	II	7150	7150	50	Crossing	0.9	4	CI	Perpendicular	Elevated	No
30	II	7080	7350	270	LHS	0.3	3	CI	Parallel	Elevated	Yes
31	II	7350	7625	275	LHS	0.3	3	CI	Parallel	Elevated	No
32	II	7625	7625	50	Crossing	0.3	3	CI	Perpendicular	Elevated	No
33	II	7700	7700	50	Crossing	1.2	6	DI	Perpendicular	Elevated	Yes
34	II	8100	9200	1100	RHS	0.3	3.5	CI	Parallel	Elevated	No
35	II	9200	10100	900	RHS	0.4	4	CI	Parallel	Elevated	No
36	II	10100	10520	420	RHS	0.4	5	DI	Parallel	Elevated	No
37	II	10520	10700	180	RHS	0.4	6	DI	Parallel	Elevated	No
38	II	10700	10700	50	Crossing	1.6	6	DI	Perpendicular	Elevated	Yes

TABLE 5.54: GAS PIPE LINE OF GREEN GAS LIMITED

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (mm)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Reqd
1	I	1220	1450	230	LHS	63	1-2	MDPE	Parallel	Elevated	No
2	I	2260	2260	50	Crossing	100	1-2	STEEL	Perpendicular	Elevated	No
3	I	2350	3400	1050	LHS	93/63	1-2	MDPE	Parallel	Elevated	No
4	I	2640	2640	50	Crossing	125	1-2	MDPE	Perpendicular	Elevated	No
5	I	4210	4210	50	Crossing	63	1-2	MDPE	Perpendicular	Elevated	No
6	I	4320	4320	50	Crossing	63	1-2	MDPE	Perpendicular	Elevated	No
7	I	4470	4470	50	Crossing	63/32	1-2	MDPE	Perpendicular	Elevated	Yes
8	I	4500	4790	290	RHS	63/32	1-2	MDPE	Parallel	U/G	Yes
9	I	4500	4790	290	LHS	63/32	1-2	MDPE	Parallel	U/G	Yes
10	I	4790	4790	50	Crossing	63	1-2	MDPE	Perpendicular	U/G	Yes
11	I	4800	4800	50	Crossing	63/90	1-2	MDPE	Perpendicular	U/G	Yes
12	I	4800	5150	350	LHS	63	1-2	MDPE	Parallel	U/G (RBS College)	Yes
13	I	4800	5150	350	RHS	63	1-2	MDPE	Parallel	U/G (RBS College)	Yes
14	I	5680	5680	50	Crossing	63	1-2	MDPE	Perpendicular	U/G (Raja Ki Mandi)	Yes

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (mm)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Reqd
15	I	5750	5750	50	Crossing	63	1-2	MDPE	Perpendicular	U/G (Raja Ki Mandi)	Yes
16	I	9370	9725	355	RHS	200	1-2	STEEL	Parallel	U/G	No
17	I	9725	13450	3725	RHS	200	1-2	STEEL	Parallel	Elevated	No
18	I	10540	10540	50	Crossing	200	1-2	STEEL	Perpendicular	Elevated	No
19	I	12980	13450	470	RHS	200	1-2	STEEL	Parallel	Elevated	No
20	II	6580	6720	140	RHS	90	1-2	MDPE	Parallel	Elevated	No
21	II	6720	6720	50	Crossing	90	1-2	MDPE	Perpendicular	Elevated	No
22	II	7150	7615	465	RHS	63	1-2	MDPE	Parallel	Elevated (Sursadan Stn.)	Yes
23	II	7615	7615	50	Crossing	63	1-2	MDPE	Perpendicular	Elevated	No
24	II	10700	11000	300	Centre	200	1-2	STEEL	Parallel	Elevated	Yes

TABLE 5.55: GAS PIPE LINES OF GAIL

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (mm)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Reqd
1	I	-300	1950	2250	RHS	200	1-2	STEEL	Parallel	Elevated	No
2	I	1900	1900	50	Crossing	200	1.9	STEEL	Perpendicular	Elevated	No
3	I	1950	2500	550	RHS	200	1-2	STEEL	Parallel	Elevated	No
4	I	2250	2250	50	Crossing	100	1-2	STEEL	Perpendicular	Elevated (ISBT)	Yes
5	I	2500	3750	1250	LHS	200	1-2	MDPE	Parallel	Elevated/UG	No
6	I	3750	3750	50	Crossing	200	1-2	STEEL	Perpendicular	U/G	No
7	II	8150	8150	50	Crossing	200	1-2	STEEL	Perpendicular	Elevated	Yes
8	II	8150	8800	650	RHS	200	1-2	STEEL	Parallel	Elevated	No
9	II	8800	11000	2200	RHS	200	1-2	STEEL	Parallel	Elevated	Yes
10	II	10700	11100	400	LHS	200	1-2	STEEL	Parallel	Elevated	Yes
11	II	11100	11550	450	LHS	200	1-2	STEEL	Parallel	Elevated	Yes
12	II	11550	11950	400	LHS	200	1-2	STEEL	Parallel	Elevated	Yes
13	II	11750	11780	30	RHS	100	1-2	STEEL	Parallel	Elevated	Yes

TABLE 5.56: OPTICAL FIBRE CABLE OF TATA

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (mm)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Reqd
1	I	1150	3750	2600	LHS	96 F-1	2M	Fibre	Paraller	Elevated	No
2	I	1440	1440	50	Crossing	96 F-1	1.5M	Fibre	Perpendicular	Elevated	Yes
3	I	4800	5310	510	RHS	24 F-1 96 F-1	1.5	Fibre	Paraller	U/G	No
4	I	5315	5800	485	LHS	24 F-1 48 F-1	1.5	Fibre	Paraller	U/G	No
5	I	5320	5800	480	LHS	24 F-1	1.5	Fibre	Paraller	U/G	No
6	I	7700	8315	615	RHS/LHS	24 F-1 96 F-1	1.5	Fibre	Paraller	U/G	No
7	I	7700	8350	650	RHS/LHS	96 F-1	1.5	Fibre	Paraller	U/G	No
8	I	8300	8300	50	Crossing	24 F-1 48 F-1	1.5	Fibre	Perpendicular	U/G	No
9	I	8300	8300	50	Crossing	96 F-1	1.5	Fibre	Perpendicular	U/G	No
10	I	11400	11550	150	RHS	24 F-1	1.5	Fibre	Paraller	Elevated	No
11	II	1600	2000	400	RHS/LHS	48 F-1	1.5	Fibre	Paraller	Elevated Station Block (Sadar Bazar)	Yes
12	II	2000	2850	850	LHS	48 F-1	1.5	Fibre	Paraller	Elevated	No
13	II	2850	3600	750	LHS	48 F-1	1.5	Fibre	Paraller	Elevated Station Block (Partap Pura /Collectorate)	Yes
14	II	3600	6300	2700	LHS	48 F-1	1.5	Fibre	Paraller	Elevated	No
15	II	1600	2430	830	RHS	24 F-1 96 F-1	1.5	Fibre	Paraller	Elevated	No
16	II	1810	1810	50	Crossing	48 F-1	2	Fibre	Perpendicular	Elevated	Yes
17	II	2390	2390	50	Crossing	96 F-1	1.5	Fibre	Perpendicular	Elevated	Yes
18	II	2390	2460	70	LHS	96 F-1	1.5	Fibre	Paraller	Elevated	No
19	II	2690	2690	50	Crossing	12 F-1 24 F1	1.5	Fibre	Diagonally	Elevated	Yes

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (mm)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Reqd
20	II	2690	2690	50	Crossing	48 F-196 F1	1.5	Fibre	Perpendicular	Elevated	No
21	II	2690	2690	50	Crossing	24 F-1 48 F-1 96 F-1	1.5	Fibre	Perpendicular	Elevated	Yes
22	II	3450	6415	2965	RHS/LHS	24 F-1	2	Fibre	Paraller	Elevated	No
23	II	4890	4890	50	Crossing	48 F-2	2	Fibre	Perpendicular	Elevated	Yes
24	II	4910	4910	50	Crossing	48 F-2	2	Fibre	Perpendicular	Elevated	Yes
25	II	6450	6450	50	Crossing	24 F-1 48 F1	1.5	Fibre	Perpendicular	Elevated	Yes
26	II	6450	6650	200	LHS/RHS	96 F-1	1.5	Fibre	Perpendicular	Elevated	Yes
27	II	6450	7200	750	RHS	96 F-1	1.5	Fibre	Paraller	Elevated	No
28	II	6575	6575	50	Crossing	48 F1	1.5	Fibre	Perpendicular	Elevated	Yes
29	II	7200	7450	250	RHS	96 F-1	1.5	Fibre	Paraller	Elevated Station Block (Sur Sadan)	Yes
30	II	6600	7050	450	LHS	48 F-1	1.5	Fibre	Paraller	Elevated	No
31	II	7050	7050	50	Crossing	48 F-1	1.5	Fibre	Perpendicular	Elevated	No
32	II	7130	7130	50	Crossing	24 F-1 96 F1	1.5	Fibre	Perpendicular	Elevated	Yes
33	II	7790	8150	360	RHS	24 F-1 96 F1	1.5	Fibre	Paraller	Elevated	No
34	II	8120	8120	50	Crossing	48 F-1	1.5	Fibre	Perpendicular	Elevated	No
35	II	8130	8130	50	Crossing	24 F-1 96 F1	1.5	Fibre	Perpendicular	Elevated	No
36	II	8100	8750	650	LHS	96 F-1	1.5	Fibre	Paraller	Elevated	Yes
37	II	8750	11850	3100	LHS	96 F-1	1.5	Fibre	Paraller	Elevated	No
38	II	10480	10480	50	Crossing	24 F-1 96 F1	1.5	Fibre	Perpendicular	Elevated	Yes
39	II	10700	10700	50	Crossing	24 F-1 96 F1	1.5	Fibre	Perpendicular	Elevated	Yes

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (mm)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Reqd
40	II	11725	11725	50	LHS	96 F-1	1.5	Fibre	Perpendicular	Elevated	No
41	II	11750	11750	50	RHS	24 F-1	1.5	Fibre	Perpendicular	Elevated	Yes
42	II	11750	11750	50	LHS	24 F-1	1.5	Fibre	Perpendicular	Elevated	Yes

TABLE 5.57: OPTICAL FIBRE CABLE OF VODAFONE

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (mm)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Reqd
1	I	2950	2950	50	Crossing	48 F-1, HDD	1.5	Fibre	Perpendicular	Elevated	No
2	I	2950	3350	400	LHS	48 F-1	1.5	Fibre	Parallel	Elevated/UG	No
3	I	3350	3350	50	Crossing	48 F-1	1.5	Fibre	Perpendicular	U/G	No
4	I	4500	4500	50	Crossing	48 F-1	1.5	Fibre	Perpendicular	U/G	No
5	I	4500	4800	300	RHS	48 F-1	1.5	Fibre	Parallel	U/G	No
6	I	4800	4800	50	RHS	48 F-1	1.5	Fibre	Perpendicular	U/G	No
7	I	8350	8350	50	RHS	48 F-1	2.5	Fibre	Perpendicular	U/G	No
8	I	8350	8350	50	RHS	48 F-1	1.5	Fibre	Perpendicular	U/G	No
9	I	8900	9300	400	RHS/LHS	48 F-2	1.5	Fibre	Parallel	U/G	No
10	I	8950	9840	890	RHS/LHS	48 F-1	1.5	Fibre	Parallel	U/G	No
11	I	9300	9840	540	RHS/LHS	48 F-1	1.5	Fibre	Parallel	U/G	No
12	I	10150	10700	550	RHS	48 F-1	1.5	Fibre	Parallel	Elevated	No
13	I	10150	10750	600	RHS	48 F-1	1.5	Fibre	Parallel	Elevated	No
14	I	10700	11700	1000	LHS	48 F-1	1.5	Fibre	Parallel	Elevated, Fatehabad Road Stn.	Yes
15	I	10760	10760	50	Crossing	48 F-1	1.5	Fibre	Perpendicular	Elevated	No
16	I	11150	11500	350	RHS	48 F-1	1.5	Fibre	Parallel	Elevated	No
17	I	12000	12500	500	RHS	48 F-2	1.5	Fibre	Parallel	Elevated	No
18	I	11700	12550	850	LHS	48 F-1	1.5	Fibre	Parallel	Elevated	No
19	I	12550	12650	100	LHS	48 F-1	1.5	Fibre	Parallel	Elevated, Basai Stn.	Yes

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (mm)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Reqd
20	I	12650	14050	1400	LHS	48 F-1	1.5	Fibre	Parallel	Elevated	No
21	I	13000	13450	450	RHS	48 F-2	1.5	Fibre	Parallel	Elevated, Taj East Gate Stn.	Yes
22	I	13450	14050	600	RHS	48 F-2	1.5	Fibre	Parallel	Elevated	No
23	II	1750	1850	100	LHS	48 F-1	1.5	Fibre	Parallel	Elevated	No
24	II	1820	1820	50	Crossing	48 F-1	2	Fibre	Perpendicular	Elevated	Yes
25	II	1850	1850	50	Crossing	48 F-1	1.5	Fibre	Perpendicular	Elevated	No
26	II	3100	3150	50	LHS	48 F-1	1.5	Fibre	Parallel	Elevated	Yes
27	II	3100	3170	70	RHS	48 F-1	2	Fibre	Parallel	Elevated	No
28	II	3550	3550	50	RHS	48 F-2	2	Fibre	Perpendicular	Elevated	No
29	II	3900	4700	800	LHS	48 F-2	2	Fibre	Parallel	Elevated	No
30	II	3900	6400	2500	LHS/RHS	48 F-2	1.5	Fibre	Parallel	Elevated	No
31	II	4700	4700	50	Crossing	48 F-1	2	Fibre	Perpendicular	Elevated	No
32	II	4710	4710	50	Crossing	48 F-1	1.5	Fibre	Perpendicular	Elevated	No
33	II	4810	5600	790	LHS	48 F-1	2	Fibre	Parallel	Elevated	Yes
34	II	5600	7670	2070	LHS	48 F-1	2	Fibre	Parallel	Elevated	No
35	II	4150	4300	150	RHS	48 F-1	2	Fibre	Parallel	Elevated	No
36	II	5600	5600	50	RHS	48 F-1	1.5	Fibre	Perpendicular	Elevated	No
37	II	5620	5620	50	RHS	48 F-2	2	Fibre	Perpendicular	Elevated	No
38	II	6430	6430	50	Crossing	48 F-1	1.5	Fibre	Perpendicular	Elevated	No
39	II	6460	6460	50	Crossing	48 F-2	2	Fibre	Perpendicular	Elevated	No
40	II	6460	7150	690	RHS	48 F-2	2	Fibre	Parallel	Elevated	No
41	II	7150	7400	250	RHS	48 F-2	2	Fibre	Parallel	Elevated, Sur Sadan Stn.	Yes
42	II	7400	7700	300	RHS	48 F-2	2	Fibre	Parallel	Elevated	No
43	II	7700	7700	50	LHS	48 F-1	1.5	Fibre	Perpendicular	Elevated	No
44	II	7700	7700	50	Crossing	48 F-1	2	Fibre	Diagonally	Elevated	Yes
45	II	7700	8150	450	RHS	48 F-1	2	Fibre	Parallel	Elevated	No
46	II	9330	9330	50	Crossing	48 F-1	2	Fibre	Perpendicular	Elevated	Yes
47	II	9940	9940	50	Crossing	48 F-1	2	Fibre	Perpendicular	Elevated	Yes
48	II	11740	11740	50	Crossing	48 F-1,	1.5	Fibre	Perpendicular	Elevated	Yes

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (mm)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Reqd
						HDD					
49	II	13750	14650	900	LHS	48 F-1	2	Fibre	Parallel	Elevated	No
50	II	13900	13900	50	RHS	48 F-1	2	Fibre	Perpendicular	Elevated	No
51	II	14650	14650	50	LHS	48 F-1	2	Fibre	Perpendicular	Elevated	No
52	II	14750	15000	250	Crossing	48 F-1	2	Fibre	Diagonally	Elevated	Yes

TABLE 5.58: OPTICAL FIBRE CABLE OF RAIL TEL

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (mm)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Reqd
1	I	750	1150	400	RHS	24 F-1	2	Fibre	Parallel	Elevated	No
2	I	5760	5760	50	Crossing	24 F-1, LMC	2	Fibre	Perpendicular	Elevated	Yes
3	I	5770	5770	50	Crossing	24 F-1	2	Fibre	Perpendicular	Elevated	Yes
4	I	8160	8160	50	Crossing	24 F-1	1.5	Fibre	Perpendicular	Elevated	Yes
5	I	8170	8170	50	RHS	24 F-1	2	Fibre	Perpendicular	Elevated	Yes
6	I	11450	12700	1250	RHS	24 F-1, LMC	2	Fibre	Parallel	Elevated	Yes
7	II	20	20	50	Crossing	24 F-1	2	Fibre	Perpendicular	Elevated	Yes
8	II	20	130	110	RHS	24 F-1	2	Fibre	Parallel	Elevated	Yes
9	II	3550	3550	50	RHS	24 F-1	2	Fibre	Perpendicular	Elevated	No
10	II	3770	3770	50	Crossing	24 F-1	2	Fibre	Perpendicular	Elevated	Yes
11	II	3790	3790	50	Crossing	24 F-1	2	Fibre	Perpendicular	Elevated	Yes
12	II	6250	7100	850	LHS	24 F-1, LMC	2	Fibre	Parallel	Elevated	No
13	II	6440	6440	50	Crossing	24 F-1	2	Fibre	Perpendicular	Elevated	Yes
14	II	7100	7100	50	Crossing	24 F-1, LMC	2	Fibre	Perpendicular	Elevated	Yes

TABLE 5.59: OPTICAL FIBRE CABLE OF PGCIL

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (mm)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Reqd
1	I	8300	9350	1050	LHS	24 F-1	1.5	Fibre	Parallel	U/G	No
2	II	2410	2410	50	Crossing	24 F-1	1.5	Fibre	Perpendicular	Elevated	Yes
3	II	2410	2850	440	LHS	24 F-1	1.5	Fibre	Parallel	Elevated	No
4	II	2850	3600	750	LHS	24 F-1	1.5	Fibre	Parallel	Elevated	Yes
5	II	3600	4700	1100	LHS	25 F-1	1.5	Fibre	Parallel	Elevated	No
6	II	4840	4840	50	Crossing	26 F-1	1.5	Fibre	Perpendicular	Elevated	Yes
7	II	4700	4850	150	LHS	27 F-1	1.5	Fibre	Parallel	Elevated	Yes
8	II	4850	6450	1600	LHS	28 F-1	1.5	Fibre	Parallel	Elevated	No
9	II	6450	6840	390	LHS	29 F-1	1.5	Fibre	Parallel	Elevated	Yes

TABLE 5.60: OFC CABLES OF AIRTEL

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (mm)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Reqd
1	I	2000	2400	400	RHS	100 & 400 Pair	2	Copper	Parallel	Elevated	No
2	I	2270	2270	50	RHS	100 & 400 Pair	2	Copper	Perpendicular	Elevated	No
3	I	3100	3850	750	LHS	100 & 400 Pair	2	Copper	Parallel	U/G	No
4	I	3100	3850	750	LHS	96 F-1 Cable	1.5	Fibre	Parallel	U/G	No
5	I	3100	3380	280	LHS	100 & 400 Pair	2	Copper	Parallel	U/G	No
6	I	3350	3350	50	LHS	96 F-1 Cable	1.5	Fibre	Perpendicular	U/G	No
7	I	3350	3350	50	LHS	100 Pair	2	Copper	Perpendicular	U/G	No
8	I	3380	3380	50	RHS	96 F-1 Cable	1.5	Fibre	Perpendicular	U/G	No
9	I	3380	3380	50	RHS	400 Pair	2	Copper	Perpendicular	U/G	No
10	I	4200	4200	50	Crossing	400 Pair	2	Copper	Perpendicular	U/G	No
11	I	4150	4450	300	RHS/LHS	96 F-1 Cable	1.5	Fibre	Parallel	U/G	No
12	I	4150	4450	300	RHS/LHS	400 Pair	2	Copper	Parallel	U/G	No
13	I	4500	4780	280	LHS	400 Pair	2	Copper	Parallel	U/G	No

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (mm)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Reqd
14	I	4780	4780	50	Crossing	400 Pair	2	Copper	Perpendicular	U/G	No
15	I	4800	4800	50	Crossing	96 F-1 Cable	1.5	Fibre	Perpendicular	U/G	No
16	I	4800	4800	50	Crossing	100 & 400 Pair	2	Copper	Perpendicular	U/G	No
17	I	4800	4950	150	RHS	96 F-1 Cable	1.5	Fibre	Parallel	U/G	No
18	I	4800	4950	150	RHS	100 & 400 Pair	2	Copper	Parallel	U/G	No
19	I	7800	8340	540	RHS/LHS	12 F-1 Cable 96 F-1 Cable	1.5	Fibre	Parallel	U/G	No
20	I	8290	8290	50	Crossing	24F-1 Cable 96 F-1 Cable	1.5	Fibre	Perpendicular	U/G	No
21	I	8900	9400	500	RHS/LHS	48F-1 Cable	1.5	Fibre	Parallel	U/G	No
22	I	9350	11150	1800	RHS	96F-1 Cable	1.5	Fibre	Parallel	U/G, Elevated	No
23	I	11150	12600	1450	RHS	96F-1 Cable	1.5	Fibre	Parallel	Elevated	Yes
24	I	12600	12600	50	Crossing	96F-1 Cable	1.5	Fibre	Perpendicular	Elevated	Yes
25	II	1550	2400	850	RHS	24F-1 Cable 48F-1 Cable	1.5	Fibre	Parallel	Elevated	Yes
26	II	1550	2400	850	RHS	400 Pair	2	Copper	Parallel	Elevated	Yes
27	II	1880	1880	50	RHS	24 F-1 Cable 96 F-1 Cable	1.5	Fibre	Perpendicular	Elevated	No
28	II	2400	2400	50	RHS	24 F-1 Cable 96 F-1 Cable	1.5	Fibre	Perpendicular	Elevated	No
29	II	2400	4640	2240	RHS/LHS	48 F-1 Cable 96 F-1 Cable	1.5	Fibre	Parallel	Elevated	Yes
30	II	2400	4640	2240	RHS/LHS	100 & 400 Pair	2	Copper	Parallel	Elevated	Yes
31	II	4640	4700	60	Crossing	24 F-1 Cable 96 F-1 Cable	1.5	Fibre	Diagonally	Elevated	Yes
32	II	4640	4700	60	Crossing	100 & 400 Pair	2	Copper	Diagonally	Elevated	Yes
33	II	4680	4680	50	Crossing	96F-1 Cable	1.5	Fibre	Perpendicular	Elevated	No
34	II	4680	5000	320	LHS	96F-1 Cable	1.5	Fibre	Parallel	Elevated	Yes
35	II	5000	5940	940	LHS	96F-1 Cable	1.5	Fibre	Parallel	Elevated	No
36	II	5940	5940	50	LHS	96F-1 Cable	1.5	Fibre	Perpendicular	Elevated	No
37	II	4700	5550	850	RHS	24 F-1 Cable	1.5	Fibre	Parallel	Elevated	No

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (mm)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Reqd
						48 F-1 Cable					
38	II	4700	5550	850	RHS	100 & 400 Pair	2	Copper	Parallel	Elevated	No
39	II	5550	6150	600	RHS/LHS	24 F-1 Cable 48 F-1 Cable	1.5	Fibre	Parallel	Elevated	Yes
40	II	5550	6150	600	RHS/LHS	100 & 400 Pair	2	Copper	Parallel	Elevated	Yes
41	II	6150	6570	420	RHS	24 F-1 Cable 48 F-1 Cable	1.5	Fibre	Parallel	Elevated	No
42	II	6150	6570	420	RHS	100 & 400 Pair	2	Copper	Parallel	Elevated	No
43	II	6740	6740	50	LHS	96 F-2 Cables	1.5	Fibre	Perpendicular	Elevated	No
44	II	6740	7130	390	LHS	96 F-2 Cables	1.5	Fibre	Parallel	Elevated	No
45	II	7130	7130	50	Crossing	96 F-2 Cables	1.5	Fibre	Perpendicular	Elevated	Yes
46	II	7140	7140	50	RHS	96 F-2 Cables	1.5	Fibre	Perpendicular	Elevated	No
47	II	7140	7630	490	RHS	96 F-2 Cables	1.5	Fibre	Parallel	Elevated	Yes
48	II	7630	7630	50	Crossing	96 F-2 Cables	1.5	Fibre	Perpendicular	Elevated	Yes
49	II	7690	7690	50	Crossing	100 & 400 Pair	2	Copper	Perpendicular	Elevated	Yes
50	II	8100	8800	700	Centre	96 F-2 Cables	1.5	Fibre	Parallel	Elevated	Yes
51	II	8800	12950	4150	LHS	96 F-2 Cables	1.5	Fibre	Parallel	Elevated	No
52	II	8150	8950	800	RHS	100 & 400 Pair	2	Copper	Parallel	Elevated	No
53	II	8950	9100	150	RHS	100 & 400 Pair	2	Copper	Parallel	Elevated	Yes
54	II	9100	11000	1900	RHS	100 & 400 Pair	2	Copper	Parallel	Elevated	No
55	II	11000	12000	1000	RHS/LHS	100 & 400 Pair	2	Copper	Parallel	Elevated	Yes
56	II	12000	12950	950	RHS	100 & 400 Pair	2	Copper	Parallel	Elevated	No
57	II	9340	10900	1560	RHS	96 F-2 Cables	1.5	Fibre	Parallel	Elevated	No
58	II	10900	12400	1500	RHS/LHS	96 F-2 Cables	1.5	Fibre	Parallel	Elevated	Yes
59	II	12400	12950	550	RHS	96 F-2 Cables	1.5	Fibre	Parallel	Elevated	No
60	II	12950	12950	50	Crossing	96 F-4 Cables	1.5	Fibre	Perpendicular	Elevated	Yes
61	II	11730	11730	50	Crossing	24 F-1 Cable	1.5	Fibre	Perpendicular	Elevated	Yes
62	II	11740	11740	50	Crossing	100 & 400 Pair	2	Copper	Perpendicular	Elevated	Yes
63	II	14900	14900	50	Crossing	48 F-1 Cable	1.5	Fibre	Diagonally	Elevated	Yes
64	II	14900	15530	630	LHS	48 F-1 Cable	1.5	Fibre	Parallel	Elevated	No

TABLE 5.61: OPTICAL FIBRE CABLES OF BSNL

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (mm)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Reqd
1	I	-300	850	1150	RHS	12 F-1	1.5	Fibre	Parallel	Elevated	No
2	I	-300	850	1150	RHS	24 F-2	2	Fibre	Parallel	Elevated	No
3	I	850	1900	1050	RHS	12 F-1	1.5	Fibre	Parallel	Elevated	Yes
4	I	850	1900	1050	RHS	24 F-2	2	Fibre	Parallel	Elevated	Yes
5	I	1900	2400	500	LHS	12 F-1	1.5	Fibre	Parallel	Elevated	No
6	I	1900	2400	500	LHS	24 F-2	2	Fibre	Parallel	Elevated	No
7	I	2260	2260	50	Crossing	24 F-1	2	Fibre	Perpendicular	Elevated, ISBT Stn.	Yes
8	I	2260	2260	50	Crossing	48 F-1	1.5	Fibre	Perpendicular	Elevated, ISBT Stn.	Yes
9	I	2260	2260	50	Crossing	96 F-1	1.5	Fibre	Perpendicular	Elevated, ISBT Stn.	Yes
10	I	3375	3375	50	Crossing	12 F-1	1.5	Fibre	Perpendicular	U/G	No
11	I	3375	3375	50	Crossing	24 F-1	2	Fibre	Perpendicular	U/G	No
12	I	3375	3375	50	Crossing	48 F-1	1.5	Fibre	Perpendicular	U/G	No
13	I	3375	3375	50	Crossing	96 F-1	1.5	Fibre	Perpendicular	U/G	No
14	I	4200	4200	50	Crossing	12 F-1	1.5	Fibre	Perpendicular	U/G	No
15	I	4200	4200	50	Crossing	48 F-1	2	Fibre	Perpendicular	U/G	No
16	I	4200	4200	50	Crossing	96 F-1	1.5	Fibre	Perpendicular	U/G	No
17	I	4800	4800	50	Crossing	12 F-1	1.5	Fibre	Perpendicular	U/G	No
18	I	4800	4800	50	Crossing	24 F-1	2	Fibre	Perpendicular	U/G	No
19	I	4800	4800	50	Crossing	48 F-1	1.5	Fibre	Perpendicular	U/G	No
20	I	4800	4800	50	Crossing	96 F-1	2	Fibre	Perpendicular	U/G	No
21	I	8290	8290	50	Crossing	6 F-1	2	Fibre	Perpendicular	U/G	No
22	I	8290	8290	50	Crossing	12 F-1	1.5	Fibre	Perpendicular	U/G	No
23	I	8290	8290	50	Crossing	24 F-1	2	Fibre	Perpendicular	U/G	No
24	I	8290	8290	50	Crossing	48 F-2	2	Fibre	Perpendicular	U/G	No
25	I	8290	8290	50	Crossing	96 F-2	1.5	Fibre	Perpendicular	U/G	No

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (mm)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Reqd
26	I	8330	9350	1020	LHS	48 F-2 96 F-2	1.5	Fibre	Parallel	U/G	No
27	I	9350	10700	1350	RHS	48 F-2 96 F-2	1.5	Fibre	Parallel	U/G/ Elevated	No
28	I	10750	12700	1950	LHS	48 F-2 96 F-2	1.5	Fibre	Parallel	Elevated	Yes
29	I	12700	14050	1350	LHS	48 F-2 96 F-2	1.5	Fibre	Parallel	Elevated	No
30	I	13900	13900	50	LHS	12 F-1	1.5	Fibre	Perpendicular	Elevated	No
31	II	1300	1600	300	LHS	6 F-1	1.5	Fibre	Parallel	Elevated	Yes
32	II	1600	2000	400	LHS	6 F-1 12 F-1	1.5	Fibre	Parallel	Elevated	Yes
33	II	1600	2000	400	LHS	24 F-1	2	Fibre	Parallel	Elevated	Yes
34	II	2000	2700	700	LHS	6 F-1 12 F-1	1.5	Fibre	Parallel	Elevated	No
35	II	2000	2700	700	LHS	24 F-1	2	Fibre	Parallel	Elevated	No
36	II	2700	3000	300	LHS	12 F-2 96 F-2	1.5	Fibre	Parallel	Elevated	No
37	II	2700	3000	300	LHS	24 F-2	2	Fibre	Parallel	Elevated	No
38	II	3000	4450	1450	LHS	12 F-1 96 F-2	1.5	Fibre	Parallel	Elevated	Yes
39	II	3000	4450	1450	LHS	24 F-1 48 F-2	2	Fibre	Parallel	Elevated	Yes
40	II	4450	5400	950	LHS	12 F-1 96 F-2	1.5	Fibre	Parallel	Elevated	No
41	II	4450	5400	950	LHS	24 F-1 48 F-2	2	Fibre	Parallel	Elevated	No

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (mm)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Reqd
42	II	4680	4680	50	Crossing	48 F-2 96 F-2	1.5	Fibre	Perpendicular	Elevated	No
43	II	5400	6450	1050	LHS	12 F-1 96 F-2	1.5	Fibre	Parallel	Elevated	No
44	II	5400	6450	1050	LHS	24 F-1 48 F-2	2	Fibre	Parallel	Elevated	No
45	II	6450	6450	50	Crossing	12 F-2	1.5	Fibre	Perpendicular	Elevated	Yes
46	II	6450	6450	50	Crossing	24 F-4	2	Fibre	Perpendicular	Elevated	Yes
47	II	6450	7400	950	LHS	12 F-1	1.5	Fibre	Parallel	Elevated	No
48	II	6450	7400	950	LHS	24 F-2	2	Fibre	Parallel	Elevated	No
49	II	7400	8150	750	LHS	12 F-1	1.5	Fibre	Parallel	Elevated	Yes
50	II	7400	8150	750	LHS	24 F-2	2	Fibre	Parallel	Elevated	Yes
51	II	8150	8150	50	Crossing	12 F-1	1.5	Fibre	Perpendicular	Elevated	No
52	II	8150	8150	50	Crossing	24 F-2	2	Fibre	Perpendicular	Elevated	No
53	II	11730	11730	50	Crossing	12 F-1 24 F-1 48 F-1 96 F-1	1.5	Fibre	Perpendicular	Elevated	Yes
54	II	14670	14670	50	Crossing	24 F-1	2	Fibre	Perpendicular	Elevated	Yes
55	II	14670	14670	50	Crossing	48 F-1 96 F-1	1.5	Fibre	Perpendicular	Elevated	Yes
56	II	14670	14870	200	RHS	24 F-1	2	Fibre	Parallel	Elevated	No
57	II	14670	14870	200	RHS	48 F-1 96 F-1	1.5	Fibre	Parallel	Elevated	No
58	II	14900	15500	600	RHS	24 F-1	2	Fibre	Parallel	Elevated	No

TABLE 5.62: COPPER CABLES OF BSNL

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (mm)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Reqd
1	I	8320	8320	50	Crossing	800 x 22 Cables	2	Copper	Perpendicular	U/G	No
2	I	8330	8330	50	Crossing	800 x 22 Cables	2	Copper	Perpendicular	U/G	No
3	I	8300	9350	1050	LHS	100 x 1 Cable	2	Copper	Parallel	U/G	No
4	I	9350	10750	1400	RHS	100 x 1 Cable	2	Copper	Parallel	U/G, Elevated	No
5	I	10740	10740	50	Crossing	100 x 1, Cable 200 x 1, Cable	2	Copper	Perpendicular	Elevated	Yes
6	I	10750	10750	50	Crossing	50 x 1 Cable	2	Copper	Perpendicular	Elevated	No
7	I	10750	11470	720	LHS	50 x 1 Cable	2	Copper	Parallel	Elevated	Yes
8	I	11470	12920	1450	LHS	100 x 1 Cable 200 x 3 Cables 400 x 5 Cables 800 x 5 Cables 1200 x 2 Cables	2	Copper	Parallel	Elevated	Yes
9	I	10740	11600	860	RHS	100 x 1, Cable 200 x 1, Cable	2	Copper	Parallel	Elevated	No
10	I	11600	12920	1320	RHS	100 x 2 Cables 200 x 6 Cables 400 x 10 Cables 800 x 10 Cables 1200 x 4 Cables	2	Copper	Parallel	Elevated	No
11	I	12920	14050	1130	LHS	50 x 1 Cable	2	Copper	Parallel	Elevated	No
12	I	12920	14050	1130	RHS	100 x 5 Cables	2	Copper	Parallel	Elevated	No
13	II	-50	60	110	RHS	50 x 1 Cable	2	Copper	Parallel	Elevated	Yes
14	II	60	1100	1040	RHS	100 x 1, Cable 400 x 1, Cable	2	Copper	Parallel	Elevated	No
15	II	240	240	50	RHS	400 x 1 Cable	2	Copper	Perpendicular	Elevated	No
16	II	320	320	50	Crossing	400 x 1 Cable	2	Copper	Perpendicular	Elevated	Yes
17	II	1090	1090	50	Crossing	100 x 2 Cable	2	Copper	Perpendicular	Elevated	Yes
18	II	1090	1650	560	LHS	400 x 2 Cables	2	Copper	Parallel	Elevated	No

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (mm)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Reqd
19	II	1700	2420	720	LHS	800 x 1 Cable	2	Copper	Parallel	Elevated	No
20	II	1700	2420	720	RHS	400 x 1 Cable	2	Copper	Parallel	Elevated	Yes
21	II	2720	3000	280	RHS	200 x 1, Cable 400 x 1, Cable 800 x 1 Cable	2	Copper	Parallel	Elevated	Yes
22	II	3000	3390	390	RHS	200 x 1, Cable 400 x 1, Cable 800 x 1 Cable	2	Copper	Parallel	Elevated	No
23	II	3390	3820	430	RHS	100 x 1, Cable 800 x 2, Cables	2	Copper	Parallel	Elevated	Yes
24	II	3820	3820	50	Crossing	400 x 1, Cable 800 x 2, Cables	2	Copper	Perpendicular	Elevated	Yes
25	II	3820	5300	1480	LHS/RHS	400 x 1, Cable	2	Copper	Parallel	Elevated	No

TABLE 5.63: OPTICAL FIBRE CABLE OF NORTH TELECOM REGION

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (mm)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Reqd
1	I	8300	8900	600	LHS	12 F-15 24 F-10	1.5	Fibre	Parallel	U/G	No
2	I	8900	9340	440	LHS	12 F-1	2	Fibre	Parallel	U/G	No
3	I	9340	11500	2160	RHS	12 F-1	2	Fibre	Parallel	UG/ Elevated	No
4	I	11000	14050	3050	RHS	12 F-1	2	Fibre	Parallel	Elevated	Yes
5	II	1600	2000	400	LHS	24 F-1	2	Fibre	Parallel	Elevated	Yes
6	II	2000	2680	680	LHS	24 F-1	2	Fibre	Parallel	Elevated	No
7	II	1600	2500	900	RHS	12 F-1	2	Fibre	Parallel	Elevated	Yes
8	II	2680	2680	50	Crossing	12 F-1	1.5	Fibre	Perpendicular	Elevated	No

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (mm)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Reqd
9	II	2680	2680	50	Crossing	24 F-4	2	Fibre	Perpendicular	Elevated	No
10	II	2680	3600	920	LHS	12 F-1	1.5	Fibre	Parallel	Elevated	Yes
11	II	2680	3600	920	LHS	24 F-4	2	Fibre	Parallel	Elevated	Yes
12	II	3600	4710	1110	LHS	12 F-1	1.5	Fibre	Parallel	Elevated	No
13	II	3600	4710	1110	LHS	24 F-4	2	Fibre	Parallel	Elevated	No
14	II	4710	4710	50	Crossing	12 F-1	1.5	Fibre	Perpendicular	Elevated	No
15	II	4710	4710	50	Crossing	24 F-4	2	Fibre	Perpendicular	Elevated	No
16	II	4710	6450	1740	LHS	12 F-1	1.5	Fibre	Parallel	Elevated	No
17	II	4710	6450	1740	LHS	24 F-2	2	Fibre	Parallel	Elevated	No
18	II	11750	11750	50	Crossing	12 F-1	1.5	Fibre	Perpendicular	Elevated	Yes
19	II	11750	11750	50	Crossing	24 F-2	2	Fibre	Perpendicular	Elevated	Yes
20	II	14660	14660	50	Crossing	12 F-2	1.5	Fibre	Perpendicular	Elevated	Yes
21	II	14660	14660	50	Crossing	24 F-1	2	Fibre	Perpendicular	Elevated	Yes
22	II	14660	14900	240	RHS	12 F-2	1.5	Fibre	Parallel	Elevated	No
23	II	14660	14900	240	RHS	24 F-1	2	Fibre	Parallel	Elevated	No
24	II	14900	14900	50	Crossing	12 F-2	1.5	Fibre	Perpendicular	Elevated	Yes
25	II	14900	14900	50	Crossing	24 F-1	2	Fibre	Perpendicular	Elevated	Yes
26	II	14900	15523	623	RHS	6 F- 1	2	Fibre	Parallel	Elevated	No
27	II	14900	15523	623	RHS	12 F- 2	1.5	Fibre	Parallel	Elevated	No

TABLE 5.64: OPTICAL FIBRE CABLE OF TORRENT

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (mm)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Reqd
1	I	-300	1050	1350	RHS	48 F x 1 96 F x 1 288 F x 1	1.5	Fibre	Parallel	Elevated	No
2	I	1050	1950	900	RHS/LHS	48 F x 1 96 F x 1 288 F x 1	1.5	Fibre	Parallel	Elevated	Yes
3	I	1950	3350	1400	LHS	48 F x 1 96 F x 1 288 F x 1	1.5	Fibre	Parallel	Elevated	No
4	I	3280	3280	50	LHS	48 F x 1 96 F x 1 288 F x 1	1.5	Fibre	Perpendicular	Elevated	No
5	I	3350	3350	50	LHS	48 F x 1 96 F x 1 288 F x 1	1.5	Fibre	Perpendicular	Elevated	No
6	I	3800	3800	50	LHS	96 F x 1 288 F x 1	1.5	Fibre	Perpendicular	Elevated	No
7	I	3780	3950	170	LHS	48 F x 1 96 F x 1 288 F x 1	1.5	Fibre	Parallel	Elevated	No
8	II	2400	2400	50	RHS	96 F x 1	1.5	Fibre	Perpendicular	Elevated	No
9	II	2400	3080	680	RHS/LHS	96 F x 1	1.5	Fibre	Parallel	Elevated	Yes
10	II	3080	3080	50	RHS	96 F x 1	1.5	Fibre	Perpendicular	Elevated	Yes
11	II	3080	3080	50	RHS	96 F x 1	1.5	Fibre	Perpendicular	Elevated	No

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (mm)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Reqd
12	II	3100	3100	50	RHS	96 F x 1 288 F x 1	1.5	Fibre	Perpendicular	Elevated	No
13	II	3800	3800	50	Crossing	96 F x 1 288 F x 1	1.5	Fibre	Perpendicular	Elevated	Yes
14	II	3800	4250	450	RHS	96 F x 1 288 F x 1	1.5	Fibre	Parallel	Elevated	No
15	II	4250	4700	450	RHS/LHS	48 F x 2 96 F x 2 288 F x 1	1.5	Fibre	Parallel	Elevated	Yes
16	II	4470	4470	50	LHS	96 F x 1	1.5	Fibre	Perpendicular	Elevated	No
17	II	5480	5600	120	RHS	288 F x 1	1.5	Fibre	Parallel	Elevated	No
18	II	5600	5600	50	Crossing	288 F x 1	1.5	Fibre	Perpendicular	Elevated	Yes
19	II	5970	5970	50	Crossing	96 F x 2 288 F x 1	1.5	Fibre	Perpendicular	Elevated	Yes
20	II	5970	7360	1390	LHS	96 F x 2 288 F x 1	1.5	Fibre	Parallel	Elevated	No
21	II	7040	7040	50	LHS	96 F x 2 288 F x 1	1.5	Fibre	Perpendicular	Elevated	No
22	II	7080	7080	50	LHS	96 F x 2 288 F x 1	1.5	Fibre	Perpendicular	Elevated	No
23	II	7360	7690	330	RHS	96 F x 2 288 F x 1	1.5	Fibre	Parallel	Elevated	No
24	II	7440	7440	50	Crossing	96 F x 2 288 F x 1	1.5	Fibre	Perpendicular	Elevated	Yes
25	II	8150	9570	1420	LHS	288 F x 1	1.5	Fibre	Parallel	Elevated	No
26	II	8700	9540	840	RHS	96 F x 1 288 F x 1	1.5	Fibre	Parallel	Elevated	Yes

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (mm)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Reqd
27	II	10230	10230	50	Crossing	288 F x 1	1.5	Fibre	Perpendicular	Elevated	Yes
28	II	10720	11360	640	LHS	48 F x 1	1.5	Fibre	Parallel	Elevated	No
29	II	11360	11790	430	LHS	48 F x 1 96 F x 1 288 F x 1	1.5	Fibre	Parallel	Elevated	No
30	II	11790	11930	140	RHS	48 F x 1 96 F x 1 288 F x 1	1.5	Fibre	Parallel	Elevated	Yes
31	II	11730	11730	50	Crossing	48 F x 1 96 F x 1 288 F x 1	1.5	Fibre	Perpendicular	Elevated	Yes
32	II	14650	14660	10	Crossing	96 F x 1288 F x 1	1.5	Fibre	Diagonally	Elevated	Yes
33	II	14660	14930	270	RHS	96 F x 1 288 F x 1	1.5	Fibre	Parallel	Elevated	No
34	II	14750	14930	180	RHS	96 F x 1 288 F x 1	1.5	Fibre	Parallel	Elevated	No

TABLE 5.65: OPTICAL FIBRE CABLE OF IDEA

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (mm)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Reqd
1	I	4500	4500	50	Crossing	48 F-1	2	Fibre	Perpendicular	U/G	No
2	I	4500	4800	300	RHS	48 F-1	2	Fibre	Parallel	U/G	No
3	I	8310	8310	50	Crossing	48 F-1	1.5	Fibre	Perpendicular	U/G	No

S. No.	Corridor	Chainage From (M)	Chainage To (M)	Length (M)	LHS/RHS	DIA/SIZE (mm)	Depth (BGL) in M	Type	Position	Metro Alignment	Diversion Reqd
4	I	8310	9370	1060	LHS	48 F-1	1.5	Fibre	Parallel	U/G	No
5	I	8970	9700	730	RHS/LHS	48 F-1	1.5	Fibre	Parallel	U/G	No
6	I	9370	10700	1330	RHS	48 F-1	1.5	Fibre	Parallel	U/G, Elevated	No
7	I	10700	11000	300	LHS	48 F-1	1.5	Fibre	Parallel	Elevated	Yes
8	I	10770	10770	50	RHS	48 F-1	1.5	Fibre	Perpendicular	Elevated	No
9	I	11000	11550	550	LHS	48 F-1	1.5	Fibre	Parallel	Elevated	No
10	I	11420	11420	50	Crossing	48 F-1	1.5	Fibre	Perpendicular	Elevated	Yes
11	I	11550	11800	250	LHS	48 F-1	1.5	Fibre	Parallel	Elevated	Yes
12	I	11800	14050	2250	LHS	48 F-1	1.5	Fibre	Parallel	Elevated	No
13	I	12980	12980	50	Crossing	48 F-1	1.5	Fibre	Perpendicular	Elevated	Yes
14	I	13230	13230	50	Crossing	48 F-1	1.5	Fibre	Perpendicular	Elevated	Yes
15	II	2400	2400	50	Crossing	48 F-1	1.5	Fibre	Perpendicular	Elevated	Yes
16	II	2700	2700	50	Crossing	48 F-1	2	Fibre	Perpendicular	Elevated	Yes
17	II	3560	3560	50	Crossing	48 F-1	2	Fibre	Perpendicular	Elevated	Yes
18	II	3570	4240	670	LHS	48 F-1	2	Fibre	Parallel	Elevated	No
19	II	4240	4240	50	Crossing	48 F-1	2	Fibre	Perpendicular	Elevated	Yes
20	II	4300	4750	450	LHS/RHS	48 F-1	1.5	Fibre	Parallel	Elevated	Yes
21	II	4850	5600	750	RHS	48 F-1	1.5	Fibre	Parallel	Elevated	No
22	II	5600	6570	970	RHS	48 F-1	1.5	Fibre	Parallel	Elevated	Yes
23	II	6570	6570	50	Crossing	48 F-1	1.5	Fibre	Perpendicular	Elevated	No
24	II	6580	6580	50	Crossing	48 F-1	1.5	Fibre	Perpendicular	Elevated	No
25	II	6580	7150	570	RHS	48 F-1	1.5	Fibre	Parallel	Elevated	No
26	II	6800	6800	50	Crossing	48 F-1	1.5	Fibre	Perpendicular	Elevated	No
27	II	7150	7150	50	Crossing	48 F-1	1.5	Fibre	Perpendicular	Elevated	No

5.6 LAND REQUIREMENT FOR THE CORRIDOR, DEPOTS STATIONS , PARKING , MULTI MODEL STATIONS

5.6.1 Main Components

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 Elevated stretches

No land at surface is required permanently for elevated section, except for small areas for entry/exit structures, traffic integration and 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. Wherever stations are proposed off the road, land for station building is also required permanently.

5.6.3 Land for Underground stretches

No land at surface is required permanently for underground section, except for small areas for entry/exit structures, traffic integration and ventilation shafts/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 underground stations are planned with island platforms except Taj Mahal which is planned with side platforms.

5.6.4 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 4570 sqm and 1177 sqm of Irrigation Department and RBS College has been proposed near Shastri Nagar for locating elevated to underground ramp. Further, an area of 4250 sqm has been proposed along Fatehabad Road for locating underground to elevated ramp.

Corridor-2 has been proposed completely elevated, hence no switchover ramp has been proposed except at depot entry where an area of 3152 sqm has been proposed for locating elevated to At-grade ramp.

5.6.5 Land for Traffic integration

Govt. land has been proposed for integration with Rail system, Metro corridors and Bus system.

5.6.6 Land for Maintenance Depot

About 20.80 Hectares (including 4.5 Hectares for Property Development) of State Govt. PAC land for Depot has been proposed for corridor-1. The depot for Corridor-2 has been proposed at Kalindi Vihar in State Govt. land with an area of about 11.90 Hectares. List of Structures of PAC to be relocated for PAC Depot are given in **Table 5.66.**

TABLE 5.66: LIST OF PAC STRUCTURES TO BE RELOCATED

S. No.	Building	Floor Area (Sqm)
1	06 buildings (G+0) in Commissioner's Office	516
2	01 building (G+1)in Commissioner's Office Campus	436
3	01 building (G+2)in Commissioner's Office Campus	2712
4	62 PAC Staff Quarters (G+0)	20651
5	19 PAC Staff Quarters (G+3)	23028
	Total	**47343***

* Out of 47343 sqm floor area, 40000 sqm is required for parking/PD.

5.6.7 Land for TSS, RSS, ASS and DG Sets

Total of two RSS have been proposed on the corridor-I at ISBT and PAC Depot and two in Corridor-II at Sadar Bazar and Kalindi Vihar Depot. An area of 3500 sqm has been proposed for each RSS**.** ASS and DG Sets are required at all stations.

5.6.8 Summary of Land Requirement

Abstract of land requirements for different components of corridors are given in **Table 5.67 and 5.68.**

TABLE 5.67: CORRIDOR-1 LAND & STRUCTURES REQUIREMENT (IN SQM)

Ownership	Purpose	Permanent Land	Temporary Land	Structures (Floor area)
Central Govt. - RAILWAY	Alignment, Stations & Ancillary Building etc	591	4500	0
	Total	**591**	**4500**	**0**
Central Govt. - DEFENCE	Alignment, Stations & Ancillary Building etc	6032	5700	0
	Total	**6032**	**5700**	**0**

Ownership	Purpose	Permanent Land	Temporary Land	Structures (Floor area)
State Govt.	Alignment, Stations & Ancillary Building etc	33790	27000	200
	Depot	208000	0	47343
	PD & Parking	67415	0	0
	Construction Depot	0	125000	0
	RSS & MISC.	10000	0	0
	Total	**319205**	**152000**	**47543**
Private	Alignment, Stations & Ancillary Building etc	7596	9300	214
	Depot	0	0	0
	Total	**7596**	**9300**	**214**

TABLE 5.68: CORRIDOR-2 LAND & STRUCTURES REQUIREMENT (IN SQM)

Ownership	Purpose	Permanent Land	Temporary Land	Structures (Floor area)
Central Govt. - RAILWAY	Alignment, Stations & Ancillary Building etc	2798	0	278
	Total	**2798**	**0**	**278**
Central Govt. - DEFENCE	Alignment, Stations & Ancillary Building etc	5047	0	0
	Total	**5047**	**0**	**0**
State Govt.	Alignment, Stations & Ancillary Building etc	17775	0	909
	Depot	119000	0	0
	PD & Parking	60300	0	0
	Construction Depot	0	122300	0
	RSS & MISC.	10000	0	0
	Total	**207075**	**122300**	**909**
Private	Alignment, Stations & Ancillary Building etc	5595	0	6264
	Depot	0	0	0
	Total	**5595**	**0**	**6264**

5.7 OWNERSHIPS DETAILS OF THE LAND REQUIRED FOR THE CORRIDOR

5.7.1 Permanent Land Requirement

Land is required permanently for entry/exit, Viaduct, stations and ramps etc. Permanent requirement of Land for stations for Corridor - I & II is tabulated in **Table 5.69** and **Table 5.70**. Permanent requirement of Land for running section, ramps etc. for Corridor - I & II is tabulated in **Table 5.71** and **Table 5.72**.

TABLE 5.69: PERMANENT LAND REQUIREMENT FOR STATIONS CORRIDOR - I

S. NO.	STATION NAME	PLOT NO.	AREA (SQM)	DETAILS	OWNERSHIP	PURPOSE	PROPERTIES AFFECTED	NOS OF PROPERTIES	PLOT AREA (SQM)	FLOOR AREA (SQM)
1	SHASTRI NAGAR	ST1-4A	1628	OPEN LAND, IRRIGATION DEPT.	State Govt	STATION BUILDING	-	-	-	-
2	UNIVERSITY	ST1-5A	5165	OPEN LAND, RBS COLLEGE	PVT.	ENTRY & EXIT	-	-	-	-
3	RBS COLLEGE	ST1-6A	162	OPEN LAND, RBS COLLEGE	PVT.	ENTRY & EXIT	-	-	-	-
		ST1-6B	7	OPEN LAND, RBS COLLEGE	PVT.	LIFT	-	-	-	-
		ST1-6C	352	OPEN LAND, RBS COLLEGE	PVT.	DG SET & COOLING TOWER	-	-	-	-
		ST1-6D	7	OPEN LAND, RBS COLLEGE	PVT.	LIFT	-	-	-	-
4	RAJA KI MANDI	ST1-7A	150	OPEN LAND	PVT.	ENTRY & EXIT & Lift	-	-	-	-
		ST1-7B	150	OPEN LAND, INDIAN RAILWAY	Central GOVT., Railway	ENTRY & EXIT & Lift	-	-	-	-
		ST1-7C	434	OPEN LAND, INDIAN RAILWAY	Central GOVT., Railway	DG SET & COOLING TOWER	-	-	-	-
		ST1-7D	7	OPEN LAND, INDIAN RAILWAY	Central GOVT., Railway	LIFT	-	-	-	-

S. NO.	STATION NAME	PLOT NO.	AREA (SQM)	DETAILS	OWNERSHIP	PURPOSE	PROPERTIES AFFECTED	NOS OF PROPERTIES	PLOT AREA (SQM)	FLOOR AREA (SQM)
5	AGRA COLLEGE	ST1-8A	149	BUILT-UP, COMM. BUILDING	PVT.	ENTRY & EXIT	COMM. BUILDING (G+0)	2	112	112
6	MEDICAL COLLEGE	ST1-9A	121	OPEN LAND, MEDICAL COLLEGE	State Govt	ENTRY & EXIT	-	-	-	-
		ST1-9B	162	OPEN LAND, MEDICAL COLLEGE	State Govt	ENTRY & EXIT	-	-	-	-
		ST1-9C	352	OPEN LAND, MEDICAL COLLEGE	State Govt	DG SET & COOLING TOWER	-	-	-	-
		ST1-9D	14	OPEN LAND, MEDICAL COLLEGE	State Govt	LIFT	-	-	-	-
7	JAMA MASJID	ST1-10A	235	TEMP. SHOPS	PVT.	ENTRY & EXIT	TEMP SHOP (G+0)	1	102	102
		ST1-10B	167	OPEN LAND, BIJLI GHAR BUS STAND	State Govt	ENTRY & EXIT	-	-	-	-
		ST1-10C	1131	OPEN LAND	CENTRAL GOVT., Defence	ANCILLIARY BUILDING, DG SET & COOLING TOWER	-	-	-	-
8	AGRA FORT	ST1-11A	121	OPEN LAND, CAR PARKING	State Govt	ENTRY & EXIT	-	-	-	-
		ST1-11B	121	OPEN LAND	State Govt	ENTRY & EXIT	-	-	-	-

S. NO.	STATION NAME	PLOT NO.	AREA (SQM)	DETAILS	OWNERSHIP	PURPOSE	PROPERTIES AFFECTED	NOS OF PROPERTIES	PLOT AREA (SQM)	FLOOR AREA (SQM)
		ST1-11C	352	OPEN LAND	CENTRAL GOVT., Defence	DG SET & COOLING TOWER	-	-	-	-
		ST1-11D	7	OPEN LAND	State Govt	LIFT	-	-	-	-
		ST1-11E	121	OPEN LAND	CENTRAL GOVT., Defence	ENTRY & EXIT	-	-	-	-
		ST1-11F	4428	OPEN LAND	CENTRAL GOVT., Defence	Station building	-	-	-	-
9	TAJ MAHAL	ST1-12A	5818	OPEN LAND, SHAHJAHAN PARK	State Govt	STATION BUILDING & ENTRY/EXIT	-	-	-	-
10	FATEHABAD ROAD	ST1-13B	192	OPEN LAND, TORRENT POWER	PVT.	ENTRY & EXIT	-	-	-	-
11	BASAI	ST1-14B	192	OPEN LAND, IRRIGATION DEPT.	State Govt	ENTRY & EXIT	-	-	-	-
12	TAJ EAST GATE	ST1-15B	103	OPEN LAND, IRRIGATION DEPT.	State Govt	ENTRY & EXIT	-	-	-	-

TABLE 5.70: PERMANENT LAND REQUIREMENT FOR STATIONS CORRIDOR-II

S. NO.	STATION NAME	PLOT NO.	AREA (SQM)	DETAILS	OWNERSHIP	PURPOSE	PROPERTIES AFFECTED	NOS OF PROPERTIES	PLOT AREA (SQM)	FLOOR AREA (SQM)
1	AGRA CANTT.	ST2-1A	267	AUTO PARKING, INDIAN RAILWAY	Central GOVT., Railway	ENTRY & EXIT	-	-	-	-
		ST2-1B	943	Partially Built-up area	Central GOVT., Railway	STATION BUILDING	Railway Quarters (G+0)	2	278	278
2	PARTAP-PURA	ST2-3B	207	OPEN LAND, HOTEL LAURIES	PVT.	ENTRY & EXIT	-	-	-	-
3	COLLECTORATE	ST2-4A	193	OPEN LAND, STATE BANK OF INDIA	State Govt.	ENTRY & EXIT	-	-	-	-
4	SUBHASH PARK	ST2-5A	2128	OPEN LAND, SUBHASH PARK	State Govt.	STATION BUILDING & ENTRY/EXIT	-	-	-	-
5	AGRA COLLEGE	ST2-6A	285	OPEN LAND	State Govt.	ENTRY & EXIT & LIFT	-	-	-	-
6	SUR SADAN	ST2-8A	207	OPEN LAND, NAGAR NIGAM	State Govt.	ENTRY & EXIT	-	-	-	-
7	M.G. ROAD	ST2-9B	753	OPEN LAND, SESSION COURT	State Govt.	STATION BUILDING & ENTRY/EXIT	-	-	-	-
8	SULTAN GANJ CROSSING	ST2-10A	1754	OPEN LAND	State Govt.	STATION BUILDING & ENTRY/EXIT	-	-	-	-
9	KAMLA NAGAR	ST2-11A	90	POLICE CHOWKI	State Govt.	ENTRY & EXIT	-	-	-	-
9	RAM BAGH	ST2-12A	1202	OPEN LAND	State Govt.	STATION BUILDING & ENTRY/EXIT	-	-	-	-

TABLE 5.71: PERMANENT LAND REQUIREMENT FOR RUNNING SECTION CORRIDOR-I

<table>
<tr><th rowspan="2">S. No.</th><th rowspan="2">LOCATION</th><th colspan="2">CHAINAGE</th><th rowspan="2">PLOT NO.</th><th rowspan="2">AREA (SQM)</th><th rowspan="2">OWNERSHIP</th><th rowspan="2">PURPOSE</th><th rowspan="2">PROPERTIES AFFECTED</th><th rowspan="2">NO. OF PROPERTIES</th><th rowspan="2">PLOT AREA (SQM)</th><th rowspan="2">FLOOR AREA (SQM)</th></tr>
<tr><th>FROM (m)</th><th>TO (m)</th></tr>
<tr><td>1</td><td>ISBT</td><td>1725</td><td>2256</td><td>RS1-1</td><td>9778</td><td>STATE GOVT.</td><td>VIADUCT</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td rowspan="4">2</td><td rowspan="4">SHASTRI NAGAR</td><td rowspan="4">2660</td><td rowspan="4">3300</td><td rowspan="4">RS1-2</td><td rowspan="4">6406</td><td rowspan="4">STATE GOVT.</td><td rowspan="4">VIADUCT</td><td>Cabin</td><td>1</td><td>23</td><td>23</td></tr>
<tr><td>Abandoned Forest Deptt. (G+0)</td><td>1</td><td>58</td><td>58</td></tr>
<tr><td>Abandoned Forest Deptt. (G+0)</td><td>1</td><td>31</td><td>31</td></tr>
<tr><td>TANK (G+0)</td><td>1</td><td>25</td><td>25</td></tr>
<tr><td>3</td><td>SHASTRI NAGAR</td><td>3410</td><td>3820</td><td>RS1-3</td><td>4550</td><td>STATE GOVT.</td><td>RAMP</td><td>TEMP. RES. BUILDING (G+0)</td><td>1</td><td>63</td><td>63</td></tr>
<tr><td>4</td><td>SHASTRI NAGAR</td><td>3820</td><td>3885</td><td>RS1-4</td><td>1177</td><td>PVT.</td><td>RAMP</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>5</td><td>TAJ MAHAL</td><td>11175</td><td>11600</td><td>RS1-5</td><td>4250</td><td>STATE GOVT.</td><td>RAMP</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
</table>

TABLE 5.72: PERMANENT LAND REQUIREMENT FOR RUNNING SECTION CORRIDOR-II

S. No.	LOCATION	CHAINAGE		PLOT NO.	AREA (SQM)	OWNERSHIP	PURPOSE	PROPERTIES AFFECTED	NO. OF PROPERTIES	PLOT AREA (SQM)	FLOOR AREA (SQM)
		FROM (m)	To (m)								
1	AGRA CANTT.	50	230	RS2-1	1588	CENTRAL GOVT., RAILWAY	VIADUCT	-	-	-	-
2	SULTANPURA	850	1050	RS2-2	2276	CENTRAL GOVT., DEFENCE	VIADUCT, STABLING LINES	-	-	-	-
3	SADAR BAZAR	1300	1650	RS2-3	2771	CENTRAL GOVT., DEFENCE	VIADUCT	-	-	-	-
4	SADAR BAZAR	1670	1728	RS2-4	540	PVT.	VIADUCT	Old Building(G+0)	2	214	214
5	COLLECTORATE	3790	3815	RS2-5	513	PVT.	VIADUCT	OLD SHOPS (G+1)	8	227	454
6	SUBHASH PARK	4500	4555	RS2-6	593	STATE GOVT.	VIADUCT	-	-	-	-
7	SUBHASH PARK	4650	4700	RS2-7	371	STATE GOVT.	VIADUCT	-	-	-	-
8	MG ROAD	7950	8000	RS2-8	390	PVT.	VIADUCT	BHAGABATI ENTERPRISES (G+1)	1	78	156
								MODI CRAFT (G+1)	1	148	296
								MAWASI LAL & SONS (G+1)	1	148	296
								NATHANI HOSPITAL (G+1)	1	82	164
9	SULTAN GANJ CROSSING	8150	9000	RS2-9	2811	STATE GOVT.	VIADUCT	-	-	-	-

S. No.	LOCATION	CHAINAGE		PLOT NO.	AREA (SQM)	OWNERSHIP	PURPOSE	PROPERTIES AFFECTED	NO. OF PROPERTIES	PLOT AREA (SQM)	FLOOR AREA (SQM)
		FROM (m)	To (m)								
10	SULTAN GANJ CROSSING	9080	9250	RS2-10	5000	STATE GOVT.	VIADUCT, STABLING LINES	-	-	-	-
11	WATER WORKS	10750	11000	RS2-11	2388	STATE GOVT.	VIADUCT	AC SHED	1	24	24
								AC SHEDS	4	150	150
								TEMP HUTS	2	163	163
								TEMP. SHEDS	2	73	73
								TEMP. SHEDS	4	150	150
								PWD BUILDING	1	71	71
12	RAM BAGH	11750	11900	RS2-12	793	PVT.	VIADUCT	AGGARWAL COMM. (G+0)	2	276	276
								Shree Rajdeep Brothers & Aggarwal Garments (G+0)	2	216	216
								Shree Rajdeep Brothers & Shree Bihariji Finance (G+0)	2	125	125
								Sankalp Enterprises (G+0)	1	491	491
								Gopal Babu (G+0)	1	498	498
								JAIN BHAWAN (G+1)	1	325	650
14	KALINDI VIHAR	14850	Till Depot	RS2-14	3152	PVT.	VIADUCT, DEPOT ENTRY	SHOPS (G+0)	7	309	309
								GODOWN (G+0)	1	2119	2119

5.7.2 Temporary Land Requirement

Land is required temporarily for underground stations by cut & cover, TBM shafts etc. Temporary requirement of Land for underground stations of Corridor - I is tabulated in **Table 5.73**.

TABLE 5.73: TEMPORARY LAND REQUIREMENT CORRIDOR - I

S. No.	Plot No.	Station Location	Details	Ownership	Area In Sqm	Remark
1	Temp-1	UNIVERSITY	OPEN LAND, RBS COLLEGE	PVT.	4800	FOR CUT & COVER, U/G STATION
2	Temp-2	RBS COLLEGE	OPEN LAND, RBS COLLEGE	PVT.	4500	FOR CUT & COVER, U/G STATION
3	Temp-3	RAJA KI MANDI	OPEN LAND, INDIAN RAILWAY	CENTRAL GOVT., Railway	4500	FOR CUT & COVER, U/G STATION
4	Temp-4	AGRA COLLEGE	OPEN LAND, AGRA COLLEGE	STATE GOVT.	6000	FOR CUT & COVER, U/G STATION
5	Temp-5	MEDICAL COLLEGE	OPEN LAND, MEDICAL COLLEGE	STATE GOVT.	4500	FOR CUT & COVER, U/G STATION
6	Temp-6	JAMA MASJID	OPEN LAND, DEFENCE	CENTRAL GOVT., Defence	3000	FOR CUT & COVER, U/G STATION
7	Temp-7	AGRA FORT	OPEN LAND, DEFENCE	CENTRAL GOVT., Defence	2700	FOR CUT & COVER tunnel
8	Temp-8	TAJ MAHAL	OPEN LAND	STATE GOVT.	16500	FOR CUT & COVER tunnel

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 **12.50 Hac** land for Corridor-I and **12.23 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 5.74: LAND TEMPORARILY REQUIRED FOR CONSTRUCTION DEPOT

S. No.	Plot No.	Station	Details	Land Ownership	Area (Sqm)
CORRIDOR I: SIKANDARA TO TAJ EAST GATE					
1	CD1-1	GURU KA TAAL	OPEN LAND	STATE GOVT.	40000
2	CD1-2	UNIVERSITY	OPEN LAND, NEAR JAIL	STATE GOVT.	45000
3	CD1-3	AGRA FORT	OPEN LAND, ALONG YAMUNA	STATE GOVT.	40000
CORRIDOR II: AGRA CANTT. TO KALINDI VIHAR					
1	CD2-1	SUBHASH PARK	OPEN LAND, GIC	STATE GOVT.	25000
2	CD2-2	AGRA COLLEGE	Open land	STATE GOVT.	33600
3	CD2-3	SULTAN GANJ CROSSING	Open land	STATE GOVT.	43700
4	CD2-4	RAM BAGH	OPEN LAND	STATE GOVT.	20000

ANNEXURE 5.1: LETTER TO NHAI DATED 29TH SEPTEMBER, 2015 FOR ISSUE OF HIGHWAY DEVELOPMENT PLAN FOR NH-2 IN AGRA

RITES
THE INFRASTRUCTURE PEOPLE

राइट्स लिमिटेड
(भारत सरकार का प्रतिष्ठान)
RITES LIMITED
(Schedule 'A' Enterprise of Govt. of India)
CIN: U74[illegible]

No. RITES/UT/CO/AGRA/624/2015
Dated: 29th September, 2015

46589
01/10/15

Project Director,
National Highway Authority of India,
Faridabad,
Haryana

SUB: DPR FOR RAIL BASED MASS TRANSIT SYSTEM IN AGRA – ISSUE OF HIIGHWAY DEVELOPMENT PLAN OF NH-2 IN AGRA AREA

Dear Sir,

Agra Development Authority has engaged RITES Ltd for consultancy work for "Feasibility and DPR for Metro Rail Transit System (MRTS)" in Agra City. In connection with this study, RITES is conducting topographic survey of following corridors. (Map enclosed for ready reference):-

1. Agra Cantt to TYC via Bhagwan Talkies (Along NH-2)
2. Taj East Gate to Sikandra via Red Fort.

Some of the stretches of above corridors involve ongoing/planned projects of widening/ROB etc being executed by NHAI. To finalize the Metro alignment, understanding of such proposals of NHAI is necessary.

In view of above, it is requested to kindly arrange soft copy of NH-2 development works (ongoing/planned) along the above proposed corridors.

Yours Sincerely,

29/9/15
(Alok Misra)
GM/C/UT

Copy for Kind info to:

1. Managing Director (LMRCL), Administrative Office, Lucknow Metro Rail Corporation, near Ambedkar Samajik Parivartan Sthal, Vipin Khand, Gomti Nagar, Behind Taj Hotel, Lucknow – 226010

M(T)
P.A.

कॉर्पोरेट कार्यालय: राइट्स भवन, नं० 1, सेक्टर–29, गुड़गाँव–122 001 (भारत), Corporate Office: RITES Bhawan, No.1, Sector-29, Gurgaon-122 001 (INDIA)
पंजीकृत कार्यालय: स्कोप मीनार, लक्ष्मी नगर, दिल्ली–110 092 (भारत), Registered Office: SCOPE Minar, Laxmi Nagar, Delhi-110 092 (INDIA)
दूरभाष (Tel.): (0124) 2571666, फैक्स (Fax): (0124) 2571660, ई-मेल (E-mail) info@rites.com वेबसाइट (website): www.rites.com

ANNEXURE 5.2: Letter to NHAI dated 20th November, 2015 FOR ISSUE OF HIGHWAY DEVELOPMENT PLAN FOR NH-2 IN AGRA

RITES
THE INFRASTRUCTURE PEOPLE

राइट्स लिमिटेड
(भारत सरकार का प्रतिष्ठान)
RITES LIMITED
(Schedule 'A' Enterprise of Govt. of India)

No: RITES/UT/Agra (DPR)/2015 **Dt: 20.11.15**

The Project Director,
National Highway Authority of India,
Faridabad, Haryana
Mob: - 8650900012

Kind Attention: - Sh. Mohammad Safi

SUB: DPR for rail based Mass Transit System at Agra.....Issue of Highway Development Plan of NH-2 in Agra.
REF: i) RITES letter No:RITES/UT/CO/AGRA/624/2015 dt:29.09.15 addressed to PD, NHAI, Faridabad.

Sir,
Govt. of UP has awarded work of Consultancy services for preparation of DPR for Rail based MRTS at **Agra** to RITES Ltd vide **LOA dtd: 10.03.15.** Work involves various Engineering Inputs along following two prioritized corridors & depot location within the city.

- **Corridor-1 (14 Kms):** From Sikandra to Hotel Trident.
- **Corridor-2 (16 Kms):** From Agra Cant to TYC Phase-II via Bhagvan Talkies (Along NH-2)

The above consultancy project is being intensively monitored by State Govt. of UP.

Some of the stretches of above corridors involve ongoing/planned projects of widening/ROB etc. being executed by NHAI. During various discussions it is learnt that at **03** locations flyovers are falling at following locations:

- Waterworks Chauraha,
- Sultanganj Pulia,
- Khandari Chauraha,

In addition to above, widening from 4 lanes to 6 lanes is also in progress from Bhagwan talkies towards Sikandra.

Vide RITES letter dtd. 29.09.2015, under reference (i) above, it was requested to kindly arrange soft copy of NH-2 works (ongoing/ planned) and matter was further followed up through frequent visits of RITES Officers to Faridabad office of NHAI. However till date no information has been received from NHAI, due to which consultancy report to UP Govt is held up.

It is requested to kindly arrange soft copy of NH-2 development works **(ongoing/planned)** along above proposed corridors at the earliest.

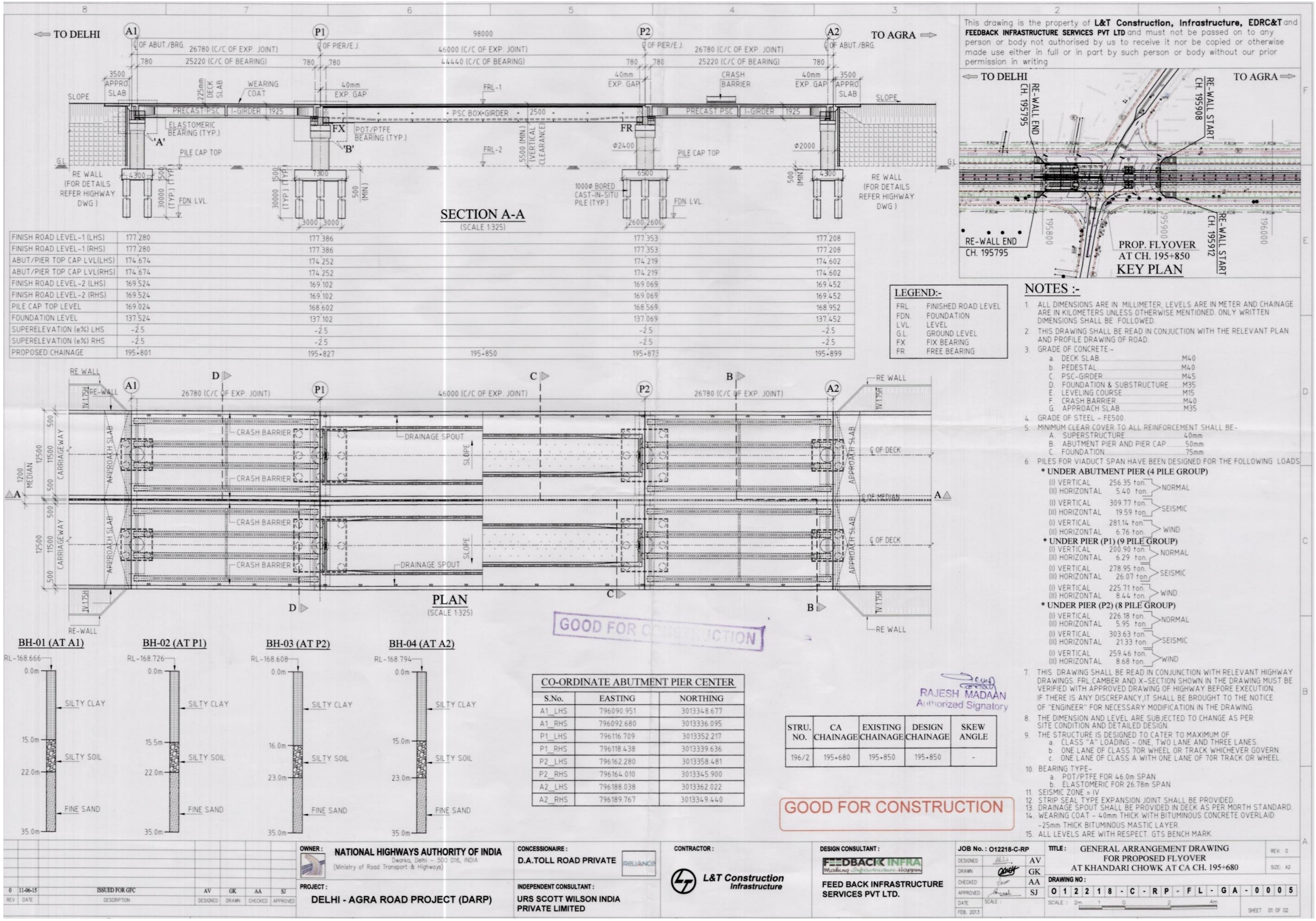
Thanking you
Yours faithfully,

(PIYUSH KANSAL)
Group General Manager/UT

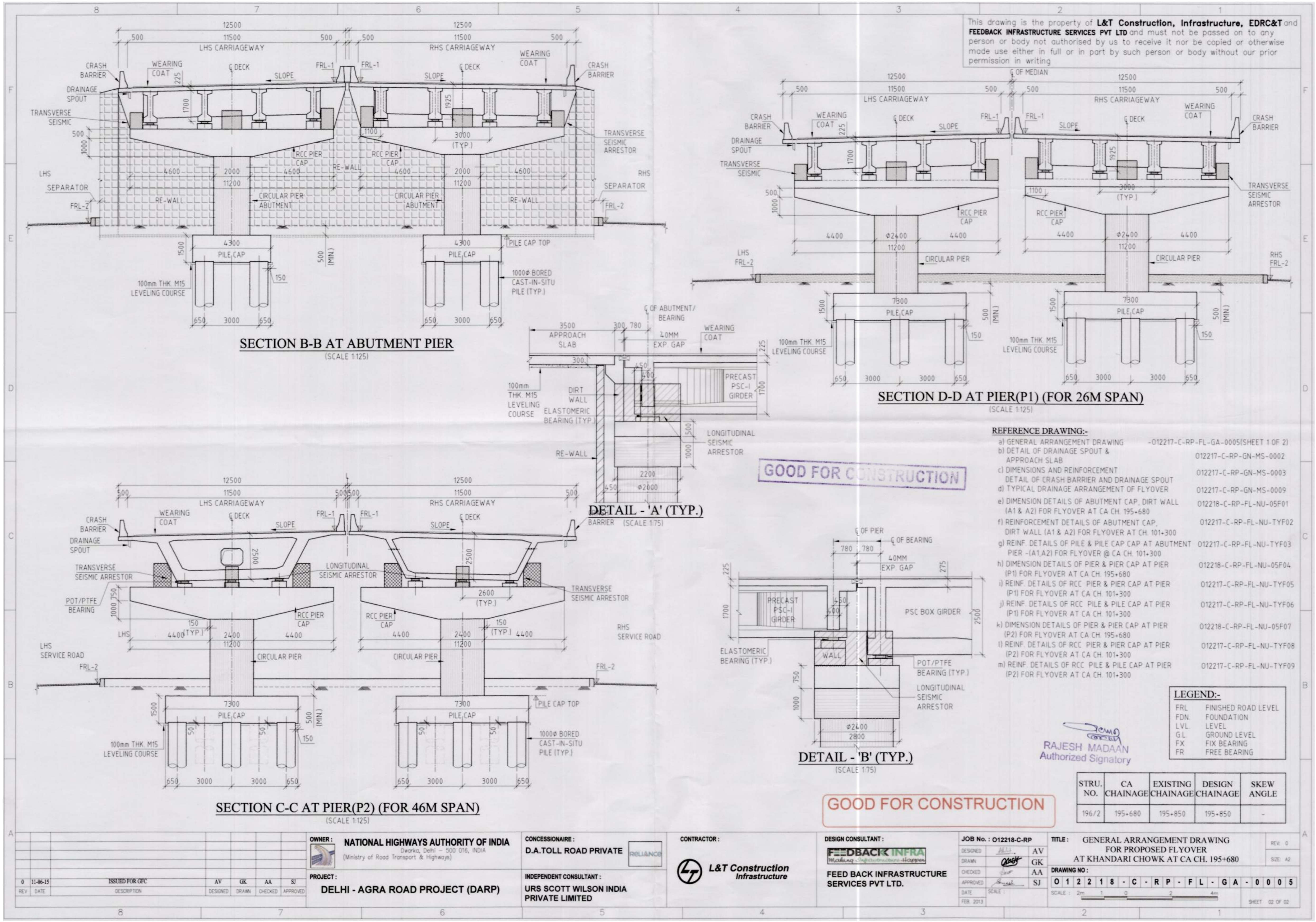
Copy for Kind Info to:
1) Commissioner, Agra Division, Agra (UP) with request to advise NHAI
2) MD (LMRCL), Administrative Office, Lucknow Metro Rail Corporation near Ambedkar Samajik Parivartan Sthal, Vipin Khand, Gomti Nagar, Behind Taj Hotel, Lucknow-226010.

कॉर्पोरेट कार्यालयः राइट्स भवन, न० 1, सेक्टर–29, गुड़गाँव–122 001 (भारत), **Corporate Office:** RITES Bhawan, No.1, Sector-29, Gurgaon-122 001 (INDIA)
पंजीकृत कार्यालयः स्कोप मीनार, लक्ष्मी नगर, दिल्ली–110 092 (भारत), **Registered Office:** SCOPE Minar, Laxmi Nagar, Delhi-110 092 (INDIA)
दूरभाष (Tel.): (0124) 2571666, फैक्स (Fax): (0124) 2571660, ई-मेल (E-mail) info@rites.com वेबसाइट (website): www.rites.com

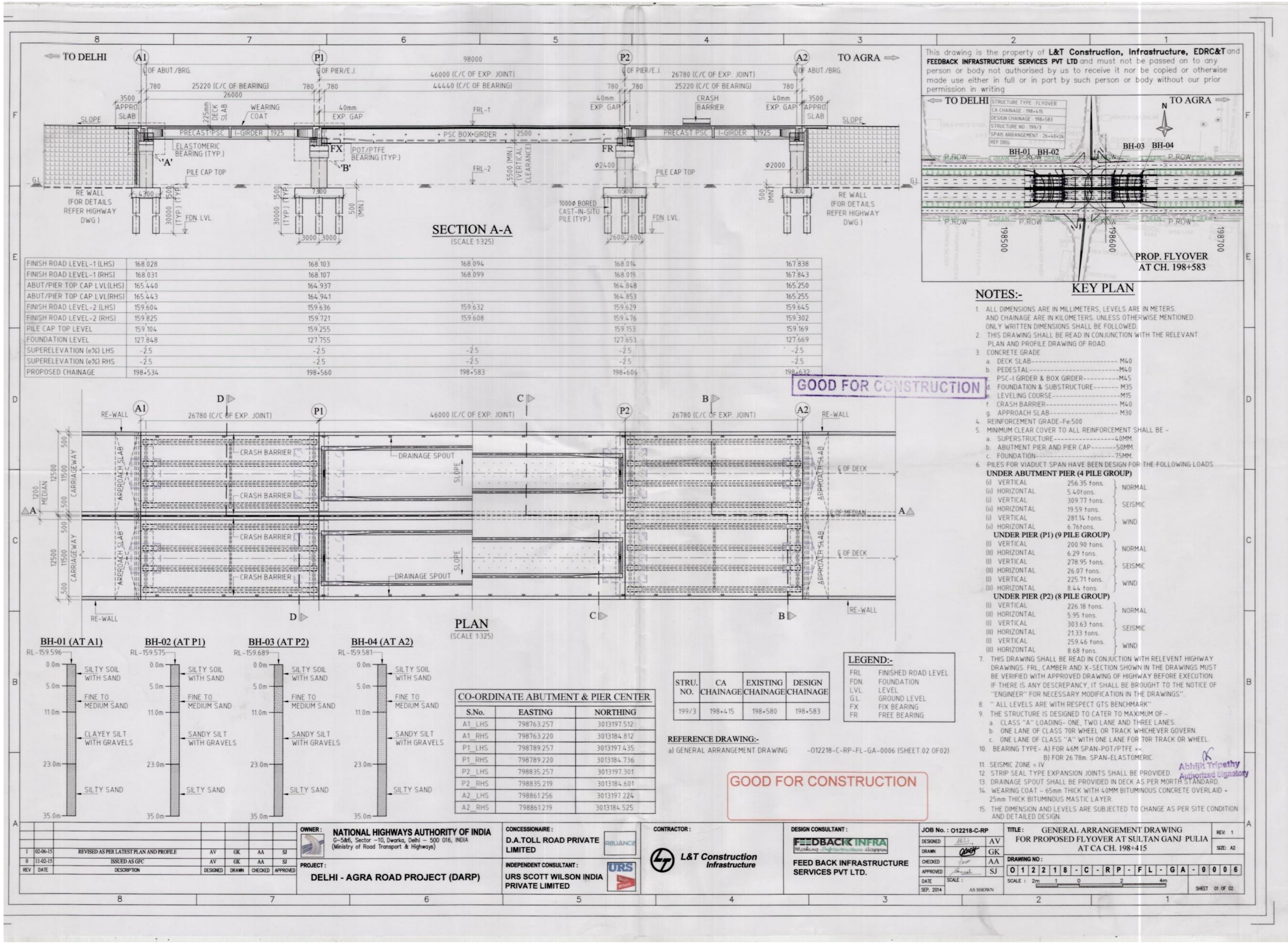
ANNEXURE 5.3: GAD FOR PROPOSED FLYOVER AT KHANDARI CHOWK AS PROVIDED BY NHAI



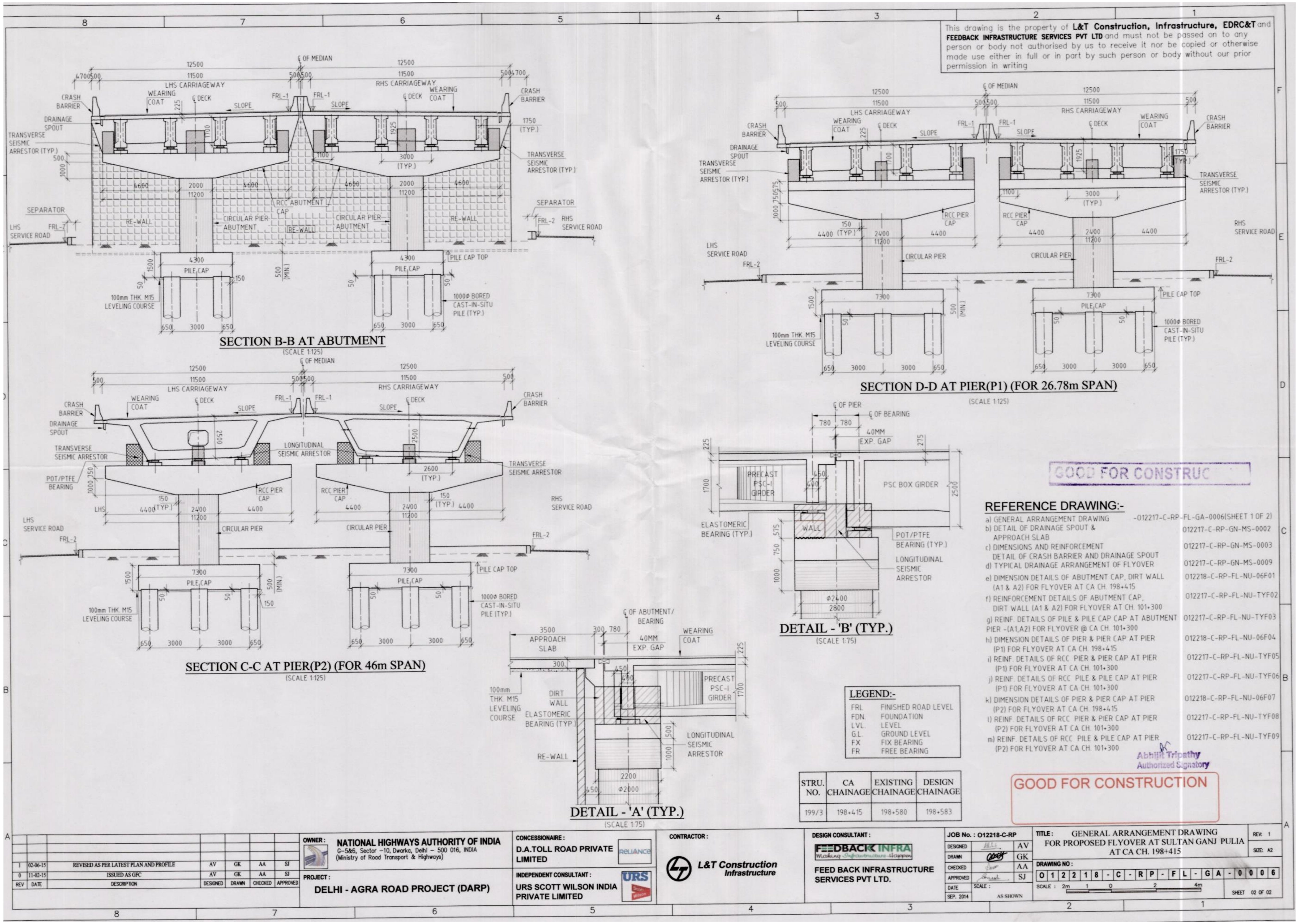
ANNEXURE 5.4: GAD FOR PIER OF PROPOSED FLYOVER AT KHANDARI CHOWK AS PROVIDED BY NHAI



ANNEXURE 5.5: GAD FOR PROPOSED FLYOVER AT SULTAN GANJ PULIA AS PROVIDED BY NHAI



ANNEXURE 5.6: GAD FOR PIER OF PROPOSED FLYOVER AT SULTAN GANJ PULIA AS PROVIDED BY NHAI



Chapter – 6

STATION PLANNING

6.STATION PLANNING

6.1. STATION PLANNING - BASED ON SITE CONDITIONS

The proposed metro rail 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.

The locations of stations along the metro corridors from Sikandara to Taj East Gate and Agra Cantt. to Kalindi Vihar have been finalized after site visits and detailed discussion with Commissioner, District Magistrate, Vice Chairman/ADA, LMRC officials and other Stakeholders.

The stations attributes are presented in **Table 6.1** and **Figure 6.1**.

TABLE 6.1: INTER-STATION DISTANCE AND TYPE OF PROPOSED STATIONS

S. No.	Station Name	Tentative Chainage(Km)	Inter Station Distance (Km)	Underground/ Elevated	Remarks
Corridor-1: Sikandara to Taj East gate (14 Km)					
1	Sikandara	0.000	-	Elevated	Terminal
2	Guru Ka Taal	1.262	1.262	Elevated	
3	ISBT	2.511	1.249	Elevated	Integration with ISBT
4	Shastri Nagar	3.471	0.960	Elevated	Elevated with concourse on ground
5	University	4.236	0.765	Underground	Underground with station building at surface
6	RBS College	5.039	0.803	Underground	
7	Raja Ki Mandi	5.832	0.793	Underground	Integration with Raja Ki Mandi Railway Station
8	Agra College	6.576	0.744	Underground	Interchange Station with elevated station of Corridor 2
9	Medical College	7.203	0.627	Underground	
10	Jama Masjid	8.668	1.465	Underground	
11	Agra Fort	9.304	0.636	Underground	Underground, with Station Building At-surface

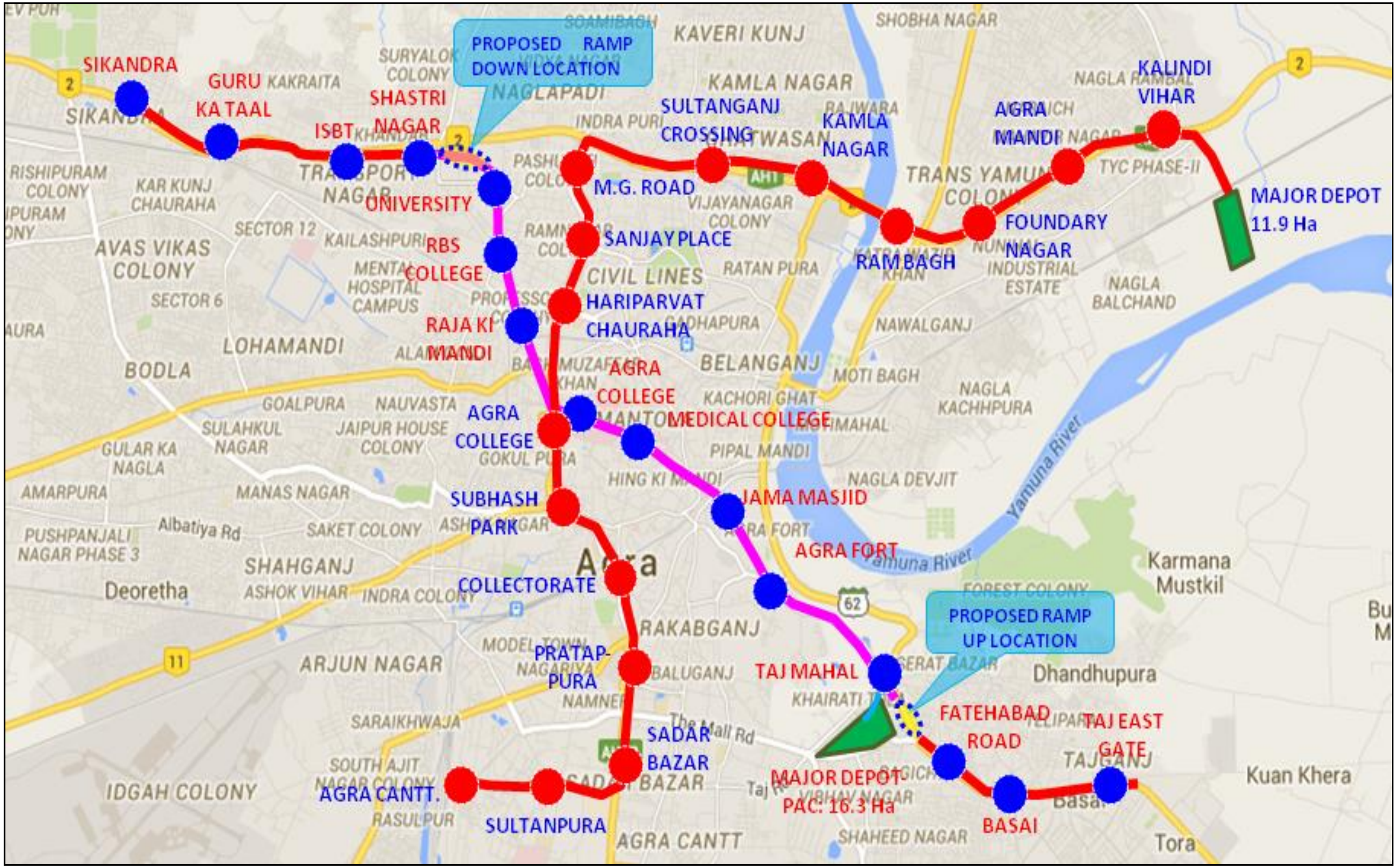
S. No.	Station Name	Tentative Chainage(Km)	Inter Station Distance (Km)	Underground/ Elevated	Remarks
12	Taj Mahal	10.782	1.478	Underground	Underground, with Station Building At-surface
13	Fatehabad Road	11.853	1.071	Elevated	
14	Basai	12.822	0.969	Elevated	
15	Taj East Gate	13.606	0.784	Elevated	Terminal
Corridor-2: Agra Cantt. Rly Station to Kalindi Vihar (16 Km)					
1	Agra Cantt.	0.000	-	Elevated	Terminal station having integration facilities with Agra Cantt Rly Stn
2	Sultanpura*	0.950	0.950	Elevated	
3	Sadar Bazar	1.887	0.937	Elevated	
4	Pratap Pura	2.890	1.003	Elevated	
5	Collectorate	3.464	0.574	Elevated	
6	Subhash Park	4.529	1.065	Elevated	Interchange Station with U/G station of Corridor 1
7	Agra College	5.656	1.127	Elevated	
8	Hariparvat Chauraha	6.459	0.803	Elevated	
9	Sanjay Place	7.216	0.757	Elevated	
10	M.G.Road	7.864	0.648	Elevated	Mid Terminal Station
11	Sultan Ganj Crossing	9.029	1.165	Elevated	
12	Kamla Nagar	10.169	1.140	Elevated	
13	Ram Bagh	11.606	1.437	Elevated	
14	Foundary Nagar	12.570	0.964	Elevated	
15	Agra Mandi	13.630	1.060	Elevated	Terminal
16	Kalindi Vihar	14.542	0.912	Elevated	

*Future Station

6.1.1 Station Area Characteristics

The catchment areas for all stations, issues and concerns, potential improvements along both the priority metro corridors are summarized below.

FIGURE 6.1: PRIORITY MRTS CORRIDORS ALONG WITH STATION LOCATIONS



1. Corridor 1: Sikandara to Taj East Gate

i. Sikandara

<table>
<tr><td colspan="2">Sikandara is the first station of the proposed MRTS Corridor 1. It is an elevated station proposed at a safe distance of about 200 m from the Sikandara monument along NH-2. This station provides dispersal connectivity to Sikandara monument and residential & commercial areas of Krishnapuram, Radha Nagar, Sikandara, Mahadev Nagar, Mahadev Pur, Bain Bazar, Awas Vikas Colony etc. through NH-2 and other connecting roads.</td></tr>
<tr><th>Issues & Concerns</th><th>Potential for Improvements</th></tr>
<tr><td>• Chaotic operations of 2-Wheelers and autos
• Pedestrian Safety is a concern due to lack of pedestrians facilities like footpath/ FOB along NH-2.
• On-street parking causes reduction in efficient road width
• Damaged median causes traffic disobedience
• Dumping of construction materials near carriageway</td><td>• Dedicated Parking areas and bays for pick up/ drop facilities for Bus and IPT.
• Dedicated pedestrian and NMT facilities like footpath, FOB and cycle tracks.
• Planning of dispersal activities through feeder modes will cater to a larger catchment.
• Strengthening of road median and removal of construction materials for effective utilization of RoW.</td></tr>
<tr><td colspan="2">
</td></tr>
<tr><td></td><td></td></tr>
<tr><td>1. Chaotic operations of 2-Wheelers due to damaged median</td><td>2. Lack of Pedestrian facilities</td></tr>
<tr><td></td><td></td></tr>
<tr><td>3. Dumping of Construction material and Parking of Auto adjacent to Carriageway</td><td>4. Road side encroachments due to On-street parking</td></tr>
</table>

ii. Guru Ka Taal Station

It is an elevated station proposed along NH-2. The major roads connecting the station are NH-2 in the west & east and Madia Katra road in the south. The station caters the residential and commercial areas of Maharishi Puram colony in north, Bajrang Nagar in West, Awas Vikas Colony and Karkunj Choraha in South and Sikandara scheme in the east.

Issues & Concerns	Potential for Improvements
• Damaged road surface causes hindrance in smooth flow of traffic and leads to accidents. • Absence of pedestrian facilities like footpath and FOB. • Reduction in road width due to encroachments and on-street parking. • Absenceof trafficsignal leads to disorganized situation at the junction. • Absence of dedicated IPT bays and lack of enforcement leads to passenger boarding and alighting on carriageway.	• Pick up/ drop facilities along with Parking areas and dedicated bays for IPT. • Planning of dispersal activities through feeder modes will cater to a larger catchment. • Enforcement and education for adherence to traffic rules. • Dedicated pedestrian facilities like footpath and FOB on NH-2.

1. Damage road surface causes accidents

2. On-street parking of heavy vehicles reduces road width.

3. Boarding/alighting of IPT passengers on the carriageway.

4. Absence of traffic signal leads to congestion at junction.

iii. ISBT

ISBT Station is proposed as an elevated station near the existing ISBT premises along NH-2. Catchment area of the station comprises mainly residential areas of Khandar, Nirbhay Nagar, Karaita in the north, Sikandara Scheme in the west, Shastri Nagar in the east, Transport nagar, Awas Vikas Colony, Lata Kunj Colony & Kailashpuri in the south. The station is proposed to have direct integration with existing ISBT.

Issues & Concerns	Potential for Improvements
• Boarding/Alighting of Bus passengers on road causes congestion. • Encroachment due to temporary vendors. • On-Street parking of heavy vehicles like Buses and Trucks causes loss of efficient carriageway. • Lack of pedestrian facilities like footpath and FOB results in pedestrian spillover on road. • Absences of IPT pick up/drop bays.	• Parking areas and dedicated bays for pick up/ drop facilities • Planning of dispersal activities through feeder modes will cater to a larger catchment. • Dedicated pedestrian facilities like footpath on NH-2.

1. Encroachment due to temporary vendors.

2. Lack of pedestrian facilities etc.

3. Boarding/ Alighting of passengers on road causes congestion.

4. Damaged road surface leads to accidents.

iv. Shastri Nagar

It is an elevated station proposed along along NH-2. Dispersal through station will be provided by Asopa road, Mau road and NH-2. Catchment area of the station comprises of residential areas of Khandar and Krishna Puram in the north, Transport Nagar in west and Shastri Nagar & Azad Nagar in the South.

Issues & Concerns	Potential for Improvements
• Fast moving traffic is interupted/ hampered due to the movement of NMT. • Lack of pedestrian facilities like FOB results in pedestrian spillover on road. • Lack of enforcement and damaged road infrastructure leads to disobeyance of traffic rules by users. • Movement of cycle rickshaw in wrong direction causes disruption in traffic movement.	• Dedicated facilities for NMT. • Access controlled movement on NH-2 to improve the flow of traffic. • Provision of footpath and FOB. • Enforcement and education for adherence to traffic rules.

1. Speed of motorised vehicles is hampered due to the movement of NMT.

2. Lack of Pedestrian facilities like FOB causes pedestrian spillover on road.

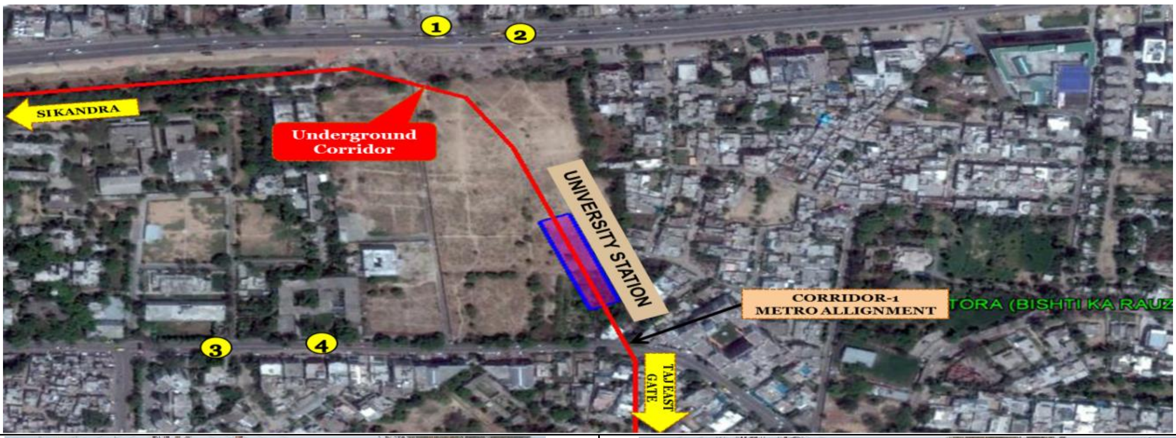
3. Damaged road infrastructure leads to dis-obeyance of traffic rules by road users.

4. Movement of cycle rickshaw in wrong direction.

v. University

This is the first underground station of Corridor-1 proposed near Ambedkar University Khandari Campus. Dispersal through station will be provided by Khandari Road and NH-2. Catchment area of the station comprises mainly of institutional area of Ambedkar Universityalong with the residential areas of Krishna Puram in the north, Azad Nagar in the west, Pushpa Vihar colony in the south and Kunwar Colony in the east.

Issues & Concerns	Potential for Improvements
• Uncontrolled movement of animals on road leads to disruption in movement of traffic and causes accidents. • Lack of pedestrians facilities and encroachment on footpath causes issues in movement of pedestrians. • On-Street parking & Encroachment reduces effective carriageway width.	• Access controlled movement on NH-2 to reduce accidents and improve the flow of traffic. • Dedicated pedestrian friendly facilities like footpath and FOB and removal of encroachment.



1. Lack of pedestrian facilities like footpath and FOB results in pedestrian spillover on road.

2. Uncontrolled movement of animals on road leads to disruption in movement of traffic and causes accidents.

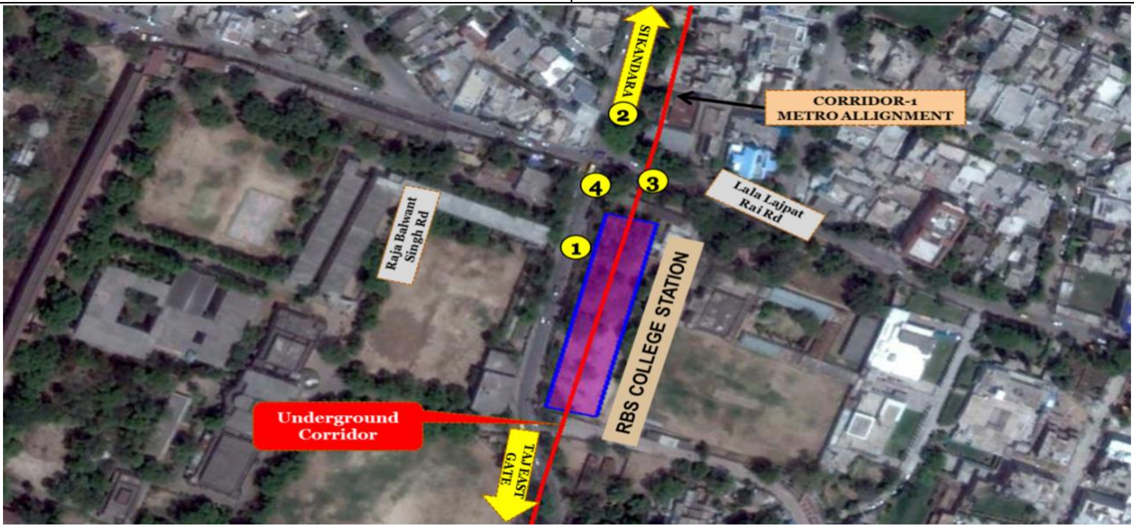
3. On-Street parking & Encroachment causes loss of efficient carriageway.

4. Encroachment & Parking of vehicles on footpath causes loss of Pedestrian facilities.

vi. RBS College

It is an underground station proposed under RBS college ground along the Raja Balwant Singh road. Catchment area of the station comprises mainly of institutional area RBS College, Rawat P.G. Girls College and Pushp Vihar Colony in the west, Surya Nagar in the north, Lajpat Kunj & Bagh Farzana in the east and Professors colony in the south. Raja Balwant Singh Road and Lala Lajpat Rai Road will provide dispersal through the station in the north-south and east-west directions

Issues & Concerns	Potential for Improvements
• Boarding/Alighting of IPT passengers on Carriageway causes disruptions in smooth flow of traffic. • On-Street parking and encroachments causes loss of efficient carriageway. • Narrow road width and absence of footpath causes safety issues in pedestrian movement.	• Parking/ pick up/ drop facilities for IPT. • Provision of footpath all along the road. • Enforcement and education for adherence to traffic rules.



1. Boarding/ Alighting of IPT passengers on Carriageway.

2. Encroachment due to temporary vendors and tree at turning of junction.

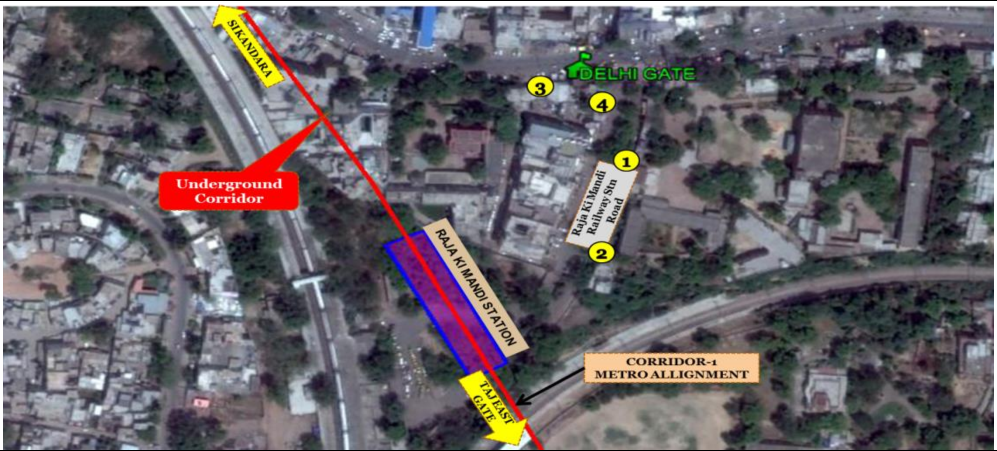
3. On-street parking and encroachmet along the road.

4. Narrow road width and absence of footpath.

vii. Raja Ki Mandi

It is an underground station proposed within Raja Ki Mandi Railway Station premises. The major road connecting the station is Raja Ki Mandi railway station road. Catchment area of the station comprises residential and commercial areas of Professors Colony in north, Billochpura in west and Khatipara in south. It will be integrated with the existing Raja Ki Mandi Railway Station through Subways/ Pathways, lifts, escalators and staircases.

Issues & Concerns	Potential for Improvements
• On-street parking and encroachment by hawkers on both sides of the roads causes loss of efficient carriageway width and hindrance in smooth flow of traffic. • Uncontrolled intersection and heavy traffic flow from all directions. • Lack of pedestrians facilities like footpath and FOB.	• Integration of metro with existing Raja Ki Mandi Railway Station. • Dedicated facilities for pedestrians. • Provision for NMT/ IPT vehicle bays. • Removal of encroachment along the carriageway.



1. Boarding/ Alighting of IPT passengers on carriageway.

2. Congested road condition and absence of pedestrian facilities.

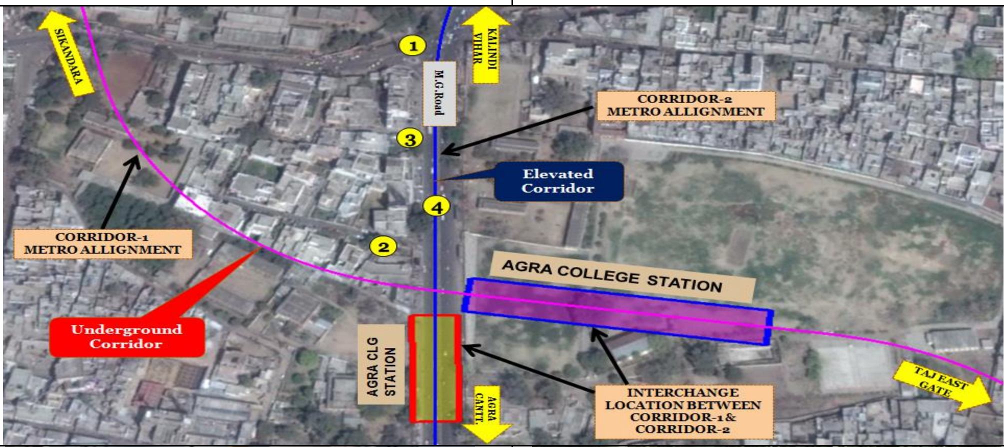
3. Parking of Cycle Rickshaws on carriageway.

4. Encroachment due to temporary vendors on carriageway.

viii. Interchange Station: Agra College

It is an underground station (elevated in Corridor-2) proposed under Agra College grounds along the M.G. Road. It is an interchange station with Agra College station of Corridor-2. The major road connecting the station is M.G. Road. This important interchange station connecting the institutions like M.D. Jain Inter College apart from Agra College, St. John's College in the north, commercial and residential areas of old Agra (near Ghatia Azam Khan chowk) in east, Bagh Muzaffar Khan in south and Gokalpura in west.

Issues & Concerns	Potential for Improvements
• Encroachments and on-street parking on footpath & carriageway causes loss of efficient roadway width. • Lack of pedestrian facilities • Boarding/ Alighting of IPT on carriageway causes disruption in traffic flow. • Movement of animals on road causes hindrance in smooth flow of traffic.	• Integration with proposed St. John's College metro station of Corridor-2. • Provision of dedicated parking lot. • Planning of dispersal activities through feeder modes will cater to a larger catchment. • Dedicated pedestrian friendly facilities like footpath and FOB. • Being located in prominent area, it will generate ridership from surrounding areas.



1. Parking of auto and cycle riackshaws on both sides of carriage-way.

2. Encroachment of footpath due to parking of 2-wheelers.

3. Boarding/ Alighting of IPT passengers on carriageway.

4. Movement of animals on road.

ix. Medical College

It is proposed as an underground station in the S.N.Medical College ground near dilapidated hostel buildings. This station provides dispersal of passengers through Capt. Naresh road and S.N.Medical College road which leads to M.G. Road. Catchment area of the station comprises mainly of residential and commercial areas of Bagh Muzaffar Khan and Garhia Azam Khan in north, Moti Katra, Patel Nagar & Bodhi Ka Nagla in the east, Nai Ki Mandi in south and Gokulpura in the west.

Issues & Concerns	Potential for Improvements
• Heavy traffic and narrow road width leads to congestion. • Undefined IPT/NMT bays leads to loss of efficient carriageway width • Movement of horse carts on road causes disruptions in traffic movement. • Absence of footpath, lack of pedestrian facilities results in pedestrian spillover on road.	• Provision for traffic management measures. • Dedicated pedestrian friendly facilities to ensure pedestrian safety. • Bays for IPT/ NMT stops at designated locations to prevent traffic chaos.

1. Pedestrian Safety is a concern in absence of footpath.

2. Heavy traffic & narrow road width.

3. Movement of horse carts and animals on road on road causes disruptions in traffic movement.

4. Undefined IPT/NMT bays & Encroachment leads to loss of efficient carriageway width

x. Jama Masjid

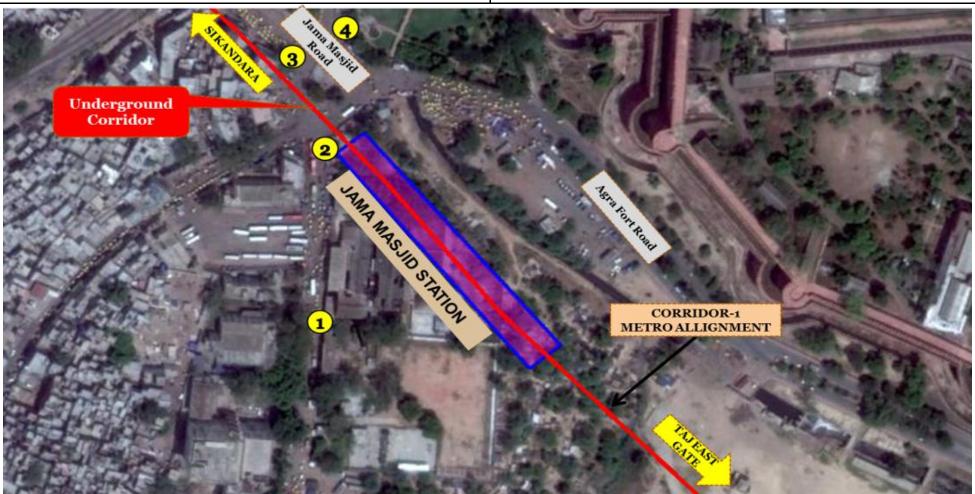
It is proposed as an underground station near Bijlighar chowk along Agra Fort road. The major roads connecting to this station are Agra Fort road and Jama Masjid road. The station would serve Jama Masjid, Agra Fort Railway Station, Bijli Ghar Bus Terminal along with the residential cum commercial areas of Kinari Bazar in north, Nala Kazi Pada in west and Chhipitola in south.

Issues & Concerns

- Unorganized operation of Intermediate Public Transport. Autos are operated near Bijli Ghar chowk without having designated terminal parking areas.
- Absence/discontinuity of footpath, lack of pedestrian facilities.
- On-street parking and Encroachments on both sides of the roads causes loss of efficient roadway width and increases congestion.
- Improper parking facilities inside and outside of Bus Terminal.

Potential for Improvements

- Integration of metro with Bijlighar Bus Terminal and Agra Fort Railway Station.
- Dispersal activities through feeder modes will cater to a larger catchment.
- Enforcement and education for adherence to traffic rules.
- Provision of parking areas and dedicated bays for pick up/ drop facilities.
- Dedicated pedestrian friendly facilities like footpath etc.



2. Unorganized movement of IPT services.

3. On-street parking and Encroachments on both sides of the road.

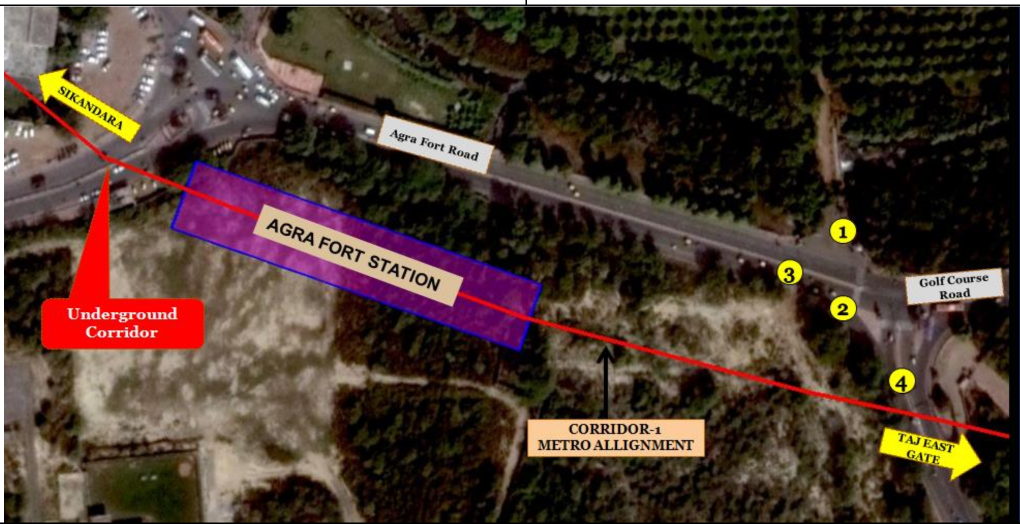
4. Absence/discontinuity of footpath, lack of pedestrian facilities.

5. Boarding/ alighting of IPT passengers on carriageway.

xi. Agra Fort

It is an underground station proposed under the Cantt. Area near Agra Fort entry gate. The major roads connecting this station are Agra Fort road in the west and Golf Course on the east. Catchment area of the station comprises mainly of Rakabganj & Nai Basti in south along with the tourists visiting Agra Fort.

Issues & Concerns	Potential for Improvements
• Movement of Horse cart and Hand cart causes hindrance to smooth flow of motorized traffic. • Undefined PT/IPT stops leads to messy situation. • Encroachment on footpath results in pedestrian spillover on road.	• Enforcement and education for adherence to traffic rules. • Provision of bays for PT/IPT stops at designated locations to prevent traffic chaos. • Removal of encroachments along the carriageway.



1. Movement of Horse cart and Hand cart causes disruption in traffic movement.

2. Encroachments on footpath due to temporary vendors.

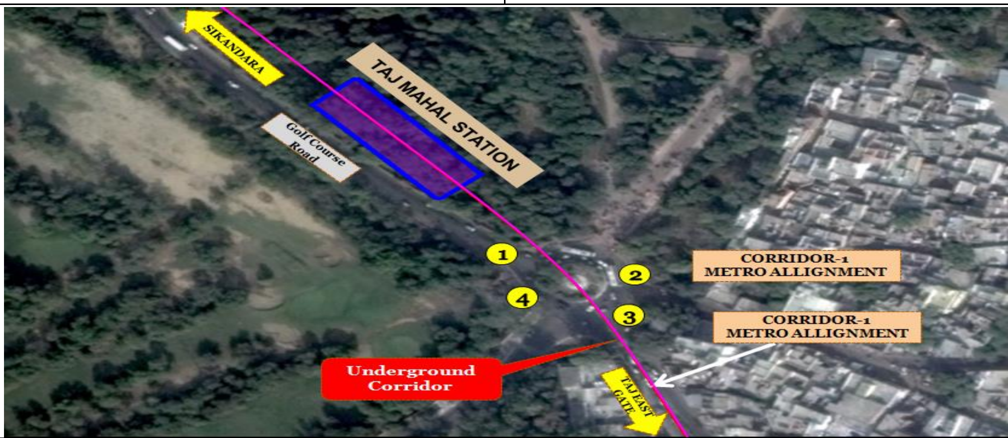
3. Undefined PT/IPT stops.

4. Lack of Pedestrian facilities.

xii. Taj Mahal

It is the last underground station of corridor-1 proposed along the Shajahan Park boundary near Purani Mandi chowk. The station will also connect to the PAC Depot for operation & maintenance of the trains.The major roads connecting this station are Fatehabad road, Taj road and Golf Course road. The station will cater Kaserat Bazar in west, Khairati Tola & Bansal Nagar in south and Nai Basti in the east along with thousands of tourists visiting Taj Mahal daily.

Issues & Concerns	Potential for Improvements
• Undefined PT/IPT stops resulting in boarding/ alighting of tourists on carriageway creating chaotic situation. • Pedestrian spillover on road. • Heavy traffic, narrow road width and on-street parking reduceefficient road width and increases congestion. • Movement of horse carts on carriageway causes disruptions in movement of motorized vehicles.	• Dispersal activities through feeder modes will cater to a larger catchment. • Dedicated pedestrian friendly facilities to ensure pedestrian safety. • Bays for PT/IPT stops at designated locations to prevent traffic chaos.



1. 

1. Narrow road width and intermixing of heterogeneous traffic at Purani Mandi chowk.
2. No dedicated bays for PT/IPT stops and boarding/ alighting for Taj Mahal tourists on carriageway near Taj West Gate entry.

3. Lack of pedestrian facilities like footpath & FOB
4. Movement of loaded horse carts causes disruptions in traffic movement.

xiii. Fatehabad Road

<table>
<tr><td colspan="2">It is proposed as an elevated station on the median of Fatehabad road near Hotel Gateway. This station provides dispersal of passengers through Fatehabad Road, Mall Road and other connecting roads. Catchment area of the station comprises mainly of residential and commercial areas of Bansal Nagar in the north, CPWD Colony, Vaibhav Nagar in the west, Bagichi, Shaheed Nagar in the south and Dalihai in the east.</td></tr>
<tr><th>Issues & Concerns</th><th>Potential for Improvements</th></tr>
<tr><td>• On-street parking of goods vehicle and encroachment reduce efficient roadway width, increases congestion in the station area and results in pedestrian spillover on road.
• Absence of footpath, lack of pedestrian facilities results in pedestrian spillover on road.</td><td>• Removal of encroachments and junction improvement measures.
• Provision for pedestrian friendly facilitieslike footpath and FOB.
• Bays for PT/IPT stops at designated locations to prevent traffic chaos.
• Dispersal activities through feeder modes will cater to a larger catchment.
• Commuter facilities at PT/IPT stops.</td></tr>
<tr><td colspan="2">
</td></tr>
<tr><td></td><td></td></tr>
<tr><td>1. On-street parking of Goods vehicle on carriage way.</td><td>2. Absence of FOB/ footpath.</td></tr>
</table>

xiv. Basai

It is the penultimate station and has been proposed as an elevated station at the T-junction of Basai road and Fatehabad road. Dispersal from station area will be possible through Fatehabad road and Basai road. This will cater Residential and Commercial activities of Basai Khurd & Taj Nagari Phase-I in north, Taj Ganj in the west and Basai in the south.

Issues & Concerns	Potential for Improvements
• Absence of traffic signal causes chaotic situations and leads to congestion. • On-street parking and encroachment reduce efficient roadway width. • Slow moving animal drawn vehicles like horse carts causes hindrance in free flow of traffic.	• Provision of traffic management measures. • Enforcement and education for adherence to traffic rules. • Improvement in pedestrian facilities. • Dispersal activities through feeder modes will cater to a larger catchment.

1. Absence of traffic signal at Basai junction.

2. Movement of horse carts on carriageway along with fast moving vehicles causes disruptions.

3. Vehicles moving in wrong direction leads to accidents.

4. On-street parking and encroachment along the carriageway.

xv. Taj East Gate

This is the last station on Corridor-1 from Sikandara to Taj East gate and has been proposed as an elevated station along Fatehabad road near Hotel Trident. The major connecting roads are Fatehabad road and Taj East Gate Road. Catchment area of the station comprises of residential and commercial areas of Basai Khurd & Taj Nagari Phase-1 in the north, Basai & Tora in south and also to the Hotels on Fatehabad road along with the tourists going to Taj Mahal from Taj East Gate.

Issues & Concerns	Potential for Improvements
• Lack of pedestrian facilities • On-street parking causes reduction in carriageway	• Designated bays for IPT's • Dedicated footpath and cycle tracks • Better Management of Auto Operations • Dispersal activities through feeder modes will cater to a larger catchment.

1. On-street parking along the carriageway

2. Lack of pedestrian facilities results in pedestrian spillover on road.

3. Non- functional traffic signals and lack of enforcement leads to dangerous situations.

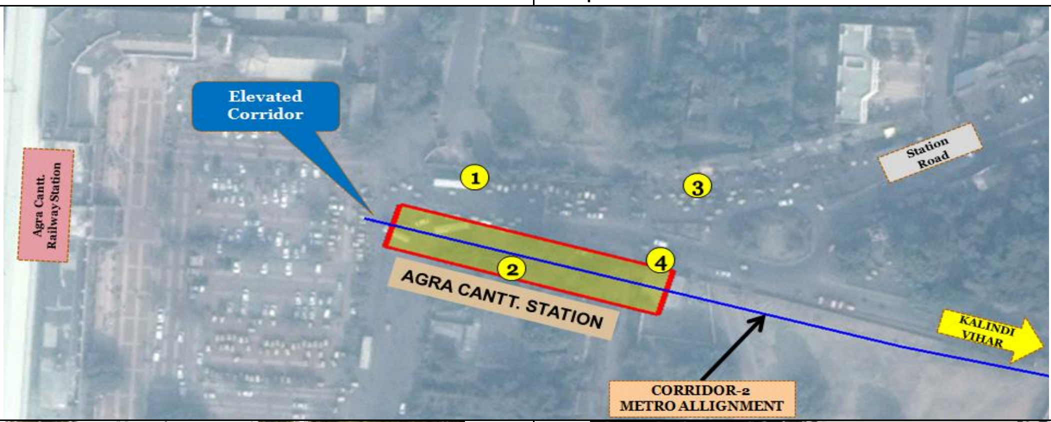
4. Movement of Horse carts causes disruptions in traffic movement.

CORRIDOR 2: AGRA CANTT. TO KALINDI VIHAR

i. Agra Cantt.

It is the first station of Corridor-2 from Agra Cantt. to Kalindi Vihar is proposed as an elevated station at the parking area of the Agra Cantt railway station premises. The station catchment comprises of residential and commercial areas of Sultan Pura, ADRDE Staff Colony, Kushwaha colony, Ashu Malik colony, Naripura in the east and Nagla Kachhan in the south. The major connecting roads are Station road and road along N.C.Vedic Inter college.

Issues & Concerns	Potential for Improvements
• Loading/ unloading of personal goods and boarding/ alighting of passenger on carriageway creates confusion. • Absence/discontinuity 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.	• Intercjange with Agra Cantt. Railway Station. • Dedicated pedestrian friendly facilities • Planning of dispersal activities through feeder modes will cater to a larger catchment. • Removal of temporary & permanent encroachments to road capacity. • Designated bays for PT/IPT stops at to prevent traffic chaos.



1. On-street parking of IPT's reducing the effective carriageway width.

2. Boarding/ Alighting of IPT passengers on carriageway.

3. Lack of pedestrian facilities results in pedestrian spillover on road

4. Loading/ un-loading of personal goods on carriageway causes disruptions in traffic movement.

ii. Sultanpura Station

It is an elevated station proposed along Agra Cantt. road near Hotel Grand. This station has been planned as future station and will be constructed later depending upon the requirement. The major roads connecting the station are Avtar singh road in north and Prithvi Raj road in the east. It will cater the residential and institutional areas of Sultanpura in north, N.C. Vedic Inter college in west and Military hospital in the south.

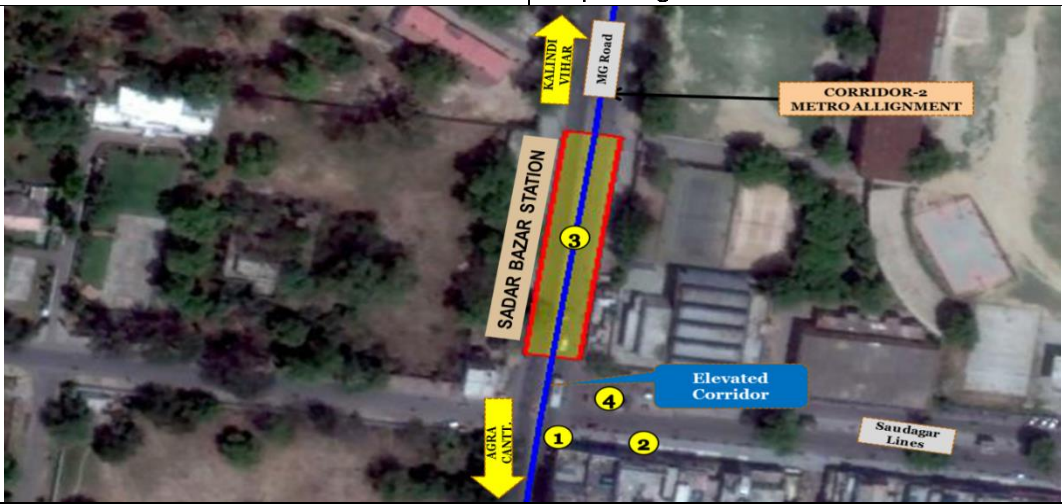
Issues & Concerns	Potential for Improvements
• Reduction in road width due to encroachments by temporary vendors. • Absence of pedestrian facilities.	• Dedicated pedestrian facilities like footpath. • Removal of encroachments.

1. Encroachment due to temporary vendors reduces effective carriageway width

2. Absence of footpath, lack of pedestrian facilities.

iii. Sadar Bazar

<table>
<tr><td colspan="2">It is proposed as an elevated station on M.G.Road near Sadar Bazar. It is accessible by M.G.Road and Sadar Bazar Road. Catchment area of the station comprises of residential and commercial areas of Sadar Bazar and Jeet Singh Stadium in the south, Agra Cantt. Station and Sultan Pura in the west, Eklavya Stadium in the east.</td></tr>
<tr><th>Issues & Concerns</th><th>Potential for Improvements</th></tr>
<tr><td>
• On-street parking and encroachments causes reduction in efficient roadway width and increases congestion.
• Un-organised IPT/NMT Stands.
• Pedestrian movement on the road due to absence of footpath.
• Stray animals causes disruption in traffic
</td><td>
• Dedicated pedestrian facilities like footpath and table top crossing to be planned for pedestrian dispersal.
• Removal of encroachments to widen carriageway.
• Designated bays for PT/IPT stop to prevent traffic chaos.
• Provision of feeder services and dedicated parking lots.
</td></tr>
</table>



1. Encroachments and On-street parking causes reduction in efficient roadway width

2. Absence of footpath.

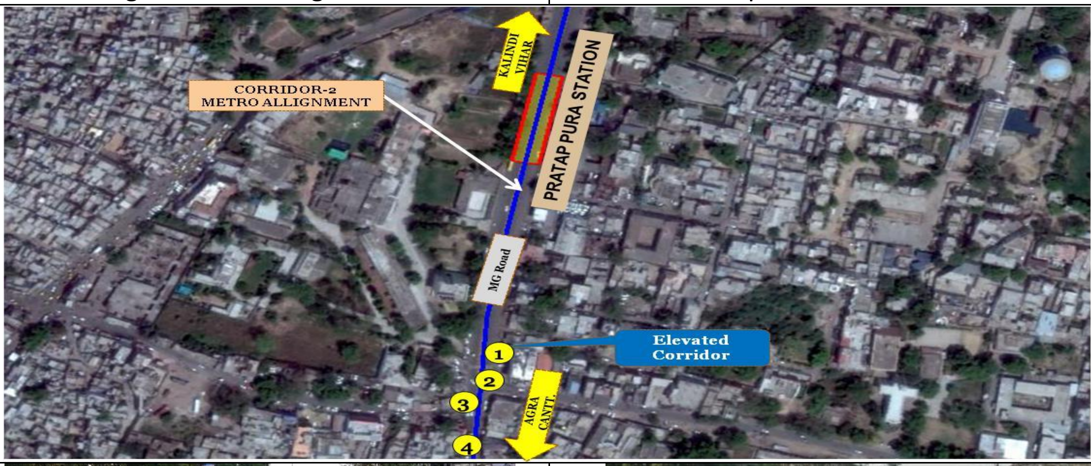
3. Stray animals causes disruption in traffic

4. Un-organised IPT/NMT Stands.

iv. Pratap Pura

It is an elevated station proposed on M.G. Road near Pratap Pura chowk. The major roads connecting to the Station are M.G. Road, Dak Tar Colony Road & road to Idgah Railway Station. Catchment area of the station comprises of residential cum commercial areas of Pratap Pura and Shahzadi Mandi in the west and east directions along with residential areas of Adarsh Nagar and Namner in the north and east directions respectively.

Issues & Concerns	Potential for Improvements
• Pedestrian safety is a concern due to absence of pedestrian facilities. • On-street parking and encroachment causes reduction in efficient roadway width. • Intermixing of heterogeneous traffic & absence of signal causes congestion.	• Better enforcement would reduce encroachment activities. • Dedicated pedestrian friendly facilities to ensure pedestrian safety. • Bays for PT/IPT stops at designated locations to prevent traffic chaos.



1. Encroachment on Footpaths due to permanent vendors.

2. Pedestrians moving across the traffic movement due to absence of pedestrian facilities.

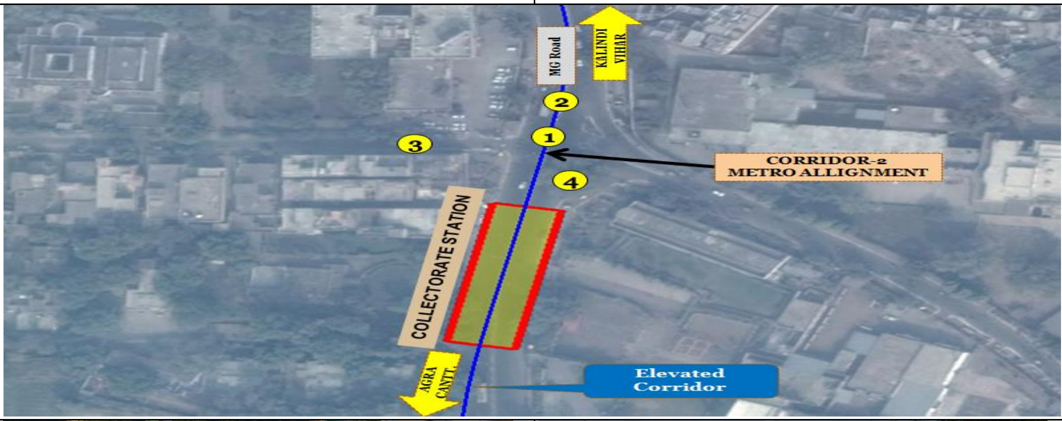
3. Absence/ Non functional traffic signal at Pratap Pura chowk.

4. On-street parking on both sides of the road.

v. Collectorate

It is an elevated station proposed on M.G. Road near Chhipitola intersection. The major roads connecting to the Station are M.G. Road in the north & south and Rakabganj Road in the west & east respectively. Catchment area of the station comprises of Residential cum commercial areas of Dholpur House in the northern side, Chhipitola in the east and Mohanpura & Katlupur in the west.

Issues & Concerns	Potential for Improvements
• On-street parking and encroachments causes reduction in efficient roadway width. • Absence/ discontinuity of footpath. • Intermixing of heterogeneous traffic leads to congestion. • Un-organized IPT/NMT stands resulting in reduction in efficient roadway width.	• Bays for PT/IPT stops at designated locations to prevent traffic chaos. • Enforcement and education for adherence to traffic rules. • Provision of footpath all along the road.



1. Lack of pedestrian facilities causing safety issues.

2. Intermixing of heterogeneous at Chhipitola chowk.

3. Open drains and on-street parking on both sides of the road.

4. Un-organised IPT/NMT Stands.

vi. Subhash Park

It is an elevated station proposed on M.G.Road near Subash Park & Nalband chowraha. Catchment area of the station comprises residential and commercial areas of Panchkuian & Bank Colony in the west and Chanderi in the east directon. M.G.Road & M.G.Road-2 provides connectivity to areas in the north - south and west side respectively.

Issues & Concerns	Potential for Improvements
• On-street parking and encroachments reduces efficient road width. • Intermixing of heterogeneous traffic leads to disruption in traffic movement. • Vehicles moving in wrong direction due to lack of enforcement leads to chaotic situation.	• Provision for dedicated parking area. • Dedicated footpath and cycle tracks at Station area and approach roads which forms a major access for pedestrian dispersal. • Removal of encroachments

1. Intermixing of heterogeneous traffic leads to disruption in traffic movement.

2. Vehicles moving in wrong direction due to lack of enforcement leads to accidents.

3. Encroachments on carriageway causes reduction in efficient roadway width.

4. Absence of Pedestrian facilities like footpath raises safety concerns and fore pedestrian to move on carriageway.

vii. Agra College

Please refer to 6.2.1 (vii) Agra College for location of station, issues, concerns and potentials for improvements.

viii. Hariparvat Chauraha

It is proposed as an elevated station along M.G. Road after the Interchange station at Agra College. The road approaching Raja Ki Mandi railway station will also be connected with this station near Hari Parvat chowk. The approaching roads to the station are M.G.Road and Wazirpura road. The station catchment area includes the institutional and residential areas of M.D.Jain Inter College in the south and Sanjay Place HIG Apartments & Professors Colony in the east.

Issues & Concerns	Potential for Improvements
• Un-authorised NMT stand on carriageway reduces effective road width. • Absence of pedestrian facilities like footpath, FOB leads to Pedestrian Spillover on road. • Non-functional signals and inter-mixing of heterogeneous traffic leads to disruption in traffic movement.	• Dedicated pedestrian facilities near Station area which forms a major access for pedestrian dispersal. • Better Management of NMT/ Auto Operations and provision of feeder services. • Enforcement and education for adherence to traffic rules.

1. Un-authorised NMT stand on carriageway.

2. Absence of pedestrian facilities like footpath, FOB leads to Pedestrian Spillover on road.

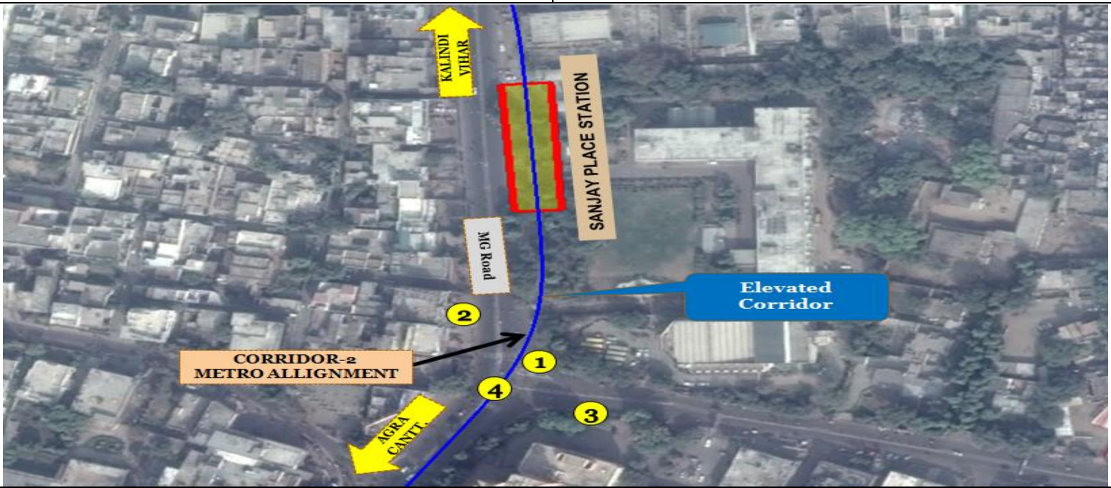
3. Non-functional signals leads to congestion at junction.

4. Inter-mixing of heterogeneous traffic causes disruption in traffic movement.

ix. Sanjay Place

It is proposed as an elevated station near Agra Municipal Corporation on M.G. Road and also connects the commercial complex at Sanjay Place. The major roads connecting to the Station are M.G. Road, Wazirpura road and Church road. The station catchment area includes official areas of Agra Nagar Nigam in the south along with commercial and residential areas of Ram Nagar Colony & Lajpat Kunj on the west, Nehru Nagar in north and Wazirpura in the east respectively.

Issues & Concerns	Potential for Improvements
• Non- functional signals leads to chaotic situations at junction. • Vehicles moving in wrong direction create hindrance in smooth flow of traffic. • Encroachment along carriage way causes reduction in effective road width. • Boarding/ Alighting of IPT on carriageway cretaes messy situation.	• Provision for traffic management measures. • Improvement of pedestrian friendly facilities. • Removal of encroachment near junction • Enforcement and education for adherence to traffic rules.



1. Non- functional signals leads to congestion at junction.

2. Movement in wrong direction by IPT shows dis-obeyance to traffic rules.

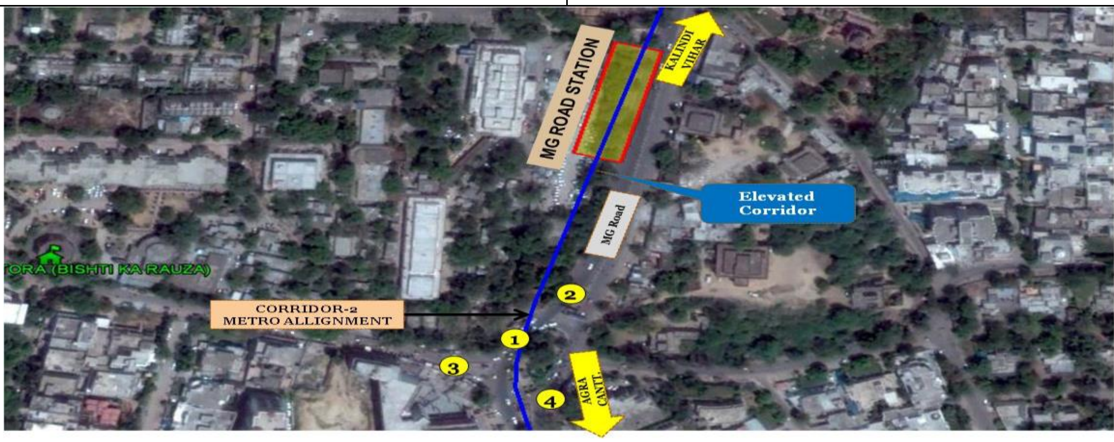
3. Encroachments along carriageway reduces effective road width.

4. Boarding/ Alighting of IPT passengers on carriageway.

x. M.G. Road

It is proposed as elevated station after Diwani chowk along the boundary of Agra Court on M.G.Road. The major roads connecting to the Station are M.G.Road and Raja Balwant Singh road. The station catchment area includes official areas of Agra Court in the west,along with commercial and residential areas of Ram Nagar Colony, Surya Nagar, Nagar Nigam Colony, Pashupati Colony, Wazirpura etc.

Issues & Concerns	Potential for Improvements
• Encroachment and On-street parking on M.G. Road causes disruption in traffic movement. • Pedestrian Safety is a concern with chaotic movement of traffic. • Intermixing of heterogeneous traffic causes congestion. • Un-organized NMT stand and lack of enforcement on M.G.Road reduces effective road width.	• Dedicated footpath all along the road and cross roads for effective pedestrian dispersal. • Removal of encroachment near junction and cross roads. • Provision for dedicated parking lot.



1. On-street parking on M.G. Road causes disruption in traffic movement.

2. Intermixing of heterogeneous traffic causes congestion.

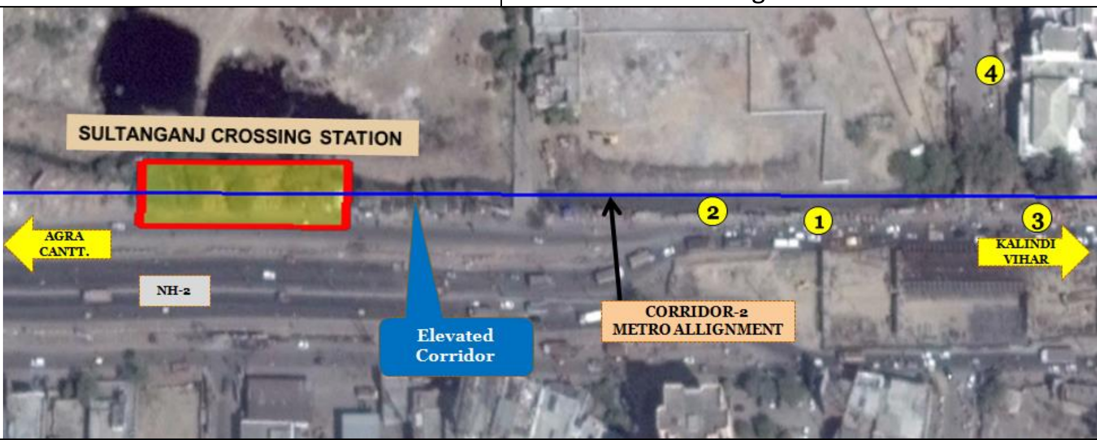
3. Encroachments by hawkers.

4. Absence of pedestrian facilities.

xi. Sultan Ganj Crossing

It is proposed as an elevated station on NH-2 near Sultan Ganj Crossing. The major roads connecting to the Station are NH-2 in the west & east directions, Karbala road in the south direction and Mughal road in the north direction. This station is characterized by commercial activities along the NH-2. It will provide connectivity to the residential and commercial areas of Karbala in the northern side, Dwarika Puram on the eastern side, Vijay Nagar Colony on the southern side and Suresh Nagar & Gandhi Nagar on the western side respectively.

Issues & Concerns	Potential Improvements
• Heavy Traffic movement and on-going construction work leads to congestion. • Absence of pedestrian facilities results in pedestrian spillover on road. • Encroachment &On-street parking leads to loss of carriageway width.	• Provision of Pedestrian friendly facilities for effective pedestrian dispersal. • Removal of On-street parking near station area. • Enforcement and education for adherence to traffic rules. • Dispersal activities through feeder modes will cater to a larger catchment.



1. Heavy Traffic and on-going construction work leads to congestion.

2. Absence of Pedestrian facilities leads to pedestrian spillover on road.

3. Movement of cycle rickshaw in the wrong direction.

4. On-street parking of vehicles at junction.

xii. Kamla Nagar

It is proposed as an elevated station on the median of NH-2 near Langre Ki Chowki choraha. The major roads connecting to the Station NH-2 and Tanki Road. This station provide connectivity to residential cum commercial areas of Kamla Nagar, Ghatwasan and Balkeshwar Colony in north, Langre Ki Chowki in south, Dwarika Puram and Vijay Nagar Colony in west and New Radha Nagar in the east respectively.

Issues & Concerns	Potential Improvements
• Damaged road infrastructure leads traffic dis-obidience. • Encroachment leads to loss of carriageway width • Pedestrian Safety is a concern due to chaotic movement of auto/ bus services.	• Enforcement and education of adherence to traffic rules. • Provision of Pedestrian friendly facilities such as dedicated footpath, FOBfor effective pedestrian dispersal. • Dispersal activities through feeder modes will cater to a larger catchment. • Provision of proper road infrastructure.

1. Damaged road infrastructure.

2. Encroachment & movement of heavy passenger vehicles on service road causes disruption in movement of traffic

3. Damaged/ encroached footpath.

4. Heavy Congestion due to intermixing of heterogeneous vehicles.

xiii. Ram Bagh

Ram Bagh elevated station is proposed opposite to Ram Bagh heritage monument along NH-2. The major roads connecting to the Station NH-2 and Aligarh-Hathras Road. It will be the first station after crossing river Yamuna and will provide connectivity to the Ram Bagh heritage park and Ram Bagh Colony in north along with commercial and residential areas of Ram Nagar, Nawal Ganj, Katra Wazir Khan in south and Trans Yamuna Colony Phase-I in west.

Issues & Concerns	Potential Improvements
• Lack of pedestrian facilities results in pedestrian spillover on the road. • Movement of bullock cart disrupts fast moving traffic. • Uncontrolled junction with heavy traffic flow from all directions,. • On-street parking and encroachment reduce efficient roadway width and increases congestion in the station area.	• Provision of dedicated parking lots. • Dedicated facilities for pedestrians. • Removal of On-street parkingnear station area. • Dispersal activities through feeder modes will cater to a larger catchment. • Enforcement and education of Auto and adherence to traffic rules.

1. Un-organized IPT stand reduces almost 2 lanes of carriageway.

2. Fast moving traffic interupted due to movement of bullock cart

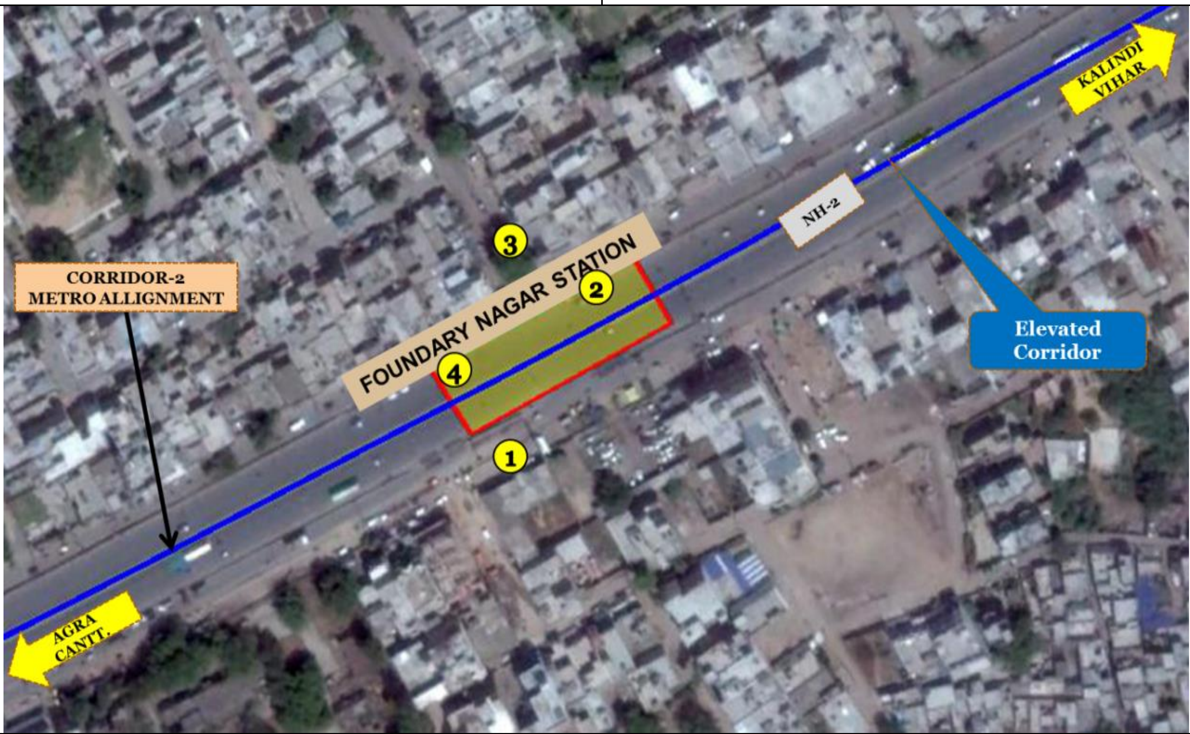
3. Intermixing of heterogeneous traffic causes congestion

4. Heavy encroachment and Lack of pedestrian facilities.

xiv. Foundary Nagar

It is proposed as an elevated station on NH-2 near Nunhai. The major roads connecting to the Station are NH-2 and other minor roads connecting NH-2 near the station area. It will provide connectivity to commercial and residential areas of Trans Yamuna Colony Phase-I in the north, Nunhai, Ram Nagar and Industrial Estate in the south.

Issues & Concerns	Potential Improvements
• Absence/ dis-continuity of footpath • Encroachment and on-street parking reduces effective carriageway.	• Provision of Pedestrian friendly facilities for effective pedestrian dispersal. • Removal of On-street parking near station area.



1. Lack of Pedestrian facilities along NH-2.

2. Heavy Encroachment leads to loss of carriageway width

xv. Agra Mandi

It is the penultimate station of Corridor-2 and proposed as an elevated station along NH-2 near Sri Nagar Colony area. The major roads connecting to the Station are NH-2 and Mandi road. It will provide connectivity to the commercial area of Agra Mandi in the North residential areas of Sri Nagar Colony, Mahavir Nagar on the west, Agrasen Puram on the south and Trans Yamuna Colony Phase-II on the east.

Issues & Concerns	Potential Improvements
• Poor road condition and encroachment along the road. • Reduction in carriageway width due to on-street parking and encroachment. • Pedestrian safety is concern due to lack of pedestrian facilities.	• Provision for dedicated parking lots. • Dedicated bays of IPT/ NMT. • Provision of footpath and FOB

1. Un-organized auto stand on carriageway.

2. Pedestrian moving on the carriageway due to absence of footpath.

3. Damaged road condition.

4. On-street parking of trucks and Auto Rickshaws

xvi. Kalindi Vihar

The last station of Corridor-2 is Kalindi Vihar and is proposed as an elevated station on NH-2 near Sahadra. The major roads connecting to the Station are NH-2 and 100 Feet Road. It will provide connectivity to the residential areas of Nagla Ramball in north, Agrasen Puram, Trans Yamuna Colony Phase-II and Sahadra in the south.

Issues & Concerns	Potential Improvements
• Poor condition of road surface causing hindrance in smooth flow of traffic. • On-street parking and encroachment reduce efficient roadway width and increases congestion. • Lack of Pedestrian facilities leads to pedestrian spillover on road.	• Dedicated bays for NMT/ IPT. • Improvement in road infrastructure. • Provision of Pedestrian friendly facilities for effective pedestrian dispersal. • Dispersal activities through feeder modes will cater to a larger catchment. • Removal of On-street parking near station area.

1. Poor conditions of road surface.

2. Unauthorised of IPT stand.

3. Encroachments on approach road (100 feet road) to NH-2.

4. On Street Parking of Trucks reduces almost 1 lane each side of carriageway.

6.1.2 Planning Norms & Standards

a. General

- The horizon year of the Study is taken as 2051, when a maximum PHPDT of about 23700 between **Sikandra to Taj East Gate** and 27800 between **Agra Cantt. to Kalindi Vihar** is expected to be achieved. Accordingly, maximum capacity required at any station for emergency evacuation has been adopted.
- The platform length is planned with the capacity of 3 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) in underground stations. However this is 5.5 minutes in elevated stations considering that the stations are open and the risk is much less.
- The Station Design is 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 2051 - 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

- The arrangement of the concourse is assessed on a station-by-station basis and is determined by site constraints and passenger access requirements. However, it is planned in such a way that maximum surveillance can be achieved by the ticket hall supervisor over ticket machines, automatic fare collection (AFC) gates, stairs and escalators. Ticket machines and AFC gates are positioned to minimize cross flows of passengers and provide adequate circulation space. Sufficient space for queuing and passenger flow has been allowed in front of the AFCs.
- 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 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 in **Table 6.2**. The description of such areas is also detailed in the subsequent paragraphs.

- 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.
- 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).
- 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.

TABLE 6.2: STATION FACILITIES ACCOMMODATION

PST (POWER SUPPLY & TRACTION)	**STAFF FACILITIES**
Auxiliary substation Track disconnection switch DG set, Fuel tank Traction Substation at every alternate station	Staff toilets/ locker (male) Staff toilets/ locker (female) First aid Staff mess room Train crew room
SYSTEM ROOMS	**TUNNEL VENTILATION SYSTEM**
SIGNALLING	Tunnel ventilation plant room-1 Tunnel ventilation plant room-2 ECS plant room-1 ECS plant room-2
Signalling Equipment Room (SER) UPS room (signaling)	
TELECOMMUNICATION	
TER Mobile phone equipment room UPS room (telecom)	
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 year 2051 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 forDisabled 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.

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 .

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

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 (Sikandra, Agra College, Taj East Gate, Agra Cantt., St. John's College and Kalindi Vihar 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 20 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 the location 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 0.6-0.75 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 design of the escalators which act as emergency stairways should meet all the criteria requirements in NFPA 130. The design of the 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.

Lift will 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 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.
The Interfacing Requirements shall be monitored by the SCADA and abnormal conditions will be alarmed - Incoming power lines healthy, Direction status, Running, Fault and Emergency Status

- **Design Criteria- Stairs Requirements**
  - A central handrail is provided where stair width is 4.5m 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 the Platform will be 75 meter. This allows for the length of 3 car train and a stopping tolerance for the rail corridor Platforms.

- The nominal platform width measured from the platform edge to any continuous (longer than 2000mm) fixed structure shall be a minimum of 3000 mm. The minimum distance from the 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 a 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.

iv. The train will not move from the platform until passengers have begun clearing the platform and hence the 500 mm unoccupied zone adjacent to the platform edge for platform is included in the calculations.

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:

- 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 6.2.**

- 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 6.3.**

- 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.

FIGURE 6.2: ADVERTISEMENTS AT STATIONS& PLATFORM

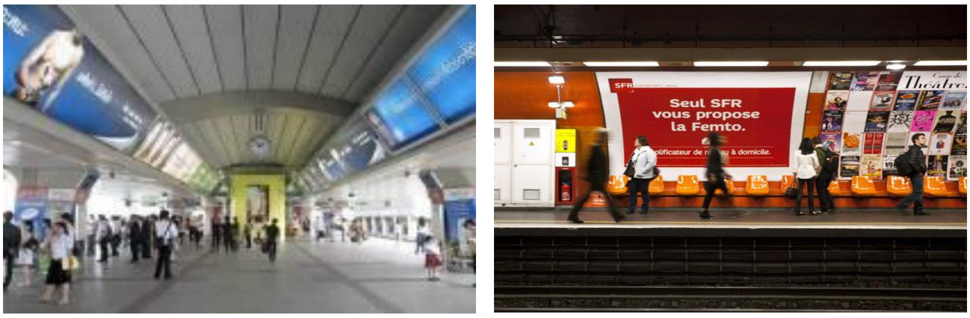


FIGURE 6.3: ADVERTISEMENTS ON ROLLING STOCK

iv. 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.

v. 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

vi. On the platforms
   - Space: 15 m² per platform for automatic vending machines (for drinks, eatables, etc.) or small convenience stores

vii. 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.

viii. 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.

6.1.3 Typical Planning of Metro Stations

The conceptual station designs are the adaptations of the typical stations finalized keeping projected traffic, site conditions and land & cost optimization in consideration.
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 **Annexure 6.1, 6.2 and 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 to the design. The stations have been designed 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/platform 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.

A number of standardized station typologies, which can respond to the context at specific locations have been developed. The design of stations is based on the 3 car rake composition with length of train to be 67.8m. Therefore, the length of the platforms in both elevated stations and underground stations have been kept as 75m with 3.6m buffer space on either side.

The width of a typical elevated station has been derived on the basis of egress requirements where a minimum of 2.4m wide staircase is provided on one side of the platform and an escalator in up direction is provided on other side of the same platform. Provision of 2 lifts has been kept for the typical elevated stations primarily to disperse the alighting traffic from the up direction escalator side. A minimum of 3m wide platform have been proposed on either side to ease circulation.

In elevated stations, single unpaid concourse has been proposed primarily due to reduced length of stations to 75m (3 car rake). Also traffic requirements being low for most of the stations, single unpaid concourse with minimum 2 entry/exits from ground to concourse have been proposed. In stations, where entry/exit requirements are more than 2 nos., 2 more entry/exits could be added on either side of the road linking to the same Foot over bridge.

For typical underground stations, minimum of 2 staircases of 2.4m width and 4 escalators have been proposed between concourse and platform level. Also, platform width has been kept as 13m to provide for the required staircase and escalator widths and keeping 3m distance from platform edge to escalator/staircase edge. Provision of 1 lift from concourse to platform level has been proposed for the physically disabled. Entry/exits from ground to concourse level has been planned on both sides of the station box with unpaid concourse on both sides of paid concourse. Double unpaid concourse with TOMs and AFC gates on both sides have been proposed to meet the safety requirement of Underground stations where minimum of 2 exits are required.

Based on the above mentioned criteria and traffic calculations, the typology of stations has been determined. Emphasis has been laid on keeping minimum typologies that would broadly cover design of all 30 stations in both corridors. Any minor variations from the one type have been included as a subtype and a separate typology has not been created for the same, **Table 6.3.**

Also, every alternate Elevated/UG station along both the corridors has been kept 10m longer than the typical length of 75m (for elevated), 130m (for Underground) and 170m (for Underground) to accommodate the Traction Substation (TSS) which would support 750 V DC third rail traction system. Separate typology for this increase in length has not been considered in the report. However, Type A, B, F and G stations have been proposed with 10m increased length to explain the change in design on incorporating TSS. These standard typologies will be further developed for specific conditions at station planning stage.

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TABLE 6.3: STATION TYPOLOGIES

Sr. No.	Proposed Type	Elevated U/G	Remarks
1	**Type A**	**Elevated**	i. 75/85m x 19.2m – 1 set of 2.4m staircase + 1 escalator ii. 75/85m x 19.2m – 2 set of 2.4m staircases iii. 75/85m x 20.5m – 1 set of 3m staircase + 1 escalator
2	**Type B**	**Elevated**	75/85m x 21.7m
3	**Type C**	**Elevated**	75/85m x 20.45m
4	**Type D**	**Elevated**	75/85m x 21.7 m with at grade concourse
5	**Type E**	**Elevated**	75m x 27.9 m (3 Track Mid Level)
6	**Type F**	**U/G**	130/140m x 26.55m - 3 levels
7	**Type G**	**U/G**	170/180m x 24.6 m - 2 levels
8	**Type H**	**U/G**	130m x 26.55 m - 2 levels U/G with at grade concourse
9	**Type I**	**U/G**	130m x 26.55 m - 1 level U/G with at grade concourse
10	**Type J**	**Elevated/ U/G**	Interchange Station of Underground and Elevated Station

i. Typical Elevated Station

The elevated stations are generally located on the road median consisting of two-level structure. The passenger areas on concourse level is concentrated in a length of about 40m in the middle of the station, with 2-3 staircases, escalators & elevators leading from either side of the road. Passenger facilities like ticketing, information, etc. as well as operational areas are provided at the concourse level. Typically, the concourse is divided into public and non-public zones. The non-public zone or the restricted zone contains station operational areas such as Station Control Room, Station Master’s Office, Waiting Room, Meeting Room, UPS & Battery Room, 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 7.6m above the road. Consequently, platforms are at a level of about 14.4m from the road. The length of every alternate elevated/UG station along the corridor has been kept as 85m to accommodate the Traction Substation to support 750 V DC third rail traction system.
With respect to its spatial quality, an elevated MRT structure makes a great impact on the viewer as compared to an At-grade station. The positive dimension of this impact has been accentuated to enhance the acceptability of an elevated station and the above ground section of tracks. Structures that afford maximum transparency and are light looking have been envisaged. A slim and ultra-modern concrete form is proposed, as they would look both compatible and modern high-rise environment as well as the lesser-built, low-rise developments along some parts of the corridor.

Platform roofs that can invariably make a structure look heavy; have been proposed to be of steel frame with aluminium cladding to achieve a light look. Platforms would be protected from the elements by providing an overhang of the roof and sidewalls would be avoided, thereby enhancing the transparent character of the station building. In order to allow unhindered traffic movement below the stations, portals across the road have been proposed 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.

- **Type A – 75/85m x 19.2m Cantilevered Structure**

The size of Type A elevated station has been kept as **75m x 19.2m** where 2.4m wide staircase is provided on one side of the platform and an escalator in up direction is provided on other side of the same platform and provision of 2 lifts has been proposed. It is planned to be a cantilevered structure thereby keeping flexibility for provision of a wider carriageway in future below the concourse with 3 m wide central median.

In a few stations where traffic requirements suggest only increase in staircase width, the station width has been increased to a maximum of 3m thereby keeping all other parameters same. These stations have been proposed as a sub-type to Type A with a different size of **75m x 20.5m**.

The room schedule for Type A, isometric view and Plan are presented in **Table 6.4**. The typical plans for Type A is presented in **Figure 6.4.**

TABLE 6.4: ROOM SCHEDULE FOR STATION TYPE A

Room No.	Room Name	Size of Room(m)		Area Provided (sq.m)
U01	Station Entrance/Unpaid Area			794.89
U02	Concourse Paid Area			620.03
U03	Station Control Room (SCR)	7.48	3.14	23.48
U04	Station Manager Room (SMR)	3.45	7.90	27.25

Room No.	Room Name	Size of Room(m)		Area Provided (sq.m)
U05	T.O.M.	3.45	7.90	27.25
U06	First Aid Room	2.91	2.35	6.83
U08	Security Room	4.15	2.35	9.75
U09	Store for Maintenance	8.51	2.48	23.82
U10	Cleaner's Room	4.15	2.35	9.75
U11	Refuge Store	2.88	2.35	6.77
U12 (F) +T	Staff Locker Room (Female)			16.78
U12 (M) +T	Staff Locker Room (Male)	6.80	7.03	25.58
U13 (F)	Female Toilet	4.33	2.50	10.84
U13 (M)	Male Toilet			20.44
U13 (H)	Handicapped Toilet	2.00	4.26	8.52
U14	Signalling Room			37.55
U15	Tele Communication Room	5.78	5.91	34.20
U16	UPS Room	5.48	5.91	32.43
U17A & 17B	Platform			412.73
U18A & 18B	Auxiliary Substation			133.98
	Electrical UPS Room	4.67	5.04	23.56
U 21 & 22	Fire Fighting Tank	10.36	5.95	61.29
	Pump Room			
	DG Room			

- **Type B – 75/85m x 21.7m Cantilevered Structure**

The size of **Type B** elevated station has been kept as **75m x 21.7m**.Passenger areas on concourse are spread throughout the length of the station, with staircases leading from either side of the road. Provision of 2 escalators and 1 staircase of 3.6m width have been given on the same side of platform due to high traffic projections. Only 1 lift has been proposed, as dispersal at platform level is evenly distributed. These stations are also planned as cantilevered structures thereby keeping flexibility for provision of a wider carriageway in future below the concourse with 3 m wide central median. The total width of the station is restricted to 21.7 m.

The room schedule for Type B is presented in **Table 6.5.** The typical plans for Type B is presented in **Figure 6.5**

TABLE.6.5: ROOM SCHEDULE FOR STATION TYPE B

<table>
<tr><th>Room No.</th><th>Room Name</th><th colspan="2">Size of Room (m)</th><th>Area Provided (sq.m)</th></tr>
<tr><td>U01</td><td>Station Entrance/Unpaid Area</td><td></td><td></td><td>845.44</td></tr>
<tr><td>U02</td><td>Concourse Paid Area</td><td></td><td></td><td>644.17</td></tr>
<tr><td>U03</td><td>Station Control Room (SCR)</td><td>7.48</td><td>3.14</td><td>23.48</td></tr>
<tr><td>U04</td><td>Station Manager Room (SMR)</td><td>3.45</td><td>9.15</td><td>31.56</td></tr>
<tr><td>U05</td><td>T.O.M.</td><td>3.45</td><td>8.50</td><td>29.32</td></tr>
<tr><td>U06</td><td>First Aid Room</td><td>2.91</td><td>2.75</td><td>8.00</td></tr>
<tr><td>U08</td><td>Security Room</td><td>4.15</td><td>2.75</td><td>11.41</td></tr>
<tr><td>U09</td><td>Store for Maintenance</td><td>8.51</td><td>3.73</td><td>31.80</td></tr>
<tr><td>U10</td><td>Cleaner’s Room</td><td>4.15</td><td>3.00</td><td>12.45</td></tr>
<tr><td>U11</td><td>Refuge Store</td><td>2.88</td><td>3.00</td><td>8.64</td></tr>
<tr><td>U12 (F) +T</td><td>Staff Locker Room (Female)</td><td>6.65</td><td>5.39</td><td>19.39</td></tr>
<tr><td>U12 (F) +T</td><td>Staff Locker Room (Male)</td><td>6.80</td><td>8.30</td><td>29.9</td></tr>
<tr><td>U13 (F)</td><td>Female Toilet</td><td>4.34</td><td>2.50</td><td>10.85</td></tr>
<tr><td>U13 (M)</td><td>Male Toilet</td><td>4.80</td><td>4.26</td><td>20.44</td></tr>
<tr><td>U13 (H)</td><td>Handicapped Toilet</td><td>2.00</td><td>4.26</td><td>8.52</td></tr>
<tr><td>U14</td><td>Signalling Room</td><td>5.5</td><td>5.56</td><td>30.58</td></tr>
<tr><td>U15</td><td>Tele Communication Room</td><td>5.83</td><td>6.84</td><td>39.87</td></tr>
<tr><td>U16</td><td>UPS Room</td><td>5.54</td><td>6.86</td><td>38.00</td></tr>
<tr><td>U17A & 17B</td><td>Platform</td><td></td><td></td><td>573.68</td></tr>
<tr><td rowspan="2">U18A & 18B</td><td>Auxiliary Substation</td><td></td><td></td><td>150.37</td></tr>
<tr><td>Electrical UPS Room</td><td>4.67</td><td>5.67</td><td>26.64</td></tr>
<tr><td rowspan="3">U 21 & 22</td><td>Fire Fighting Tank</td><td rowspan="3">10.36</td><td rowspan="3">5.95</td><td rowspan="3">61.64</td></tr>
<tr><td>Pump Room</td></tr>
<tr><td>DG Room</td></tr>
<tr><td>U23</td><td>Traction Substation (TSS)</td><td>9.49</td><td>21.19</td><td>201.09</td></tr>
</table>

- **Type C– 75/85m x 20.45m on Portals (with island platform)**

The size of Type C elevated station has been kept as **85m x 20.45m**. This station type is a two level structure with central platform having two tracks on either side.

Passenger areas on concourse are spread throughout the length of the station, with one staircase of 2.4m width & 2 escalators along with 2 lifts leading from the road. The total width of the station is 20.45m to accommodate 2 tracks. The length of the station has been proposed as 85m to accommodate Traction Substation. Passenger facilities like ticketing, information, etc as well as operational areas are provided at the concourse level.
The room schedule for Type C is presented in **Table 6.6.** The typical plans for Type C are presented in **Figure 6.7.**

TABLE.6.6: ROOM SCHEDULE FOR STATION TYPE C

Room No.	Room Name	Size Of Room (m)		Area Provided (Sq.m)
U01	Station Entrance/Unpaid Area			115.13
U02	Concourse Paid Area			398.26
U03	Station Control Room (SCR)			31.77
U04	Station Manager Room (SMR)	2.47	5.82	14.37
U05	Ticket Office Cash Room (TOM)	2.47	8.53	21.06
U06	First Aid Room	2.27	2.77	6.28
U08	Security Room	3.77	2.77	10.44
U09	Store for Maintenance			22.67
U10	Cleaner's Room	2.77	2.77	7.67
U11	Refuse Store	2.40	2.77	6.65
U12 (F)+T	Staff Locker Room (Female)	4.38	3.70	16.20
U12 (M)+T	Staff Locker Room (Male)	5.80	4.06	23.58
U13 (F)	Female Toilet	4.33	2.67	11.56
U13 (M)	Male Toilet	3.36	4.29	14.42
U13 (H)	Handicapped Toilet	1.80	4.68	8.42
U14	Signalling Room	5.30	4.77	25.28
U15	Tele Communication Room	10.09	3.50	35.30
U16	UPS Room	9.60	3.50	33.6
U17	Platform			906.86
U18A & 18B	Auxiliary Substation	15.90	8.23	130.86
	Electrical UPS Room	5.41	4.29	23.20
U21 & 22	Fire Fighting Tank	10.36	5.95	61.64
	Pump Room			
	DG Room			
U23	Traction Substation (TSS)	12.00	14.59	175.00
U24	Room for Screen Doors	3.00	4.00	12.00
U25	Lost and Found Room	3.00	4.00	12.00

- **Type D– 75/85m x 21.7m with at grade concourse**

Type D is an elevated station of **75 m x 21.7m** size. This typology is for stations which are located off the road with concourse at grade and platforms at level +1. Passenger areas on concourse are planned to be spread throughout the length of the station, with entries leading from either side of the stations from the nearest roads. A total set of 4 escalators (2 up and 2 down direction) and 2 sets of staircases of 3.6 m width along with 2 lifts are provided to access the platform level. The total width of the station is restricted to 21.7 m. Passenger facilities like ticketing, information, etc as well as operational areas are provided at grade - the concourse level.

The room schedule for Type D is presented in **Table 6.7**. The typical plans for Type D are presented in **Figure 6.7**

TABLE.6.7: ROOM SCHEDULE FOR STATION TYPE D

<table>
<tr><th>Room No.</th><th>Room Name</th><th colspan="2">Size Of Room (m)</th><th>Area Provided (Sq.m)</th></tr>
<tr><td>U01</td><td>Station Entrance/Unpaid Area</td><td></td><td></td><td>845.44</td></tr>
<tr><td>U02</td><td>Concourse Paid Area</td><td></td><td></td><td>644.17</td></tr>
<tr><td>U03</td><td>Station Control Room (SCR)</td><td>7.48</td><td>3.14</td><td>23.48</td></tr>
<tr><td>U04</td><td>Station Manager Room (SMR)</td><td>3.45</td><td>9.15</td><td>31.56</td></tr>
<tr><td>U05</td><td>Ticket Office Cash Room (TOM)</td><td>3.45</td><td>8.50</td><td>29.32</td></tr>
<tr><td>U06</td><td>First Aid Room</td><td>2.91</td><td>2.75</td><td>8.00</td></tr>
<tr><td>U08</td><td>Security Room</td><td>4.15</td><td>2.75</td><td>11.41</td></tr>
<tr><td>U09</td><td>Store for Maintenance</td><td>8.51</td><td>3.73</td><td>31.74</td></tr>
<tr><td>U10</td><td>Cleaner’s Room</td><td>4.15</td><td>3.00</td><td>12.44</td></tr>
<tr><td>U11</td><td>Refuse Store</td><td>2.88</td><td>3.00</td><td>8.65</td></tr>
<tr><td>U12 (F)+T</td><td>Staff Locker Room (Female)</td><td>6.65</td><td>5.39</td><td>19.39</td></tr>
<tr><td>U12 (M)+T</td><td>Staff Locker Room (Male)</td><td>7.80</td><td>8.30</td><td>29.90</td></tr>
<tr><td>U13 (F)</td><td>Female Toilet</td><td>4.34</td><td>2.50</td><td>10.84</td></tr>
<tr><td>U13 (M)</td><td>Male Toilet</td><td>4.80</td><td>4.26</td><td>20.44</td></tr>
<tr><td>U13 (H)</td><td>Handicapped Toilet</td><td>2.00</td><td>4.26</td><td>8.52</td></tr>
<tr><td>U14</td><td>Signalling Room</td><td></td><td></td><td>30.02</td></tr>
<tr><td>U15</td><td>Tele Communication Room</td><td>5.83</td><td>6.84</td><td>39.87</td></tr>
<tr><td>U16</td><td>UPS Room</td><td>5.54</td><td>6.86</td><td>38.00</td></tr>
<tr><td>U17A & B</td><td>Platform</td><td></td><td></td><td>573.68</td></tr>
<tr><td rowspan="2">U18A & 18B</td><td>Auxiliary Substation</td><td></td><td></td><td>134.42</td></tr>
<tr><td>Electrical UPS Room</td><td>4.67</td><td>5.67</td><td>26.53</td></tr>
<tr><td rowspan="3">U21 & 22</td><td>Fire Fighting Tank</td><td rowspan="3">10.36</td><td rowspan="3">5.95</td><td rowspan="3">61.29</td></tr>
<tr><td>Pump Room</td></tr>
<tr><td>DG Room</td></tr>
</table>

- **Type E – Elevated Station with three tracks (Two for normal services and one for stabling)**

The size of such typology is **75m x 27.9m**. This specific type of station is a mid-terminal having three tracks for both boarding/alighting and access to stabling line. In this station type, 2.4m wide staircase is provided on one side of the platform and an escalator in up direction is provided on other side of the same platform and provision of 2 lifts has been proposed. The other platform is an island platform with provision of 2 escalators on one side and 1 no. 3.45m wide staircase on the other side along with provision of 2 nos. lifts. The room schedule for Type E is presented in **Table 6.8**. The typical plans for Type E are presented in **Figure 6.8.**

TABLE.6.8: ROOM SCHEDULE FOR STATION TYPE E

<table>
<tr><th>Room No.</th><th>Room Name</th><th colspan="2">Size of Room(m)</th><th>Area Provided (sq.m)</th></tr>
<tr><td>U01</td><td>Station Entrance/Unpaid Area</td><td></td><td></td><td>241.68</td></tr>
<tr><td>U02</td><td>Concourse Paid Area</td><td></td><td></td><td>693.29</td></tr>
<tr><td>U03</td><td>Station Control Room (SCR)</td><td>7.48</td><td>3.14</td><td>23.48</td></tr>
<tr><td>U04</td><td>Station Manager Room (SMR)</td><td>3.45</td><td>7.90</td><td>27.25</td></tr>
<tr><td>U05</td><td>Ticket Office Cash Room (T.O.M.)</td><td>3.45</td><td>9.19</td><td>31.70</td></tr>
</table>

<table>
<tr><th>Room No.</th><th>Room Name</th><th colspan="2">Size of Room(m)</th><th>Area Provided (sq.m)</th></tr>
<tr><td>U06</td><td>First Aid Room</td><td>2.91</td><td>2.35</td><td>6.83</td></tr>
<tr><td>U08</td><td>Security Room</td><td>4.15</td><td>2.35</td><td>9.75</td></tr>
<tr><td>U09</td><td>Store for Maintenance</td><td>8.51</td><td>2.81</td><td>19.06</td></tr>
<tr><td>U10</td><td>Cleaner’s Room</td><td>4.15</td><td>2.35</td><td>9.75</td></tr>
<tr><td>U11</td><td>Refuge Store</td><td>2.88</td><td>2.35</td><td>6.77</td></tr>
<tr><td>U12(F) + T</td><td>Staff Locker Room (Female)</td><td>6.65</td><td>5.38</td><td>15.77</td></tr>
<tr><td>U12(M) + T</td><td>Staff Locker Room (Male)</td><td>6.80</td><td>6.98</td><td>25.42</td></tr>
<tr><td>U13 (F)</td><td>Female Toilet</td><td>4.33</td><td>2.50</td><td>10.82</td></tr>
<tr><td>U13 (M)</td><td>Male Toilet</td><td></td><td></td><td>19.82</td></tr>
<tr><td>U13 (H)</td><td>Handicapped Toilet</td><td>2.00</td><td>4.13</td><td>8.26</td></tr>
<tr><td>U14</td><td>Signalling Room</td><td></td><td></td><td>47.25</td></tr>
<tr><td>U15</td><td>Tele Communication Room</td><td>5.79</td><td>6.81</td><td>39.44</td></tr>
<tr><td>U16</td><td>UPS</td><td>5.49</td><td>6.81</td><td>37.40</td></tr>
<tr><td>U17A, B & C</td><td>Platform</td><td>74.77</td><td>6.11</td><td>456.84</td></tr>
<tr><td rowspan="2">U18A & 18B</td><td>Auxiliary Substation</td><td></td><td></td><td>129.39</td></tr>
<tr><td>Electrical UPS Room</td><td>4.67</td><td>4.66</td><td>21.80</td></tr>
<tr><td rowspan="3">U21 & 22</td><td>Fire Fighting Tank</td><td rowspan="3">10.36</td><td rowspan="3">5.95</td><td rowspan="3">61.64</td></tr>
<tr><td>Pump Room</td></tr>
<tr><td>DG Room</td></tr>
<tr><td>U24</td><td>Room for Screen Doors</td><td>7.46</td><td>3.47</td><td>25.40</td></tr>
<tr><td>U25</td><td>Lost & Found Room</td><td>3.00</td><td>3.47</td><td>10.41</td></tr>
<tr><td>U26</td><td>Cabin Crew Room</td><td>4.00</td><td>3.47</td><td>13.80</td></tr>
</table>

ii. Typical Underground Stations

The typical underground stations consist of underground concourse and platform level. Certain typologies consist of upper and lower concourse depending upon the availability of land. The concourse level comprises of unpaid concourse, TOMs, AFC In and out Gates, public toilets (located in paid area) and EFO and few retail spaces. The lower concourse level houses all the passenger amenities, ECS plant rooms, electrical and S&T equipment rooms, station operation areas such as Station Control Room, Station Manager Room, Meeting Room, UPS & Battery Room, Signalling & Train Crew Room, etc. Platform level has platforms, tracks, seepage room, sewage room Tunnel ventilation room, Auxiliary Substation and similar ancillary spaces beyond the platforms on either side.

Ventilation shafts, equipment hatch, entrances and chiller plants for ECS plant are generally planned above ground on the open spaces by the road side. Two entrances have been provided to the station, one at each end. Entrances could be increased to 4 nos. as requirements based on traffic projections and better connectivity.

Structure of the underground station is essentially a concrete box whose height and width varies with the typology. Sides of the box are made of 0.8-1.2-m thick RCC walls. The ancillary building would accommodate the chiller room, pump room, water tanks at lower levels and DG & Cooler tower at surface level.

- **Type F - 130/140m x 26.55m x 3 levels**

The typical underground station is a three-level station with a platform level, lower concourse and upper concourse level. In this typology, the size of station has been kept as **130m x 26.55m** with 3 levels to ease construction and avoid hindrance to neighboring buildings due to space constraints.

Two banks of 2.4 m of staircases and 4 escalators have been designed from concourse to platform to meet the traffic demands. In addition, provision of lift has been made to bring passengers from concourse to platform level and vice versa.

Structure of the underground station is essentially a concrete box about 26.55-m wide, 18.75m high and 130m long with two intermediate slabs. The two entrances/exits at the road and upper concourse level and an ancillary building of about 18 m x 20m have been placed outside the box. The room schedule for Type F underground stations is presented in **Tables 6.9.** The typical plans of it are presented in **Figure 6.9**.

TABLE.6.9: ROOM SCHEDULE FOR STATION TYPE F

Room	Room Name	Room Size (m)		Area Provided (Sq.m)
U01	Station Entrance Unpaid Area			767.46
U02	Concourse Paid Area			737.89
U03	Station Control Room (SCR)	7.40	5.01	37.01
U04	Station Manager Room (SMR)	4.00	5.01	20.05
U05A	Ticket office machine (TOM)	5.70	3.10	17.67
U05B	Ticket office machine (TOM)	5.70	3.10	17.67
U07A	Excess Fare Office & Customer Care (EFO)	2.5	2.5	6.25
U07B	Excess Fare Office & Customer Care (EFO)	2.5	2.5	6.25
U09	Security Room	6.76	2.45	16.57
U12 & U13	Cleaners Room			23.23
U15L	Public Toilets(L)	2.90	2.45	7.10
U15G	Public Toilets(G)	4.80	2.45	11.75
U16	Mess Room	3.00	5.01	15.04
U19A	ECS Plant Room (ECS)			536.16
U19B	ECS Plant Room (ECS)			507.27
UNA-1	Unnamed area	5.00	5.48	27.43
UNA-2	Unnamed area	5.00	5.48	27.43
U25A	Auxiliary Sub-Station			158.45
U25B	Auxiliary Sub-station			150.20
U27A	Electrical UPS Room	5.00	4.40	21.99
U31A	Seepage Room	5.00	3.90	19.49
U31B	Seepage Room	5.20	4.40	22.88
U32	Sewage Room	5.20	3.89	20.26
U40	Fireman Access Staircase	1.20	10.69	12.82
U57	Platform supervisor's booth (PSB)	2.50	2.90	7.25
U19B	ECS Plant Room	25.31	21.53	507.27
U22	Signaling Equipment Room (SER)	5.25	5.01	26.32

Room	Room Name	Room Size (m)		Area Provided (Sq.m)
U23	Telecom Equipment Room (TER)	6.00	5.01	30.08
U24	UPS Room for S & T	13.55	5.01	67.95
U28	CDMA Room	4.00	5.01	20.05
U29	GSM Room	4.00	5.01	20.05
R1	Retail-1			188.49
R2	Retail-2	37.25	4.15	155.71
U51	Emergency Equipment Room	2.50	5.01	12.53

- **Type G – 170/180m x 24.6m x 2 levels**

The typical underground station with size **170/180m x 24.6m**is a two-level station with platforms at the lower level and concourse on the upper level.

Two banks of 2.4 m of staircases and 4 escalators have been designed from concourse to platform to meet the traffic demands. Platform width has been kept as 13m. Provision of one lift has been given to bring passengers from concourse to platform level and vice versa.
Structure of the underground station is essentially a concrete box about 24.6m wide, 14m high and 170/180m long with an intermediate slab. The two entrances/exits at the road and two ancillary buildings of about 50 m x 22 m and 28 m x 15 m respectively have been placed outside the box.

The room schedule for Type G underground stations is presented in **Table 6.10.** The typical plans of Type G are presented in **Figure 6.10.**

TABLE.6.10: ROOM SCHEDULE FOR UNDERGROUND STATION TYPE G

Room	Room Name	Room Size (m)		Area Provided (Sq.m)
U01(A)	Unpaid public area			537.40
U01	Station Entrance Unpaid Area			599.15
U02	Concourse Paid Area			1122.39
U03	Station Control Room (SCR)	10.55	4.66	49.23
U04	Station Manager Room (SMR)	2.50	4.66	11.66
U05A	Ticket office machine (TOM)	5.70	3.10	20.64
U05B	Ticket office machine (TOM)	5.70	3.10	20.64
U07A	Excess Fare Office & Customer Care (EFO)	2.5	2.5	6.25
U07B	Excess Fare Office & Customer Care (EFO)	2.5	2.5	6.25
U09	Security Room	4.00	4.65	18.65
U15L	Public Toilets(L)	4.25	4.66	19.82
U15G	Public Toilets(G)	4.25	4.66	19.82
U16	Mess Room	3.00	4.66	13.33
U18	DB Room	4.00	4.66	20.52
U19A	ECS Plant Room (ECS)			392.96
U19B	ECS Plant Room			411.22
U20A	Tunnel Ventilation Plant Room	13.00	23.95	311.34

U20B	Tunnel Ventilation Plant Room	12.90	20.99	270.77
U21	Platform Public Area			974.56
U22	Signaling Equipment Room (SER)	6.07	4.00	24.35
U23	Telecom Equipment Room (TER)	7.05	4.00	28.26
U24	UPS Room for S & T	5.35	8.01	42.85
U25A	Auxiliary Sub-Station			267.67
U25B	Auxiliary Sub-station			267.67
U27A	Electrical UPS Room	5.20	8.97	45.94
U27B	Electrical UPS Room	5.20	8.97	45.94
U28	CDMA Room	5.50	8.84	48.62
U29	GSM Room	5.50	8.84	48.62
U31A	Seepage Room	6.00	4.32	26.71
U31B	Seepage Room	6.00	4.32	26.71
U40A	Fireman Access Staircase	21.16	1.20	37.99
U40B	Fireman Access Staircase	8.92	1.32	13.73
U41B	Fireman Access Staircase	6.50	1.20	7.80
ST41.1	Staircase	2.60	6.15	15.99
ST41.2	Staircase	2.60	6.15	15.99
U43	Pump Room			189.67
U48	Chiller Plant Room			189.86
U51	Emergency Equipment Room	7.26	4.43	32.16
U57	Platform Supervisor’s Booth (PSB)	2.50	4.50	11.25
U58A	Ventilation Plenum			94.91
U58B	Ventilation Plenum			111.24
U63 & 64	E & M Staff & Store Room	6.63	4.66	30.92

- **Type H - 130m x 26.55m x 2 levels with concourse at ground level**

This typology is a two level underground station with concourse at grade. The size of this station type has been kept as **130m x 26.55m**. The at-grade concourse level comprises of unpaid concourse, TOMs, AFC (in and out Gates), public toilets (located in paid area) and EFO and retail spaces. One entrance houses the unpaid area having TOM's, TVM's, AFC's, etc to reach the paid area. Common passage leads to the staircases, lifts and escalators for reaching platforms.

Two banks of 2.4 m of staircases, 4 escalators and a lift have been designed from concourse to platform to meet the traffic demands. In addition, provision of lift has been done to bring passengers from concourse to platform level and vice versa.

Structure of the underground station is essentially a concrete box about 26.55-m wide and 130m long with two intermediate slabs.
The room schedule for Type H underground stations is presented in **Tables 6.11.** The typical plans of it are presented in **Figure 6.11**

TABLE.6.11: ROOM SCHEDULE FOR STATION TYPE H

ROOM	ROOM NAME	ROOM SIZE (m)		AREA PROVIDED (sq.m)
U01	Station Entrance Unpaid Area			257.00
U02	Concourse Paid Area			1644.36
U03	Station Control Room (SCR)	26.00	4.00	104.00
U04	Station Manager Room (SMR)	16.67	4.14	69.01
U05	Ticket office machine (TOM)	8.00	3.05	24.40
U07	Excess Fare Office & Customer Care (EFO)	2.50	2.50	6.25
U09	Security Room	6.22	2.94	18.30
U12 & U13	Cleaners Room	6.76	4.00	27.05
U15L/A, U15L/B	Public Toilets(L)	2.90	2.45	7.10
U15G/A, U15G/B	Public Toilets(G)	4.80	2.45	11.75
U16	Mess Room	3.00	5.01	15.04
U18	DB Room	5.19	5.01	26.02
U19A	ECS Plant Room (ECS)			536.16
U19B	ECS Plant Room (ECS)			507.27
U22	Signalling Equipment Room (SER)	7.4	5.01	37.10
U23	Telecom Equipment Room (TER)	6.00	5.01	30.06
U24	UPS Room for S & T	13.55	5.01	67.88
U28	CDMA Room	5.25	5.01	26.32
U29	GSM Room	6.00	5.01	30.08
U51	Emergency Equipment Room	6.7	5.01	33.59
UNA 1	Unnamed Area	5.00	5.48	27.43
UNA 2	Unnamed Area	5.00	5.48	27.43
UNA 3	Unnamed Area	7.19	5.61	40.33
R1	Retail 1			236.13
R2	Retail 2			339.95
R3	Retail 3	21.23	4.60	97.65
R4	Retail 4	22.73	4.60	104.56
U21	Platform Public Area			999.72
U25A	Auxiliary Sub-Station	14.20	10.50	158.45
U25B	Auxiliary Sub-station	13.39	10.50	150.20
U27A	Electrical UPS Room	5.00	4.40	21.99
U31A	Seepage Room	5.00	3.90	19.49
U31B	Seepage Room	5.20	4.40	22.88
U32	Sewage Room	5.20	3.89	20.26
U40	Fireman Access Staircase	1.20	10.69	12.82
U57	Platform supervisor’s booth (PSB)	2.50	2.90	7.25

- **Type I-130m x 26.55m x 1 level underground side platforms with concourse at ground level**

  This typology has one level of side platforms underground with concourse at grade. One side entry having unpaid concourse, TOMS, TVMs, AFCs, retail gives access to both the sides of the concourse building through 4.0 m wide passage.

  One 3.6 m wide staircase and one set of two up & down escalators have been proposed on either side of the platforms for access to concourse to meet the traffic demands. In addition, provision of one lift each on either side of the platform has been done to bring passengers from concourse to platform level and vice versa. Structure of the underground station is essentially a concrete box about 26.55m wide and 130m long.

The room schedule for Type I underground station is presented in **Tables 6.12.** The typical plans of it are presented in **Figure 6.12**.

TABLE.6.12: ROOM SCHEDULE FOR STATION TYPE I

ROOM	ROOM NAME	ROOM SIZE (m)		AREA PROVIDED (sq.m)
U01	Station Entrance Unpaid Area			444.58
U02	Concourse Paid Area			1824.99
U03	Station Control Room (SCR)	8.0	7.22	57.76
U04	Station Manager Room (SMR)	4.31	7.22	31.12
U05	Ticket office machine (TOM)	5.95	2.44	14.55
U07	Excess Fare Office & Customer Care (EFO)	2.5	2.5	6.25
U09	Security Room	3.0	3.0	9.0
U12 & U13	Cleaners Room	14.23	4.17	59.34
U14.1	Staff Toilet (G)	3.6	6.86	24.7
U14.2	Staff Toilet (L)			22.6
U15.1	Public Toilets(G)	3.59	7.2	25.9
U15.2	Public Toilets(L)			16.71
U16	Mess Room	10.04	4.17	40.9
U18	DB Room			49.75
U19A	ECS Plant Room (ECS)			480.98
U19B	ECS Plant Room (ECS)			517.14
U22	Signaling Equipment Room (SER)	9.81	4.17	40.9
U23	Telecom Equipment Room (TER)			57.65
U24	UPS Room for S & T			80.89
U25A	Auxiliary Sub-Station			364.4
U25B	Auxiliary Sub-station	10.0	18.4	184
U27A	Electrical UPS Room			61.74
U31A	Seepage Room	4.2	3.36	14.16
U31B	Seepage Room	4.2	3.36	14.16
U32	Sewage Room	4.36	3.39	14.7
U40	Fireman Access Staircase	5.1	2.65	13.53
U46	Toilet for Physically Handicapped	4.79	3.37	16.18
U51	Emergency Equipment Room	7.0	7.2	50.43
U63 & U64	E&M Staff Room and Store Room	14.23	4.17	59.34
U28	CDMA Room	7.0	5.69	49.89
U29	GSM Room	7.22	7.0	50.58
U43	Pump Room	18.40	15.90	292.68
U66	Room for Screen Door	4.0	4.98	19.92

- **Type J – Interchange station**

The underground section of Corridor 1 and the elevated section of Corridor-2 intersect at Agra College and facilitate interchange between the two corridors.

The entrance houses facilities for ticketing for corridors, lifts, stairs and escalators to reach the elevated, as well as, underground platforms. Passengers have to enter the common concourse and thereafter enter to paid area for both the stations for going to platforms. To enable seamless transfer of passengers between one line and another, it is proposed to connect the paid area of the proposed underground station with the paid area of the Elevated Station through a set of staircases and escalator to negotiate the height of 15-16mts between the two concourses of elevated and underground stations.

This type of station is projected to be one of the busiest stations due to interchange facility. There will be a large no. of passengers interchanging between the two lines as per traffic projections. The station has been sized accordingly. As the construction of elevated station could commence before or after the Underground Station, it is proposed to locate the elevated station such that it does not have any interference with the construction of the two underground tunnels of Corridor 1 passing beside it.

The platform level of the underground station is contained within a two-storied cut and cover structural box of 180 m x 26.55 m. The platforms are 15.4m below the ground level. The size of the island platform is 75 m x 13 m. Vertical circulation, in the form of two sets of, adequately sized, stairs and escalators have been provided in the Centre of the island platform, to cater to normal and emergency passenger movement for the design load. Separate firemen access stairs have also been provided at each station. Two to three entry/exits (including main common entry mentioned above) would have to be planned for ground to concourse connectivity for the underground interchange station.

The size of the elevated station is planned to be **80 m x 27.15m**. There are 2 side platforms of the elevated station at 13.310 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 two entry structures which are located to address the passengers’ catchment areas and local site constraints. There is commercial development proposed under and adjacent to the elevated station combined with the entrance lobby. In addition, elevators have been provided for the use of physically challenged passengers.

FIGURE 6.4: ELEVATED STATION – TYPE A

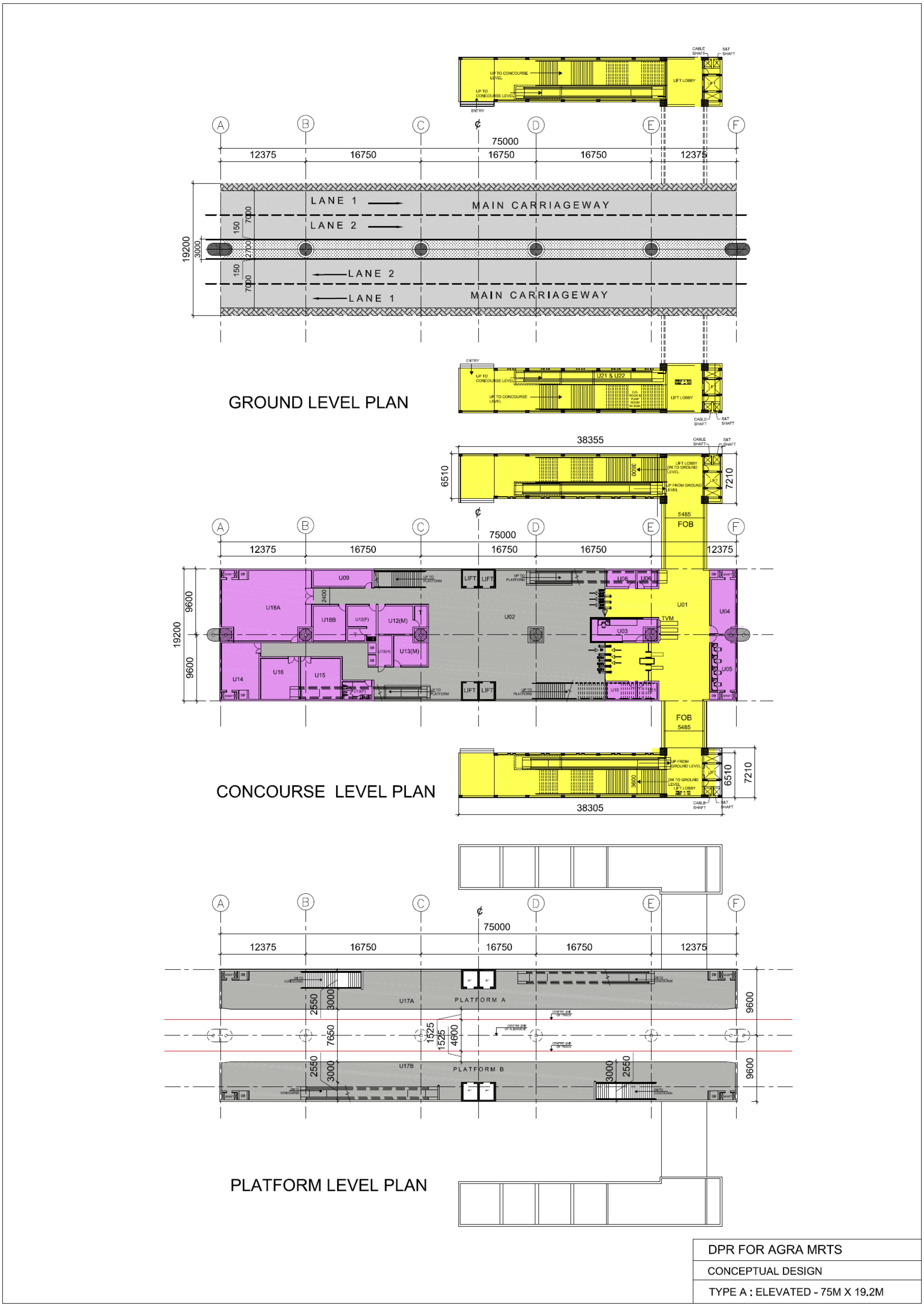


FIGURE 6.5: ELEVATED STATION – TYPE B

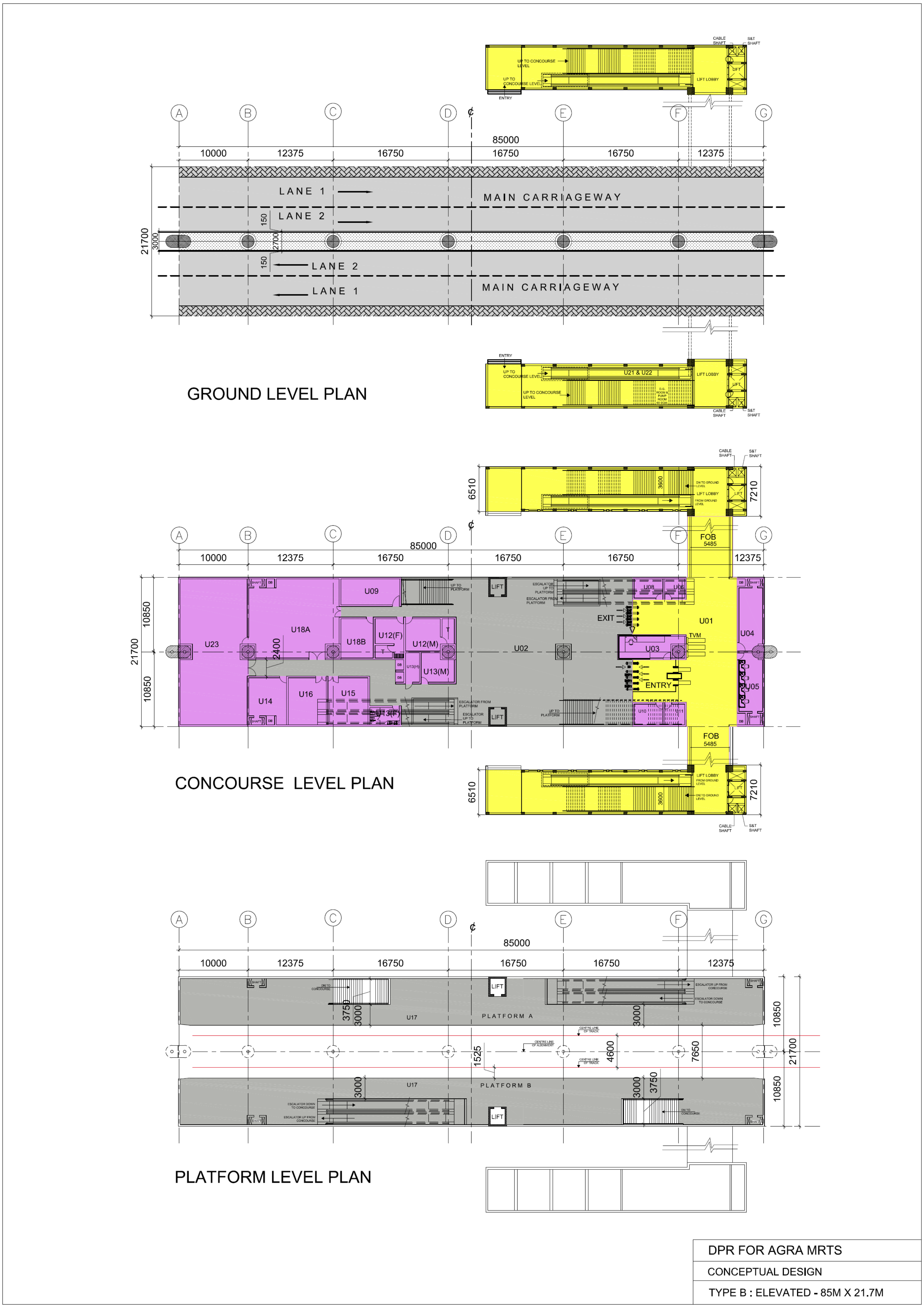


FIGURE 6.6: ELEVATED STATION – TYPE C

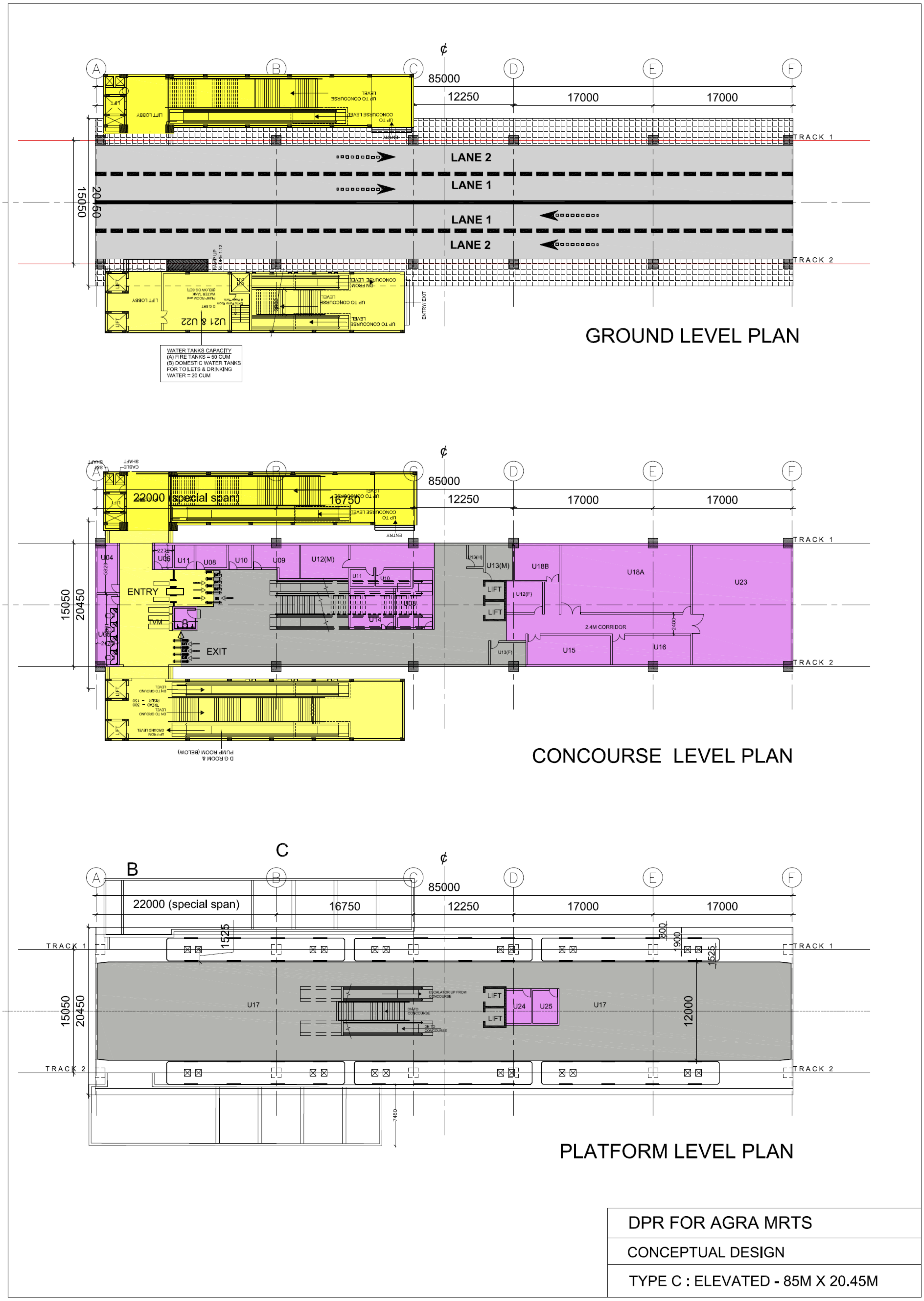


FIGURE 6.7: ELEVATED STATION – TYPE D

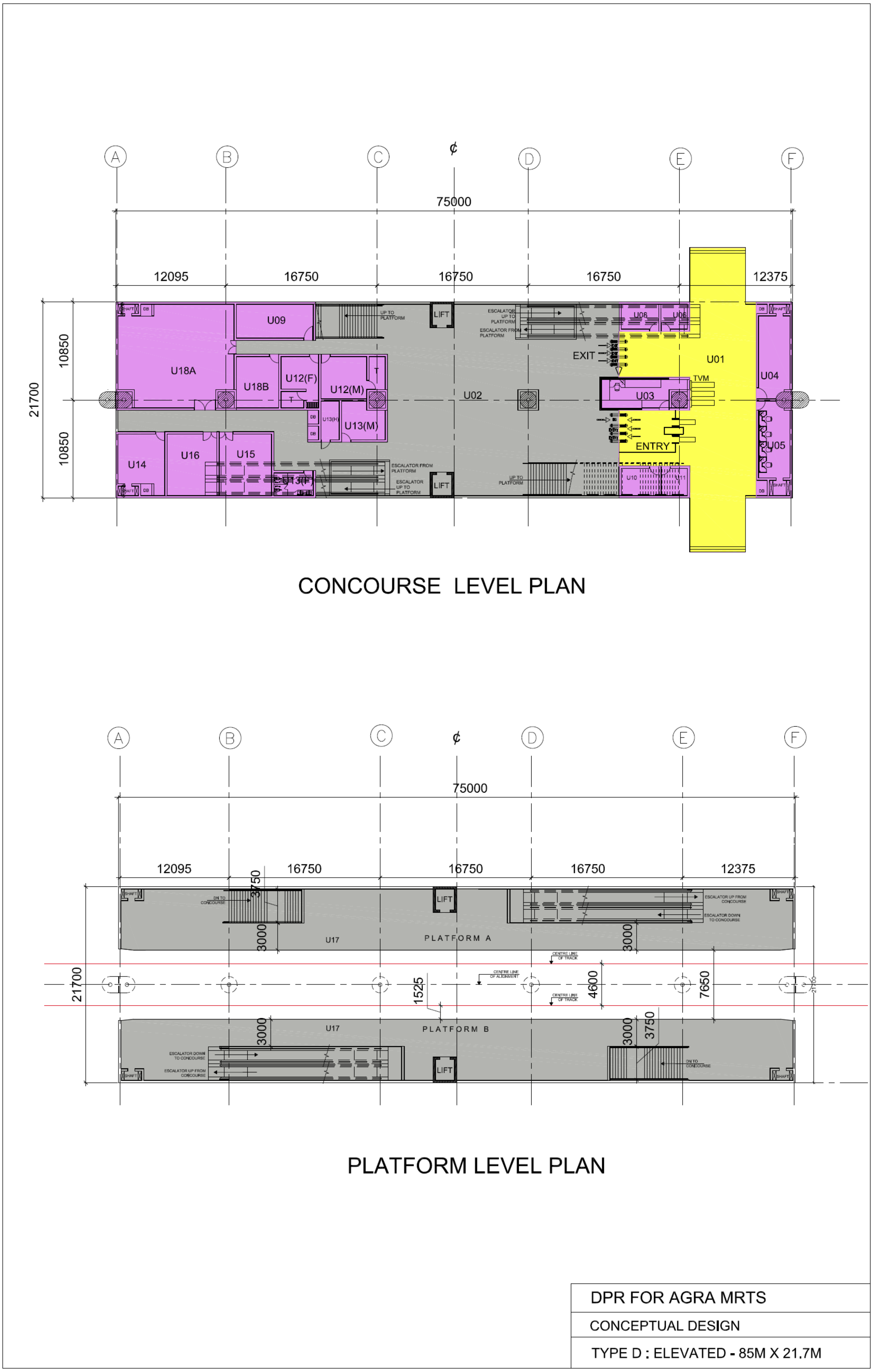


FIGURE 6.8: ELEVATED STATION – TYPE E

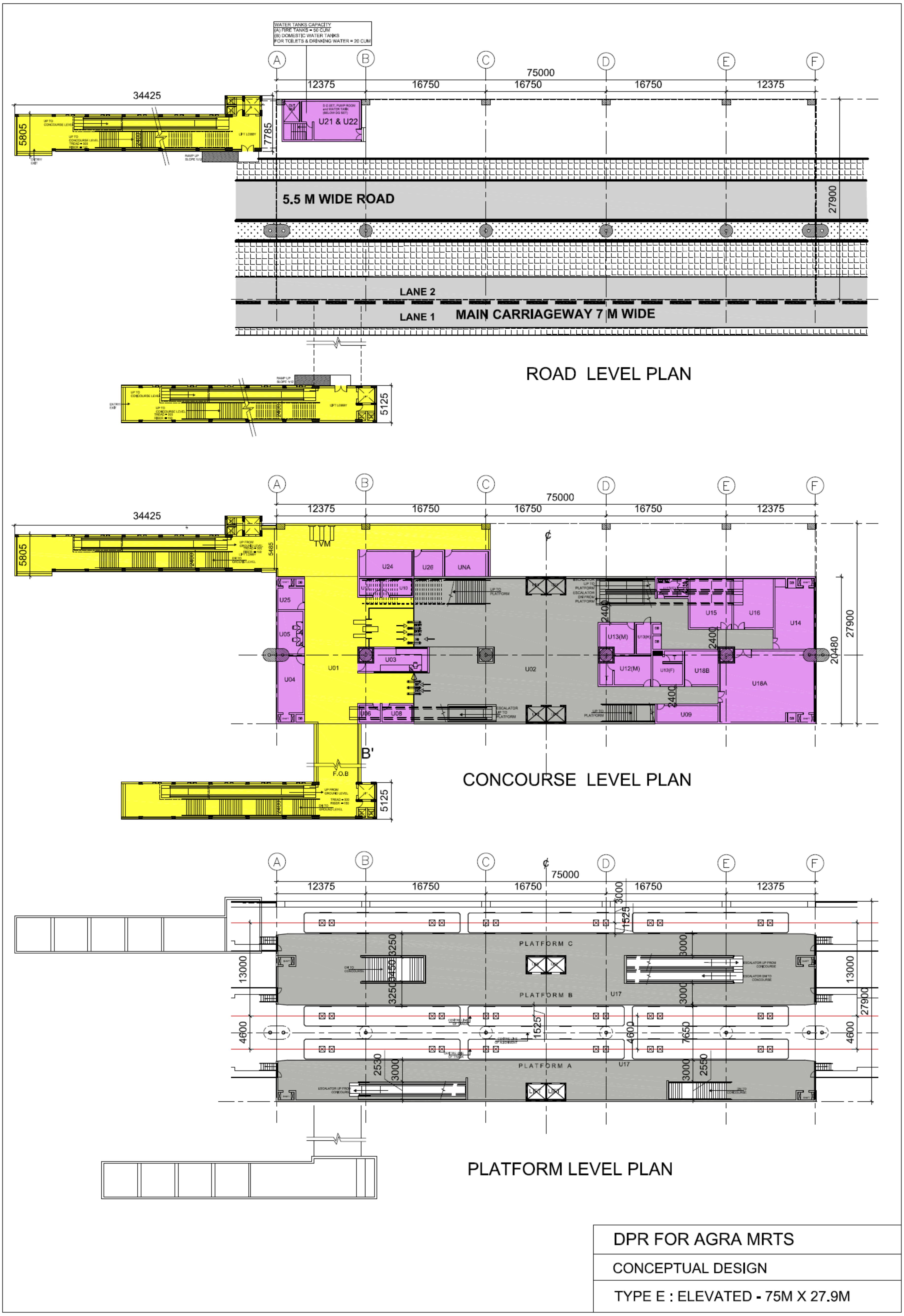


FIGURE 6.9: 3 LEVELS UNDERGROUND STATION – TYPE F

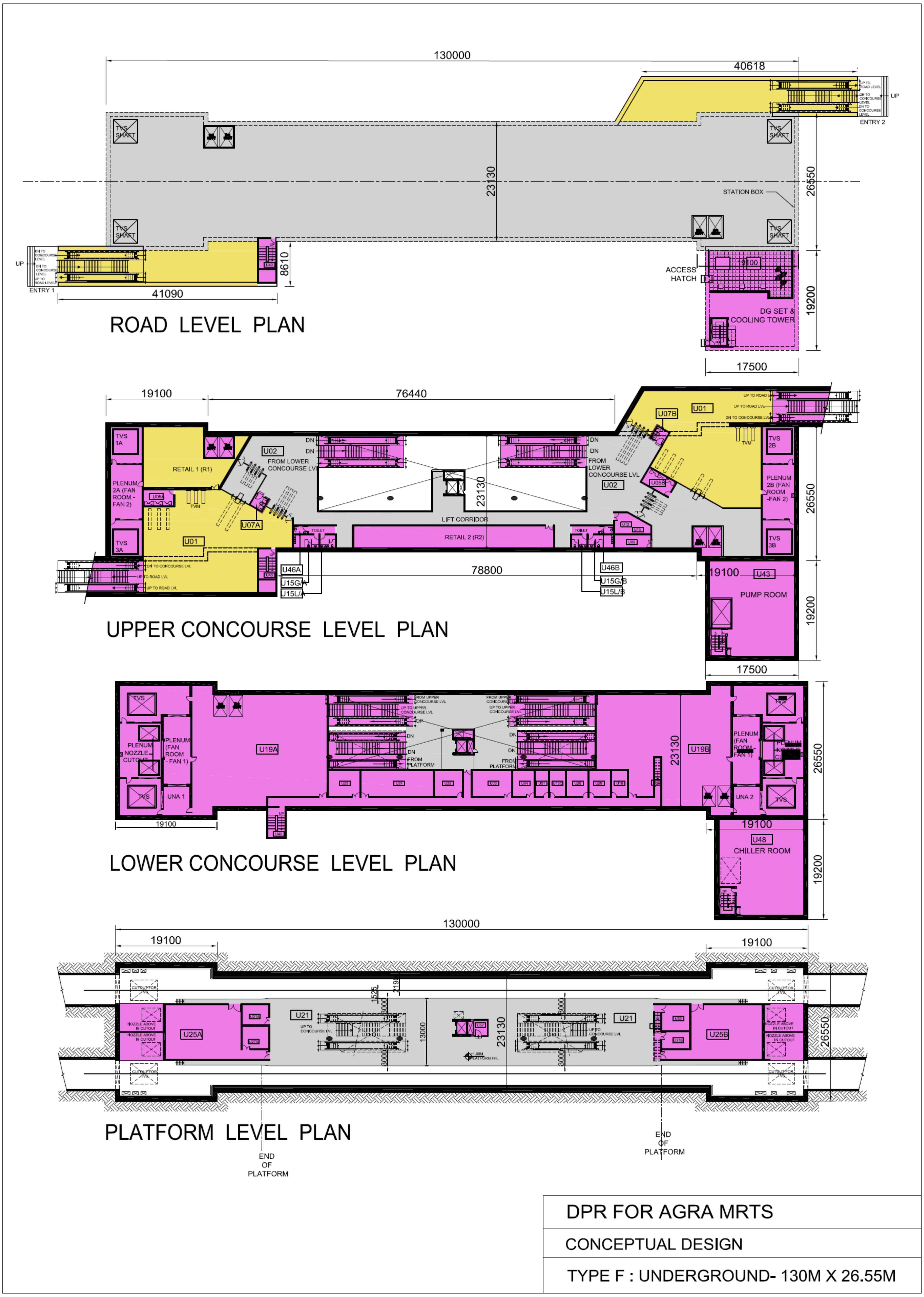
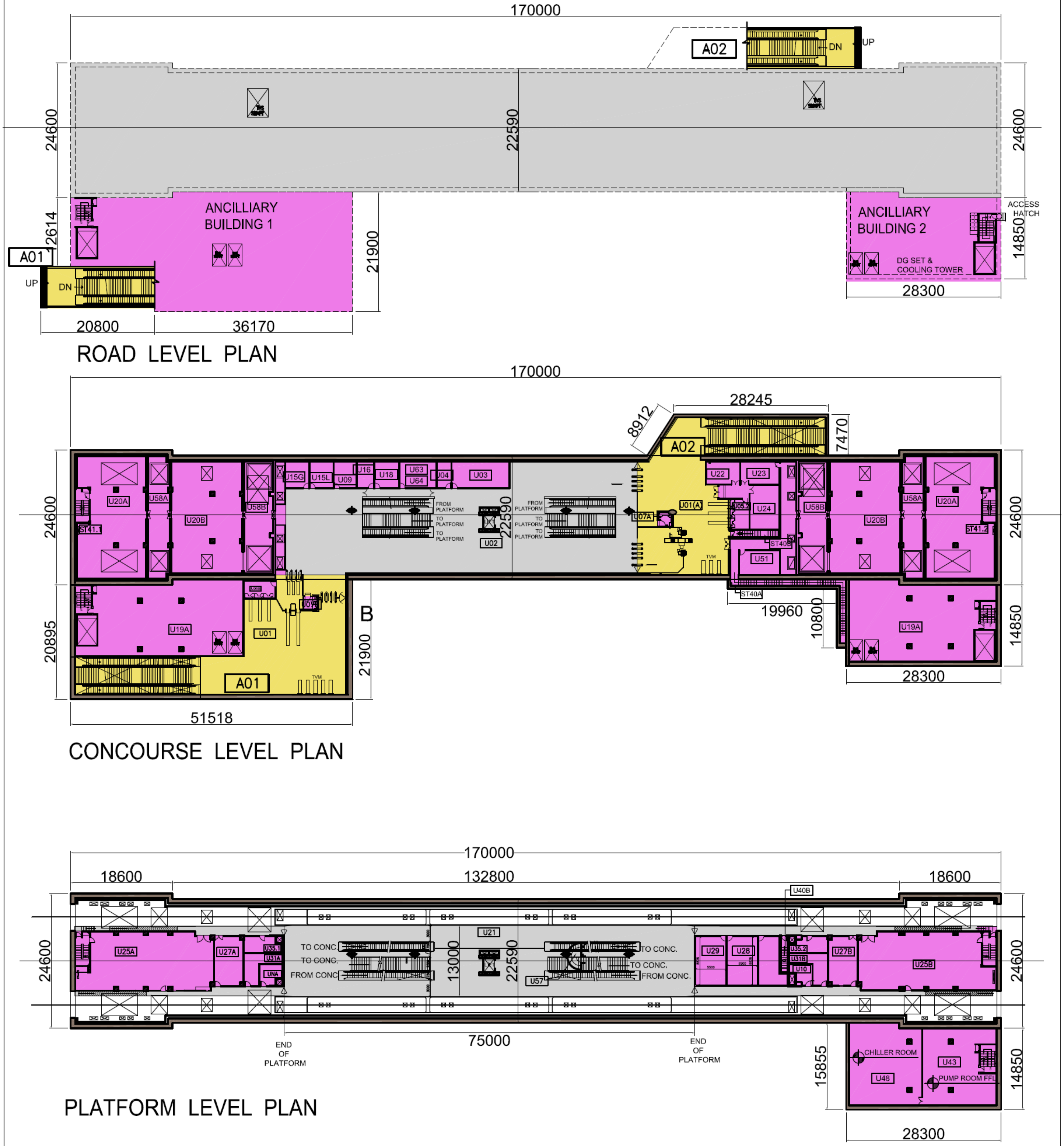


FIGURE 6.10: TWO LEVELS UNDERGROUND STATION – TYPE G



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TYPE G : TWO LEVEL UNDERGROUND- 170M X 24.6M

FIGURE 6.11: TWO LEVELS UNDERGROUND STATIONWITH AT-GRADE CONCOURSE– TYPE H

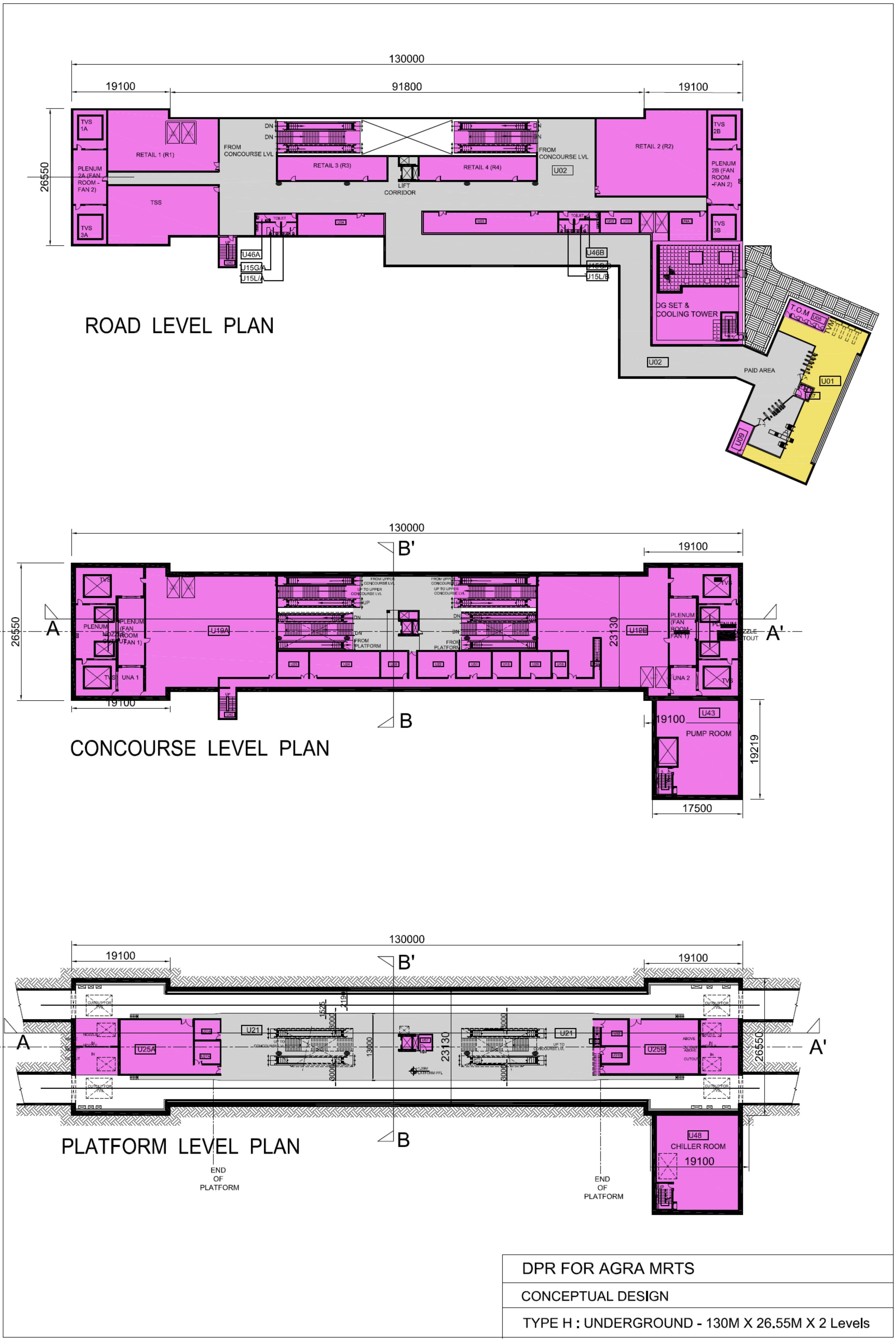
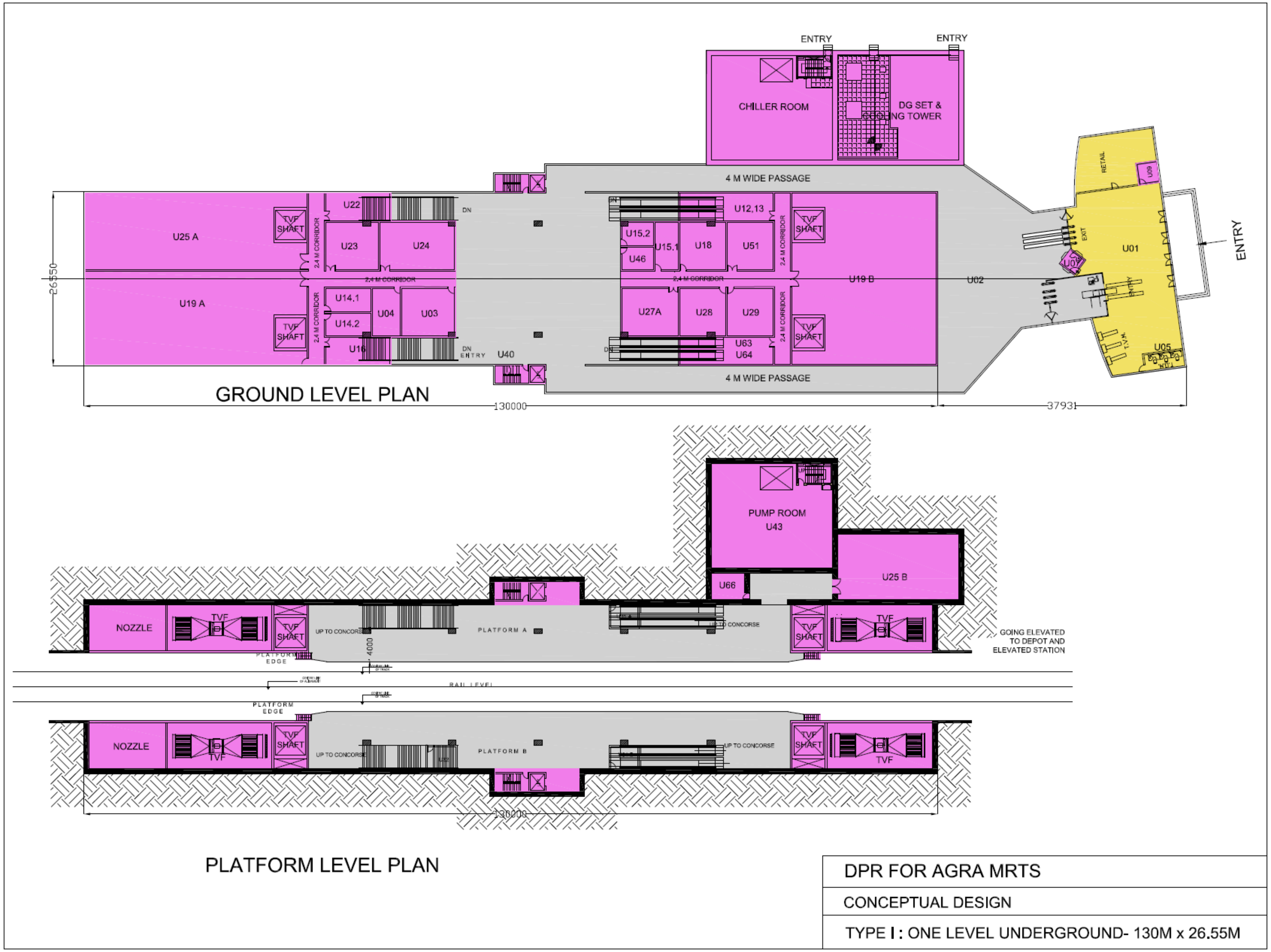


FIGURE 6.12: ONE LEVEL UNDERGROUND STATIONWITH AT-GRADE CONCOURSE– TYPE I



iii. Stations and their respective typologies of both the corridors

Station Types in Corridors 1 and 2 are presented in **Table 6.13.**

TABLE.6.13: STATIONS AT THEIR RESPECTIVE TYPOLOGIES

S. No.	Station Name	U/G or Elevated	Station Type
Corridor1: Sikandra to Taj East Gate			
1	Sikandra	Elevated	C
2	Guru Ka Taal	Elevated	A
3	ISBT	Elevated	A
4	Shastri Nagar	Elevated with concourse on ground	D
5	University	Underground, with Station Building At-surface	H
6	RBS College	Underground	F
7	Raja Ki Mandi	Underground	F
8	Agra College	Underground	J
9	Medical College	Underground	F
10	Jama Masjid	Underground	G
11	Agra Fort	Underground, with Station Building At-surface	G
12	Taj Mahal	Underground, with Station Building At-surface	I
13	Fatehabad Road	Elevated	B
14	Basai	Elevated	A
15	Taj East Gate	Elevated	B
Corridor2: Agra Cantt. to Kalindi Vihar			
1	Agra Cantt.	Elevated	C
2	Sultanpura*	Elevated	A
3	Sadar Bazar	Elevated	B
4	Partap-Pura	Elevated	B
5	Collectorate	Elevated	B
6	Subhash Park	Elevated	B
7	Agra College	Elevated	J
8	Hariparvat Chauraha	Elevated	A
9	Sanjay Place	Elevated	A
10	M.G.Road	Elevated	A
11	Sultan Ganj Crossing	Elevated	E
12	Kamla Nagar	Elevated	A
13	Ram Bagh	Elevated	A
14	Foundary Nagar	Elevated	A
15	Agra Mandi	Elevated	A
16	Kalindi Vihar	Elevated	A

*Future Station

6.1.4 Conceptual Design of 7 Metro Stations

The seven stations have been selected judiciously on the basis of the following:

S.No	Station	Remarks
1.	ISBT	Provides intermodal connectivity with the existing Inter State Bus Terminus
2.	Raja Ki Mandi	Intermodal connectivity with Raja Ki Mandi Railway Station
3.	Agra College	Interchange metro station between an underground station of Corridor 1 and an elevated station of Corridor 2
4.	Jama Masjid	Important station providing accessibility to Jama Masjid, Agra Fort, Agra Fort Railway Station and Bijli Ghar Bus Stand. It would also cater to the commercial areas of Hing Ki Mandi, Kinari Bazar and areas surrounding Jama Masjid.
5.	Agra Cantt.	Intermodal integration with Agra Cantt. Railway Station
6.	Sadar Bazar	Important station due to its catchment
7.	Sultanganj Crossing	Mid Terminal Station

i. ISBT –85 x 19.2m

ISBT is an elevated station which is located along NH 2 inside the proposed PD area. It is near to Inter State Bus Terminus. Station is proposed to be of two level, cantilevered structure of size 85m x 19.2m. It is planned to have 4 entry/exits,

- One, across NH 2 connected to the station through foot over bridge. This entry/exit is proposed to have a 2.4m wide staircase and an elevator.
- Second, adjacent to the station with a staircase 2.8m wide, 1 escalators and an elevator. DG Set, pump room and fire fighting water tank are provided below this entry structure.
- Third, along the road which is parallel to NH 2 leading to ISBT, with a 2.4m wide staircase and an elevator. The entry is connected to station by a foot over bridge.
- Fourth, adjacent to ISBT compound within the dedicated parking catering to intermodal connectivity with a 2.8m wide staircase, 1 no. escalator and an elevator. The entry is connected to station by a foot over bridge.

Four entry/exits meet at a common station entrance/unpaid area. 3 TVM's, 2TOM's, 7 AFC's for in and out have been provided at concourse wherein Passenger facilities like ticketing, information, etc. as well as operational areas are provided at the concourse level.

The Ground Level Plan, Concourse Level Plan, Platform Level Plan, Roof plan, Elevation and Sections for ISBT Station are presented in **Annexure 6.4 to 6.7.**

ii. Raja Ki Mandi – 140 X 26.55m

Raja Ki Mandi station is a three level underground station having station size of 140m x 26.55m.The length of this underground station has been kept as 140m to accommodate the Traction Substation to support 750 V DC third rail traction system.The station box consists of a platform level, lower concourse and upper concourse level to ease construction and avoid hindrance to Railway station operations and neighboring buildings. A separate ancillary building of about 15.5m x 21.5m has been proposed outside the station box near the station retiring room, accommodating chiller room, pump room, water tanks at lower levels and DG Set & cooler tower at surface level.

One entrance has been provided inside the railway station premise parallel to station forecourt area to cater to railway passengers. This entry inside the station has a staircase 2.4m wide, 2 escalators and an elevator and the second entry/exit is near Ravi Hospital with a 4m wide staircase, 2 escalators and an elevator.

The two entry/exits lead to unpaid areas in the upper concourse level where 8 TVM's, 18 AFC's, 12 TOM's have been provide. The upper concourse level comprises of unpaid concourse, TOMs, AFC In and out Gates, public toilets (located in paid area) and EFO and few retail spaces. The lower concourse level has, in addition to the concourse, all the passenger amenities, ECS plant rooms, electrical and S&T equipment rooms, station operation areas such as Station Control Room, Station Manager Room, Meeting Room, UPS & Battery Room, Signalling & Train Crew Room, etc. Platform level has platforms, tracks, seepage room, sewage room Tunnel ventilation room, Auxiliary Substation and similar ancillary spaces beyond the platforms on either side.

The Ground Level Plan, Concourse Level Plan, Platform Level Plan and Sections for Raja Ki Mandi Station are presented in **Annexure 6.8 to 6.10.**

iii. Agra College (Interchange Station)

Agra College station is an interchange between Underground and Elevated Station of Corridor-1 and Corridor-2, respectively. To enable seamless transfer of passengers between one line and another, it is proposed to connect the paid area of the proposed underground station with the paid area of the elevated Agra College through a set of staircases and escalators to negotiate the height of 15.51M between the two concourses of elevated and underground stations.

This station is likely to be one of the busiest stations owing to the Interchange facility. There will be a large no. of passengers interchanging between the two lines. The station has been sized accordingly. The structural arrangement of columns of the elevated station (27.15 m X 80 m) is proposed to allow the construction of the two underground tunnels of Corridor 2 passing under the elevated station in future. The platform level of the underground station is contained within a two storied cut and cover structural box of 180 m x 26.55 m. The platforms are 14.3 m below the ground level. The size of the island platform is planned as

140 m x 13 m.

There are 2 side platforms of the elevated station at 13.31 m above ground level with a full length concourse between platforms and ground. A common entrance lobby at ground level has been planned with 18 ticket counters and 20 AFC gates for in and out. A passenger can go to the elevated or underground from this entrance. Apart from the common entrance, there are three separate entry/exit structures which are located to address the passengers' catchment areas and local site constraints. The elevated station has been provided with 2 entry/exits i.e.

- one at-grade entrance into a common lobby which facilitates paid to paid interchange
- Another, across the road within the premises of Sahid Bhagat Singh Boys Hostel with a 4m wide staircase, 2 nos. escalators and an elevator.

The underground station is provided with 2 nos. entry/exits apart from the common lobby entrance.

- One entry/exit with a 4 m wide staircase and 2 escalators is provided next to a Masjid on the road parallel to the station
- Second, provided with a 4m wide staircase and an elevator in front of SBI Bank.

The Ground Level Plan, Concourse Level Plan, Platform Level Plan, Roof plan, Elevation and Cross Section for Agra College are presented in **Annexure 6.11 to 6.15.**

iv. Jama Masjid – 170 x 24.6m

Jama Masjid station is a two level underground station of size **170m x 24.6m** comprising of concourse and platform level. The station is located in the vicinity of Agra Fort Railway Station and Bijli Ghar bus stand thereby catering to intermodal connectivity. As this station is located at a distance of approx. 1.5km from the next station, it would cater to the densely populated commercial areas of Hing ki Mandi, Kinari Bazaar and surrounding areas around Jama Masjid.

Three set of entrances have been planned to bring the passengers to the station located near the Bijli Ghar bus stand, Ram Lila Maidan and Agra Fort Railway Station. First entry/exit with a 2.85m staircase, escalator and an elevator caters to Agra Fort and Ram Lila Maidan and is proposed across the existing nala. The second entrance across Dr. Ambedkar Park, with a 2.85m staircase, escalator and an elevator caters to Jama Masjid and Agra Fort Railway Station. The third entry/exit towards Bijli Ghar bus stand is proposed to have a staircase, 2 nos. escalators and an elevator and caters to the dedicated parking cum property development area and Bijli Ghar Bus Stand, proposed above and around the station box.

The station box consists of station operational, functional, public and non-public areas with two separate ancillary structures accommodating the ECS Plant Rooms, Chiller rooms, UG

Tanks and DG Sets. The entry/exits lead to unpaid areas in the concourse level where 24 AFC's, 10 TOM's and 6 TVM's have been provided in both the station entrances.

The Ground Level Plan, Concourse Level Plan, Platform Level Plan and Cross Section for Jama Masjid Station are presented in **Annexure 6.16 to 6.18.**

v. Agra Cantt. – 85 x 20.45m

Agra Cantt. is an elevated terminal station of 85 x 20.45m size located perpendicular to Agra Cantt. Railway station. The length of this elevated station has been kept as 85m to accommodate the Traction Substation to support 750 V DC third rail traction system.
The station is proposed to be on portals with a full concourse. A special span of 22m is planned so that the station pillars do not obstruct the road which is passing underneath the station box.

A single entry/exit connecting ground to concourse level is provided in the station catering to the passenger traffic coming from the railway station and surrounding sparsely populated neighbourhood. A staircase of 3m width, 2 nos. escalators and 2 nos. elevators are provided. It leads to unpaid area at the concourse level where 3 TVM's, 6 TOM's, 9 AFC's for both in and out passenger flow have been provided along with other B.O.H, operational rooms and set of elevators/escalators/staircase for accessing platforms.

The Ground Level Plan, Concourse Level Plan, Platform Level Plan, Roof plan, Elevation and Cross Sections for Agra Cantt. station is presented in **Annexure 6.19 to 6.22.**

vi. Sadar Bazar – 85 x 21.7m

Sadar Bazar is a two-level station with station size of **85m X 21.7m**. It is designed as a cantilever structure for column free space considering the present RoW of the road. The length of the station is kept as 85m to accommodate the Traction Substation to support 750V DC third rail traction system.

This station is planned for high passenger volumes and therefore, three entry/exits have been proposed ,two along MG Road and one entry/exit towards Sadar Bazar road.

The first entry with 3m staircase, 2 escalators and a lift is proposed in front of Army Medical Corps. Second, entry with a staircase of 3m and an escalator is proposed in front of Eklabya Sports Stadium and is in close proximity to the proposed parking and PD area. The third entry has a staircase of 2.6m width and is proposed on the Sadar Bazar Road.

The three entry/exits lead to unpaid area at the concourse level where 3 TVM's, 12 TOM's, 20 AFC's for both in and out passenger flow have been provided with other B.O.H, operational rooms and set of elevators/escalators/staircase for accessing platforms.

The Ground Level Plan, Concourse Level Plan, Platform Level Plan, Roof plan, Elevation and Sections for Sadar Bazar Station are presented in **Annexure 6.23 to 6.26.**

vii. Sultanganj Crossing – 75 x 27.9m

Sultanganj metro station is planned to be a mid terminal station of size 75m x27.9m located at the north of NH 2 on the available open space. It is proposed to have three tracks, one for stabling and two for normal operations. The station has 2 nos. platforms with one platform being an island platform catering to 2 tracks and a side platform serving the third track.

It is planned as a partial cantilevered structure and part of it is placed on portals. This has been done to avoid any hindrance of station columns on the highway as portion of it projects over the highway. Also, since there is a flyover proposed on NH 2 immediately beside the station, portion of the station has been cantilevered to make provision for service/slip road beside the flyover.

Two set of entrances with 2.4m wide staircase, an escalator and 1 elevator are located adjacent to the station and across the highway near Saket Mall, respectively. At grade ancillary building is planned adjacent to the north entry/exit where pump room, firefighting water tanks and DG room are accommodated.

These entry/exits leads to concourse level where 3 TVM's, 2 TOM's, 7 AFC's for both in and out passenger flows have been provided along with other B.O.H, operational rooms and set of elevators/escalators/staircase for accessing platforms.

The Ground Level Plan, Concourse Level Plan, Platform Level Plan, Roof plan, Elevation and Cross Sections for Sultanganj Crossing Station are presented in **Annexure 6.27 to 6.30.**

6.2. STATION AREA PLANNING FOR NON-MOTORIZED VEHICLE AND PEDESTRIANS FACILITIES

The following pedestrian facilities 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

- A minimum of 1.8m wide footpath has been proposed on the local roads whereas a continuous footpath of 2 m width on the major roads to provide accessibility to people on wheel chairs.

- 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 THE 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 planned within the station influence area for smooth circulation based on 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 by Ministry of Home and Urban Affairs 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 differently abled features as proposed in a metro station.

FIGURE 6.15: VARIOUS 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 ON STATIONS

Dedicated parking provision for metro are key factors in determining success of a metro system. Parking provisions along pedestrian facilities like footpath and feeder systems would encourage more commuters to use the transit system who could safely park their vehicles at the nearest station, walk to the station or rely on feeder connectivity. The tentative station wise parking facility area for personal vehicles and bicycle as planned along both the Phase I metro corridors is presented in **Table 6.14.**

TABLE 6.14: DETAILS OF PARKING FOR PHASE-I CORRIDORS

S. No.	Metro Station/Location	Parking Area in Sqm
Corridor-1 (Sikandra to Taj East Gate)		
1	Sikandara	14840
2	Guru Ka Taal	2975
3	ISBT	10000
4	Agra College	1400
5	Jama Masjid	16000
Corridor 2 Agra Cantt To Kalindi Vihar		
7	Sadar Bazar	2200
8	Subhash Park	7000
9	M.G.Road	6900
10	Ram Bagh	9700
11	Agra Mandi	24500
Total along the Corridor		**95515**

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.

ANNEXURE 6.1: EGRESS REQUIREMENTS (PLATFORM TO CONCOURSE) AND PLATFORM CALCULATIONS – 2051

S No	Station Name	Direction 1					Headway	Evacuation Time	Direction 2					Platform width			Platform Net Area		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**	**Width Provided**	**Net Area Required**	**Net Area Provided**	**Direction1**	**Direction 2**	**Provided**
Corridor 1 Sikandra to Taj East Gate																					
1	Sikandara	7270	146	0	0	832	1.9	5.5	0	0	7,800	247	247	2.22	0.66	3	166.44	393.3	2.40	0.71	4.45
2	Guru Ka Taal	3612	73	7,300	231	647	1.9	5.5	1548	31	11,500	364	541	1.73	1.44	3	129.45	360.33	1.87	1.56	3
3	ISBT	966	20	10,400	329	443	1.9	5.5	414	8	12,900	409	456	1.18	1.22	3	91.14	331.32	1.28	1.32	2.4
4	Shastri Nagar	966	20	11,800	374	488	1.9	5.5	414	8	12,800	405	453	1.30	1.21	3	97.53	331.32	1.41	1.31	2.4
5	University	1554	32	11,900	377	585	1.9	4	666	13	16,300	516	653	1.56	1.74	13	130.58	806.7	2.61	2.91	9.3
6	RBS College	2156	44	13,700	434	720	1.9	4	924	18	16,300	516	705	1.92	1.88	13	143.95	806.7	3.21	3.15	9.3
7	Raja Ki Mandi	7182	144	13,600	431	1368	1.9	4	3078	62	23,700	751	1375	3.65	3.67	13	275.00	806.7	6.11	6.14	9.3
8	Agra College	10304	207	22,500	713	2060	1.9	4	4416	88	15,800	500	1397	5.49	3.73	13	412.04	1035.25	9.20	6.24	12.9
9	Medical College	4431	89	12,200	386	966	1.9	4	1899	38	15,300	485	870	2.58	2.32	13	193.16	806.7	4.31	3.88	9.3
10	Jama Masjid	8582	172	10,100	320	1440	1.9	4	3678	74	15,100	478	1224	3.84	3.26	13	288.00	974.55	6.43	5.47	9.3
11	Agra Fort	2653	54	9,500	301	652	1.9	4	1137	23	15,100	478	710	1.74	1.89	13	142.08	974.55	2.91	3.17	9.3
12	Taj Mahal	1813	37	9,200	291	502	1.9	5.5	777	16	13,300	421	510	1.34	1.36	3	101.95	331.32	1.45	1.47	2.4
13	Fatehabad Road	3689	74	7,700	244	666	1.9	5.5	1581	32	12,200	386	567	1.78	1.51	3	133.13	393.3	1.92	1.64	4.45
14	Basai	2471	50	7,600	241	526	1.9	5.5	1059	21	7,250	230	350	1.40	0.93	3	105.13	331.32	1.52	1.01	2.4
15	Taj East Gate	0	-	5,000	158	158	1.9	5.5	7250	145	0	0	827	0.42	2.20	3	165.30	360.33	0.46	2.39	4.45
Corridor 2 Agra Cantt To Kalindi Vihar																					
1	Agra Cantt.	4910	99	0	0	505	1.7	5.5	0	0	4,400	125	125	1.35	0.33	3	100.98	331.32	1.46	0.36	2.4
2	Sadar Bazar	10983	220	4,900	139	1261	1.7	5.5	4707	94	13,100	371	851	3.36	2.27	3	252.17	393.3	3.64	2.46	4.45
3	Partap-Pura	7455	150	18,600	527	1292	1.7	5.5	3195	64	18,000	510	836	3.45	2.23	3	258.40	393.3	3.73	2.41	4.45
4	Collectorate	1344	27	27,300	774	911	1.7	5.5	576	12	18,700	530	589	2.43	1.57	3	182.24	393.3	2.63	1.70	4.45
5	Subhash Park	2422	49	27,800	788	1038	1.7	5.5	1038	21	20,200	572	678	2.77	1.81	3	207.51	393.3	2.99	1.96	4.45
6	Agra College	15113	303	27,400	776	2322	1.7	5.5	6477	130	18,100	513	1173	6.19	3.13	3.25	464.33	552.75	6.70	3.39	8.3
7	Hariparvat Chauraha	2877	58	26,300	745	1041	1.7	5.5	1233	25	18,400	521	647	2.78	1.73	3	208.19	331.32	3.00	1.87	4.8
8	Sanjay Place	1505	31	24,500	694	852	1.7	5.5	645	13	19,000	538	604	2.27	1.61	3	170.45	360.33	2.46	1.74	3
9	M.G.Road	1673	34	21,000	595	768	1.7	5.5	717	14	18,800	533	606	2.05	1.62	3	153.68	360.33	2.22	1.75	3
10	Sultan Ganj Crossing	959	20	20,800	589	691	1.7	5.5	411	8	18,600	527	569	1.84	1.52	3	138.27	331.32	2.00	1.64	2.4
11	Kamla Nagar	2408	49	19,900	564	814	1.7	5.5	1032	21	16,600	470	576	2.17	1.53	3	162.75	360.33	2.35	1.66	3
12	Ram Bagh	3689	74	18,400	521	899	1.7	5.5	1581	32	16,800	476	637	2.40	1.70	3	179.75	360.33	2.59	1.84	3
13	Foundary Nagar	2569	52	14,700	417	682	1.7	5.5	1101	22	16,800	476	588	1.82	1.57	3	136.34	331.32	1.97	1.70	2.4
14	Agra Mandi	3374	68	14,700	417	763	1.7	5.5	1446	29	7,600	215	363	2.04	0.97	3	152.66	360.33	2.20	1.05	3
15	Kalindi Vihar	0	-	7,100	201	201	1.7	5.5	7610	152	0	0	776	0.54	2.07	3	155.24	360.33	0.58	2.24	3

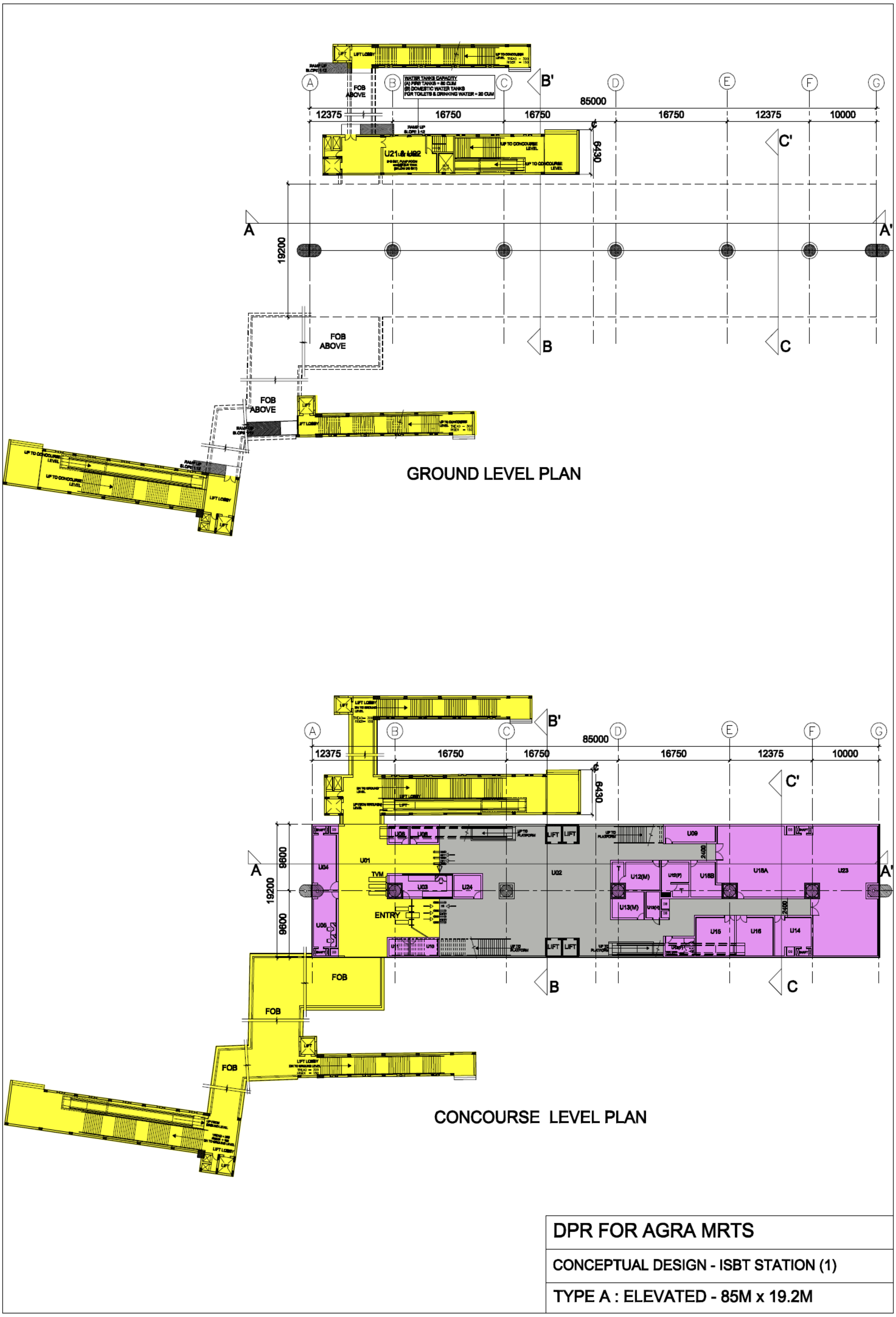
ANNEXURE 6.2: EVACUATION TIME CALCULATIONS - 2051

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) G-C		
							Direction 1	Direction 2	Direction 1	Direction 2	Total	Normal conditions	Abnormal conditions	Staircase	Escalator	Provided
Corridor 1 Sikandra to Taj East Gate																
1	Sikandara	7270	7810	145.4	156.2	301.6	832	297	166	59	226	4.79	3.58	5.2	1	6.2
2	Guru Ka Taal	5160	5630	103.2	112.6	215.8	647	59	129	12	141	3.43	2.24	5.2	0	5.2
3	ISBT	1380	1400	27.6	28	55.6	443	16	89	3	92	0.88	1.46	7.6	1	8.6
4	Shastri Nagar	1380	1130	27.6	22.6	50.2	488	16	98	3	101	0.80	1.60	2.4	0	2.4
5	University	2220	3810	44.4	76.2	120.6	585	25	167	7	174	2.15	3.11	5.7	1	6.7
6	RBS College	3080	3160	61.6	63.2	124.8	720	35	206	10	216	2.23	3.85	5.7	3.5	9.2
7	Raja Ki Mandi	10260	8730	205.2	174.6	379.8	1368	117	391	33	424	6.78	7.58	5.7	4.5	10.2
8	Agra College	14720	17160	294.4	343.2	637.6	2060	168	589	48	637	11.39	11.37	8.55	6	14.55
9	Medical College	6330	7850	126.6	157	283.6	966	72	276	21	297	5.06	5.30	5.7	3.5	9.2
10	Jama Masjid	12260	12740	245.2	254.8	500	1440	140	411	40	451	8.93	8.06	8.1	2.5	10.6
11	Agra Fort	3790	4090	75.8	81.8	157.6	652	43	186	12	199	2.81	3.55	5.7	2.5	8.2
12	Taj Mahal	2590	2310	51.8	46.2	98	502	30	100	6	106	1.56	1.69	5.2	0	5.2
13	Fatehabad Road	5270	4260	105.4	85.2	190.6	666	60	133	12	145	3.03	2.30	5.2	0	5.2
14	Basai	3530	3600	70.6	72	142.6	526	40	105	8	113	2.26	1.80	5.2	0	5.2
15	Taj East Gate	7250	5000	145	100	245	190	276	38	55	93	3.89	1.48	5.2	0	5.2
Corridor 2 Agra Cantt To Kalindi Vihar																
1	Agra Cantt.	4910	4400	98.2	88	186.2	505	150	101	30	131	2.96	2.08	2.8	1	3.8
2	Sadar Bazar	15690	10640	313.8	212.8	526.6	1261	160	252	32	284	8.36	4.51	8	2	10
3	Partap-Pura	10650	6350	213	127	340	1292	109	258	22	280	5.40	4.45	5.2	0	5.2
4	Collectorate	1920	2110	38.4	42.2	80.6	911	20	182	4	186	1.28	2.95	5.2	0	5.2
5	Subhash Park	3460	5960	69.2	119.2	188.4	1038	35	208	7	215	2.99	3.41	5.2	1	6.2
6	Agra College	21590	20570	431.8	411.4	843.2	2322	220	464	44	508	13.38	8.07	12.4	1	13.4
7	Hariparvat Chauraha	4110	6180	82.2	123.6	205.8	1041	42	208	8	217	3.27	3.44	5.2	0	5.2
8	Sanjay Place	2150	6220	43	124.4	167.4	852	22	170	4	175	2.66	2.78	5.2	0	5.2
9	M.G. Road	2390	2460	47.8	49.2	97	768	24	154	5	159	1.54	2.52	5.2	0	5.2
10	Sultan Ganj Crossing	1370	1980	27.4	39.6	67	691	14	138	3	141	1.06	2.24	5.2	0	5.2
11	Kamla Nagar	3440	3040	68.8	60.8	129.6	814	35	163	7	170	2.06	2.69	4.8	0	4.8
12	Ram Bagh	5270	9150	105.4	183	288.4	899	54	180	11	190	4.58	3.02	2.8	1	3.8
13	Foundary Nagar	3670	4440	73.4	88.8	162.2	682	37	136	7	144	2.57	2.28	4.8	0	4.8
14	Agra Mandi	4820	3220	96.4	64.4	160.8	763	49	153	10	162	2.55	2.58	4.8	0	4.8
15	Kalindi Vihar	7610	7090	152.2	141.8	294	241	259	48	52	100	4.67	1.59	4.8	0	4.8

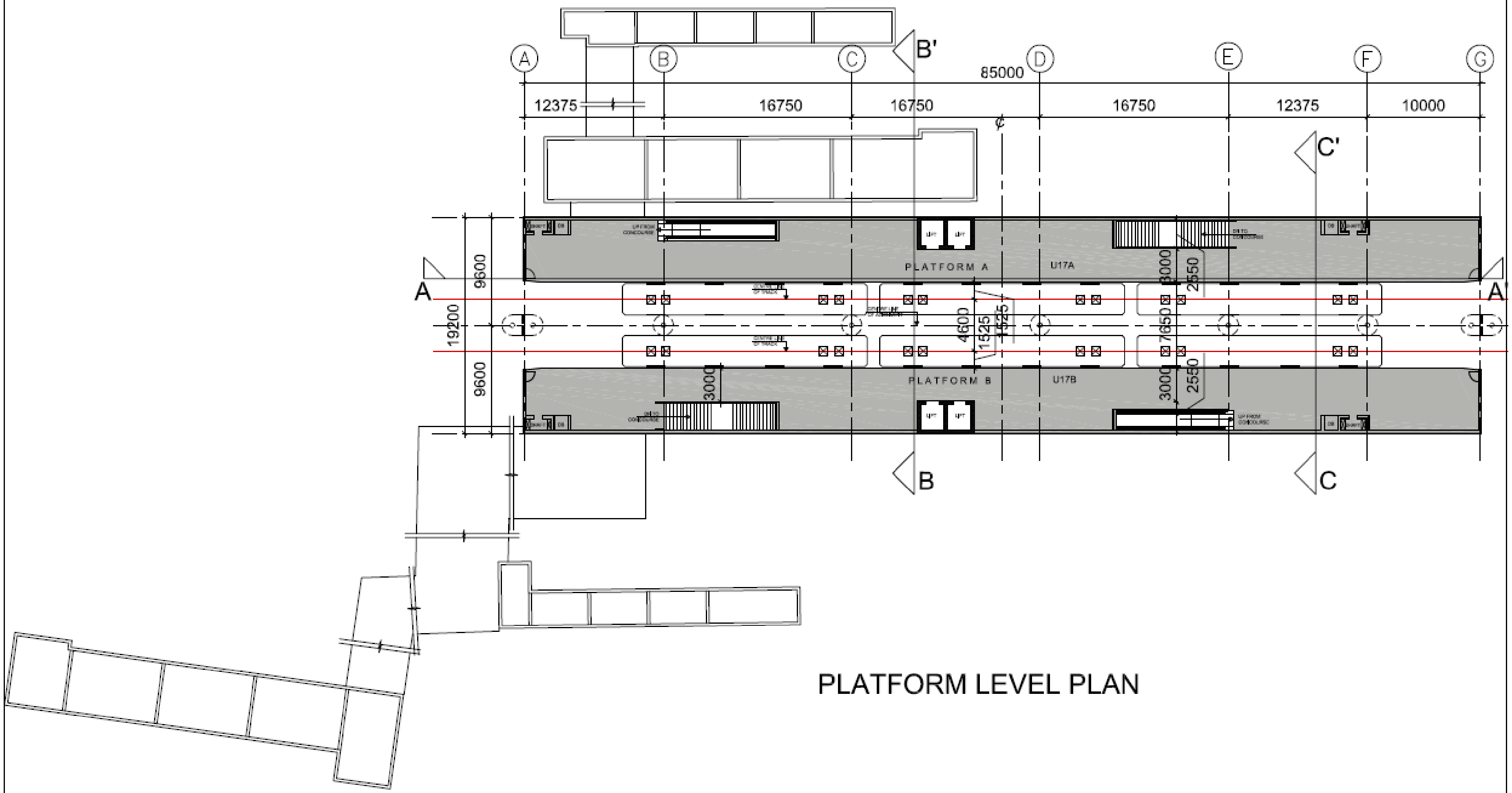
ANNEXURE 6.3: REQUIREMENT OF PASSENGER RELATED FACILITIES – 2051

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	1 Emergency gate	Provided		Gate for disabled	Total no. of Gates
		Direction 1	Direction 2	Total					Direction 1	Direction 2	Total						IN Gates	OUT Gates		
Corridor 1 Sikandra to Taj East Gate																				
1	Sikandara	7270	0	7270	145	131	15	13	0	7810	7810	156	6	5	5	1	5	5	2	13
2	Guru Ka Taal	3612	1548	5160	103	93	10	9	3941	1689	5630	113	4	3	4	1	4	4	2	11
3	ISBT	966	414	1380	28	25	3	2	980	420	1400	28	2	1	1	1	2	2	2	7
4	Shastri Nagar	966	414	1380	28	25	3	2	791	339	1130	23	2	1	1	1	2	2	2	7
5	University	1554	666	2220	44	40	4	4	2667	1143	3810	76	2	2	3	1	3	3	2	9
6	RBS College	2156	924	3080	62	55	6	6	2212	948	3160	63	3	2	2	1	2	2	2	7
7	Raja Ki Mandi	7182	3078	10260	205	185	21	18	6111	2619	8730	175	8	6	5	1	6	6	2	15
8	Agra College	10304	4416	14720	294	265	29	26	12012	5148	17160	343	12	9	10	1	14	14	2	31
9	Medical College	4431	1899	6330	127	114	13	11	5495	2355	7850	157	5	4	5	1	5	5	2	13
10	Jama Masjid	8582	3678	12260	245	221	25	22	8918	3822	12740	255	10	8	8	1	8	8	2	19
11	Agra Fort	2653	1137	3790	76	68	8	7	2863	1227	4090	82	3	3	3	1	3	3	2	9
12	Taj Mahal	1813	777	2590	52	47	5	5	1617	693	2310	46	2	2	2	1	2	2	2	7
13	Fatehabad Road	3689	1581	5270	105	95	11	9	2982	1278	4260	85	5	4	3	1	4	4	2	11
14	Basai	2471	1059	3530	71	64	7	6	2520	1080	3600	72	3	3	3	1	3	3	2	9
15	Taj East Gate	0	7250	7250	145	131	15	13	5000	0	5000	100	6	5	3	1	2	2	2	7
												Total	**73**	**58**	**58**	**15**	**65**	**65**	**30**	**175**
Corridor 2 Agra Cantt To Kalindi Vihar																				
1	Agra Cantt.	4910	0	4910	98	88	10	9	0	4400	4400	88	4	3	3	1	3	3	2	9
2	Sadar Bazar	10983	4707	15690	314	282	31	28	7448	3192	10640	213	12	9	7	1	13	13	2	29
3	Partap-Pura	7455	3195	10650	213	192	21	19	4445	1905	6350	127	9	7	4	1	5	5	2	13
4	Collectorate	1344	576	1920	38	35	4	3	1477	633	2110	42	2	2	2	1	2	2	2	7
5	Subhash Park	2422	1038	3460	69	62	7	6	4172	1788	5960	119	3	2	4	1	4	4	2	11
6	Agra College	15113	6477	21590	432	389	43	39	14399	6171	20570	411	17	13	12	1	17	17	2	37
7	Hariparvat Chauraha	2877	1233	4110	82	74	8	7	4326	1854	6180	124	4	3	4	1	4	4	2	11
8	Sanjay Place	1505	645	2150	43	39	4	4	4354	1866	6220	124	2	2	4	1	4	4	2	11
9	M.G. Road	1673	717	2390	48	43	5	4	1722	738	2460	49	2	2	2	1	2	2	2	7
10	Sultan Ganj Crossing	959	411	1370	27	25	3	2	1386	594	1980	40	2	1	2	1	2	2	2	7
11	Kamla Nagar	2408	1032	3440	69	62	7	6	2128	912	3040	61	3	2	2	1	2	2	2	7
12	Ram Bagh	3689	1581	5270	105	95	11	9	6405	2745	9150	183	5	4	6	1	6	6	2	15
13	Foundary Nagar	2569	1101	3670	73	66	7	7	3108	1332	4440	89	3	3	3	1	3	3	2	9
14	Agra Mandi	3374	1446	4820	96	87	10	9	2254	966	3220	64	4	3	2	1	3	3	2	9
15	Kalindi Vihar	0	7610	7610	152	137	15	14	7090	0	7090	142	6	5	5	1	2	2	2	7
												Total	**78**	**61**	**62**	**15**	**72**	**72**	**30**	**189**

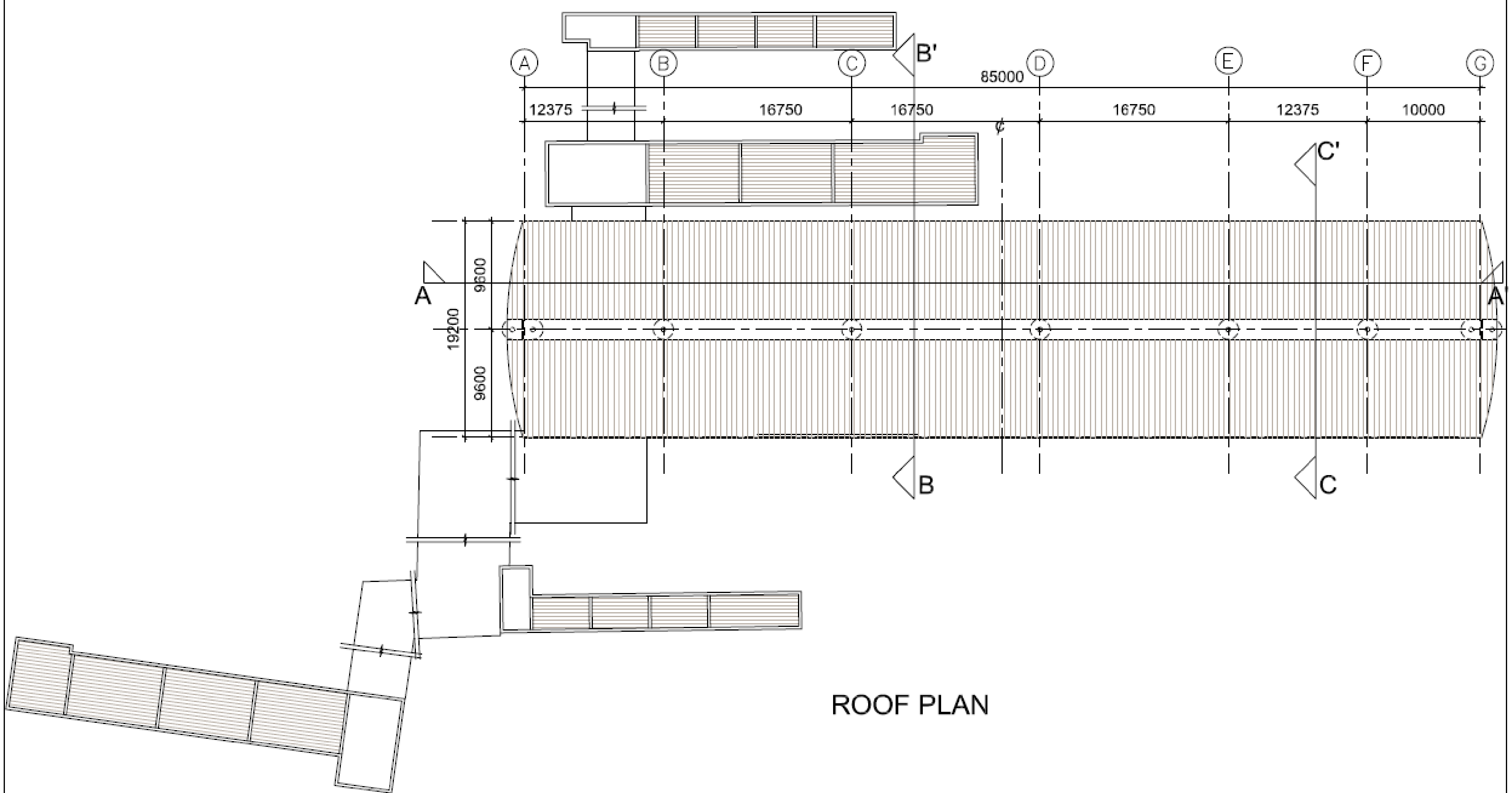
ANNEXURE 6.4: GROUND AND CONCOURSE LEVEL PLANS OF ISBT STATION



ANNEXURE 6.5: PLATFORM LEVEL PLAN AND ROOF PLAN OF ISBT STATION



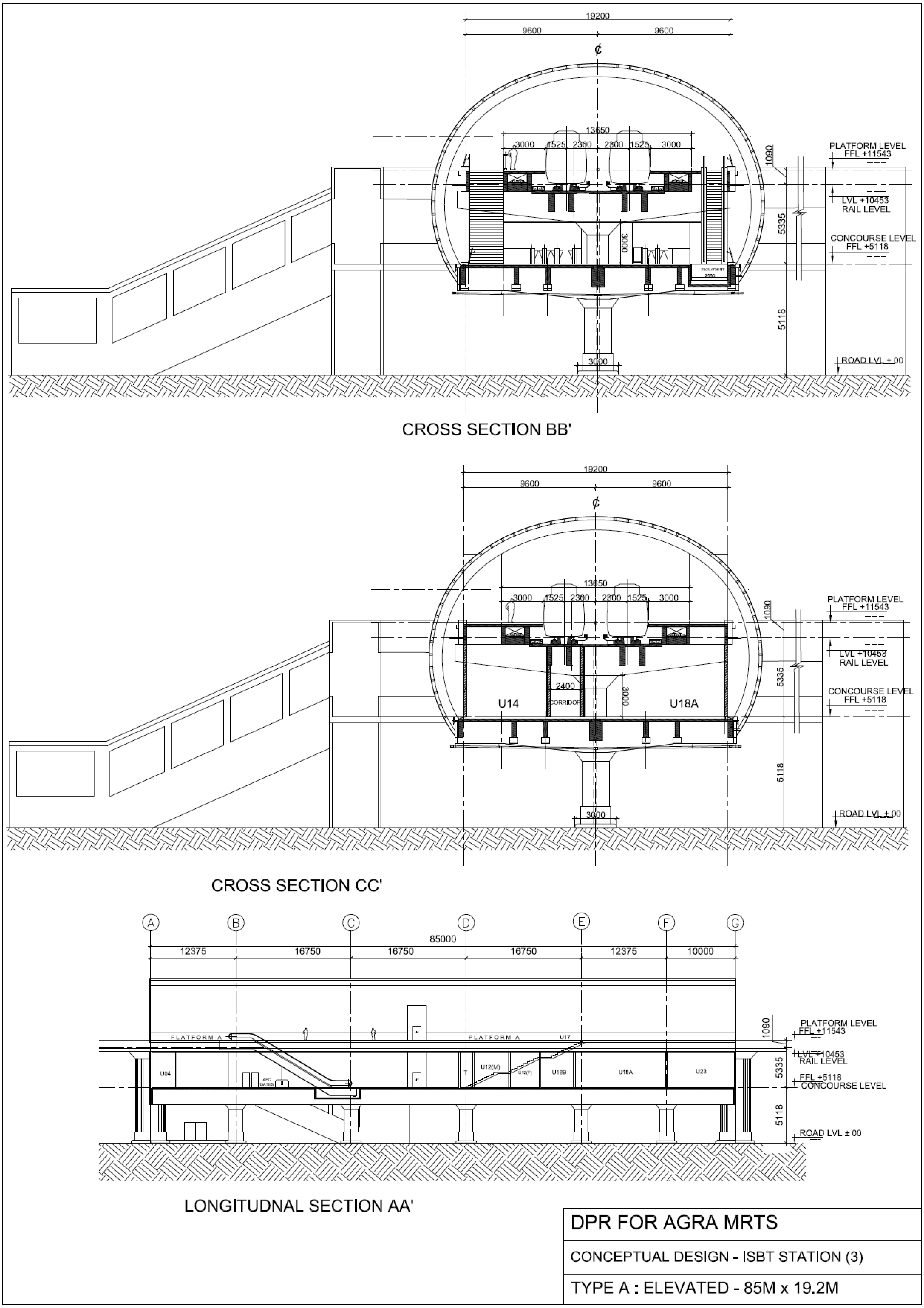
PLATFORM LEVEL PLAN



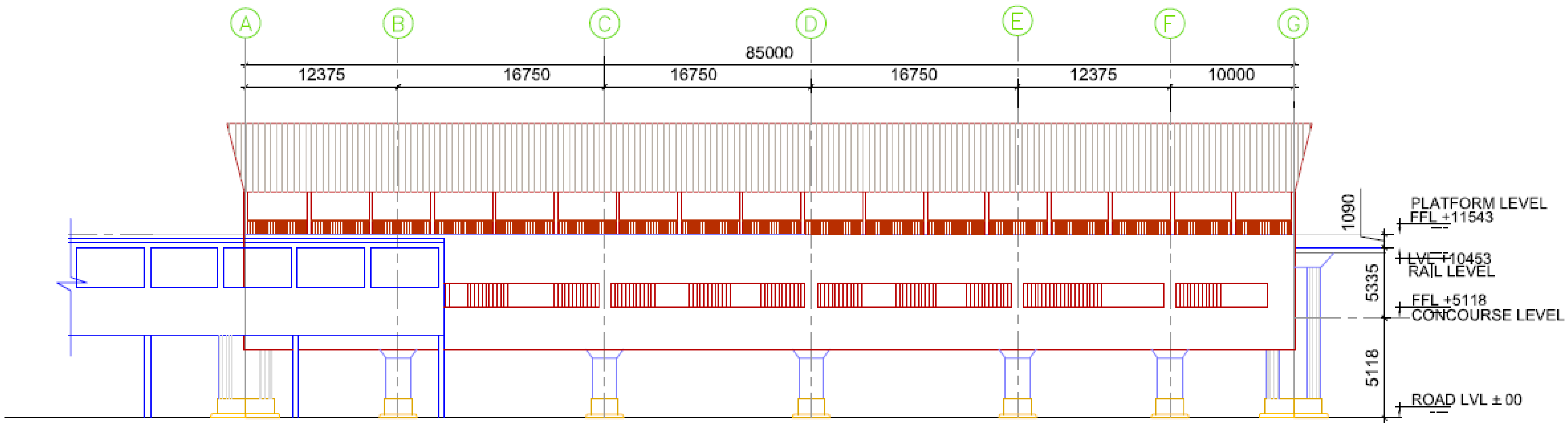
ROOF PLAN

DPR FOR AGRA MRTS
CONCEPTUAL DESIGN - ISBT STATION (2)
TYPE A : ELEVATED - 85M x 19.2M

ANNEXURE 6.6: CROSS SECTIONS OF ISBT STATION



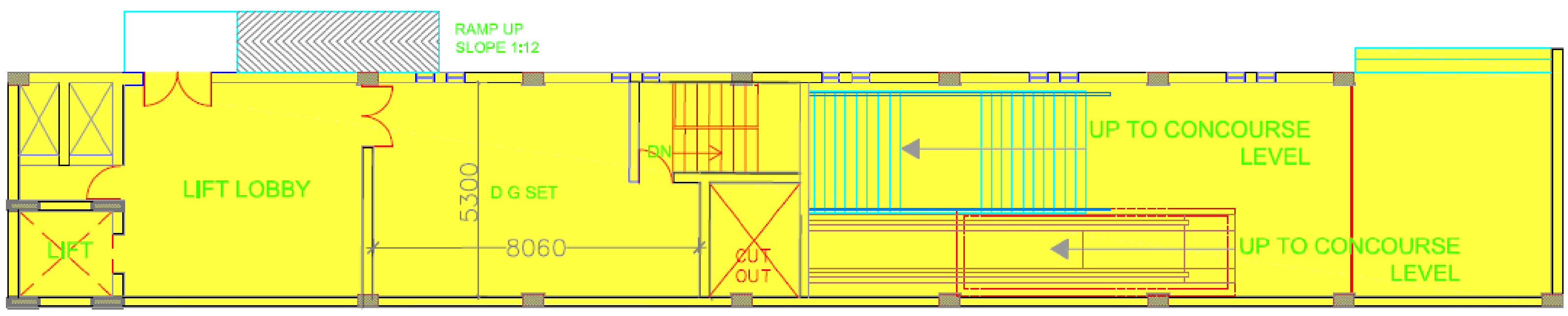
ANNEXURE 6.7: LONGITUDNAL ELEVATION AND ANCILLARY BUILDING PLAN OF ISBT STATION



LONGITUDNAL ELEVATION

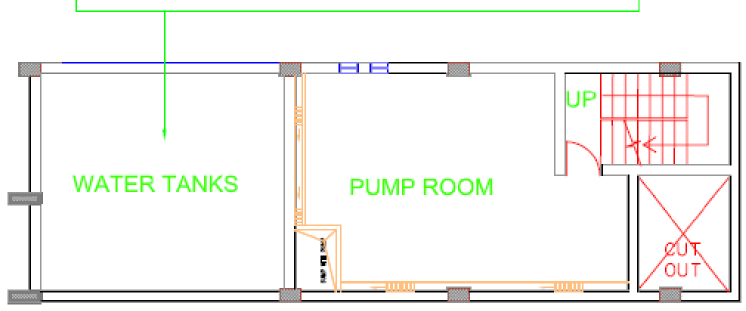
ROOM SCHEDULE				
ROOM. NO.	ROOM NAME	SIZE OF ROOM (M)		AREA PROVIDED (SQ.M)
U01	STATION ENTRANCE UNPAID AREA			217.80
U02	CONCOURSE PAID AREA			634.50
U03	STATION CONTROL ROOM (SCR)	7.48	3.14	25.84
U04	STATION MANAGER ROOM (SMR)	3,45	7,90	26,24
U05	TICKET OFFICE CASH ROOM	3,45	7,90	26,24
U06	FIRST AID ROOM	2,91	2,35	6.83
U08	SECURITY ROOM	4.15	2.35	9.75
U09	STORE FOR MAINTENANCE	7.51	2.27	17.05
U10	CLEANERS ROOM	4,15	2,35	9.75
U11	REFUSE STORE	2,88	2,35	6.77

U012 (F)+T	STAFF / LOCKER ROOM (F)	4.15 2.50	2.96 1.80	15.16 4.50
U012 (M)+T	STAFF / LOCKER ROOM (M)	5.05 1.75	4.02 3.01	20.32 5.28
U013 (F)	FEMALE TOILET	4,33	2,50	10.84
U013 (M)	MALE TOILET	4.80	3.74	15.91
U013 (H)	HANDICAP TOILET	2.00	3.74	7.50
U014	SIGNALLING ROOM	5.45	4,21	24.85
U015	TELE COMMUNICATION ROOM	5,81	5,51	31.98
U016	UPS ROOM	5.48	5,51	30.24
U017A & U017B	PLATFORM	84.74	5.52	434.05
U018A & U018B	AUXILIARY SUB STATION ELEC, UPS ROOM	14.11 3.67	10.22 5.04	130.81 20.32
U021 & U022	FIRE FIGHTING TANK PUMP ROOM D G ROOM	10.36	5.95	61.29
U23	TSS	9,72	18,69	175.18



PLAN OF ANCILLAIRY BUIDING
SHOWING DG SET

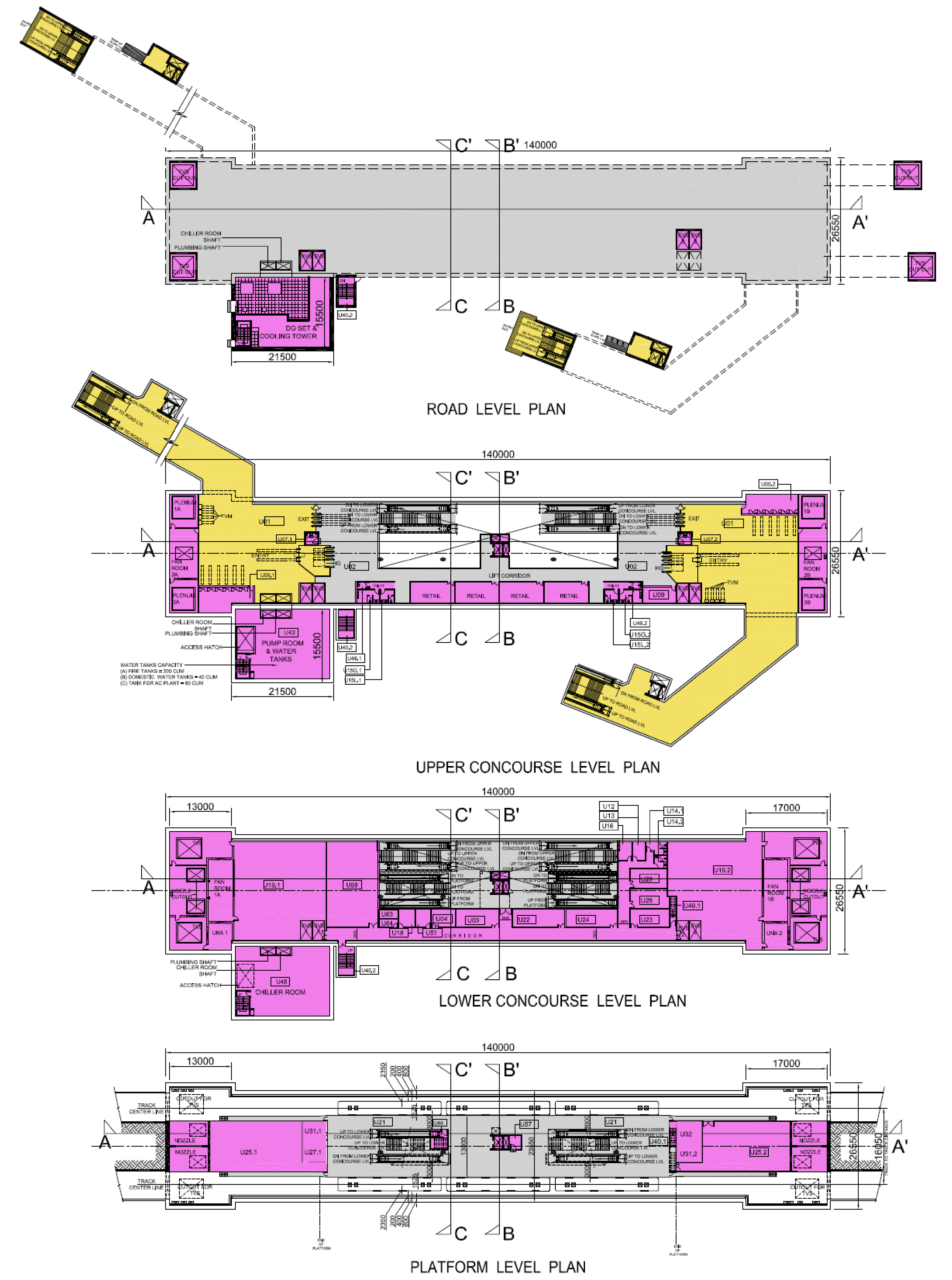
WATER TANKS CAPACITY
(A) FIRE TANKS = 50 CUM
(B) DOMESTIC WATER TANKS
FOR TOILETS & DRINKING WATER = 20 CUM



PLAN OF ANCILLAIRY BUIDING SHOWING
UNDERGROUND WATER TANKS AND
PUMP ROOM BELOW DG SET AND LIFT
LOBBY

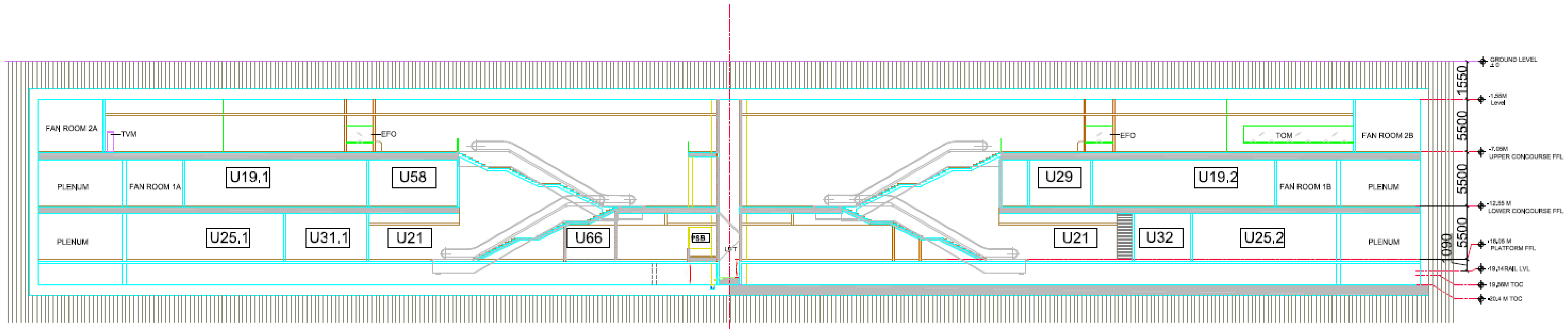
DPR FOR AGRA MRTS
CONCEPTUAL DESIGN - ISBT STATION (4)
TYPE A : ELEVATED - 85M x 19.2M

ANNEXURE 6.8: ROAD, CONCOURSE AND PLATFORM LEVEL PLANS OF RAJA KI MANDI STATION



DPR FOR AGRA MRTS
CONCEPTUAL DESIGN - RAJA KI MANDI (1)
TYPE F : UNDERGROUND - 140M x 26.55M x 3-LEVEL

ANNEXURE 6.9: ROAD, CONCOURSE AND PLATFORM LEVEL PLANS OF RAJA KI MANDI STATION



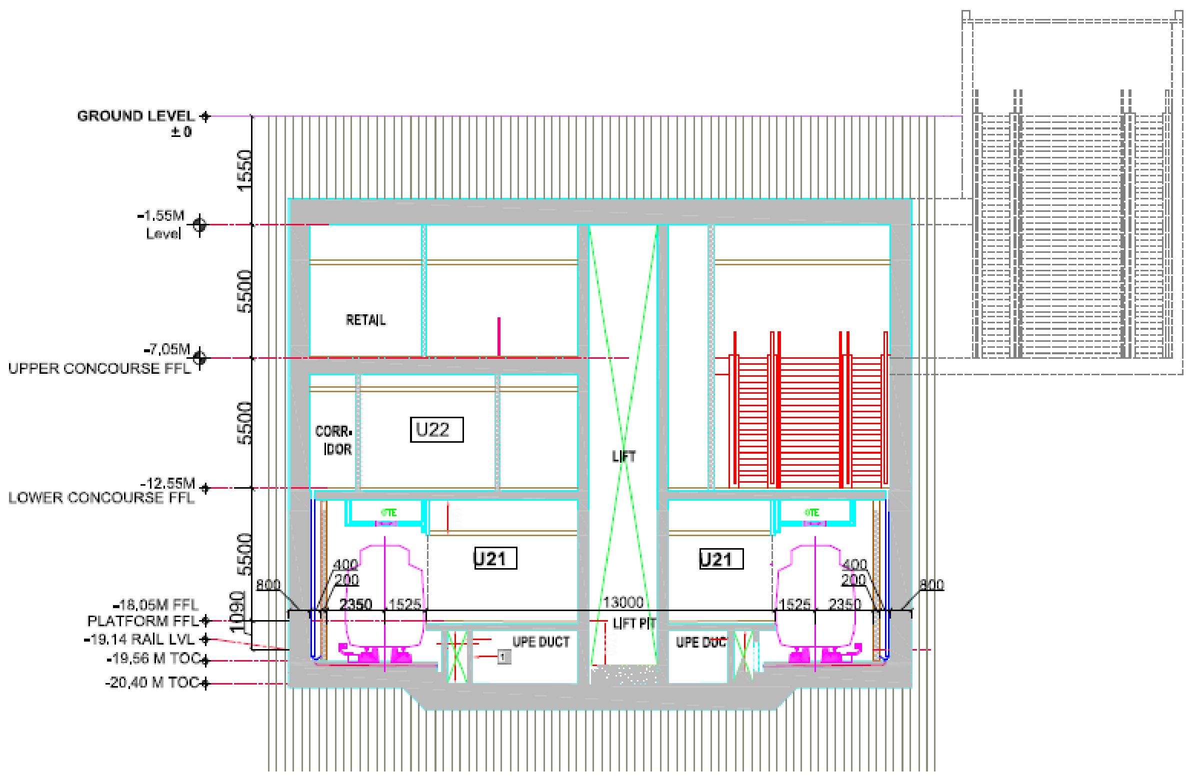
LONGITUDNAL SECTION- AA'

SCALE: N.T.S

ROOM, NO.	ROOM NAME	SIZE OF ROOM (M)		AREA PROVIDED (SQ,M)
U01	STATION ENTRANCE UNPAID AREA	20,75 20.66	24,68 24.58	484.58 501.35
U02	CONCOURSE PAID AREA			601,74
U03	STATION CONTROL ROOM (SCR)	9.00	3.83	34.34
U04	STATION MANAGER ROOM (SMR)	5,00	3,83	19,12
U05.1	TICKET OFFICE MACHINE (TOM)	11.46	5.40	52.10
U05.2	TICKET OFFICE MACHINE (TOM)	11,64	4,20	47,13
U07.1	EXCESS FARE OFFICE & CUSTOMER CARE (EFO)	2.50	2.50	6.25
U07,2	EXCESS FARE OFFICE & CUSTOMER CARE (EFO)	2,50	2,50	6,25
U09	SECURITY ROOM	6.91	3.30	22.83
U12 & U13	CLEANERS ROOM	2,63	3,92	10,31
U14.1	TOILET STAFF (G)	4.36	2.83	10.79
U14,2	TOILET STAFF (L)	2,66	2,60	6,91
U15L .1 U15L ,2	PUBLIC TOILETS (L)	2.90	2.66	7.72
U15G .1 U15G ,2	PUBLIC TOILETS (G)	4,80	2,66	12,77
U16	MESS ROOM	2.83	3.92	11.10
U18	DISTRIBUTION BOARD ROOM	3,50	3,83	13,39
U19,1	ECS PLANT ROOM (ECS)	19.31	20.75	400.68

ROOM, NO.	ROOM NAME	SIZE OF ROOM (M)		AREA PROVIDED (SQ,M)
U19.2	ECS PLANT ROOM (ECS)	19.90	20.75	409.68
U22	SIGNALLING EQUIPMENT ROOM (SER)	11,00	3,83	42,00
U23	TELECOM EQUIPMENT ROOM (TER)	8.52	3.82	31.06
U24	UPS ROOM FOR S & T	10,66	3,82	41,55
U28	CDMA ROOM	8.52	4.00	31.82
U29	GSM ROOM	8,01	4,00	30,47
U51	EMERGENCY EQUIPMENT ROOM	3.00	3.83	11.48
R1	RETAIL 1	9,28	4,36	40,46
R2	RETAIL 2	9.18	4.36	39.96
R3	RETAIL 3	9,18	4,36	40,03
R4	RETAIL 4	9,28	4,36	40,46

ROOM, NO.	ROOM NAME	SIZE OF ROOM (M)		AREA PROVIDED (SQ,M)
U21	PLATFORM PUBLIC AREA	72.00	13.00	687.40
U25,1	AUXILIARY SUB-STATION ROOM	19,20	10,50	211,25
U25,2	AUXILIARY SUB-STATION ROOM	18.40	10.50	203.03
U27,1	ELECTRICAL UPS ROOM	5,00	4,40	21,99
U31.1	SEEPAGE ROOM	5,00	3,90	19.49
U31,2	SEEPAGE ROOM	5.20	3.24	16,88
U32	SEWAGE ROOM	5.20	5.04	26.24
U40,1	FIREMAN ACCESS STAIRCASE	1,20	10,79	12,95
U40,2	FIREMAN ACCESS STAIRCASE	3.40	6.07	20,65
U43	PUMP ROOM & DG SET (ABOVE)	21,50	15,50	292,27
U48	CHILLER ROOM & COOLING TOWER (ABOVE)	21,50	15,50	292,27
U57	PLATFORM SUPERVISOR'S BOOTH (PSB) ONLY AT TERMINAL STATION	2,50	2,90	7.25
U63 & U64	E&M STAFF AND STORE ROOM	3,90	3,83	14,92
U68	TSS	20,00	10,00	200

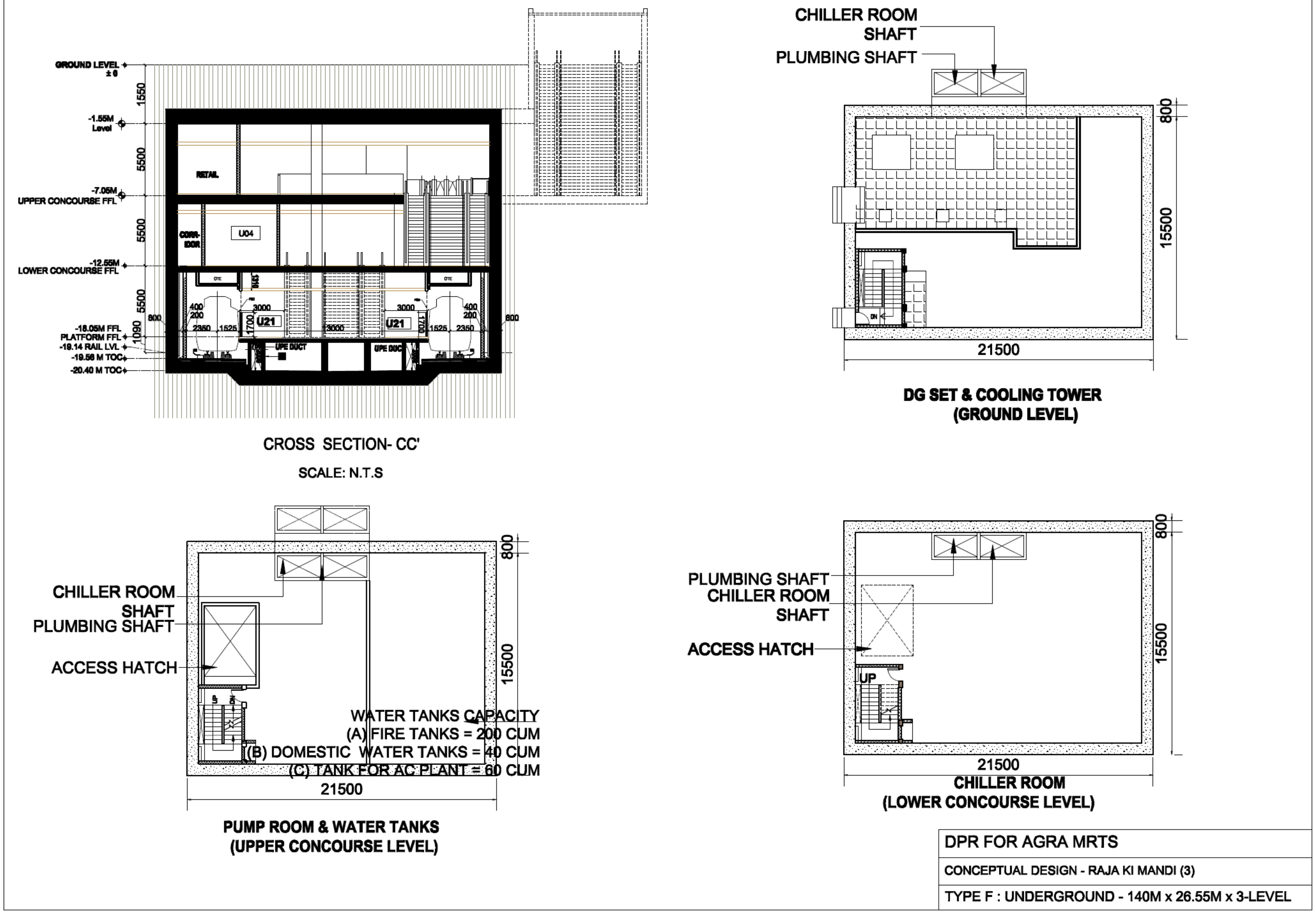


CROSS SECTION- BB'

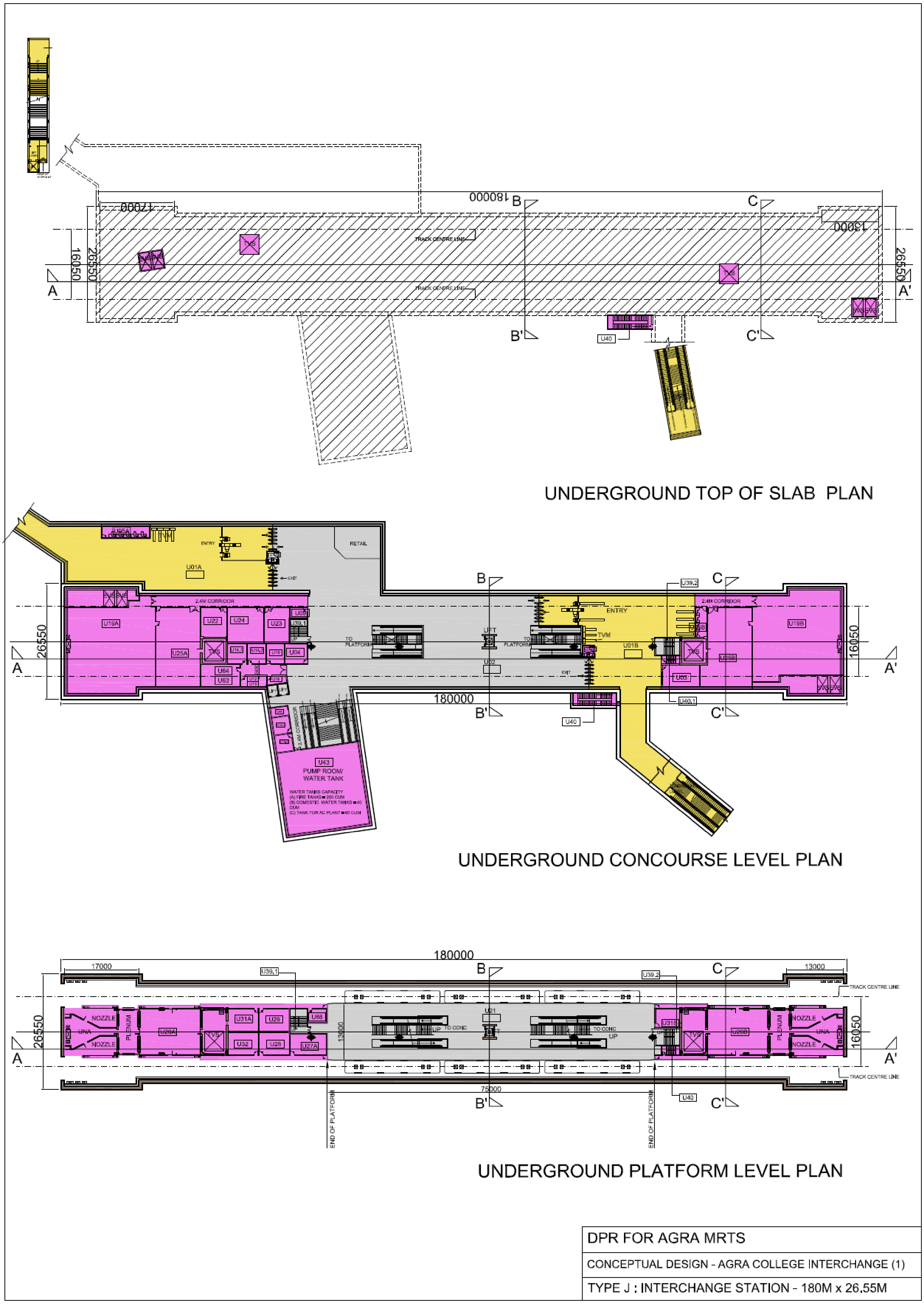
SCALE: N.T.S

DPR FOR AGRA MRTS	
CONCEPTUAL DESIGN - RAJA KI MANDI (2)	
TYPE F : UNDERGROUND - 140M x 26,55M x 3-LEVEL	

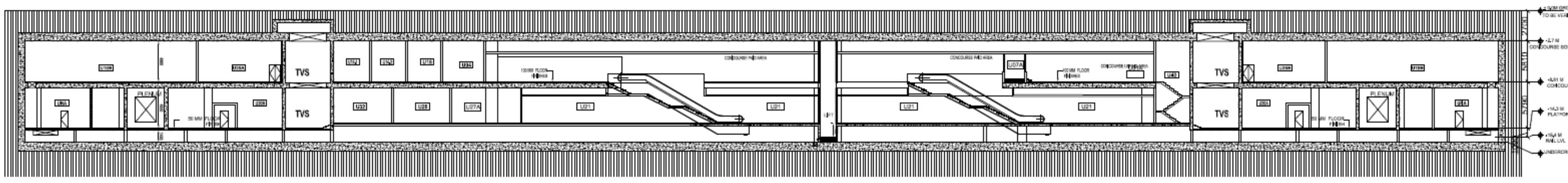
ANNEXURE 6.10: CROSS SECTION AND ANCILLARY BUILDING PLANS OF RAJA KI MANDI STATION



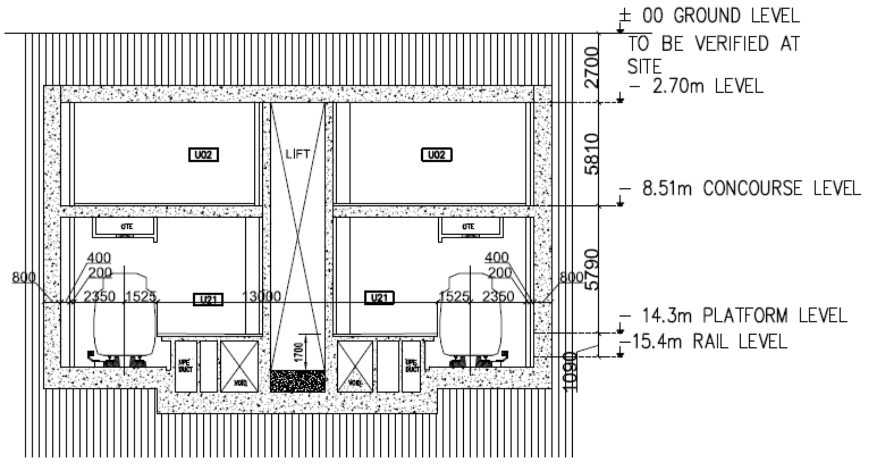
ANNEXURE 6.11: GROUND, CONCOURSE AND PLATFORM LEVEL PLANS OF UNDERGROUND STATION OF AGRA COLLEGE INTERCHANGE



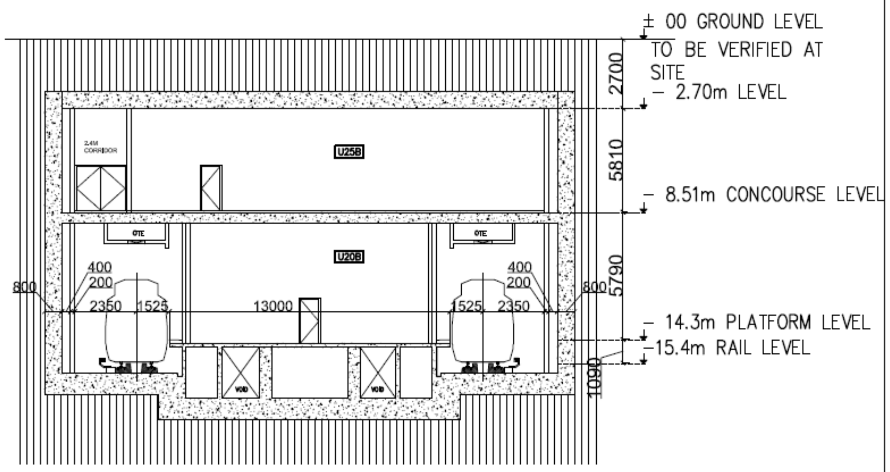
ANNEXURE 6.12: CROSS SECTIONS OF UNDERGROUND STATION OF AGRA COLLEGE INTERCHANGE



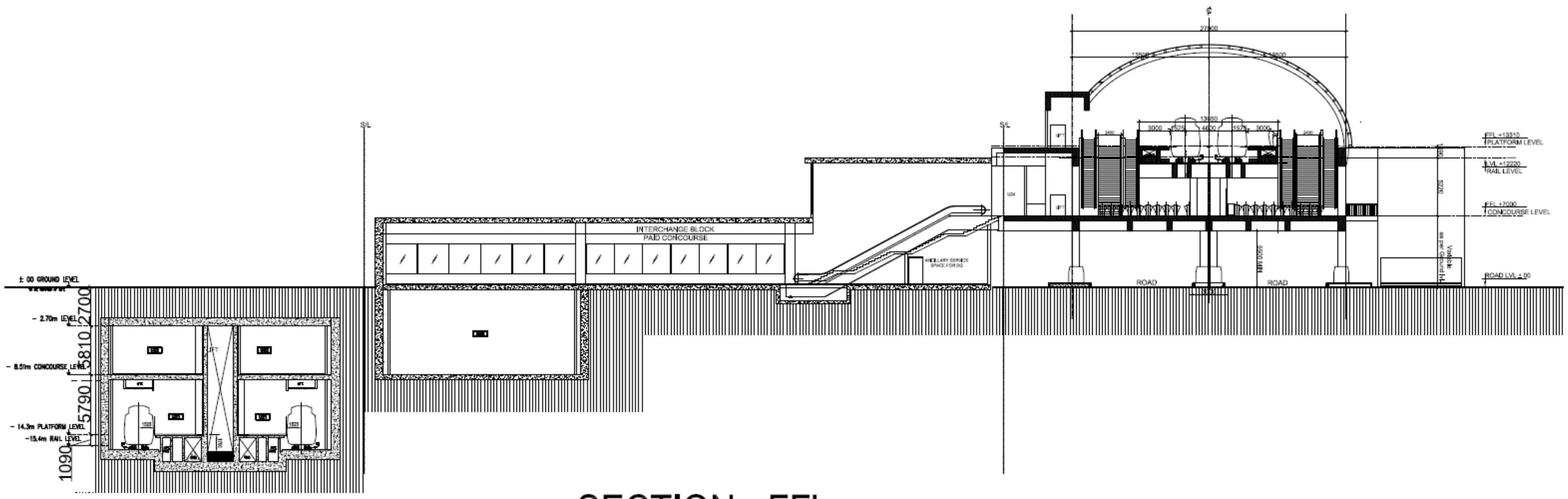
LONG SECTION - AA'



CROSS SECTION - BB'



CROSS SECTION - CC'



SECTION - FF'

ROOM SCHEDULE				
ROOM. NO.	ROOM NAME	SIZE OF ROOM (M)		AREA PROVIDED (SQ.M)
CONCOURSE LEVEL				
U01A	UNPAID PUBLIC AREA			652.00
U01B	UNPAID PUBLIC AREA			520.05
U02	PAID PUBLIC AREA			1967.13
U03	STATION CONTROL ROOM (SCR)	8.57	4.98	42.66
U04	STATION MANAGER ROOM (SMR)	3.00	7.52	22.54
U05A	TICKET WINDOW	10.81	2.50	27.03
U05B	TICKET WINDOW	2.50	6.76	16.66
U07A	CUSTOMER CARE (EFO)	2.5	2.5	6.25
U07B	CUSTOMER CARE (EFO)	2.5	2.5	6.25
U09	SECURITY ROOM	3.80	2.4	9.03
U12,13	CLEANERS ROOM & REFUSE STORE ROOM	5.86	2.46	14.38
U14.1	STAFF TOILET (G)	4.34	4.52	19.62
U14.2	STAFF TOILET (L)	4.14	4.52	18.72
U15.1	PUBLIC TOILET (G)	3.84	3.9	14.99
U15.2	PUBLIC TOILET (L)	3.84	3.9	14.99
U16	MESS ROOM	4.03	4.52	18.21
U18	DB ROOM	4.20	2.09	7.81
U19A	ECS PLANT ROOM (ECS)	20.19	19.55	401.86
U19B	ECS PLANT ROOM (ECS)	20.20	19.55	391.53
U22	SIGNALING EQUIPMENT ROOM	5.90	6.76	39.92
U23	TELECOM EQUIPMENT ROOM	5.60	7.78	43.54
U24	S & T UPS ROOM	8.25	7.78	64.13
U25A	AUXILIARY SUB-STATION ROOM	10.12	18.15	183.59
U25B	AUXILIARY SUB-STATION ROOM	10.12	18.15	191.36
U39.1	FIRE ESCAPE STAIRCASE	3.80	5.50	20.93
U39.2	FIRE ESCAPE STAIRCASE	5.51	3.79	20.93
U40	FIREMAN ACCESS STAIRCASE	10.00	2.9	29.61
U40.1	FIREMAN ACCESS STAIRCASE	4.06	1.90	7.71
U43	PUMP ROOM	18.80	18.60	349.68
U46	TOILET FOR PHYSICALLY DISABLED	3.84	2.00	7.69
U48	CHILLER PLANT ROOM	18.95	17.37	305.28
U51	EMERGENCY EQUIPMENT ROOM	5.00	4.90	24.5
U63 & U64	E&M STAFF AND STORE ROOM	8.84	5.09	44.96

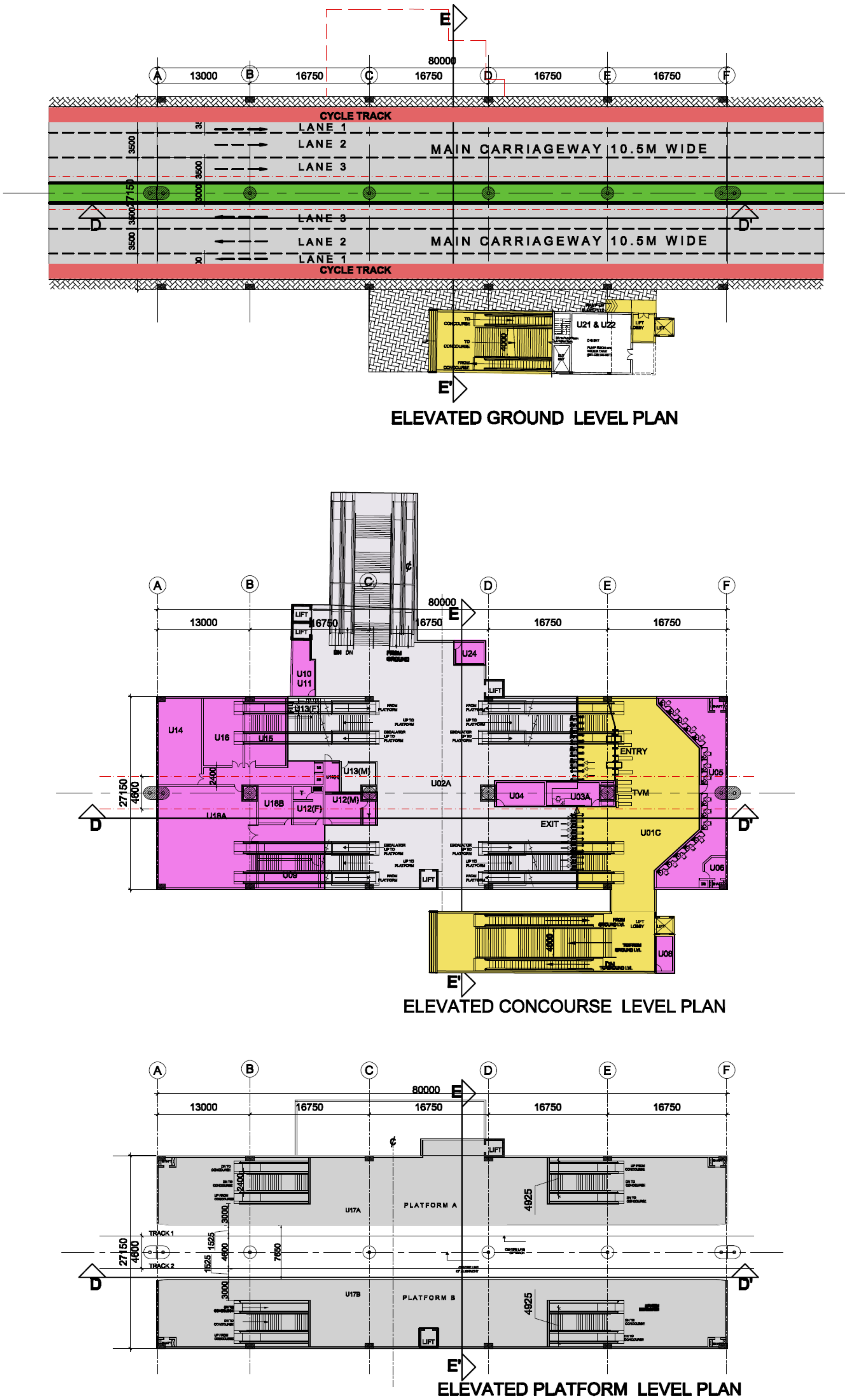
ROOM SCHEDULE				
ROOM. NO.	ROOM NAME	SIZE OF ROOM (M)		AREA PROVIDED (SQ.M)
PLATFORM LEVEL				
U20A	TUNNEL VENTILATION PLANT ROOM	13.85	10.40	143.28
U20B	TUNNEL VENTILATION PLANT ROOM	13.85	10.40	143.28
U21	PLATFORM PUBLIC AREA	13.00	75.00	975.00
U27A	ELECTRICAL UPS ROOM	8.28	4.59	38.10
U28	CDMA ROOM	6.89	5.07	34.94
U29	GSM ROOM	6.89	5.07	34.94
U31A	SEEPAGE ROOM	6.89	5.07	34.95
U31B	SEEPAGE ROOM	5.51	4.22	23.24
U32	SEWAGE ROOM	6.89	5.07	33.94
U32	SEWAGE ROOM	6.89	5.07	34.95
U66	ROOM FOR UTILITIES	4.25	3.00	12.76

DPR FOR AGRA MRTS

CONCEPTUAL DESIGN - AGRA COLLEGE INTERCHANGE (2)

TYPE J : INTERCHANGE STATION - 180M x 26.55M

ANNEXURE 6.13:GROUND, CONCOURSE AND PLATFORM LEVEL PLANS OF ELEVATED STATION OF AGRA COLLEGE INTERCHANGE

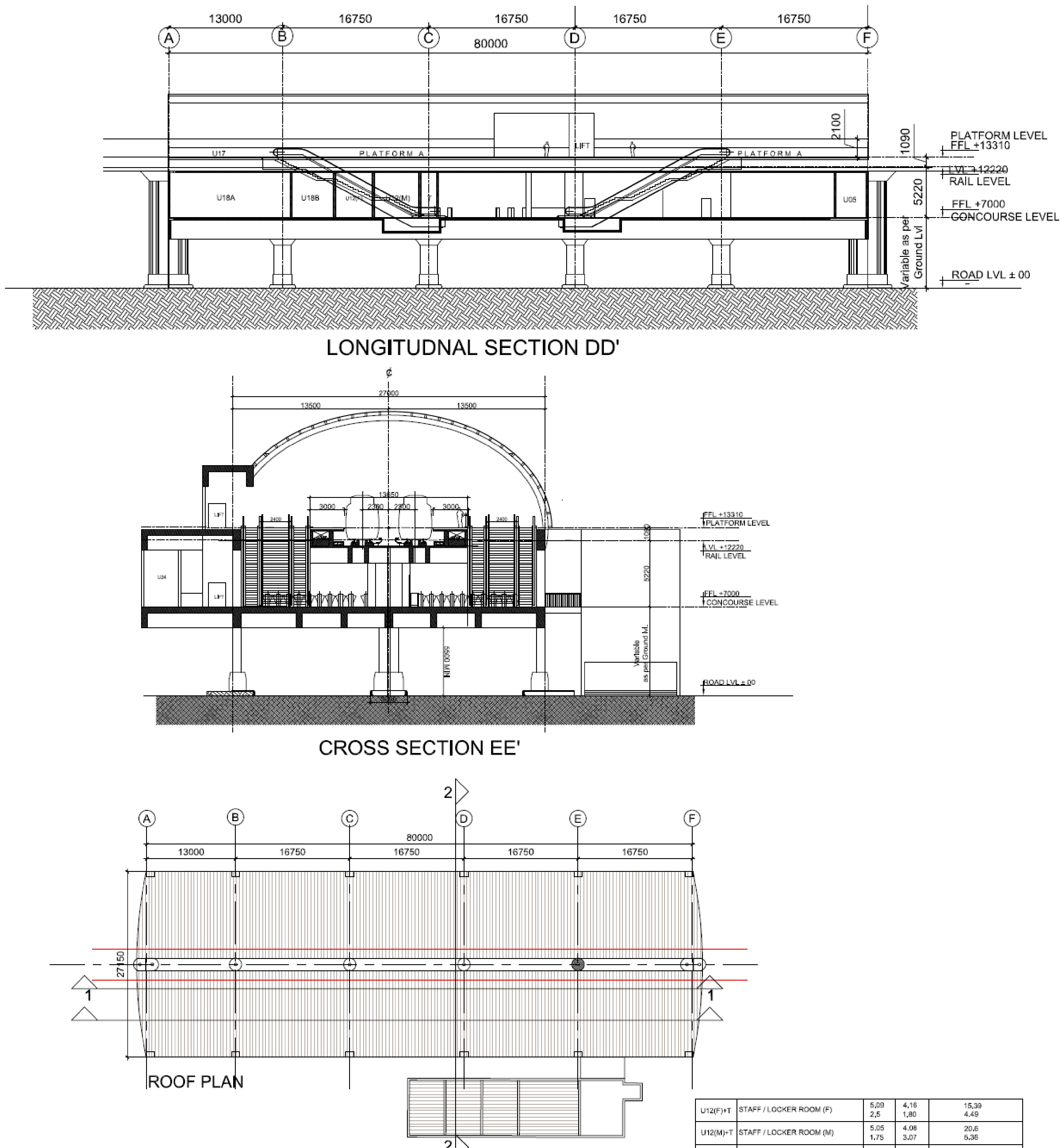


DPR FOR AGRA MRTS

CONCEPTUAL DESIGN - AGRA COLLEGE INTERCHANGE (3)

TYPE J : INTERCHANGE STATION - 80M x 27.15M

ANNEXURE 6.14: CROSS SECTIONS AND ROOF PLAN OF ELEVATED STATION OF AGRA COLLEGE INTERCHANGE



ROOM SCHEDULE				
ROOM. NO.	ROOM NAME	SIZE OF ROOM (M)		AREA PROVIDED (SQ.M)
U01C	STATION ENTRANCE UNPAID AREA			383.39
U02A	CONCOURSE PAID AREA			1180.35
U03A	STATION CONTROL ROOM (SCR)	7,46	3,12	23,26
U04	STATION MANAGER ROOM (SMR)	6.71	3.12	20.92
U05	TICKET OFFICE CASH ROOM	9,79	28,69	482,15
U06	FIRST AID ROOM	3.00	3.00	8,49
U08	SECURITY ROOM	2,28	4,85	11,12
U09	STORE FOR MAINTENANCE	8,52	3,81	32,44
U10 U11	CLEANERS ROOM REFUSE STORE	3,08	7,94	22,16

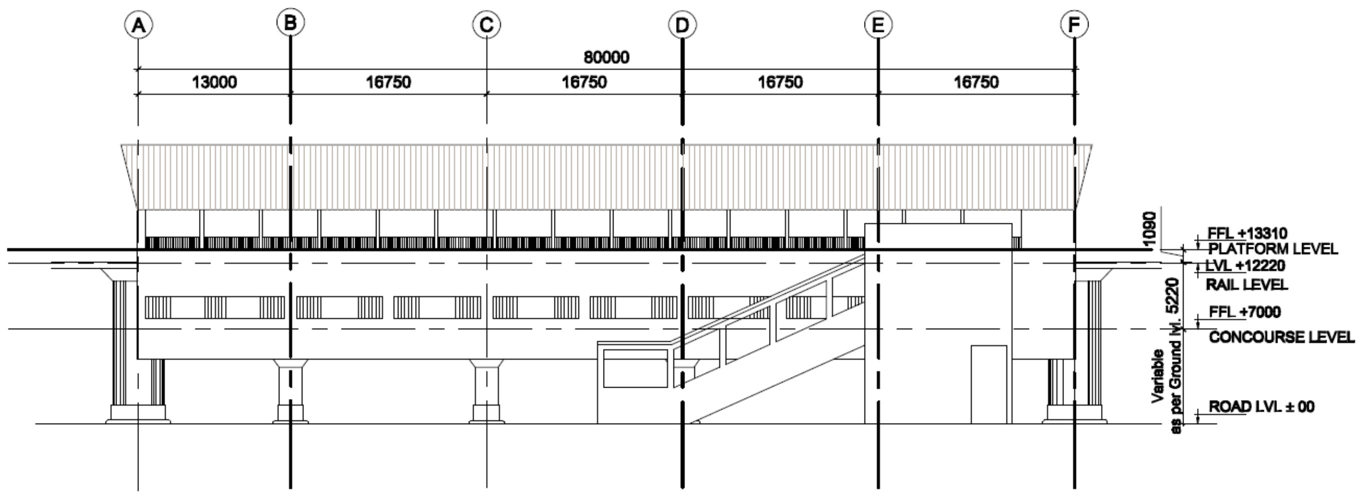
U12(F)+T	STAFF / LOCKER ROOM (F)	5,09 2,5	4,16 1,80	15,39 4.49
U12(M)+T	STAFF / LOCKER ROOM (M)	5.05 1.75	4.08 3.07	20.6 5.36
U13(F)	FEMALE TOILET	4,34	2,50	10.85
U13(M)	MALE TOILET	4.80	4.08	17,50
U13(H)	HANDICAP TOILET	2,00	4,08	8.16
U14	SIGNALLING ROOM	6,10	12,17	74.25
U15	TELE COMMUNICATION ROOM	5,78	9.51	55,04
U16	UPS ROOM	5,48	9,51	52,19
U17A & U17B	PLATFORM	84.74	6.77	573.68
U18A & U18B	AUXILIARY SUB STATION ELEC. UPS ROOM	13.76 4.67	14.19 5,09	195.32 23.82
U21 & U22	FIRE FIGHTING TANK PUMP ROOM D G ROOM	8,12	8,27	67,15
U24	ROOM FOR UTILITIES	4,00	3,00	12,00

DPR FOR AGRA MRTS

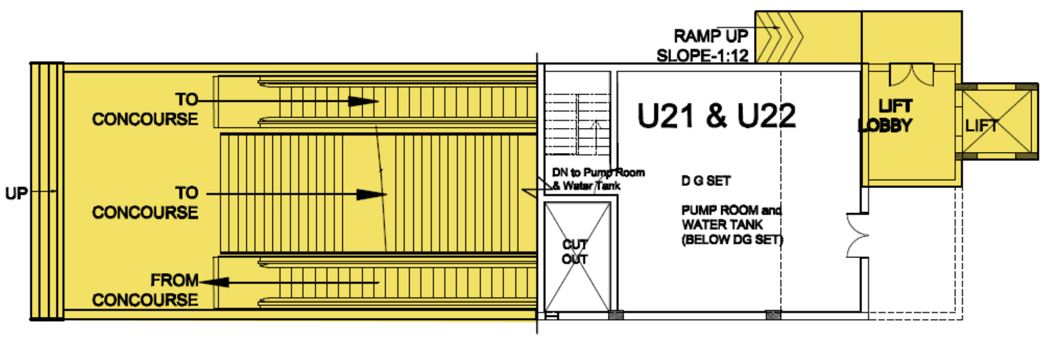
CONCEPTUAL DESIGN - AGRA COLLEGE INTERCHANGE (4)

TYPE J : INTERCHANGE STATION - 80M x 27.15M

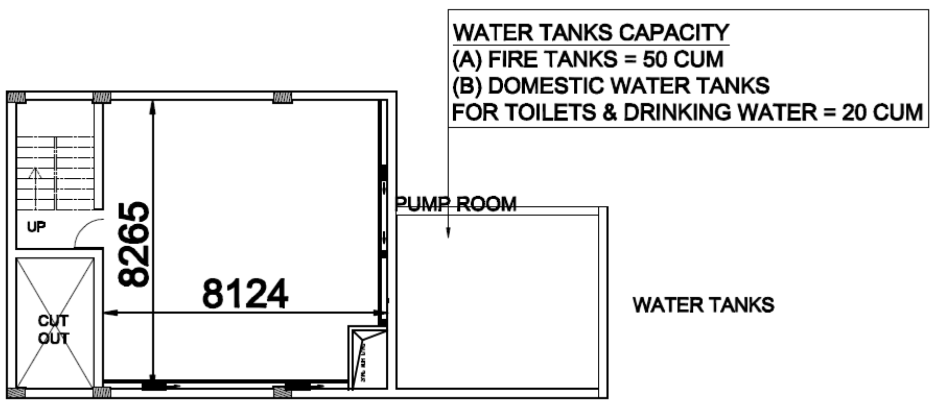
ANNEXURE 6.15: LONGITUDNAL ELEVATION AND ANCILLARY BUILDING PLAN OF ELEVATED STATION OF AGRA COLLEGE INTERCHANGE



LONGITUDNAL ELEVATION



PLAN OF ANCILLAIRY BUIDING
SHOWING DG SET



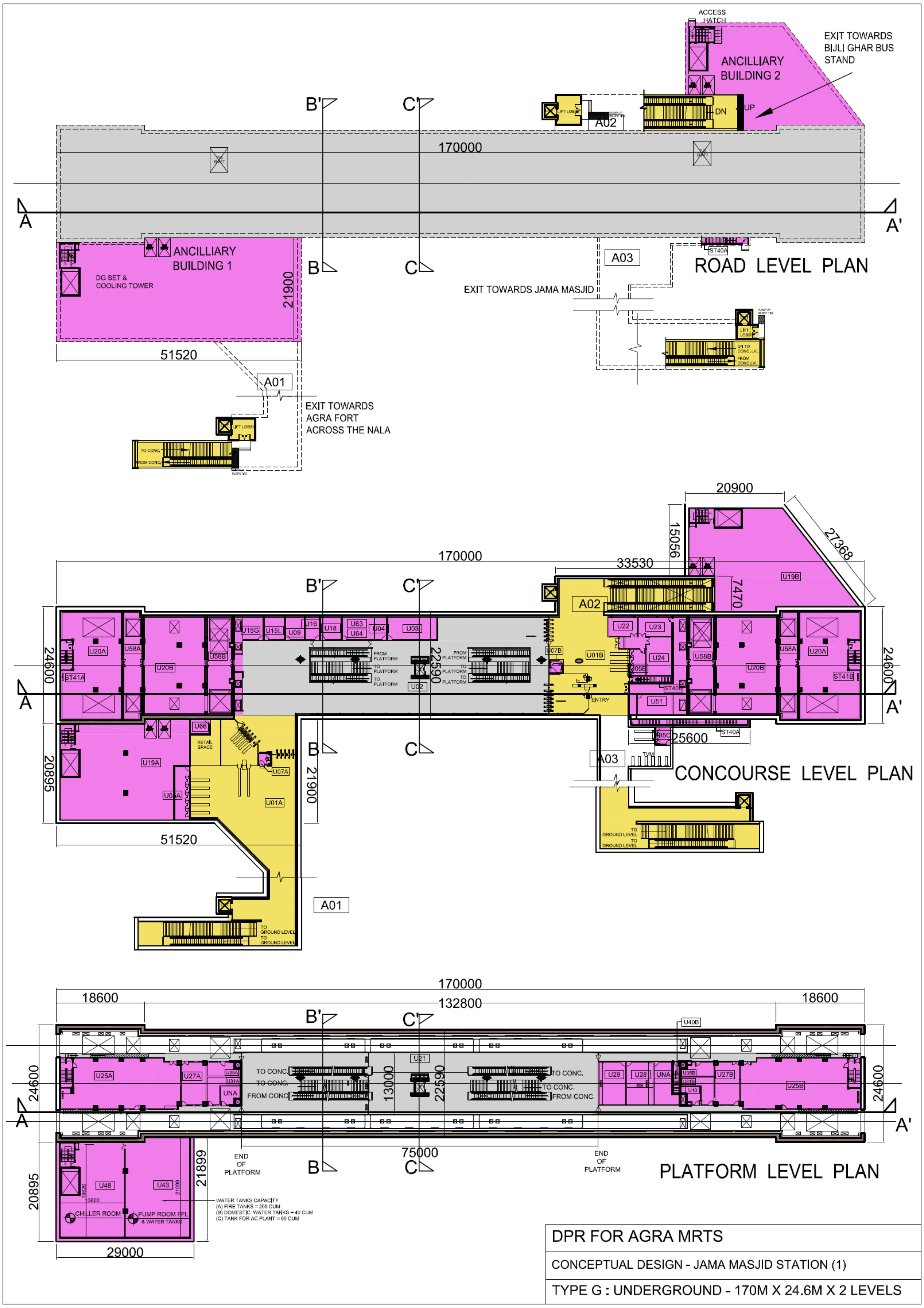
PLAN OF ANCILLAIRY BUIDING SHOWING
UNDERGROUND WATER TANKS AND PUMP ROOM
BELOW DG SET AND LIFT LOBBY

DPR FOR AGRA MRTS

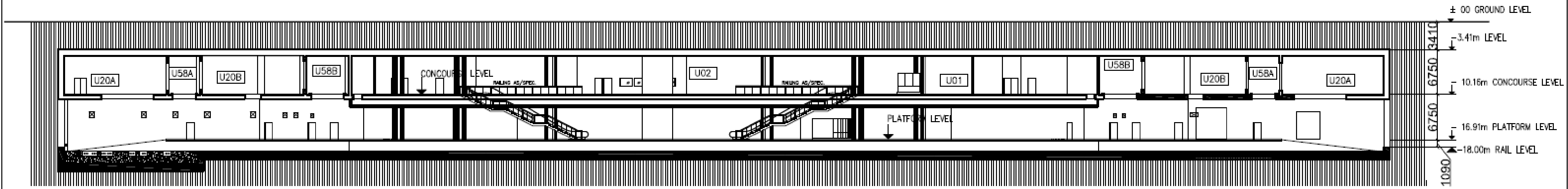
CONCEPTUAL DESIGN - AGRA COLLEGE INTERCHANGE (5)

TYPE J : INTERCHANGE STATION - 80M x 27.15M

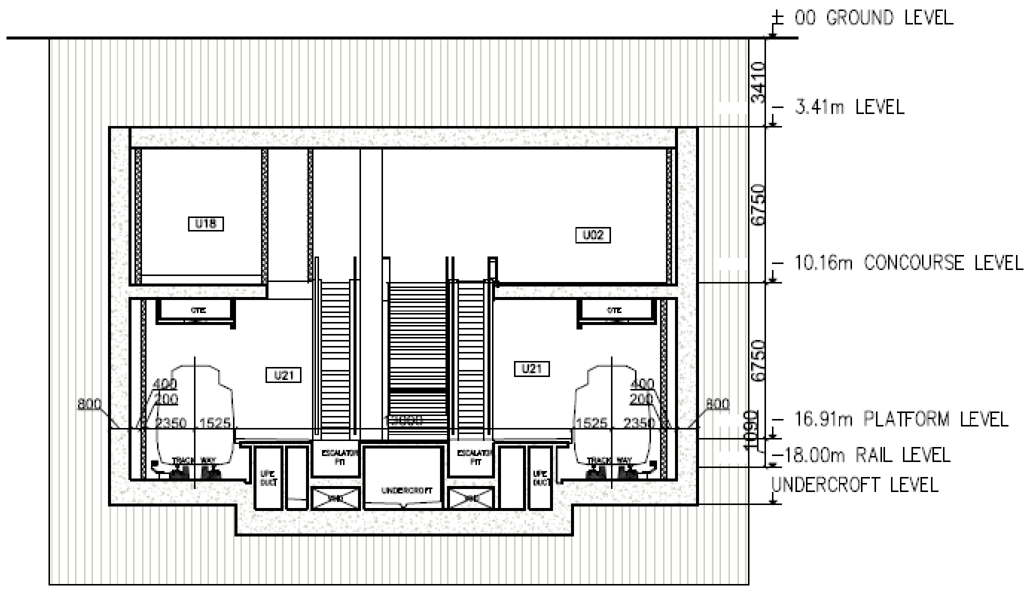
ANNEXURE 6.16: ROAD, CONCOURSE AND PLATFORM LEVEL PLANS OF JAMA MASJID STATION



ANNEXURE 6.17: LONGITUDINAL SECTION AND CROSS SECTION OF JAMA MASJID STATION



LONGITUDNAL SECTION - AA'



CROSS SECTION - BB'

ROOM SCHEDULE				
ROOM. NO.	ROOM NAME	SIZE OF ROOM (M)		AREA PROVIDED (SQ.M)
CONCOURSE LEVEL				
U01A	UNPAID PUBLIC AREA			772.55
U01B	UNPAID PUBLIC AREA			537,40
U02	PAID PUBLIC AREA			1122.39
U03	STATION CONTROL ROOM (SCR)	10.55	4.66	49.23
U04	STATION MANAGER ROOM (SMR)	2,50	4,66	11,66
U05A	TICKET WINDOW	3.30	6.975	23.01
U05B	TICKET WINDOW	3.41	5.41	18.45
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	4,66	18,65
U15	PUBLIC TOILET (G)	4.25	4.66	19.82
U15	PUBLIC TOILET (L)	4,25	4.66	19.82
U16	MESS ROOM	3,00	4,66	13,33
U66	ROOM FOR UTILITIES	3,10	4,00	12,40
U18	DB ROOM	4,00	4,66	20.52
U19A	ECS PLANT ROOM (ECS)	27.2	19,61	510,02
U19B	ECS PLANT ROOM (ECS)	27,8	20,72	563,29
U20A	TUNNEL VENTILATION PLANT ROOM	13.00	23.95	311.34
U20B	TVS ROOM	12.90	20.99	270.77
U22	SIGNALING EQUIPMENT ROOM	6,07	4,00	24,35
U23	TELECOM EQUIPMENT ROOM	7.05	4.00	28.26
U24	S & T UPS ROOM	5.35	8.01	42.85
U40A	FIREMAN ACCESS STAIRCASE	21,16	1,20	37,99
U40B	FIREMAN ACCESS STAIRCASE	8.92	1.32	13.73
ST41,A	STAIRCASE	2,60	6,15	15.99
ST41.B	STAIRCASE	2.60	6.15	15.99
U51	EMERGENCY EQUIPMENT ROOM	7,26	4,43	32,16
U58A	VENTILATION PLENUM	4,00	23,95	94,91
U58B	VENTILATION PLENUM	5.30	20.99	111.24
U63 & U64	E&M STAFF AND STORE ROOM	6,63	4,66	30,92

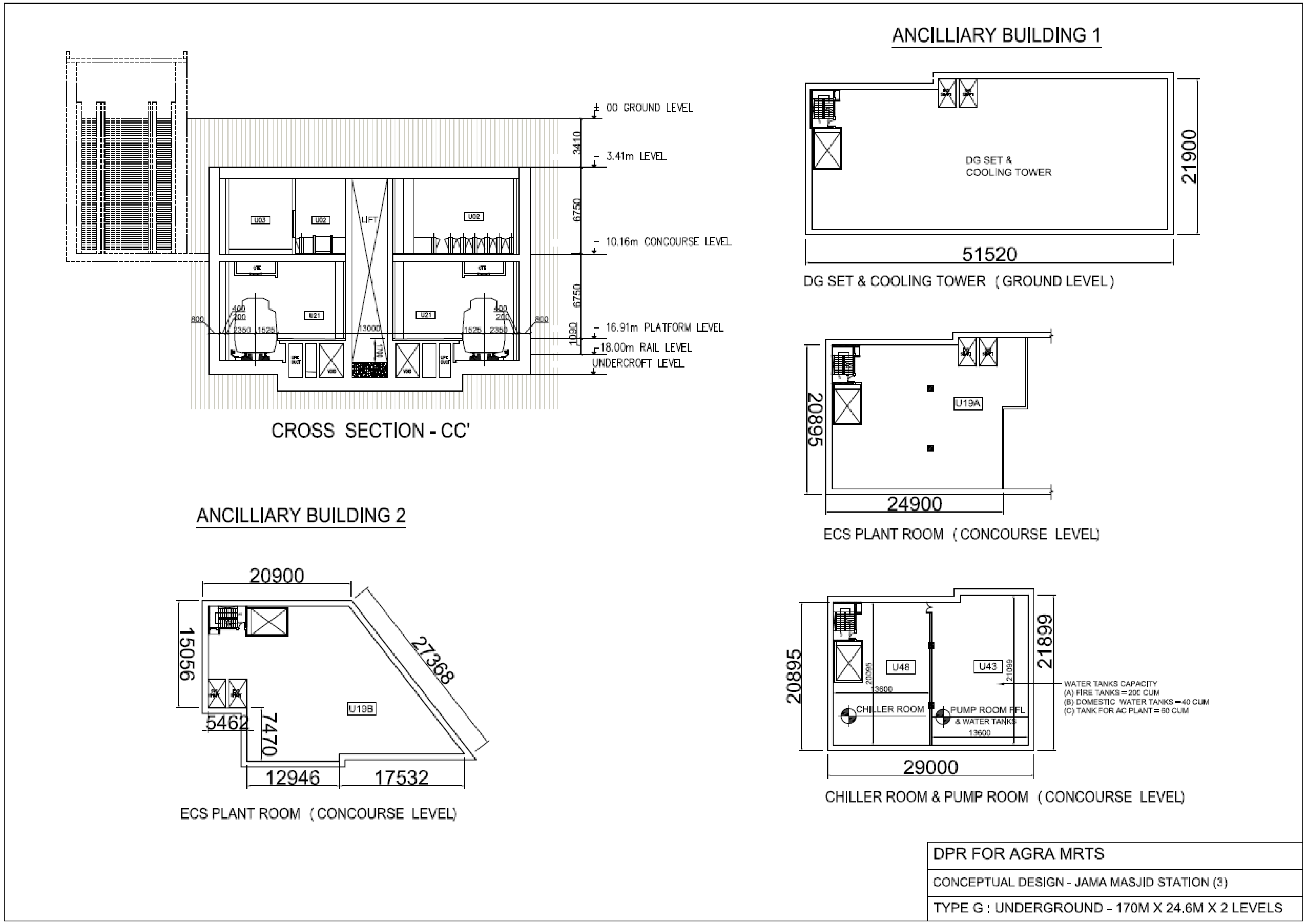
ROOM SCHEDULE				
ROOM, NO.	ROOM NAME	SIZE OF ROOM (M)		AREA PROVIDED (SQ.M)
PLATFORM LEVEL				
U21	PAID PUBLIC AREA			974.56
U25A	AUXILIARY SUB-STATION ROOM	25,3	10,58	267.67
U25B	AUXILIARY SUB-STATION ROOM	25,3	10,58	267.67
U27A	ELECTRICAL UPS ROOM	5,20	8,97	45,94
U27B	ELECTRICAL UPS ROOM	5.20	8.97	45.94
U28	CDMA ROOM	5.50	8,84	48,62
U29	GSM ROOM	5.50	8.84	48.62
U31A	SEEPAGE ROOM	6.00	4.32	26.71
U31B	SEEPAGE ROOM	6.00	4.32	26,71
U41B	FIREMAN ACCESS STAIRCASE	6,50	1,20	7,8
U43	PUMP ROOM	13,6	21.10	280,03
U48	CHILLER PLANT ROOM	13,6	19.62	266,83

DPR FOR AGRA MRTS

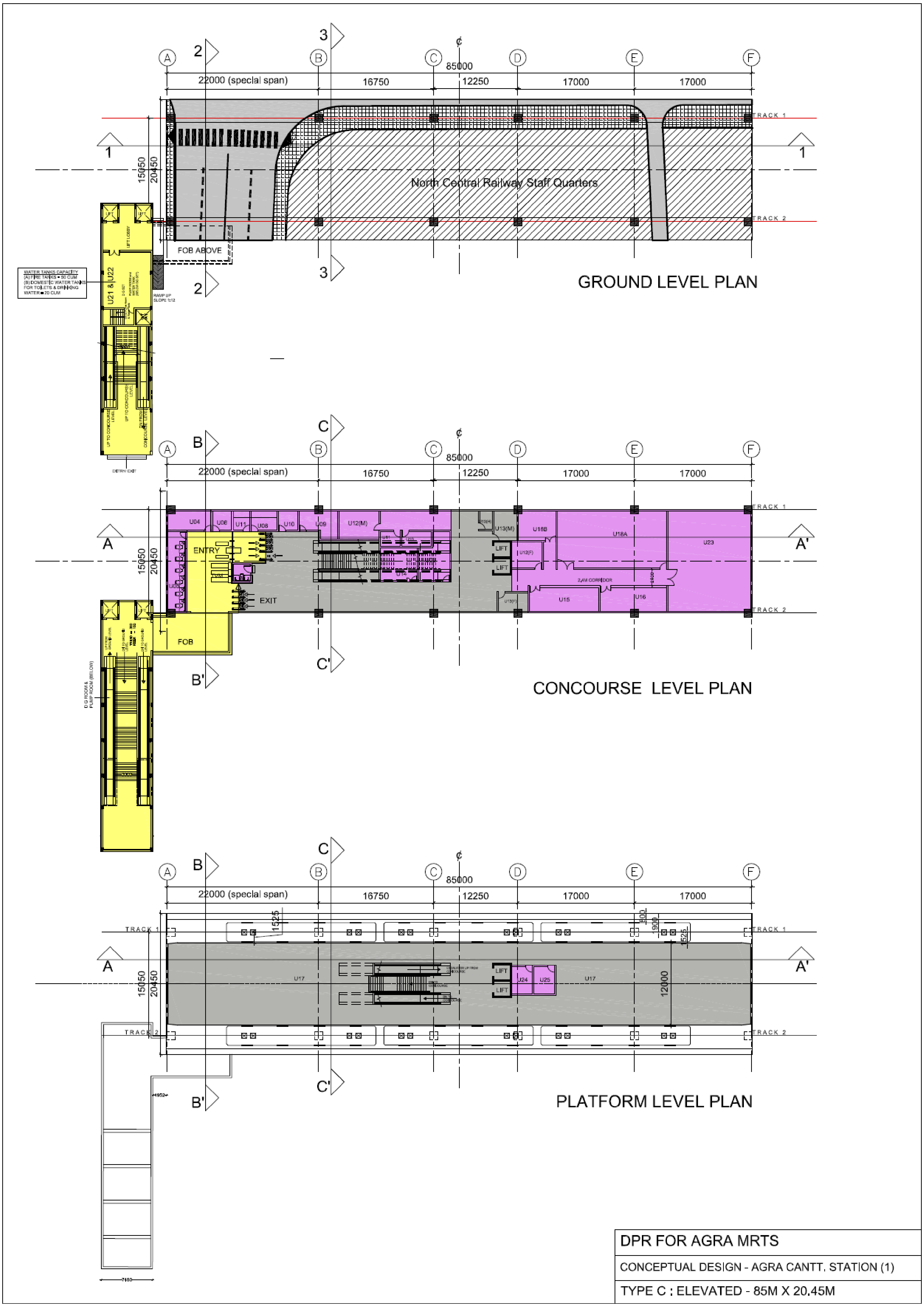
CONCEPTUAL DESIGN - JAMA MASJID STATION (2)

TYPE G : UNDERGROUND - 170M X 24,6M X 2 LEVELS

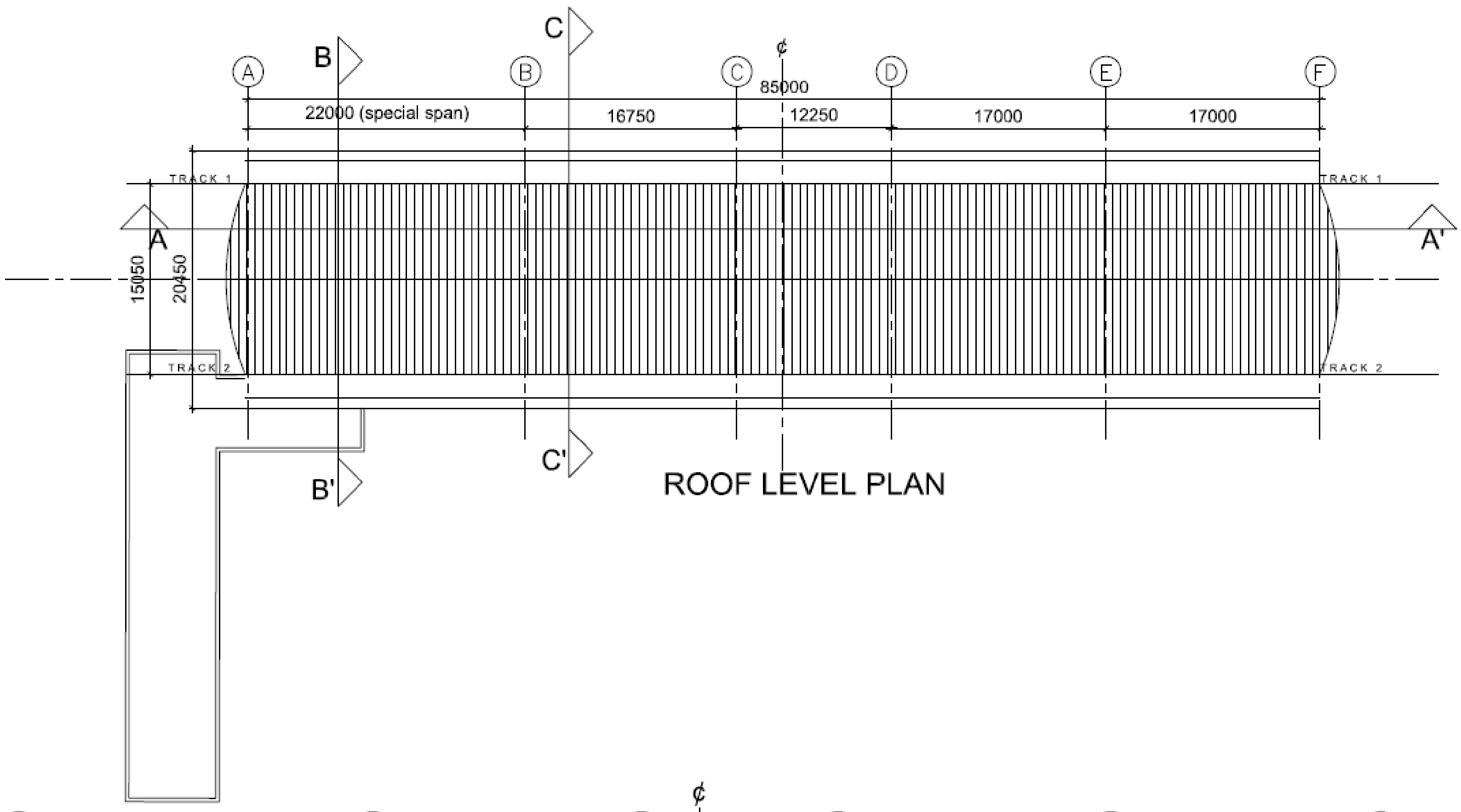
ANNEXURE 6.18: CROSS SECTION AND ANCILLARY BUILDING PLANS OF JAMA MASJID STATION



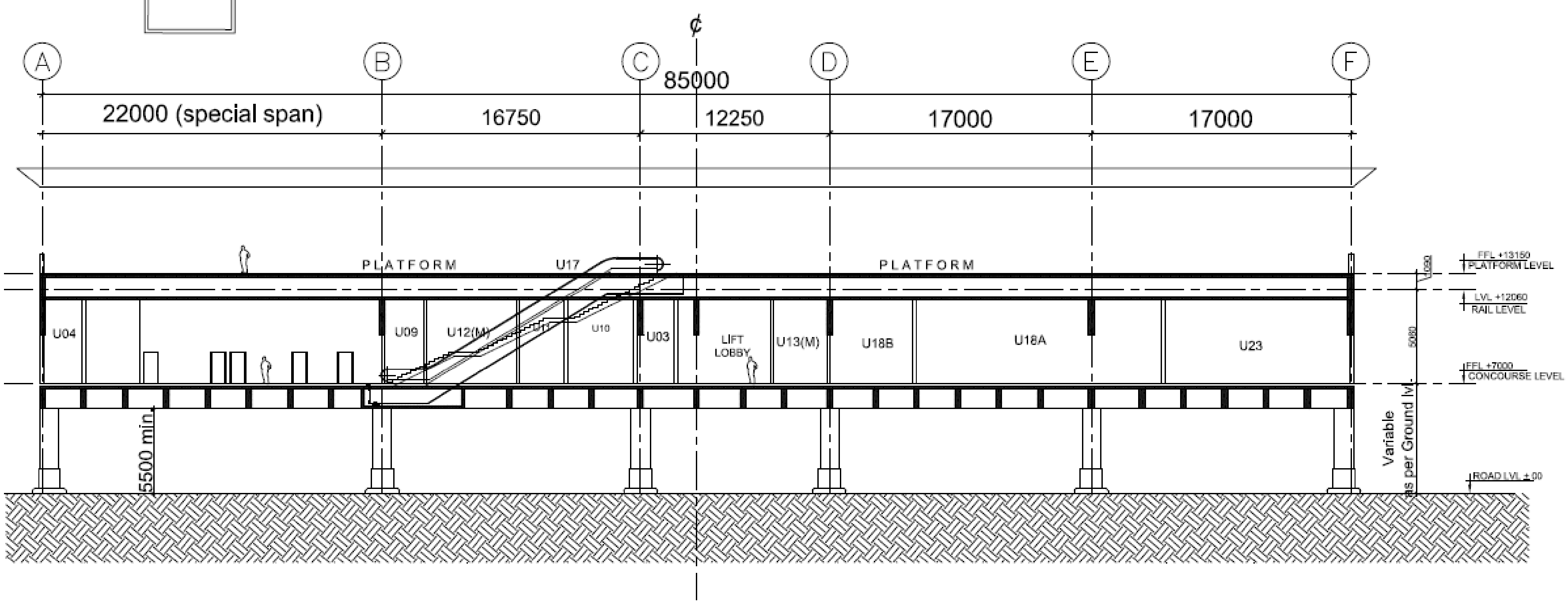
ANNEXURE 6.19: GROUND, CONCOURSE AND PLATFORM LEVEL PLANS OF AGRA CANTT. STATION



ANNEXURE 6.20: ROOF PLAN AND LONGITUDNAL SECTION OF AGRA CANTT. STATION



ROOF LEVEL PLAN

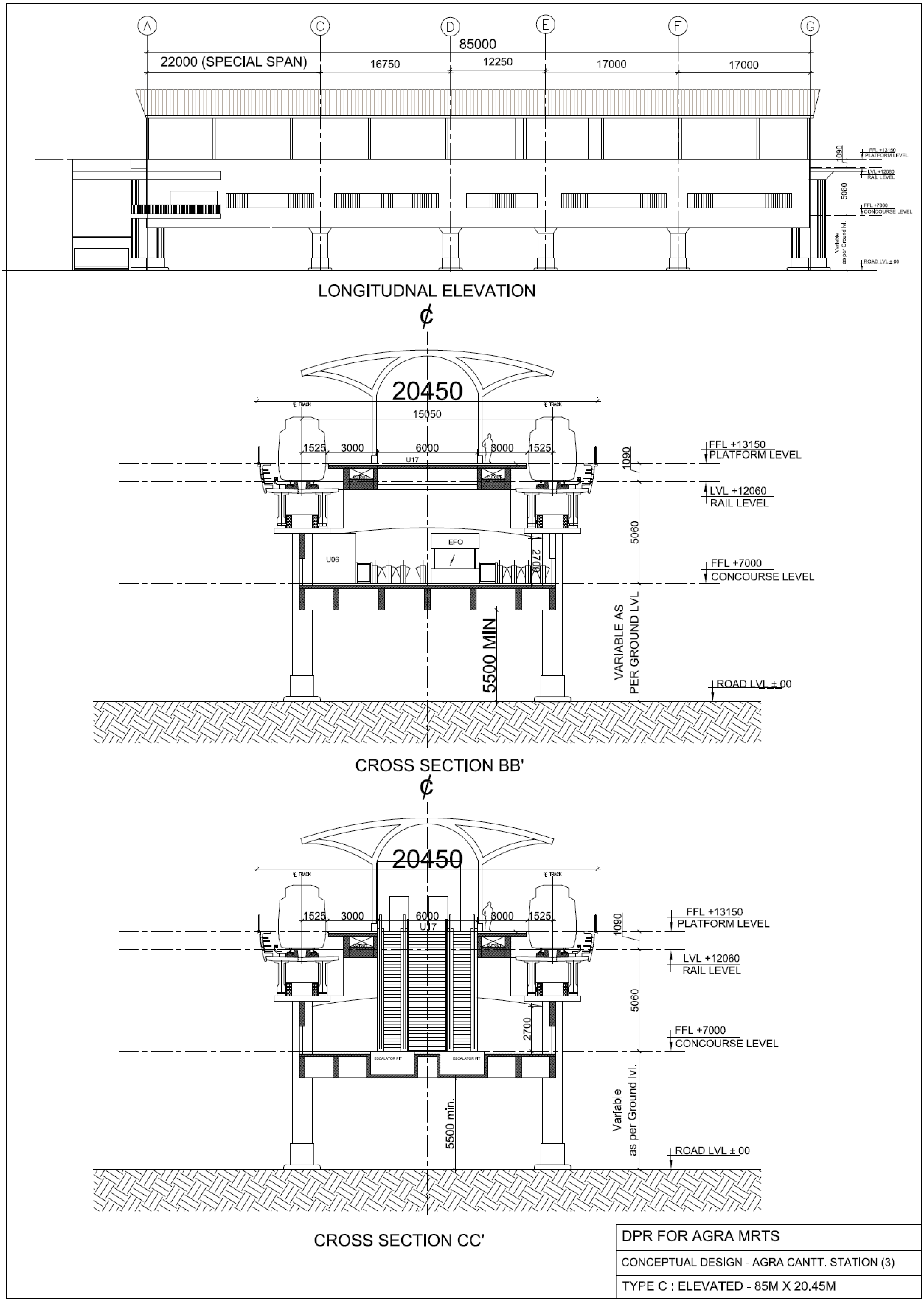


LONGITUDNAL SECTION AA'
(N.T.S)

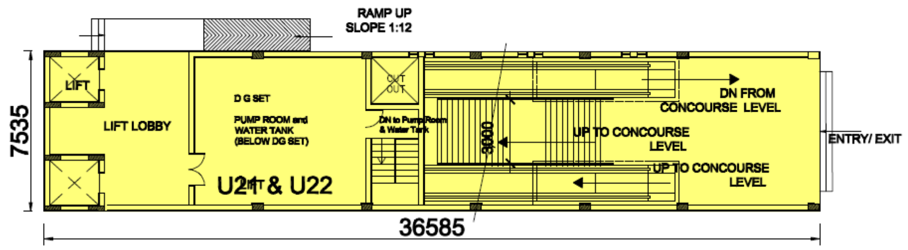
ROOM SCHEDULE				
ROOM. NO.	ROOM NAME	SIZE OF ROOM (M)		AREA PROVIDED (SQ.M)
U01	STATION ENTRANCE UNPAID AREA			115,13
U02	CONCOURSE PAID AREA			398,26
U03	STATION CONTROL ROOM (SCR)	4,50	7,06	26,96
U04	STATION MANAGER ROOM (SMR)	8,25	2,77	17,29
U05	TICKET OFFICE CASH ROOM	2,50	11,59	28,98
U06	FIRST AID ROOM	2,40	2,77	6.65
U08	SECURITY ROOM	3.77	2.77	10,44
U09	STORE FOR MAINTENANCE	5.57	4.07	18.58
U10	CLEANERS ROOM	2.77	2.77	7.67
U11	REFUSE STORE	2.40	2.77	6,65
U012(M)+T	STAFF / LOCKER ROOM (M)	5,80	4,06	23,58
U012(F)+T	STAFF / LOCKER ROOM (F)	4,38	3,70	16,25
U013 (F)	FEMALE TOILET	4.33	2.67	11.61
U013 (M)	MALE TOILET	3,36	4,29	14.42
U013 (H)	HANDICAP TOILET	1,80	4,68	4.82
U014	SIGNALLING ROOM	5,30	4,77	25.28
U015	TELE COMMUNICATION ROOM	10,09	3,50	35,30
U016	UPS ROOM	9,60	3,50	33,6
U017	PLATFORM			906,86
U018A & U018B	AUXILIARY SUB STATION	15.90	8.23	130.86
	ELEC. UPS ROOM	5,41	4,29	23.24
U021 & U022	FIRE FIGHTING TANK	10,36	5,95	61,29
	PUMP ROOM			
	D G ROOM			
U23	TSS	12.00	14.59	175.00
U24	ROOM FOR SCREEN DOORS	3,00	4,00	12,00
U25	LOST AND FOUND ROOM	3.00	4.00	12.00

DPR FOR AGRA MRTS
CONCEPTUAL DESIGN - AGRA CANTT. STATION (2)
TYPE C : ELEVATED - 85M X 20,45M

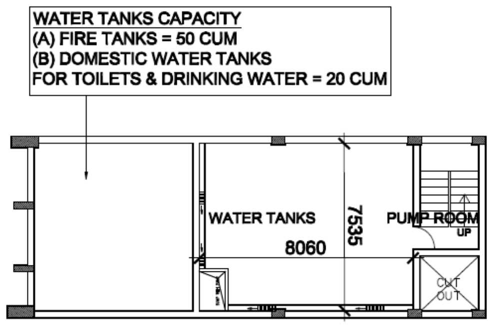
ANNEXURE 6.21: LONGITUDNAL ELEVATION AND CROSS SECTIONS OF AGRA CANTT. STATION



ANNEXURE 6.22: ANCILLARY BUILDING PLAN AT AGRA CANTT. STATION



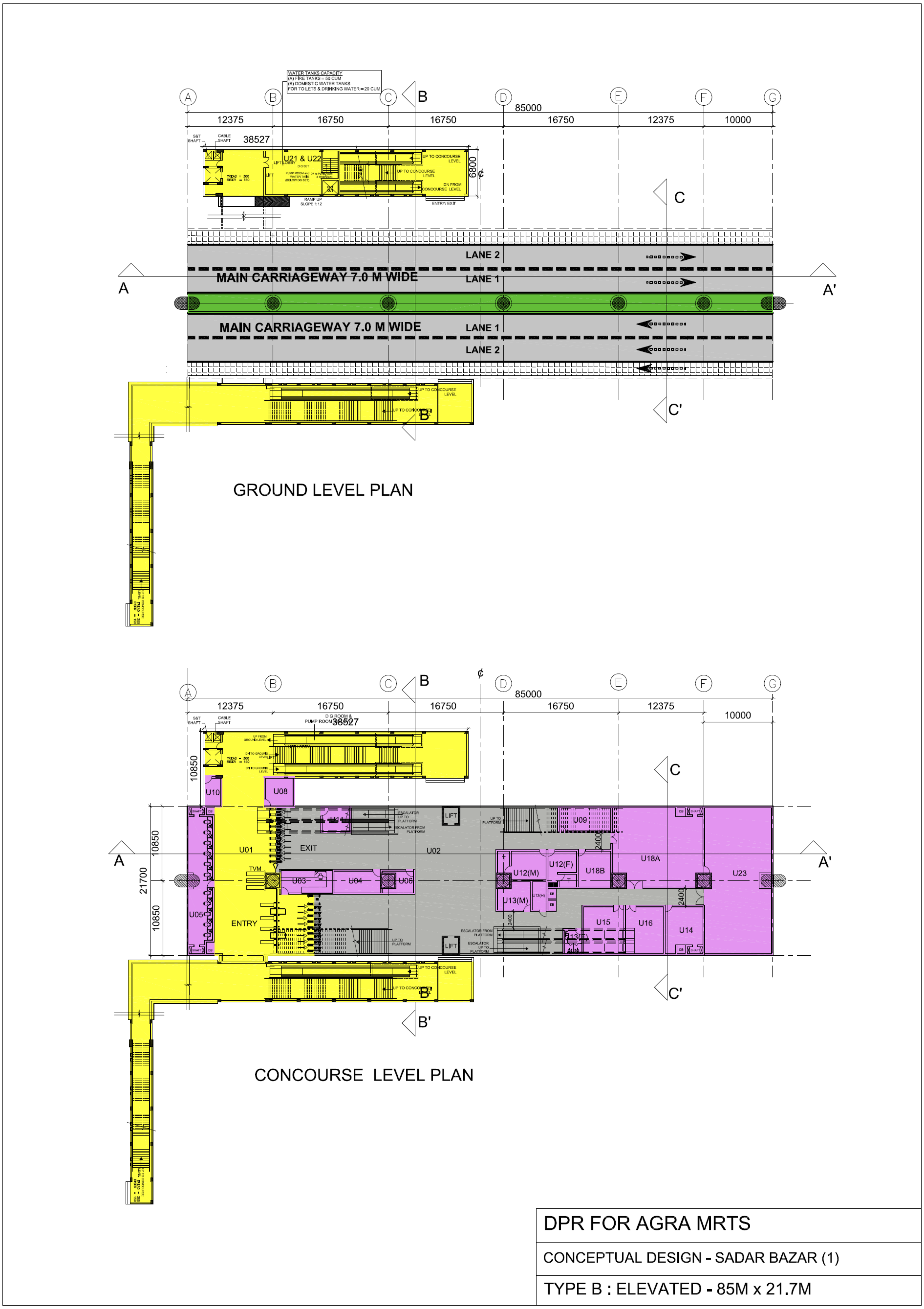
PLAN OF ANCILLAIRY BUIDING
SHOWING DG SET



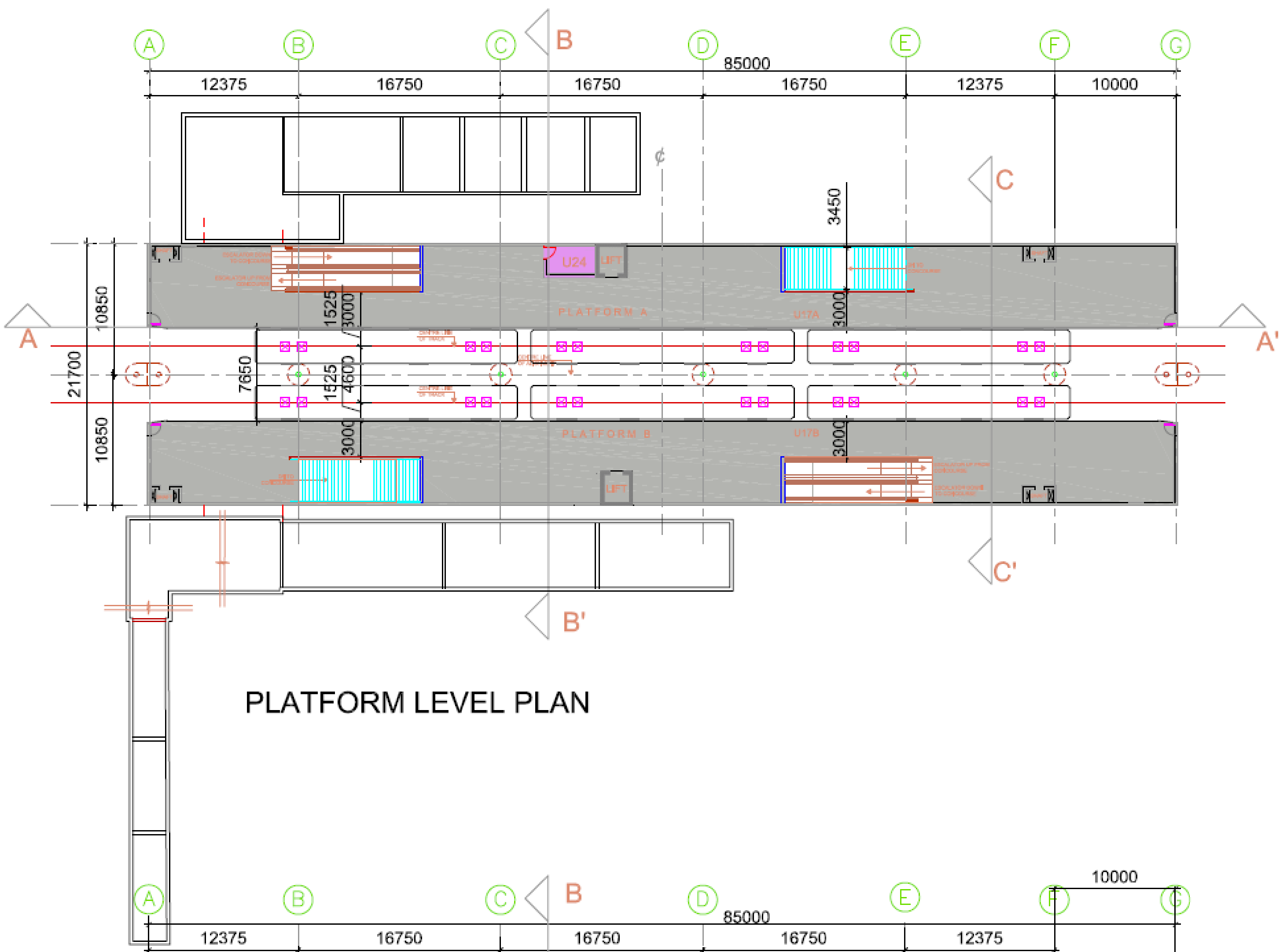
PLAN OF ANCILLAIRY BUIDING SHOWING
UNDERGROUND WATER TANKS AND
PUMP ROOM BELOW DG SET AND LIFT
LOBBY

DPR FOR AGRA MRTS
CONCEPTUAL DESIGN - AGRA CANTT. STATION (4)
TYPE C : ELEVATED - 85M X 20.45M

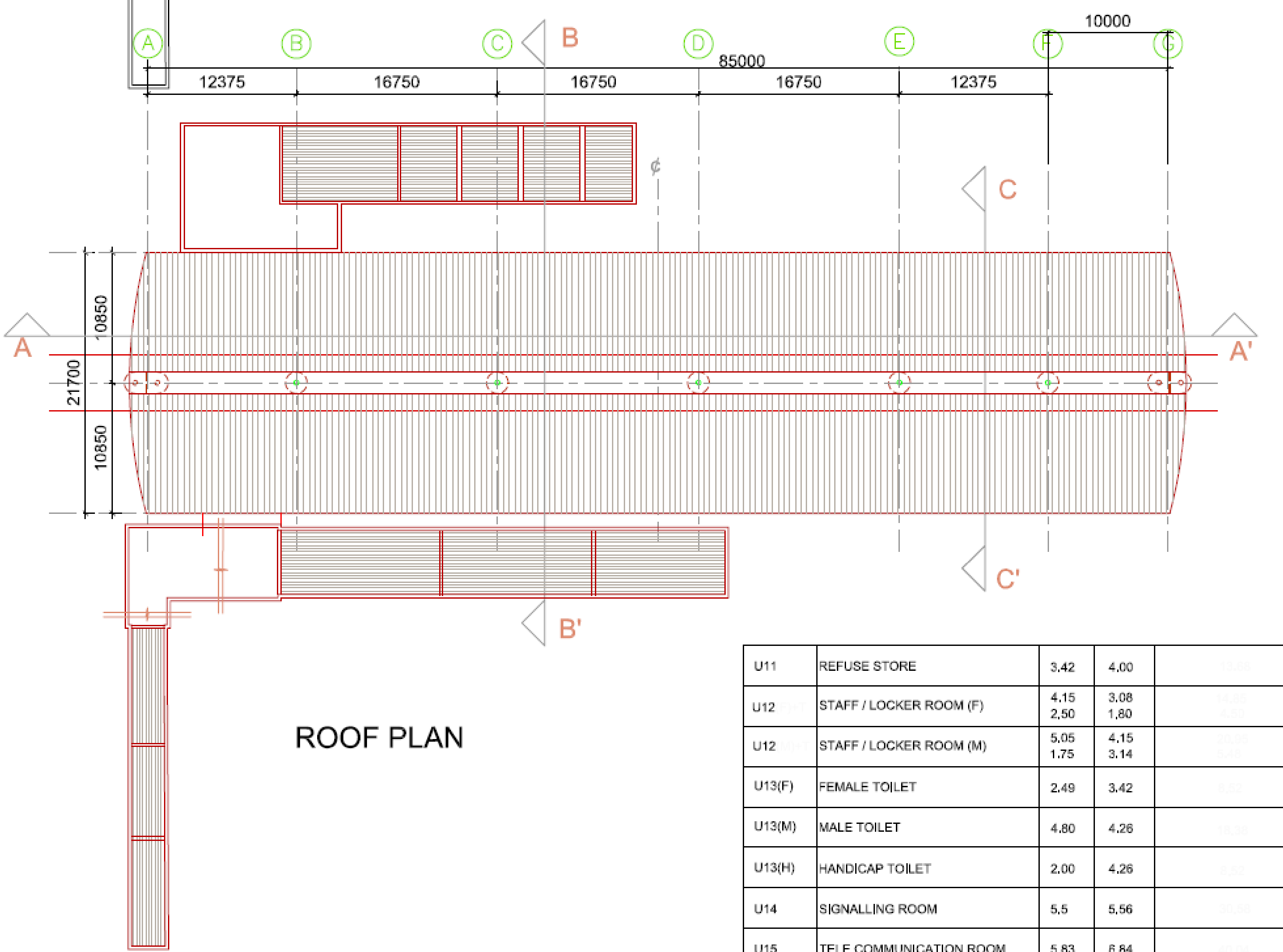
ANNEXURE 6.23: GROUND AND CONCOURSE LEVEL PLANS OF SADAR BAZAR



ANNEXURE 6.24: PLATFORM AND ROOF LEVEL PLANS OF SADAR BAZAR



PLATFORM LEVEL PLAN



ROOF PLAN

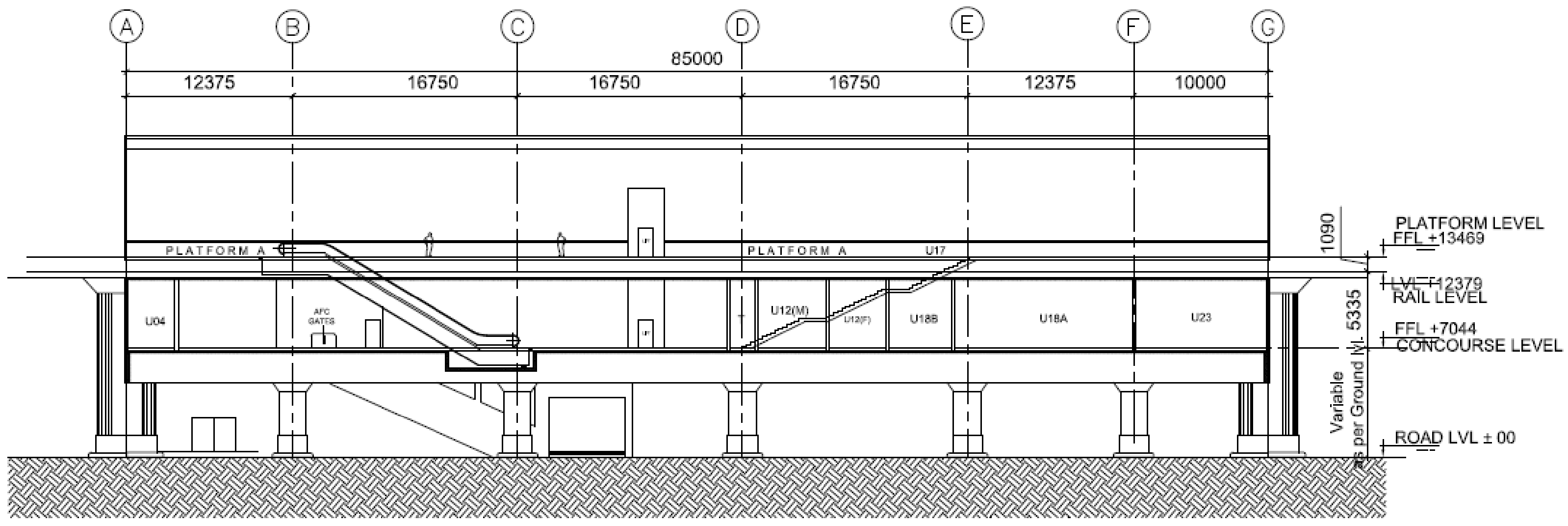
ROOM SCHEDULE				
ROOM. NO.	ROOM NAME	SIZE OF ROOM (M)		AREA PROVIDED (SQ.M)
U01	STATION ENTRANCE UNPAID AREA			225.40
U02	CONCOURSE PAID AREA			734.40
U03	STATION CONTROL ROOM (SCR)	7.48	3.14	25.84
U04	STATION MANAGER ROOM (SMR)	6.75	3.14	21.24
U05	TICKET OFFICE CASH ROOM	3.45	17.94	59.15
U06	FIRST AID ROOM			
U08	SECURITY ROOM	4.0	4.0	
U09	STORE FOR MAINTENANCE	7.45	3.34	
U10	CLEANERS ROOM	4.0	2.3	
U11	REFUSE STORE	3.42	4.00	
U12	STAFF / LOCKER ROOM (F)	4.15 2.50	3.08 1.80	
U12	STAFF / LOCKER ROOM (M)	5.05 1.75	4.15 3.14	
U13(F)	FEMALE TOILET	2.49	3.42	
U13(M)	MALE TOILET	4.80	4.26	
U13(H)	HANDICAP TOILET	2.00	4.26	
U14	SIGNALLING ROOM	5.5	5.56	
U15	TELE COMMUNICATION ROOM	5.83	6.84	
U16	UPS ROOM	5.54	6.86	
U17A & U17B	PLATFORM	84.74	6.77	
U18A & U18B	AUXILIARY SUB STATION ELEC. UPS ROOM			
U21 & U22	FIRE FIGHTING TANK PUMP ROOM D G ROOM			
U23	TSS	9.49	21.19	
U24	ROOM FOR UTILITIES	4.00	2.30	

DPR FOR AGRA MRTS

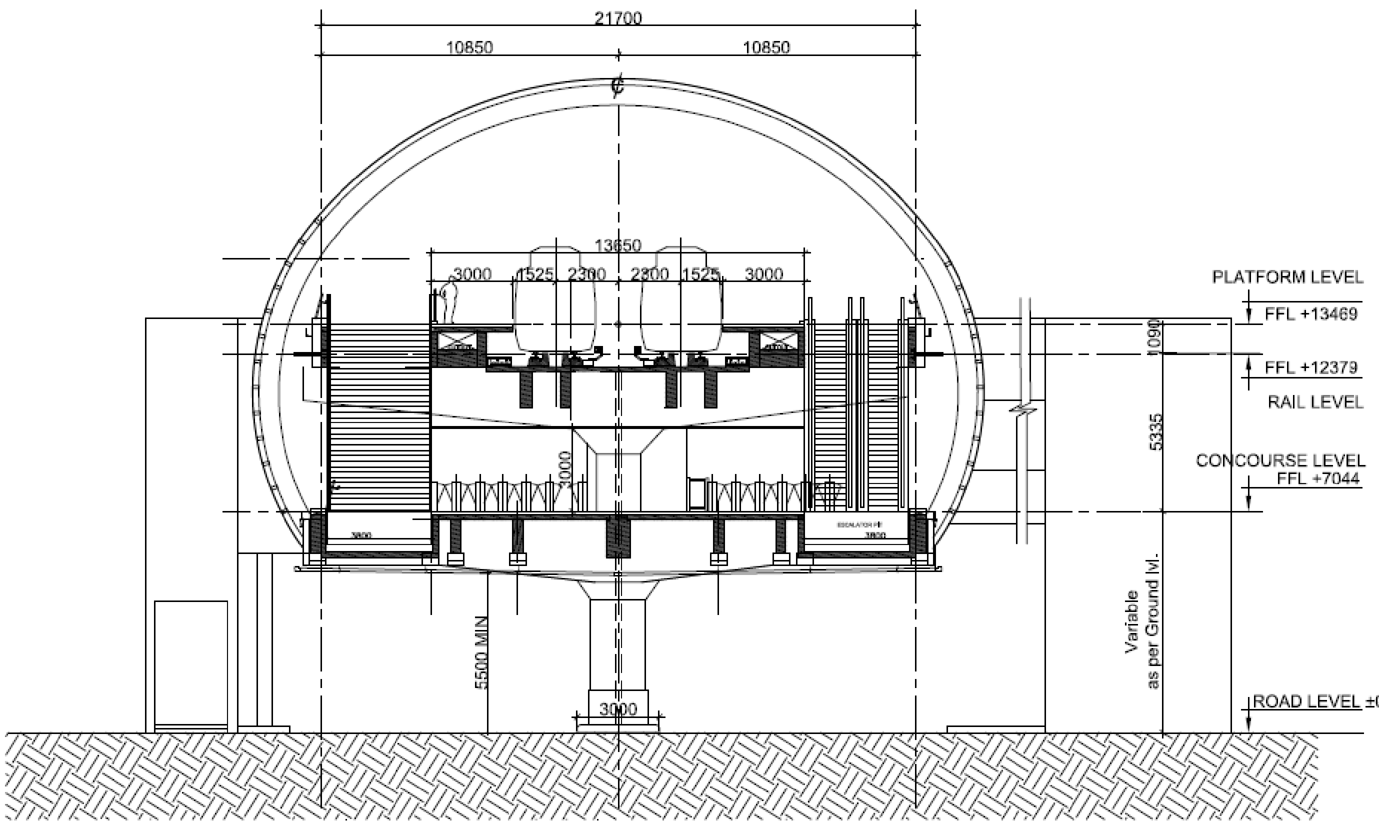
CONCEPTUAL DESIGN - SADAR BAZAR (2)

TYPE B : ELEVATED - 85M x 21.7M

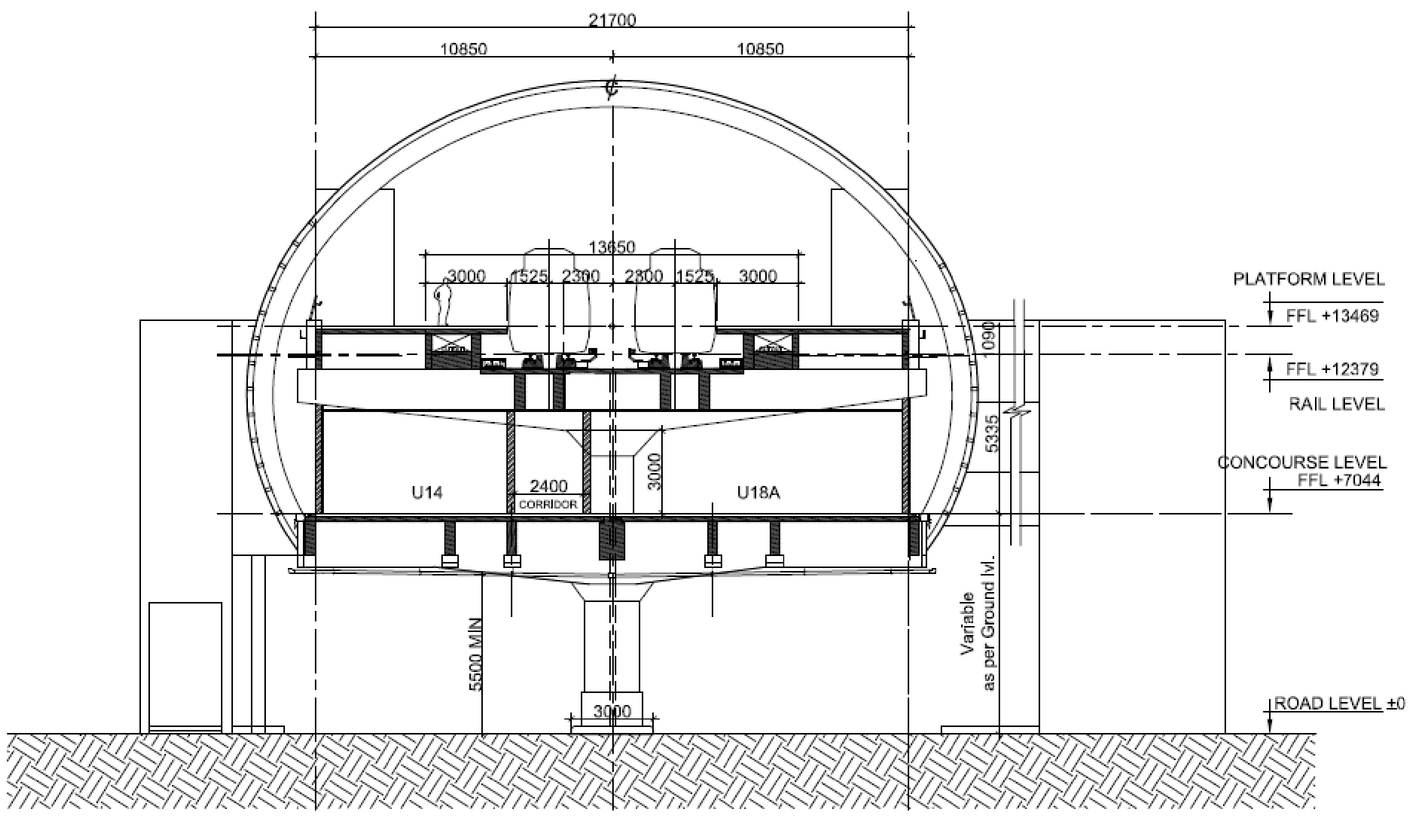
ANNEXURE 6.25: LONGITUDINAL SECTION AND CROSS SECTION OF SADAR BAZAR



LONGITUDNAL SECTION AA'



CROSS SECTION BB'



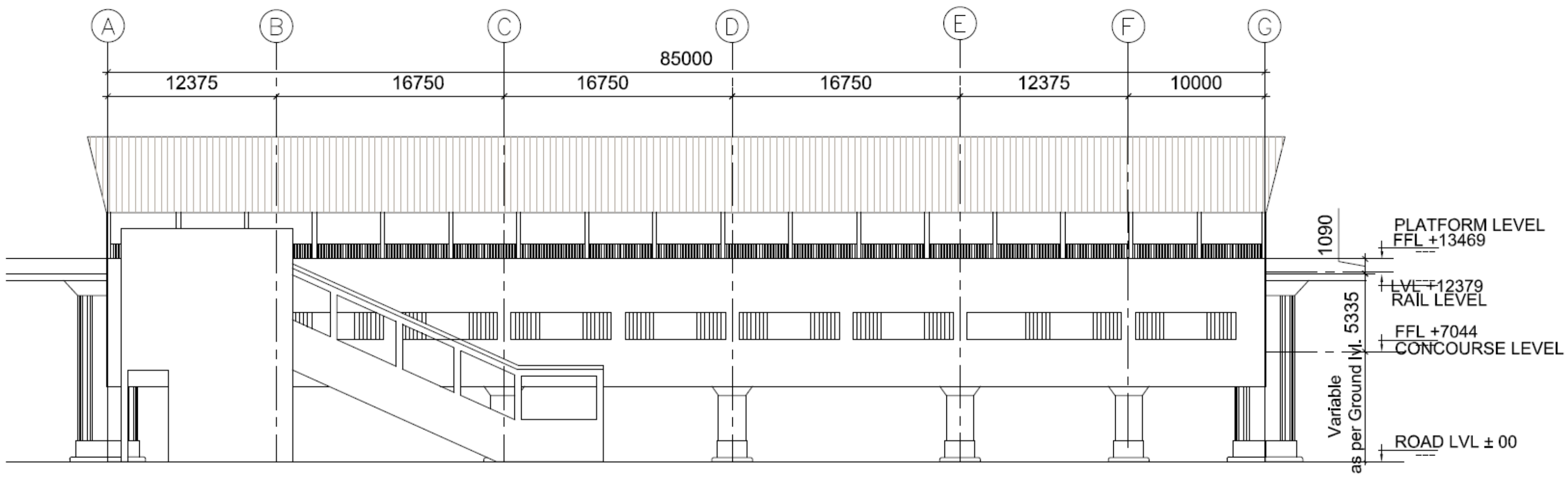
CROSS SECTION CC'

DPR FOR AGRA MRTS

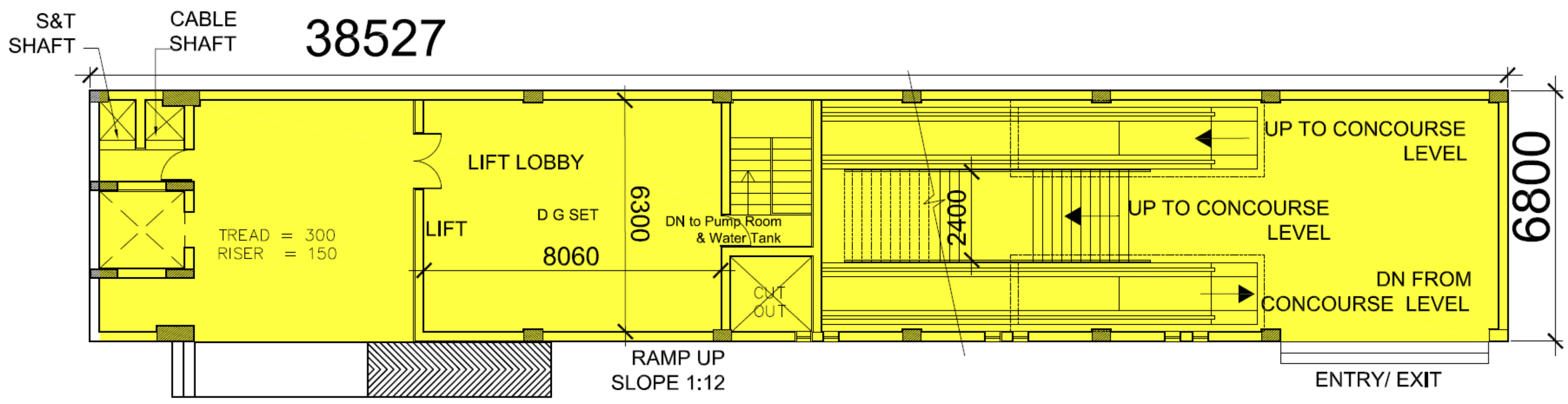
CONCEPTUAL DESIGN - SADAR BAZAR (3)

TYPE B : ELEVATED - 85M x 21.7M

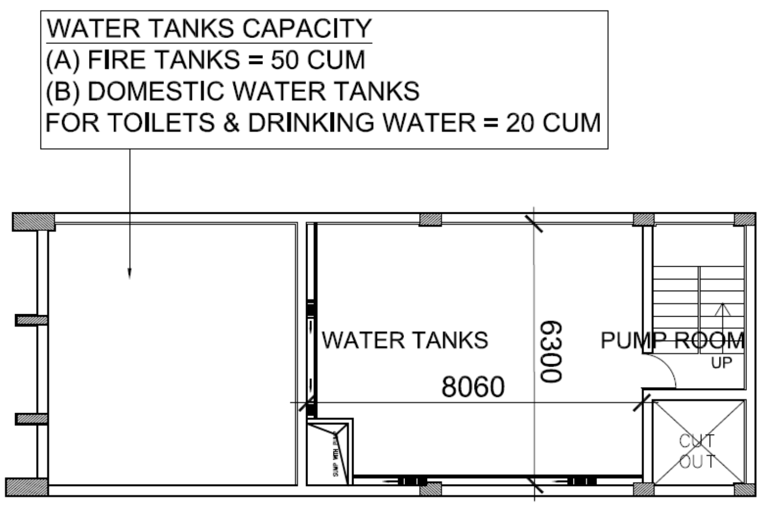
ANNEXURE 6.26: LONGITUDINAL ELEVATION AND ANCILLARY BUILDING OF SADAR BAZAR



LONGITUDNAL ELEVATION



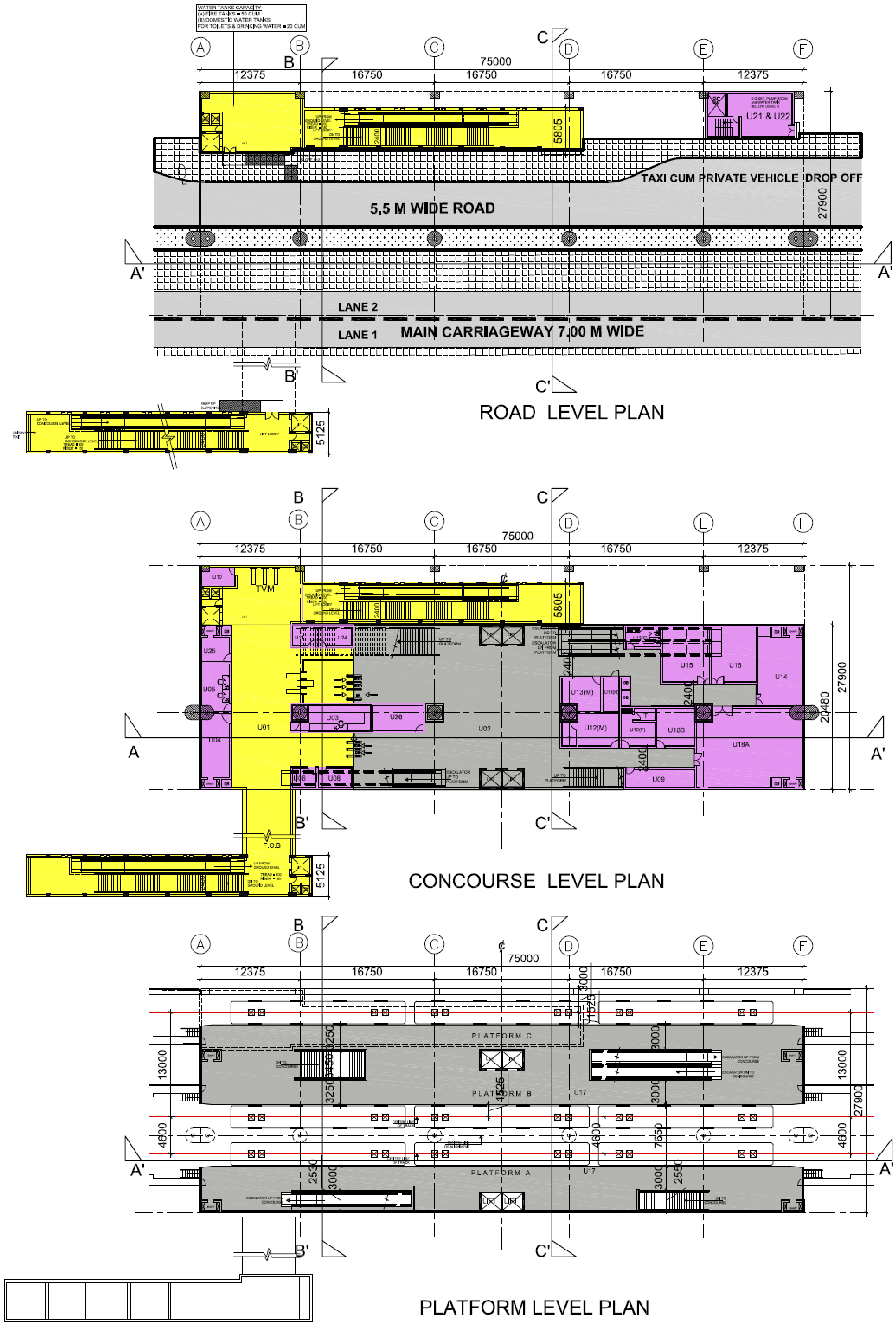
PLAN OF ANCILLAIRY BUIDING
SHOWING DG SET



PLAN OF ANCILLAIRY BUIDING SHOWING
UNDERGROUND WATER TANKS AND
PUMP ROOM BELOW DG SET AND LIFT
LOBBY

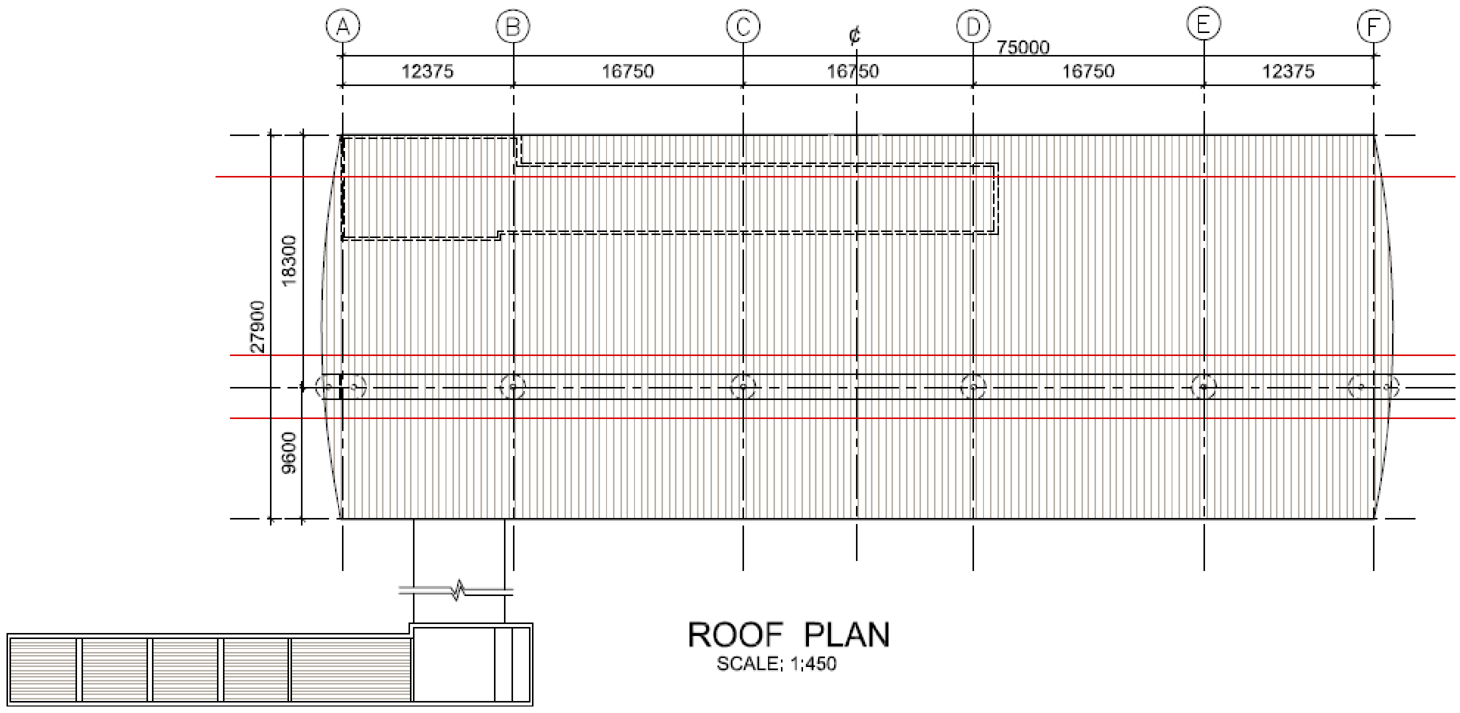
DPR FOR AGRA MRTS
CONCEPTUAL DESIGN - SADAR BAZAR (4)
TYPE B : ELEVATED - 85M x 21.7M

ANNEXURE 6.27: ROAD, CONCOURSE AND PLATFORM LEVEL PLANS OF SULTANGANJ CROSSING STATION

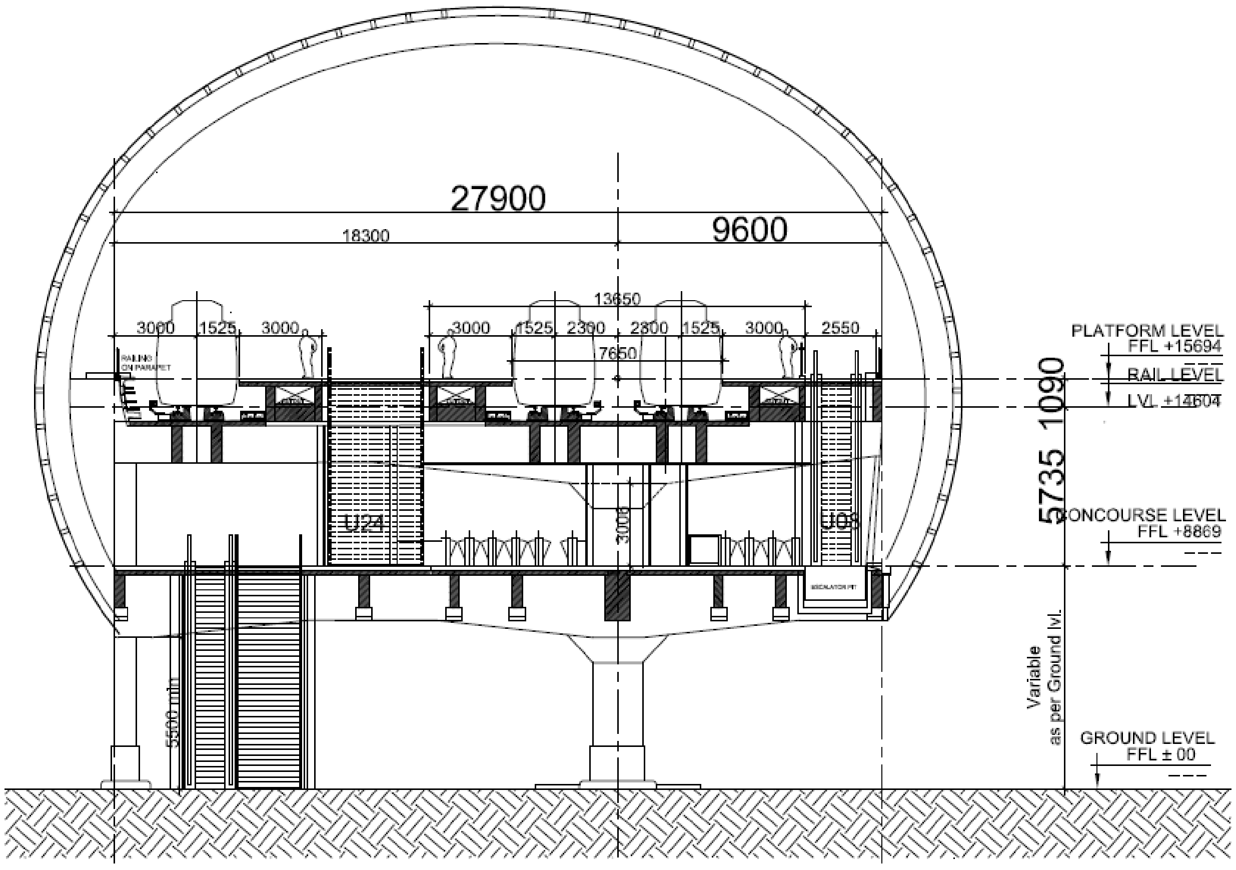


DPR FOR AGRA MRTS
CONCEPTUAL DESIGN - SULTAN GANJ CROSSING (1)
TYPE E : ELEVATED - 75M X 27.9M (3 TRACK MID TERMINAL)

ANNEXURE 6.28: ROOF PLAN AND CROSS SECTION OF SULTANGANJ CROSSING STATION



ROOF PLAN
SCALE: 1:450



CROSS SECTION - BB'
SCALE: N.T.S

ROOM SCHEDULE				
ROOM. NO.	ROOM NAME	SIZE OF ROOM (M)		AREA PROVIDED (SQ.M)
U01	STATION ENTRANCE UNPAID AREA			241.68
U02	CONCOURSE PAID AREA			693,29
U03	STATION CONTROL ROOM (SCR)			26.4
U04	STATION MANAGER ROOM (SMR)	3.45	7.90	26.24
U05	TICKET OFFICE CASH ROOM	3.45	9.19	19,38
U06	FIRST AID ROOM	2.91	2.35	6.78
U08	SECURITY ROOM	4.15	2.35	9.75
U09	STORE FOR MAINTENANCE	8,51	2,24	19,12
U10	CLEANERS ROOM	4.15	2.27	9,42
U11	REFUSE STORE	2.88	2.35	6,77
U12(F)+T	STAFF / LOCKER ROOM (F)	4.15 2,50	2.93 1,45	14,57 3.62
U12(M)+T	STAFF / LOCKER ROOM (M)	5,05 1.75	4,00 2.98	20,20 5.22

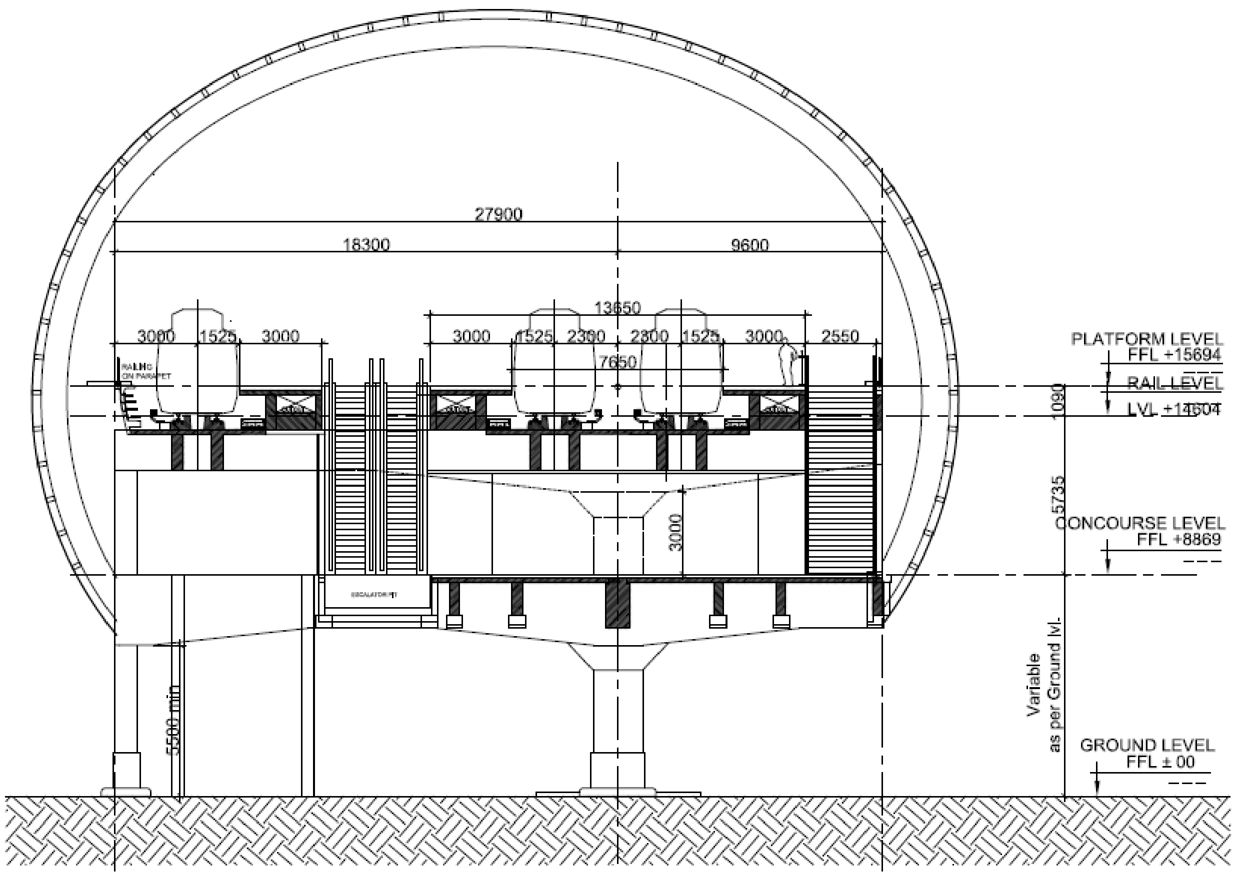
ROOM SCHEDULE				
U13 (F)	FEMALE TOILET	4.33	2.50	10.84
U13 (M)	MALE TOILET	4.80	4.13	17.76
U13 (H)	HANDICAP TOILET	2.00	4.13	8.26
U14	SIGNALLING ROOM	5.45	8.67	49.67
U15	TELE COMMUNICATION ROOM	5.79	6.81	39.44
U16	UPS ROOM	5.49	6.81	37.40
U17A U17B & U17C	PLATFORM	74.77	6.11	392.81
U18A & U18B	AUXILIARY SUB STATION ELEC. UPS ROOM	13.11 4.67	9.87 4.66	119.0 21.80
U21 & U22	FIRE FIGHTING TANK PUMP ROOM D G ROOM	10.36	5.95	61.29
U24	ROOM FOR SCREEN DOORS	4.15	2.35	9.75
U25	LOST & FOUND ROOM	3.00	3.47	10.35
U26	CABIN CREW ROOM	6.23	3.12	19.4

DPR FOR AGRA MRTS

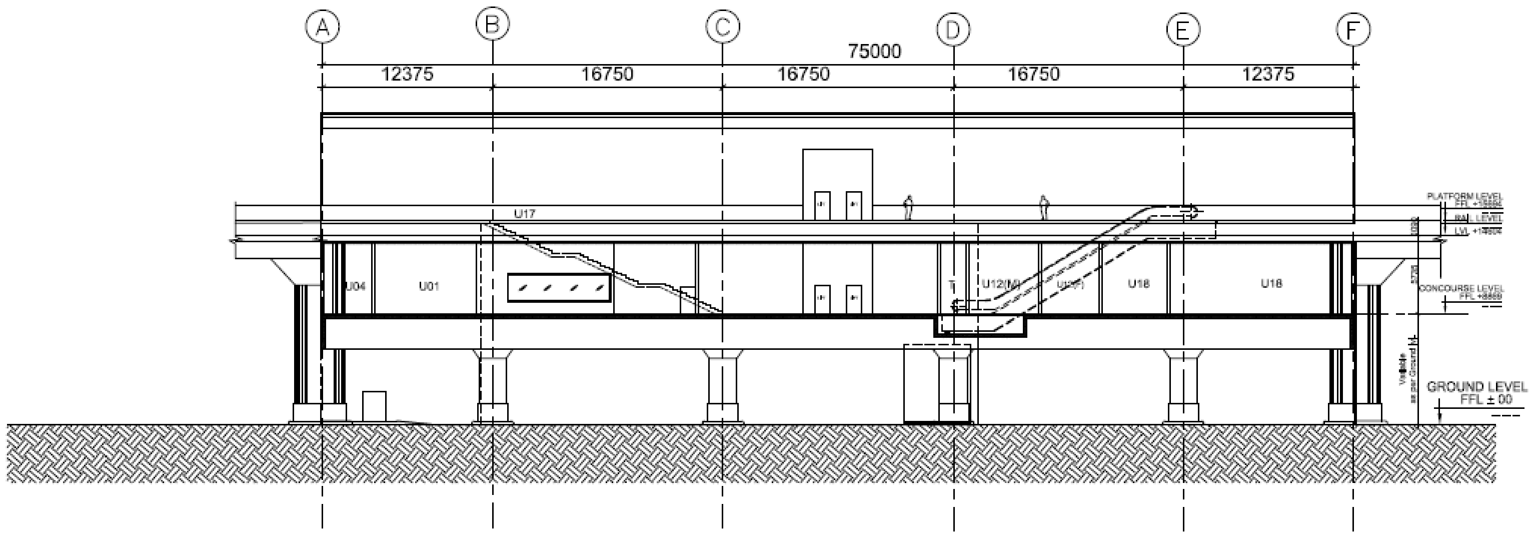
CONCEPTUAL DESIGN - SULTAN GANJ CROSSING (2)

TYPE E : ELEVATED - 75M X 27.9M (3 TRACK MID TERMINAL)

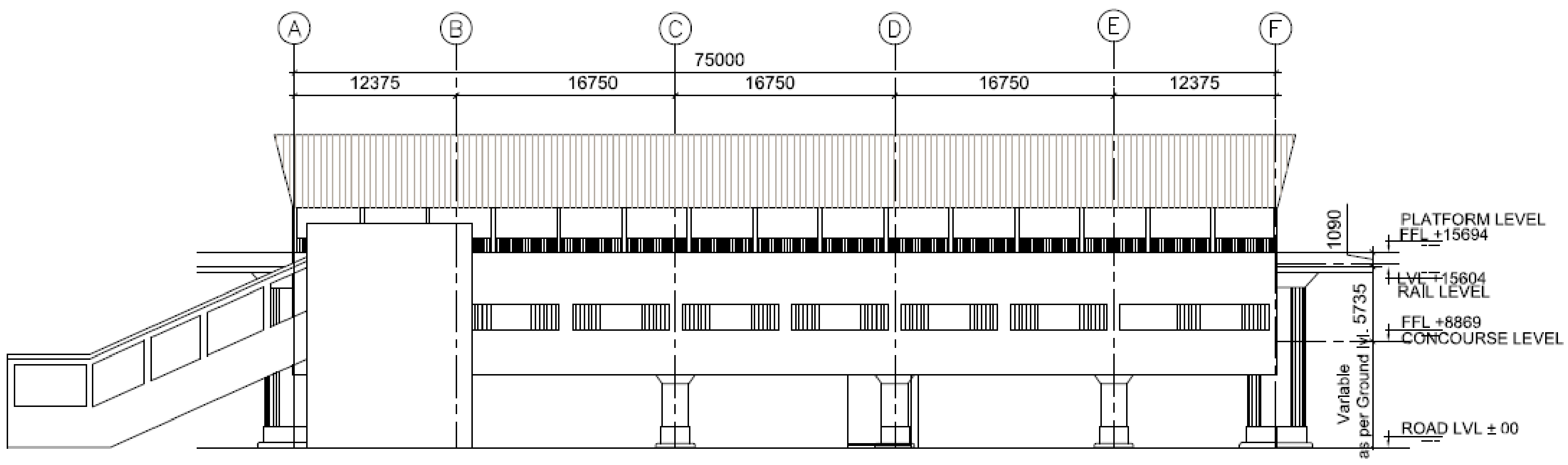
ANNEXURE 6.29: CROSS SECTION, LONGITUDNAL SECTION AND ELEVATION OF SULTANGANJ CROSSING STATION



CROSS SECTION - CC'
SCALE: N.T.S



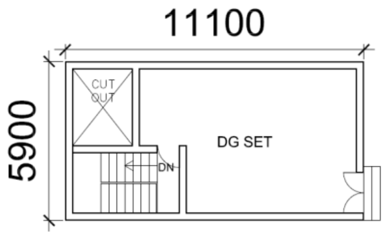
LONGITUDNAL SECTION- AA'
SCALE: N.T.S



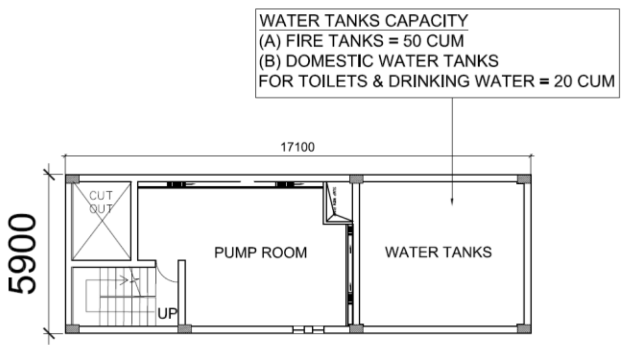
LONGITUDNAL ELEVATION
SCALE: N.T.S

DPR FOR AGRA MRTS
CONCEPTUAL DESIGN - SULTAN GANJ CROSSING (3)
TYPE E : ELEVATED - 75M X 27.9M (3 TRACK MID TERMINAL)

ANNEXURE 6.30: ANCILLARY BUILDING PLAN AT SULTANGANJ CROSSING STATION



PLAN OF ANCILLAIRY BUIDING
SHOWING DG SET



PLAN OF ANCILLAIRY BUIDING SHOWING
UNDERGROUND WATER TANKS AND
PUMP ROOM BELOW DG SET AND LIFT
LOBBY

DPR FOR AGRA MRTS
CONCEPTUAL DESIGN - SULTAN GANJ CROSSING (4)
TYPE E : ELEVATED - 75M X 27.9M (3 TRACK MID TERMINAL)

Chapter – 7

INTERMODAL INTEGRATION

7. INTER-MODAL INTEGRATION

7.1 INTER MODAL INTEGRATION WITH EXISTING MODES

The concept of intermodal integration with the modes is to provide last mile connectivity to the commuters residing/working in the metro influence zone. The Ministry of Urban Development 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.

Intermodal 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 intermodal 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 etcupto 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
ii. Metro - Bus
iii. Metro - Rail

i. Agra College Station - (Metro -Metro)

Agra College station is an interchange between Underground and Elevated Station of Corridor-1 and Corridor-2, respectively. To enable seamless transfer of passengers between one mode and to another, it is proposed to connect the paid area of the underground station with the paid area of the elevated Agra College through a set of staircases and escalators.

This station is likely to be one of the busiest stations owing to the Interchange facility. There will be a large no. of passengers interchanging between the two lines. Infrastructure facilities for such interchange station have been proposed on the basis of peak hour passenger flow.

Proper road markings, Traffic Signages, Zebra crossings and pedestrian signals are proposed near the station area to provide safe and uninterrupted pedestrian movements. Continuous foot path of 2.0 m is proposed near station influences 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. ISBT Station - (Metro-Bus)

It is an underground station, integrated with the existing ISBT through foot over bridge. The passengers will directly access the public transport systems without creating hindrance to road traffic. Infrastructure facilities for such interchange station have been 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. Demarcated pick and drop zones and bays for feeder modes like buses, IPT have been proposed near the station areas.

A continuous, encroachment free and well-maintained footpath of 2.0 m width is 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. Relocate the vendors/hawkers and parking for unobstructed movement of pedestrians and vehicles. Proper road markings, Traffic Signages, Zebra crossings and pedestrian signals are proposed to provide safe and uninterrupted pedestrian movements.

iii. Agra Cantt. Station – (Metro-Rail)

The proposed Agra Cantt. station on MRTS corridor-2 is an elevated station. It is integrated with the existing Agra Cantt. Railway Station directly near the main entry gate. The passengers will directly access the station without creating hindrance to road traffic. A single entry/exit connecting ground to concourse level is provided in the station catering to the passenger traffic coming from the railway station and surrounding sparsely populated neighbourhood.Other transport infrastructure facilities have been provided as per peak hour passenger demand.

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. Raja Ki Mandi Station– (Metro-Rail)

The proposed Raja Ki Mandi Station on MRTS Corridor-1 is an underground station. It is integrated with the existing Raja Ki Mandi Railway Station through lifts and staircases so that the passengers will directly access the two systems without obstructing the road traffic. One entrance has been provided inside the railway station premise parallel to station forecourt area to cater to railway passengers. Other transport infrastructure facilities have been 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 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 movements.

7.1.2 The inter-modal integration plans are presented from **Annexure 7.1** to **7.12.**

7.2 FEEDER SERVICES PLANNING AT STATIONS

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.

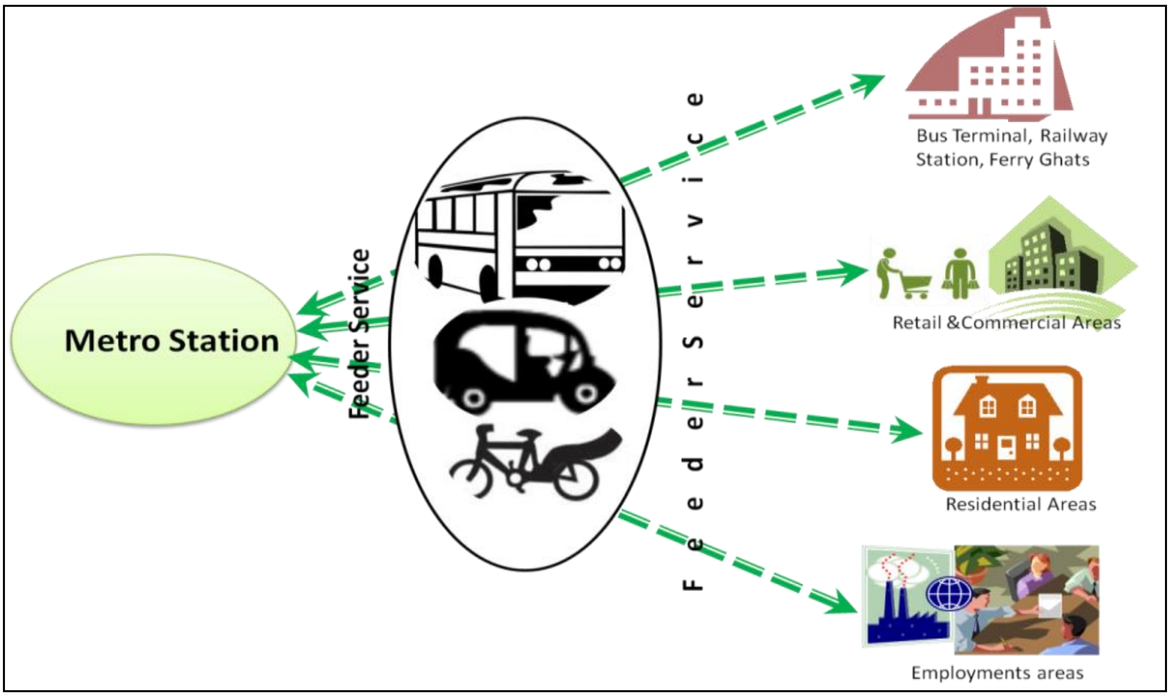
Various modes of transportation like feeder buses, auto rickshaw/taxi and bicycles can provide first mile as well as last mile connectivity to the metro station. For catchment area of about 0.5 -1 km from the proposed network, commuter can easily access it by walk. People residing in the next 1 km can 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.

7.2.1 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.

FIGURE 7.1 CONCEPT OF FEEDER SERVICES AT METRO STATIONS



The facilities of feeder buses have been estimated for peak hours of various horizon years. The fleets required along metro corridors are presented in **Table 7.1.** The total number of fleet required in the year 2024 is 44 for Corridor-1 and 44 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 8 stations in corridor -1 and 9 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 various stations based on station loads. The feeder services at more stations may be provided after detailed study at time of implementation.

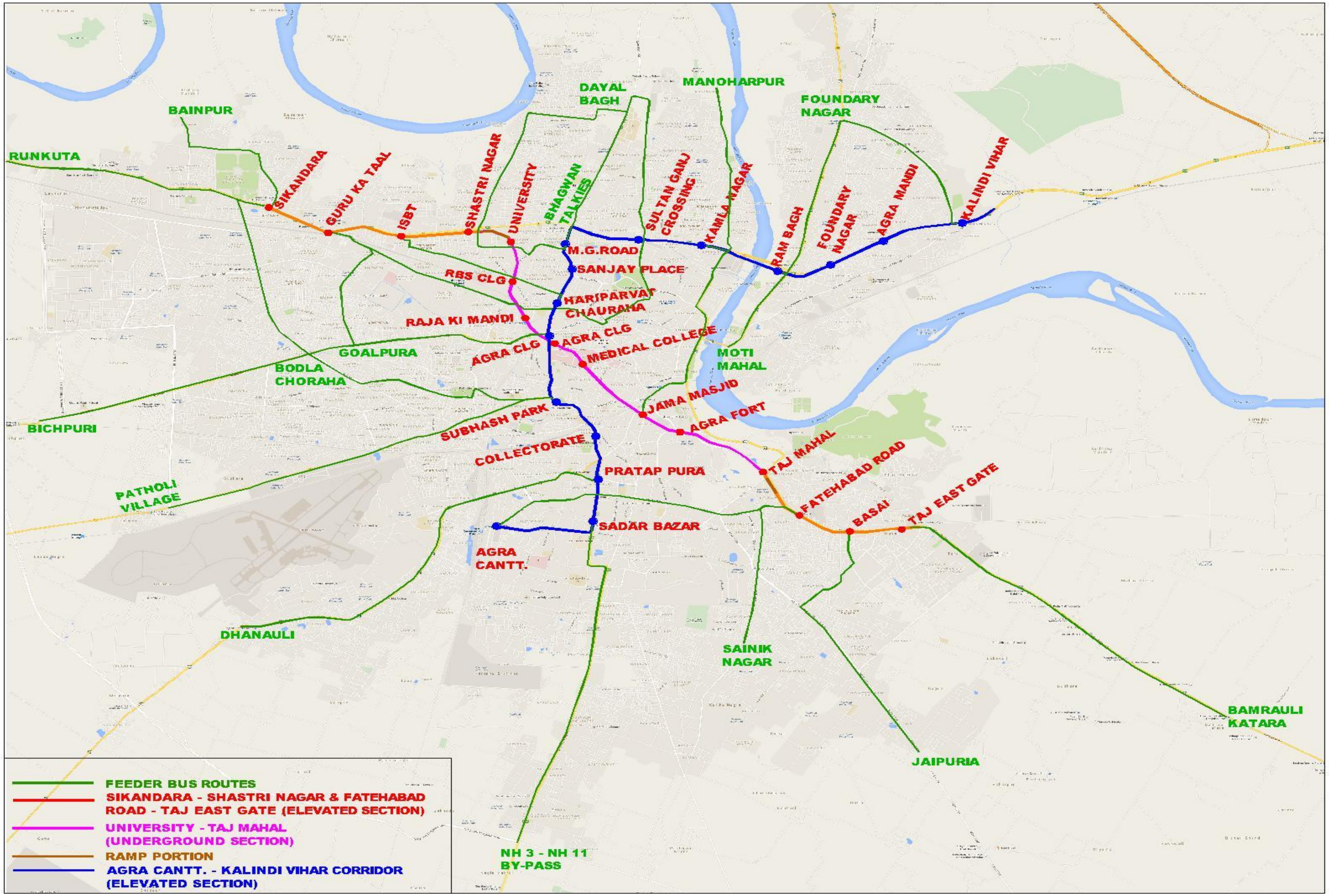
Table 7.1: FLEET REQUIREMENT FOR PHASE I METRO CORRIDORS

S. No.	Metro Station	Route No.	Route Bus Route Name	Length (in Km)	Buses in Peak Hour			
					2024	2031	2041	2051
Corridor-1: Sikandara to Taj East Gate								
1	Sikandara	R1	Sikandara to Runkuta	8.0	5	5	6	6
		R2	Sikandara to BodlaChoraha	3.5	2	2	3	3
		R3	Bainpur	3.0	2	2	2	2
2	Guru Ka Taal	R1	Lohamandi	3.0	2	2	2	2
		R2	Sanjay Place (Via Raja Ki Mandi)	4.0	3	3	3	3

S. No.	Metro Station	Route No.	Route Bus Route Name	Length (in Km)	Buses in Peak Hour 2024	2031	2041	2051
3	ISBT	R1	Sanjay Place (Via RBS College)	3.0	2	2	2	2
4	Agra College	R1	Bichpuri	8.5	9	12	15	18
5	Jama Masjid	R1	Kamla Nagar	4.0	3	5	6	7
6	Fatehabad Road	R1	Agra Cantt.	5.2	3	3	4	4
		R2	Sainik Nagar	5.1	3	3	4	4
7	Basai	R1	Jaipuria	5.3	3	3	4	4
8	Taj East Gate	R1	BamrauliKatara	6.1	7	9	12	14
	Total Buses Required for Corridor-1				**44**	**51**	**63**	**69**
Corridor-2: Agra Cantonment to KalindiVihar								
1	Sadar Bazar	R1	NH3-NH11 By-Pass	7.0	6	15	20	31
2	Pratap Pura	R1	Dhanauli (via Ajeet Nagar)	7.1	5	8	8	10
3	Subhash Park	R1	BodlaChoraha	4.5	3	4	4	4
		R2	Patholi Village	6.5	5	5	5	5
4	HariparvatChauraha	R1	Sultan Ganj Crossing	3.0	4	4	4	5
5	M.G.Road	R1	Dayal Bagh (Via University)	6.3	5	5	5	5
		R2	Dayal Bagh (Via Bhagwan Talkies)	3.1	3	3	3	3
6	Sultan Ganj Crossing	R1	Dayal Bagh	3.0	2	3	3	3
7	Kamla Nagar	R1	Manoharpur	4.0	3	3	3	3
8	Ram Bagh	R1	Moti Mahal	2.0	2	2	2	2
		R2	Foundary Nagar	3.1	2	3	3	3
9	KalindiVihar	R1	Foundary Nagar	3.0	4	5	6	7
	Total Buses Required for Corridor-2				**44**	**60**	**66**	**81**

Note: Number of buses have been estimated assuming average peak hour bus speed of 15 kmph and turnout time of 5 minutes.

Figure 7.2: FEEDER BUS ROUTE PLANNING AT METRO STATIONS



5.7.2 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 17 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

S. No.	Metro Station	Bicycles in Peak Hour			
		2024	2031	2041	2051
Corridor-1: Sikandara to Taj East Gate					
1	Sikandara	55	64	85	104
2	Guru ka Taal	26	28	31	38
3	ISBT	5	6	8	9
4	Agra College	61	81	94	114
5	Jama Masjid	31	52	70	85
6	Fatehabad Road	25	28	29	35
7	Basai	11	15	20	24
8	Taj East Gate	43	57	79	97
	Total Sharing Bicycles required	**257**	**331**	**416**	**506**
Corridor-2: Agra Cantonment to KalindiVihar					
1	Sadar Bazaar	47	120	172	209
2	Pratap Pura	35	51	58	71
3	Subhash Park	21	28	33	40
4	HariparvatChauraha	23	29	34	41
5	M.G.Road	9	11	13	16
6	Sultanganj Crossing	7	9	11	13
7	Kamla Nagar	13	16	19	23
8	Ram Bagh	24	30	50	61
9	KalindiVihar	55	71	83	101
	Total Sharing Bicycles required	**234**	**365**	**473**	**575**

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 areas 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 sservices - 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 Agra city.

7.4.4 Information Integration

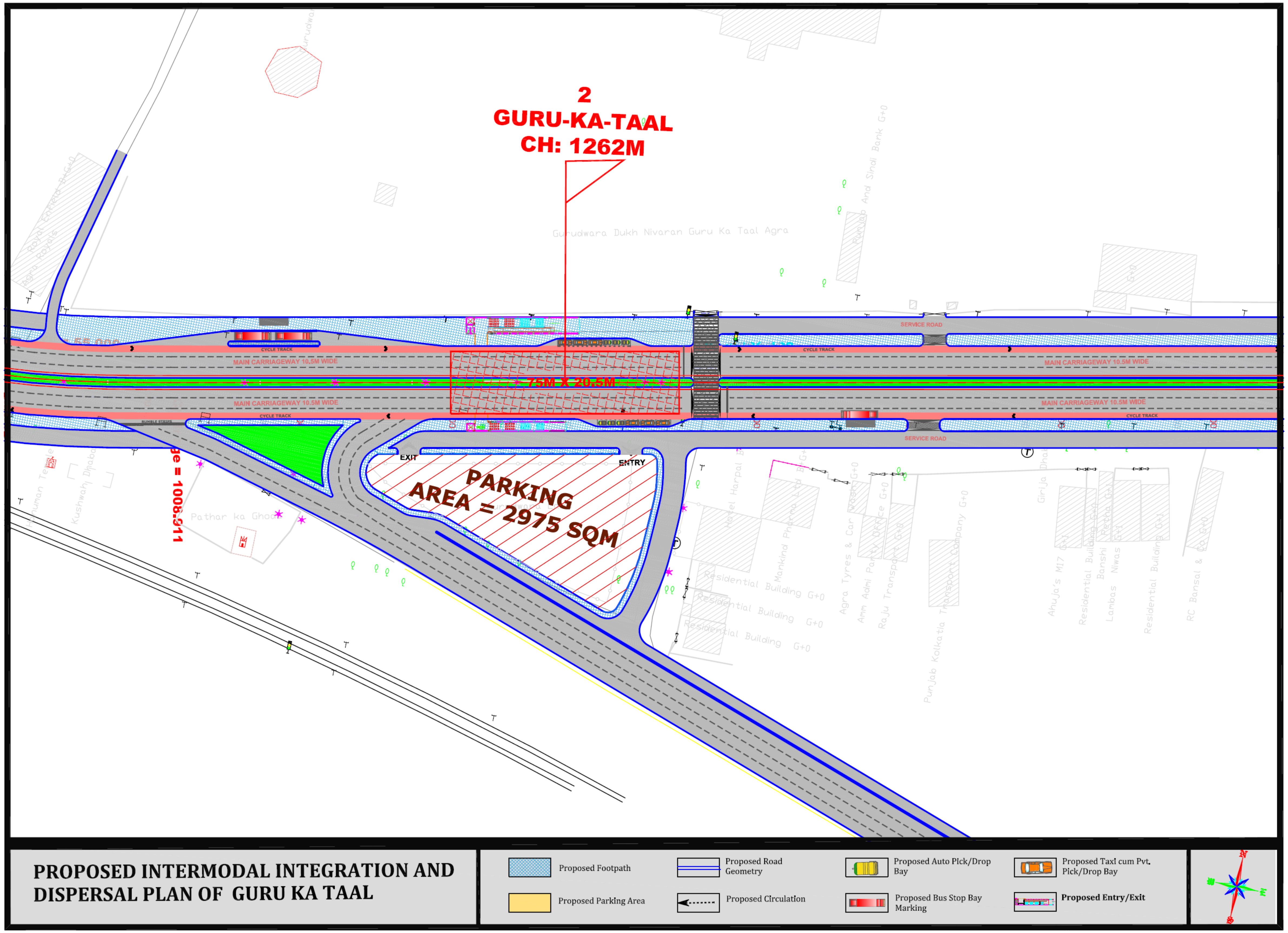
Creating the possibility to get information about the entire journey and not having to enquire at different sources. To take an informed decision during travel, real-time access to information is of strategic importance.

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.

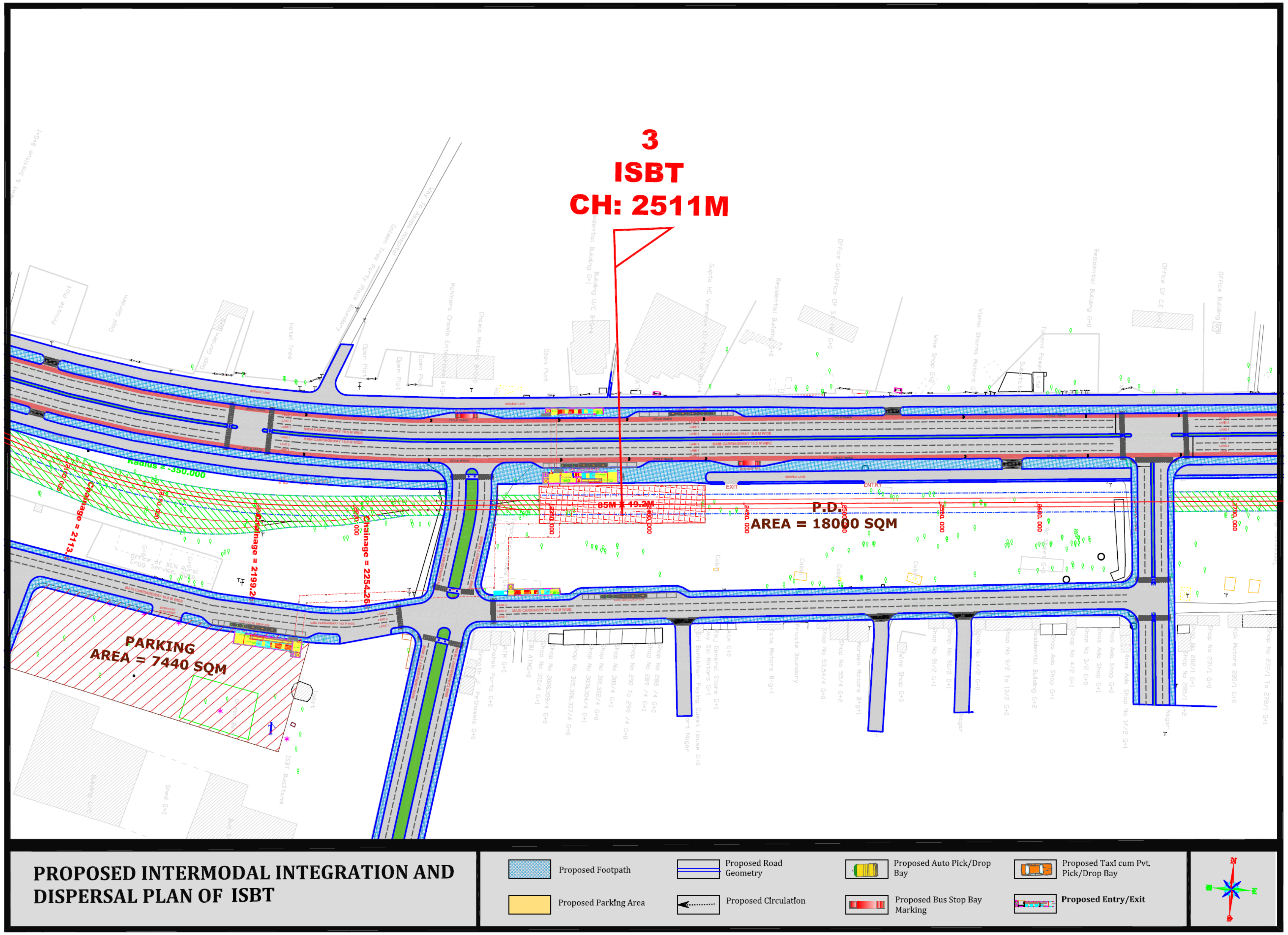
7.4.5 Institutional Integration

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.

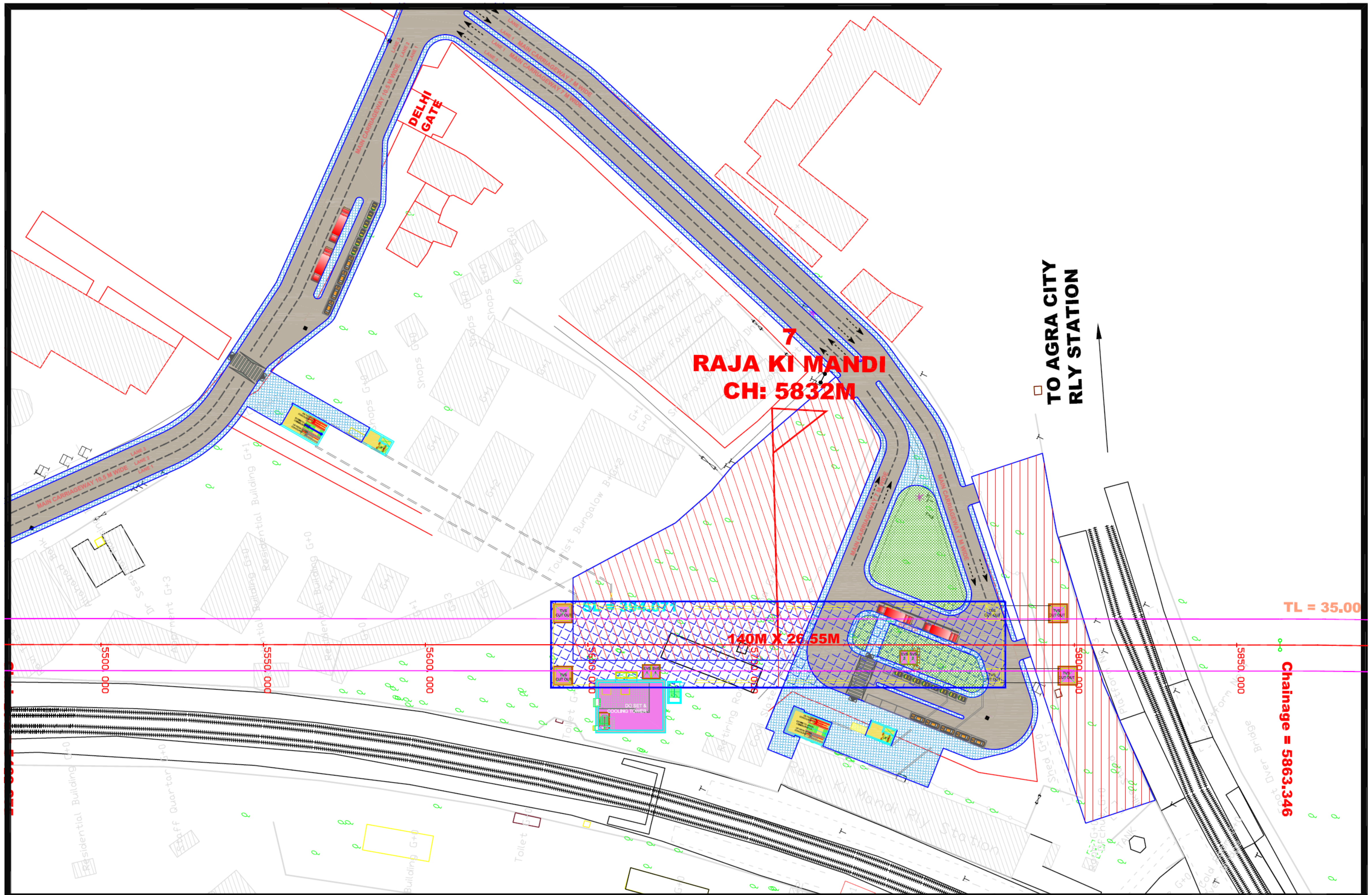
ANNEXURE 7. 1: TRAFFIC DISPERSAL AND MANAGEMENT PLAN OF GURU KA TAAL METRO STATION



ANNEXURE 7. 2: TRAFFIC DISPERSAL AND MANAGEMENT PLAN OF ISBT METRO STATION



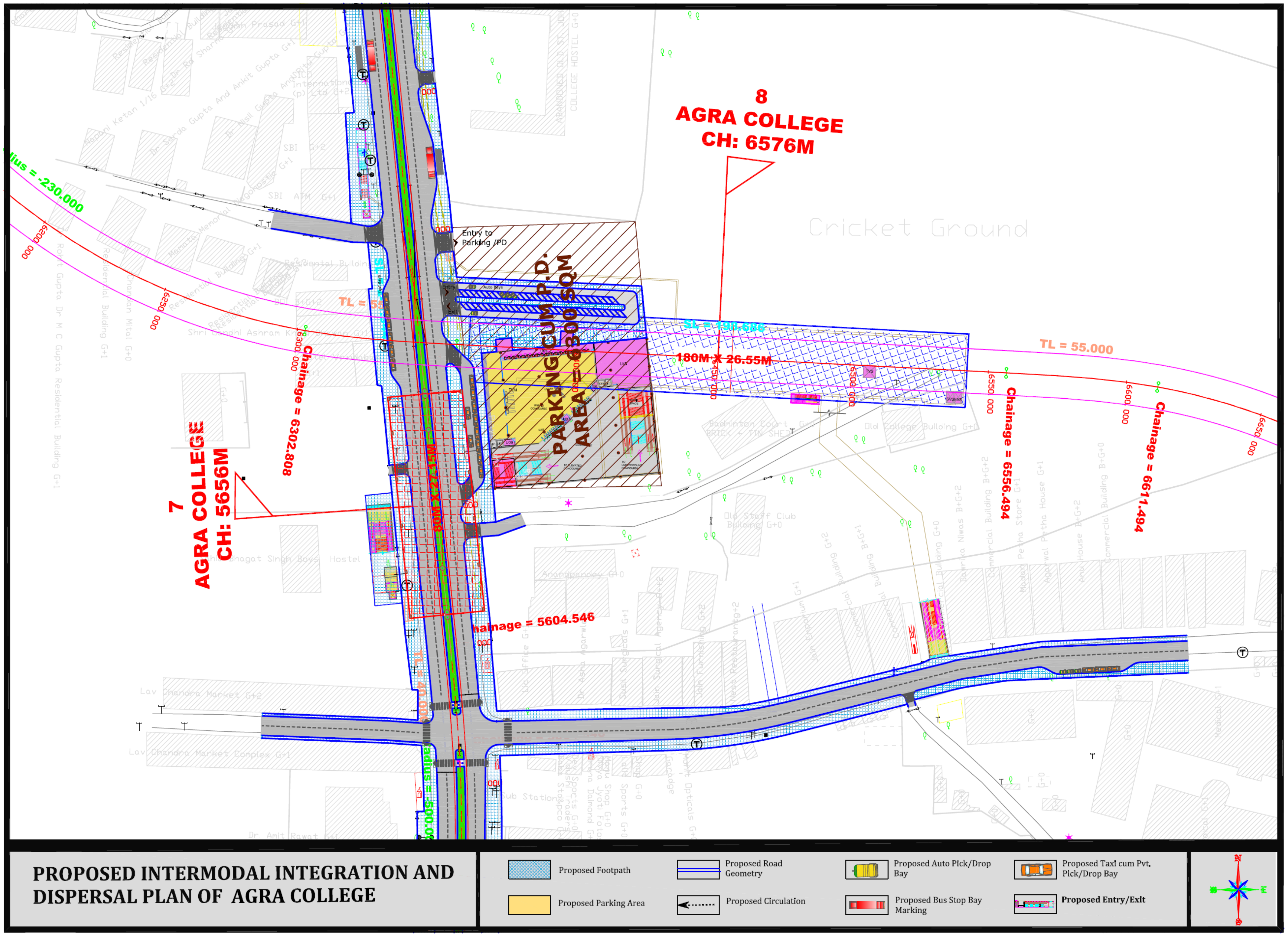
ANNEXURE 7. 3: TRAFFIC DISPERSAL AND MANAGEMENT PLAN OF RAJA KI MANDI METRO STATION



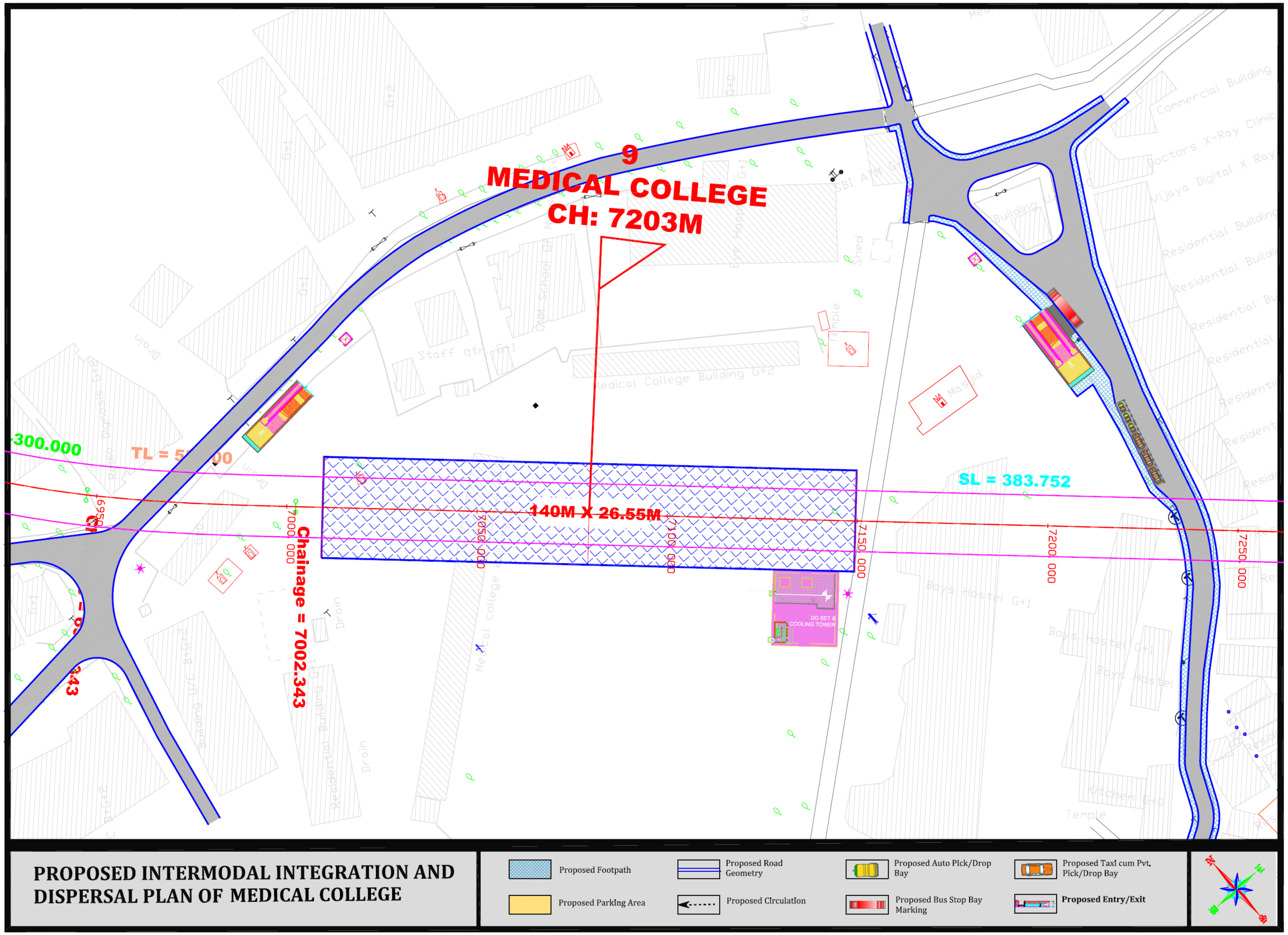
PROPOSED INTERMODAL INTEGRATION AND DISPERSAL PLAN OF RAJA KI MANDI

Proposed Footpath
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

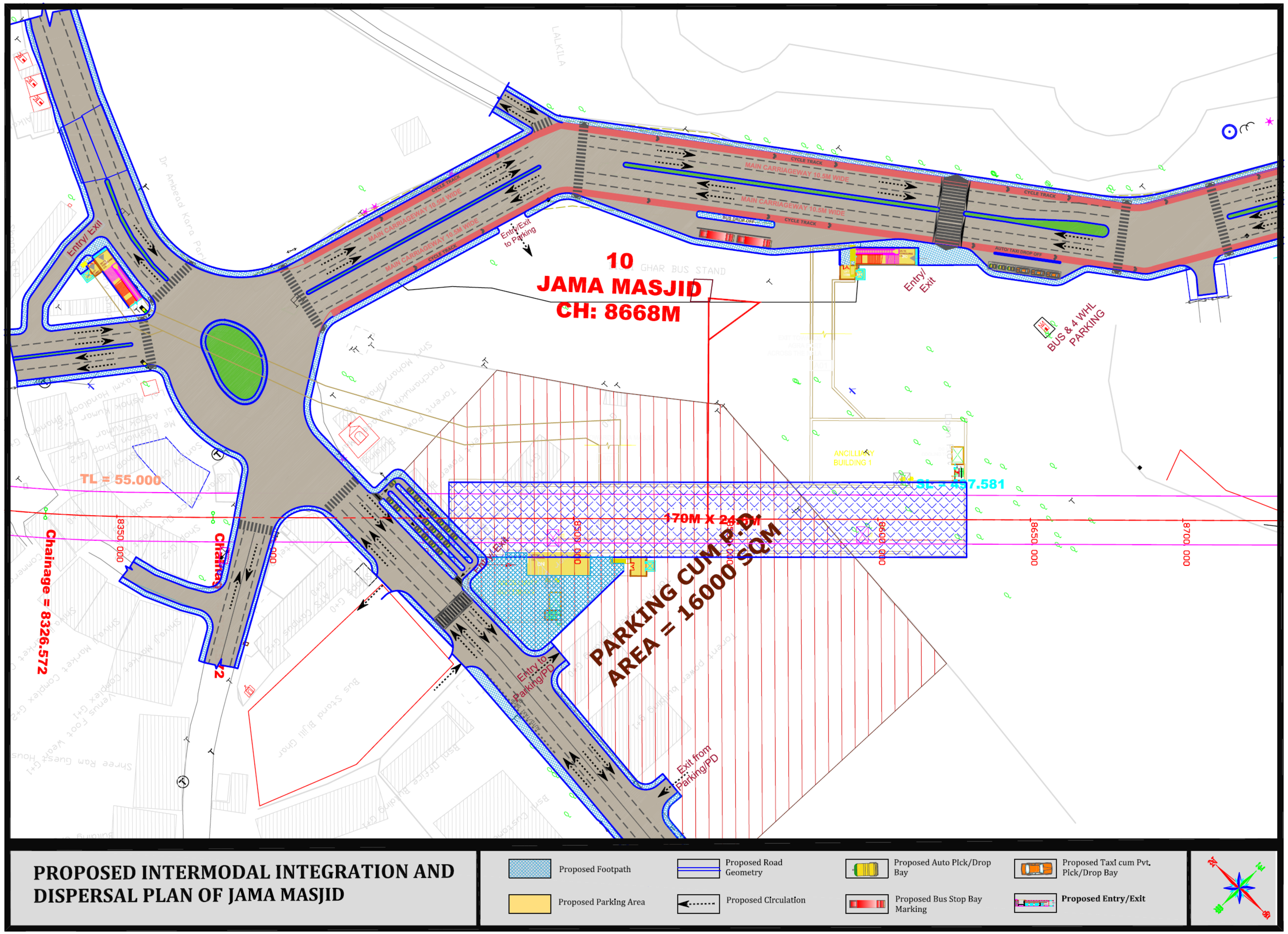
ANNEXURE 7. 4: TRAFFIC DISPERSAL AND MANAGEMENT PLAN OF AGRA COLLEGE - INTERCHANGE STATION



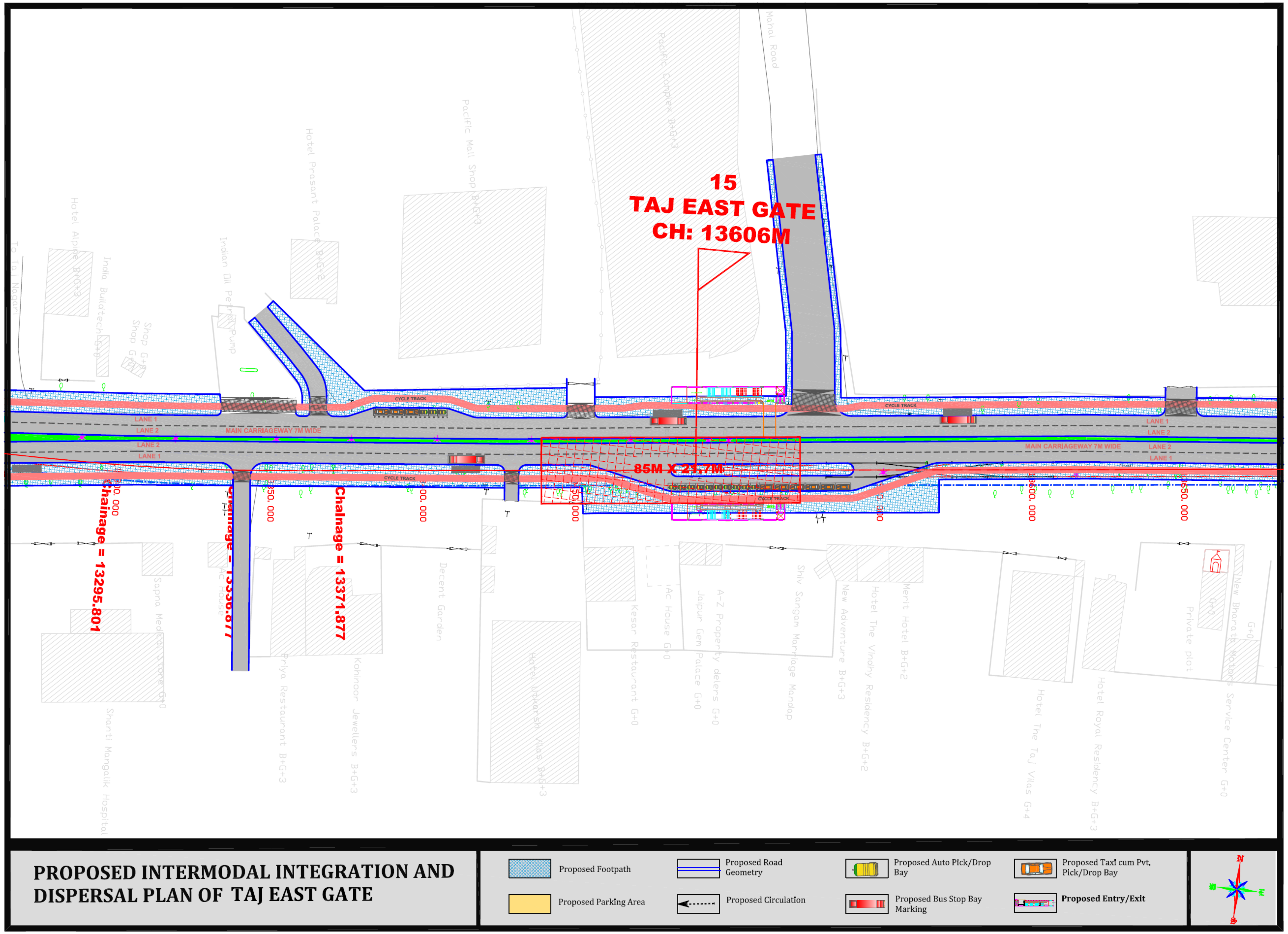
ANNEXURE 7. 5: TRAFFIC DISPERSAL AND MANAGEMENT PLAN OF MEDICAL COLLEGE METRO STATION



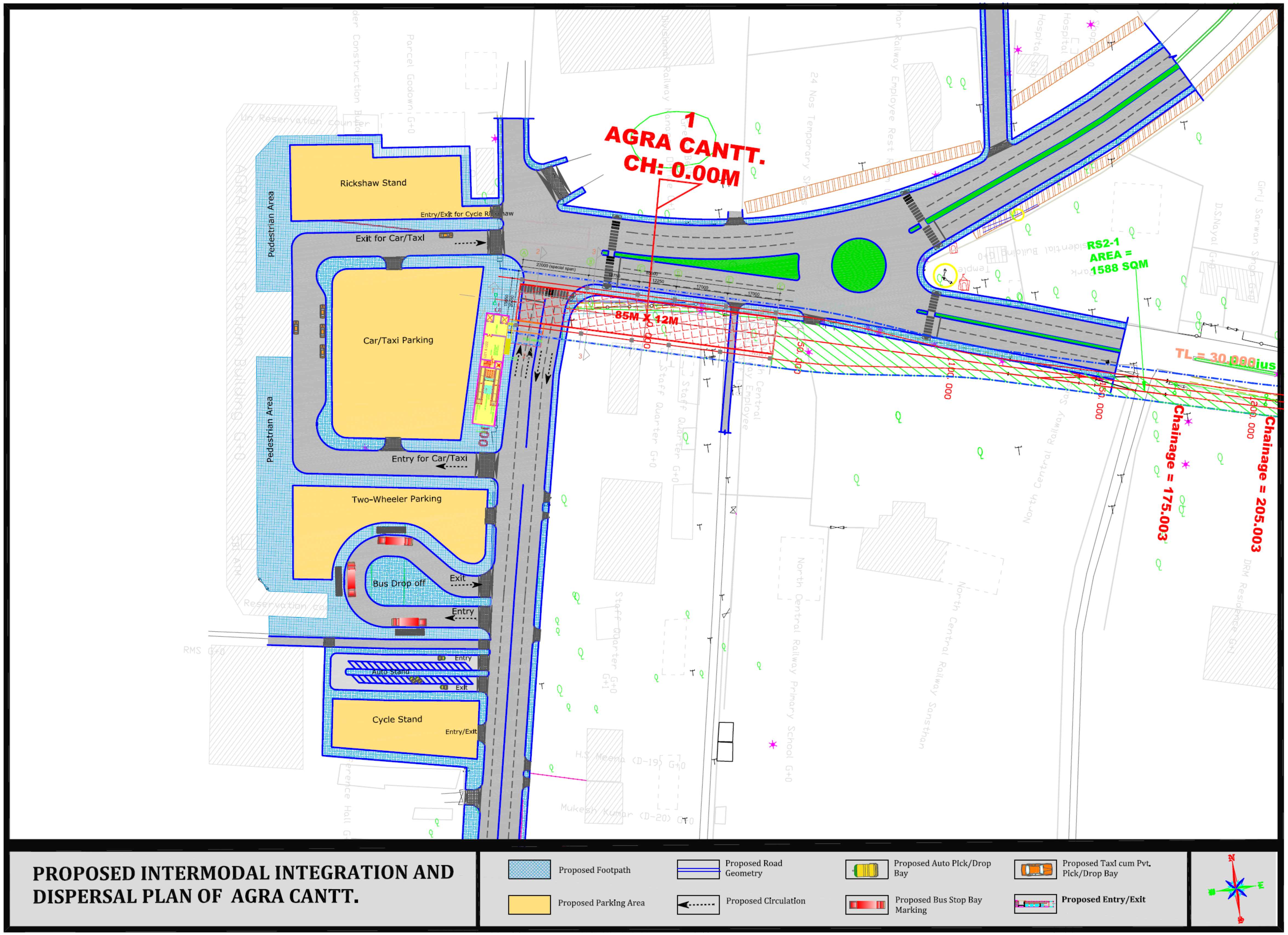
ANNEXURE 7. 6: TRAFFIC DISPERSAL AND MANAGEMENT PLAN OF JAMA MASJID METRO STATION



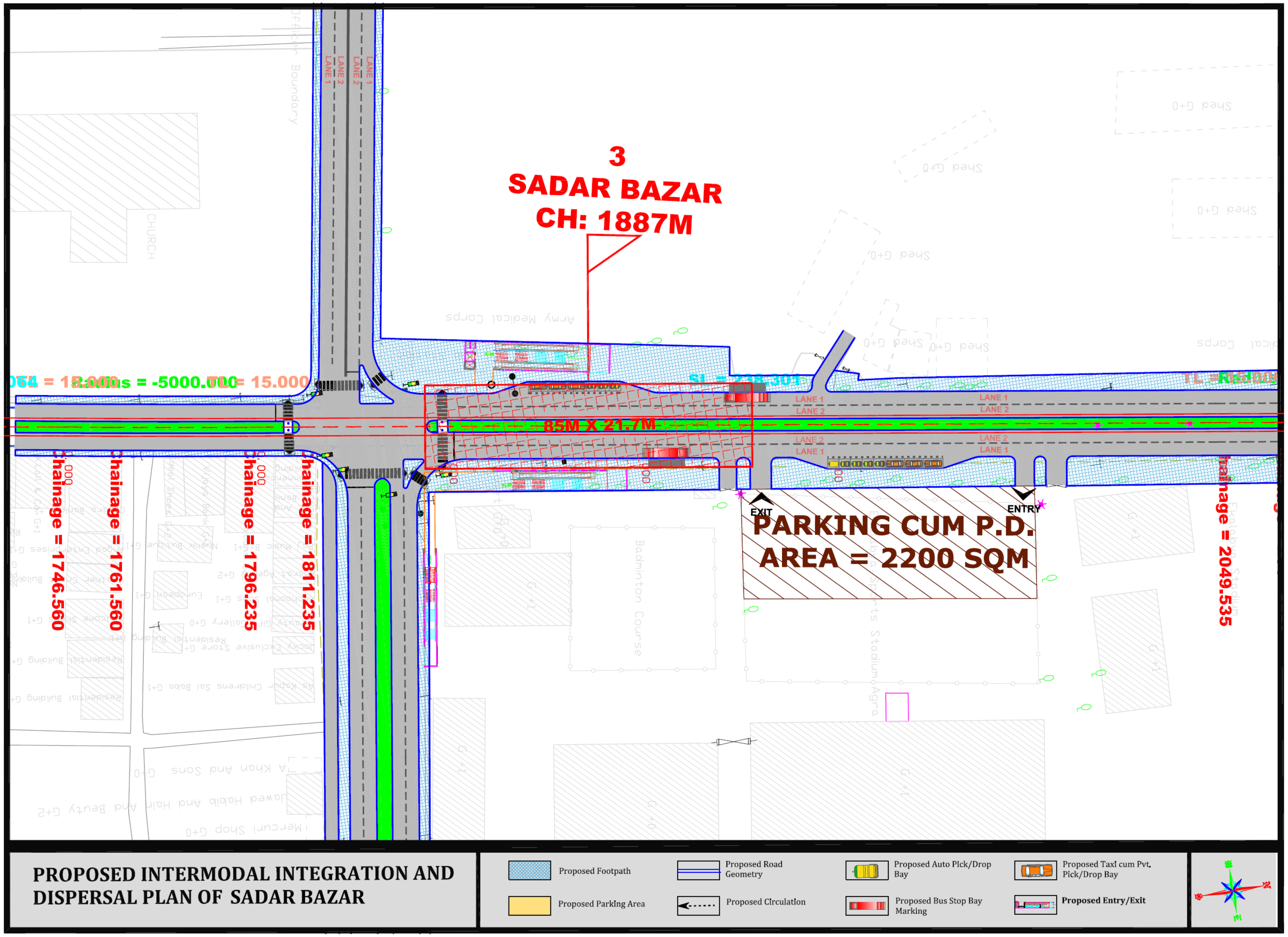
ANNEXURE 7. 7: TRAFFIC DISPERSAL AND MANAGEMENT PLAN OF TAJ EAST GATE METRO STATION



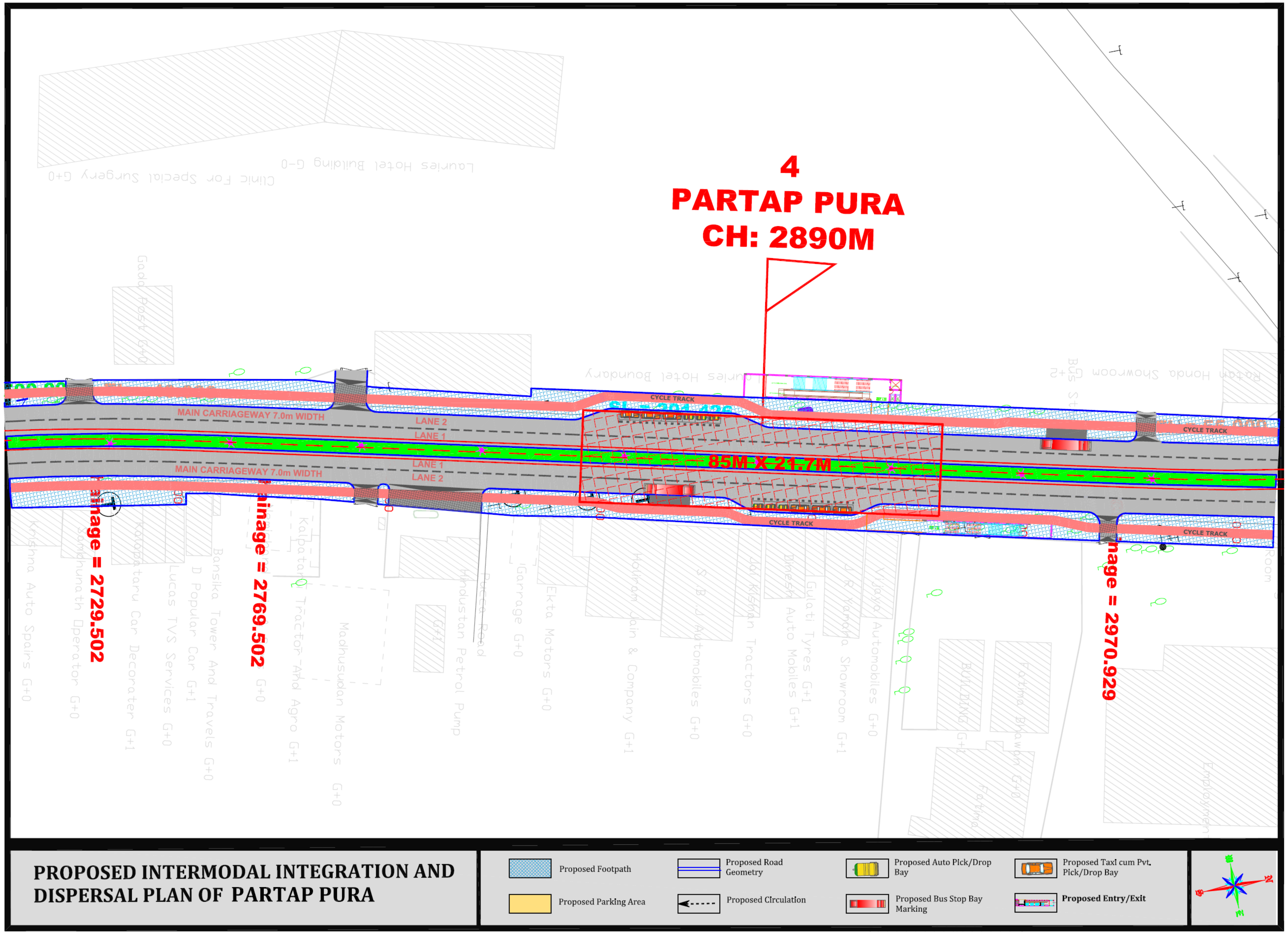
ANNEXURE 7. 8: TRAFFIC DISPERSAL AND MANAGEMENT PLAN OFAGRA CANTT. METRO STATION



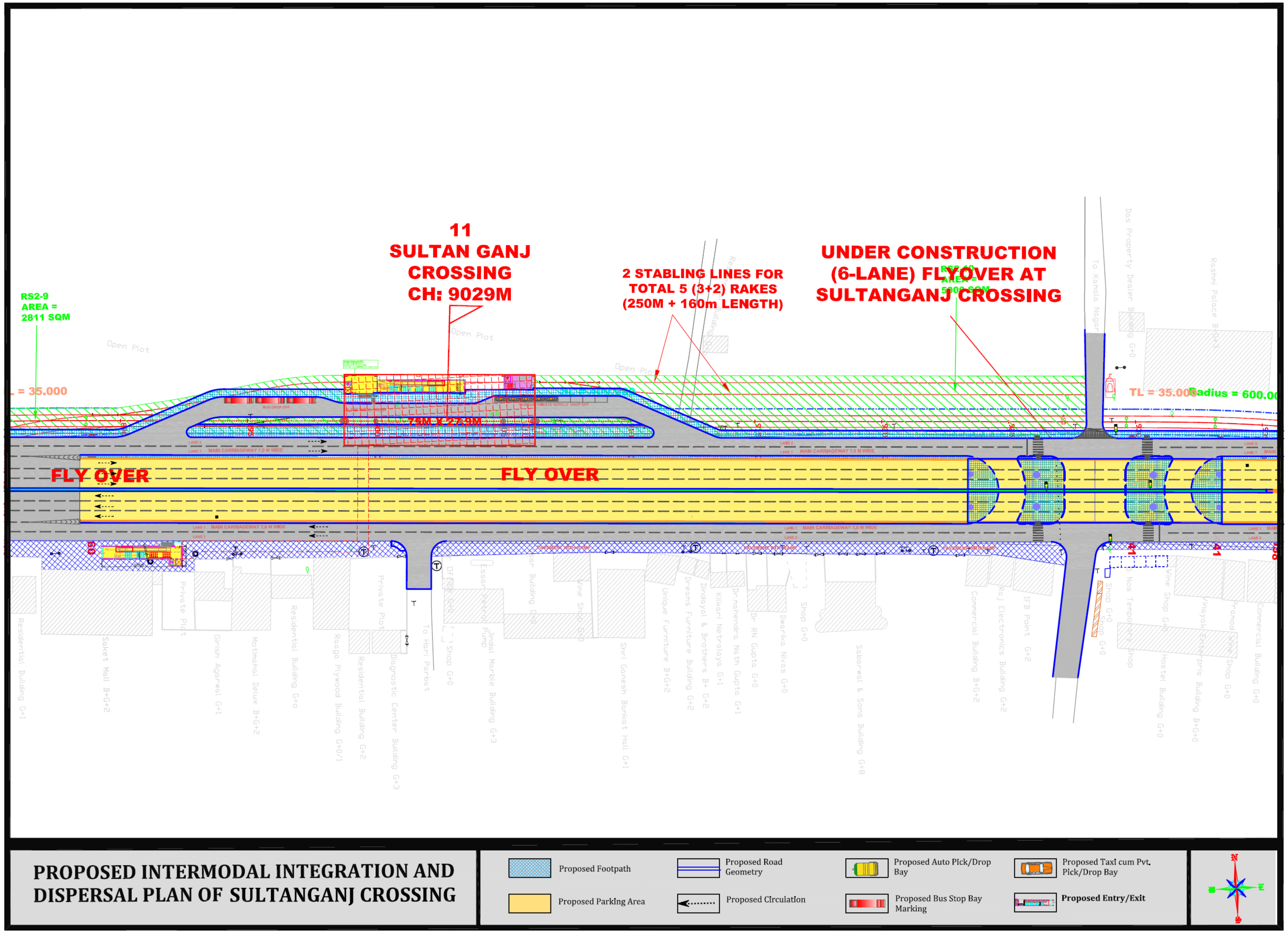
ANNEXURE 7. 9: TRAFFIC DISPERSAL AND MANAGEMENT PLAN OF SADAR BAZAR METRO STATION



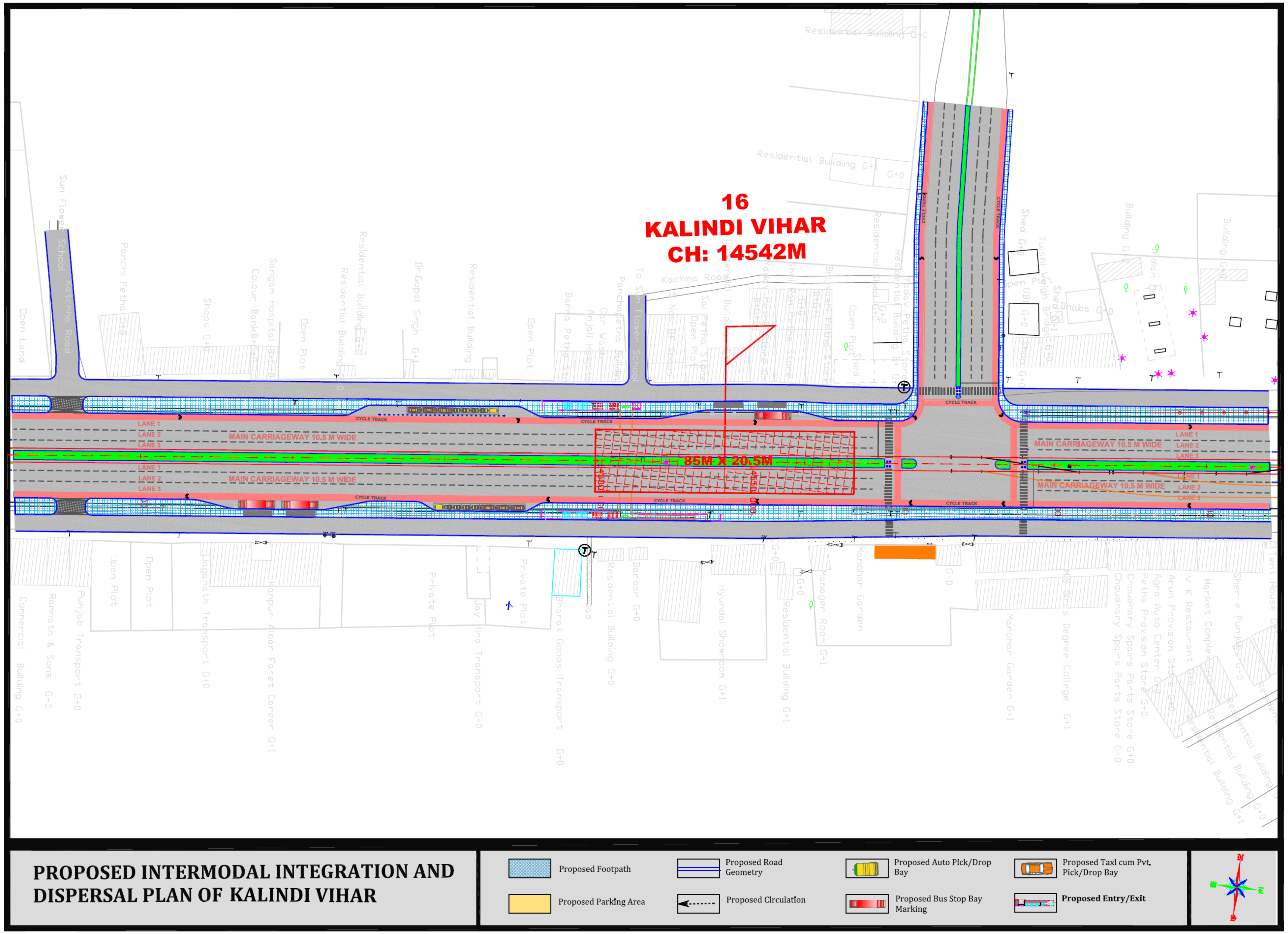
ANNEXURE 7. 10: TRAFFIC DISPERSAL AND MANAGEMENT PLAN OF PARTAP PURA METRO STATION



ANNEXURE 7. 11: TRAFFIC DISPERSAL AND MANAGEMENT PLAN OF SULTANGANJ CROSSING METRO STATION



ANNEXURE 7. 12:TRAFFIC DISPERSAL AND MANAGEMENT PLAN OF KALINDI VIHAR METRO STATION



Chapter – 8

TRAIN OPERATION PLAN

8. TRAIN OPERATION PLAN

8.1 SYSTEM OPERATION APPROACH, STATION YARD PLANNING, TRAIN OPERATIONS PLAN

8.1.1 Train Operation Philosophy

Train operation plan has been prepared considering the maximum PHPDT of 23700 for Sikandara to Taj East Gate Corridor and 27800 passengers for Agra Cantt. to Kalindi Vihar 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 two motor car and one trailer car.

The train operation plan is based on the following salient features:

- Running of services for 16 hours of a day (6:00 hrs to 22:00 hrs) with a station dwell time of 20-30 seconds.
- Scheduled speed of 34 kmph.
- 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

PHPDT for the purpose of planning of services for proposed corridors for years 2024, 2031 and 2041 are indicated below in **Table 8.1.**

TABLE 8.1: YEAR WISE PEAK HOUR PEAK DIRECTION TRIPS (PHPDT)

Corridor	2024	2031	2041	Design Year
Sikandara to Taj East Gate	10200	15300	19400	23700
Agra Cantt. to Kalindi Vihar	14200	18700	23300	27800

8.1.3 Train Formation

To meet 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 operation are given below:

i. Composition

The car composition to be adopted for Agra MRTS is given below-

DMC : Driving Motor Coach

TC : Non Driving Trailer Coach

3-Car Rake Composition: ***DMC-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)			3 Car Train		
	Normal	Crush	Dense Crush	Normal	Crush	Dense Crush	Normal	Crush	Dense Crush
Seated	43	43	43	50	50	50	136	136	136
Standing	103	205	273	110	220	293	316	630	839
Total	146	248	316	160	270	343	452	766	975

Normal *- 3 Per/sqm,* ***Crush****- 6 Per/Sqm,* ***Dense Crush*** *– 8 Per/Sqm of standee area*

iii. Headway

To meet the above projected traffic demand, the possibility of running trains with 3 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 Sikandara to Taj East Gate corridor with 3 car rake composition in the inception year 2024, 2031 and 2041. Train operation in the inception year 2024, 2031 and 2041 for Agra Cantt. to Kalindi Vihar Corridor has been formulated such that few of the trains originating from Agra Cantt. will return from mid terminal planned at Sultan Ganj Crossing station and remaining trains will continue upto Kalindi Vihar. This arrangement will help in optimum utilization of Rolling Stock and the empty running of trains is reduced.

The infrastructure and the train operation plan for the two corridors of Agra Metro are proposed to be designed for 3 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 as below in **Table 8.3.**

TABLE 8.3: TRAIN OPERATION PLAN, HEADWAY AND CAPACITY PROVIDED

Train Operation/ Corridors	Items		Year			
			2024	2031	2041	Design Year
Sikandara to Taj East Gate (14 km)	Cars/ Train		3	3	3	3
	Headway (Sec.)		276	228	180	114
	Trains/hr		13	16	20	31
	Capacity Provided	@6p/m^2	9958	12256	15320	23746
		@8p/m^2	12675	15600	19500	30225
	PHPDT Demand		10200	15300	19400	23700
Agra Cantt. to Kalindi Vihar (15.4 km)	Cars/ Train		3	3	3	3
	Headway (Sec.)		330	276	210	138
	Trains/hr		11	13	17	26
	Capacity Provided	@6p/m^2	8426	9958	13022	19916
		@8p/m^2	10725	12675	16575	25350
	PHPDT Demand		9900	12600	16400	19900
Agra Cantt. to Sultan Ganj Crossing (9.0 km)	Cars/ Train		3	3	3	3
	Headway (Sec.)		720	516	450	330
	Trains/hr		5	7	8	11
	Capacity Provided	@6p/m^2	3830	5362	6128	8426
		@8p/m^2	4875	6825	7800	10725
	PHPDT Demand		4300	6100	6900	7900

The above train operation and headway for different horizon years is proposed to meet the Peak hour peak direction traffic demand (PHPDT) with standees @ 6 passengers/ m^2 in most of the sections, except in small section (few stations) meeting with standees @ 8 passengers/ m^2. This arrangement will optimise the rolling stock requirement.

8.1.4 Train Operation Plan

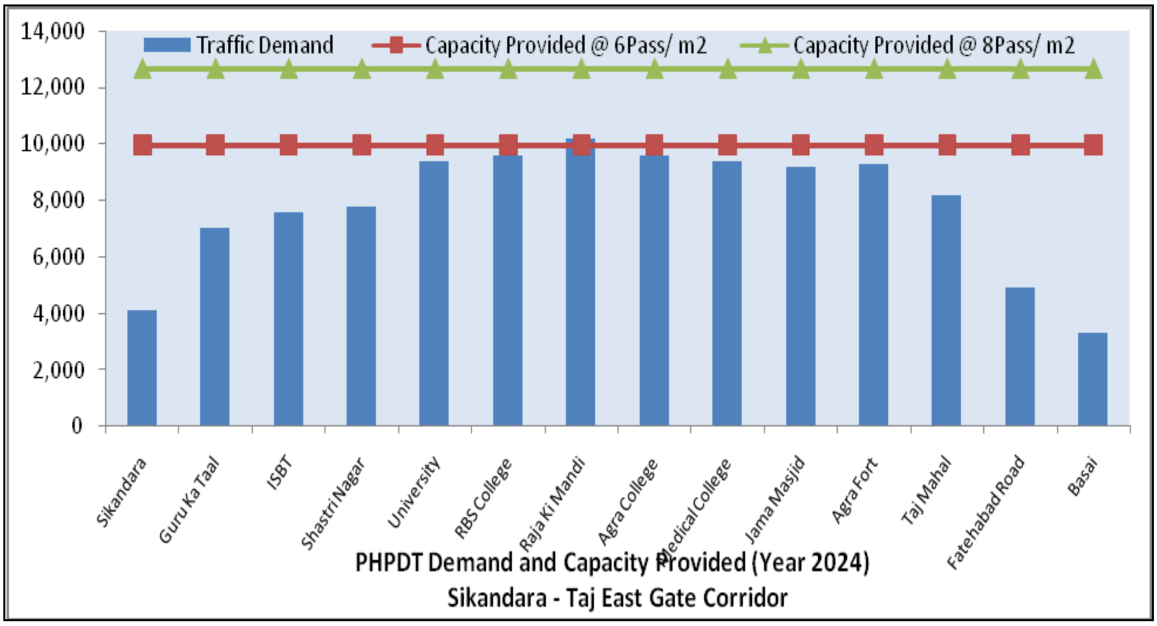
1. Corridor 1 - Sikandara to Taj East Gate

Train operation for different horizon years for Sikandara to Taj East Gate Corridor has been formulated such that there is optimum utilization of rolling stock and the empty running of trains is reduced.

- **Year 2024**

Train operation plan for the corridor in year 2024 is planned with 3 car rake composition and 276 seconds headway during peak period. The planned peak hour peak direction traffic (PHPDT) capacity is 9958 @ 6 passengers/m^2 of standee area (Capacity of 12675 @ 8 passengers/m^2 of standee area under dense loading conditions). The planned capacity is slightly less than the PHPDT demand of 10200 passengers in the section between Raja ki Mandi to Agra College. 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. The demand and capacity for the year 2024 is shown in **Figure 8.1**.

FIGURE 8.1: DEMAND AND CAPACITY (YEAR 2024) – SIKANDARA TO TAJ EAST (CORRIDOR-1)



- **Year 2031**

Train operation plan for the corridor in year 2031 is planned with 3 car rake composition and 228 seconds headway during peak period. The planned peak hour peak direction traffic (PHPDT) capacity is 12256 @ 6 passengers/m^2 of standee area (Capacity of 15600 @ 8 passengers/m^2 of standee area under dense loading conditions). The planned capacity is less than the PHPDT demand of 15300 passengers in the section between Raja ki Mandi to Agra College. 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. The demand and capacity for the year 2031 is shown in **Figure 8.2**.

- **Year 2041**

Train operation plan for the corridor in year 2041 is planned with 3 car rake composition and 180 seconds headway during peak period. The planned peak hour peak direction traffic (PHPDT) capacity is 15320 @ 6 passengers/m^2 of standee area (Capacity of 19500 @ 8 passengers/m^2 of standee area under dense loading conditions). The planned capacity is less than the PHPDT demand of 19400 passengers in the section between

Raja ki Mandi to Agra College. 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. The demand and capacity for the year 2041 is shown in **Figure 8.3**.

FIGURE 8.2: DEMAND AND CAPACITY (YEAR 2031) – SIKANDARA TO TAJ EAST (CORRIDOR-1)

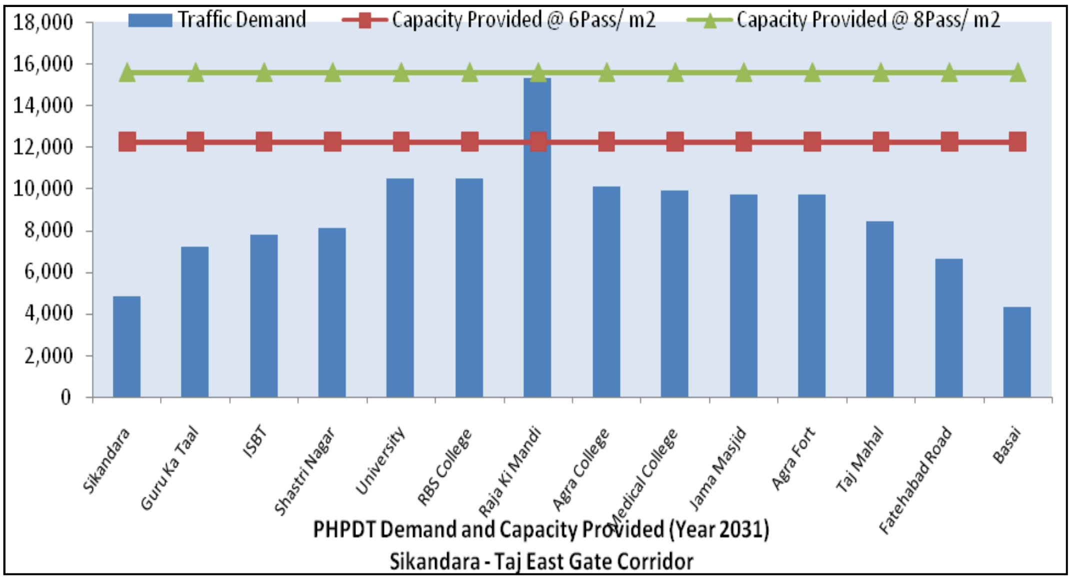
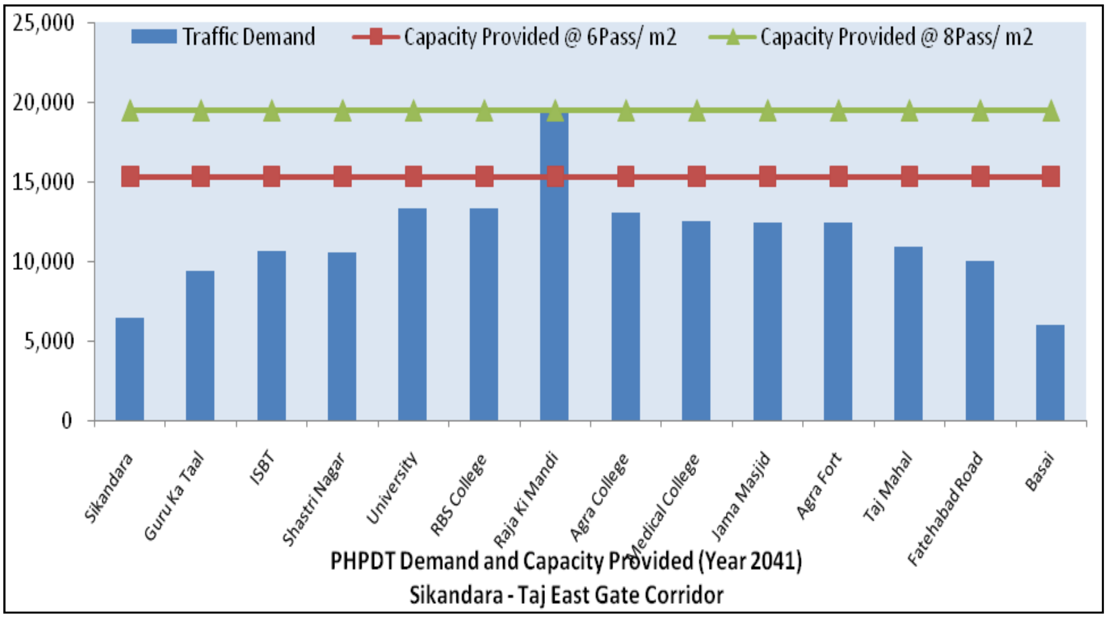


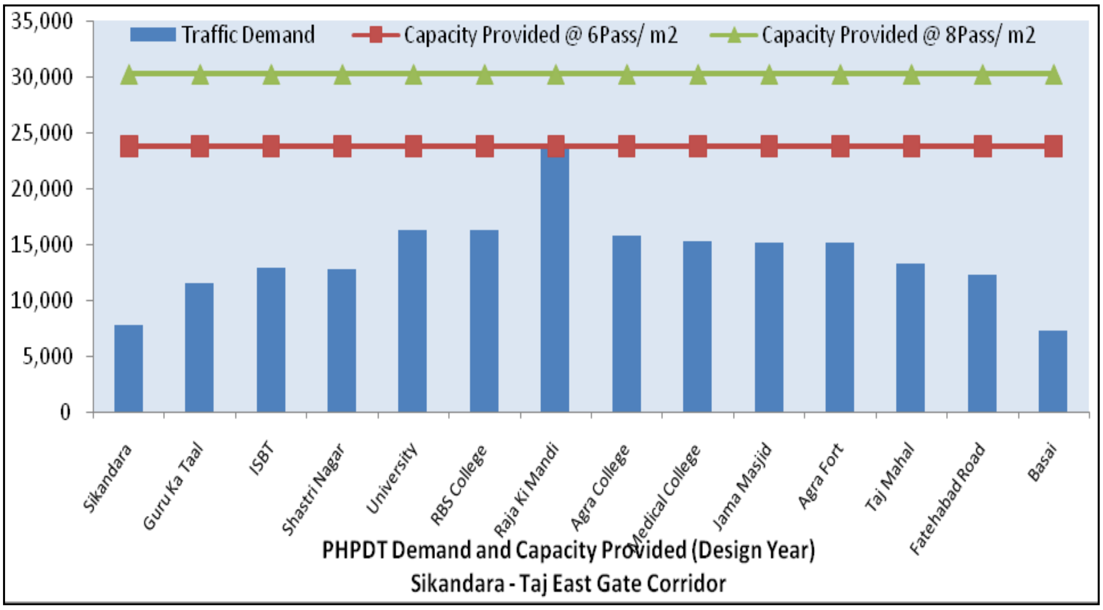
FIGURE 8.3: DEMAND AND CAPACITY (YEAR 2041) – SIKANDARA TO TAJ EAST (CORRIDOR-1)



- **Design Year**

Train operation plan for the corridor in design year is planned with 3 car rake composition and 114 seconds headway during peak period. The planned peak hour peak direction traffic (PHPDT) capacity is 23746 @ 6 passengers/m^2 of standee area (Capacity of 30225 @ 8 passengers/m^2 of standee area under dense loading conditions). The planned capacity for the corridor is higher than the PHPDT demand of 23700 passengers to ensure adequate frequency and comfortable journey to passengers. The demand and capacity for the design year is shown in **Figure 8.4**.

FIGURE 8.4: DEMAND AND CAPACITY (DESIGN YEAR) – SIKANDARA TO TAJ EAST (CORRIDOR-1)



Train operation with 3 car rake composition at 114 seconds headway is envisaged for Sikandara to Taj East Gate corridor to meet the design capacity of 23700 PHPDT.

2. Corridor 2 - Agra Cantt. To Kalindi Vihar

Train operation for the different horizon years for Agra Cantt. to Kalindi Vihar Corridor has been formulated such that few of the trains originating from Agra Cantt. will return from mid terminal planned at Sultan Ganj Crossing station and remaining trains will continue upto Kalindi Vihar. This arrangement will help in optimum utilization of Rolling Stock and the empty running of trains is reduced. The train operation has been formulated for the following two sections:

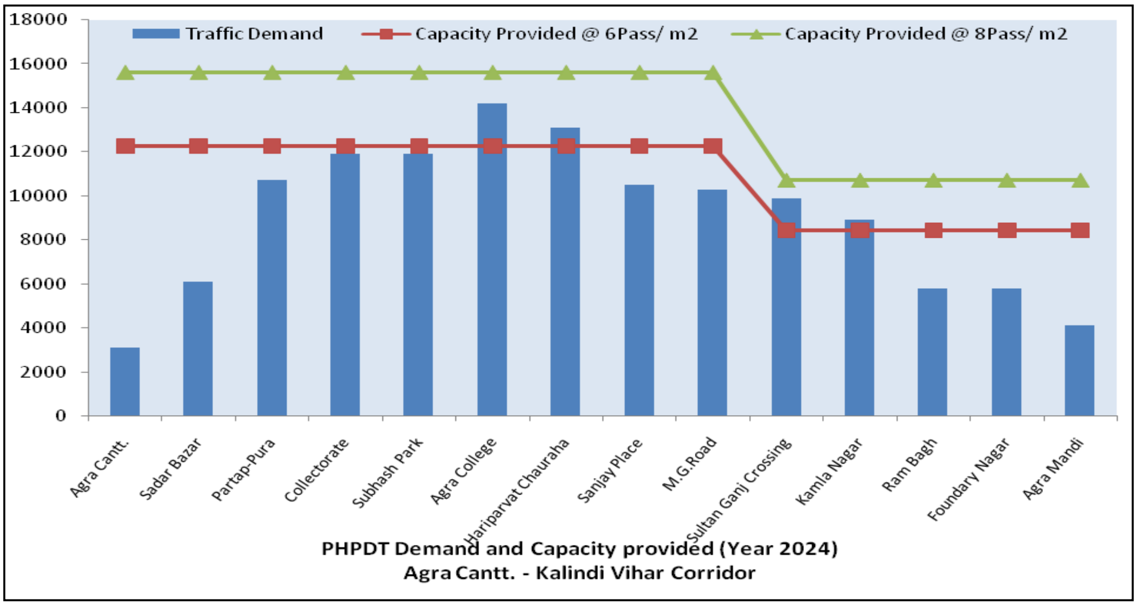
- Agra Cantt. to Kalindi Vihar (15.4 km)
- Agra Cantt. to Sultan Ganj Crossing (9.0 km)

- **Year 2024**

Train operation plan for the corridor in year 2024 is planned with 3 car rake composition. The planned peak hour peak direction traffic (PHPDT) capacity is 12256 @ 6 passengers/m^2 of standee area (Capacity of 15600 @ 8 passengers/m^2 of standee area under dense loading conditions) for Agra Cantt. to Sultan Ganj Crossing section. The planned capacity is less than the PHPDT demand of 14200 passengers in the section between Agra College to Sanjay Place. 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.

The planned peak hour peak direction traffic (PHPDT) capacity is 8426 @ 6 passengers/m^2 of standee area (Capacity of 10725 @ 8 passengers/m^2 of standee area under dense loading conditions) for Sultan Ganj Crossing to Kalindi Vihar section. The planned capacity is less than the PHPDT demand of 9900 passengers in the section between Sultan Ganj Crossing to Ram Bagh. 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. The demand and capacity for the year 2024 is shown in **Figure 8.5**.

FIGURE 8.5: DEMAND AND CAPACITY (YEAR 2024) – AGRA CANTT. TO KALINDI VIHAR

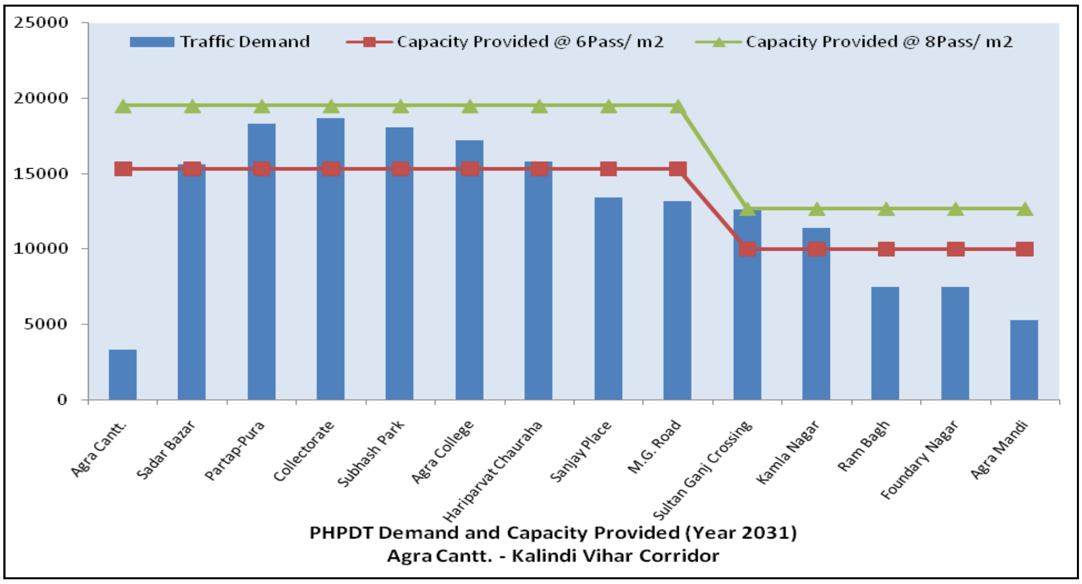


- **Year 2031**

Train operation plan for the corridor in year 2031 is planned with 3 car rake composition. The planned peak hour peak direction traffic (PHPDT) capacity is 15320 @ 6 passengers/m^2 of standee area (Capacity of 19500 @ 8 passengers/m^2 of standee area under dense loading conditions) for Agra Cantt. to Sultan Ganj Crossing section. The planned capacity is less than the PHPDT demand of 18700 passengers in the section between Sadar Bazar to Sanjay Place. 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.

The planned peak hour peak direction traffic (PHPDT) capacity is 9958 @ 6 passengers/m^2 of standee area (Capacity of 12675 @ 8 passengers/m^2 of standee area under dense loading conditions) for Sultan Ganj Crossing to Kalindi Vihar section. The planned capacity is less than the PHPDT demand of 12600 passengers in the section between Sultan Ganj Crossing to Ram Bagh. 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. The demand and capacity for the year 2031 is shown in **Figure 8.6**.

FIGURE 8.6: DEMAND AND CAPACITY (YEAR 2031) – AGRA CANTT. TO KALINDI VIHAR (CORRIDOR-2)

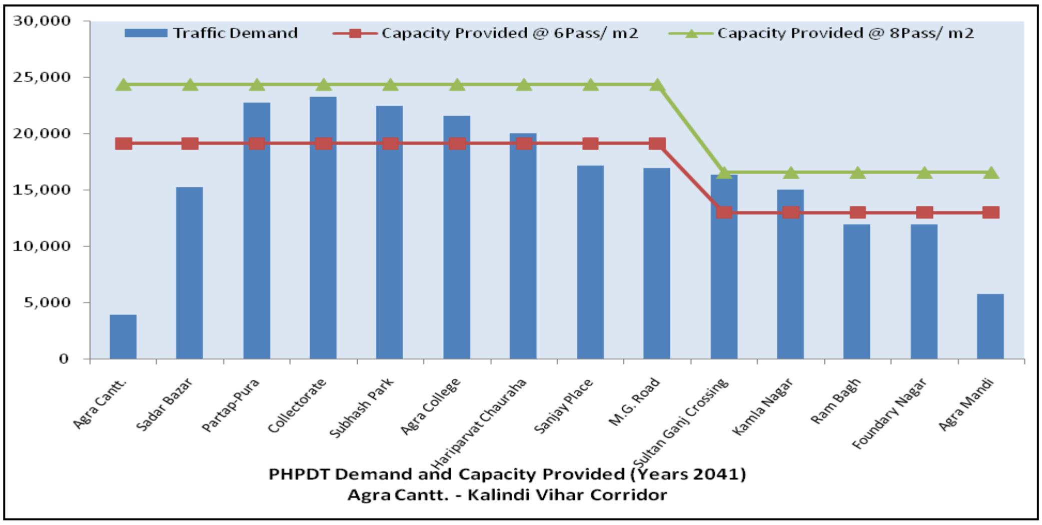


- **Year 2041**

Train operation plan for the corridor in year 2041 is planned with 3 car rake composition. The planned peak hour peak direction traffic (PHPDT) capacity is 19150 @ 6 passengers/m^2 of standee area (Capacity of 24375 @ 8 passengers/m^2 of standee area under dense loading conditions) for Agra Cantt. to Sultan Ganj Crossing section. The planned capacity is less than the PHPDT demand of 23300 passengers in the section between Partap-Pura to Sanjay Place. 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.

The planned peak hour peak direction traffic (PHPDT) capacity is 13022 @ 6 passengers/m^2 of standee area (Capacity of 16575 @ 8 passengers/m^2 of standee area under dense loading conditions) for Sultan Ganj Crossing to Kalindi Vihar section. The planned capacity is less than the PHPDT demand of 16400 passengers in the section between Sultan Ganj Crossing to Ram Bagh. 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. The demand and capacity for the year 2041 is shown in **Figure 8.7**.

FIGURE 8.7: DEMAND AND CAPACITY (YEAR 2041) – AGRA CANTT. TO KALINDI VIHAR

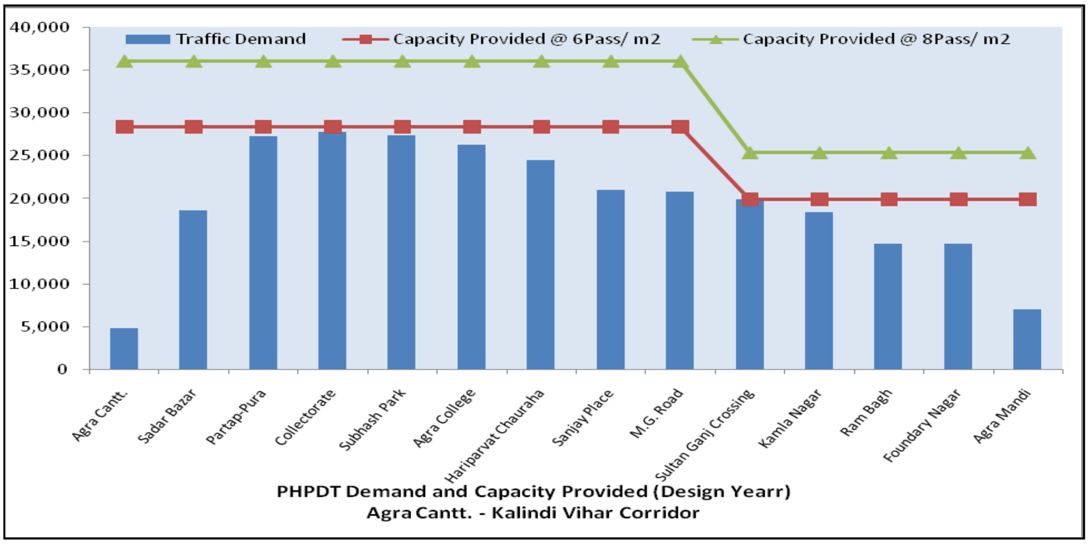


- **Design Year**

Train operation plan for the corridor in design year is planned with 3 car rake composition. The planned peak hour peak direction traffic (PHPDT) capacity is 28342 @ 6 passengers/m^2 of standee area (Capacity of 36075 @ 8 passengers/m^2 of standee area under dense loading conditions) for Agra Cantt. to Sultan Ganj Crossing section. The planned capacity for the corridor is higher than the PHPDT demand of 27800 passengers to ensure adequate frequency and comfortable journey to passengers.

The planned peak hour peak direction traffic (PHPDT) capacity is 19916 @ 6 passengers/m^2 of standee area (Capacity of 25350 @ 8 passengers/m^2 of standee area under dense loading conditions) for Sultan Ganj Crossing to Kalindi Vihar section. The planned capacity for the corridor is higher than the PHPDT demand of 19900 passengers to ensure adequate frequency and comfortable journey to passengers. The demand and capacity for the design year is shown in **Figure 8.8** below.

FIGURE 8.8: DEMAND AND CAPACITY (DESIGN YEAR) – AGRA CANTT. TO KALINDI VIHAR



8.2 SYSTEM FREQUENCY & TIME TABLING

The services for Agra 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 Sikandara to Taj East Gate and Agra Cantt. to Kalindi Vihar for various horizon years is enclosed in **Annexure 8.1(a), (b) & (c)**.

8.3 ROLLING STOCK REQUIREMENT & STABLING DETAILS

8.3.1 Requirements of coaches for the corridor are calculated based on following assumptions:

i. Coach requirement has been calculated based on headway during peak hours.

ii. Schedule speed is taken as **34 Kmph** for the round trip.

iii. Turn round time is taken as **4 min** at terminal stations.

iv. The calculated number of rakes in fraction is rounded off to next higher number.

v. Traffic reserve is taken as 5% to cater to failure of train on line and to make up for operational time lost.

vi. 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 the time horizon 2024 to 2041 are indicated below in **Table 8.4**

TABLE 8.4: ROLLING STOCK REQUIREMENT

Train Operation/ Corridor	Time horizon Year	Headway in sec.	Section length km	Rakes Reqd.	Bare rake Reqmt	Traffic spare @5%	Maint. Spare @10%	Total rake req.	Total coach req.
Sikandara to Taj East Gate (14 km)	2024	276.0	14.0	12.5	13	1	2	16	48
	2031	228.0	14.0	15.1	16	1	2	19	57
	2041	180.0	14.0	19.1	20	1	3	24	72
	Design	114.0	14.0	30.2	31	2	4	37	111

Train Operation/ Corridor	Time horizon Year	Headway in sec.	Section length km	Rakes Reqd.	Bare rake Reqmt	Traffic spare @5%	Maint. Spare @10%	Total rake req.	Total coach req.
Agra Cantt. to Kalindi Vihar (15.4 km)	2024	330.0	15.4	11.3	12	1	2	15	45
	2031	276.0	15.4	13.6	14	2	2	18	54
	2041	210.0	15.4	17.8	18	1	2	21	63
	Design	138.0	15.4	27.1	28	2	3	33	99
Agra Cantt. to Sultan Ganj Crossing (9.0 km)	2024	720.0	9.0	3.3	4	1	1	6	18
	2031	516.0	9.0	4.6	5	1	1	7	21
	2041	450.0	9.0	5.3	6	1	1	8	24
	Design	330.0	9.0	7.2	8	1	1	10	30

8.3.2 Stabling of Rakes

Stabling facility for the rakes of corridor 1 i.e. Sikandara to Taj East corridor has been provided at PAC Depot. For the stabling requirements of corridor 2, the depot has been planned at Kalindi Vihar Depot. 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 design year is given below in **Tables 8.5, 8.6 & 8.7.**

TABLE 8.5: VEHICLE KILOMETER: SIKANDARA - TAJ EAST GATE CORRIDOR

Year	2024	2031	2041	Design Year
Section Length	14.0	14.0	14.0	14.0
No. of Cars per Train	3	3	3	3
No. of working Days/year	340	340	340	340
No. of Trains/Day/Direction	136	160	195	290
Daily Train –KM	3808	4480	5460	8120
Annual Train - KM (10^5)	12.95	15.23	18.56	27.61
Annual Vehicle - KM (10^5)	38.84	45.70	55.69	82.82

TABLE 8.6: VEHICLE KILOMETER: AGRA CANTT. - KALINDI VIHAR CORRIDOR

Year	2024	2031	2041	Design Year
Section Length	15.4	15.4	15.4	15.4
No. of cars per Train	3	3	3	3
No. of Days/Rake/Year	340	340	340	340
No. of Trains/Day/Direction	137	159	199	271
Daily Train –KM	4219.6	4897.2	6129.2	8346.8

Year	2024	2031	2041	Design Year
Annual Train - KM (10^5)	14.35	16.65	20.84	28.38
Annual Vehicle - KM (10^5)	43.04	49.95	62.52	85.14

TABLE 8.7: VEHICLE KILOMETER: AGRA CANTT. – SULTAN GANJ CROSSING CORRIDOR

Year	2024	2031	2041	Design Year
Section Length	9.0	9.0	9.0	9.0
No. of cars per Train	3	3	3	3
No. of Days/Rake/Year	340	340	340	340
No. of Trains/Day/Direction	67	91	107	131
Daily Train –KM	1206	1638	1926	2358
Annual Train - KM (10^5)	4.10	5.57	6.55	8.02
Annual Vehicle - KM (10^5)	12.30	16.71	19.65	24.05

Annexure-8.1(a)

HOURLY TRAIN OPERATION PLAN: SIKANDARA TO TAJ EAST GATE CORRIDOR

Time of Day	Year 2024 (3 Car)		Year 2031 (3 Car)		Year 2041 (3 Car)		Design (3 Car)	
	Headway in Seconds	Trains per hour	Headway in Seconds	Trains per hour	Headway in Seconds	Trains per hour	Headway in Seconds	Trains per hour
6 to 7	720	5	600	6	516	7	360	10
7 to 8	450	8	360	10	300	12	180	20
8 to 9	**276**	13	**228**	16	**180**	20	**114**	32
9 to 10	**276**	13	**228**	16	**180**	20	**114**	32
10 to 11	450	8	360	10	300	12	180	20
11 to12	516	7	450	8	360	10	300	12
12 to 13	600	6	516	7	450	8	360	10
13 to 14	720	5	600	6	516	7	450	8
14 to 15	600	6	516	7	450	8	360	10
15 to 16	516	7	450	8	360	10	300	12
16 to 17	360	10	360	10	300	12	180	20
17 to 18	**276**	13	**228**	16	**180**	20	**114**	32
18 to 19	**276**	13	**228**	16	**180**	20	**114**	32
19 to 20	360	10	360	10	300	12	180	20
20 to 21	516	7	450	8	360	10	300	12
21 to 22	720	5	600	6	516	7	450	8
Total No. of trains per direction per day		**136**		**160**		**195**		**290**

Annexure-8.1(b)

HOURLY TRAIN OPERATION PLAN: AGRA CANTT. TO KALINDI VIHAR CORRIDOR

Time of Day	Year 2024 (3 Car)		Year 2031 (3 Car)		Year 2041 (3 Car)		Design (3 Car)	
	Headway in Seconds	Trains per hour	Headway in Seconds	Trains per hour	Headway in Seconds	Trains per hour	Headway in Seconds	Trains per hour
6 to 7	720	5	600	6	516	7	450	8
7 to 8	360	10	450	8	360	10	240	15
8 to 9	**330**	11	**276**	13	**210**	17	**138**	26
9 to 10	**330**	11	**276**	13	**210**	17	**138**	26
10 to 11	360	10	300	12	240	15	180	20
11 to12	450	8	360	10	300	12	240	15
12 to 13	516	7	450	8	360	10	300	12
13 to 14	600	6	516	7	450	8	360	10
14 to 15	516	7	450	8	360	10	300	12
15 to 16	450	8	360	10	300	12	240	15
16 to 17	360	10	300	12	240	15	180	20
17 to 18	**330**	11	**276**	13	**210**	17	**138**	26
18 to 19	**330**	11	**276**	13	**210**	17	**138**	26
19 to 20	360	10	300	12	240	15	180	20
20 to 21	516	7	450	8	360	10	300	12
21 to 22	720	5	600	6	516	7	450	8
Total No. of trains per direction per day		**137**		**159**		**199**		**271**

Annexure-8.1(c)

HOURLY TRAIN OPERATION PLAN: AGRA CANTT. TO SULTAN GANJ CROSSING

Time of Day	Year 2024 (3 Car)		Year 2031 (3 Car)		Year 2041 (3 Car)		Design (3 Car)	
	Headway in Seconds	Trains per hour	Headway in Seconds	Trains per hour	Headway in Seconds	Trains per hour	Headway in Seconds	Trains per hour
6 to 7	900	4	720	5	600	6	516	7
7 to 8	900	4	600	6	516	7	450	8
8 to 9	**720**	5	**516**	7	**450**	8	**330**	11
9 to 10	**720**	5	**516**	7	**450**	8	**330**	11
10 to 11	900	4	600	6	516	7	450	8
11 to12	900	4	720	5	600	6	516	7
12 to 13	900	4	720	5	600	6	516	7
13 to 14	1200	3	900	4	720	5	600	6
14 to 15	900	4	720	5	600	6	516	7
15 to 16	900	4	720	5	600	6	516	7
16 to 17	900	4	600	6	516	7	450	8
17 to 18	**720**	5	**516**	7	**450**	8	**330**	11
18 to 19	**720**	5	**516**	7	**450**	8	**330**	11
19 to 20	900	4	600	6	516	7	450	8
20 to 21	900	4	720	5	600	6	516	7
21 to 22	900	4	720	5	600	6	516	7
Total No. of trains per direction per day		**67**		**91**		**107**		**131**

Chapter – 9

SIGNALING AND TELECOMMUNICATION

9. SIGNALING AND 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 following design parameters:

- Ridership 23700 PHPDT(Corri.-I)/ 27800 PHPDT(Corri.-II)
- Standard Gauge 1435 mm
- Average Speed 34 Kmph
- Corridor Length 14 Km (Corri.-I)/ 15.4 km (Corri.-II)
- Total Stations 15(Corri.-I)/ 15 (Corri.-II)
- Train Configuration 3 Car Rake

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 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 cost, 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 Agra Metro corridors.

b) Communication based Train Control (CBTC) Signaling System

Communication based Train Control (CBTC) Signaling System is mainly used for mass transit 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 Agra Metro corridor. Grade of Automation proposed is GoA3 upgradable to GoA4.

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 equipment has 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 below shows the standards that will be adopted with regard to the Signaling system.

TABLE 9.1: STANDARDS TO BE ADOPTED FOR SIGNALING SYSTEM

Description	Standards
CBTC System	IEEE 1474.1
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

Description	Standards
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 Coverage

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. 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
		B	network
		C	Telephone System : EPABX
		D	Mobile Radio Communications: Digital Trunk Radio System
		E	(TETRA)
			Public Address (PA) System
		F	Centralized Clock System: Digital & Analog Clocks and Time
		G	Synchronization System
		H	Passenger Information Display System: LED based
			Network Management & Station Management System
			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

Metro Operator		System Used	
		E	Centralized Clock System: Digital and Analog Clock System
		F	Passenger Information Display System: LED & LCD based.
		G	Network Management & Station
		H	Closed Circuit Television System : Fixed and PTZ Camera with monitors
Hyderabad Metro	Phase I	A	Digital Transmission System (DTS) - Optical Fiber Cable - 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	Ph- 1	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

9.2.2 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 Agra MRTS.

9.2.3 Digital Transmission System (DTS)

i. 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 144 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.

ii. 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.

iii. Mobile Radio Communication

Mobile Radio communication system having minimum 8 logical channels is proposed for on-line emergency communication between Motorman (Front end and Rear end) of moving train and the Central Control. The system shall be based on Digital Trunk Radio Technology to TETRA International standard. 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.

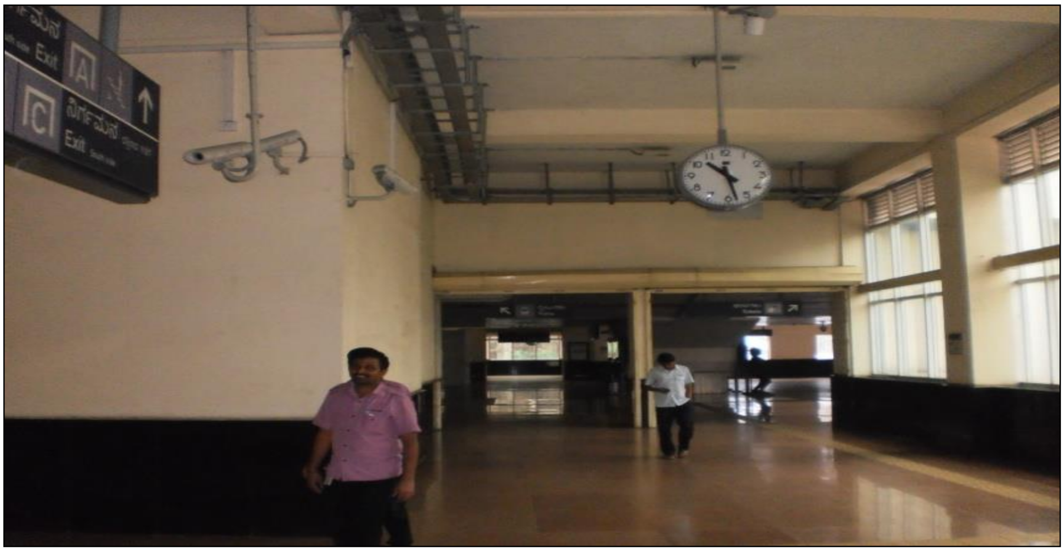
iv. Public Address System

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.

v. Centralized Clock System

The Clock System shall provide synchronized time for the whole Rail system. The time source shall be obtained from Global Positioning System (GPS). The synchronized time information shall be displayed on slave clock units and provided to all other sub systems including signaling & AFC via the Digital Transmission System as shown in **Figure 9.2.**

FIGURE 9.2: MASTER CLOCK



vi. Passenger Information Display System (PIDS)

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.

vii. 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.

viii. 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.

ix. 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.

x. Wi-Fi Services

The Wi-Fi services are proposed to be provided at stations as well as on-board to the passengers. The passengers have to search the available Wi-Fi network of metro and after registering their mobile number, they will get login ID and password through SMS. After receiving the login ID and password, passengers can access the Metro Wi-Fi network irrespective of their mobile network operator.

xi. LED Display walls

Two (02 nos.) of LED Display walls having size approximately 2.88m (W) x 1.92 m (H), (5.52 Sqm) each are proposed to be provided at suitable locations at all platforms. The outdoor LED displays may be used to run the commercials as well as other useful passenger information as per requirements.

xii. 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 TELECOMMUNICATION 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 be 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 cables shall be used to maintain the circuit integrity in case of fire.
Telephone Exchange	IP based Electronic Exchange (IP PBX)

Description	Standards
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.

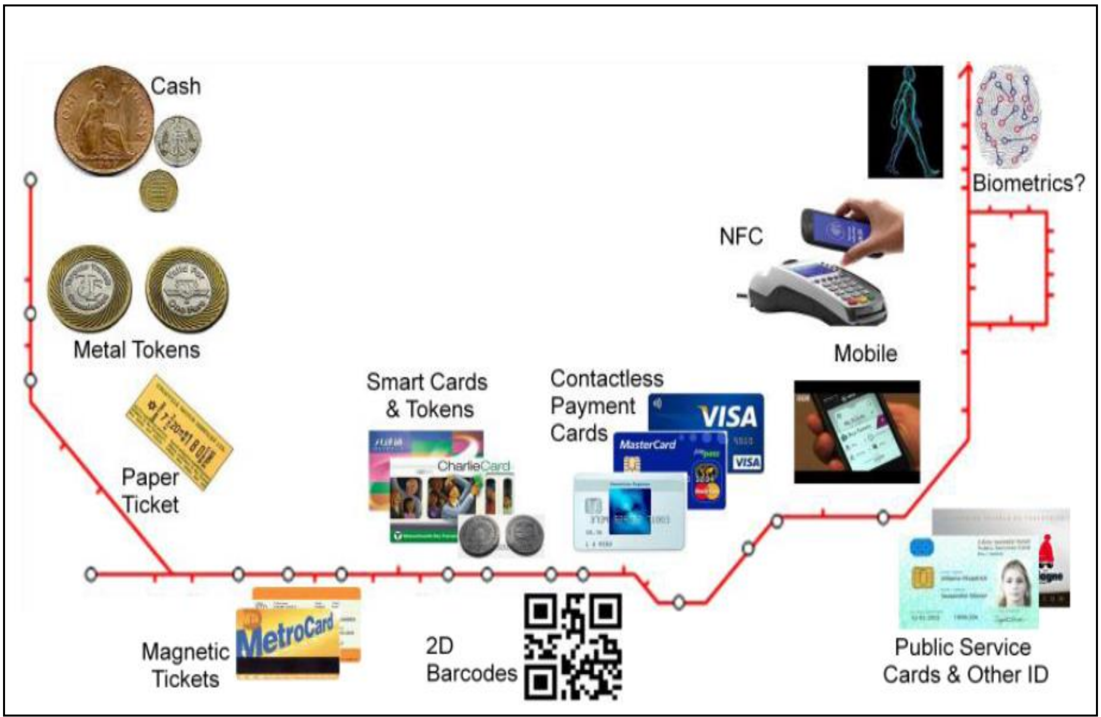
Chapter – 10
FARE COLLECTION SYSTEM

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** below.

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 Agra Metro.

The equipment 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 & 10.3** respectively.

FIGURE 10.2: AFC OPERATION PROCESS

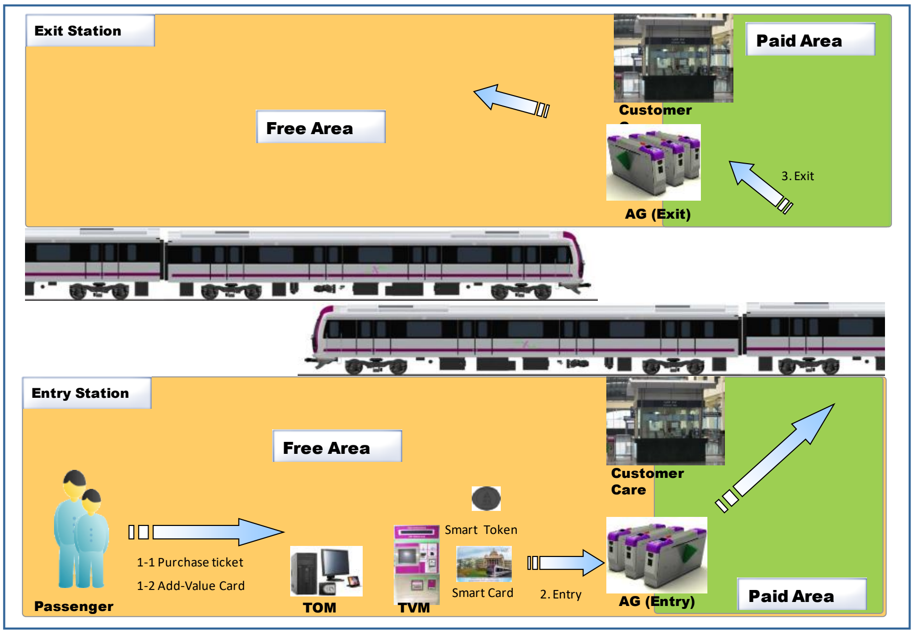
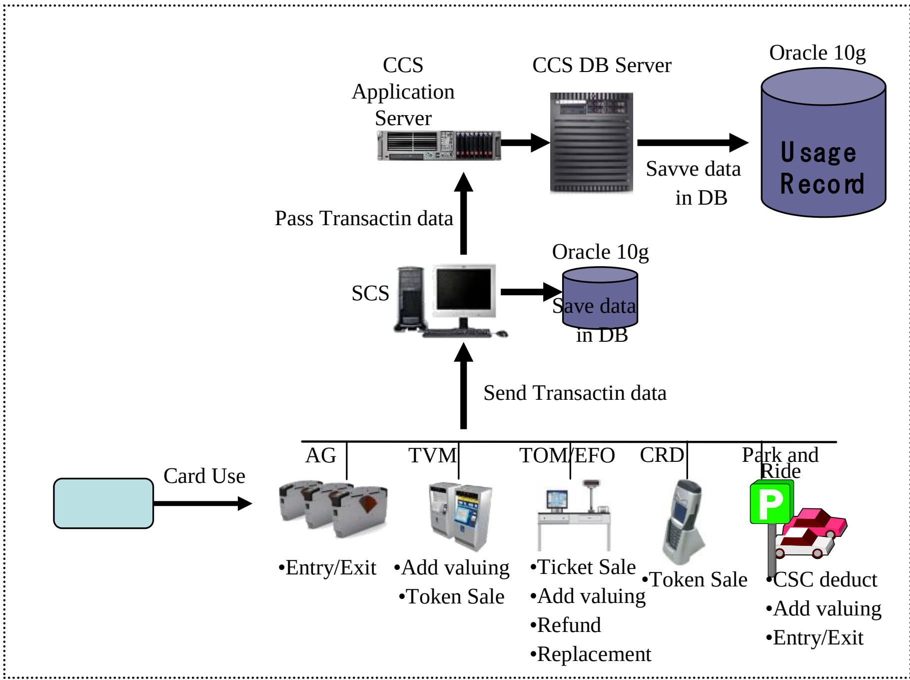


FIGURE 10.3: AFC SYSTEM ARCHITECTURE



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.

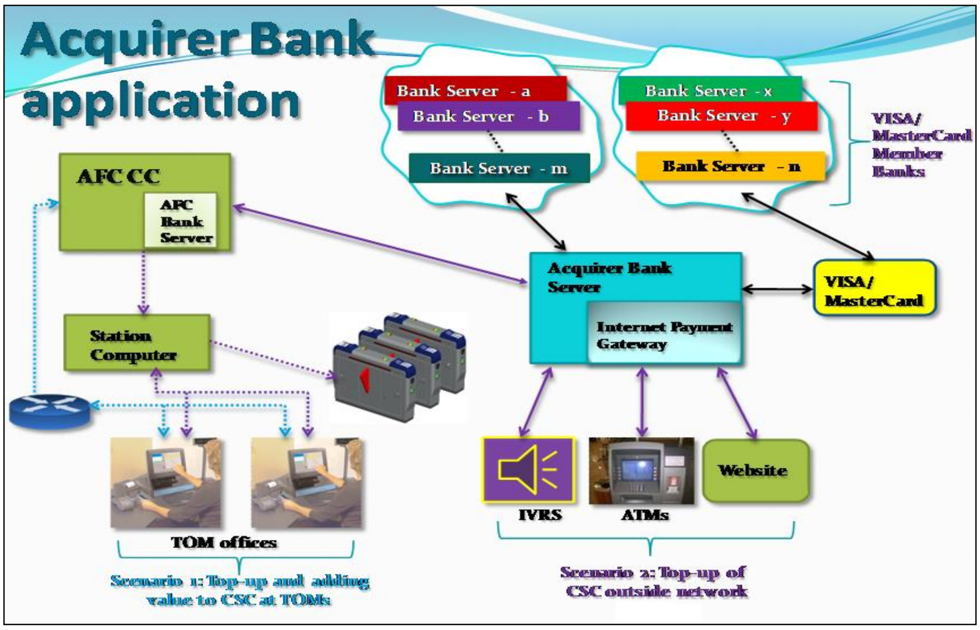
In addition, the proposed AFC system shall also be NFC (Near Field Communication) enabled so that customers can use their NFC enabled Mobile phones for metro travel. Facility of recharging of Travel Cards using Cash, Debit/Credit Cards and Net banking/web portal shall also be available. AFC system shall also support offsite sales terminals also, wherein cards and tokens can be dispensed at locations outside metro premises.

10.2 AUTMATIC FARE COLLECTION SYSTEM OPTIONS

i. 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** below.

FIGURE 10.4: BANKING INTERFACE



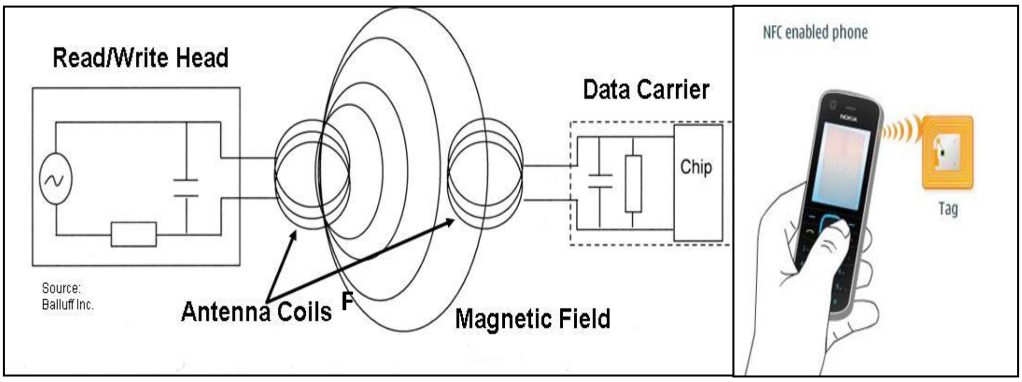
The scope of banks is to provide the following services:

- 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.

ii. 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) as shown in **Figure 10.5**. 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.

FIGURE 10.5: NEAR FIELD COMMUNICATION



iii 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 showm in **Figure 10.6.**

iv 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 10.6: BIOMETRIC SYSTEM FLOW CHART

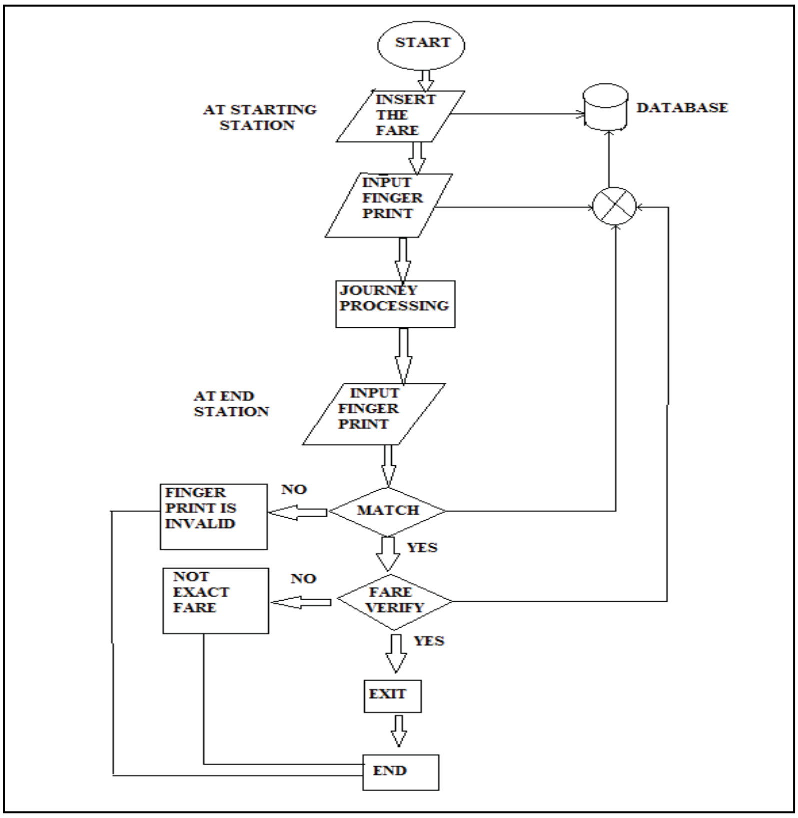
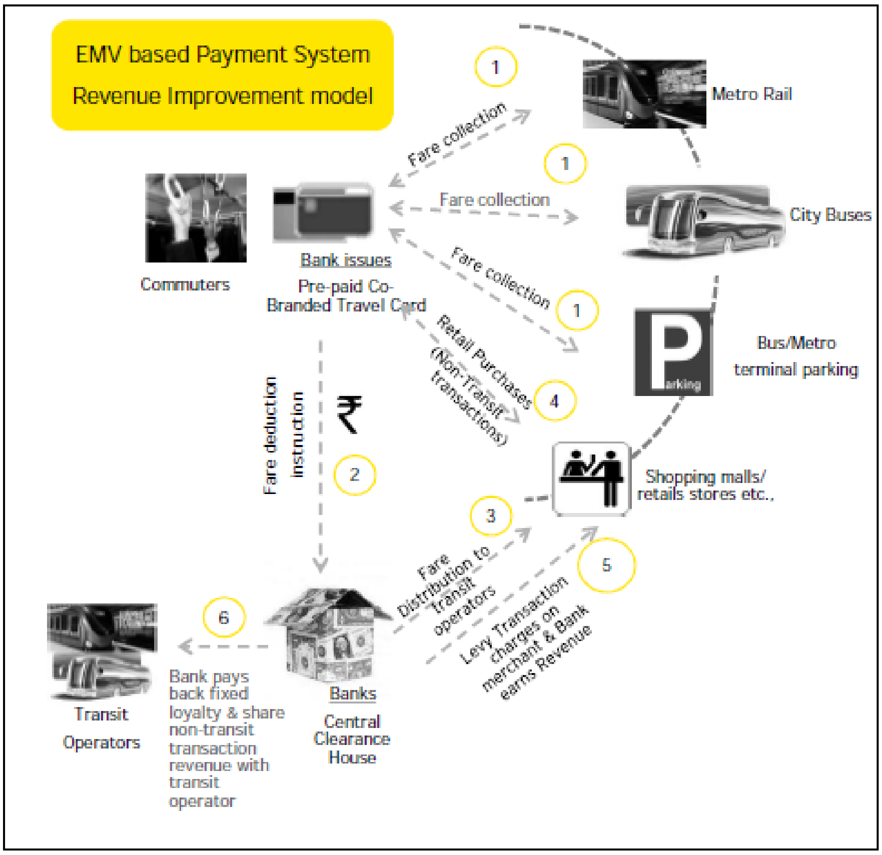


FIGURE 10.7:EMV BASED PAYMENT SYSTEM

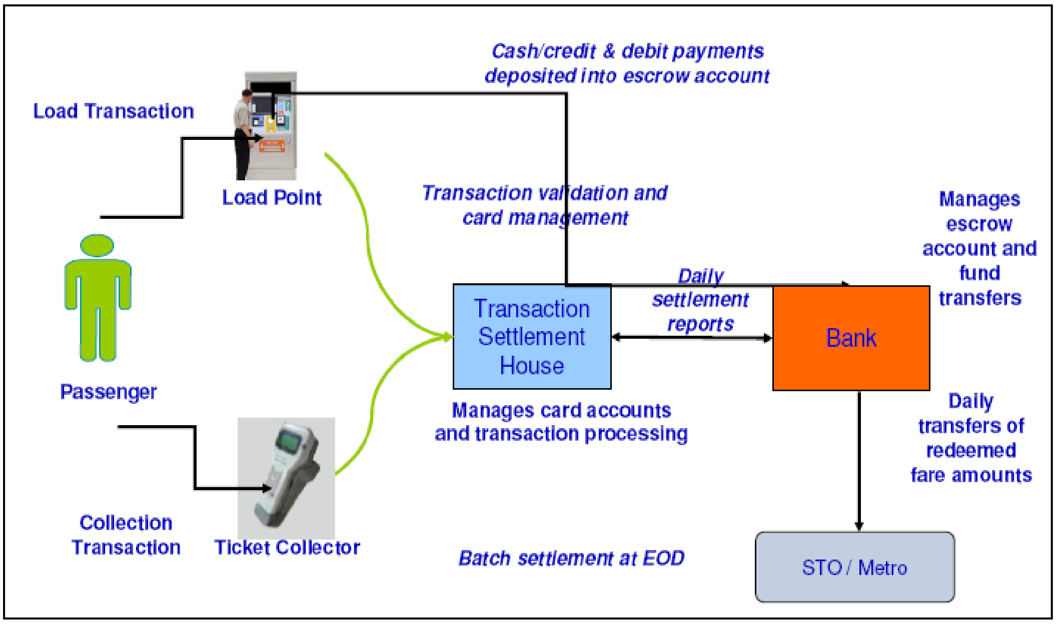


10.3 FARE SYSTEM INTEGRATION WITH OTHER TRANSPORT SYSTEM

i. 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 **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 **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.

Equipment	Description
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 ROLLING STOCK

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 Agra Metro corridors. State of the art proven technology has been proposed for rolling stock of Agra 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 Agra Metro 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 equipment 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 faster passenger movement especially in emergency.

vi. Passenger Doors

For swift evacuation of 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 passengers inside train are able to evacuate within least possible time. 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 equipment 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 Agra Metro corridors will be similar to Bangalore/ Kochi 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	Description
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
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	750V DC Third Rail System

b) Coach Dimensions

The following coach dimensions are proposed to be chosen for Agra MRTS corridors as mentioned in **Table 11.2.**

TABLE 11.2:COACH DIMENSIONS

Type of coach	Length	Width	Height
Driving Motor Car (DMC)	23 m	2.9 m	3.9 m
Trailer car (TC)	23 m	2.9 m	3.9 m

c) Passenger Carrying Capacity

In order to maximize the passenger carrying capacity, longitudinal seating arrangement shall be adopted. The whole train shall be vestibule 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). The carrying capacity of Metro Rail Vehicle is indicated in **Table 11.3.**

TABLE 11.3:CARRYING CAPACITY OF METRO RAIL

Description	Driving Motor Car (DMC)			Trailer Car (TC)			3 Car Train		
	Normal	Crush	Dense Crush	Normal	Crush	Dense Crush	Normal	Crush	Dense Crush
Seated	43	43	43	50	50	50	136	136	136
Standing	103	205	273	110	220	293	316	630	839
Total	146	248	316	160	270	343	452	766	975

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	3 Car
TARE WEIGHT (Max.)	40	40	120
Passenger			
(Normal @ 3p/ m^2)	9.49	10.40	29.38
(Crush @ 6p/ m^2)	16.12	17.55	49.79
(Dense Crush @ 8p/ m^2)	20.54	22.30	63.38
Gross			
(Normal @ 3p/ m^2)	49.49	50.40	149.38
(Crush @ 6p/ m^2)	56.12	57.55	169.79
(Dense Crush @ 8p/ m^2)	60.54	62.30	183.38
Axle Load @ 6p/ m^2	14.03	14.39	
Axle Load @ 8p/ m^2	15.14	15.57	

The axle load @ 6 persons/ m^2 of standees works out in the range of 14.03T 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

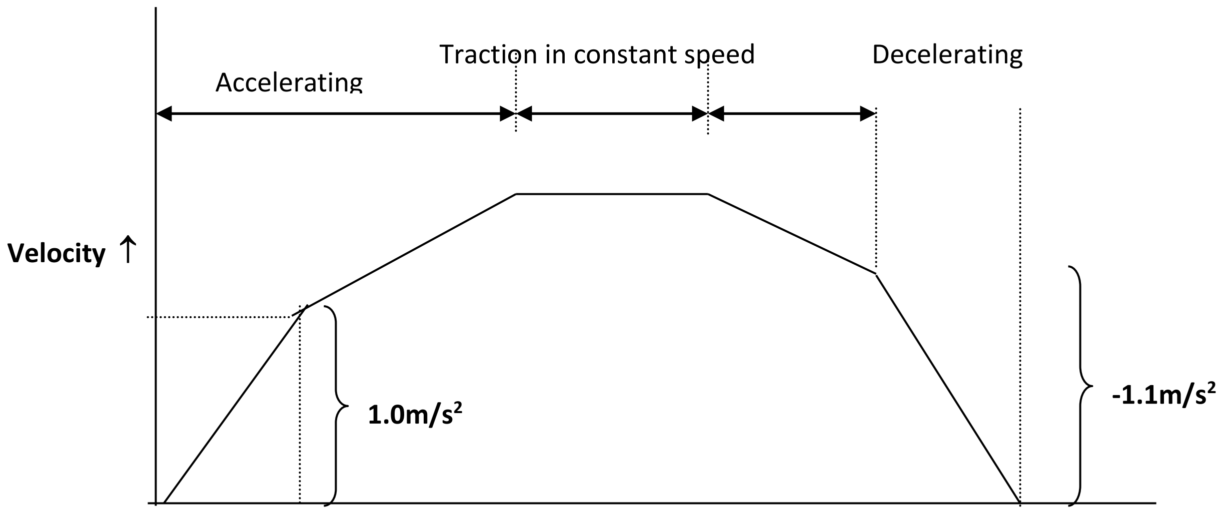
To achieve the desired schedule speed and running time between stations, the following values of acceleration and deceleration are recommended in consideration of riding comfort, adhesion and requirement of makeup time.

- Max. operating speed :90 kmph
- Max. Acceleration : 1.0 m/s^2
- Max. Deceleration : 1.1 m/s^2 (Normal brake)

  More than 1.3 m/s^2(Emergency brake)

The velocity time operation curve is shown in **Figure 11.1.**

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 for different horizon years is given in Chapter 8. The coach requirement for two corridors of Agra Metro is given in **Table 11.5**.

TABLE 11.5: COACH REQUIREMENT FOR AGRA CORRIDORS

Corridor	2024	2031	2041	Design
Sikandara to Taj East Gate	48	57	72	111
Agra Cantt. to KalindiVihar	63	75	87	129

Chapter – 12
POWER SUPPLY AND TRACTION

12. POWER SUPPLY & TRACTION

12.1 CHOICE OF ELECTRIC TRACTION

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:

- 25 KV AC system
- 1500 V DC Third Rail/ Overhead Catenary System
- 750 V DC Third Rail System

The merits and demerits of these systems are discussed below:

- **25 KV AC System**

25 KV AC traction system has been adopted by Lucknow, 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.

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 equipment's for 25kV ac traction system is significantly lower compared to that for 1500V dc 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 systems.

- **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 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 5.4m 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, signaling, 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. Mumbai suburban section of Western Railway and Central Railway which was provided with 1500 V DC catenary, has been converted to 25 kV AC system due to limitation of this system to handle increase in the traffic demand.

- **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 and Bangalore Metro have 750V DC traction system introduced in 1984 and 2011 respectively. 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 traction system is also being provided in Kochi and Ahmedabad metro.

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. The civil structure should be compatible with 750V dc third rail traction system in view of mitigation of stray current.

Merits and Demerits of 750V dc third rail traction system

The selection of proper traction system has a great 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. The merits of 750V dc third rail traction system over 1500V DC OHE or 25kV ac OHE traction system are discussed in brief as below:

Aesthetics: In the absence of any overhead conductors and supporting structures, the 750V DC Third Rail System offers the best aesthetic solution, compared to the Overhead Catenary System. Since Agra City is a popular tourist point and attracts large number of tourists, the aesthetics of the city should be taken care.

Lower Tunneling Costs: Since there is no requirement of maintaining overhead clearances, third rail system can be accommodated in a lower tunnel diameter than the tunnel diameter required for overhead catenary systems, leading to reduced cost of tunneling.
Experience in Installation and O&M: This system is oldest and extensively used in various World Metros and thus is time tested due to availability of considerable experience in installation and O&M.

Low wear and Tear: Due to its solid rigid design it is able to withstand passing of current collector devices of the trains without any significant wear and tear. The effect of wind and rain on the third rail is minimum and on account of the low height. Thus, little maintenance is required for the third rail. However maintenance of substation costs more as they are more in number.

Low Tare Weight: 750V dc Third Rail System like ac traction system do not require provision of transformers and front end converters, the train cost becomes less for 750V dc systems compared to 25 kV ac traction. The weight of train decreases by 5% on this account which also decreases energy consumption.

Other Benefits: Suitable measures are required for mitigation of EMC/EMI caused by single phase 25 kV AC traction systems; whereas no such arrangement is required in case of 750V DC Third Rail System. 25 kV OCS system can be prone to thunderstorms, lightning and intrusion by birds and animals if appropriate measures are not taken. Whereas, 750V DC Third Rail System is not accessible to such situations.

750V DC system has certain demerits which are given below:

Traffic Handling Capacity: The traffic handling capacity of 750V DC Third Rail system is limited to 45,000 PHPDT. However, the estimated PHPDT for the ultimate design year is 23700 passengers for Sikandara to Taj East Gate corridor and 27800 passengers for Agra Cantt. to Kalindi Vihar corridor. Hence, the system is capable of handling the traffic for Agra Metro corridors.

Stray Current: In DC systems, the stray currents cause the corrosion of the metallic structures. However, these stray currents can be suppressed by adopting proper mitigation measures.

In view of above merits of 750V DC third rail traction system and considering the ultimate traffic demand i.e. 27800 PHPDT, it is proposed to adopt 750V DC Third Rail System for Agra Metro corridors.

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 is proposed to be designed for 23700 PHPDT (peak hour peak direction trips) for Sikandara to Taj East Gate Corridor and 27800 PHPDT for Agra Cantt. to Kalindi Vihar Corridor.

The Power supply system design has been conceptualized considering 3 car rake composition and train operation at peak headway for the corridors. 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 3 car rakes with carrying capacity of 766 passengers (standing @ 6 passengers/ m²).
- Peak period headway for Sikandara to Taj East Gate and Agra Cantt. to Kalindi Vihar corridors.
- Specific energy consumption of rolling stock – 75 KWh/ 1000 GTKM
- Regeneration @ 20%
- At grade/ Elev. station load – initially 200 kW, ultimate design 300 kW
- Underground station load – initially 2000 kW, ultimate design 2500 kW
- Depot auxiliary load – initially 1500 kW, ultimate design 2000 KW
- Power factor of load – 0.9
- Transmission losses @ 5%

Keeping in view of the above norms, power demand estimation for the proposed corridors of Agra Metro is given in **Table 12.1.**

Table 12.1: POWER DEMAND ESTIMATION (MVA)

Corridor	Sikandara to Taj East Gate Corridor				Agra Cantt. to Kalindi Vihar Corridor			
Year	**2024**	**2031**	**2041**	**Design**	**2024**	**2031**	**2041**	**Design**
Traction	5.68	7.07	8.69	13.09	6.48	8.04	10.02	14.71
Auxiliary	22.05	23.57	25.08	28.12	5.25	5.83	6.42	7.58
Total	**27.73**	**30.63**	**33.77**	**41.20**	**11.73**	**13.87**	**16.44**	**22.29**

The calculations for the traction and auxiliary power demand estimation are shown in

Annexure 12.1 (a) and **Annexure 12.1 (b)**. However, 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 OF POWER SUPPLY

12.3.1 Need for High Reliability of Power Supply

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

In order to ensure high reliability of power supply, feed from more than one Receiving Substation (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

Agra 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, four Receiving Sub-stations 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 132 kV voltage through cable feeders for the proposed Agra Metro corridors i.e. Sikandara – Taj East Gate corridor and Agra Cantt. – Kalindi Vihar corridor.

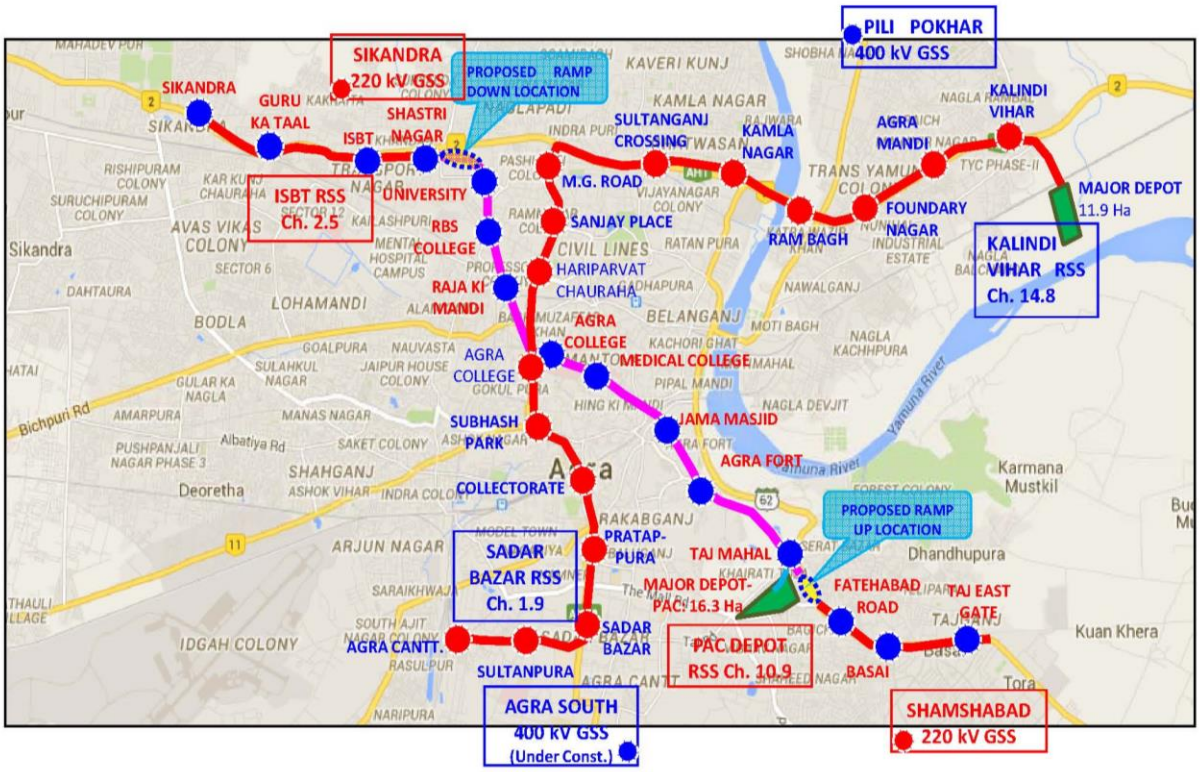
Discussions were held with M/s UPPTCL to finalize the Input Power Supply Sources & Supply Voltage. M/s UPPTCL vide letter no. 4297 C.E.(TS)/Ag/ dated 16.07.15 (**Annexure 12.2**) has confirmed the availability of power supply at Pili Pokhar (400 kV), Sikandara (220 kV), Shamshabad (220 kV) and Agra South (400 kV) (under constructon) Grid Substations (GSS). The details are presented in **Table 12.2** and **Figure 12.1.**

TABLE 12.2 : SOURCES OF POWER SUPPLY

Grid sub-station	RSS of Metro Authority	Approx. Dist. GSS to RSS	Feeding Zone
Sikandara GSS (220/132 kV)	ISBT RSS (132/33 kV)	01 km	Sikandara – Agra College
Shamshabad GSS	PAC Depot RSS	10 km	Agra College – Taj East

Grid sub-station	RSS of Metro Authority	Approx. Dist. GSS to RSS	Feeding Zone
(220/132 kV)	(132/33 kV)		Gate
Agra South GSS (400/132 kV)	Sadar Bazar RSS (132/33 kV)	06 km	Agra Cantt– M.G. Road
Pili Pokhar GSS (400/132 kV)	Kalindi Vihar RSS (132/33 kV)	08 km	M.G. Road – Kalindi Vihar

FIGURE 12.1: REPRESENTATION OF SOURCES OF POWER SUPPLY



HT power supply from grid substations at 132 kV is stepped down to 33 KV at each RSS and fed to Traction cum Auxiliary substations located at stations. 33 kV cable will be laid from RSS along viaduct and tunnel and will consist of two separate networks i.e. Traction network and Auxiliary network. Each network will consist of two cables, each of one having the possibility to be fed from each RSS. The two circuit will loop in – loop out at alternate TSS and ASS. In Traction Substations, the 33 kV power supply will be stepped down and rectified by 2.6 MVA, 33 KV/ 292-292V transformer rectifier set to 750 Volts D.C. and fed to 3rd rail for traction purpose. However, type of rectifier rating of transformer etc. may be firmed up during detailed design stage. In the Auxiliary Substations, 33 KV is stepped down to 415 Volts for lighting, Air conditioning and Ventilations, Pumps, Elevators, Escalators, AFC, PSD, Signaling and Telecommunication etc.

The average spacing of traction sub stations is 2~3 Km. The Auxiliary substations (ASSs) are proposed to be provided at every station to meet the station auxiliary load requirements.

The entire power supply system & auxiliary power supply system will be monitored and controlled from a centralized Operation Control Center (OCC) using a SCADA system. The summary of expected power demand at various sources is given below 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**	**Design**	**2024**	**2031**	**2041**	**Design**
ISBT RSS								
Traction	2.43	3.03	3.72	5.61	5.68	7.07	8.69	13.09
Auxiliary	10.27	10.97	11.67	13.07	19.95	21.35	22.75	25.55
Total (A)	**12.7**	**14**	**15.39**	**18.68**	**25.63**	**28.42**	**31.44**	**38.64**
PAC Depot RSS								
Traction	3.24	4.04	4.96	7.48	5.68	7.07	8.69	13.09
Auxiliary	9.68	10.38	11.08	12.48	19.95	21.35	22.75	25.55
Total (B)	**12.93**	**14.42**	**16.05**	**19.96**	**25.63**	**28.42**	**31.44**	**38.64**
Sadar Bazar RSS								
Traction	3.32	4.12	5.14	7.54	6.48	8.04	10.02	14.71
Auxiliary	2.1	2.36	2.63	3.15	5.25	5.83	6.42	7.58
Total (C)	**5.42**	**6.48**	**7.76**	**10.69**	**11.73**	**13.87**	**16.44**	**22.29**
Kalindi Vihar RSS								
Traction	3.16	3.92	4.89	7.17	6.48	8.04	10.02	14.71
Auxiliary	3.15	3.47	3.79	4.43	5.25	5.83	6.42	7.58
Total (D)	**6.31**	**7.39**	**8.68**	**11.6**	**11.73**	**13.87**	**16.44**	**22.29**

For Sikandara - Taj East Gate Corridor in normal conditions, ISBT RSS will feed the section from Sikandara to Agra College and PAC Depot RSS will feed from Agra College to Taj East Gate. In case ISBT RSS fails, the feed can be extended from PAC Depot RSS. In case of failure of PAC Depot RSS, then ISBT RSS will feed from Sikandara to Taj East Gate i.e complete length of the Corridor.

For Agra Cantt. - Kalindi Vihar Corridor in normal conditions, Sadar Bazar RSS will feed from Agra Cantt. to M.G. Road and Kalindi Vihar RSS will feed from M.G. Road to Kalindi Vihar. In case Sadar Bazar RSS fails, the feed can be extended from Kalindi Vihar RSS. In case of failure of Kalindi Vihar RSS, then Sadar Bazar RSS will feed from Agra Cantt. to Kalindi Vihar i.e complete length of the Corridor.

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. Typical receiving sub-station is presented in **Figure 12.2.**

FIGURE 12.2: TYPICAL HIGH VOLTAGE RECEIVING SUB– STATION

Based on emergency demand expected at each RSS as shown in **Table 12.3**, 2 nos. power transformers of 132/33 kV, 30 MVA (ONAN)/ 42 MVA (ONAF) capacity each at ISBT RSS & PAC Depot RSS and 132/33 kV, 21.6 MVA (ONAN)/ 30.24 MVA (ONAF) capacity each at Sadar Bazar RSS & Kalindi Vihar RSS are proposed to meet the traction and auxiliary power requirements of the proposed corridors.

33kV 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.

Initially equipments may be installed to cater to the expected power requirements during initial years of operations. As and when the traffic builds up in subsequent years, the power supply system will need slight augmentation by way of adding traction transformer-rectifier sets. However, cables of adequate rating to meet designed power demand should be laid at the initial stage itself keeping in view the difficulties associated with laying of cables at a later stage.

The rating of major equipments are given below, which have been worked out based on the conceptual design and therefore, these capacities needs to be reaffirmed and fine tuned by conducting necessary simulation study during detailed design stage of project implementation.

Each RSS shall be provided with 2 nos. (one as standby) 132/33kV three phase transformers having 30 MVA (ONAN)/ 42 MVA (ONAF) or 21.6 MVA (ONAN)/ 30.24 MVA (ONAF) Capacity to meet peak traction and auxiliary demand in case of outage of adjoining RSS. If one RSS trips on fault or on input supply failure, services can be maintained by extending supply from the other RSS. However, in case of total grid failure, trains will come to stop but station lighting & other essential services can be catered to by stand-by power backup.

12.4 TRACTION POWER SUPPLY

Traction sub-stations (33kV/ 750V DC)

Traction sub-stations (33kV/ 750V DC) **(Figure 12.3)** are required to be set up for feeding 750V DC power supply to the third rail. In order to cater to traction load as per design criteria, it is proposed to provide traction sub-stations (TSS) at an approximate distance of about 2 – 3 Km. The TSS along with Auxiliary Sub-Stations (ASS) will be located at station building itself at mezzanine or platform level inside a room. The power distribution schematic and typical layouts for ASS & TSS for elevated sections and underground sections are given in Drawings at **Annexure 12.3 to 12.8** respectively.

FIGURE 12.3: TYPICAL TRACTION SUB-STATION

As per conceptual design, Traction transformer-rectifier set 33kV/ 292-292 (750V DC) are proposed to be 2.6 MVA rated capacity with 12 pulse rectification similar to system adopted in BMRCL with overload requirement of 150% for 2 hours with four intermittent equally spaced overloads of 300% for 1 minute, and with one 450% full load peak of 15 seconds duration at the end of 2 hour period. However, type of rectifier rating of transformer etc. may be firmed up during detailed design stage.

Self-cooled, cast resin dry type rectifier-transformer is proposed, which is suitable for indoor application. 2x2.6 MVA transformer-rectifier set shall be provided in the proposed TSS. One rectifier transformer will be able to meet the power supply demand and the second set will be standby.

The traction transformer-rectifier set shall produce 750V DC nominal output voltage with 12-pulse rectification so as to minimize the ripple content in the output dc voltage. The IEC 60850 and BS EN 50163 international standard envisages the minimum and maximum voltages of 500V and 900V respectively for 750V DC traction system and therefore, the dc equipment shall be capable of giving desired performance in this voltage range.

Each TSS will have IGBT based inverters to convert excess energy during regeneration to AC and this excess energy will be utilized by auxiliary system.

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.

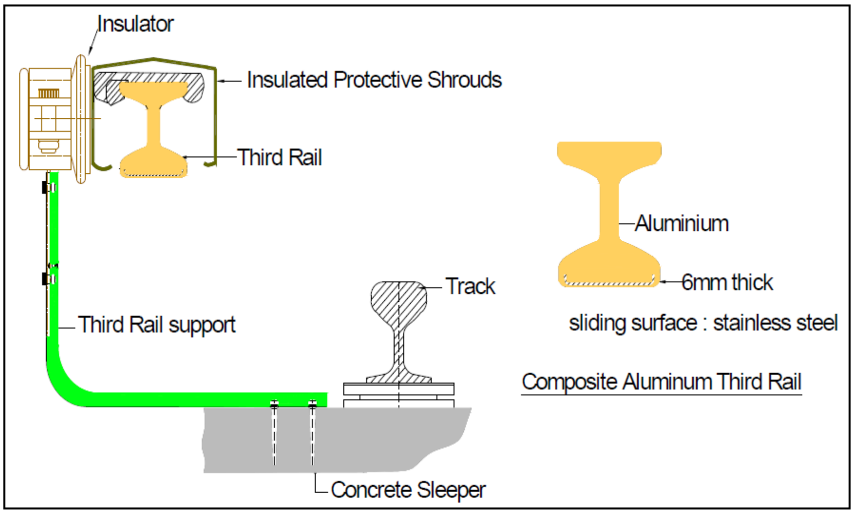
The above capacities of transformers, switchgear, cables etc. have been worked out based on the conceptual design. Therefore, these may be required to be revised and fine-tuned during detailed design stage of project implementation.

750v DC third rail current collection system

For the 750V DC Third Rail Current Collection System, Bottom current collection with the use of composite Aluminum steel third rail on main lines is envisaged from reliability and safety considerations as shown in **Figure 12.4**.

Low carbon steel third rail available indigenously is proposed for the depot because of reduced current requirements. The cross-section of third rail will be about 5000 mm^2. The longitudinal resistance of composite and steel third rail is about 7 and 20 milli-ohm/km respectively. The life of composite and steel third rail is expected to be 25-30 years.

FIGURE 12.4: 750V DC THIRD RAIL CURRENT COLLECTION SYSTEM



Special Arrangements in Depot

A separate traction sub-station (TSS) shall be provided for the depot so as to facilitate isolation of depot traction supply system from main lines in order to prevent the leakage of return currents to depot area. Tracks of depot area shall also be isolated from main line through insulated rail joints (IRJ). Remote operated sectionilizing switches shall be provided to feed power from depot to main line and vice-versa in case of failure of TSS.

The prescribed limit of highest touch potential in depot is 60V as per EN50122-1 and therefore Track Earthing Panels (TEP) shall be provided at suitable locations to earth the rails in case the rail potential exceeds tha limit. In areas, where leaky conditions exist (e.g.washing lines, pit wheel lathe etc.), insulated rail joints (IRJ) shall be provided with power diodes to bridge the IRJ to facilitate passage of return current. A detailed scheme shall be developed during the design stage.

12.5 AUXILIARY POWER ARRANGEMENTS

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 – Signaling, Telecom, Platform Screen Doors and Automatic Fare Collection etc.

Auxiliary sub-stations (ASS) **(Figure 12.5)** 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 during detailed design stage.

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).

FIGURE 12.5: TYPICAL INDOOR AUXILIARY SUB-STATION

Apart from stations, separate ASS is required at each depot with 2x2000 kVA auxiliary transformers to cater to depot cum workshop load.

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 IEC60331 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 Agra Metro corridors is given in **Table 12.4.**

TABLE 12.4: REQUIREMENT OF LIFTS & ESCALATORS

Corridor	Lift	Escalator
Corridor 1: Sikandara to Taj East Gate		
Elevated Stations	33	31
UG Stations	23	79
Total	**56**	**110**
Corridor 2: Agra Cantt. to Kilindi Vihar		
Total Elevated Stations	72	71
Grand Total	**128**	**181**

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 m 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
- Signaling & 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, 750V DC switchgear and associated electrical equipment. DPCS will utilize microprocessor-based fast-acting numerical relays & Programmable Logic Controllers (PLCs) with suitable interface with SCADA system. The SCADA system is presented in **Figure 12.6.**

FIGURE 12.6: SCADA SYSTEM

12.7 ELECTROMAGNETIC INTERFERENCE (EMI) & ELECTROMAGNETIC COMPATIBILITY (EMC)

AC traction currents produce alternating magnetic fields that cause voltages to be induced in any conductor running along the track. Though, dc traction currents normally do not cause electromagnetic induction effect resulting induced voltages and magnetic fields, yet there is a possibility of electromagnetic interference due to sudden increase/ decrease in traction load. In addition, the rectifier-transformer used in dc traction system produces harmonic voltages, which may also cause interference to telecommunications and train control/ protection systems. The rectifier-transformer shall be designed with the recommended limits of harmonic voltages, particularly the third and fifth harmonics. The proposed 12-pulse rectifier-transformer reduces the harmonics level considerably. Detailed specification of equipment e.g. power cables, rectifiers, transformer, E&M equipment etc shall be framed to reduce conducted or radiated emissions as per appropriate international standards. The Metro system as a whole (trains, signaling & telecomm, traction power supply, E&M system etc) shall comply with the EMC requirements of international standards viz. EN50121, EN50123, IEC61000 series etc. A detailed EMC plan will have to be developed during project implementation stage.

12.8 STRAY CURRENT CORROSION PROTECTION MEASURES

Concept of DC Stray Current Corrosion

In dc traction systems, bulk of return current finds its path back to the traction sub-station via the return circuit i.e. running rails. The running rails are normally insulated to minimize leakage of currents to the track bed. However, due to leaky conditions, some current leakage takes place, which is known as 'stray current'. The current follows the path of least resistance. Return current deviates from its intended path if the resistance of the unintended path is lower than that of intended path. The stray current may flow through the unintended path of metallic reinforcements of the structure back to the substation. It is also possible that part of the stray current may also flow into soil, where it may be picked up by metallic utilities and discharged back to soil and then to near the sub-station.

DC stray currents cause corrosion of metallic structure where it leaves the metal. This is shown in schematic Drawing at **Annexure 12.9.** Pitting and general form of corrosion are most often encountered on dc electrified railways.

Measures for Protection against Stray Current Corrosion

Earthing & bonding and protection against stray current corrosion are inter-related and conflicting issues. Therefore, suitable measures are required to suppress the stray currents as well as the presence of high touch potentials. Safety of personnel is given preference even at a cost of slightly increased stray currents.

Following measures are required to restrict the stay current:-

i. Decreasing the resistance of rail-return circuit
ii. Increasing the resistance of rail to ground insulation

Whenever buried pipes and cables are in the vicinity of dc systems, efforts shall be made to ensure that metal parts are kept away as far as practicable to restrict stray current. A minimum distance of 1 meter has been found to be adequate for this purpose.

Generally, three types of earthing arrangements (viz. Earthed System, Floating System & Hybrid Earthing System) are prevalent on metros Worldover for protection against stray current corrosion. Traditionally, earthed system was used by old metros. Hybrid earthing system is being tried on experimental basis on few new metros. Floating system has been extensively used by recent metros. As per the trends Worldover, floating system (i.e. traction system with floating negative) is proposed which reduces the dc stray current to considerable level. The arrangement shall comply with following latest CENELEC standards:-

- EN 50122-1:- Railway Applications (fixed installations) protective provisions relating to electrical safety & earthing
- EN 50122-2:- Railway Applications (fixed installations) protective provisions against the effects of stray currents caused by dc traction system

The conceptual scheme of proposed floating system is described below :-

i. The running rails shall be adequately insulated as per EN50122-2. The recommended conductance per unit length for single track sections are as under:

Elevated section: - 0.5 Siemens/ km
Underground section: - 0.1 Siemens/ km

ii. Stray Current Collector Cables {commonly known as structural earth (SE) cable} (2x200 mm^2 copper) shall be provided along the viaduct and all the metallic parts of equipment, cable sheath, viaduct reinforcement, signal post etc. shall be connected to SE cable.

iii. The continuity of the reinforcement bars of the viaduct/ tunnel as well as track slabs has to be ensured along with a tapping point for connection with separate earthing for viaduct reinforcement.

iv. A provision shall be made to earth the running rail (i.e. negative bus) in case of rail potential being higher than limits prescribed in relevant standard (EN 50122-1) in order to ensure safety of personnel. This will be achieved by providing Track Earthing Panel (TEP) at stations close to platform and at traction sub-stations.

v. In addition, provisions shall be made for connection of SE cable to negative return path through diode only for the purpose of periodical monitoring of stray currents. Under normal operations, switch provided for this connection will be in normally open (NO) position and switch will be closed for monitoring of stray current once or twice in a year as required. The proposed scheme is shown in Drawing at **Annexure 12.10**.

12.9 SOLAR ENERGY HARNESSING SYSTEM

12.9.1 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 Agra MRTS.

12.9.2 Solar PV Power Generation Potential

The roof top on the elevated stations of Agra 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/m2.

The mean global solar radiant exposure at Agra varies from 3.7 kWh/ m2/ day in the month of December to 6.6 kWh/ m2/ day in the month of May.

Based on the solar radiation intensity in the city of Agra, the peak solar power generation of Agra Metro corridor is expected to be about 50 kWp for the elevated stations and about 2000 kWp 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 Agra metro corridors is required to be reviewed and finalized during detail design stage.

12.10 ENERGY SAVING MEASURES

Energy charges of any metro system constitute a substantial portion of its operation & maintenance (O&M) costs. Therefore, it is imperative to incorporate energy saving measures in the system design itself. The auxiliary power consumption of metros is generally more than the traction energy consumed by train movement during initial years of operation. Subsequently, traction power consumption increases with increase in train frequency/composition in order to cater more traffic. The proposed system of 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 20% of total traction energy will be regenerated and fed back to 750 V DC third rail to be consumed by nearby trains.

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

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

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

vi. The latest state of art and energy efficient electrical equipment (e.g. transformers, motors, light fittings etc).

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)

TRACTION AND AUXILIARY POWER REQUIREMENT FOR SIKANDARA TO TAJ EAST GATE CORRIDOR

S.N	Description	2024	2031	2041	Design
(A)	**TRACTION LOAD**				
1	Average speed (S) (Kmph)	34	34	34	34
2	Frequency of service (F) (Sec.)	276	228	180	114
3	Headways (H) (Km.)	2.6	2.1	1.7	1.1
4	Nos of trains per hour (N)	13	16	20	31
5	Specific energy consumption (SEC) (KWh/Thou GTKM)	75	75	75	75
6	Gross tonnage (T) of 3 car rake	177	177	177	177
7	Corridor length (D) (Km)	14.0	14.0	14.0	14.0
8	Power factor of load (PF)	0.9	0.9	0.9	0.9
9	Max. demand on TSS (KW)	4832	5947	7434	11523
10	Energy Saving on the account of Regeneration @20%	966	1189	1487	2305
11	Net Demand	3866	4758	5947	9218
12	Depot Traction Load	1000	1300	1500	2000
	Total Traction Load	4866	6058	7447	11218
	Max. demand on TSS in KVA	5406	6731	8275	12465
	Max. demand on TSS in MVA assuming 5 % loss (MVA)	**5.68**	**7.07**	**8.69**	**13.09**
(B)	**AUXILIARY LOAD**				
1	Load of each elevated stations (KW)	200	225	250	300
2	Nos of at grade/elevated station	7	7	7	7
3	Load of each U/G stations (KW)	2000	2125	2250	2500
4	Nos of U/G stations	8	8	8	8
5	Load of shed (KW)	1500	1625	1750	2000
6	Total load of the stations & 1 Depot (KW)	18900	20200	21500	24100
7	Power factor of the load	0.9	0.9	0.9	0.9
	Total max. power demand of Stations and Depot (KVA)	21000	22444	23889	26778
	considering 5 % loss (MVA)	**22.05**	**23.57**	**25.08**	**28.12**
	Total Max. power Demand Traction + Aux. (MVA)	26.41	29.18	32.16	39.24
	Net demand (MVA) considering 5% distribution loss	**27.73**	**30.63**	**33.77**	**41.20**

Annexure 12.1 (b)

TRACTION AND AUXILIARY POWER REQUIREMENT FOR AGRA CANTT. TO KALINDI VIHAR CORRIDOR

S.N	Description	2024	2031	2041	Design
(A1) TRACTION LOAD (Agra Cantt. to Kalindi Vihar (15.4 km))					
1	Average speed (S) (Kmph)	34	34	34	34
2	Frequency of service (F) (Sec.)	330	276	210	138
3	Headways (H) (Km.)	3.1	2.6	2	1.3
4	Nos of trains per hour (N)	11	13	17	26
5	Specific energy consumption (SEC) (KWh/Thou GTKM)	75	75	75	75
6	Gross tonnage (T) of 3 car rake	177	177	177	177
7	Corridor length (D) (Km)	15.4	15.4	15.4	15.4
8	Power factor of load (PF)	0.9	0.9	0.9	0.9
9	Max. demand on TSS (KW)	4498	5315	6951	10631
10	Energy Saving on the account of Regeneration @20%	900	1063	1390	2126
11	Traction Demand	3598	4252	5561	8504
12	Depot Traction Load	1000	1300	1500	2000
	Net Traction Load (KW) (A1)	4598	5552	7061	10504
(A2) TRACTION LOAD (Agra Cantt. to Sultan Ganj Crossing (9.0 km))					
1	Average speed (KMPH)	34	34	34	34
2	Frequency of service (Sec.)	720	516	450	330
3	Headways (Km.)	6.8	4.9	4.3	3.1
4	Nos of trains per hour	5	7	8	11
5	Specific energy consumption (KWh/Thou GTKM)	75	75	75	75
6	Gross tonnage of 3 car rake	177	177	177	177
7	Corridor length (Km)	9	9	9	9
8	Power factor of load	0.9	0.9	0.9	0.9
9	Max. demand on TSS (KW)	1195	1673	1912	2628
10	Energy Saving on the account of Regeneration @20%	239	335	382	526
11	Net Traction Load (KW) (A2)	956	1338	1529	2103
	Total Traction Load (KW) (A1+A2)	5554	6890	8590	12607
	Max. demand on TSS in KVA	6171	7656	9544	14008
	Max. demand on TSS in MVA assuming 5 % loss (MVA)	**6.48**	**8.04**	**10.02**	**14.71**
(B) AUXILIARY LOAD					
1	Load of each elevated station (KW)	200	225	250	300
2	Nos of at grade/elevated station	15	15	15	15
3	Load of each U/G stations (KW)	2000	2125	2250	2500
4	Nos of U/G stations	0	0	0	0
5	Load of shed (KW)	1500	1625	1750	2000
6	Total load of the stations & 1 Depot (KW)	4500	5000	5500	6500
7	Power factor of the load	0.9	0.9	0.9	0.9
	Total max. power demand of Stations and Depot (KVA)	5000	5556	6111	7222
	Max. demand of Stations and Depot assuming 5 % loss (MVA)	**5.25**	**5.83**	**6.42**	**7.58**
	Total Max. power Demand Traction + Aux. (MVA)	11.17	13.21	15.66	21.23
	Net demand (MVA) considering 5% distribution loss	**11.73**	**13.87**	**16.44**	**22.29**

ANNEXURE 12.2: LETTER NO. 4297 C.E.(TS)/AG/ FROM UPPTCL DATED 16.07.15 FOR AVAILABILITY OF POWER SUPPLY FOR METRO RAIL CORRIDORS IN AGRA & KANPUR

U.P. POWER TRANSMISSION CORPORATION LIMITED
उ0प्र0पावर ट्रांसमिशन कारपोरेशन लिमिटेड
(उ0प्र0 सरकार का उपक्रम)

OFFICE OF THE CHIEF ENGINEER
(TRANSMISSION SOUTH)
NEAR AMAR UJALA PRESS, KAKRAITHA ROAD
AGRA-282007
Tel-No-2604414(O) 2604414(F)
e-mail:- cets@upptcl.org

UPPTCL

मुख्य अभियन्ता
(पारेषण दक्षिण)
अमर उजाला प्रेस के पास, ककरैठा रोड
आगरा ।
दूरभाषः– 2604414(का.) 2604414(फै.)
e-mail:- cets@upptcl.org

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-

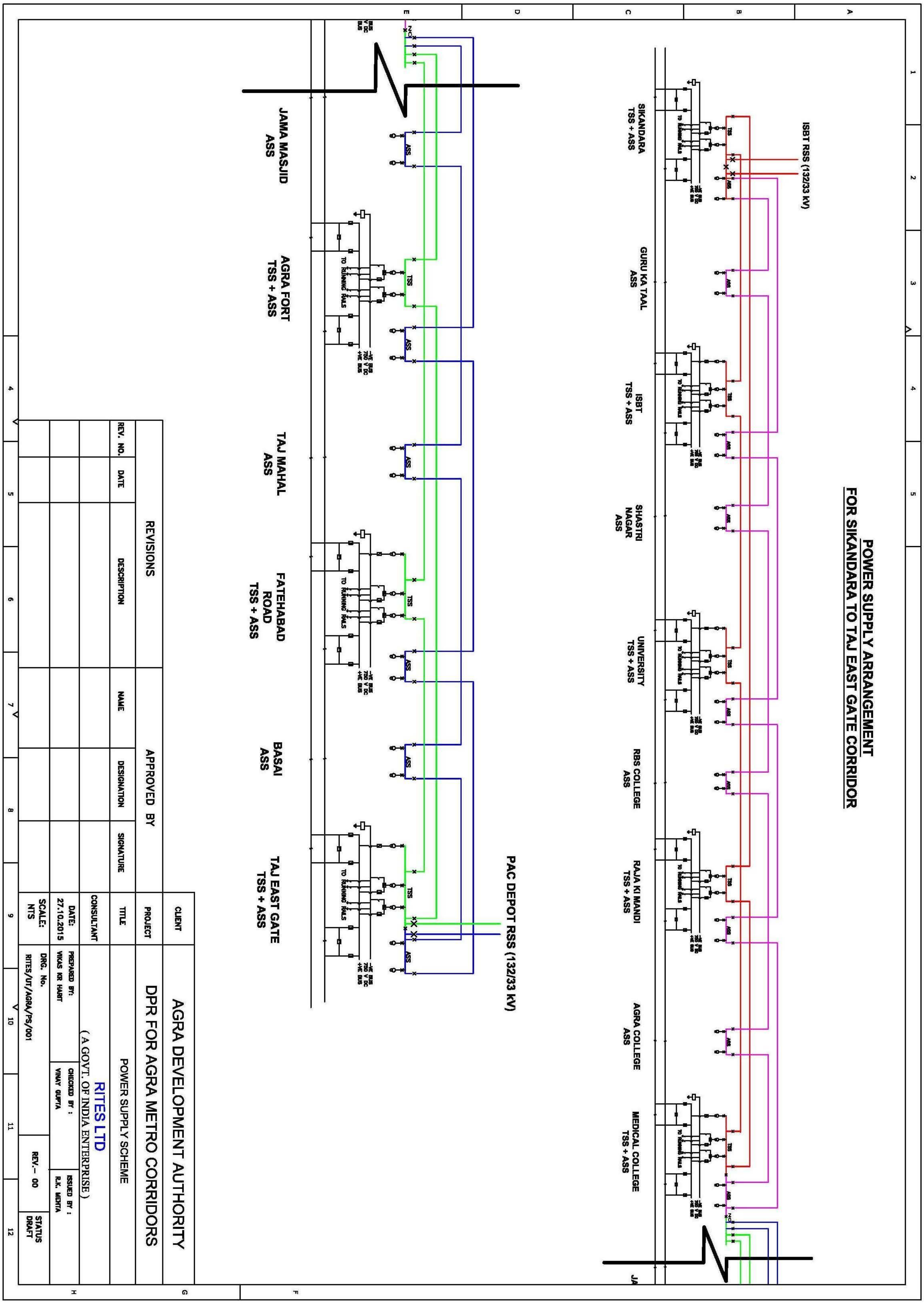
Copy forwarded to the following for information & necessary action.

1. Superintending Engineer, Electy Trans. Circle, Agra/Kanpur-I/II.

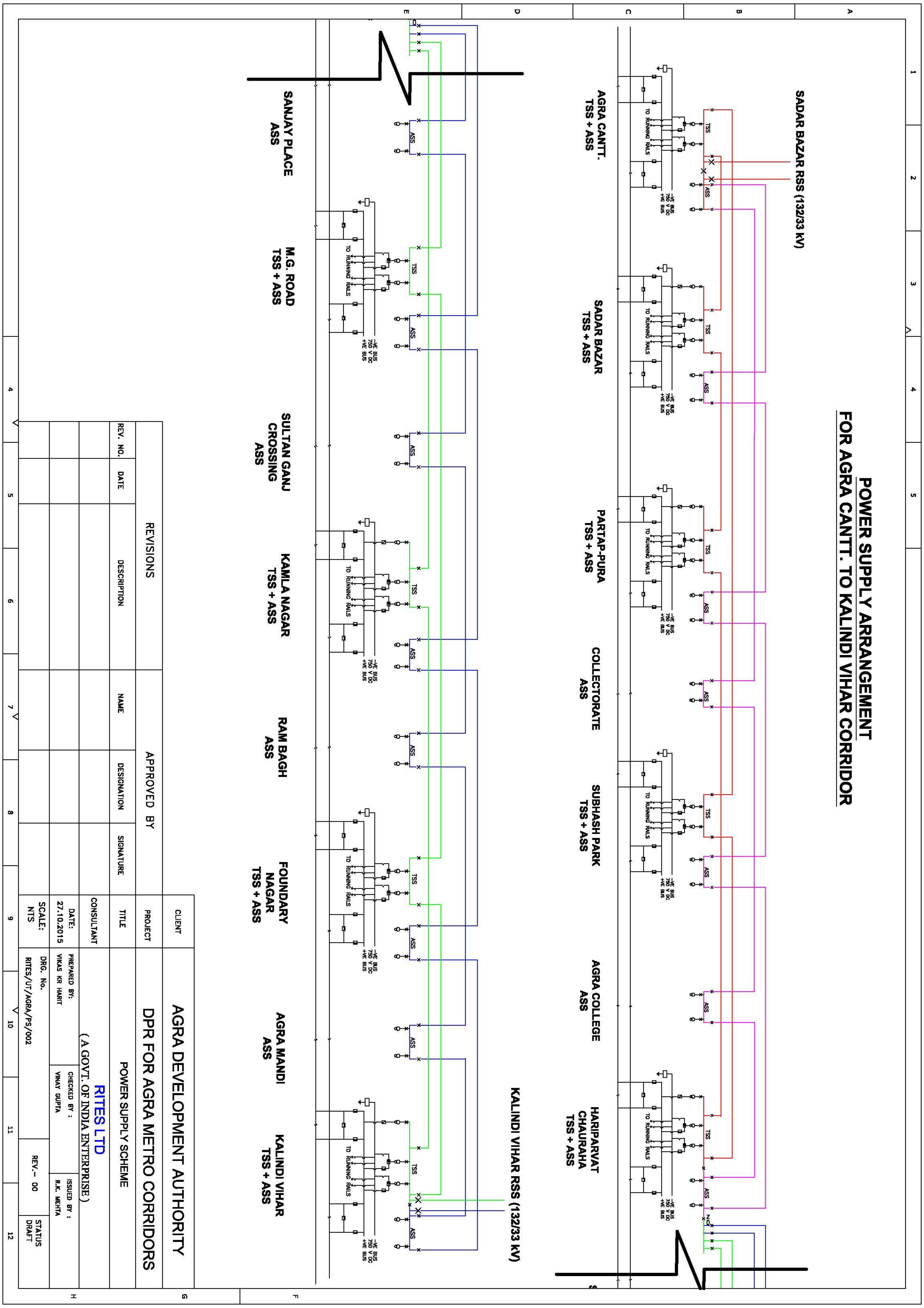
(Puran Chanra)
Executive Engineer (A)

My document (MA)/English letter (b)/751

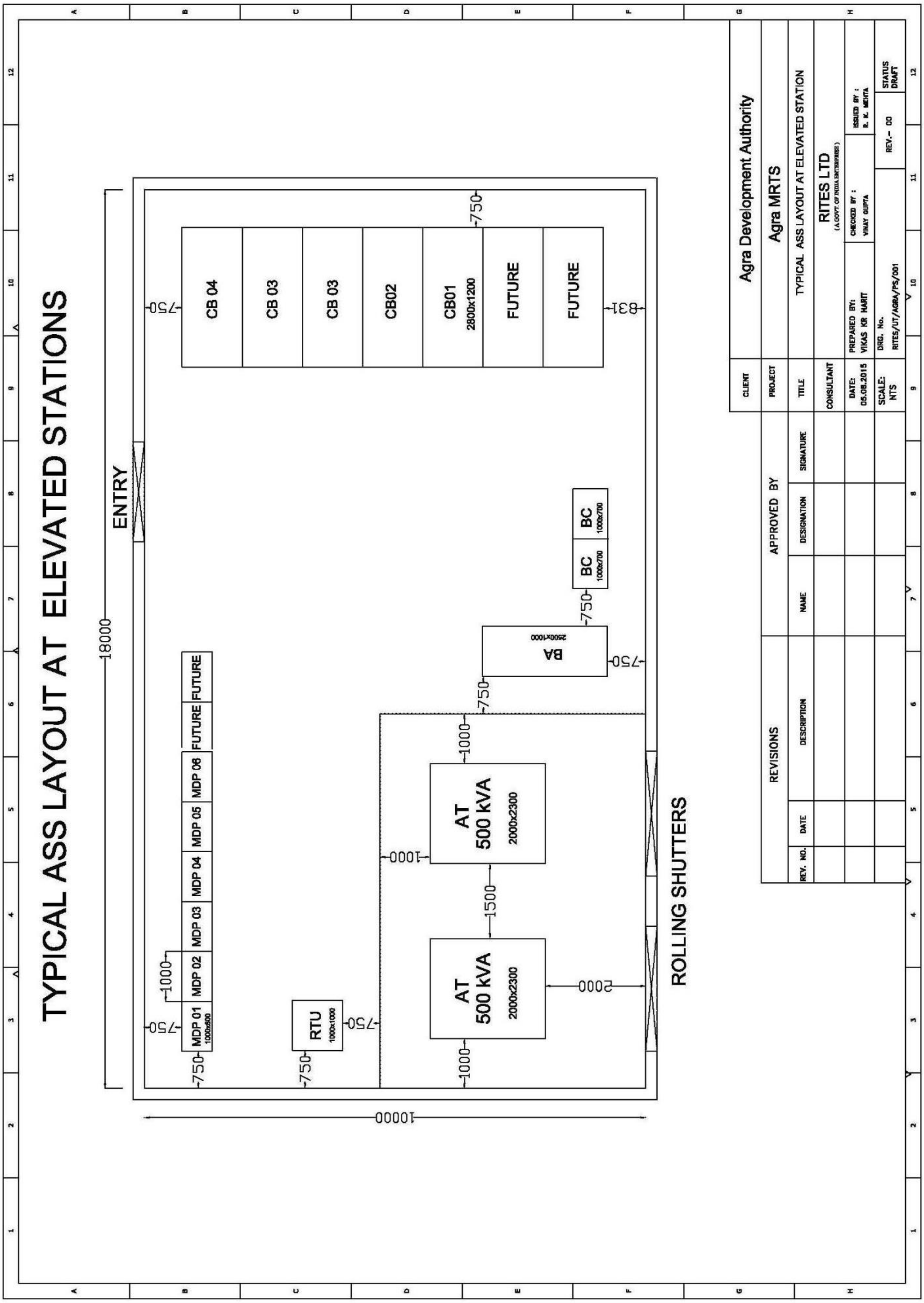
ANNEXURE 12.3 : POWER SUPPLY ARRANGEMENT FROM SIKANDARA TO TAJ EAST GATE VORRIDOR



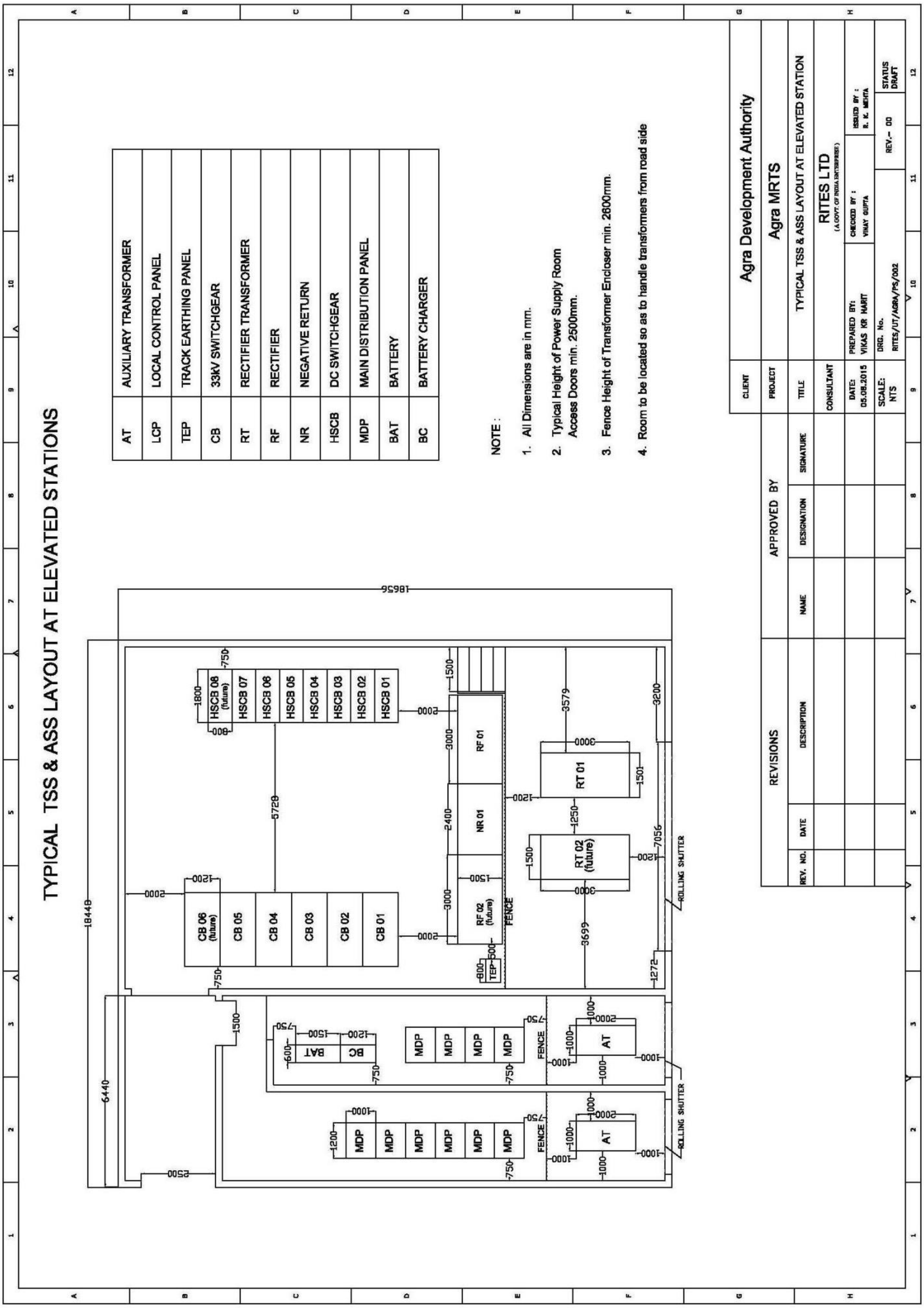
ANNEXURE 12.4: POWER SUPPLY ARRRANGEMENT FOR AGRA CANT TO KALINDI VIHAR CORRIDOR



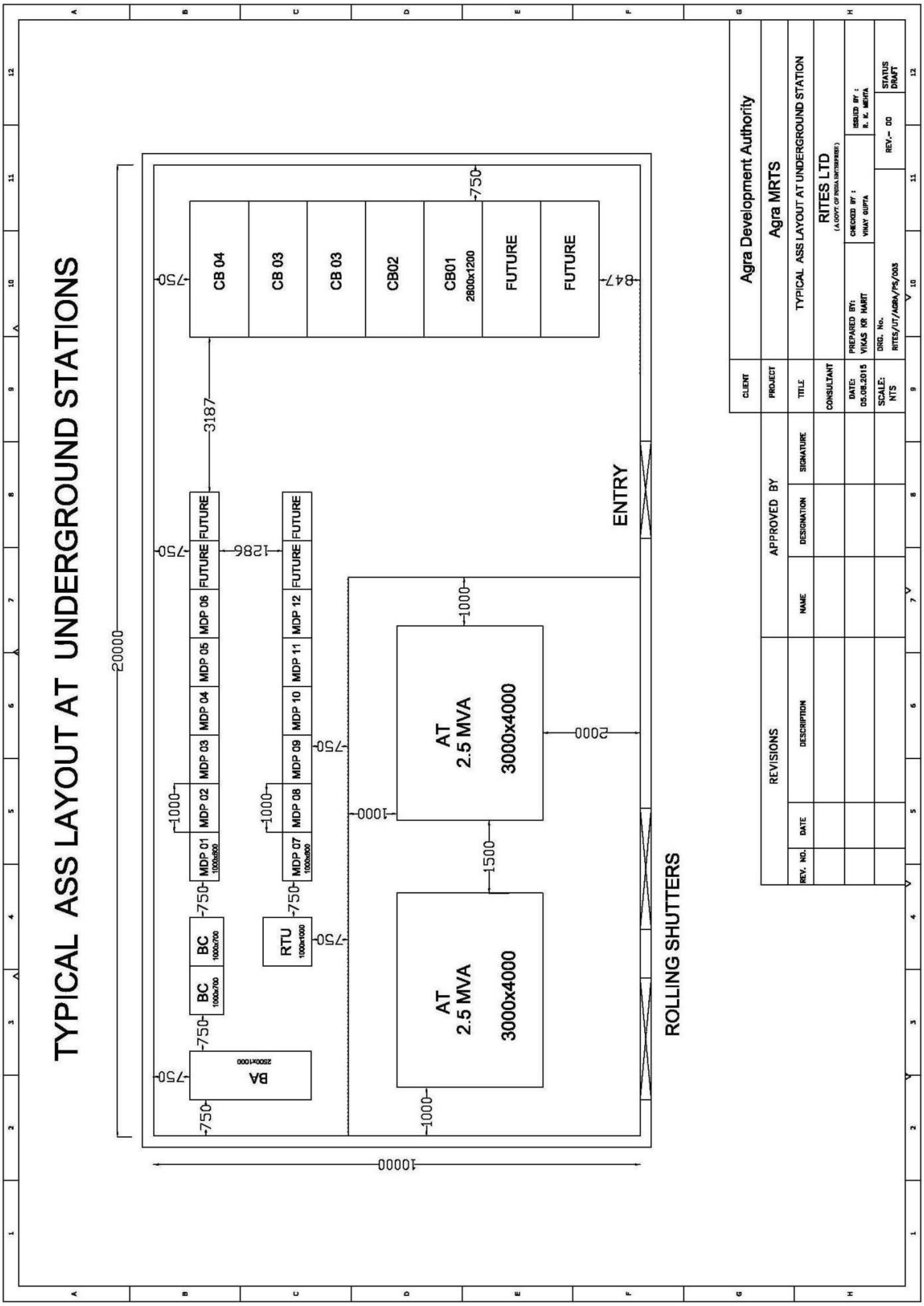
ANNEXURE 12.5: TYPICAL ASS LAYOUT AT ELEVATED STATION



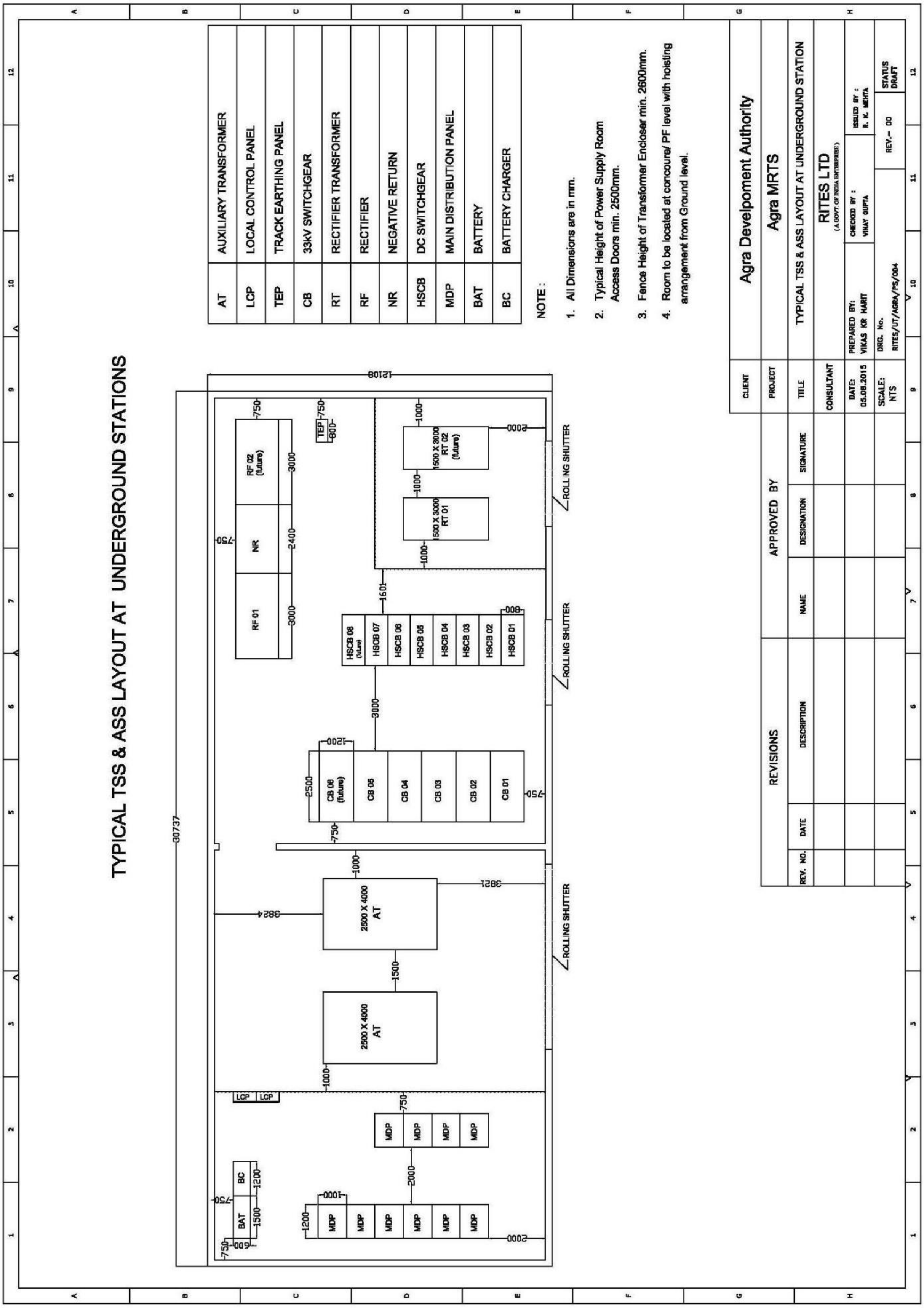
ANNEXURE 12.6: TYPICAL TSS & ASS LAYOUT AT ELEVATED STATION



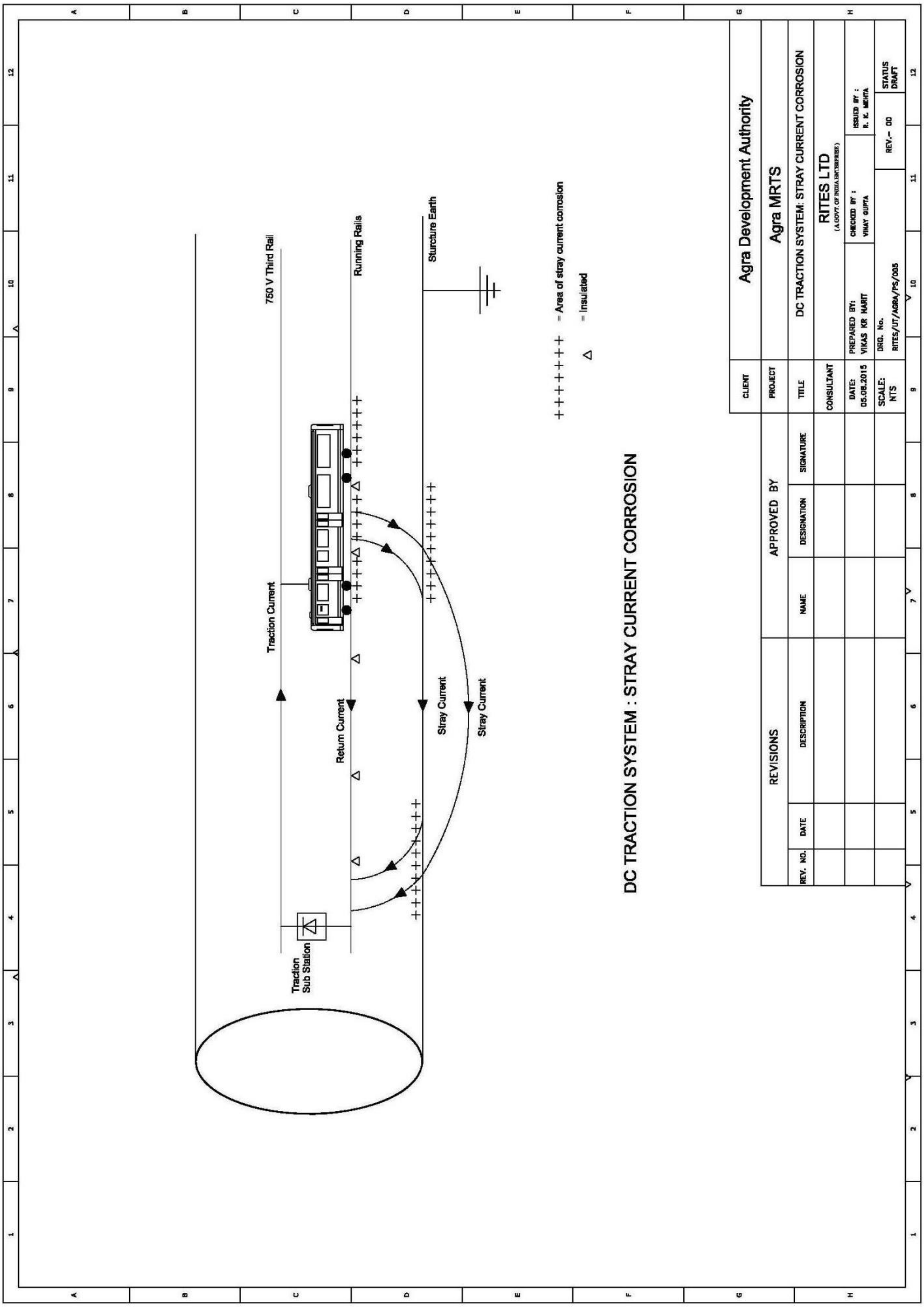
ANNEXURE 12.7: TYPICAL ASS LAYOUT AT UNDERGROUND STATION



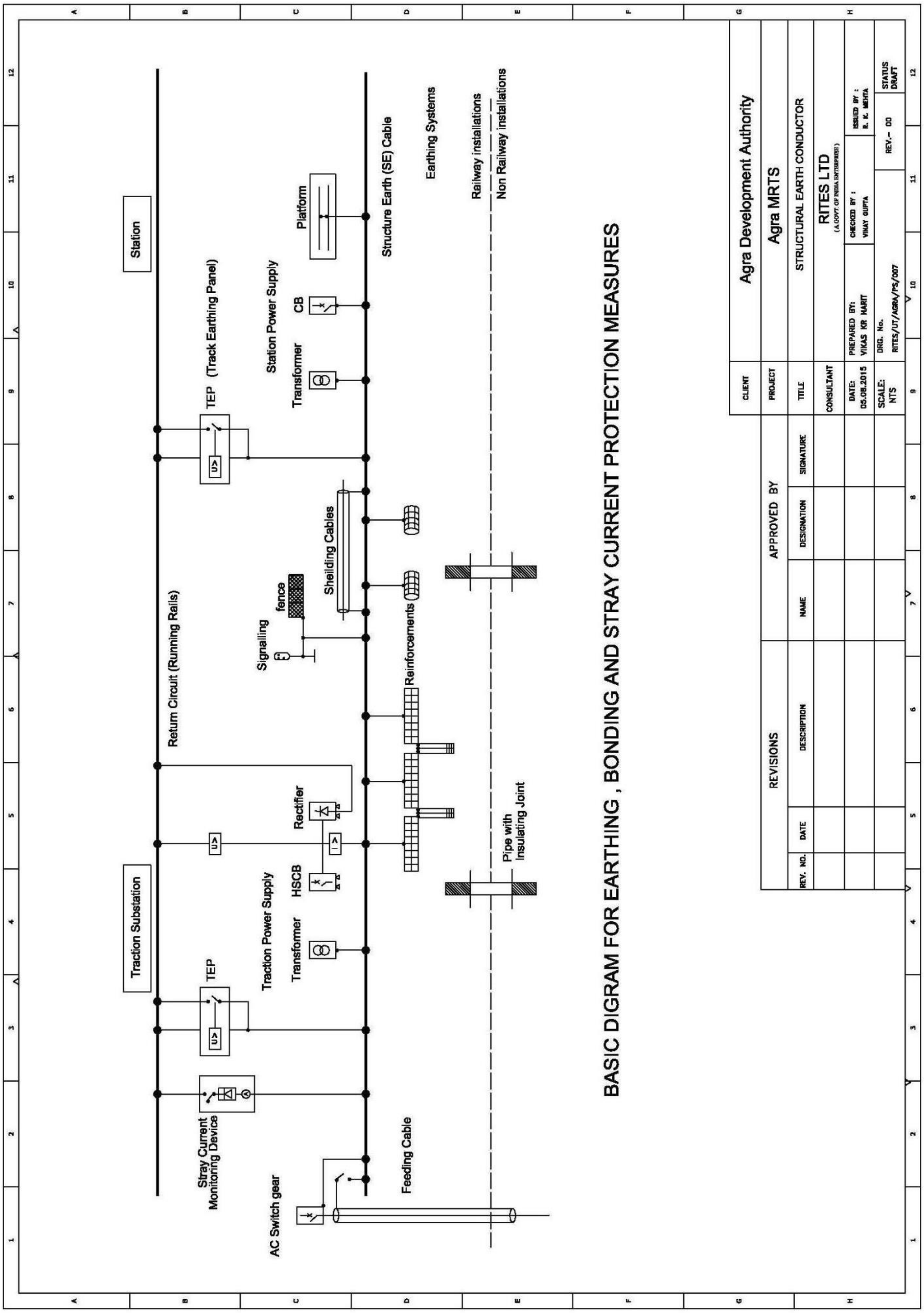
ANNEXURE 12.8: TYPICAL ASS & TSS LAYOUT AT UNDERGROUND STATIONS



ANNEXURE 12.9: DC TRACTION SYSTEM : STRAY CURRENT CORROSION



ANNEXURE 12.10: BASIC DIAGRAM FOR EARTHING, BONDING AND STRAY CURRENT PROTECTION MEASURES



Chapter – 13
VENTILATION AND AIR CONDITIONING SYSTEM

13. VENTILATION AND AIR CONDITIONING SYSTEM

13.1 NEED FOR VENTILATION AND AIR-CONDITIONING

The alignment of Agra Metro is combination of underground and elevated sections. The elevated section generally has less requirement for air conditioning and ventilation system. The air conditioning is required for a few equipment rooms within 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 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 stations of the Corridor 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 tunnel;
- 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 are considered appropriate.

13.2 INTERNAL DESIGN CONDITIONSIN 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 an underground 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

Agra has 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 Agra, the following VAC system design parameters are assumed to be provided for underground sections.

i. Outside ambient conditions:
   - Summer : 42°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 metro 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; platform screen doors etc. 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 under platform void and over 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 CONDITIONINGOF 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 track-way 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.**

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.

FIGURE 13.2: STATION AIR CONDITIONING CLOSED SYSTEM SCHEME

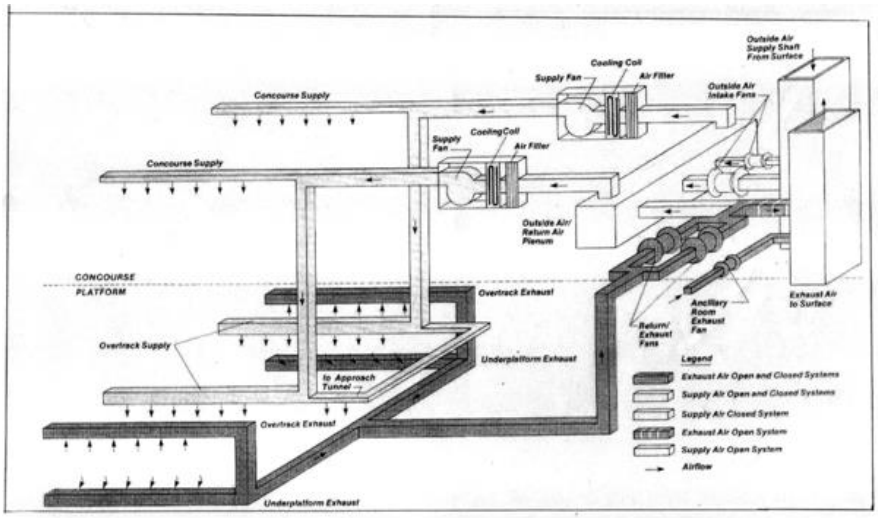
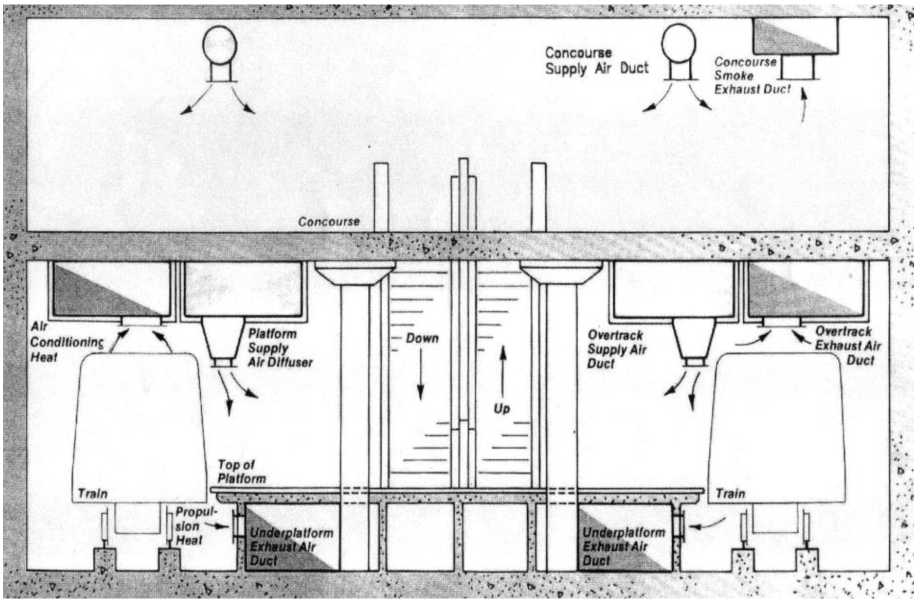


FIGURE 13.3: STATION AIR CONDITIONING SECTION VIEW



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 Metro 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.

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.

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:

SEDH – Subway Environment Design Handbook

ASHRAE – Handbook, current series.

CIBSE – relevant document.

NFPA – 130, 2003 edition.

ECBC – Energy Conservation Building Code

Chapter – 14
DEPOTS

14. DEPOTS

14.1 DEPOT LOCATION AN APPROACH TO MAINTENANCE

The Maintenance facilities for Sikandara to Taj East Gate Corridor and Agra Cantt. to Kalindi Vihar corridor of Agra MRTS are proposed to be provided at PAC Depot for about 37 rakes of 3 cars and at Kalindi Vihar Depot for about 43 rakes of 3 car respectively for maintenance and repairs of the rolling stock operational on each corridor. Since, track connectivity between the two corridors is not feasible, separate maintenance depots have been proposed for each corridor. The depots will have infrastructure to maintain 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 operational on the corridor as well as maintenance facilities for Civil – track, buildings, water supply; Electrical – Traction, E&M; Signaling & Telecomm.; Automatic Fare Collection etc.

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.

The details of the two depots are provided on conceptual design basis and will work as a guideline for detailed design later.

14.1.1 Maintenance Philosophy

The outline of maintenance philosophy followed would be as below:

- Typical Maintenance schedules being followed by Bangalore 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. Labor intensive procedures will 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 for cleaning of rakes.

14.1.2 Planning of 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	Design
Sikandara to Taj East Gate (14 km)	Headway (seconds)	276	228	180	114
	No. of Cars/Train	3	3	3	3
	Rakes Required	16	19	24	37
	Cars Required	48	57	72	111
Agra Cantt. to Kalindi Vihar (15.4 km)	Headway (seconds)	330	276	210	138
	No. of Cars/Train	3	3	3	3
	Rakes Required	15	18	21	33
	Cars Required	45	54	63	99
Agra Cantt. to Sultan Ganj Crossing (9.0 km)	Headway (seconds)	720	516	450	330
	No. of Cars/Train	3	3	3	3
	Rakes Required	6	7	8	10
	Cars Required	18	21	24	30

All the systems and infrastructure on the proposed corridors has been conceptualized considering 3 car trains operating at design headway for Sikandara – Taj East Gate Corridor and Agra Cantt. – Kalindi Vihar Corridor.

14.1.3 Rolling Stock Maintenance Needs

➢ **Maintenance schedule**

Servicing requirements shall be determined from 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 and fully equipped facilities are to be provided that meet these requirements efficiently and in full. In meeting these requirements, it is assumed that the average daily distance travelled by each rolling stock unit is approximately 300 km. The maintenance schedule shown in **Table 14.2** below 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
Intermediate 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.

14.1.4 Washing needs of Rolling Stock

The Metro trains are maintained to a high degree of cleanliness and therefore needs the maintenance schedule as mentioned in **Table 14.3.**

TABLE 14.3: SCHEDULE OF CLEANING

S.N.	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

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 this 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.

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. Tower wagon shall be housed inside the ETU cum emergency rerailing building along with the Accident Relief Train.

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.

The layout for PAC depot has been planned with options placed at **Annexure 14.1(A) & 14.1(B)** for Sikandara to Taj East Gate Corridor. Kalindi Vihar depot layout placed at **Annexure 14.2** is planned for Agra Cantt. to Kalindi Vihar Corridor.

- **PAC Depot (Option I): Entry from Fatehabad Road**

Ideal entry for depot from operational point of view is from Fatehabad Road. However the entry from Fatehabad Road is not possible because of lots of private property on alignment and narrow road. Option I has been developed with entry on narrow road from Fatehabad Road. With this entry the geometry of the area available does not permit direct connection to inspection and workshop. The movement of train from main line to workshop will require reverse shunting. The layout of entry from Fatehabad Road is placed at **Annexure 14.1(A).** However RITES is not recommending this option because of non feasibility and operational constraint inside depot.

- **PAC Depot (Option II): Entry from Agra Fort**

The depot layout with entry from Agra Fort is placed at **Annexure 14.1(B).** It is considered that both end of Sikandara to Taj East Gate corridor will have 6 stabling on terminal stations. This layout will put constraint in induction and withdrawal of trains when train services reach near design headway. Consultant recommends Option II as Option I is not feasible.

14.2.2 Infrastructure Facilities Planned at Depot

A) Inspection Lines and Workshop Lines in Depot

As per the frequency of inspections as indicated in maintenance schedule (**Table 14.2),** the visits of rakes to Depots are as shown below in **Figure 14.1.**

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).

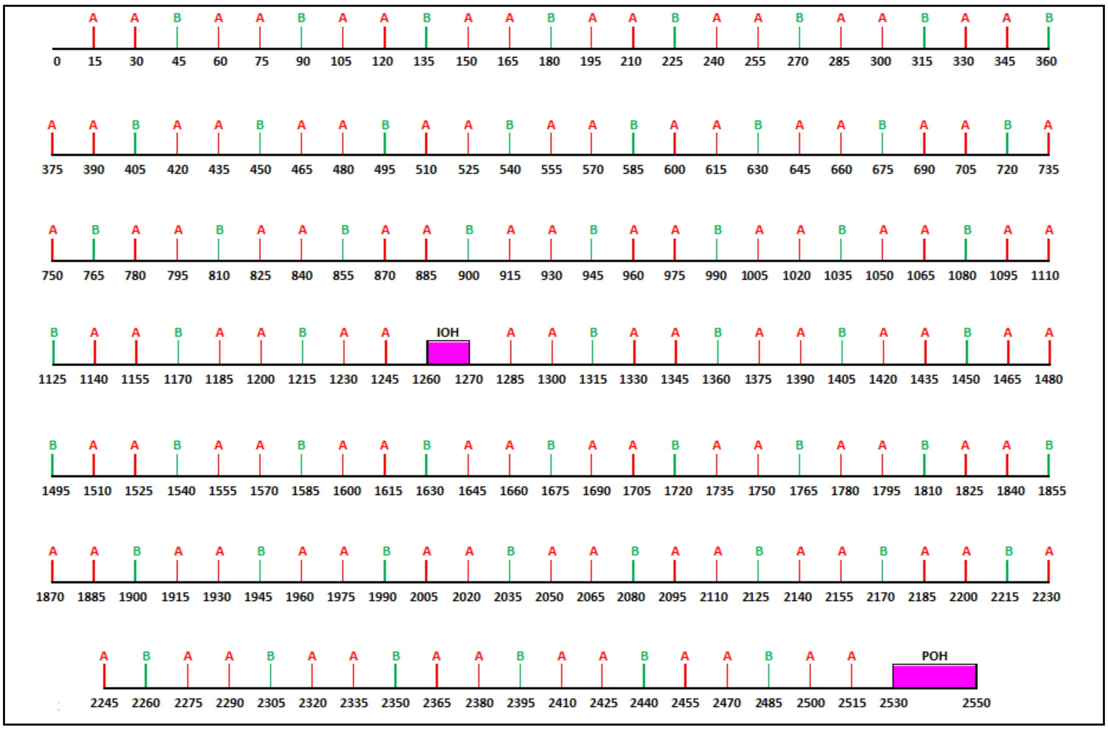
ii) In a day, two rakes are taken for ‘A check’ on a pit line.

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.

FIGURE 14.1: RAKE VISITS TO DEPOTS AND WORKSHOPS



As against above requirement, the infrastructure provided for schedule inspection of the rakes is indicated in **Table 14.4** and **Table 14.5**.

TABLE 14.4: INSPECTION AND WORKSHOP LINES PROVIDED FOR SIKANDARA – TAJ EAST GATE CORRIDOR

Schedule	Total visits per rake in 7 years	Avg. visits /year	Total Arising (for 37 rakes)	Line Occupancy	Lines Required (3 car length)	Lines Provided (6 car length)
Inspection Shed						
A Service Check	112	16	592	2 rakes/ day	0.9867	1
B Service Check	54	7.71	285	1 rakes/ day	0.9514	1
Adjustment line for minor repair/testing after POH						1
Inspection Lines Provided						3
Workshop Shed						
IOH	1	0.14	5.29	1 rake 10 days	0.1762	2
POH	1	0.14	5.29	1 rake 20 days	0.3524	
Unscheduled Repair / Lifting /Wheel/Bogie sections etc.						2
Workshop Lines Provided						**4**

Sikandara – Taj East Gate corridor will have maintenance facility at PAC Depot which will have the infrastructure to maintain 37 rakes of 3 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 AGRA CANTT. – KALINDI VIHAR CORRIDOR

Schedule	Total visits per rake in 7 years	Avg. visits /year	Total Arising (for 43 rakes)	Line Occupancy	Lines Required (3 car length)	Lines Provided (6 car length)
Inspection Shed						
A Service Check	112	16	688	2 rakes/ day	1.1467	2
B Service Check	54	7.71	332	1 rakes/ day	1.1057	
Adjustment line for minor repair/testing after POH						1
Total Inspection Lines Provided						3
Workshop Shed						
IOH	1	0.14	6.14	1 rake 10 days	0.2048	1
POH	1	0.14	6.14	1 rake 20 days	0.4095	
Unscheduled Repair / Lifting /Wheel/Bogie sections etc.						1
Workshop Lines Provided						**2**

Kalindi Vihar Depot will have the infrastructure for the inspection and overhaul of 43 rakes of 3 car. Accordingly, 3 lines are proposed to be provided for the schedule inspections & 2 lines for periodical overhaul/major unscheduled repairs etc.

The facilities have been proposed to ensure the maintenance services to complete fleet of rolling stock to meet the requirement of future extensions of the corridor (if any). It will also ensure adequacy of system to meet unforeseen growth of traffic beyond the horizon year.

B) Stabling Facilities for Rakes

- **Sikandara to Taj East Gate Corridor:**

  The rake requirement for Sikandara to Taj East corridor is 37 rakes of 3 car for ultimate design year. PAC depot on Sikandara to Taj East corridor is planned with 12 lines of 6 car length each i.e. capacity of 24 rakes of 3 car each. At a given time, three rakes would remain under inspection and the remaining rakes will be stabled at terminal/enroute stations for the start of early morning services.

- **Agra Cantt. to Kalindi Vihar:**

  The rake requirement for Agra Cantt. to Kalindi Vihar corridor is 43 rakes of 3 car for ultimate design year. Kalindi Vihar Depot proposed on Agra Cantt. to Kalindi Vihar corridor will have stabling facility for 30 rakes of 3 car. Fifteen number of stabling lines have been provided with the 6 car length so as to stable two rakes of 3 car in each line. At a given time, three rakes would remain under inspection and the remaining rakes will be stabled at terminal/enroute stations for the start of early morning services.

Hence, the depot layouts kept at **Annexure 14.1(B)** and **14.2** for the proposed corridors are sufficient to cater to the maintenance requirements of the rolling stock operational on the corridors for the design year.

14.2.3 Depot cum Workshop Planning

As per the dimensions of the Rolling Stock, the approximate length of 3-car trains would be 65 m (approx). However in the design of the Inspection shed, workshop lines and stabling lines at depot, length of 6-car train is taken in consideration.

i) Stabling Lines in Depot

For the design of the stabling lines in the depot, following approximate lengths have been taken in consideration:

a. Length of one 3-car rake= 65 m
b. Gap between two 3 car trains= 10m
c. Free length at outer ends of the rake (for cross pathway, Signal and Friction buffers)= 10m each side
d. Total length of Stabling line = (iii)+(i)+(ii)+(i)+(iii)= 10+ 65+10+65+10= 160 m

Considering the car width of 2900 on Standard Gauge, 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.

ii) Inspection Lines in Depot

For the design of the Inspection Bay Lines in the depot, following approximate lengths have been taken in consideration:

a. Length of one 3-car rake= 65 m (approx)
b. Gap between two 3 car trains= 10m
c. Cross path at each end = 10 m
d. Total length of Inspection line = (iii)+(i)+(ii)+(i)+(iii)= 10+ 65+10+65+10 = 160m

The inspection bay in PAC Depot and Kalindi Vihar Depot of 160 X 23.5m² size with three inspection lines having sunken floor is provided. Track spacing between the adjacent inspection Bay Lines is considered as 6.25 m.

There would be lighting below rail level to facilitate under frame inspection. Ramps of 1:8 slopes, 3 meter wide have been provided with sunken floor system for movement of material for the cars. Further, 3.5 m cross pathways are left at each end for movement of material by fork lifter/ Leister/ Hand trolley. Stinger system shall be provided for 750V DC traction power supply to the rolling stock. 415V 3 phase 50 Hz, 230V 1 phase 50 Hz AC supply and Pneumatic supply is made available on each inspection shed columns. Air-circulators have been provided on each column.

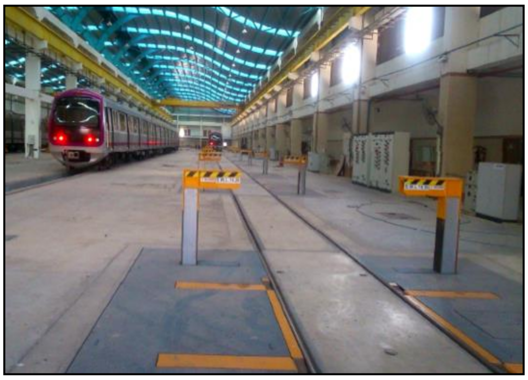
Roof and walls shall be of such design that optimum natural air ventilation occurs all the time and sufficient natural light is also available. Each Inspection bay will have arrangement close by for cleaning of HVAC filter under high pressure water jet.

iii) Workshop in depot

The size of the workshop shed in PAC depot and Kalindi Vihar Depot of 160 x 44.5 m² and 160 x 23 m² respectively and an additional covered space of 160 x 7.5 m² have been 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
- Battery.
- Air compressor.
- Air conditioning equipments
- Brake equipment.
- Door actuators.
- Control and measuring equipments.
- Pneumatic equipments
- Dampers and Springs
- Couplers/ Gangways

Cross track equipped with bogie turntables have been provided for movement between bays.



iv) Pit Wheel Lathe

A separate building is planned for housing pit wheel lathe (PWL) for Kalindi Vihar Depot which is 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.

Mobile wheel turning lathe having improved, demand oriented vehicle maintenance with short rolling stock downtimes and considerably high efficiency in maintenance is proposed to be provided in PAC Depot.

v) 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.

vi) 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.

vii) Automatic Coach Washing Plant (AWP)

Provision has been 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.

viii) Test Track

A test track of 900 mts. length in PAC Depot and 700 mts. length in Kalindi Vihar 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. In compliance to safety norms, the boundary of the track shall be completely fenced to prevent unauthorized trespassing across or along the track.

ix) Internal 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.

x) 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.

xi) 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.

xii) Operation Control Centre and Depot Control Centre

Control of train operation will be done centrally from Operations Control Center (OCC), which will house Traffic Control Centre, SCADA System for Traction Power Control & Monitoring, SCADA System for Auxiliary Power, VAC Control & Monitoring, Telecommunication, CCTV Control & Monitoring etc. Movement of trains inside depot shall be controlled from Depot Control Centre (DCC) located inside the depot.

xiii) Parking Facilities

a) Ample parking space shall be provided for the two wheelers and four wheelers at the following points.

i. Close to the depot entry.
ii. Close to the stabling lines.
iii. Close to the Workshop/ IBL.

b) Space for parking of road and re-railing equipments

Enough space for parking of road vehicle/ trailers/ trucks etc. Enough space will also have to be earmarked adjacent to workshops. Similarly, provision of space for parking of re-railing equipments will have to be made close to the main exit gate of the Depot.

xiv) Watch Towers

There shall be provision of adequate number of watch towers for the vigilance of depot boundary.

xv) 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.

xvi) 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.

xvii) 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.

Synchronized Mobile Jacks

Synchronized Pit Jacks

xviii) Water Supply, Sewerage and Drainage Works

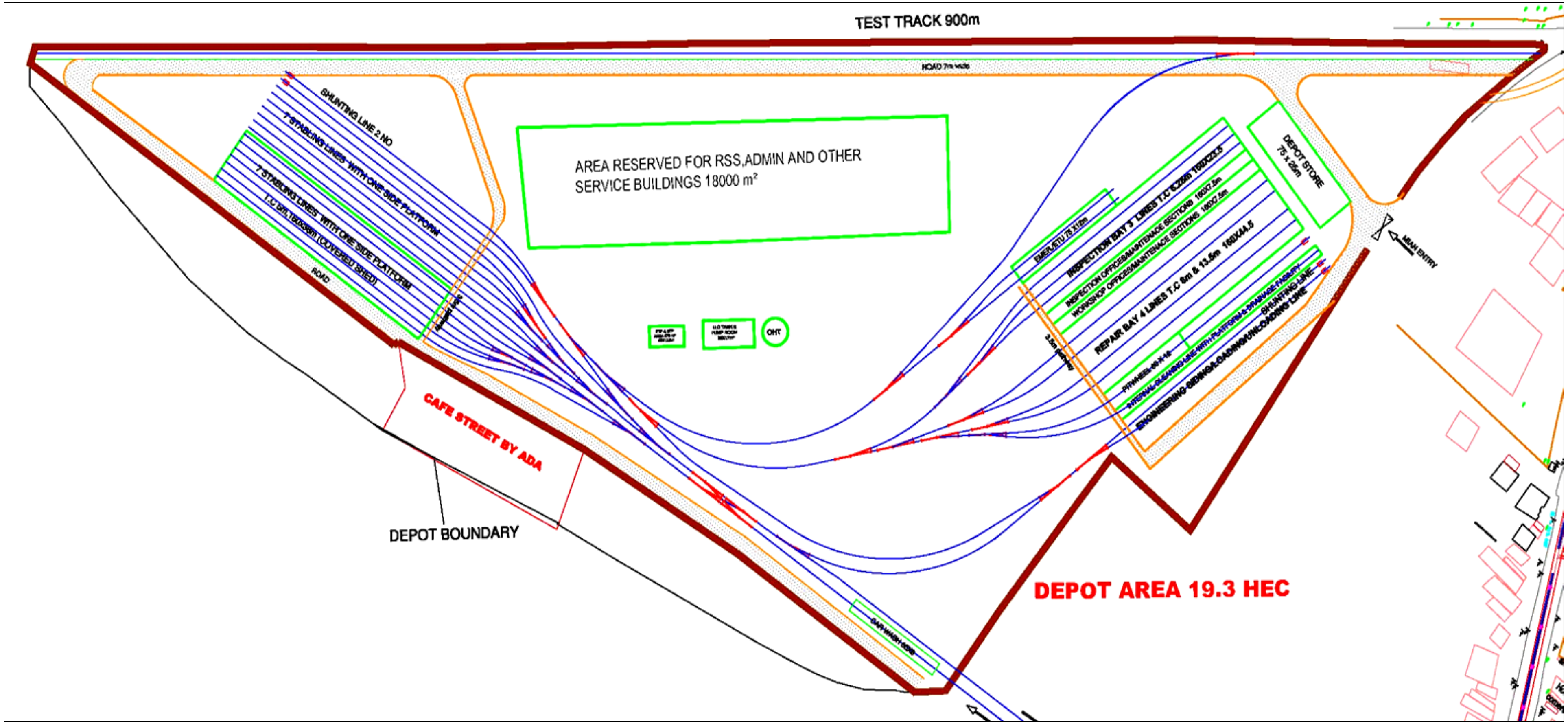
In house facilities shall be developed for the water supply of each depot. Sewerage, storm water drainage shall be given due care while designing the depots for efficient system functioning. Past records of Municipal Corporation shall be used to design the drainage system. Rainwater harvesting would be given due emphases to charge the underground reserves.

xix) Plant And Machinery

Plant and machinery proposed for the maintenance facilities at PAC depot and Kalindi Vihar depot have been listed in **Annexure 14.3 and 14.4**. Some of the major equipments used in the Maintenance Depot are given in figure below:

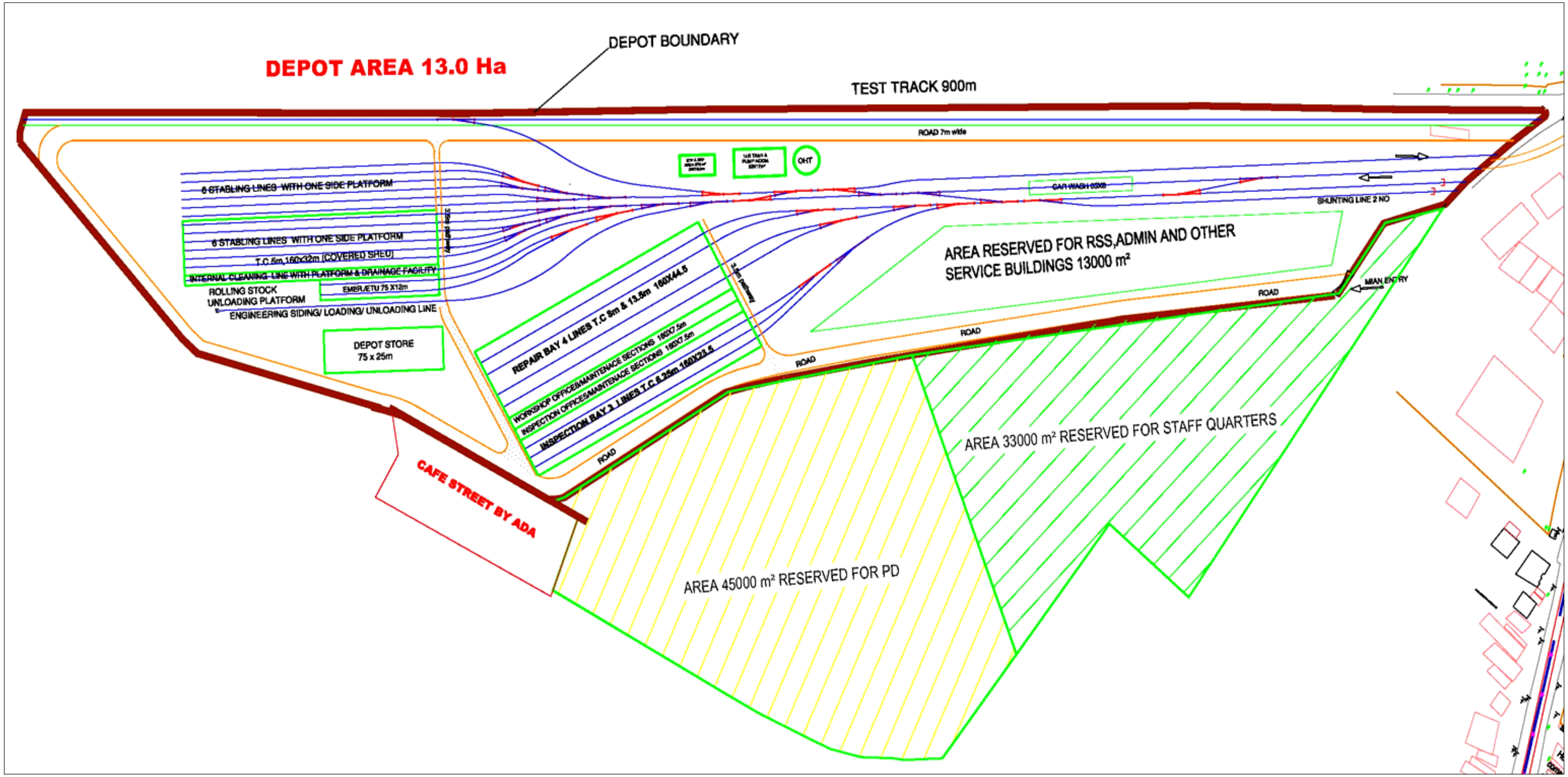
Annexure 14.1(A)

LAYOUT PLAN FOR PAC DEPOT (OPTION I)



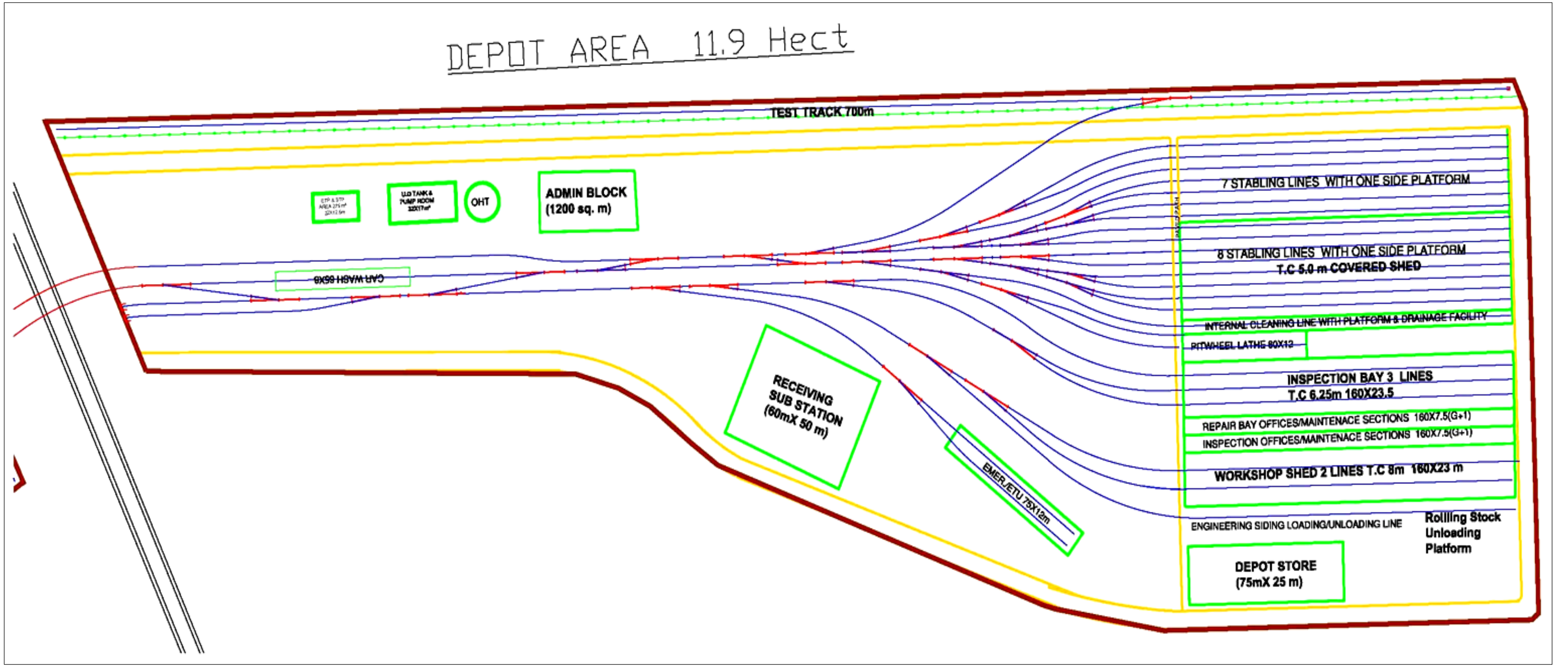
Annexure 14.1(B)

LAYOUT PLAN FOR PAC DEPOT (OPTION II)



Annexure 14.2

LAYOUT PLAN FOR KALINDI VIHAR DEPOT



Annexure 14.3

LIST OF MAJOR PLANT AND MACHINERY FOR PAC DEPOT

Sl no.	PLANT & MACHINERY	Depot
A.	**MATERIAL HANDLING**	
	Travelling over head EOT cranes for workshop 15/2T	2
	Travelling over head EOT cranes for workshop 3.2T	2
	Travelling over head EOT cranes for inspection bay 1.5T	2
	Travelling over head EOT cranes for ETU shed 5T	1
	Synchronized pit jacks system for 3 car lifting	1
	Car body stands for keeping 3 car shells	24
	Dummy bogies	3
	Mobile lifting jacks-15T	12
	Mobile lifting jacks 10T	12
	Battery powered locomotive	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
B.	**Wheel shop**	
	500T wheel press	1
	Vertical boring m/c (Turret Lathe)	1
	Surface 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**	
	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
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
	Mobile Wheel Turning Lathe	1
	Chip crusher and conveyor for pit wheel lathe	1

Sl no.	PLANT & MACHINERY	Depot
	Automatic Washing plant for Metro cars.	1
	High-pressure washing pump for front and rear end cleaning of	1
	Turn table for one car	1
	Turntable for bogies	4
	Driving Cab Simulator	1
	Painting booth for separate parts	1
	Floor cleaning machine	4
	Welding equipments	5
	Compressor 500Cfm	2
	Stinger system for traction power supply	1
	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
	Oscilloscope	1
H.	**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

Annexure 14.4

LIST OF MAJOR PLANT AND MACHINERY FOR KALINDI VIHAR DEPOT

Sl no.	PLANT & MACHINERY	Depot
A.	**MATERIAL HANDLING**	
	Travelling over head EOT cranes for workshop 15/2T	2
	Travelling over head EOT cranes for workshop 3.2T	2
	Travelling over head EOT cranes for inspection bay 1.5T	2
	Travelling over head EOT cranes for ETU shed 5T	1
	Synchronized pit jacks system for 3 car lifting	1
	Car body stands for keeping 3 car shells	24
	Dummy bogies	3
	Mobile lifting jacks-15T	12
	Mobile lifting jacks 10T	12
	Battery powered locomotive	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	4
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
	Chip crusher and conveyor for pit wheel lathe	1
	Automatic Washing plant for Metro cars.	1
	High-pressure washing pump for front and rear end cleaning of	1
	Turn table for one car	1
	Turntable for bogies	4
	Driving Cab Simulator	1
	Painting booth for separate parts	1
	Floor cleaning machine	4

Sl no.	PLANT & MACHINERY	Depot
	Welding equipments	5
	Compressor 500Cfm	2
	DG set 320 KVA	3
	Battery charger	2
E.	**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
F.	**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
G.	**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 & 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
	Noise due to DG sets

ASPECT OF ENVIRONMENT	LIKELY IMPACTS
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 MONITORING

S. NO.	ATTRIBUTE	PARAMETER	FREQUENCY	SOURCE
LAND ENVIRONMENT				
1	Soil	Soil Characteristics	Once	Field studies/ literature review
2	Geology	Geological History	---	Literature review
3	Seismology	Seismic Hazard	---	Literature review
WATER ENVIRONMENT				
4	Water Quality	Physical, Chemical and Biological parameters	One Season	Field studies/ literature review
AMBIENT ENVIRONMENT				
5	Ambient Air Quality	$PM_{2.5}$, PM_{10}, SO_2,,NO_2, CO, HC, O_3, Pb, and NH_3	24 hr in one Season	Field Studies
6	Meteorology	Temperature, Relative humidity, Rainfall, wind direction and speed	Last five years	India Meteorological Department/ literature review
7	Noise	Noise levels in dB (A)	24 hr in one Season	Field studies
SOCIO-ECONOMIC				
9	Socio-economic aspects	Socio-economic characteristics	Once	Field Studies, Literature review
ECOLOGY				
10	Ecology	Flora & Fauna	Once	Literature and Field observations

15.1.2. Land Environment

The land environment primarily consists of Physiography, soil, geology & minerals, and land use pattern.

Physiography: Agra is a city on the banks of river Yamuna in the northern state of Uttar Pradesh, India. It is 378 kilometers west of the state capital, Lucknow, 206 kilometers south of the national capital New Delhi and 125 kilometers north of Gwalior. It is located at latitude 270 18' N and longitude 780 02' E with an elevation of 171 m above mean sea level and having the area of 188.40 sq km. The physiographical map is shown in **Figure 15.1.**

Soil: The soil mostly consists of the quaternary sediments of the Indo-Gangetic plains. It consists of recent unconsolidated fluvial formations containing sand, silt and clay. Its texture is mostly fine. The seven soil samples were collected along both the corridors, location details are provided in **Table 15.3** and sampling location map is shown in **Figure 15.2**. The laboratory analysis results so obtained are reported in **Table 15.4**. The soils are slightly alkaline in nature. The soils are mainly clay loam, slightly silty and loam in texture. Organic matter content in soils varies from 0.66% to 0.86%. The soil map of Agra district is shown in **Figure 15.3.**

TABLE 15.3: SAMPLING LOCATIONS FOR SOIL

Location
Corridor - 1
Near Agra Fort (Electric) office
Near Hotel Trident
Agra ISBT
Corridor - 2
Agra Cantt. Railway Station
St. John College
TYC Phase-II
Vijay Nagar

Corridor-1: Sikandara to Taj East Gate,
Corridor-2: Agra Cantt. Rly Station to Kalindi Vihar

Geology and Minerals: Most of the state of Uttar Pradesh lies in the Gangetic Plain. This is a fore-deep, a downward of the Himalayan foreland, of variable depth, converted into flat plains by long-vigorous sedimentation. This is known as a geosyncline and the Gangetic Plain is the Indo-Gangetic Geosyncline. A generalized geological succession of the formations present in and around Agra city is given below:

Formation	Lithology	Age
Quaternary	Gangetic Alluvium	Recent Pleistocene
------------	--Unconformity--	------------
Vindhyan	Upper Bhander Sandstone Lower Rewa Sandstone	Pre-cambrian

The entire city of Agra is underlain by quaternary sediments constituting an admixture of sand, silt, clay and kanker. The geological map of Uttar Pradesh is shown in **Figure 15.2.**

FIGURE 15.1: PHYSIOGRAPHICAL MAP OF STUDY AREA

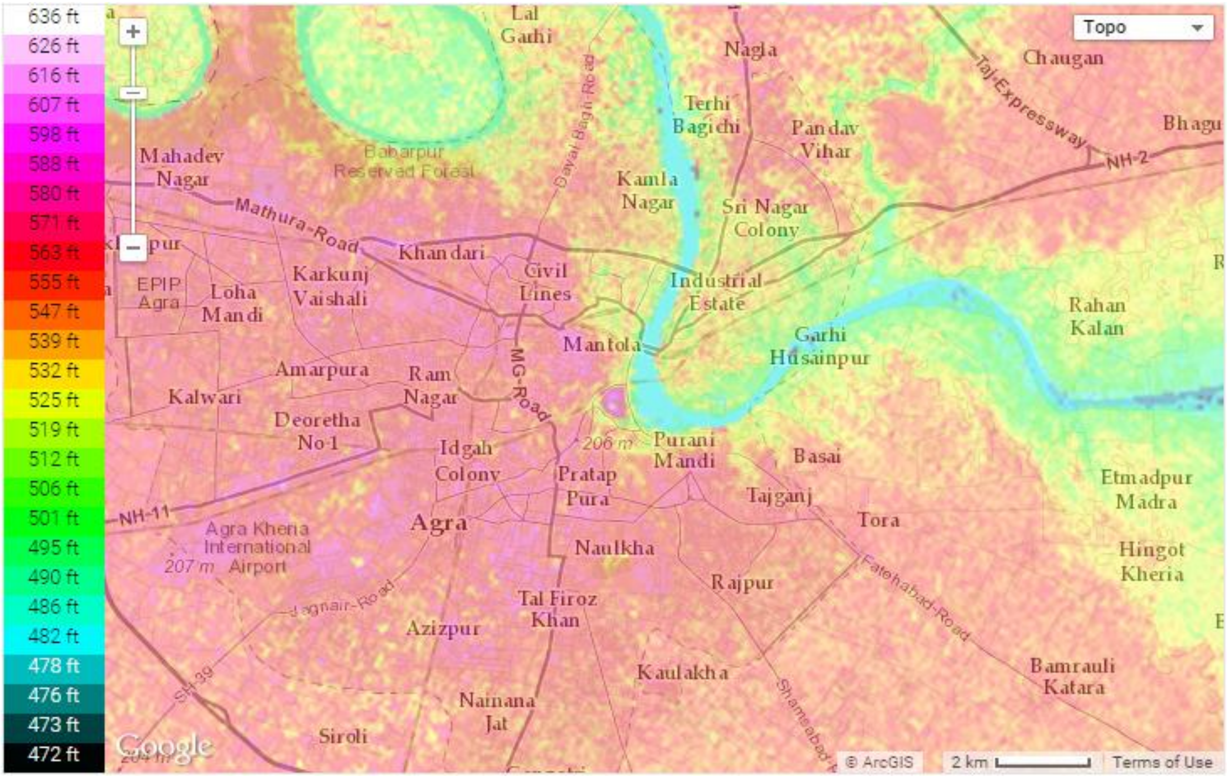


FIGURE 15.2: GEOLOGICAL MAP OF UTTAR PRADESH

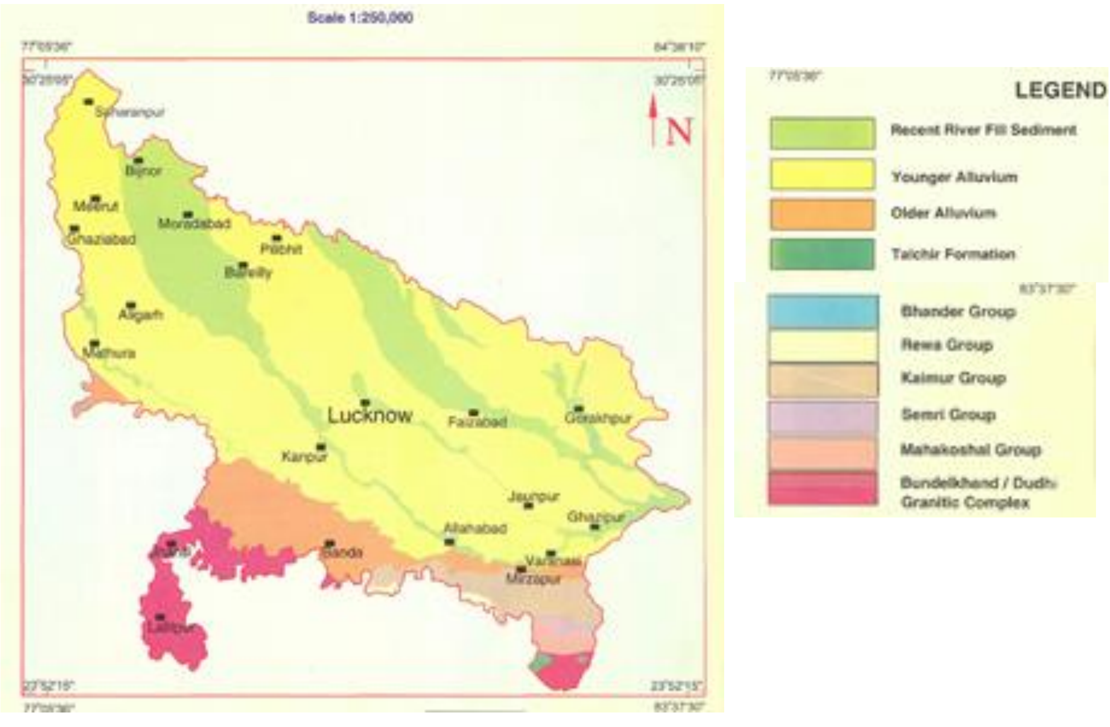
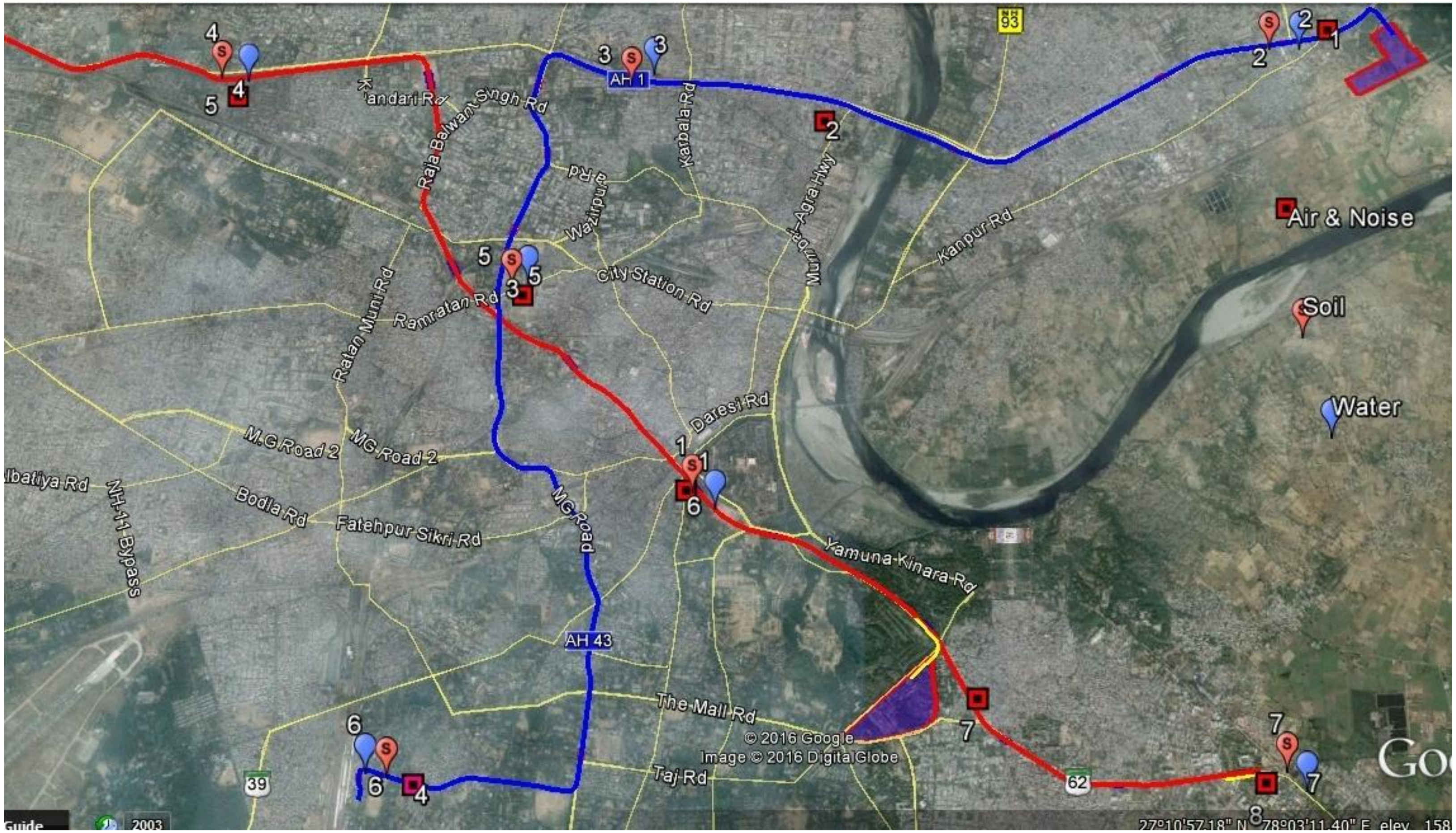


FIGURE 15.3: MONITORING LOCATION MAP FOR AIR, NOISE, WATER AND SOIL



Sampling Location - Soil & Water: 1) Near Agra Fort (Electric) office; 2) Near Hotel Trident; 3) St. John College; 4) Agra ISBT; 5) Agra Cantt. Railway Station; 6) TYC Phase-II; 7) Vijay Nagar

Air & Noise: 1)Near Agra Cant Railway Station 2) Near St. John's College 3) Near Kagarol Ki Sarai (Near Agra Fort) 4) Near Agra ISBT (Transport Colony) 5) Near Impeypur (Bansal Nagar) 6) Basai (Near Hotel Trident) 7) Near 100 foot road (Near Kuberpur) 8) Water Works near Langre Ki Chawki

TABLE 15.4: RESULTS OF LABORATORY ANALYSIS OF SOIL SAMPLE

S. No.	Parameter	Unit	Corridor - 1			Corridor - 2			
			Near Agra Fort	Agra ISBT	Near Hotel Trident	St. John College	Trance Yamuna Colony Phase-II	Vijay Nagar	Agra Cantt Rly Stn
1	pH (at 25^0C)	-	7.81	8.00	8.30	7.92	8.21	8.35	8.19
2	Electrical Conductivity (EC)	mS/cm	0.18	0.21	0.38	0.22	0.24	0.23	0.32
3	Chloride	Mg/kg	478.58	708.29	804.01	861.44	430.72	469.00	363.72
4	Available Nitrogen	Kg/hec	12.10	15.77	15.16	16.33	101.10	14.30	13.56
5	Total Zinc as Zn	mg/kg	87.43	78.16	84.14	81.65	81.41	84.10	71.86
6	Manganese as Mn	mg/kg	516.14	519.15	577.18	578.14	488.14	542.16	482.10
7	Total Lead as Pb	mg/kg	15.74	14.12	15.06	13.44	12.14	13.10	11.46
8	Total Copper as Cu	mg/kg	22.4	24.66	23.88	26.32	19.14	23.14	20.18
9	Organic Carbon	%	0.38	0.39	0.44	0.48	0.42	0.44	0.50
10	Water soluble Sulphate	mg/kg	60.55	61.23	53.14	57.46	46.14	54.18	48.62
11	Boron	mg/kg	0.61	0.71	0.52	0.63	0.48	0.54	0.43
12	Iron	mg/kg	101.10	81.32	64.12	76.18	82.16	78.14	62.14
13	Nickel	mg/kg	21.41	17.40	14.23	16.01	18.14	19.10	12.58
14	Bicarbonate (HCO_3)	mg/kg	4.50	4.45	4.31	4.08	3.76	4.10	3.65
15	Calcium as Ca	mg/kg	2084.96	842.16	1700.67	1913.26	147.17	1144.68	163.53
16	Magnesium as Mg	mg/kg	57.05	133.95	64.50	119.07	54.57	153.80	69.46
17	Sand	%	28.20	30.10	33.20	31.60	32.10	35.10	34.20
18	Silt	%	42.30	45.10	45.20	47.20	43.20	41.30	44.30
19	Clay	%	29.50	24.80	21.60	21.20	24.70	23.60	21.50
20	Sodium as Na	mg/kg	228.0	508.00	563.00	200.00	369.00	515.00	310.20
21	Potassium as K	kg/hec	518.20	387.52	320.32	618.20	302.40	176.90	565.31
22	Nitrogen	Kg/hec	203.67	223.14	234.14	233.10	184.15	211.41	207.41
23	Sulphur	mg/kg	24.15	26.18	22.14	28.14	21.14	23.41	20.14
24	Phosphate	mg/kg	102.10	103.18	82.14	110.14	92.00	98.14	88.22
25	Organic Matter	%	0.66	0.67	0.76	0.83	0.72	0.76	0.86
26	Orthophosphate	mg/kg	105.0	106.27	84.60	113.44	94.76	101.08	91.32
27	Carbonate	mg/kg	4.51	4.66	4.66	5.21	3.67	4.23	4.08
28	Arsenic	mg/kg	BDL	BDL	BDL	BDL	BDL	BDL	BDL

S. No.	Parameter	Unit	Corridor - 1			Corridor - 2			
			Near Agra Fort	Agra ISBT	Near Hotel Trident	St. John College	Trance Yamuna Colony Phase-II	Vijay Nagar	Agra Cantt Rly Stn
29	Mercury	mg/kg	BDL	BDL	BDL	BDL	BDL	BDL	BDL
30	Cadmium as Cd	mg/kg	26.30	20.45	15.10	17.46	21.16	19.88	14.12
31	Molybdenum	mg/kg	0.14	0.16	0.18	0.21	0.09	0.10	0.08

FIGURE 15.4: SOIL MAP OF AGRA DISTRICT

Alluvial plain (0-1% slope): 1. Deep, loamy soils and slightly eroded, 2.Deep, fine soils moderately saline and sodic associated with loamy soils, slightly eroded, 3. Deep, fine soils and slightly eroded associated with loamy soils slightly saline and moderately sodic, 4. Deep, silty soils associated with loamy soils slightly eroded, 5. Deep, silty soils and slightly eroded associated with fine soils

Ravinous land (3-5% slope): 6. Deep, loamy soils and severely eroded, 7. Deep, loamy soils, very severely eroded associated with silty soils, very severely eroded

Dissected uplands (3-5% slope): 8. Deep, loamy soils and moderately eroded associated with loamy soils, slightly eroded **Undulating Lands with hillocks (1-3% slope):** 9. Deep, loamy soils with moderate erosion associated with sandy soils with moderate erosion

Gentle to very gentle sloping lands with monad nocks:

10. Deep, loamy soils and slightly eroded associated with loamy skeletal soils, severely eroded, 11. Deep, loamy soils, moderately eroded, 12. Deep, loamy soils and slightly eroded associated with silty soils, slightly saline and moderately sodic, 13. Deep, loamy soils and slightly eroded associated with loamy soils, moderately eroded

Source: NBSS & LUP, Regional Centre Delhi

Land-use: Existing land use for the Agra Development Area is given in **Table 15.5**.The residential area having majority i.e. more than 60% of total area than the community facility and Traffic and Transportation.

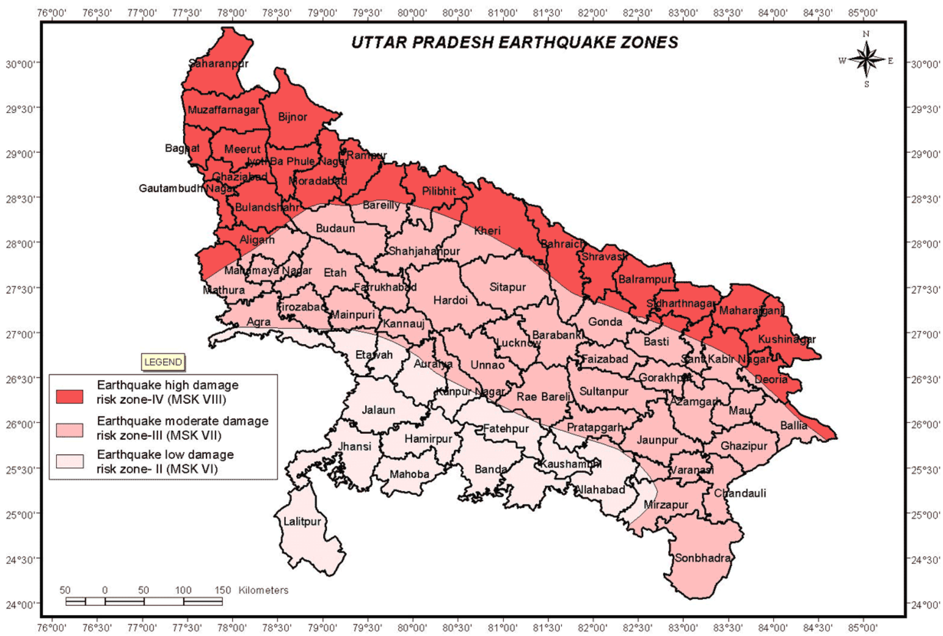
TABLE 15.5: EXISTING LAND USE OF AGRA DEVELOPMENT AREA 2001

Land use class	Area	Percentage (%)
Residential	4886.34	61.84
Commercial	148.74	1.88
Wholesale Commercial	58.88	0.75
Industrial	542.72	6.87
Community facility	842.62	10.66
Office	177.93	2.25
Traffic & Transportation	858.65	10.87
Crenulations / Burial ground	31.25	0.4
Park Place Ground	105.22	1.33
Historical Monument	116.48	1.47
Nursery	24.09	0.3
Gardens	69.12	0.87
Sewage Farms	38.35	0.49
Total	7901.39	100
Other Agricultural, forest, settlement, rivers, open spaces etc	4411	
Total	**52020.63**	

Source: Agra Master Plan – 2021

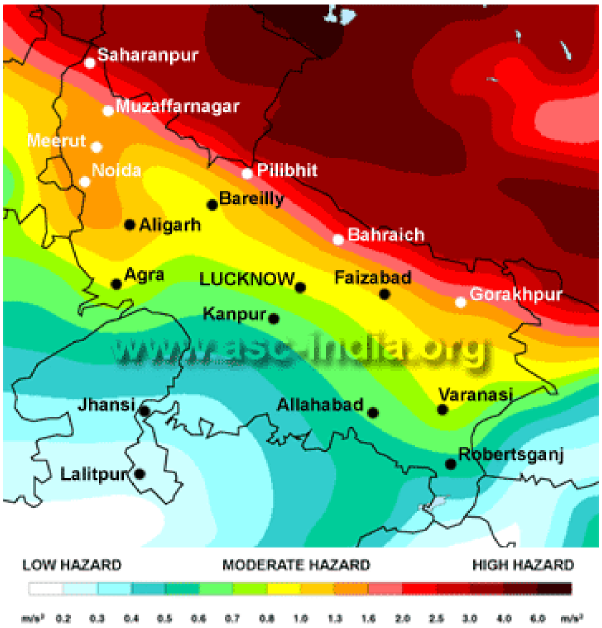
Seismicity: In the seismic zoning map of India prepared by Bureau of Indian Standards (BIS) the area of Agra and its neighborhood lies in Zone III as shown in **Figure 15.5**.

FIGURE 15.5: SEISMIC ZONING MAP OF UTTAR PRADESH



According to Global Seismic Hazard Assessment Program (GSHAP) data, the state of Uttar Pradesh falls in a region of moderate to high seismic hazard as shown in **Figure 15.6**.

FIGURE 15.6: SEISMIC HAZARD MAP OF UTTAR PRADESH



Source: Amateur Seismic Centre, Pune

Agra falls in moderate to least active seismic zone and corresponds to MSK intensity VII, making it prone to Earthquakes. The existence of the Great Boundary Fault near Jalesar, dense urban population and weak structures in old Agra city make it highly vulnerable to seismic hazards. Although no major earthquake has occurred in Agra in recent years, yet tremors have been felt whenever there is an earthquake in the NCR. One of the most powerful earthquakes in Uttar Pradesh struck the districts of western Uttar Pradesh at 21:01 IST on October 10th, 1956. The massive shock was centered near Jehangirpur, in Bulandshahr District. No fatalities were reported. The shock was also strongly felt at Delhi, where there was some minor damage.

15.1.3. Water Environment

Water environment consists of water resources and its quality. Its study is important from the point of view to assess the sufficiency of water resources for the needs of in its various stages of the project cycle and also to assess the impact of the project activities on water environment.

Hydro-geological Characteristics: Groundwater occurs under unconfined to semi-confined conditions. Depth to water level varies from 17 to 23 m below ground level (bgl) but in the topographic lows and in the vicinity of Agra canal and Yamuna, water table is within depth of 10 mbgl. The water level data show a declining trend. The regional water table data shows that the ground water movement in general is from west to east on the right bank and east to west on the left bank. The local topography plays an important role in controlling the ground water movement in the area. Some of the portion of the corridors like Jama Masjid to Tajmahal for Corridor -1 and Kamla Nagar to Foundary Nagar for Corridor – 2 is falling near Yamuna River where ground water level is about 10mbgl.

Water Resources: The source of water supply in the city is mainly surface water. The river Yamuna is the onlysurface water source, which enters the town from northeast corner, flow towards south of thecity for some distance and then turns towards left. The Jal Nigam has also installed Hand-pumps to supplement the required water supply. The urban water supply is a perpetual problem in this saline tract, where fresh water is available only in patches. According to the Agra JalSansthan (AJS), the total water demand of the city is 320 million litres per day (MLD), which includes the demand for bulk supply, estimated at 75 MLD in the year 2006. The water demand as estimated for the 1.42 million-population in 2005 was 245 MLD, which was calculated on a 170 litres per capita daily (lpcd) standard. For this, the city has two water treatment plants with a capacity to treat 410 MLD in entirety. The forecasted water demand for 2016 is 402 MLD.

Drainage: River Yamuna forms the major drainage of the city and it flows from North to South-East of the city. The overall drainage is controlled by the Yamuna River. The drainage system of Agra was laid about 55 years back and drains are in bad condition. The system comprises hierarchy of natural and man-made drains that ultimately discharge surface run off and sewage to River Yamuna because at most part of the city there is no sewerage system. Natural nalhas are the main carriers of the storm water. These drains were formerly natural water drainage. Now they serve as sewage disposal drains.

Water Quality: Water quality includes the physical, chemical and biological characteristics of water. An understanding of the various factors influencing water quality is thus very important as human health is largely dependent on the quality of water available for use.

In order to assess the baseline water quality status of the study area, 7 samples along both the corridors were collected in the project area. The sample locations from which water sample were collected are shown in **Figure 15.2** and description of water sample locations are given in **Table 15.6**. The samples were analyzed for physical and chemical constituents for the purpose of domestic and irrigation use. The results of water analysis are compared with CPHEEO manual for Drinking Water Specifications and IS 10500-2012. The results of analysis are presented in **Table 15.7**.

TABLE 15.6: DESCRIPTION OF WATER QUALITY MONITORING LOCATIONS

S. No.	Location No.	Location	Environmental Setting
Corridor - 1			
1	Loc-1	Near Agra Fort (Electric) office	Bore well
2	Loc-4	Agra ISBT	Bore well
3	Loc-7	Near Hotel Trident	Hand pump
Corridor - 2			
4	Loc-2	TYC Phase-II	Hand pump
5	Loc-3	Vijay Nagar	Bore well
6	Loc-5	St. John College	Hand pump
7	Loc-6	Agra Cantt. Railway Station	Bore well

Corridor-1: SikandaratoTaj East Gate,
Corridor-2: Agra Cantt. Rly Station to Kalindi Vihar

TABLE 15.7: PHYSICO-CHEMICAL ANALYSIS OF WATER SAMPLES IN PROJECT AREA

S. No	Parameter	Units	Corridor – 1				Corridor - 2			Acceptable Limit/Permissible Limit
			Loc-1	Loc-4	Loc-5	Loc-7	Loc-2	Loc-3	Loc-6	
1	pH at $25^{O}C$	-	7.23	7.62	7.01	7.32	7.67	7.32	6.69	6.5-8.5/no relaxation
2	Turbidity	NTU	0	0	17.8	64.3	0	0	0	1/5 max
3	Total Dissolved Solids	mg/l	1708	1375	2280	1928	1264	2618	3896	500/2000 max
4	Aluminium as Al	mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.03/0.02 max
5	Free Amonia (as NH3)	mg/l	<1	<1	<1	<1	<1	<1	<1	-
6	Barium (as Ba)	mg/l	BDL	0.003	BDL	BDL	0.009	BDL	BDL	0.7 max/ no relaxation
7	Boran (as B)	mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.5/1
8	Calcium as Ca	mg/l	162	121.4	194.3	113.3	105.3	145.7	307.7	75/200
9	Chloride as Cl	mg/l	384.3	266.1	611	473	167.5	680	1202.3	250/1000
10	Copper as Cu	mg/l	BDL	BDL	0.016	0.006	BDL	BDL	BDL	0.05/1.5
11	Fluoride as F	mg/l	>1	>1	>1	>1	>1	>1	>1	1.0/1.5
12	Iron as Fe	mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.3/ no relaxation
13	Magnesium (as Mg)	mg/l	29.5	59	128	123	5	132.8	226.3	30/100
14	Manganese as Mn	mg/l	0.024	BDL	0.03	0.09	BDL	BDL	BDL	0.1/0.3
15	Nitrate as NO3	mg/l	BDL	11.2	BDL	BDL	1.1	17.7	2.2	45/ no relaxation
16	Phenolic Compounds	mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.001/0.002
17	Seleniem (as Se)	mg/l	BDL	0.003	0.099	BDL	BDL	0.004	BDL	0.01/ no relaxation
18	Silver (as Ag)	mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.01/ no relaxation
19	Sulphate as SO4	mg/l	62.4	95.2	73.1	66.5	59.1	155.2	152	200/400
20	Sulphide (as S)	mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.05/ no relaxation
21	Total Alkalinity as CaCO3	mg/l	484.8	636.3	899	666.6	495	444.4	565.6	200/600
22	Total Hardness as CaCO3	mg/l	525.2	545.4	1010	787.8	282.8	909	1696.8	200/600
23	Zinc as Zn	mg/l	BDL	BDL	BDL	0.07	BDL	BDL	BDL	5/15
24	Cadmium (as Cd)	mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.003/ no relaxation
25	Cynide (as CN)	mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.05/ no relaxation
26	Lead as Pb	mg/l	BDL	0.003	BDL	0.003	BDL	BDL	BDL	0.050.01/ no relaxation
27	Mercury (as Hg)	mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.001/ no relaxation
28	Nickel	mg/l	BDL	BDL	BDL	0.005	BDL	BDL	BDL	0.02/ no relaxation
29	Arsenic as As	mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.01/0.05
30	Total Chromium (as Cr)	mg/l	BDL	0.008	BDL	BDL	BDL	0.013	BDL	0.05 max/no relaxation
31	Total Suspended Solids	mg/l	0	0	78	25	0	0	0	-

S. No	Parameter	Units	Corridor – 1				Corridor - 2			Acceptable Limit/Permissible Limit
			Loc-1	Loc-4	Loc-5	Loc-7	Loc-2	Loc-3	Loc-6	
32	Vanadium (as V)	mg/l	BDL	0.0024	BDL	BDL	BDL	BDL	BDL	-
33	Amonical Nitrogen (as N)	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.5/No relaxation
34	Total Kjeldahl Nitrogen (as N)	mg/l	<0.1	2.66	<0.1	<0.1	0.38	6.5	0.64	-
35	Chromium (as Hexavalent Cromium)	mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	-
36	Oil and Grease	mg/l	0	0	0	0	0	0	0	-
37	Dissolved Oxygen		7	4.2	6.2	6.6	7.1	6.8	5.4	-
38	Chemical Oxygen Demand	mg/l	0	12.4	16.5	0	0	3.8	20.6	-
39	Biochemical Oxygen Demand (3 day 27 deg C)	mg/l	Nil	5	7	Nil	Nil	2	6	-
40	Total Phosphate as P	mg/l	BDL	0.69	BDL	BDL	0.57	0.4	0.78	-
41	Dissolved Phosphate (as P)	mg/l	BDL	0.6	BDL	BDL	0.5	0.4	0.70	
42	Sodium as Na	mg/l	230	285	380	335	310	555	580	-
43	Potassium as K	mg/l	160	9	10.5	160	9.5	11	14	-
44	Nitrate Nitrogen	mg/l	BDL	2.53	BDL	BDL	0.25	4.2	0.5	-
45	Total Nitrogen	mg/l	<0.1	2.66	<0.1	<0.1	0.38	6.5	0.64	-
46	Organic Phosphorus	mg/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.002 max
47	Coliform Count	MPN/100 ml	Absent	Present	Absent	Absent	Present	Present	Present	Absent
48	Fecal Coliform	MPN/100 ml	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
50	Total Coliform Organism	MPN/100 ml	Absent	Present	Absent	Absent	Absent	Present	Absent	Absent

(Acceptable Limit/Permissible Limits as per IS 10500-2012)

The results of analysis of water samples indicates that most of the parameters are within the permissible limit except Turbidity at location 5 & 7, TDS at location 3, 5 & 6, Calcium and Chloride at location 6, Magnesium at location 3, 5, 6 & 7, Total Alkalinity at location 4, 5 & 7, Total Hardness at location 3, 5, 6 & 7, COD at 3, 4, 5 & 6, BOD at location 3, 4, 5 & 6 and Coliform 2, 3, 4 & 6. Water from these sources should be treated before using it for drinking purposes. Bacteriological contamination may be due to existing sewer/drains flowing adjacent to the source.

15.1.4. Meteorology and Air Environment

Meteorology is an important parameter in environmental impact assessment study. It is responsible for the movement of air and air pollutants. Meteorological data like mean rainfall and maximum & minimum temperature of the district for a period of 1901 to 2000 and of other parameters relative humidity, wind speed and cloud for a period of 1971 to 2000 are given in **Table 15.8**. It is depicted from the table that temperature of the district varies from 22.3^{O}C - 41.7^{O}C in summer to a minimum of around 8.2^{O}C – 28.8^{O}C in winter and Relative humidity varies from 37% to 78%.

TABLE 15.8: METEOROLOGICAL DATA

Month	Mean Temperature (Deg. Cent)		Mean Rainfall (mm)	Relative Humidity (%)	Wind Speed (Kmph)	Cloud (octas)
	Max	Min				
January	22.3	7.7	13.2	69.53	2.75	1.93
February	25.5	10.3	17.6	60.02	4.26	1.94
March	31.9	15.5	9.3	48.99	5.43	1.87
April	37.9	21.5	6.3	37.78	6.76	1.64
May	41.7	26.5	11.3	37.84	7.95	1.54
June	40.7	28.9	55.7	61.64	8.16	2.85
July	35.3	26.8	203.3	72.7	7.52	5.33
August	33.2	25.7	243.2	78.59	6.24	5.31
September	34	24.3	129.7	70.18	5.22	3.04
October	34	19.1	24.8	59.45	2.52	1.05
November	29.2	12.5	4.3	62.23	1.34	0.89
December	23.9	8.2	6.1	69.67	1.55	1.52

Source: Indian Meteorological Department, Pune (National Data Centre, Pune)

The latest rainfall data for the year 2009-2013 is given in **Table 15.9** which depicts the highest rainfall i.e. 281.3 mm in the month of August 2012. August month is generally having highest rainfall in the area.

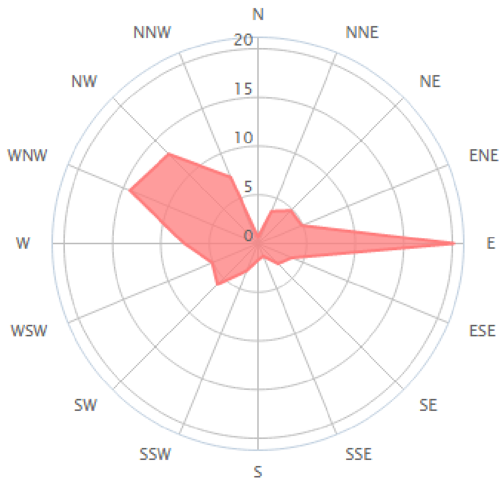
The wind rose diagram has been prepared based on the daily data for the period of 09/2011 to 05/2015. The prominent direction is East, North West and West North West. Wind rose diagram for the Agra is shown in **Figure 15.7.**

TABLE 15.9: AVERAGE RAINFALL (MM)

Month/Year	Rainfall (mm)				
	2009	2010	2011	2012	2013
January	0	1.3	0	23.4	10.5
February	0	8.6	16.9	1.1	27.3
March	0	0	3	0	2.3
April	1.6	0	2.7	5.4	0.5
May	38	0	14.3	0.7	3.2
June	16.8	13.5	86.9	5.7	70.6
July	74.1	98.2	110.5	184.8	163.1
August	76.7	119.7	116.6	281.3	269.1
September	84.4	146.7	66.4	90.2	76
October	62.6	1.5	0	0.6	83.2
November	14.8	27.8	0	0	0.2
December	2	1.7	0	0	5

Source: Indian Meteorological Centre, Delhi

FIGURE 15.7: WIND ROSE DIAGRAM



Air Quality: Eight monitoring stations selected at strategic locations along both the corridors. The monitoring result for ambient air quality is presented in **Table 15.10.** The monitoring stations were selected to generate the representative samples for air quality covering residential, institutional and industrial area along the corridors. Locations map for air monitoring stations are shown in **Figure 15.2**. The monitoring was done from 08.06.2015 (9 am) to 12.06.2015 (9 am).

The National Ambient Air Quality Standard (NAAQ) laid down by Ministry of Environment, Forest &Climate Change (MoEFCC) on 16thNovember 2009 has been given in **Table 15.11**. The result of air quality monitoring compared with National Ambient Air Quality Standard and found that particulate matter (PM_{10} &$PM_{2.5}$) is exceeding the permissible limit in residential areas at all monitoring locations except PM_{10} at location 8. Whereas other parameters like SO_2, NO_2, O_3, Pb, NH_3, CO and HC are within permissible limit except CO at locations 4, 7 & 8 are exceeding permissible limit.

TABLE 15.10: AIR QUALITY RESULT

SN	Parameters	Unit	Concentration of Pollution							
			Corridor - 1				Corridor – 2			
			3	4	5	6	1	2	7	8
1	Sulphur Dioxide (SO_2)	µg/m^3	BDL	11.2	BDL	BDL	9.8	BDL	8.5	10.4
2	Nitrogen Dioxide (NO_2)	µg/m^3	17.1	26.6	13.6	16.3	19.4	15.3	20.3	24.6
3	Particulate matter (PM_{10})	µg/m^3	166	253	138	147	185	156	172	223
4	Particulate Matter ($PM_{2.5}$)	µg/m^3	96	126	72	84	98	84	93	116
5	Ozone (O_3)*	µg/m^3	29.4	43.8	25.4	27.5	31.5	28.6	30.4	37.3
6	Lead (Pb)	µg/m^3	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
7	Carbon Monoxide (CO)*	mg/m^3	1.7	2.3	1.4	1.2	1.9	1.5	1.6	2.2
8	Ammonia (NH_3)	µg/m^3	22.3	18.9	16.3	12.8	14.6	12.4	15.2	14.1
9	Hydrocarbon	µg/m^3	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL

BDL- Below Detection Limit; BDL for Pb< 0.2 µg/m^3, Hydrocarbon < 5 mg/m^3

**Total monitoring period 8 hours*

1)Near Agra Cant Railway Station 2) Near St. John's College 3) Near Kagarol Ki Sarai (Near Agra Fort) 4) Near Agra ISBT (Transport Colony) 5) Near Impeypur (Bansal Nagar) 6) Basai (Near Hotel Trident) 7) Near 100 foot road (Near Kuberpur) 8) Water Works near Langre Ki Chawki

TABLE 15.11: NATIONAL AMBIENT AIR QUALITY STANDARDS

Pollutant	Time	Concentration	
		Industrial, Residential, Rural & other Area	Ecological Sensitive area
Sulphur Dioxide (SO_2) in µg/m3	Annual	50	80
	24 Hours	80	80
Oxides of Nitrogen (NOx) in µg/m3	Annual	40	30
	24 Hours	80	80
Particulate Matter size less than 10µm (PM_{10}) in µg/m3	Annual	60	60
	24 Hours	100	100
Particular Matter size less than 2.5µm ($PM_{2.5}$) in µg/m^3	Annual	40	40
	24 Hours	60	60
Carbon Monoxide (CO) in mg/m3	8 Hours	02	02
	1 Hour	04	04
Ozone (O_3) in µg/m^3	8 Hours	100	100
	1 Hour	180	180
Lead (Pb) µg/m^3	Annual	0.50	0.50
	24 Hours	1.0	1.0
Ammonia (NH_3)µg/m^3	Annual	100	100
	24 Hours	400	400

Source: CPCB guidelines for AAQM

15.1.5. Noise Environment

The hourly noise monitoring was carried out for 24 hours on 08.06.2015 (9 am) to 12.06.2015 (9 am) at eight locations along the proposed metro corridors. The result was analysed to evaluate Leq, L_{10}, L_{50}, L_{90}, L_{day}, L_{night}, L_{DN}, L_{MAX} and L_{MIN} which are depicted in **Table 15.12**. The Ambient Noise Quality criteria laid down by CPCB has been given in **Table 15.13**. The noise level monitoring results are exceeding the permissible limit specified for residential area.

TABLE 15.12: AMBIENT NOISE LEVEL MONITORING RESULT

S.No.	Monitoring Location	Leq	L_{10}	L_{50}	L_{90}	L_{max}	L_{min}	L_{day}	L_{night}	L_{DN}
Corridor - 1										
1	Near Kagarol Ki Sarai (Near Agra Fort)	65.2	73.3	68.0	65.7	84.9	48.1	66.7	58.7	67.5
2	Near Agra ISBT (Transport Colony)	69.3	78.0	72.1	69.7	103.5	49.6	70.9	59.4	70.4
3	Near Impeypur (Bansal Nagar)	57.7	66.4	60.5	58.1	91.9	38.0	59.3	47.3	58.7
4	Basai (Near Hotel Trident)	59.8	68.5	62.7	60.3	94.1	39.0	61.5	48.4	60.7
Corridor - 2										
5	Near Agra Cant Railway Station	68.2	77.4	71.2	68.6	91.3	45.0	69.3	64.2	71.6
6	Near St. John's College	59.1	66.6	61.9	59.6	89.2	42.0	60.2	55.7	62.9
7	Near 100 foot road (Near Kuberpur)	66.1	74.5	68.9	66.6	94.9	46.1	67.8	54.6	66.9
8	Water Works near Langre Ki Chawki	67.6	75.9	70.4	68.0	96.2	45.3	69.0	61.3	69.9

TABLE 15.13: AMBIENT NOISE STANDARDS CRITERIA

Area Code	Category of Area	Limits in dB (A) Leq	
		Day time*	Night time
A	Industrial area	75	70
B	Commercial area	65	55
C	Residential area	55	45
D	Silence Zone**	50	40

Source: *CPCB guideline (as per The Noise Pollution (Regulation and Control) Rules, 2000)*

**** Day time is from 6.00 AM to 9.00 PM, **Silence Zone is defined as an area up to 100m around premises of Hospitals, Educational Institutions and Courts.***

15.1.6. Ecology

No rare or endangered species are known in this section of river Yamuna: the nearest access point to riverine National Chambal sanctuary is about 50km from Agra. Babarpur Reserved Forest is about 1.5 km and Soor Sarovar Bird Sanctuary about 9 km away from the proposed Sikandara Metro Station of Corridor-I. Soor Sarovar Bird Sanctuary comprises of fresh water wetland, popularly known as Keetham jheel. Unique for scenic beauty, religion-cultural heritage and rich assembling of fauna and flora. It is an important birding destination for ornithologists. The predominant tree species along the corridors are Bargad, Cassia, Champa, Gulmohar, Karanj, Neelgiri, Neem, Pakad, Peepal, Sagwan, Seijan, Arjun, Jamun, Mango, Khajur, Babul, Gularand Sheesam etc.The predominant shrub species observed in the study area is *ProsopisJulifera*. Site construction activities will results in loss of trees about 2729. An inventory of trees in the two corridors and two depots likely to be lost has been prepared and summarized in the **Table 15.14**. Estimated cost of compensatory afforestation is included in the EMP.

TABLE 15.14: SUMMARY OF TREE INVENTORY

S. No	Description	Number of Trees
Corridor-I (Sikandara – Taj East Gate)		
1	Alignment	784
2	PAC Depot	1226
	Sub-Total	**2010**
Corridor-II (Agra Cantt. – KalindiVihar)		
3	Alignment	565
4	Kalindi Vihar Depot	154
	Sub-Total	**719**
	Total	**2729**

Common birds observed in the project area are pigeons, parrot, crows, and doves. The Saras Crane was observed near Kalindi Vihar Depot. On consultation with the local people in the vicinity of the project area, it is learnt that peacocks and swift are frequently observed at lush green vegetation of Shahjahan Park. The predominant mammals observed in the project area are mongoose, bat, monitor lizard, monkey, languor and mice etc.

15.1.7. Archaeological Sites

There are about 67archaeological monuments protected by Archaeological Survey of India (ASI) in Agra Circle including two world heritage sites i.e. Taj Mahal and Agra Fort. These monuments are as per Archaeological Survey of India (ASI) under the provision of Ancient Monument and Archaeological Sites and Remains (Amendments and Validation) Act, 2010 (AMASR).The Act specifies the prohibited area of 100 m from site whereas regulated area is 200m from the limit of prohibited area. No construction is allowed in prohibited area while construction can be taken up in regulated area after getting the approval from the Archaeological Survey of India(ASI).There are 2 monuments along Corridor-1 and 2 monuments along Corridor-2 are coming under prohibited area of ASI as listed in **Table 15.15**.

TABLE 15.15: ASI SITES/MONUMENTS ALONG THE CORRIDORS

S No	Name of Monument or Site	Distance from boundary (M)
Corridor-1		
1	Akbar’s Tomb, Sikandara	305
2	PatharKaGhoda	20
3	Guru Ka Tal	12.5
4	Tomb of Salamat Khan	160
5	Sadiq Khan Tomb	160
6	Delhi Gate	140
7	Jama Masjid	170
8	Agra Fort	103
9	Taj Mahal	505
Corridor-2		
10	Delhi Gate	355
11	Roman Catholic Cemetery	14
12	Lal Masjid (Jafar Khan’s Masjid)	65
13	Ram Bagh	105

15.1.8. Depot

Two depots are proposed for the Agra metro. One depot is at PAC land, Mall Road Agra has been proposed having 16.3 hectare land and another depot near Kalindi Vihar along NH 2 having 11.9 hectare land. PAC Depot is in between Taj Road and Fatehabad Road as shown in **Figure 15.8**. Depot site at Kalindi Vihar is near NH 2 is mostly vacant land/agriculture land as shown in **Figure 15.9**.

FIGURE 15.8: PROPOSED PAC DEPOT FOR CORRIDOR-1

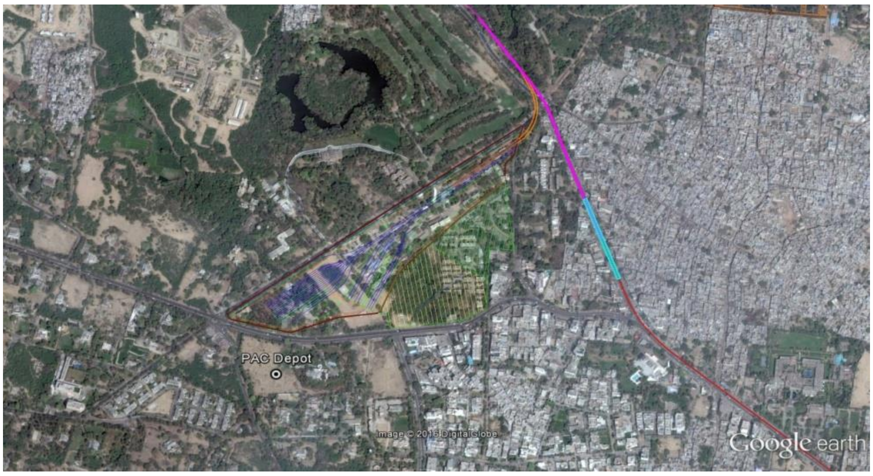
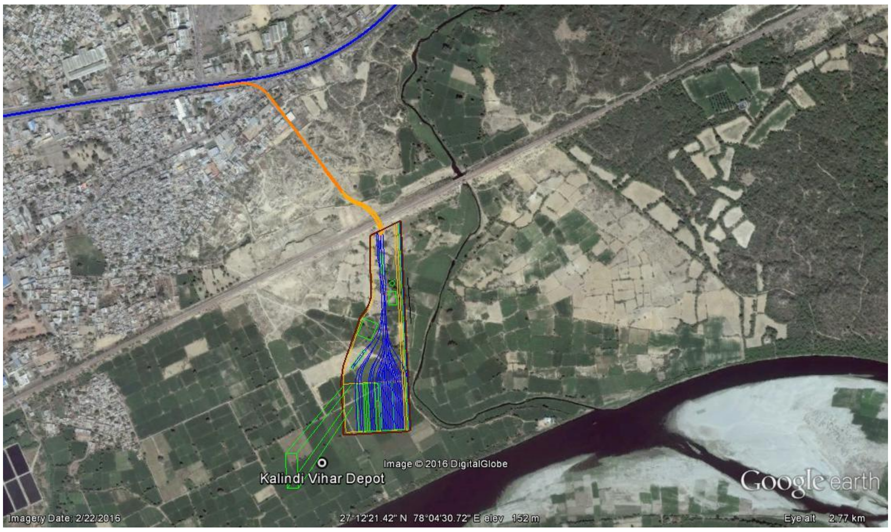


FIGURE 15.9: PROPOSED KALINDI VIHAR DEPOT FOR CORRIDOR-2



15.2. ENVIRONMENTAL NORMS AND REGULATIONS

The following legislative Acts and standards have been referred:

- 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)
- National Ambient Air Quality Standards 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 Trans-boundary 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 ENVIRONMENT IMPACT ASSESSMENT

15.3.1. Positive Environmental Impacts

Based on project particulars and existing environmental conditions, positive potential impacts have been identified that are likely to result from the proposed metro project and where feasible within the scope of this Report these are quantified. The positive environmental impacts are listed below:

- Employment Opportunities
- Benefits to Economy
- Traffic Congestion Reduction, Quick Service and Safety
- Traffic Noise Reduction
- Reduction of Traffic on Road
- Less Fuel consumption
- Reduced Air pollution

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. In post-construction phase, about 980 people will be employed for operation and maintenance of the system. Thus, the project would provide substantial direct employment equal to the above number. In addition to these, more people would be indirectly employed for allied activities.

2. Benefits to Economy

The project will streamline and facilitate movement of public from different parts of Agra. These corridors will yield saving due to reduction in road traffic and reduction in number of buses, usage of private vehicles. Reduction in fuel consumption, vehicle operating cost and travel time of passengers was observed. With the development of the 2 corridors of Agra Metro project, it is likely that more people will be involved in trade, commerce and allied services.

3. Traffic Congestion Reduction, Quick Service and Safety

With the implementation 2 corridors of Metro, travel time of passengers travelling by other modes of vehicles in the absence of Metro will got 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. The reduced vehicles on road in turn will reduce accidents and increase safety of persons.

4. Traffic Noise Reduction

Reduction in traffic volume affects the noise levels. A 50% reduction of the traffic volume may result 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. An introduction of Agra Metro Rail substantially reduces the vehicular traffic which ultimately reduces noise level.

5. Reduction of Traffic on Road

The basis of reduction of vehicle is shift of ridership from road vehicle to the proposed system. The reduction in number of vehicles gives benefits to economy by reduction in Vehicle Operating Cost (VOC), Fuel Consumption, Pollution Load, Accidents and Travel Time etc. On implementation of the project, the consumption of petrol, diesel and CNG will get reduced. The estimated numbers of vehicle trips that will be reduced due to construction of Agra Metro are given in **Table 15.16**.

TABLE 15.16: VEHICLE KM SAVED PER DAY

Mode	Daily Vehicle Km Reduced due to MRTS			
	2024	2031	2041	2051
Car	29369	36031	45016	56240
2-Wheeler	468645	625663	742389	927495
Auto Rickshaw	7904	15120	16752	20929
Bus	175923	222009	283827	354597

6. Less Fuel Consumption

Based on number of vehicle kilometre reduction, reduction in fuel (diesel and petrol) consumption is reported in **Table 15.17**. The saving of Diesel and Petrol will directly benefit the country in monetary terms. Net saving on fuel expenditure at current price level is given in **Table 15.18**.

TABLE 15.17: FUEL SAVED PER YEAR

Year	Diesel (Lakh liters)	Petrol (Lakh liters)	CNG (Lakh Kg)
2024	1.5	23.5	129.6
2031	1.9	31	164
2041	2.3	37	209.4
2051	2.9	46.2	261.6

TABLE 15.18: SAVING IN FUEL EXPENDITURE PER YEAR (RS. Lakh)

Fuel	2024	2031	2041	2051
Diesel	80	100	120	150
Petrol	1670	2200	2630	3280
CNG	2330	2950	3770	4710
Total	**4080**	**5250**	**6520**	**8150**

7. **Reduced Air Pollution**

Compared to other modes of transport, the metro is least polluting and can be classified as an environment friendly technology since no air emissions are involved in running and operating the metro trains. 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 present corridors are presented in **Table 15.19**.

TABLE 15.19: POLLUTION REDUCTION (TONS/YEAR)

Pollutant	2024	2031	2041	2051
Carbon Monoxide (CO)	428	555	686	857
Hydro-Carbons (HC)	304	389	489	611
Nitrogen Oxide (NOx)	468	596	754	942
Particulate Matter (PM)	6	8	10	13
Carbon Dioxide (CO2)	56389	71482	90893	113556

Cost of Human Health saving from lifecycle emissions of $PM_{2.5}$ and cost of carbon capture from lifecycle emissions of GHG caused by gasoline and diesel is worked out (Climate change and health costs of air emissions from bio-fuels and gasoline, Jason Hill et al, PNAS, 2008) at rate of Rs 5.82 per litre and Rs.6.42 per litre in **Table 15.20** for period up to year 2051.

TABLE 15.20: 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 savings from lifecycle emissions of GHG
2024	1.5	23.5	25	145.4	160.4
2031	1.9	31	32.9	191.2	210.9
2041	2.3	37	39.3	229	252.9
2051	2.9	46.2	49.2	286.1	315.6

15.3.2. Negative Environmental Impacts

Based on project particulars and existing environmental conditions potential negative impacts likely to result from the proposed development are quantified. Negative impacts are listed under the following headings:

- Impacts due to Project Location
- Impacts due to Project Design
- Impacts due to Construction and
- Impacts due to Project Operation
- Impacts due to Depot

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 and
- Impact on Local Transport Facilities

a. 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 Agra Metro corridors.

b. 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 detail of which is given in the section on Civil Engineering.

c. Impact on/loss of wildlife/trees/forest
By virtue of being not listed in EIA Notification 2006, the project does not require Environmental Clearance under this Notification. In regard to the requirement (as per Order of Hon. Supreme Court) that activities in ESZ of Protected Areas require clearance of NBWL before EC is considered, MoEF has clarified vide letter dated 2 July 2012 that for projects which do not attract EIA Notification 2006, NBWL clearance for activities within ESZ is not require. The project does not require forest clearance as it does not involve diversion of forest land. However activities proposed in the project should be regulated as per ESZ norms. Vide letter dated 31 July 2013, MoEF&CC informed States that a default area of 10 km from the boundary will be the ESZ of such protected areas for which proposals identifying ESZs were not forwarded by the States to MoEF&CC.

In February 2011, Guidelines for declaration of environmentally sensitive zones (ESZ) around national parks and wildlife sanctuaries were issued by MoEF&CC in which the following were clarified: i) the purpose of declaring ESZ is to create shock absorber for the protected areas ii) the Guidelines of September 2000 (Report of the Committee on identifying parameters for designating ecologically sensitive areas in India, Pronab Sen, Sept 2000) were meant to identify specific units as sensitive zones and were not meant to serve the purpose of shock absorbers.

These Guidelines identified activities in ESZ in three groups: prohibited, regulated and permitted: activities relevant to the project are tabulated below. Activities involved in the project are regulated; discharge of effluents and solid waste in natural water bodies is prohibited.

TABLE 15.21: CLASSIFICATION OF ACTIVITIES IN ESZ AROUND NATIONAL PARKS AND WILDLIFE SANCTUARIES

S.No	Activity	Prohibited	Regulated	To be promoted
1	Setting up of industries** causing pollution	Yes	--	--
2	Use or production of hazardous substances	Yes	--	--
3	Discharge of effluents and solid waste in natural water bodies or terrestrial area	Yes	--	--
4	Felling of trees	---	Yes	---
5	Commercial ** use of natural water resources including ground water harvesting	---	Yes	---
6	Erection of electrical cables	---	Yes	---
7	Widening of roads	---	Yes	---
8	Movement of vehicular traffic at night	---	Yes	---
9	Air and vehicular pollution	---	Yes	---
10	Sign boards and hoardings	---	Yes	---
11	Underground cabling	---	---	Yes
12	Rain water harvesting	---	---	Yes
13	Renewable energy	---	---	Yes
14	Green technology for all activities	---	---	Yes

*** For purpose of this EIA Report, the spirit of the guidelines has been considered: ``industrial`` to mean polluting; ``commercial`` to mean large scale.*

There are approximately 2729 trees along the two corridors and the two depot sites. These trees are likely to be affected during construction. Trees are major assets in purifications of urban air, which by utilizing CO2 from atmosphere, release oxygen into the air. However, with removal of these trees, the process for CO2 conversion will get effected and the losses are reported below:

i. Total number of Trees : 2729
ii. Decrease in CO2 absorption due to loss of trees : 59,492 kg/year
iii. Decrease in Oxygen production due to tree loss : 1,33,721 kg/year

d. 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. Plans and cost of such diversions are covered in the section on Civil Engineering.

e. Impact on archaeological monuments

The proposed metro rail project will affect residential and commercial structures at some of the portion of alignment and metro stations where construction be made by cut and cover method. No Archeological Monuments are directly affected. Some of the Archeological Monuments are close to the proposed metro alignment as depicted in **Table 12.15**. Utmost care needs be taken so that no significant impact is anticipated on the historical structures due to project activities during construction and operation.

f. Impact on Local Transport Facilities

The metro rail has been proposed to cater the additional demand of present and future traffic requirement. Hence, no loss of job to the existing transport facilities is anticipated. The drivers of local transport facilities like buses, taxis, autos and rickshaws may be utilized to cater the requirement of transport from metro stations to work place and vice-versa. Additional employment opportunities are also anticipated due to the proposed metro.

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.

3. Impact Due to Project Construction

Although environmental hazards related to construction works are mostly of temporary nature, it does not mean that these should not be considered. 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
- Muck disposal and Debris Disposal
- Dust Generation and Air Pollution
- Increased water demand
- Impact due to labor camp
- Welfare of labor on site

- Safety of labor
- Impact due to Supply of Construction Material
- Impact due to construction near Archaeological Monuments
- Impact on Ground water and Surface water quality
- Noise and Vibration

a. Soil Erosion and Pollution

Minor incidence of soil erosion due to runoff from unprotected excavated areas may result especially when erodibility of soil is high.

b. Traffic Diversion 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. Traffic Diversion Plans are required in order to look for options and remedial measures so as to mitigate any traffic congestion situations arising out due to acquisition of road space during Metro construction of various corridors under Metro Rail Project network. Such plans and their cost form part of the section on Engineering. As part of pre-construction/construction activities building condition survey will have to be conducted cost of which is not included in EMP.

c. Muck Disposal

The metro route is both elevated and underground. The construction activity involves cut and cover, tunneling, excavation and fill. 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 3.68 Mm3 of soil. Out of this, about 1.10 Mm3 is likely to be reutilized in backfilling in underground stations and Depots. The balance 2.57 Mm3 shall be disposed off in environmental friendly manner. Disposal of excess soil should be permitted in low lying areas owned by ADA. The excess soil disposal site will be those identified by ADA and communicated to UPMRC. Identification of measures required at soil disposal sites and their indicative cost forms part of EMP.

Problems could arise from dumping of construction soils (concrete, bricks), waste materials (from contractor’s camp) etc. causing surface and ground water pollution. About 10% to 15% of the construction material such as waste material from contractor camps is left behind by the contractor as construction waste/spoils.

d. Dust Generation and Air Pollution

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 0.87 Mm3 of earth will be transported in trucks for backfilling in stations, depots and final disposal. The estimated truck movement required to transport the soil/earth will be about 48 trucks per day for the entire length of construction period. On an average a truck is anticipated to move about 20 km per trip for some quantity of muck used in depot site and stations as well as final disposal. Hence total distance travelled would be 960 km per day. The total dust emission/pollution would be 1.24 gm/km or 2.2 kg/day. The emission due to truck movement i.e. CO, HC, NOx and PM will be 2.69 kg/day, 0.74 kg/day, 4.8 kg/day and 0.1 kg/day respectively.

e. 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).

f. 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.

g. Welfare of Labor on construction site

Facilities such as shelter at workplace, canteen, first aid and day crèche are statutory requirement and essential to productivity.

h. Safety of Labor

Safety of labor during construction on elevated and underground sections is a statutory requirement and also has impact on progress of work.

i. Impact due to Supply of Construction Material

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.

j. Impact due to Construction near Archaeological Monuments

No archaeological monuments are directly affected. There are 2 Archaeological Monuments along the corridor-1 and 2 along the Corridor-2 are within prohibited area of 100 meters and 6monuments are passing within 200 meters of regulated area.

In underground section the tunnel will be constructed by State of Art Technology i.e. Tunnel Boring Machine (TBM) and stations will be constructed by Cut and Cover method which is widely accepted and the safest technique being adopted by metro in India and abroad.

k. 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. One major bridge is planned on the alignment on river Yamuna, proposed to be constructed with well foundation in lean season.

l. 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. Typical predicted noise levels for combination of dumper, excavator and pneumatic tools during construction are as follows: Leq of 93.3 dB (A) at 5m distance; Leq of 65.3 dB (A) at 100m distance.

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*).

4. Impacts Due to Project Operation

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

a. Noise and Vibration

During the operation phase the main source of noise will be from running of metro trains. Noise radiated from train operations and track structures generally constitute the major noise sources. 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. Noise prediction with average train speed of 25 km/hr and no noise barriers is presented **Table 15.22**. Impact of Vibration during Vibration is mentioned in **para (l) on page 15-26** under Impact due to Construction.

TABLE 15.22: NOISE LEVELS AT DIFFERENT DISTANCES DURING OPERATION

Distance (m)	Noise Level in dB (A)
10	84
20	78
30	74
40	71
50	70
60	68
70	67
80	65
90	64
100	64

It is assumed that train average speed is 25 km/hr, and no barrier is present. Due to reduction of vehicular traffic, the road traffic noise is expected to come down.

b. 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 15.23.**

TABLE 15.23: WATER REQUIREMENT

S. No.	Particular	Water Demand at Each Station (KLD)	Total Water Demand (KLD)
1	At Stations for Drinking Purpose	6.000	186
2	In Underground stations for AC, cleaning, chiller and other purposes with softening plant	85.000	680
3	In Elevated stations for AC, cleaning, chiller and other purposes	16.600	382
Total			**1248**

c. Traffic congestion

Upon operation of metro services passenger rush at stations will increase resulting in congestion around stations.

5. Impacts Due to Depot

In order to develop areas as depot, it will need filling by earth brought from outside. The earth from underground metro corridor tunnelling and cut and cover will be utilised to fill the deport site. The facilities will generate water and noise issues. Problems anticipated at depot sites are:

- Water supply
- Sewage and Effluent disposal
- Oil Pollution
- Noise Pollution
- Surface drainage
- Solid Waste
- Cutting of trees.

a. Water Supply

Water supply will be required for different purposes in the depot. As per the Indian Railway Work Manual, the water demand for train washing and other purposes (Departments, workshop and Contractor office) is 3600 liter per day in each case. The water demand at PAC depot would be 133 KLD and for Kalindi Vihar depot will be 155 KLD. This water will be collected through bore wells at each Depot after taking approval from competent authority. Hence, there will be no negative impact on the residents living in the vicinity of tube wells whose water demand is, in any case, met by municipal water.

b. Sewage and Effluent

About 107 KLD waste water will be generated at Depot at PAC land near Mall Road and 124 KLD at Kalindi Vihar Depot. Hence total waste water generation from both depots will be about 231 KLD, which will be treated at effluent treatment plant. The treated waste water will be tested for Inland Water Discharge Standard before release in to surface water body. The part of the water will be recycled to use at depot horticulture purpose. The domestic waste /sewage generated at the Depot will be collected at one suitable point inside the depot and will be treated at packaged type sewage treatment plant. From here it will discharge to the nearest manhole of existing sewerage system of the corporation for that necessary permission/ approvals from the AMC are required. There will be minimal impact due to wastewater from the Depot.

c. Oil Pollution
Oil spillage during change of lubricants, cleaning and repair processes in the maintenance Depot cum workshop for maintenance of rolling stock should be trapped in oil and grease traps and disposed off to authorised collectors, so as to avoid any underground/ surface water contamination.

d. 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.

e. Surface Drainage
In case of filling in low-lying area of depot sites, the surface drainage pattern may change.

f. Solid Waste
Solid waste will be generated from each of the Depot sites which will be taken by the cleaning contractor weekly and recycled/disposed of at ADA waste disposal sites.

g. Loss of Trees
About 1226 numbers of trees are observed at PAC Land Depot and about 154 trees at Kalindi Vihar Depot.

15.4. POSITIVE AND NEGATIVE ENVIRONMENTAL IMPACTS

15.4.1. Positive impacts

- Employment Opportunities
- Benefits to Economy
- Traffic Congestion Reduction, Quick Service and Safety
- Traffic Noise Reduction
- Reduction of Traffic on Road
- Less Fuel consumption and
- Reduced Air pollution

15.4.2. Negative impacts

1. Impacts due to Project Location

- 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 and
- Impact on Local Transport Facilities

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

3. Impact Due to Project Construction

- Soil erosion and pollution
- Traffic diversion and risk to existing buildings
- Muck disposal and Debris Disposal
- Dust Generation and Air Pollution
- Increased water demand
- Impact due to labour camp
- Welfare of labour on site
- Safety of labour
- Impact due to Supply of Construction Material
- Impact due to construction near Archaeological Monuments
- Impact on Ground water and Surface water quality
- Noise and Vibration

4. Impacts Due to Project Operation

- Noise and Vibration
- Water supply and sanitation at Stations
- Traffic congestion

5. Impacts Due to Depot

- Water supply
- Sewage and Effluent disposal
- Oil Pollution
- Noise
- Surface drainage
- Solid Waste
- Cutting of trees

15.5. ENVIRONMENTAL MANAGEMENT PLAN

Environmental Management Plan is presented in two sections:

- Mitigation measures and
- Enhancement measures

15.5.1. Mitigation Measures

i. Compensatory Afforestation
ii. Construction Material Management
iii. Safety Management Measures
iv. Labour Camp
v. Welfare of labour

vi. Safety of labour
vii. Energy Management
viii. Hazardous Waste Management
ix. Water Pollution Management
x. Environmental Sanitation
xi. Utility Plan
xii. Protection of Archaeological Monuments
xiii. Air Pollution Control Measures
xiv. Noise Control Measures
xv. Vibration Control Measures
xvi. Traffic Diversion/Management
xvii. Soil Erosion Control
xviii. Muck Disposal
xix. Construction and Demolition Waste Management
xx. Draining of Water from Tunnel
xxi. Water Supply, Sanitation and Solid Waste management
xxii. Management Plan for Depot
xxiii. Training
xxiv. Environment Division
xxv. 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 2729 trees are likely to be lost along the two corridors and two depots. It is proposed to plant ten saplings for each tree to be cut. Hence, 28440 trees need to be planted. Cost of afforestation is taken as Rs 5,01,090/-per ha. Compensatory afforestation cost thus will be about **Rs 91.56 Lakh** for Corridor-I and **Rs 33 Lakh** for Corridor-II. The native plant species and miscellaneous indigenous tree species recommended for afforestation. 27290 trees, on maturing will absorb about 595 ton of CO2 per year and will release 1337 ton of Oxygen per year.

ii. Construction Material Management

The duties of the 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. Close liaison with the officer of the UPMRC and the head of the construction crew will be required to address any environmental issues and to set up procedures for mitigating impacts. 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

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 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.

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, scraps 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 runs along major arterial roads of the city which serves 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.
- 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.
- In case of underground utility services running across the alignment, the spanning arrangement of the viaduct may be suitably adjusted.

xii. Protection of Archaeological Monuments

The proposed alignment is passing within the prohibited area,2 archaeological monuments in case of Corridor-1 and 2 archaeological monuments in case of Corridor-2 coming in prohibited area. During construction stage, archaeological or historical structures may get affected by construction activity. Necessary procedure will be followed for Construction within the regulated area of Archaeological Monuments. Prior to the initiation of construction, UPMRC will conduct condition survey of all archaeological/heritage structures in the vicinity of alignment so as to follow up during construction and operation of the project.

xiii. Air Pollution Control Measures

During the construction period, the 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 and disposal of waste. He shall not allow emissions of fugitive dust from any transport, handling, construction or storage activity to remain visible in atmosphere beyond the property line of emission source for any prolonged period of time without notification to the Employer.

- Contractor's transport vehicles and other equipment shall conform to emission standards fixed by Statutory Agencies of Government of India or the State Government from time to time. The Contractor shall carry out periodical checks and undertake remedial measures including replacement, if required, so as to operate within permissible norms.

- The Contractor shall cover loads of dust generating materials like debris and soil being transported from construction sites. All trucks carrying loose material should be covered and loaded with sufficient free - board to avoid spills through the tailboard or sideboards.

- The temporary dumping areas shall be maintained by the Contractor at all times until excavate is re-utilized for backfilling or as directed by Employer.

- The Contractor shall place material in a manner that will minimize dust production. Material shall be minimized each day and wetted, to minimize dust production. During dry weather, dust control methods must be used daily especially on windy, dry days to prevent any dust from blowing across the site perimeter.

- 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.

Capital and operating cost are included in engineering cost and therefore is not included in EMP.

xiv. 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.

Noise level from loading and unloading of construction materials can be reduced by usage of various types of cranes and placing materials on sand or sandy bag beds.

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. The estimated cost of noise barrier is about **Rs 79.15 Lakh** for Corridor-I and **Rs 432.05 Lakh** for Corridor-II.

xv. 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.

xvi. 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.
- 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 minimized. Capital and operating cost are included in engineering cost and therefore is not included in EMP.

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.

xvii. 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. Capital and operating cost are included in engineering cost and therefore is not included in EMP.

xviii. 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 stabilized 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 stock piling 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 minimize 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.

Capital and operating cost are included in engineering cost and therefore is not included in EMP.

xix. Construction and Demolition Waste Management

Construction and Demolition (C&D) debris is 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 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.

xx. 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.

xxi. 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 recharge.

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.

xxii. Management Plan for Depot

Two maintenance depots are planned for Agra Metro. These are at i) PAC land Near Mall Road and ii) Kalindi Vihar. The management plan for depot site includes:

- Water Supply
- Oil Pollution Control
- Sewage/Effluent Pollution Control
- Solid waste disposal
- Surface Drainage
- Green belt development
- Rain water harvesting and
- Recycling of treated waste water

Water supply: Water will be required for operation and functioning of depot which will be through municipal supply or boring tube well into the ground. The ground water will need treatment depending upon its use. For Domestic application a Reverse Osmosis (RO) system will be appropriate. Capital and operating cost are included in engineering cost and therefore is not included in EMP.

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. The tank may be designed for a detention period of 5 to 15 minutes. Capital and operating cost are included in engineering cost and therefore is not included in EMP.

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 has to be treated as per requirement of UP Pollution Control Board. The estimated cost of packaged type Sewage Treatment Plant (STP) is about Rs 10 Lakh and cost of Effluent Treatment Plant (ETP) is Rs 141 Lakh at PAC depot. And, the estimated cost of Sewage Treatment Plant (STP) is about Rs 10 Lakh and cost of Effluent Treatment Plant (ETP) is Rs 164 Lakh at Kalindi Vihar Depot.

Solid Waste Disposal: The solid waste generated from the Depot will be taken by the cleaning contractor weekly and disposed to the Agra Municipal Corporation waste disposal sites in accordance with relevant National and State laws and regulations.Capital and operating cost are included in engineering cost and therefore is not included in EMP.

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. Capital and operating cost are included in engineering cost and therefore is not included in EMP.

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. Estimated cost for green belt development is about Rs 10.02 Lakh and Rs 9.01 Lakh for PAC Depot and Kalindi Vihar Depot respectively. Treated sewage and effluent in the best combination should be used for green belt development.

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 depot will be open to sky and it is estimated that approximately 10% area will be covered. Rainwater harvesting potential of depots is calculated as 17,106 cubic meter per year. The estimated cost for rainwater harvesting for both the depots is Rs 32.32 Lakh.

Recycling of treated waste water: Waste-Water generated at depots is proposed to be collected at ETP & STP through separate sewer lines for treatment. The treated waste water will be recycled for horticulture work of the depots.

xxiii. Training

The training for engineers and managers will be impacted 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. Apart from training, programme should include guidelines for safety, methods of disaster prevention, action required in case of emergency, fire protection, environmental risk analysis etc. The cost involved for such programmes is estimated as Rs 10.20 Lakh for Corridor-Iand Rs 13.80 Lakh for Corridor-II, details are given in **Table 15.24.**

TABLE 15.24: COST FOR TRAINING PROGRAMME

S. No.	Item	Cost (Rs)	
		Corridor-I	Corridor-II
1	Curriculum Development and course preparation 1 months Rs.50000/month	50,000	50,000
2	Extension Officer (1 year) Rs. 20,000/month	480000	720000
3	Instructor 20 sessions of 10 days each	240000	360000
4	Demonstration/Presentation Aids	1,00,000	1,00,000
5	Material etc	150000	150000
Total		**10,20,000**	**13,80,000**

xxiv. 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. Costs for the first ten years (including 10% annual increase has been) given **Table 15.25**. The estimated cost for one corridor is **Rs 174.24 Lakh** and for two Corridors the cost will be **Rs 348.48 Lakh**.

TABLE 15.25: ENVIRONMENTAL DIVISION COSTS PER YEAR FOR ONE CORRIDOR

S. No.	Particulars	In Rupees
1.	Environmental Engineer (1No.)	6,00,000
2.	Assistant Environmental Engineer (1No.)	4,20,000

S. No.	Particulars	In Rupees
3.	Miscellaneous Expenditure	5,64,000
Total Cost for One Year		**15,84,000**
Total Cost for Ten Years with 10% annual increase		**1,74,24,000**

xxv. 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: M**easures 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 organizations, 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*) comprise 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 updating of the process

1) For example, 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

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 corridors is about 22.4 km. Annual rainfall of Agra is 724.8 mm. Considering a runoff coefficient of 0.85 the annual rainwater harvesting potential of elevated stations and elevated section is estimated as 8,10,220 cubic meter per year. Estimated cost for rainwater harvesting for viaduct and elevated stations is Rs 79.34 Lakh for Corridor-I and Rs 192.33 Lakh for Corridor-II.

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. Environment 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. Environmental 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.

Estimated cost for Environmental monitoring during the construction and operation phases are **Rs 52.17 Lakh** for Corridor-I and **Rs 23.64 Lakh** for Corridor-II.

15.6.2. Construction Phase

During construction stage environmental monitoring will be carried out for air quality, noise levels, vibrations, water quality, and ecology. At this stage it is not possible to visualize the exact number of locations where environmental monitoring must be carried out. However keeping a broad view of the sensitive receptors and also the past experience an estimate of locations has been made and are summarized in **Table 15.26.** These numbers could be modified based on need when the construction actually commences.

TABLE 15.26: 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

i. Water Quality

The water quality parameters are to be monitored during the entire period of project construction. Monitoring should be carried out by NABL Accredited/MoEFCC 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.

ii. Air Quality

Air quality is regularly monitored by Central Pollution Control Board at number of places in Agra. 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.

iii. 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.

iv. 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 review four times a year during construction phase.

v. Workers Health and Safety

Monitoring of health risk issues that might arise throughout the project life time will be done. Epidemiological studies at construction sites will be performed to monitor the potential spread of diseases. Regular inspection and medical checkups shall be carried out to workers health and safety monitoring.

Any reoccurring 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.

vi. Operation Phase

Even though the environmental hazards during the operation phase of the project are minimal, 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 (PM2.5 and PM10), SO2, NOX, 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 15.26. Monitoring should be carried out by NABL Accredited/MoEFCC recognized private or Government agency 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 15.27: 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	(Depots)	3

15.6.3. 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 15.28** and **Table 15.29**.

TABLE 15.28: ROLES AND RESPONSIBILITIES - SECURING APPROVALS/CLEARANCES

S N	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	Archaeological / heritage assets	The Ancient Monuments and Archaeological sites and Remains (Amendment and Validation Act) 2010		National Monuments Authority for protected Archaeological assets / Municipal Corporation for heritage assets
4	Utility / traffic diversion	Respective Acts and Rules		Local Offices of respective Agencies.
5	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 Authoruty for landuse clearance
Construction Phase				
6	Consent to Establish and Operate hot mix plant, crushers, batching plant etc and Consent to Establishlabour camps	Air (Prevention and Control of Pollution) Act 1981	Before Construction	State Pollution Control Board MunicipalCorporation
7	Permission for drawalof groundwater for construction (**not recommended**)	Environment (Protection) Act, 1986	Before Construction	Regional Director, Central Ground Water Board and Municipal Corporation
8	Authorization for Disposal of Hazardous Waste	Hazardous Waste (Management and Handling and trans-boundary movement) Rules 2016	Before Construction	State Pollution Control Board
9	Consent for disposal of waste water from construction sites	Water (Prevention and Control of Pollution) Act 1974	Before Construction	State Pollution Control Board

S N	Issue	Provision of Laws & Regulations	Due Date	Approving Authority
	and sewage from labour camps			
10	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
11	Permission for management of C&D waste and muck	Environment Protection Act 1956	Before Construction	MunicipalCorporation and State Pollution Control Board
Operation Phase				
12	Consent to Operate Depot	Environment Protection Act 1956	After Construction	State Pollution Control Board
13	Installation and operation of DG sets at stations	Air (Prevention and Control of Pollution) Act 1981	After construction	State Pollution Control Board

TABLE 15.29: ROLES AND RESPONSIBILITIES –PREPARATION AND IMPLEMENTATION OF ENVIRONMENTAL MANAGEMENT PLAN (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
4	Archaeological monuments	Alignment design to avoid or minimize impact.	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

SN	Environmental Impact	Mitigation Measure	Implementing Entity	Responsible Entity
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, muck disposal and C&D waste management	Implement suitable construction methods and as per SH&E Manual	Contractor	PIU
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
23	Sewage and effluent disposal	Implement STP and ETP at depots.	PIU	PIU

SN	Environmental Impact	Mitigation Measure	Implementing Entity	Responsible Entity
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 15.10**. One indicative activity i.e., approval of EMS documents is shown in this organization chart.

15.7. SUMMARY OF COSTS

Estimated cost of implementation of EMP, EMoP and Training for the proposed metro project is about **Rs 1840 Lakh**. Summary of cost estimate is given in the following **Table 15.30.**

TABLE 15.30: SUMMARY OF COST ESTIMATE

S No	Item	Amount (Rs in Lakh)	
		Corridor-I	Corridor-II
1	Compensatory Afforestation	91.56	33.00
2	Noise Barriers	79.15	432.05
3	Rainwater Harvesting	95.50	208.49
3	Sewage Treatment Plant for Depot	10.00	10.00

S No	Item	Amount (Rs in Lakh)	
		Corridor-I	Corridor-II
4	Effluent Treatment Plant for Depot	141.00	164.00
5	Green Belt Development for Depot	10.02	9.01
6	Environmental Monitoring	78.36	108.00
7	Training and Extension	10.20	13.80
8	Environment Division	174.24	174.24
Total		**687.21**	**1152.59**

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 minimize 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 objectives of Social Impact Assessment are:

i. Identify PAPs by type and extent of loss

ii. Identify the possible adverse effects of the project on the people and the area

iii. Suggest culturally and economically appropriate measures for mitigation of adverse effects of the project

iv. Provision of institutional mechanism for implementation of RAP

v. Provision for grievance redresses mechanism;

vi. A time frame for implementation of RAP

vii. Provision of budget for each activity of RAP, and,

viii. 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 multi/bilateral funding agencies' guidelines on social and environmental consideration. 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.

- The consultant reviewed the final topographical maps and Detailed Project Report (DPR) of the project.

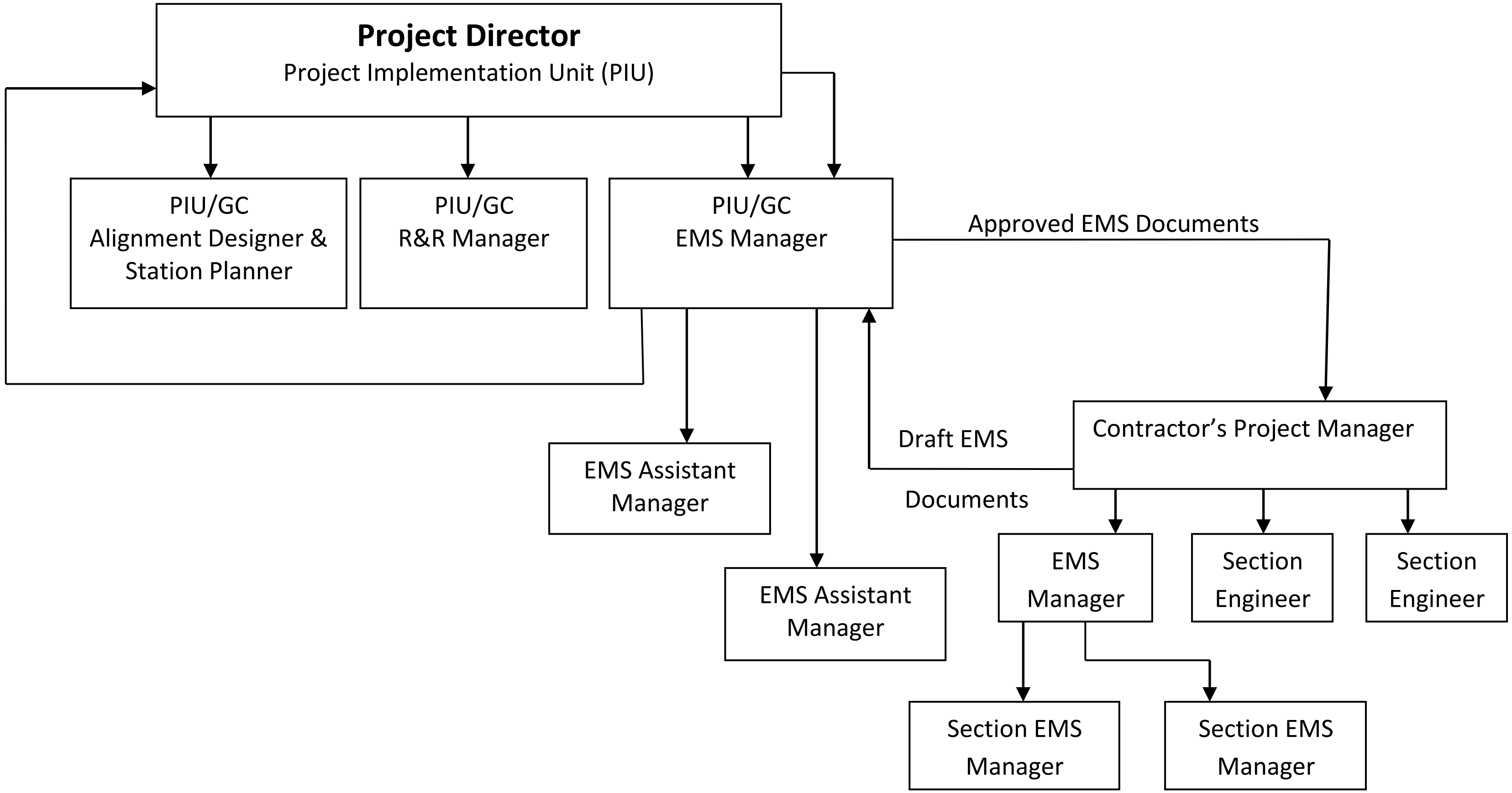
- Conducted sample socio-economic survey covering affected households, squatters, kiosks and small business entrepreneurs with the help of pretested "Household Questionnaire". Important aspects covered in the questionnaire were identification particulars of PAPs, his or her family details, social profile, 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.

- 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 by RITES Social team. The Socio-Economic Baseline data was collected during October 2015.

- The development of proposed metro project has significant positive impacts in Agra city. 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.

FIGURE 15.10: EMS ORGANIZATION



* GC: General Consultant as Project Management Consultant

15.8.3. Potential Social Impacts

The proposed metro rail will have number of 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 the project may bring myriad forms of adverse impacts on socio-economic condition of families/people that 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.

15.8.4. Inventory of Affected Structures

Table 15.31 presents the usage type of structures likely to be affected.

TABLE 15.31: CORRIDOR WISE IMPACT ON STRUCTURES

Corridor/Station	Type of Structures			Total
	Residential	Commercial	Others	
Corridor-I (Sikandra to Taj East gate)				
Sikandra	3	0	2	5
Guru Ka Taal	3	0	0	3
ISBT	7	5	0	12
Shastri Nagar	5	6	2	13
University	0	1	0	1
RBS College	0	0	1	1
Raja Ki Mandi	0	0	1	1
Agra College	0	0	2	2
Medical College	0	0	1	1
Jama Masjid	13	0	1	14
Agra Fort	0	0	0	0
Taj Mahal	0	0	0	0
Fatehabad Road	5	0	1	6
Basai	0	0	1	1
Taj East Gate	2	0	0	2

Corridor/Station	Type of Structures			Total
	Residential	Commercial	Others	
Sub Total	**38**	**12**	**12**	**62**
Corridor-II (Agra Cantt. Railway Station to KalindiVihar)				
Agra Cantt.	0	0	0	0
Sultanpura	1	3	0	4
Sadar Bazaar	0	0	1	1
Partap-Pura	0	0	1	1
Collectorate	5	0	1	6
Subhash park	0	0	2	2
Agra College	1	0	1	2
Hariparvat Chauraha	0	0	1	1
Sanjay Place	0	0	1	1
M G Road	10	0	1	11
Sultanganj Crossing	6	0	5	11
Kamla Nagar	4	2	2	8
Rambagh	35	0	0	35
Foundary Nagar	0	0	0	0
Agra Mandi	0	0	0	0
KalindiVihar	0	0	0	0
Sub Total	**62**	**5**	**16**	**83**
Total	**100**	**17**	**28**	**145**

Source: Primary Surveys, 2016

Note: R: Residential, C: Commercial, R+C: Residential+ Commercial

**Number of structures is 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 that out of total 145 structures, about 125 structures (86.2 %) will be fully affected and remaining about 20 structures (13.7%) will be partially affected (**Table 15.32**). However, the exact number of fully and partially affected structures will be known after peg marking on the ground level.

TABLE 15.32: MAGNITUDE OF PROJECT IMPACTS

Name of Corridor	Magnitude of Impacts		
	Fully	Partially	Total
Sikandara to Taj East Gate	54 (12.9)	8 (87.1)	62 (100)
Agra Cantt. Railway Station to Kalindi Vihar	71 (85.5)	12 (14.5)	83 (100)
Total	**125 (86.2)**	**20 (13.7)**	**145 (100)**

Source: Primary Surveys, 2016

15.8.5. Impact on PAFs/PAPs

About 119 families consisting 572 persons will be affected due to the proposed metro project. Corridor wise number of PAFs and PAPs is presented in **Table 15.33**. 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 15.33: IMPACT ON PAFs AND PAPs

Name of Corridor	Total PAFs	Total PAPs*
Sikandara to Taj East Gate	52	250
Agra Cantt. Railway Station to Kalindi Vihar	67	322
Total	**119**	**572**

Source: Primary Surveys, 2016

**Number of PAPs is counted based on average size of family*

Out of the total 119 families, 42 are in the category of Title Holders (TH) and the remaining 77 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 15.34**.

TABLE 15.34: TITLEHOLDERS AND NON-TITLEHOLDERS

Name of Corridor	Titleholders	Non-Titleholders	Total PAFs
Sikandara to Taj East Gate	6	46	52
Agra Cantt Railway Station to Kalindi Vihar	36	31	67
Total	**42**	**77**	**119**

Source: Primary Surveys, 2016

Table 15.35 indicates that out of the total 119 PAFs, 17 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 Sikandara to Taj East corridor.

TABLE 15.35: LOSS OF RESIDENCE

Name of the Location	Total PAFs	Residentially Affected Family
Sikandara to Taj East Gate	52	12
Agra Cantt Railway Station to KalindiVihar	67	5
Total	**119**	**17**

Source: Primary Surveys, 2015

Table 15.36 indicates that out of total 119 affected families, there are 102 PAFs whose business/livelihoods will be affected due to the loss of the commercial structures vis-a-vis business base in both corridors. Majority (62) of commercial PAFs are likely to be affected in Agra Cantt Railway Station to Kalindi Vihar corridor. About 40 PAFs are likely to be affected in Sikandara to Taj East Gate corridor.

TABLE 15.36: LOSS OF LIVELIHOOD

Name of the Location	Total PAFs	Commercially Affected Family
Sikandara to Taj East Gate	52	40
Agra Cantt Railway Station to Kalindi Vihar	67	62
Total	**119**	**102**

Source: Primary Surveys, 2015

15.8.6. 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 15.37** shows that 14 religious structures and five 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 15.37: LOSS OF COMMON PROPERTY RESOURCES

Name of the Corridors	Common Property Resources			Total
	Religious structures	Public toilet	Others	
Sikandara to Taj East Gate	6	1	5	12
Agra Cantt Railway Station to Kalindi Vihar	8	4	4	16
Total	**14**	**5**	**9**	**28**

Source: Primary Surveys, 2016

15.8.7. 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.

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 53.52 % are male and remaining 46.47 % are female. It is observed that male dominate in both corridors. The sex ratio is 837 per 1000 males in Sikandara to Taj East Gate corridor and that in Agra Cantt. Railway Station to Kalindi Vihar is 895 in corridor (**Table 15.38**).

TABLE 15.38: GENDER AND SEX RATIO

Corridor	Total Surveyed PAFs	Total PAPs	Gender		Sex Ratio
			Male	Female	
Sikandara to Taj East Gate	36	147 (100)	80 (54.42)	67 (45.58)	837
Agra Cantt Railway Station to Kalindi Vihar	54	208 (100)	110 (52.8)	98 (47.11)	895
Total	**90**	**355 (100)**	**190 (53.52)**	**165 (46.47)**	**866**

Source: Primary Surveys, 2016

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 15.39** shows that only two religions are followed in the study area viz., Hindu and Muslims. The studies results show that about (80.00%) of the surveyed families are Hindu followed by Muslim (20.00%). Majority of families are Hindu in both corridors.

TABLE 15.39: RELIGIOUS GROUP

Corridor	Hindu	Muslim	Total PAFs
Sikandara to Taj East Gate	27 (75.00)	9 (25.00)	36 (100)
Agra Cantt Railway Station to KalindiVihar	45 (84.2)	9 (15.8)	54 (100)
Total	**72 (80.00)**	**18 (20.00)**	**90 (100)**

Source: Primary Surveys, 2016

Table 15.40 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 (48.88%) belong to Other Backward Caste followed by general (44.44%) and Scheduled Caste (4.0%) and Scheduled Tribe (2.0%). Scheduled Castes and Scheduled Tribe families are found in Agra Cantt Railway Station to Kalindi Vihar corridors. Therefore, special attention is required to address their issues.

TABLE 15.40: SOCIAL GROUP

Corridor	General	OBC	Schedule Castes	Schedule Tribes	Total PAFs
Sikandara to Taj East Gate	11 (30.55)	24 (66.66)	1 (2.77)	0	36 (100)
Agra Cantt Railway Station to Kalindi Vihar	29 (53.7)	20 (37.03)	3 (5.5)	2 (3.7)	54 (100)
Total	**40 (44.44)**	**44 (48.88)**	**4 (4.4)**	**2 (2.2)**	**90 (100)**

Source: Primary Surveys, 2016

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.

4. Age Group

The distribution of person's age in various group shows that 17.3% of the total persons belong to below five years, about 25.6 % belong to the 6-18 years age group. About 30.7 % belong to 19-35 years that is potentially productive group. About 43.2% belong to the age group of 36 to 60 years. About 13.9% of total persons belong to above 60 years, who are dependent population. It is observed that majority of persons belong to 36 to 60 years age group.

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.

6. Family Pattern and Family Size

Majority of surveyed families are nuclear (92.22%) followed by joint (7.77%). Majority of surveyed families belong to nuclear family (96.29%) in Agra Cantt Railway Station to Kalindi Vihar corridor and Joint family (3.70%) in Sikandara to Taj East Gate corridor. Majority of nuclear families are found in both corridors. Family size has been classified into three categories i.e. individual, small (2-4), medium (5-7) and large (7 & above). Majority of families (67.77%) are small in size followed by 23.33% families are medium type and remaining 8.88 % families have their members more than seven. Small size families are found in both corridors.

7. Educational Attainment

The analysis indicates that out of the total surveyed people, about 7.7% are illiterate, 19.4% are educated up to primary class, 16.5 % are educated up to High School, and 19.7% have studied up to higher secondary level. Other than this, about 36.7 % of persons have attained college. Education level of surveyed people is better in Agra Cantt Railway Station to Kalindi Vihar corridor as compared to Sikandra to Taj East Gate corridor.

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 1.1% of families reported less than Rs.5000/- monthly income. About 14.5% of families' monthly income is less then Rs.5001-10000, 38.9% of families' income is between Rs.10001 to 20000/-,(30.0) % of families' income is between Rs.20001 to 40000.Families' earning more than Rs.40000/- monthly constitutes about 15.6 %. 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 15.41)**.

TABLE 15.41: FAMILY MONTHLY INCOME

Corridor	Family Monthly Income (in INR)					Total PAFs
	<5000	5001 - 10000	10001 - 20000	20001 - 40000	>40000	
Sikandara to Taj East Gate	0 (0)	5 (13.9)	20 (55.5)	7 (19.5)	4 (11.1)	36 (100)
Agra Cantt Railway Station to Kalindi Vihar	1 (1.8)	8 (14.8)	15 (27.8)	20 (37.1)	10 (18.5)	54 (100)
Total	**1 (1.1)**	**13 (14.5)**	**35 (38.9)**	**27 (30.0)**	**14 (15.6)**	**90 (100)**

Source: Primary Surveys, 2016

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 64.5% of them are involved in business, 17.7 % are in daily labour and 10% and 7.8% are in government and private sector respectively. It is observed in both corridors that majority of PAPs are involved in business/trade activities.

10. Household Assets

The TV, Refrigerator, two wheeler, and telephone are owned by majority. The other prominent assets are bicycle and computer.

11. Vulnerable Groups

As per the international funding agencies 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 twenty one families belong to vulnerable category. Out of these about one family are women headed households, three families are Scheduled Castes, two families are Scheduled Tribes, twelve families are below the line of poverty including women headed households, and four families having disability people. Numbers of vulnerable families are found more in Agra Cantt Railway Station to Kalindi Vihar

Gender Issues: There are two woman-headed household among the surveyed vulnerable families found in the Sikandra to Taj East Gate 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.

12. 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.

13. 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 15.42**.

TABLE 15.42: PROJECT RELATED INFORMATION

S. N.	Description	Sikandara to Taj East Gate	Agra Cantt Railway Station to Kalindi Vihar
1	Awareness about the Project		
	Yes	36	54
	No	0	0
2	Source of Information		
	News Paper	36	41
	Survey Team	0	0
	Television	0	0
	Friends/People	0	13
3	Opinion about the Project		
	Good	35	54
	Bad	1	0
	Can't Say	0	0

Source: Primary Surveys, 2016

15.8.8. Public Consultation and Participation

Public consultation were organised at medical college, ISBT, Agra University, St. John's College, RBS, Guru katal, Kamlanagar, Foaundry Nagar, Ram bagh, Agra fort, Taj East Gate, Raja ki Mandi from 16/09/2015 to 19/09/2015.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:

- Local people showed happiness during public consultations as the project will provide hassle free movement in the congested part of the city.
- Suitable safety measures should be taken in the project during construction and operation phases
- Vacant land should be used for metro station instead of acquiring residential and commercial plots or structures of local people.
- 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.
- Compensation for acquired land should be provided on time to the affected families/people at market rate.
- Source of livelihood should not be disturbed. The affected businessmen should be given alternate employment.
- Shop for shop- All shop keepers should be rehabilitated by constructing market

complex in nearby area.

- Govt. should provide a constructed house for each affected family.
- During construction phase, traffic on the roads should be managed in such a way that it should not cause congestion of traffic and accidents during construction phase.
- Construction labor camps should not be located near the core city area that is frequented by the tourists
- It is evident from the discussion with local people during social survey that the people in Agra have no objection to the proposed metro rail project. According to them loss of residential 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.

15.8.9. Resettlement Policy, Framework and Entitlement Matrix

The applicable laws on land acquisition, rehabilitation and resettlement for the proposed metro rail project are:

a. Right to Fair Compensation and Transparency in land acquisition, Rehabilitation and Resettlement Act, 2013(RTFCTLARR Act).

b. 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.

c. Multi/Bilateral Agencies' Involuntary Resettlement Policy

The Entitlement Matrix

An Entitlement Matrix **(Table 15.43 & Table 15.44)** 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 15.43: ENTITLEMENT MATRIX

(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 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.

**Same entitlement matrix will be followed for Agra Metro Rail Project*

TABLE 15.44: ENTITLEMENT MATRIX

(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 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

S. No.	Category of Impact	Eligibility of Entitlement	LMRC Adopted Policy/Entitlement
			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.

15.8.10. Institutional Framework

The SPV, that will be formed will be the in charge of the overall project activities and 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.

15.8.11. 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 15.11**.

15.8.12. 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.

i. 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 15.45**.

TABLE 15.45: 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 ousters Amount paid for training and capacity building of staffs

Indicators	Parameters Indicators
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

ii. 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.

iii. 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.

15.8.13. Cost Estimate of R&R

The cost for implementation of Resettlement and Rehabilitation Plan on account of two corridors of Agra Metro is presented in **Table 15.46**.The total cost for R&R implementation plan is Rs.53.7 million.

TABLE 15.46: COST FOR RESETTLEMENT & REHABILITATION*

S. No.	Description	Unit	Quantity	Rate (Rs.)	Amount (Rs.in million.)
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	4	36000	0.14
D	Transportation allowance	no	4	50000	0.20
E	Resettlement Allowance	no	4	50000	0.20
F	Commercial PAFs				
G	Subsistence allowance	no	38	36000	1.37
H	Transportation allowance	no	38	50000	1.90
I	Loss of Small traders/self employment	no	38	25000	0.95
J	Resettlement Allowance	no	38	50000	1.90
Compensation for Non-Titleholders					
	Squatters				
K	One time financial assistance	no	119	25000	2.98
Assistance for SCs ,STs or Vulnerable group					
L	Additional Subsistence Allowance	no	8	50000	0.40
Training for Skill Development					
M	Training Assistance(LS)	no	119	15000	1.79
Compensation for Community Structures					
N	Religious structures(LS)	no	14	2000000	28.00
O	Public Toilets(LS)	no	5	1000000	5.00
Engagement of NGO					
P	NGO Cost (LS)	no	1	2500000	2.50
Monitoring & Evaluation					
Q	Cost of Independent Evaluation Agency(LS)		1	1500000	1.50
Total (B+C+D+E+F+G+H+I+J+K+L+M+N+O+P+Q)					**48.82**
Miscellaneous items @ 10% of sub total					**4.88**
TOTAL					**53.70**

**R&R cost is calculated as per the Resettlement Policy Framework of Lucknow Metro Rail Corporation provided by LMRC, Lucknow.*

FIGURE 15.11: RAP IMPLEMENTATION SCHEDULE FOR AGRA METRO RAIL

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								

Chapter – 16

DISASTER MANAGEMENT & SECURITY MEASURES

16. DISASTER MANAGEMENT AND SECURITY MEASURES

16.1 DISASTER MANAGEMENT ANDIMPERATIVES

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 TYPE OF DISASTERS IN METRO SYSTEM

Metro specific disasters can be classified into two broad categories as Man-made and Natural.

a. Man Made Disaster

- Terrorist attack
- Bomb threat/ Bomb blast
- Hostage Situations
- Release of Chemical or biological gas in trains, stations or tunnels

- Fire in metro buildings, underground/ elevated infrastructures, power stations, train depots etc.
- Train accident and train collision/derailment of a passenger carrying train
- Sabotage
- Stampede

b. Natural Disaster

- Earthquakes
- 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 Agra project of UP 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

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:

i. Fire Drill - This shall include

- Making announcements
- Protecting the area
- Summoning assistance

- Using fire fighting equipments locally available
- Passenger evacuation in case of need

ii. **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.

iii. **Detrainment of passenger between stations**

- Blocking adjacent line
- Announcement to passengers.
- Use of emergency doors.
- Guiding passengers to next station.

iv. **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

v. **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

vi. Hot line telephone communication with state disaster management authority.

16.5.1 Authorities Coordination in Case of Disaster, Command & Control at the National, State & District Level

Authority 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 Agra MRTS:

i. 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:

- The Prime Minister of India, who shall be the Chairperson of the National Authority, Ex officio;
- 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.

ii. 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:

- The Chief Minister of the State, who shall be Chairperson, ex officio;
- Other members, not exceeding eight, to be nominated by Chairperson of State Authority;
- 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.

iii. 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:

i. National Crisis Management Committee (NCMC) under chairmanship of Cabinet Secretary

ii. Crisis Management Group (CMG) under chairmanship of Union Home Secretary.

iii. State Level Committee under the chairmanship of Chief Secretary.

iv. 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.

iv. 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:-

- Provisions for prevention and mitigation measures as provided for in the District Plan and as is assigned to the department or agency concerned;
- Provisions for taking measures relating to capacity-building and preparedness as laid down in the District Plan;
- 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 PROVISIONS 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:

- Rigid observance of non smoking regulations
- Total ban on carriage of inflammable/ explosive substance within metro premises and in trains
- Non accumulation of garbage in the metro station premises and inside trains
- 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,

- Report the occurrence to the nearest Station Controller (SC) or Chief Controller (OCC)
- Take all possible steps to extinguish fire
- Disconnect electric supply, if required
- Prevent the fire from spreading
- 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:

- The nature of fire whether localized or widespread in passenger area.
- 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.
- 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:

- In areas, where the passengers enter for purchasing tickets or leave the station after performing their train journey including lifts, staircases and escalators.
- Concourse
- 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

- Look for presence of smoke or fire. Furnish details of visible damage, if any coaches are derailed or
- If the other track is obstructed.
- 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:

- In the event of collision taking place involving his train, the train operator shall inform OCC by giving as many details as possible.
- In case of adjacent track is infringed, he will first protect the adjacent track to avoid multiple accidents as per prescribed procedure.
- He will inform passengers about the incident advising them about rescue and relief arrangements being made.
- 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.
- He will render first aid to passengers and check for injury and damage to the train (both his train and other train).
- Shall seek OCC's permission for passenger evacuation.
- Shall await further instructions from OCC.

C. Duties of Station Controller:

- The Station Controller on receipt of information about collision at his station shall inform OCC.
- Arrange for immediate medical assistance as required.
- Inform Metro rail police/Local police.

- Mobilize the staff for evacuation of passengers and rendering of first aid to the injured and their hospitalization as required.
- Inform passenger awaiting at the station of the likely delays.
- Station controller will evacuate passengers as per instructions of OCC.

D. Duties of Traffic Controller:

- On receiving information about train collision the Traffic Controller shall block all movement on both the tracks to protect the site of accident.
- Inform CMRL Disaster Management Team members.
- And other designated CMRL departments and Personnel.
- Mobilize medical assistance as required.
- Inform the train depot to be in readiness to move rescue and relief train.
- Instruct Station Superintendent to depute staff for evacuation of passengers and providing medical aid to the injured.
- Regulate train services and inform all stations on the route about the likely dislocation in train services.
- Activate ventilation system based on condition of the scene (for tunnel section only).
- Arrange for Public Address announcements to be made to passengers in trains and at stations.
- 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.
- 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:

- TC shall instruct TOs of trains approaching the derailment site on both tracks to stop their trains and report their positions.
- 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.
- Mobilize medical assistance as required.
- Inform the depot to be in readiness to move the rescue and relief train.
- Instruct Station Managers to depute staff for evacuation of passengers and providing medical aid to the injured in case of derailment between stations.
- Regulate train services and inform all stations on the route about the likely dislocation in train services.
- Activate ventilation system based on condition of the scene (for tunnel section only).
- Arrange for Public Address announcements to be made to passengers in trains and on stations.
- Request assistance of Police / Metro Police / Security/ Watch & Ward for crowd control at critical stations.
- 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:

- Shall visit the affected spot, assess the extent of impact on human life and also how it may affect train services.
- Shall inform the OCC about details of incident.
- Sound the hooter and get the station premises vacated of all the passenger
- 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.
- Mobilize resources to render first aid and evacuate the injured.
- In case any person is seen moving in a suspicious manner, he may be detained for interrogation with the help of security staff.
- 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.
- 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:

- Inform Police/Metro Police and security personnel and ask them to rush to the spot of occurrence.
- Mobilize Medical Assistance and/ or Fire Services to reach the spot.
- Inform the DMT and other CMRL departments and personnel.
- 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:

- A Bomb on the track which detonates under a train.
- Detonation of Bomb / igniting of inflammable material inside a train.
- Release of chemical / biological gases in a train.
- Criminal interference with train running equipments which causes fire in the coaches while on run.
- 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:

- Inform Traffic Controller
- 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.
- 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.
- Shall seek assistance of fire services and medical services as required, take the permission of the TC to detrain the passengers.
- 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.
- 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.
- The TO will arrange evacuation of the passenger when authorized by OCC.
- This will help in reaching prompt assistance to the injured and disabled passengers on arrival of the Security and Medical Team.
- 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 Agra 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, ESSENTIALS OF SECURITY MANAGEMENT, SECURITY SYSTEM DESIGN PARAMETER

16.7.1 Security Measures & 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 Parameter

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:

- The Human factor;
- Procedures; and
- Technology

Staff interaction with passengers create 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 Agra Metro.

16.8 SECURITY SYSTEMS RECOMMENDED FOR AGRA 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 alongwith 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 Agra 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:

i. Provision of Security related Infrastructure:

ii. Door Frame Metal Detectors, X-ray Baggage scanners and Hand-held Metal Detectors,

iii. CCTV Surveillance and Access Control to Technical Rooms

iv. Security Control Room at OCC,

v. Effective lighting eliminating blind spots

vi. Deployment of Private Security Personnel:

vii. 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:

i. Security checks of bags by X-BIS

ii. Regular patrolling of station area and Police Pickets at sensitive locations,

iii. Threat Assessment, Quick Response Team, Bomb Squad and Dog Squad,

iv. Respond to law & order and crime incidents as reported by LMRC, Anti Sabotage Check

v. 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. 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.

18.2. 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.

18.3. 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.

18.3.1. 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 PERCENTAGE (%)

S. No.	Land use Type	Percentage (%)
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: LAND USE TYPE IN MIXED USE WITH PERMISSIBLE PERCENTAGE (%)

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	

18.3.2. Demarcation of TOD Zones in Agra

Based on the definition of TOD zone as per the notification, the TOD zone boundaries have been demarcated and shown in **Figure 18.1**.

18.4. ASSESSMENT OF DEVELOPMENT POTENTIAL

18.4.1. List of Land Amenable For Change

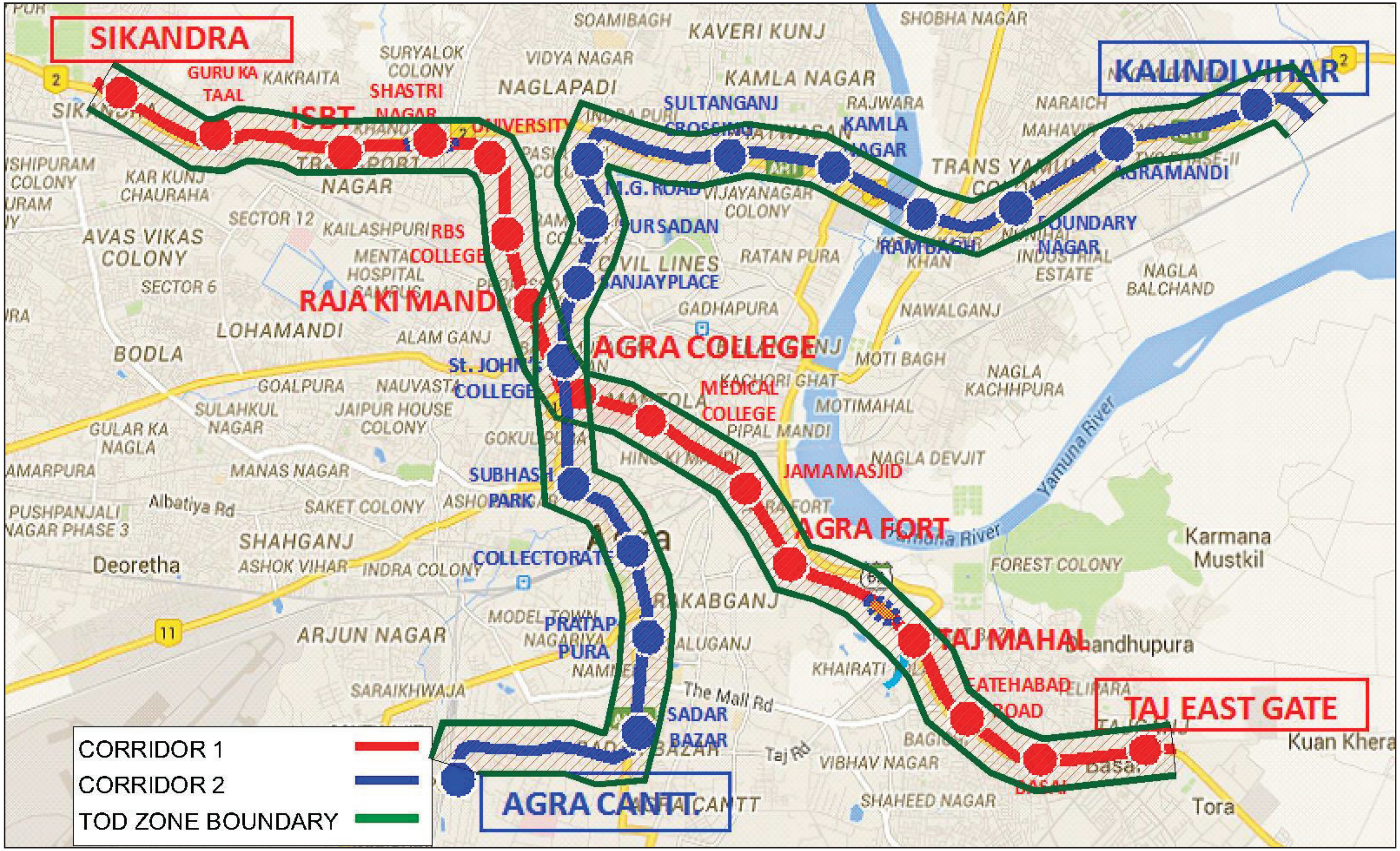
Some land parcels along and off the metro corridors have been identified after joint site visits with ADA, AMC and Revenue Department officials for property development. Property development shall be taken up, depending upon the FAR (upto 4) and permitted ground coverage of 50% as notified by the government in the year 2015. A total of about 8.32 lakh Sqm of property development having Residential, Institutional and Commercial facilities has been proposed.

The effort have been made to provide property development on suitable land pieces along and off the corridors. Cost of land towards PD along the corridor has been considered in project cost at nominal Government rates. Cost of other additional land parcels identified off the corridor has not been loaded to the project cost and it has been assumed that this land cost will be borne by State Govt. separately.

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.

Figure 18.1: TOD ZONE BOUNDARY ALONG AGRA METRO CORRIDORS



The details of the proposed development are presented in **Table 18.3**

TABLE 18.3: DETAILS OF PROPERTY DEVELOPMENT FOR PHASE-I CORRIDORS

S. No.	Metro Station/Location	Area in Sq m	
		Total Plot Area	Floor Space Property Development
Identified Land Parcels along the Corridor			
Corridor-1			
1	Sikandara	14840	44520
2	Guru Ka Taal	2975	-
3	ISBT	18000	52000#
4	Agra College	6600	20000*
		9000	36000
5	Jama Masjid	16000	48000
6	PAC Depot	45000	180000
	Over PAC Depot	100000	300000**
Corridor-2			
7	Sadar Bazar	2200	6600
8	Subhash Park	7000	21000
9	M.G.Road	6900	20700
10	Ram Bagh	19700	30300
11	Agra Mandi	24500	73500
	Total along the Corridor	**272715**	**832620**

#about 10000 m2 area will be used in station and Viaduct

*About 5000 m^2 area will be used for station and circulation

**PD over 10 Ha of Depot area with 3 FAR

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 Agra. The residential property sale rates are considered as Rs. 51,684/- per sqm. while the construction rate is calculated @ 23,573/- 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. 431/- per sqm and further escalated to arrive at operation year (2024-25) figure of Rs. 606/- 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 8.32 Lakh Sq.m of space would be required for property development. The total cost of the property development will be Rs 2,278 Crore. The developer will bring equity of Rs 1,139 Crore (50%) and balance Rs 1,139 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.

The total revenue generated from property development for SPV is summarized in **Table 18.5** for years 2024-25, 2034-35 and 2041-42.

18.4.2. 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.

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	412			206		206				-228	
20 - 21	433			216	25	241				-228	
21 - 22	454			227	51	278				-228	
22 - 23	477			239	78	317				-228	
23 - 24	501			251	107	357				-228	
24 - 25		1224	122		137	137	154	1382	184	239	525
25 - 26		1242	124			1535	154	1228	166	251	547
26 - 27		400	40				154	1075	147	264	-204
27 - 28		420	42				154	921	129	277	-181
28 - 29		441	44				154	768	111	291	-157
29 - 30		464	46				154	614	92	305	-134
30 - 31		487	49				154	461	74	320	-110
31 - 32		511	51				154	307	55	336	-85
32 - 33		537	54				154	154	37	353	-61
33 - 34		563	56				154	0	18	371	-36
34 - 35		592	59							390	143
35 - 36		621	62							409	150
36 - 37		652	65							429	158
37 - 38		685	68							451	165
38 - 39		719	72							473	174
39 - 40		755	76							497	182
40 - 41		793	79							522	192
41 - 42		832	83							548	201
42 - 43		874	87							576	211
43 - 44		918	92							604	222
44 - 45		964	96							635	233
45 - 46		1012	101							666	244
46 - 47		1062	106							700	257
47 - 48		1116	112							735	269
48 - 49		1171	117							771	283
49 - 50		1230	123							810	297

TABLE 18.5: TOTAL REVENUE FROM PROPERTY DEVELOPMENT TO SPV

	2024-25	2034-35	2041-42
Net Revenue from Property Development (Rs. in crore)	525	143	201

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

18.4.3. Land Value Capture in Agra

After discussion with LMRC, few of the above mentioned Value Capture Finance (VCF) tools have been finalised to be used in Agra 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 Agra 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 4000/ sq. m (80% of Kanpur rates), as the real estate market of Agra is lower than 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	3,000,000	3,000,000	3,000,000
Additional 1 FAR Usage Rate (Rs. Per Sq. m)	5,628	7,920	12,900
Additional 1 FAR Usage Charges (Total) (Rs. in Crore)	169	238	387
Metro Share @ 35% (in Crore)	**59**	**83**	**135**

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. 4000 (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 (Sq.m)	3,000,000	3,000,000	3,000,000
External development charges @ (Rs. Per sq. m)	844	1,188	1,935
External development charges (total) (Rs. In Crore)	253	356	581
SPV share for Metro @ 35% (Rs. in Crore)	**89**	**125**	**203**

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. 4000 (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. 4000 as the circle rate, the sector rate would be Rs. 2800/- (at 30% discount) and Rs. 1400/- (at another 50% discount on 2800/-) 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)	600,000	600,000	600,000
Change in land use @ (Rs. Per sq. m)	1,970	2,772	4,515
Fees for change in land use (Total) (Rs. In Crore)	118	166	271
Metro share @ 35% (in Crore)	**41**	**58**	**95**

The total revenue share to Agra Metro from all the above land value capture tools in different years is given in **Table 18.9.**

TABLE 18.9: TOTAL REVENUE SHARE TO AGRA METRO FROM LAND VALUE CAPTURE

S.NO.	Items	Total Revenue (Rs. in crore)		
		2024-25	**2031-32**	**2041-42**
1	Premium on Additional FAR	59	83	135
2	External Development Charges	89	125	203
3	Change in Land use	41	58	95
	Total	**189**	**266**	**433**

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 wil accrue to Agra Metro SPV (in same lines with Lucknow Metro). Remaining 65% may be used as allied investments in expanding utility capacity to densify areas around the metro station.

ANNEXURE 18.1: TOD POLICY 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।

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1.2 मिश्रित उपयोग की अनुमन्यता

मिश्रित उपयोग निम्न परिस्थितियों में केवल नए विकास में अनुमन्य होगा:–

(क) एक्सप्रेसवेज़/प्रमुख हाईवेज के साथ चिन्हित 'डेवल्पमेन्ट नोड्स' में।

(ख) 'मास रैपिड ट्रान्जिट सिस्टम (एम.आर.टी.एस.) कॉरीडोर्स' के साथ 'ट्रॉंज़िट 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/संस्थागत	15–30
(3)	व्यवसायिक	5–10
(4)	औद्योगिक (प्रदूषणमुक्त सेवा उद्योग).	5–10
(5)	सामुदायिक सुविधाएं, सेवाएं एवं मनोरंजन	10–15

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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	

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टिप्पणी:–

(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 होंगीः–

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/

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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/जोनल 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

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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

* Taj East Gate to ISBT of about 11.0 Km may be taken as Priority Section

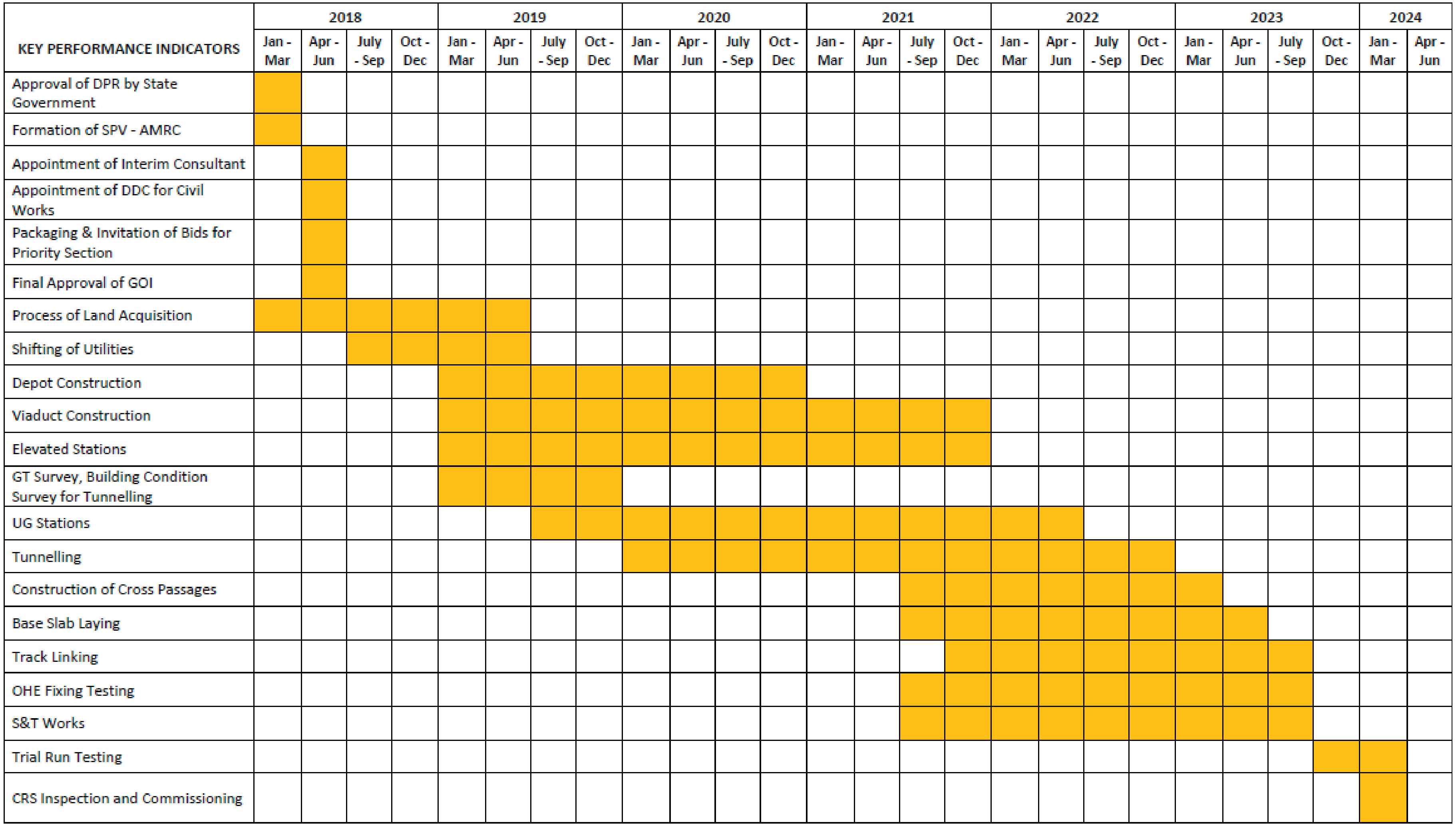
Taj East Gate to ISBT Section of about 11.0 Km may be taken up on priority. The commercial operation on Phase-I corridors may start from January 2024 after providing about 5 years for construction and 3 months for safety audit and certification.

21.2. IMPLEMENTATION STRUCTURE

Uttar Pradesh has a successful example of metro operation in Lucknow on SPV model by Lucknow Metro Rail Corporation (LMRC). Agra 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



Taj East Gate to ISBT of about 11.0 Km may be taken as Priority Section.

21.3. LEGAL AND INSTITUTIONAL FRAMEWORK FOR IMPLEMENTING THE PROJECT

21.3.1. Legal Framework

Construction of Agra Metro should commence soon. Thus, there is immediate need to have a legislation to provide legal cover to the construction stage of Agra Metro. Implementation of proposed Agra Metro can now be done under be done under 'The Metro Railways (Construction of Works) Act, 1978 (33 of 1978)- S.O. 1718 (E) and the Metro Railways (Operation and Maintenance) Act, 2002 (60 of 2002)-S.O. 1719 (E).' The copies of the Gazette notification dated 24.04.2018 is annexed at **Annexure 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.

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.

21.3.3. 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, Agra Mandal and Municipal Commissioner, Agra Nagar Nigam may also be the member of this committee.

21.3.4. 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 Agra 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 Agra 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 Agra Mandal. Other members of this Committee may be District Magistrate, Municipal Commissioner, Agra 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 Agra Metro:

- Approval of State Government (Cabinet Approval) to the Detailed Project Report
- Reconstitution of 'Lucknow Metro Rail Corporation (LMRC)' in 'Uttar Pradesh Metro Rail Corporation (UPMRC)' as Special Purpose Vehicle (SPV) 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
- In principle approval of Government of India
- 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 24.04.2018

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EXTRAORDINARY

भाग II—खण्ड 3—उप-खण्ड (ii)

PART II—Section 3—Sub-section (ii)

प्राधिकार से प्रकाशित

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(एमआरटीएस- II)

अधिसूचना

नई दिल्ली, 24 अप्रैल, 2018

का.आ.1718(अ).—केंद्रीय सरकार मेट्रो रेल (संकर्मों का संनिर्माण) अधिनियम, 1978 (1978 का 33) की धारा 1 की उप-धारा (3) द्वारा प्रदत्त शक्तियों का प्रयोग करते हुए, उत्तर प्रदेश सरकार से परामर्श करने के पश्चात, एतद्वारा यह घोषणा करती है कि उक्त अधिनियम के उपबंध राजपत्र में इस अधिसूचना के प्रकाशन की तारीख से नीचे दी गई सारणी में यथाविनिर्दिष्ट महानगर क्षेत्र पर लागू होंगे, अर्थात्:–

सारणी

महानगर क्षेत्र का नाम	राज्य का नाम
(1)	(2)
आगरा	उत्तर प्रदेश
मेरठ	उत्तर प्रदेश

[फा.सं. के-14011/2/2018-एमआरटीएस-II]

अम्बुज बाजपेयी, अवर सचिव

2356 GI/2018 (1)

MINISTRY OF HOUSING AND URBAN AFFAIRS

(MRTS-II)

NOTIFICATION

New Delhi, the 24th April, 2018

S.O. 1718 (E).—In exercise of the powers conferred by sub-section (3) of section 1 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 apply to the metropolitan areas as specified in the table below, with effect from the date of publication of this notification in the Official Gazette, namely:—

TABLE

Name of metropolitan area	Name of State
(1)	(2)
Agra	Uttar Pradesh
Meerut	Uttar Pradesh

[F.No. K-14011/2/2018-MRTS-II]

AMBUJ BAJPAI, Under Secy.

अधिसूचना

नई दिल्ली, 24 अप्रैल, 2018

का.आ. 1719(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, एतद्वारा उक्त अधिनियम के उपबंध राजपत्र में इस अधिसूचना के प्रकाशन की तारीख से नीचे दी गई सारणी में यथाविनिर्दिष्ट महानगर क्षेत्र पर लागू करती है, अर्थात्:–

सारणी

महानगर क्षेत्र का नाम	राज्य का नाम
(1)	(2)
आगरा	उत्तर प्रदेश
मेरठ	उत्तर प्रदेश

[फा.सं. के-14011/2/2018-एमआरटीएस-II]

अम्बुज बाजपेयी, अवर सचिव

NOTIFICATION

New Delhi, the 24th April, 2018

S.O. 1719(E).—In exercise of the powers conferred by sub-section (2) of section 1 of the Metro Railways (Operation and Maintenance) Act, 2002 (60 of 2002), the Central Government after consultation with the Government of Uttar Pradesh, hereby extends the provisions of the said Act to the metropolitan areas as specified in the table below, with effect from the date of publication of this notification in the Official Gazette, namely:—

TABLE

Name of metropolitan area	Name of State
(1)	(2)
Agra	Uttar Pradesh
Meerut	Uttar Pradesh

[F.No. K-14011/2/2018-MRTS-II]

AMBUJ BAJPAI, Under Secy.

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