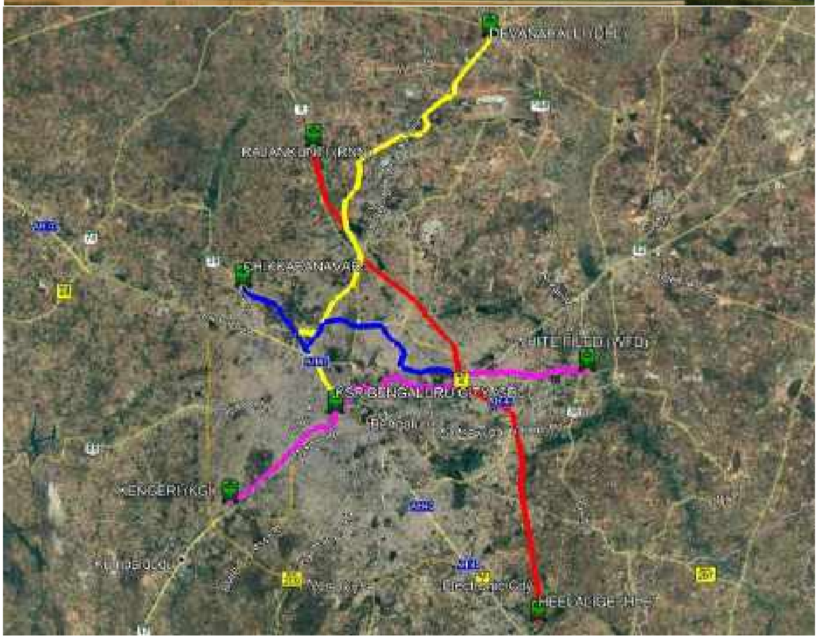
SOUTH WESTERN RAILWAY

FEASIBILITY STUDY FOR BENGALURU SUBURBAN RAIL CORRIDORS



FINAL REPORT

JULY 2019

RITES
THE INFRASTRUCTURE PEOPLE
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PREFACE

The Draft Report of "**Feasibility Study for Bengaluru Elevated/at grade Rail Corridor for Sub-urban Services"** has been prepared after reviewing and examining the Pre-Feasibility Study for Bengaluru Elevated/at grade Rail Corridor for Sub-urban Services submitted in November, 2017. The proposals were first prepared and discussions were held with South Western Railway Officials at frequent intervals including General Manager, Chief Administrative Officer, Divisional Railway Manager, Chief Engineers and other Construction and Divisional Officials.

We would like to thank Chief Administrative Officer and Divisional Railway Manager for having given valuable suggestions in the preparation of this report. We would like to specially thank Sri Amit Garg, Chief Engineer/Construction and Sri Laxman Singh, Dy. Chief Engineer/Central for sparing their valuable time in analysing the alignment proposals prepared by RITES and suggesting improvements in the alignment details during discussion in meeting conducted at various points. The suggestion/opinion raised by the officials also have been considered.

We thank South Western Railway for entrusting this prestigious project to RITES Ltd.

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ABBREVIATIONS		
1	ATO	Automatic Train Operation
2	ATP	Automatic Train Protection
3	ATS	Automatic Train Supervision
4	BBMP	Bruhat Bengaluru Mahanagara Palike
5	BG	Broad Gauge
6	BIAAPA	Bengaluru International Airport Area Planning Authority
7	BLT	Ballastless Track
8	BMTC	Bengaluru Metropolitan Transport Corporation
9	BSRC	Bengaluru Sub-urban Rail Corporation
10	CBI	Computer Based Interlocking
11	CBTC	Communication Based Train Control
12	CMG	Crisis Management Group
13	CMS	Cast Manganese Steel
14	CRS	Commuter Rail Service
15	DEM	Digital Elevation Model
16	DEMU	Diesel Electric Multiple Unit
17	DFMD	Door Frame Metal Detector
18	DMP	Disaster Management Plan
19	DMT	Disaster Management Team
20	EI	Electronic Interlocking
21	EMU	Electric Multiple Unit
22	ENPV	Economic Net Present Value
23	E-W	East-West
24	GCP	Ground Control Point
25	GoK	Government of Karnataka
26	HHMD	Hand Held Metal Detector
27	IPS	Integrated Power Supply
28	IPT	Intermediate Public Transport

ABBREVIATIONS		
29	IR	Indian Railways
30	IRS	
31	LC	Level Crossing
32	MEMU	Mainline Electric Multiple Unit
33	MWM	Malleswaram
34	NCMC	National Crisis Management Committee
35	NDMA	National Disaster Management Authority
36	NMT	Non-Motorized Traffic
37	NPDM	National Policy of Disaster Management
38	N-S	North-South
39	OCC	Operations Control Centre
40	POH	Period Over Hauling
41	ROB	Road Over Bridge
42	RoW	Right of Way
43	RUB	Road Under Bridge
44	RUB	Road Under Bridge
45	SC	Station Controller
46	SDMA	State Disaster Management Authority
47	SEC	State Executive Committee
48	SPV	Special Purpose Vehicle
49	SWR	South Western Railway
50	TC	Train Controller
51	TMDS	Train Management Dispatch System
52	TO	Train Operator
53	TPC	Traction Power Controller
54	TPMS	Traction Power Management System
55	TTMC	Travel and Transit Management Centers
56	ULB	Urban Local Bodies
57	WRU	Wayside Radio Unit

ABBREVIATIONS OF STATIONS		
1	BAND	Banaswadi
2	BAW	Chikkabanavara
3	BNC	Bengaluru Cantonment
4	BNCE	Bengaluru East
5	BWT	Bangarpet
6	BYPL	Baiyyappanahalli
7	CBP	Chikkaballapura
8	CSDR	Channasandra
9	DHL	Devanahalli
10	DMM	Dharmavaram
11	HAS	Hassan
12	HEB	Hebbal
13	HLE	Heelalige
14	HSRA	Hosur
15	JTJ	Jolarpettai
16	KDGH	Kodigehalli
17	KGI	Kengeri
18	KJM	Krishnarajapuram
19	KQZ	Kolar
20	KSR	Kranti Veera Sangolli Rayanna
21	LOGH	Lottegollahalli
22	MWM	Malleswaram
23	NMGA	Nelamangala
24	NYH	Nayandanahalli
25	RNN	Rajana Kunte
26	SA	Salem
27	SBC	Bengaluru City
28	TK	Tumakuru
29	WFD	Whitefield
30	YNK	Yelahanka
31	YPR	Yeshawantapur

ANNEXURE

ANNEXURE

EXECUTIVE SUMMARY FOR THE OBSERVATIONS COMMUNICATED BY RAILWAY BOARD ON FEASIBILITY REPORT

SN	Observations	Remarks
1	Proposed suburban lines should not compete with metro. The suburban lines should be planned to bring people from/to suburban areas of the city and for its development as nodal centres. The core of the city itself should be served by metro/bus etc. Thus the number of suburban stations within the city should be reduced.	Suburban Rail Corridors and number of Stations have been modified to avoid/minimise the overlap between Metro and Suburban Rail System. Some overlap, however considered essential in order to provide continuity of the corridors and to ensure proper integration.
2	Looking at the project contour, it appears that it can be bifurcated into several point to point projects.	The corridors have been revised as discussed with Railways and Government of Karnataka. It is not possible to bifurcate several point-to-point Projects as the ridership, rake requirements etc. are calculated based on the corridors but not based on the point-to-point projects.
3	Considering revised financials with Viability Gap Fund (VGF) and with revised project contours, possibility for implementation of individual point to point projects through PPP should be explored. This should be facilitated by State Government and MoR by offering surplus land parcels or VGF and structure it on revenue sharing basis.	The suburban rail like any infrastructure project requires large capital outlay and resources and have a long gestation period (current project 6 years). The rate of return required by the private sector is typically higher at 14% or more for such projects considering the risks involved. Also, though a private entity is better able to manage the construction risk, the cost of financing in PPP model for a private entity is higher than the cost of financing for the government, therefore, by transferring this risk completely in a PPP mode, the government shall end up paying more to the private entity. Considering the above, it will be more appropriate to enter into an EPC contract for construction in which case the construction risk excluding financing risk is

		transferred to the private entity and the SPV may explore the possibility of private participation in Operations & Maintenance phase post construction of sub urban rail duly ensuring cost-effectiveness of available PPP options. Additionally, the SPV can also employ tools of innovative contracting involving private sector that hold great potential as established with various Metro Rail projects in the country, such as for lifts & escalators, Automatic Fare Collection systems and platform screen doors. A note on possible forms of private participation is provided in Para 11.5 of the report
4	The project financials may be worked out considering the railway land as per applicable lease charge. However, this should be shown separately to facilitate any decision on models of implementation i.e PPP or otherwise in future.	The extent of Railway land required for the project has projected as 327 acres excluding important station areas and the cost of the same has been worked out as Rs. 4876 crores as per the Railway Lease Policy. The same has been indicated separately and not added to the project cost.
5	Fare box revenue shall be planned in a manner that it would meet O&M costs of the project duly comparing the fare prevalent in other modes of transport.	Fare box revenue has been planned to meet the O&M cost duly comparing the fare for the other modes of transport.

0. EXECUTIVE SUMMARY

0.1 INTRODUCTION

BACKGROUND

Bengaluru is the fifth largest metropolis in India and is one of the fastest growing cities in Asia. It is also the capital of Karnataka. It is globally recognized as IT capital of India and also as a well-developed industrial city. The city which was originally developed as a Garden City over the years, slowly transformed into an industrial and software hub of India. Emergence of IT sector has overshadowed other areas of development and has metamorphosed the city into a global hub. The establishment of the IT hubs on the outskirts has converted the city and its surroundings into Silicon Valley of India. It has also caused an urban sprawl around, to some extent lop sided towards south and east.

It has become a commercial, administrative and military centre for the Region because of its salubrious climate and cosmopolitan nature of people. It was also known as pensioner’s paradise with well-developed residential areas, roads with well grown trees, good commercial establishments, shopping malls etc.

The urban infrastructure growth however, is unable to cope up with the expansion of the city resulting in traffic congestion and long commuting time for residents.

To increase the share of public transport in Bengaluru, GoK and Railways had commissioned many studies though RITES Ltd., for introduction of Commuter Rail Services (CRS) in Bengaluru. The studies analysed the existing rail network and suggested improvements / augmentation by way of doubling / quadrupling etc.

However, to run Commuter Rail System in Bengaluru, separate tracks need to be provided, which may involve land acquisition. The land acquisition is generally a costly and time consuming affair and hence, most of the earlier proposals remained non-starter.

Railways have now decided to explore the possibility of introducing / enhancing the Commuter Rail Services in Bengaluru, with minimum land acquisition. Towards this end, Railways entrusted the work of carrying out the Feasibility of running Suburban Rail services along the existing rail network of Bengaluru to RITES Ltd.

PROBLEMS & ISSUES

Bengaluru population has been growing faster. There has been a phenomenal growth in the population of vehicles as well, especially the two and four wheelers in this period due to rising household incomes. In the absence of adequate public transport system, people are using the personalized modes which is not only leading to congestion on limited road network but also increasing environmental pollution. An average citizen of Bengaluru spends more than 240 hours stuck in traffic every year. Such delays result in loss of productivity, reduced air quality, reduced quality of life, and increased costs for services and goods.

The analysis of collected data from primary and secondary sources has brought the following major issues regarding the transport system of Bengaluru.

- Road network capacity is inadequate. Most of the major roads are four lane or less, with limited scope for widening. This indicates the need for judicious use of available road space. The junctions are closely spaced and many junctions in core area are with 5 arms. This makes traffic circulation difficult. There is need to optimise the available capacity by adopting transport system management measures and by making use of intelligent transportation systems.
- Traffic composition on roads indicate very high share of two wheelers and cars. V/C ratios on most of the roads are more than 1. Overall average traffic speed is about 12 Kmph in peak hour. This not only indicates the need for augmenting road capacity but also to plan high capacity mass transport systems on many corridors.
- Outer cordon has high through traffic to the city. This point to the need of road bypasses not only for Bengaluru Metropolitan Area (BMA) but also for Bengaluru Metropolitan Region (BMR). High goods traffic also indicates the need of freight terminals at the periphery of the city.
- Bengaluru is characterised by mutation corridors where residential areas also has commercial activities. In view of this, there is high pedestrian traffic not only in core area but also in other areas of the city. Footpath facilities are generally not adequate and their condition is deteriorating. Therefore up gradation of their facilities is very important. Share of cycle traffic has declined over the years. This mode of transport needs to be promoted by providing cycle tracks along the roads.
- Parking is assuming critical dimensions in Bengaluru. Parking facilities need to be augmented substantially. In the long run, city-wide public transport system is the only option not only to reduce congestion on roads but also to reduce parking demand.

- BMA Master Plan has provided for densification of existing areas, Mutation corridors, hi-tech areas etc. in various parts of the city. This likely to have a major impact on traffic demand. The transport network including mass transport system needs to be planned taking the proposed development in to consideration.
- Major developments have been proposed in the suburban towns of Bengaluru by BMRDA in the BMR. This is likely to increase interaction between Bengaluru and these suburban towns. Thus, there is a need to provide commuter rail services to these towns from Bengaluru.

TRANSPORT DEMAND ANALYSIS

The study area includes Bengaluru Metropolitan Area (BMA area) of about 1306 Sq.km. (including part BMICAPA area – 65.31 Sq.km.) and adjoining areas around Bengaluru International Airport Area Planning Authority (BIAAPA). Adjoining BIAAPA area has been including in the study area as public transport corridors are connecting Kempegowda International Airport and some of the localities where proposed development have been listed out in BIAAPA Master Plan. The horizon year for the study is 2041. The effect of traffic coming from outside Bengaluru and using Bengaluru’s transport system has also been taken into account.

Bengaluru's road network length exceeds 3,000 km and consists of ring roads, arterial roads, sub-arterial roads and residential streets. The city road network is mainly radial, converging in the center. Some of the National Highways and State Highways pass through Bengaluru which also form the radial roads crossing the city.

Bengaluru is an important and a major junction on the South-Western railway network. There are three major railway stations in Bengaluru - City Railway Station, Cantonment Railway Station and Yeshwantpur Railway Station. Bengaluru is served by 5 radial rail corridors**.**

- B.G. line from Chennai on east
- B.G. line from Mumbai-Pune on north-west
- B.G. line from Guntakal on the north
- B.G. line from Salem / Trivandrum from east
- B.G. line from Mysuru from south-west

Bengaluru is served by Rapid transit system called the Namma Metro, being built in stages. At present, Phase 1 covering a length of 43 km on two lines i.e. Mysuru Road to Baiyyappanahalli and Nagasandra to Yelachenahalli. Both the lines are under operation, carrying about 4.4 Lakh passengers per day. The Phase 2, 2A and 2B are under implementation.

Bengaluru is served by Kempegowda International Airport (KIA) located near Devanahalli became operational since May 2008. The Kempegowda International Airport is located north of the City at a distance of 40 Km from the city centre.

The city has very good bus transport systems in the country. BMTC has 40 depots in and around Bengaluru city. The daily ridership is approximately 50 Lakh passengers. BMTC operates 578 City and 1756 Sub-Urban routes per day. BMTC is catering to the transport services in city as well as suburban areas of Bengaluru.

Auto rickshaws and taxis are the Intermediate Public Transport (IPT) facility available in Bengaluru. Apart from the autos, regular small cars (Maruthi Omni vans and Indica diesel cars) and ola cabs as taxis are provided by several operators commonly referred to as City Taxis. The autos are also used for various trips purposes and to a large extent by the visitors to the city.

ZONING SYSTEM

The entire study area has been divided into 198 internal urban & 17 zones of Bengaluru International Airport Area Planning Authority and 10 external traffic zones. The traffic zone system map has been shown in **Figure 0.1** and **Figure 0.2.**

FIGURE 0.1: TRAFFIC ZONE SYSTEM OF BMA

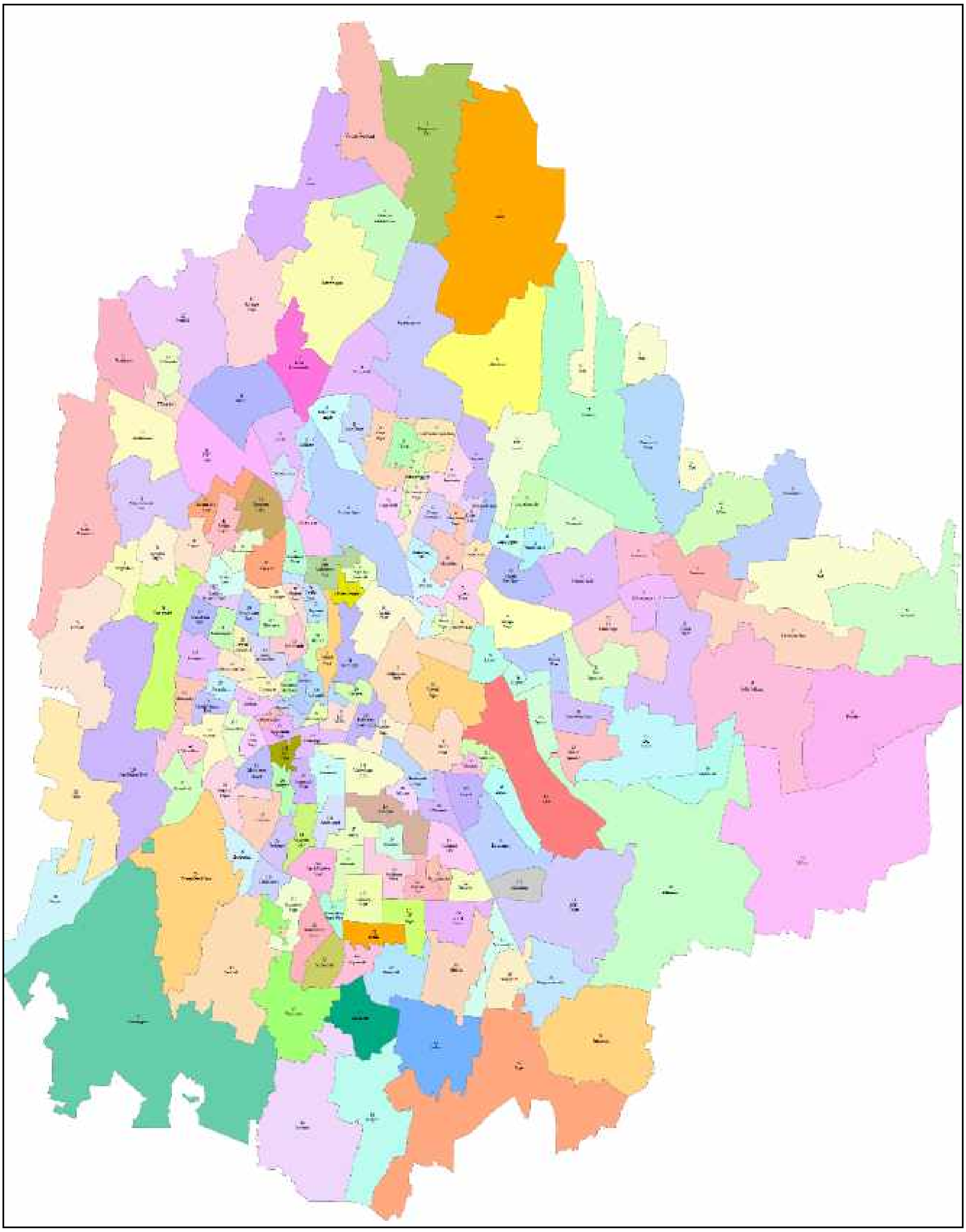
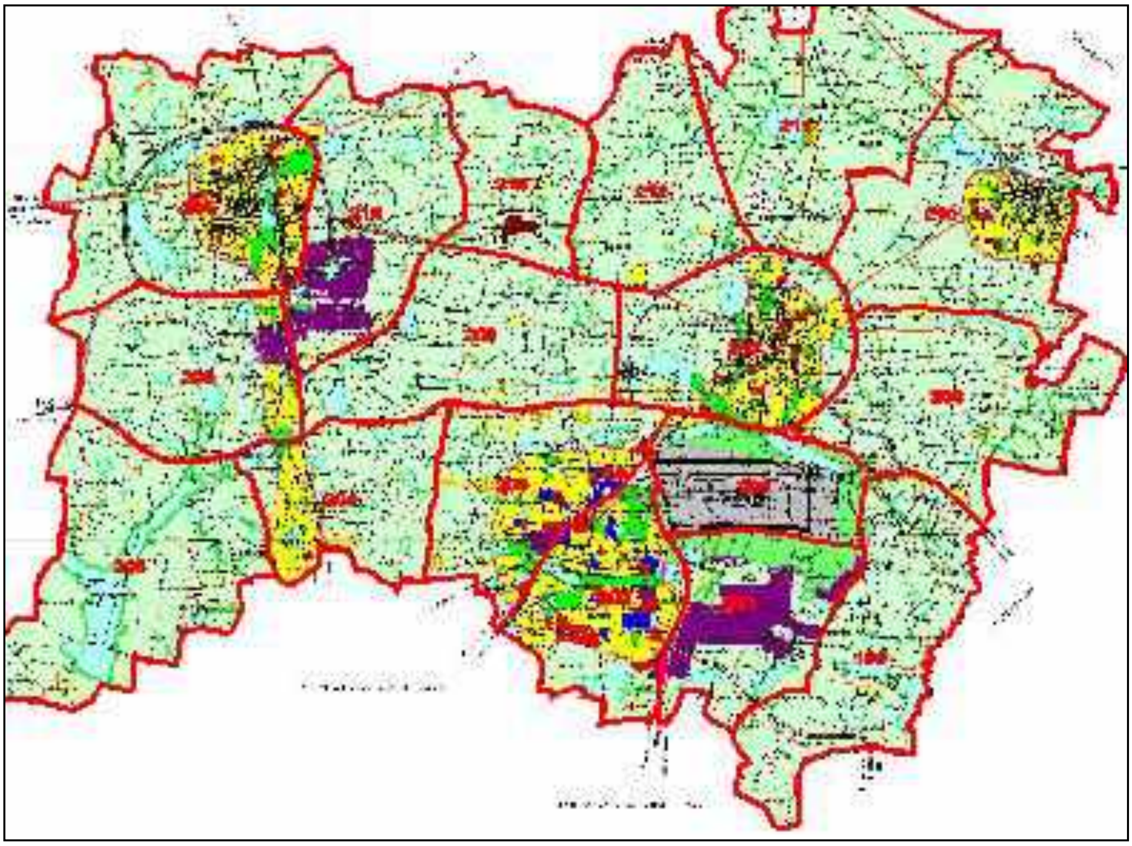


FIGURE 0.2: TRAFFIC ZONE SYSTEM OF BIAAPA



SOCIO-ECONOMIC CHARACTERISTICS

Household surveys indicate that about 8% of the households have upto 2 member and about 16% of the households belong to the category of households which have 5-6 persons per household. Majority of households (75%) have between 3 and 4 persons per households. The average household size is 3.7.

Vehicle Ownership is observed that about 60% of households have 2-Wheeler while 19.6% of household have car and only 2.2% have Cycle.

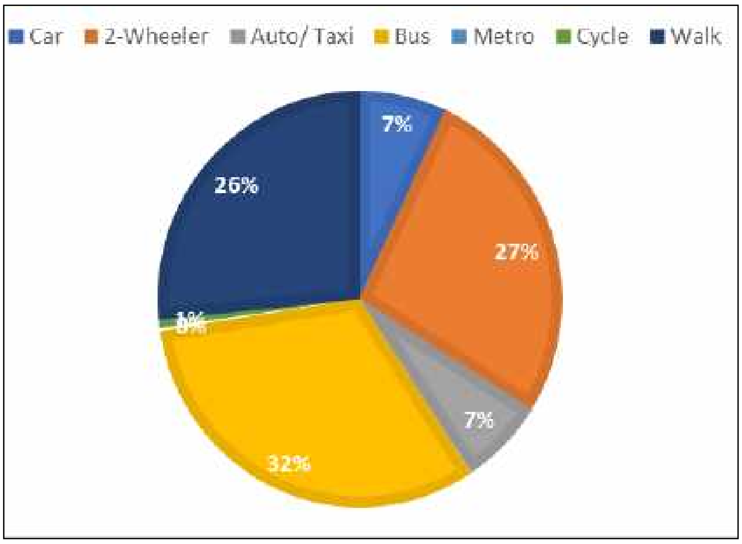
Sampled households according to their occupations, is observed that 38% of individuals are engaged in occupations like (Govt. Service, Pvt. Service & Business). The number of students and housewives is accounted for about 26%.

Individuals of sampled households according to their education, is observed that about 44% of individuals are non-matriculates, matriculates or intermediate (12th) pass. Graduates and post-graduates account for nearly 26%.

TRAVEL CHARACTERISTICS

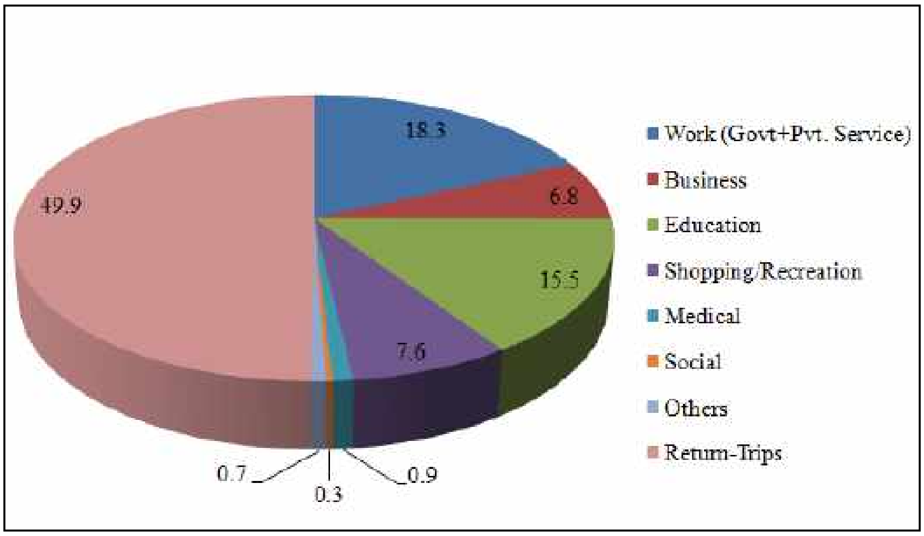
Trips by Mode of Travel observed that about 26% of the trips are walk trips. However, the trips performed by 2 wheelers are about 27% and 32% trips are performed by public transport modes including bus, minibus, school bus, chartered bus and metro. The trips performed by auto rickshaw and taxis are about 7%. Per capita trip rate including walk is 1.24 and for motorized trips is 0.91.

FIGURE 0.3:MODAL SPLIT - 2015 (INCLUDING WALK TRIPS)



Distribution of Trips by Purpose wise is observed that about 25% of the trips are performed for work and business purpose together, where as 15% trips are education and about 10% trips which includes shopping, social, health and recreation.

FIGURE 0.4: PURPOSE WISE DISTRIBUTION OF TOTAL TRIPS



Distribution of Trips by Trip Length is observed that Average trip length for walk is 2.0 Km, for 2-wheeler 8.1 km, for car and taxi is 12.2 km and 12.7 km respectively and for Bus it is about 9.7 km.

Household opinion survey was carried out to obtain preference of commuters about shifting to good public transport system. About 96% of respondent households are willing to shift to a good public transport system where as about 4% of households want to use their existing mode of travel.

A total of 198 internal zones & 17 zones of Bengaluru International Airport Area Planning Authority and 10 external zones have been considered for the Study. The study area population as per the census of India the population of Bengaluru city is about 84.5 lakh and BIAAPA Area population is about 5 lakhs in 2011. The total population of Study Area is about120 Lakh in 2018.

A four stage travel demand model has been developed for transport demand forecasting. Total Daily ridership on the Sub Urban Rail System corridors for the years 2025, 2031 and 2041 is expected to be 9.84 Lakh, 13.41 Lakh and 17.60 Lakh passengers respectively **(TABLE 0.1).**The Peak Hour Section loads are presented in **TABLE 0.2.**

TABLE 0.1: DAILY TRIPS ON SUB-URBAN RAIL SYSTEM

S No.	Corridor Name	Daily Trips		
		2025	**2031**	**2041**
1	KSR Bengaluru City - Devanahalli	282154	378901	536046
2	Baiyyappanahalli Terminal - Chikkabanavara	203317	266316	341561
3	Kengeri - White Field	164180	219644	271906
4	Heelalige - Rajankunte	334724	476304	611005
Total Daily Trips		**9,84,374**	**13,41,165**	**17,60,518**

TABLE 0.2: MAXIMUM SECTION LOADING (PHPDT) ON SUB-URBAN RAIL SYSTEM

S No.	Corridor Name	Maximum Section Load (PHPDT)		
		2025	**2031**	**2041**
1	KSR Bengaluru City - Devanahalli	11775	13750	19135
2	Baiyyappanahalli Terminal - Chikkabanavara	9009	10923	13858

S No.	Corridor Name	Maximum Section Load (PHPDT)		
		2025	2031	2041
3	Kengeri - White Field	6442	7951	10289
4	Heelalige - Rajankunte	7646	11919	13527

GROUND SURVEY AND ALIGNMENT

ENGINEERING SURVEY

The drone base aerial survey has been conducted to ascertain the existing infrastructure and constraints all along the existing railway boundary of the study area.

Four independent corridors have been studied as part of this assignment and survey has been done for the complete length.

Corridor – 1 : KSR Bengaluru City to Devanahalli
Corridor – 2 : Baiyyappanahalli Terminal to Chikkabanavara
Corridor – 3 : Kengeri to Whitefield (via KSR and Cantonment)
Corridor – 4 : Heelalige to Rajankunte

The Ground Control Point (GCP)of known coordinates have been established with traditional surveying methods or have been obtained from other sources (LiDAR, older maps of the area, Web Map Service) as they significantly increase the absolute accuracy of the data collected. The minimum number of GCPs required for this project has been considered and accordingly the GCP's have been marked on ground at appropriate locations. The total GCPs marked on ground are of 644 numbers at an approximately 4 GCPs per Km length.

Drone was flown over the corridors length according to the flight path and acquired the images through photo chromatic camera withPix4Dcapture software using grid option.

Image Processing and Ortho- rectification has been done Pre-Processing and artho rectification of imagery and pre-processing of acquired Images by way of digital surface models, digital terrain model generation and Ortho-Rectification of satellite Images.

MAJOR CONSTRAINTS

There are serious space constraints within railway ROW for laying additional tracks. There are number of private buildings at edge of the railway boundary on Kengeri-K.S.R Bengaluru City, also from Ch: 354.900 to 355.150on KSR Bengaluru City - Cantonment corridor. At some of the places temples are constructed either in railway boundary or adjacent to railway boundaries on Kengeri - KSR Bengaluru City section and Hebbal - Banaswadi section corridors.

PLANNING AND DESIGN NORMS

Salient features of planning and design norms are given in the table below:

TABLE 0.3: SALIENT FEATURES OF PLANNING AND DESIGN NORMS

S.No.	ITEM DESCRIPTION	SALIENT FEATURES
1	Tracks	BG Tracks (1676mm)
2	Centre to Centre Spacing of existing IR tracks at-Grade	5.30m
3	Centre to Centre Spacing of Proposed tracks in elevated structure	4.725m
4	Width of Proposed Viaduct	10.9m for two tracks
5	Distance of Proposed At-grade nearest Sub urban track from centre line of nearest IR track	7.8m
6	Distance of Proposed Centre line of viaduct from Centre line of nearest IR track	8.5m
7	Design Speed	90 Kmph
8	Types of track proposed	(a) Ballast-less track for elevated structure.
		(b) Ballast cushion of 350mm for At-Grade track
9	Horizontal Curves	Minimum radius of 200mm for at-grade/elevated
10	Radius of curves	1000m at stations
11	Cant Deficiency	Not to exceed 100mm
12	Actual Cant	Not to exceed 125mm
13	Vertical Curves	(a) Radius of vertical curve is 3000m (normal circumstances) & 2500m in exceptional circumstances
		(b) Minimum length shall be 20m

S.No.	ITEM DESCRIPTION	SALIENT FEATURES
14	Gradient	(a) Elevated station -Level (or) 1 in 1000, At-Grade – Existing grade
		(b) At mid sections - Not Steeper than 2 % (May be 3% for elevated section in exceptional situation)
		(c) At par with existing IR tracks in mid locations at grade
15	Turnouts/Crossovers	(a) Main lines/ other running lines 1 in 12
		(b) Depot/Yard lines 1 in 8.5
16	Depot Yards	(a) Lines are normally flat/level in yards , may not be steeper than 1 in 1200
		(b) Curves in yards shall have radii not less than 175mm
		(c) Stabling lines shall have clear standing length of 350m for one rake length

PROPOSED ALIGNMENT

Corridor – 1: KSR Bengaluru City to Devanahalli:
Total Length is 41.40 Kms out of which Elevated is 18.98 Km and At Grade is 22.42 Kms. Stations on Corridor 1 are Fifteen (15) out of which Eight (8) Stations are elevated including one future station at Srirampura and Seven (7) Stations are At Grade.

Corridor – 2: Baiyyappanahalli Terminal to Chikkabanavara:
Total Length is 25.01 Kms out of which Elevated is 12.905 Kms and At Grade is 12.105 Kms. Stations on Corridor 2 are Fourteen (14), out of which Eight (08) Stations are At Grade including one future station at Jalahalli and Six (06) Stations are elevated. Lottegollahalli station is at L-2 and is an Inter-change station.

Corridor – 3: Kengeri to Whitefield:
Total Length is 35.52 Kms out of which the suburban corridor considered for the present study is only between Kengeri and KSR Bengaluru – Bengaluru Cantonment. The length of this section between Kengeri and Bengaluru Cantt is 18.47 Kms. The stretch of 17.05 Kms between Bengaluru Cantonment and Whitefield is being taken up by SWR for quadrupling. Once this is completed and becomes operational, two lines of the same shall be utilized for the Suburban services. Stations on C-3 are Nine (9) out of which four (04) Stations are elevated and five (05) Stations are At-Grade including one future station at RV College and five (05) stations are in quadrupling section.

Corridor – 4:Heelalige to Rajankunte:

Total Length is 46.24 Kms out of which Elevated is 13.29 Kms, At Grade is 32.95 Kms. Stations on C-4 are Nineteen (19) out of which Four (4) Stations are elevated and Fifteen (15) Stations are At Grade including two future stations at Bommasandra and Kaveri Nagar. Yelahanka is an inter-change station.

TABLE 0.4: SALIENT FEATURES OF ALIGNMENT

S.No	ITEM DESCRIPTION	SALIENT FEATURES
1	Alignment	(a) Proposed along parallel to existing IR tracks.
		(b) Proposed within Railway ROW to minimize the private land acquisition.
2	Crossings	Bare minimum crossing proposed to reduce cost & avoid disturbances to train operations of IR.
3	Height of Deck	15.0m to be maintained above existing rail level.
4	Thickness of Elevated Deck Girder	Varies from 2.45m to 2.75m (based on span design)

TABLE 0.5: SALIENT FEATURES OF CORRIDORS

S. NO	ITEM DESCRIPTION	CORRIDOR 1	CORRIDOR 2	CORRIDOR 3		CORRIDOR 4
		KSR Bengaluru City to Devanahalli	Baiyyappanahalli Terminal to Chikkabanavara	Kengeri to Cantonment	Cantonment to Whitefield	Heelalige to Rajankunte
1.	Length of corridor (Km)	41.40	25.01	18.47	17.05	46.24
2.	Length of elevated section (Km)	18.98	12.905	10.40	-	13.29
3.	Length of At-Grade section (Km)	22.42	12.105	8.07	17.05	32.95
4.	Number of stations	15	14	9	5	19

S. NO	ITEM DESCRIPTION	CORRIDOR 1	CORRIDOR 2	CORRIDOR 3		CORRIDOR 4
		KSR Bengaluru City to Devanahalli	Baiyyappanahalli Terminal to Chikkabanavara	Kengeri to Cantonment	Cantonment to Whitefield	Heelalige to Rajankunte
5.	No. of Elevated stations	8 (including one future station)	6	4	-	4
6.	No. of At-Grade stations	7	8 (including one future station)	5 (including one future station)	5	15 (including two future stations)
7.	No. of stations repeated	1 (with corridor 3)	2 (with corridor 1)	0	-	1 (with corridor 1)
8.	No. of Interchange stations	3	2	1	-	1
9.	No. of Existing ROB on the corridor	10	6	3	-	10
10.	No. of Existing FOB on the corridor	6	2	5	5	4
11.	No. of Existing LCs on the corridor	10	11	3	3	14
12.	No. of LCs' under sanction for RUB/ROB	1	2	1		2
13.	No. of Existing LCs to be eliminated in At-Grade locations	6	5	1	Quadrupling section	11
14.	No. of LCs where Suburban track is elevated	3	4	1		1
15.	Land to be acquired (Vacant + Built-up) (Acres)	12.10	28.59	20.71	-	40.28

Note: On Corridor – 3, the stretch of Bengaluru Cantonment to Whitefield of 17.05 Kms is not taken for the study since Quadrupling is in progress and on completion the same will be merged with Suburban system. However, 5 stations are identified on this stretch and all the 5 are existing stations.

The Private open land of about 28.64 hectares and Private Built-up land of about 12.52 hectares will have to be acquired for implementation of the project. The total Railway land required is about 132.30 hectares.

UTILITIES

- A large number of sub-surface, surface and over-head utility services viz. sewers, water mains, storm water drains, gas pipe lines, telephone/ communication cables, overhead power transmission lines, power cables, traffic signals, etc. exist all along the proposed alignment.
- Apart from the above utilities, South Western Railway's huge network of Traction Power cables, Traction Power Installations, DC and AC traction substations, SPs and SSPs, Signal & Telecommunication cables, traction OHE masts and structures, Signal posts, power supply cubicles, location boxes etc. are spread along and across the entire alignment.
- The proposed corridors have been planned within Railway's ROW and the some of the utility services and Railways vital installations are encountered at a number of locations.
- These utility services are essential and have to be maintained in working condition 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 sensitive Sub-urban services and direct impact on the commuters, besides setback in construction and project implementation schedule.

Concerned Organizations/ Departments

The data on various utilities has been collected from following organisations **(Table 0.6).**

TABLE 0.6: ORGANISATION/ DEPARTMENT RESPONSIBLE FOR UTILITIES

S.No.	ORGANIZATION/ DEPARTMENT	UTILITY SERVICES
1.	BESCOM	Underground Electrical cables
2.	Vodafone	OFC cables Including Telecom cables.
3.	Defence	Other cables including telecom cables.
4.	BWSSB	Storm water drainages, Water Pipe Lines
5.	Gail (Gas Pipe)	Gas or Oil Pipe lines.
6.	KPTCL	UG Cables Electrical cables, H.V power transmission Lines
7.	Reliance Jio Infocom	OFC cables Including Telecom cables.
8.	BSNL	OFC cables Including Telecom cables.

STATION PLANNING

STATION PLANNING

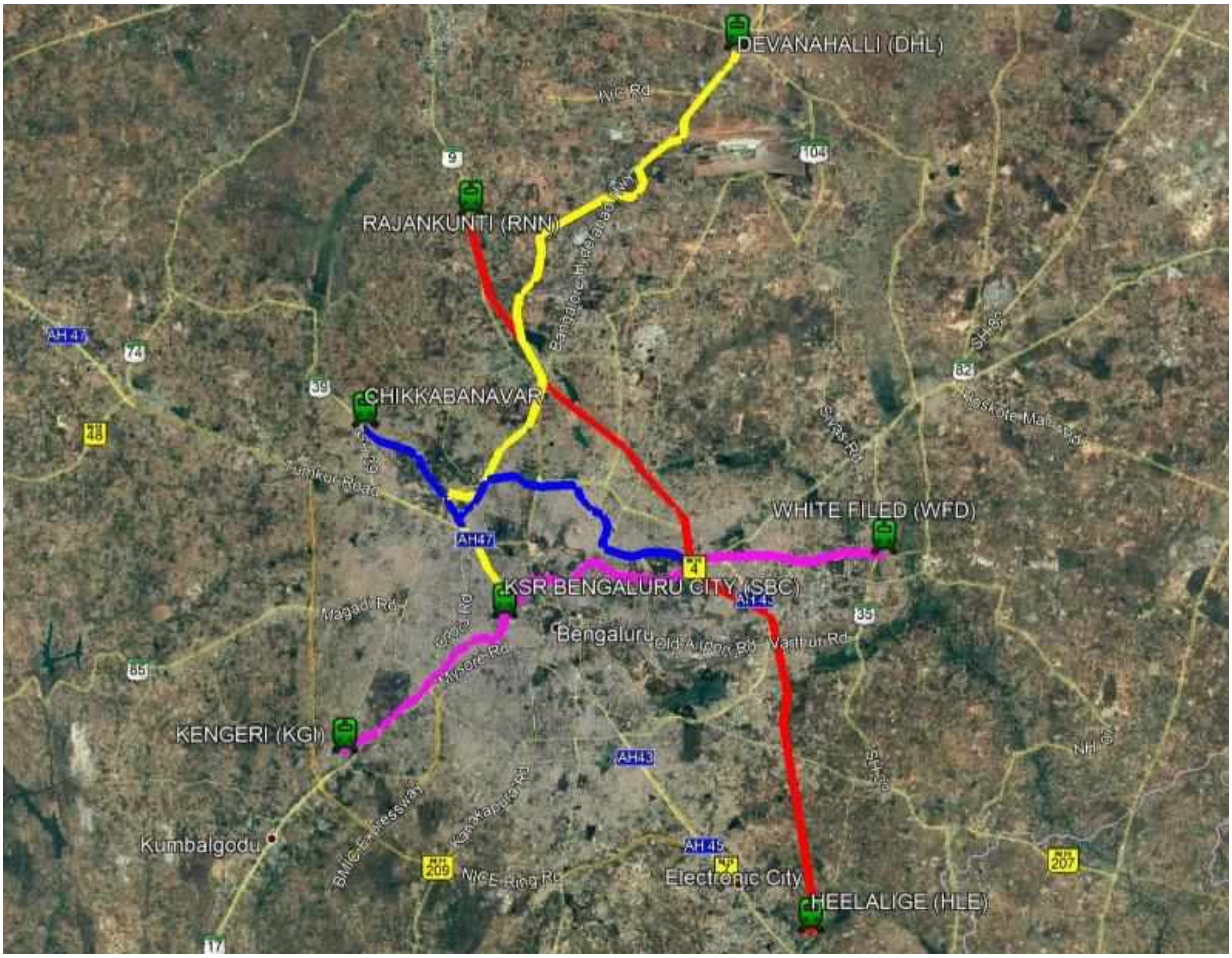
Out of 62 stations, 6 typical stations of different categories have been identified for planning and intermodal integration **(Table 0.7).**

TABLE 0.7: DETAILS OF TEN IDENTIFIED STATIONS

S. No.	Name of the station	Corridor Name	Interchange Type	Platform Type (Proposed)
1.	Kengeri Station	Kengeri – White Field	Rail - Metro	Two side platform (Elevated)
2.	Bengaluru City Station (SBC)	Kengeri – White Field and Bengaluru City - Rajankunte	Rail – Rail and Rail - Metro	Two side and one Island platform (Elevated)
3.	Bengaluru Cantonment (BNC)	Kengeri – White Field	-	Two side platform (Elevated) on curve
4.	Lottegollahalli	Bengaluru City to Devanahalli &Chikkabanavara to Baiyyappanahalli	Rail - Rail	Two side platforms (Elevated) on two levels (i.e. four tracks are crossing)
5.	Muthyalanagar	Bengaluru City – Yelahanka - Devanahalli	-	Two side platform (Elevated)
6.	Chikkabanavara	Chikkabanavara – Yeshwantpur - Baiyyappanahalli	Bus/IPT	Two side platform (Elevated)

These corridors are presented in **FIGURE 0.5**

FIGURE 0.5: PROPOSED SUBURBAN RAIL CORRIDORS IN BENGALURU



SALIENT FEATURES OF A TYPICAL STATION

1. The stations are divided into public and non-public areas (those areas where access is restricted). The public areas are further subdivided into paid and unpaid areas.
2. The platform level has adequate assembly space for passengers for both normal operating conditions and a recognized abnormal scenario.
3. The platform level in elevated stations is about 15m, and upto 21 m above ground level.
4. The concourse contains automatic fare collection system in a manner that divides the concourse into distinct areas. The 'unpaid area' is where passengers gain access to the system, obtain travel information and purchase tickets. On passing through the ticket gates, the passenger enters the 'paid area', which includes access to the platforms.

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

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

7. Station entrances are located with particular reference to passenger catchment points and physical site constraints.

8. Office accommodation, operational areas and plant room space is required in the non-public areas at each station. The system is being designed to maximize its attraction to potential passengers and the following criteria have been observed:

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

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

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

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

11. Following requirements have been taken into account:

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

- Provision of display of passenger information and advertising.

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

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

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

CONCEPTUAL PLANNING FOR SELECTED TYPICAL STATIONS

The block plans indicating the proposed layouts and configuration of representative stations w.r.t. the existing sub-urban system and surrounding urban development are presented in the following paragraphs.

KENGERI STATION

This is the first elevated suburban station of corridor Kengeri to White Field and has two side platform. The overall size of the station is 205m x 26m. At Northern side, it has two entry/exit, parallel to the station and approach from ground to concourse level. At Southern side one entry/exit placed in open space on ground, parallel to the station. At Southern side a connection with existing FOB is shown at unpaid concourse area. The station has two unpaid and one paid area at concourse level. The elevated station is on portal frame.

FIGURE 0.6: KENGERI SUBURBAN STATION (CONCOURSE LEVEL PLAN)

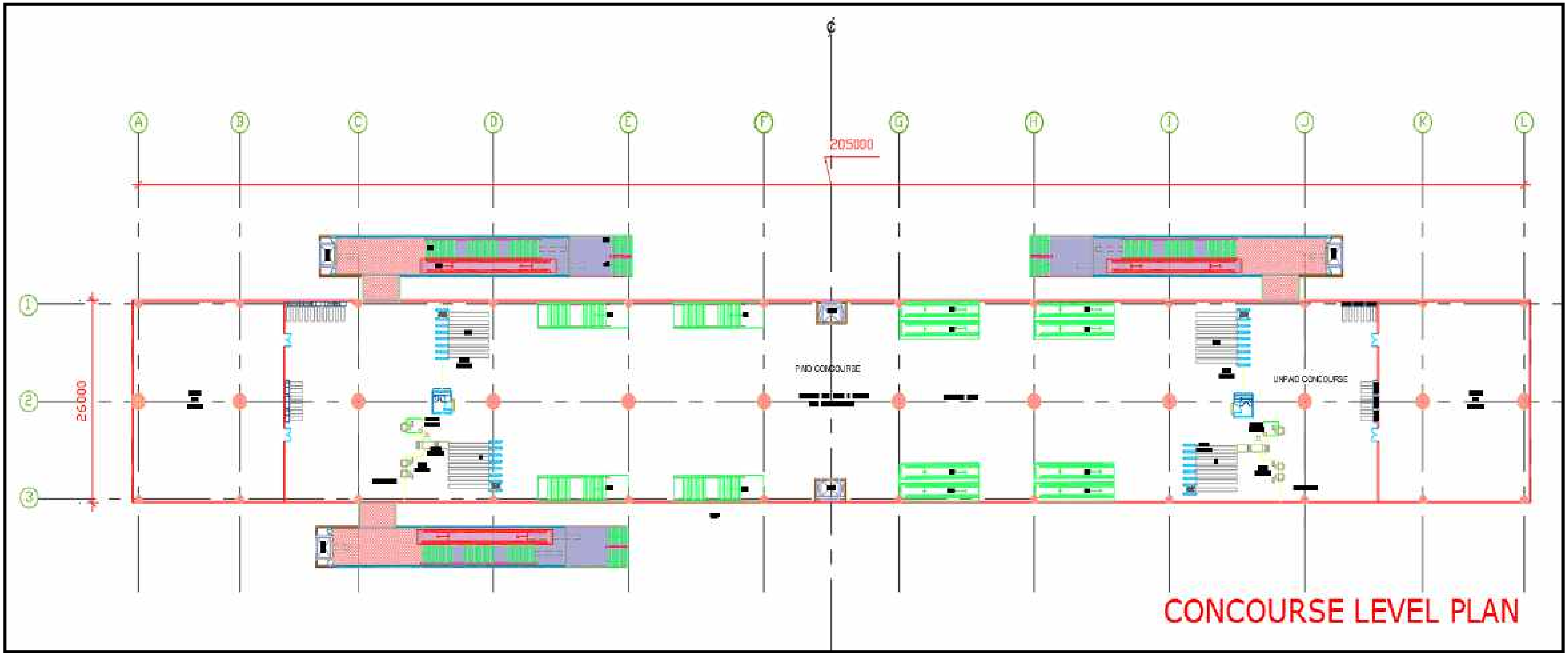


FIGURE 0.7 KENGERI SUBURBAN STATION (PLATFORM LEVEL PLAN)

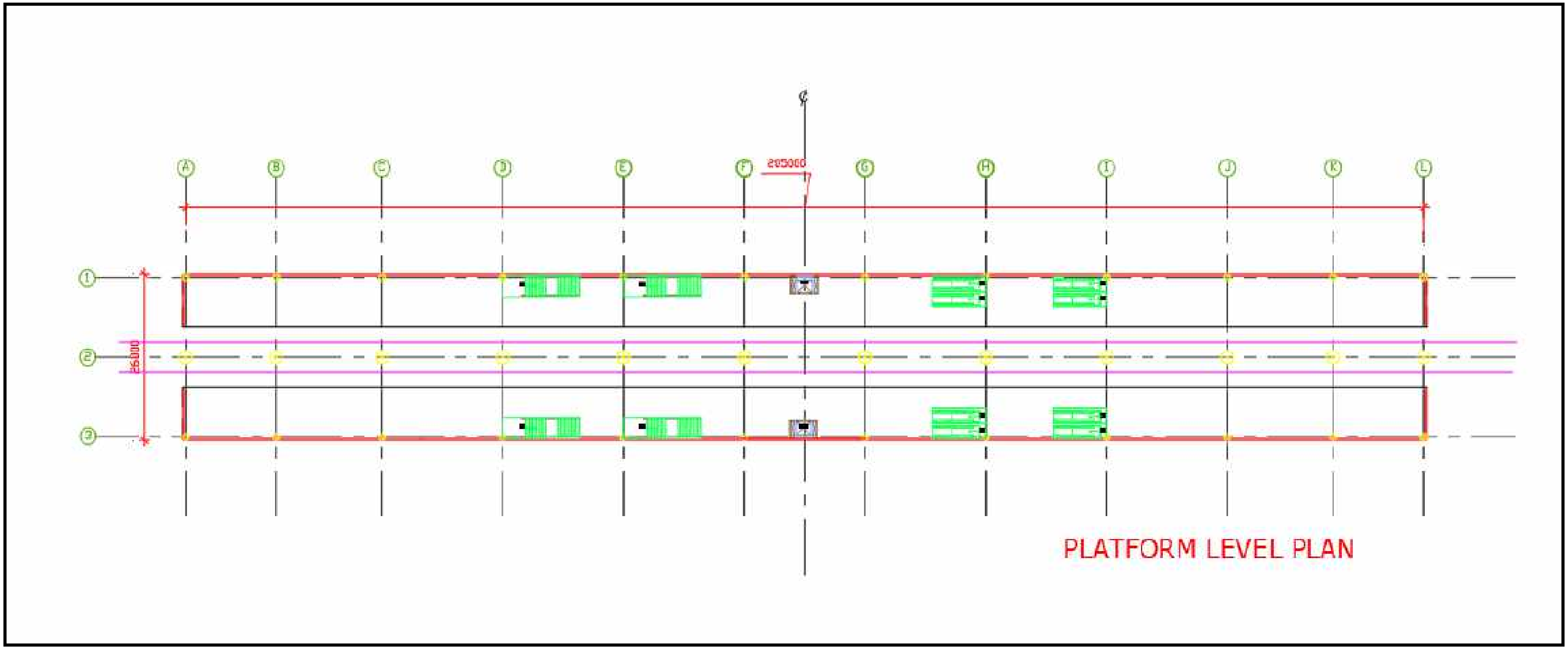


FIGURE 0.8: KENGERI SUBURBAN STATION (CROSS-SECTION)

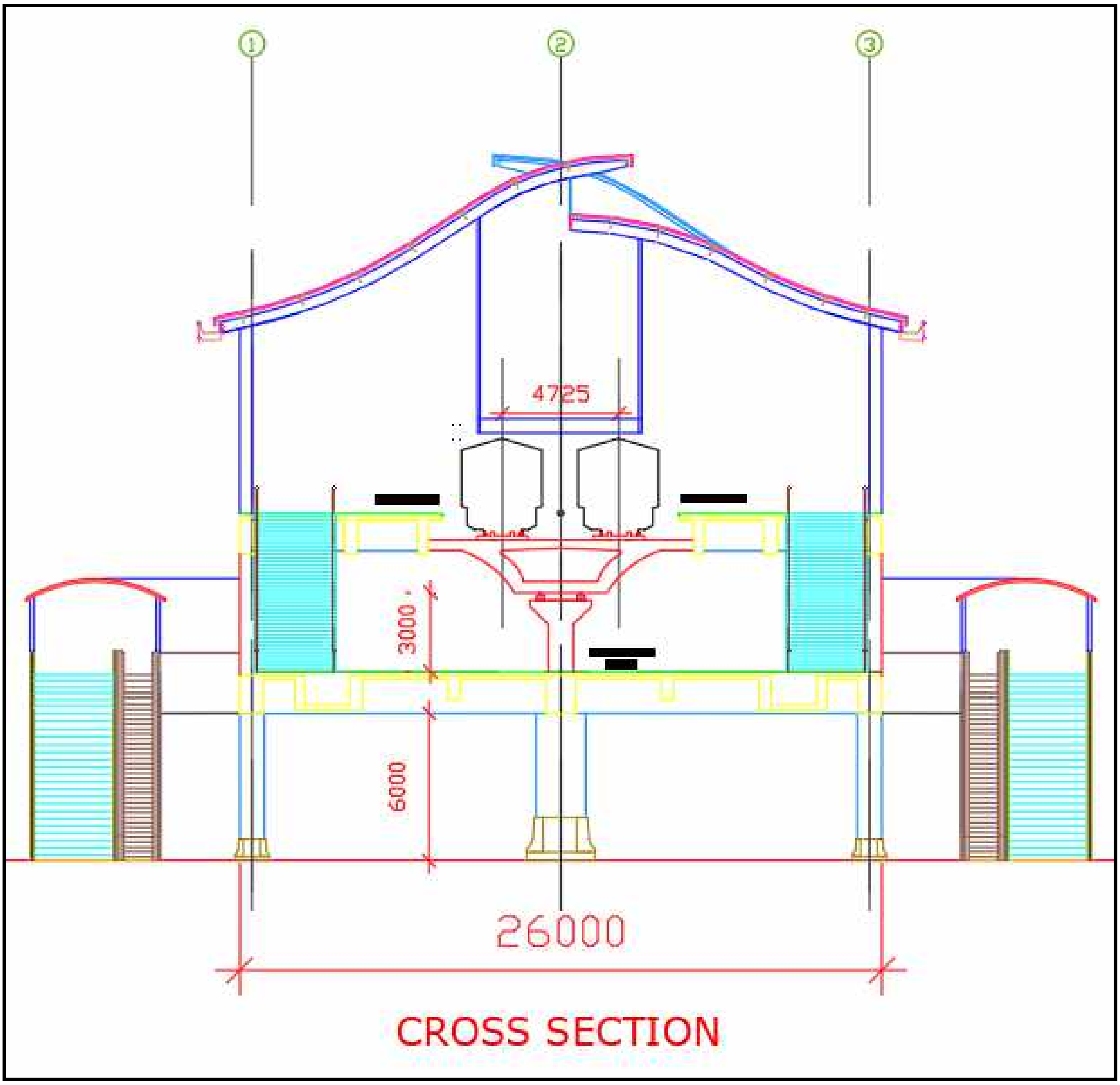
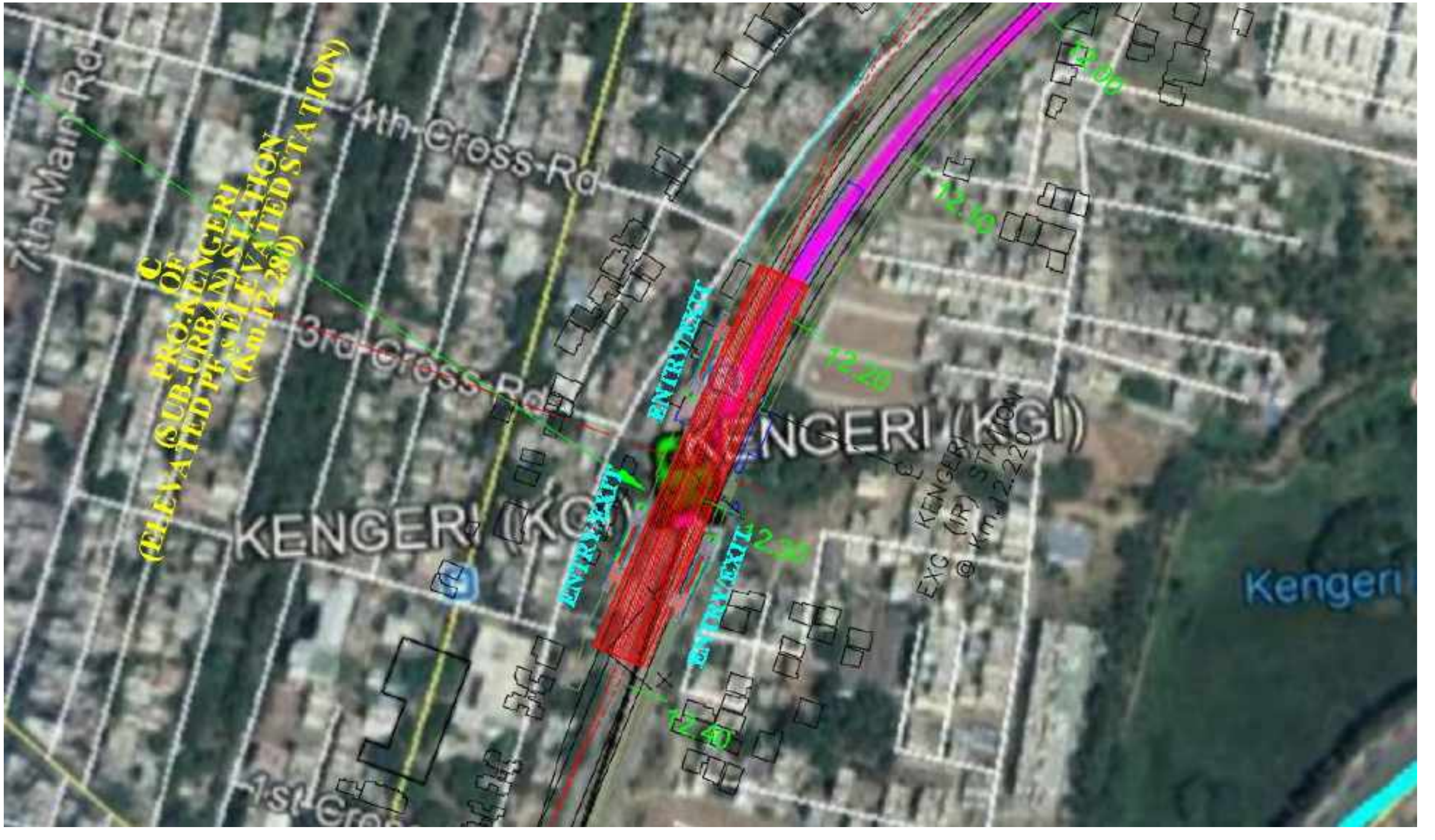


FIGURE 0.9: PROPOSED KENGERI SUBURBAN STATION ON SITE



KSR BENGALURU CITY STATION

There are two sides and one island platform for this proposed elevated station are planned for four lines. At this location, two lines are for Bengaluru City to Rajankunte corridor and two lines are for Kengeri to White Field. The length of the station is taken as 205m. One entry/exit at Northern side is placed to access passengers from left side and also passengers from Metro station. Southern side connectivity shall be placed at suitable place either outside of the existing station or on a suitable platform i.e. first platform of the existing station. Centre connectivity will be with existing FOB. Another connectivity will be with existing FOB some distance away from the station building.

BENGALURU CANTONMENT STATION

Bengaluru Cantonment is existing station of Kengeri to White Field corridor. The proposed station is slightly away from existing one. It is in curve. The proposed station is elevated, concourse is at first level and two side platforms at second level. Front side connectivity is from ground but another side connectivity is through proposed FOB. One side it connect with existing Bengaluru Cantonment station and another side it may be connect with future FOB.

LOTTEGOLLAHALLI STATION

This station has connectivity of two corridors Bengaluru City to Devanahalli &Chikkabanavara to Baiyyappanahalli. Lottegollahalli Station is a three level elevated station. First level concourse, 2nd level two side platforms and again 3rd level another two side platforms are proposed here. The Land and property acquisition will required for construction of this station and its entry/exit.

MUTHYALANAGAR STATION

The station is on corridor Bengaluru City – Yelahanka – Devanahalliand it is a proposed station. The station has two side platform. The overall size of the station is 205m x 26m. At Northern side, it has two entry/exit, parallel to the station and approach from ground to concourse level. At Southern side one entry/exit placed in open space on ground. The station has two unpaid and one paid area at concourse level. The elevated station is on portal frame.

CHIKKABANAVARA STATION

This is the elevated suburban station of corridorChikkabanavara – Yeshwantpur - Baiyyappanahalli. The station has two side platform. The overall size of the station is 205m x 26m. At Northern side, it has two entry/exit, parallel to the station and approach from ground to concourse level. At Southern side, it has one entry/exit parallel to the station. The station has two unpaid and one paid area at concourse level. The elevated station is on portal frame.

FIGURE 0.10: PROPOSED BENGALURU CITY STATION (SBC) ON SITE

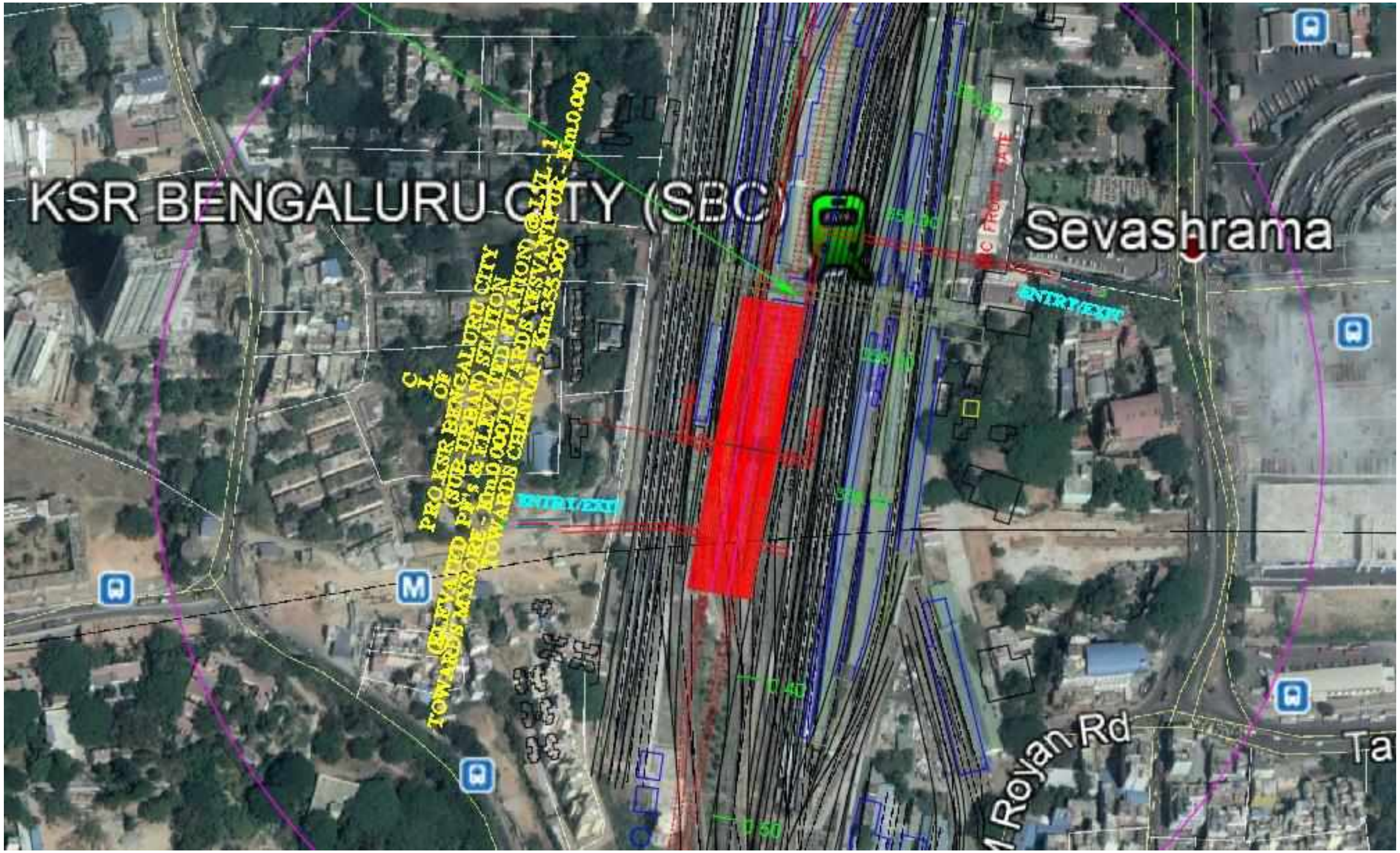


FIGURE 0.11: PROPOSED BENGALURU CANTONMENT STATION ON SITE

FIGURE 0.12 : PROPOSED LOTTEGOLLAHALLI STATION ON SITE

FIGURE 0.13 : PROPOSED MUTHYALANAGAR STATION ON SITE

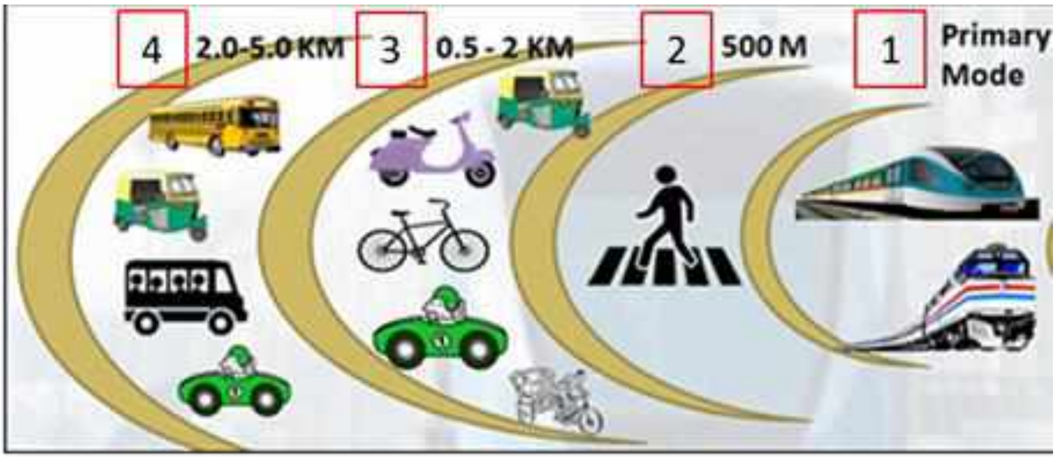
FIGURE 0.14 : PROPOSED CHIKKABANAVARA STATION ON SITE

INTERMODAL INTEGRATION AND DISPERSAL FACILITIES

Intermodal Integration is planned to provide first and last mile connectivity for commuters. A public transit system will be able to function seamlessly if there is intermodal integration. The suburban rail network will have to be provided with enhanced convenience of interchanging facility with other transport modes for better mobility and reduction in travel time for commuters. Interchange facility with secondary/intermediate transport modes is important for seamless transfer of commuters.

The preferable mode choice to be opted for access/dispersal to/from the nearest station to the surrounding neighborhood can be classified based on the distance of catchment from the station area (**Figure 0.15**).

FIGURE 0.15: INTERMODAL INTEGRATION WITH DIFFERENT MODES



PRINCIPLES OF INTEGRATION

The planning principles taken into account for intermodal integration at the station locations are as follows:

- Seamless connectivity to and from catchment area of the station - Passenger movement from the station area to the nearby land-use to be seamless i.e. obstruction free movement.
- Integration with all possible modes including other mass transport systems - The transit system is to be well integrated with other transit modes, PT modes, IPT modes, private modes and walk.
- There should be an integrated ticketing system to simplify the transfer between different transport modes. Smart Card ticketing facilitates a genuinely seamless multimodal transport system.

- Priority to pedestrians followed by public transport - To provide convenient and safe access to pedestrians to the station area and vicinity and to promote walkability.
- Minimizing pedestrian/vehicle conflict - Proper design of circulation area adjoining the station building to ensure rapid/ efficient dispersal of the passengers and avoiding conflicts between pedestrian and vehicular traffic.
- Provision of pick/drop and parking facilities for all modes- Station area with adequate parking space, designated space for embarking and disembarking for vehicular traffic (pick-drop zones) and feeder modes like bus, IPTs and NMT.
- Disabled friendly design considerations.

PROPOSED SUBURBAN RAIL CORRIDORS

Proposed Bengaluru Suburban Rail Network has four corridors with total length of 147 Km. Out of 62 stations, 6 typical stations of different categories have been identified for intermodal integration. The details of identified stations are presented in **Table 0.8**.

TABLE 0.8: DETAILS OF IDENTIFIED STATIONS FOR INTERMODAL INTEGRATION

S. NO.	STATION NAME	CORRIDOR NAME	INTERCHANGE TYPE
1	Kengeri Station	Kengeri - Whitefield	Rail - Metro
2	KSR Bengaluru City Station	Kengeri - Whitefield and KSR Bengaluru City - Devanahalli	Rail-Rail & Rail - Metro
3	Bengaluru Cantonment Station	Kengeri - Whitefield	-
4	Lottegollahalli Station	KSR Bengaluru City - Devanahalli and Chikkabanavara - Baiyyappanahalli	Rail-Rail
5	Muthyalanagar	KSR Bengaluru City - Devanahalli	-
6	Chikkabanavara	Chikkabanavara - Baiyyappanahalli	

EXISTING TRAFFIC DISPERSAL ARRANGEMENTS

It is observed that apart from the walk, Buses and IPTs in the form of autos/ taxis are the other modes of traffic dispersal. Private vehicles and drop-offs also form a significant component of the feeder trips. The summary of common issues identified at all four stations, are presented below:

- For most of the stations, good connectivity has been provided from one side only. There is either no connectivity or poor connectivity from other side.

- On-street parking of private vehicles and autos is observed on the carriageway and footpath of the main access road which reduces the carriageway capacity.
- An encroachment is also observed on the main carriageway.
- Pick drop of Autos and taxis is occurred on the access road. There is no segregation of pick drop.
- At grade pedestrian crossing to reach the station from car parking area increases the pedestrian vehicular conflicts.

PROPOSED TRAFFIC DISPERSAL AND CIRCULATION PLANS

The conceptual intermodal integration proposals have been formulated for facilitating traffic dispersal and circulation facilities based on the following considerations:

- Proper design of circulation area adjoining the station building to ensure rapid/ efficient dispersal of the passengers and avoiding conflicts between pedestrian and vehicular traffic.
- Facilitating passenger interchange with other transit systems
- Provision of FOBs and skywalks to reduce the passenger travel time and pedestrian load on the roads
- Circulation area with adequate parking space, designated space for pick-drop zones and feeder modes like Buses and IPTs.

The station wise intermodal integration proposals are presented in subsequent paragraphs.

KENGERI STATION

- Pick drop and parking of autos and private vehicles has been proposed on the existing 2 wheeler parking area.
- One way movement of vehicles has been proposed to reach the station
- Pick drop bays have been provided in front of the station building. Parking for private vehicles has been proposed on the vacant land in front of the station building
- The station has been proposed to be integrated with metro station and bus terminal.

KSR BENGALURU CITY STATION

- The pick drop bays for private vehicles (cars & two wheelers), Auto and taxis have been provided in addition to parking

- The minor road with 9m width has been proposed to be connected to the main road (Old Mysore Road) to provide connectivity to the station from west side
- Parking area has been proposed on the existing railway ground due to unavailability of space.
- There is an existing skywalk which connects the metro station with bus terminal. It has been proposed to extend this skywalk to connect the station FOB.

BENGALURU CANTONMENT STATION

- Existing parking area given towards south side of the station has been retained as parking area for cars
- The pick drop bays for cars, autos and taxis has been proposed to be given in front of the station building along with bus bay
- Auto and Taxi Stand has also been proposed along with parking for two wheelers
- Since car parking is given on other side of the road so the existing FOB has been proposed to be extended to parking area.

LOTTEGOLLAHALLI STATION

- Vehicular and pedestrian access has been proposed on the west side. The access has been proposed to be given from the Outer Ring Road with pick and drop and parking for private vehicles.
- The south side entries of the station have been proposed to be connected with new BEL road through pedestrian walkways.

MUTHYALANAGAR STATION

- Only pick drop and auto/ taxi stand has been proposed on the east side of the station due to space constraints.
- On the west side, the pick drop and auto/taxi stand along with parking have been proposed over the vacant land abutting the railway track.
- The pedestrian walkway has been proposed adjacent to the existing underpass to access the station entry.

CHIKKABANAVARA STATION

- East side road has been proposed to be strengthened. Only pick drop and auto stand has been proposed on the east side due to space constraints.
- The access road on west side is proposed to be widened to 9 m.
- The pick drops, auto/ taxi stand, car & 2 wheeler parking have been proposed on the vacant land near the station on west side. In addition, bus bay has been proposed on Hesaragatta Main Road.

FIGURE 0.16: CONCEPTUAL INTERMODAL INTEGRATION PLAN AT LOTTEGOLLAHALLI STATION

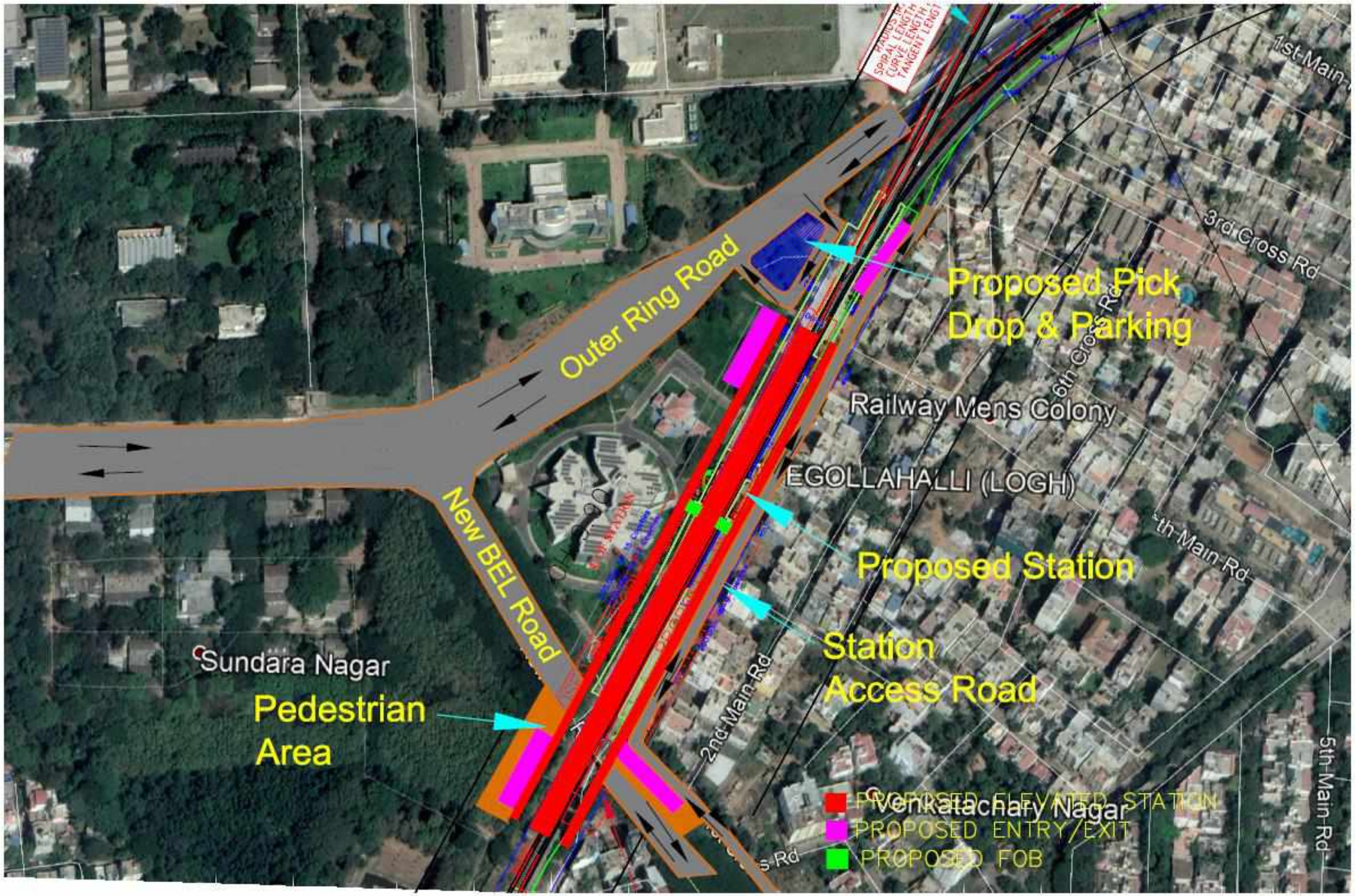


FIGURE 0.17: CONCEPTUAL INTERMODAL INTEGRATION PLAN AT MUTHYALANAGAR STATION

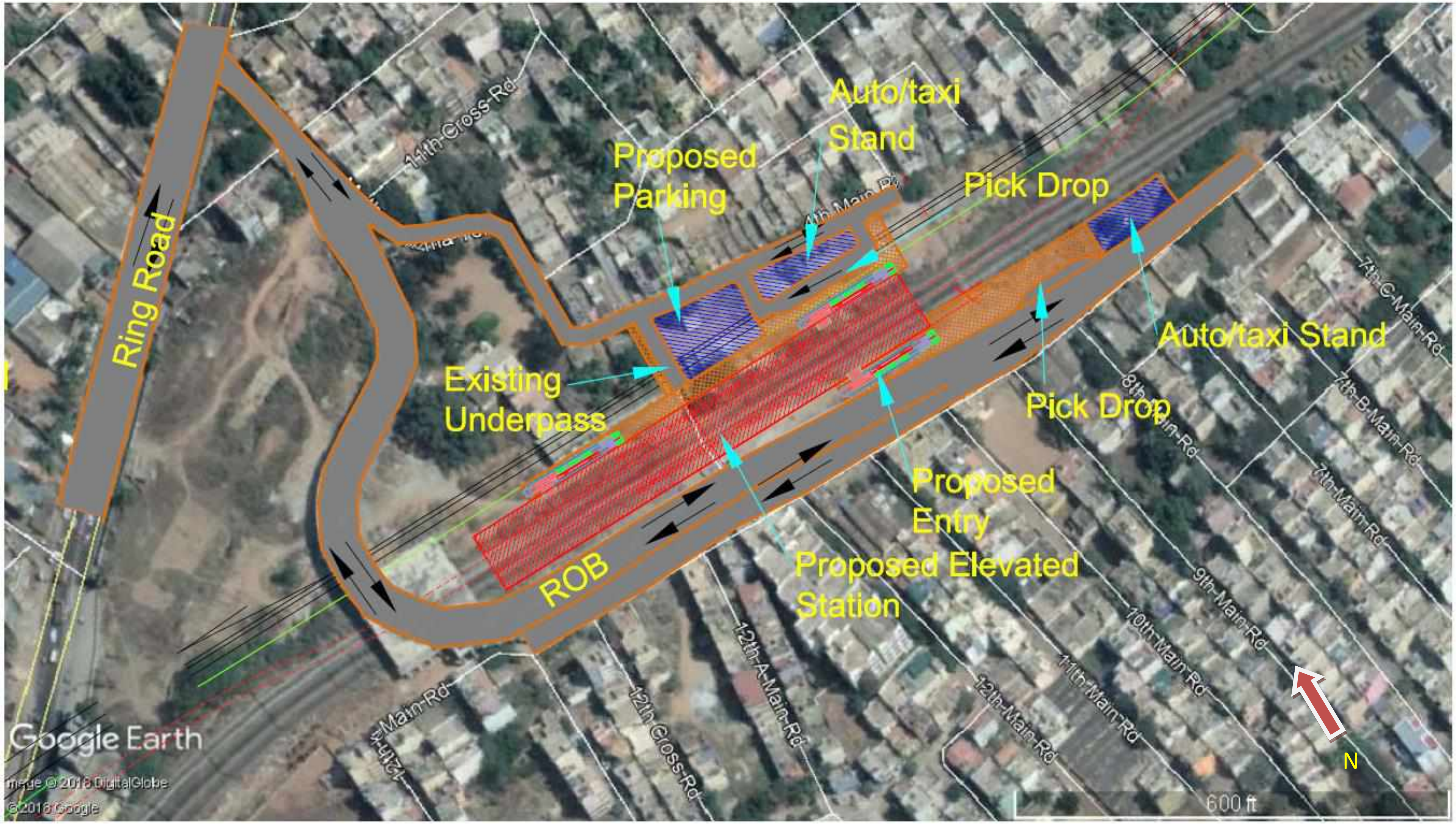
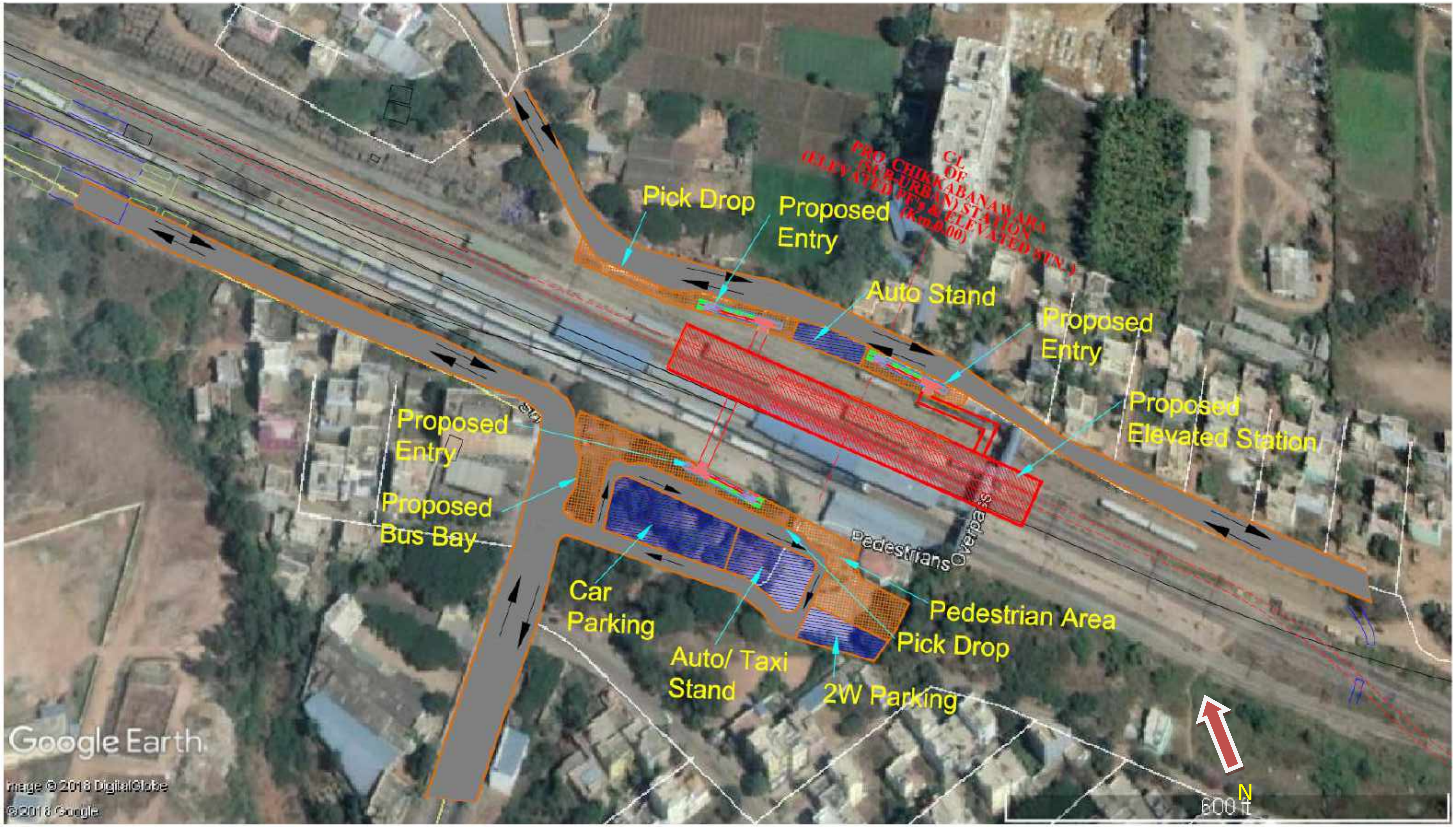


FIGURE 0.18: CONCEPTUAL INTERMODAL INTEGRATION PLAN AT CHIKKABANAVARA STATION



CONSTRUCTION PLANNING

The proposed network of Suburban rail of 148.17 km is divided into four corridors as discussed in the earlier chapters. The planning for construction is to be made keeping in view the following:

- As the proposed alignment is almost running parallel to the existing line, planning of construction of new lines to be finalized strictly in consultation with the Railways, keeping in view the operation of existing train, safety aspects etc.
- The construction activity may be taken up in phases to minimize the operational constraints / line block.
- At places of space constraints, mainly at LCs / Stations / ROBs / RUBs etc., traffic diversion shall be taken up in consultation with concerned ULBs (viz, BBMP, Traffic Police etc.).
- As the construction is of huge magnitude, resource planning for men and material has to be done meticulously.
- More than 60% of proposed alignment is within the metropolitan city limits. Hence, shift wise construction is essential to avoid peak hour road traffic as materials and equipment have to be brought to the construction site only by road.

SYSTEM DESIGN AND MAINTENANCE FACILITIES

ROLLING STOCK

To meet the traffic demand, 3.66m wide AC rolling stock is recommended for running suburban rail services in Bengaluru. Other parameters of the proposed system are given below.

Train speed – Designed	90 kmph
Acceleration at peak load on tangent track	0.82 M/Sec.Sq.
Deceleration with Full service Brake	1.00 M/Sec.Sq
Emergency brake	1.3 M/Sec.Sq
Jerk rate	0.82 M/Sec.Sq
Service brake response time	2.0 Sec
Emergency Brake response time	1.5 sec. Max.
SB and EB release time	2.0 Sec.

TRACTION AND POWER SUPPLY

- 25 KV OHE traction system has been proposed for the corridors.
- The Power supply will be through TSS (Traction Sub Stations), as identified for the corridors;
  - Corridor – 1 :- Yelahanka (SU YNK)
  - Corridor – 2 :- Hebbal (SU HEB)
  - Corridor – 3 :- Bengaluru Cantonment (SU BNC)
  - Corridor – 4 :- Benniganahalli (SU BNGH)

TRAIN OPERATION PLAN

The train operation plan is based on the following:

- Train operation with 6 car train.
- Running of services for 19 hours of a day (5 AM to Midnight) with station dwell time of 30 seconds.
- Make up time of 5-10% (on the tangent track) with 8-12% coasting.
- Average speed of 33 kmph.
- Adequate services to ensure comfortable journey for commuters during peak periods.

Based on the traffic demand, train operation plan and requirement of coaches for the suburban corridors is given in**Table 0.9**.

TABLE 0.9:CORRIDOR WISE TRAIN OPERATION PLAN &COACH REQUIRMENT

Corridor	Item	2025	2031	2041
Corridor 1 (KSR Bengaluru City - Devanahalli)	Cars/ Train	6	6	6
	Peak Period Headway (Sec)	600	514	400
	Trains/hr	6	7	9
	Capacity Provided	13548	15806	20322
	PHPDT	11775	13750	19135
Corridor 2 (Chikkabanavara-Baiyyappanahalli)	Cars/ Train	6	6	6
	Peak Period Headway (Sec)	900	720	514
	Trains/hr	4	5	7
	Capacity Provided	9032	11290	15806
	PHPDT	9009	10923	13858
Corridor 3 (Kengeri - White Field)	Cars/ Train	6	6	6
	Peak Period Headway (Sec)	1200	900	720
	Trains/hr	3	4	5
	Capacity Provided	6774	9032	11290

Corridor	Item	2025	2031	2041
	PHPDT	6442	7951	10289
Corridor 4 (Heelalige - Rajankunte)	Cars/ Train	6	6	6
	Peak Period Headway (Sec)	900	600	600
	Trains/hr	4	6	6
	Capacity Provided	9032	13548	13548
	PHPDT	7646	11919	13527

The total number of rakes required for the Bengaluru Suburban rail corridors for different horizon years is given in **TABLE 0.10.**

TABLE 0.10:REQUIREMENT OF RAKE & COACH IN 2025, 2031 & 2041

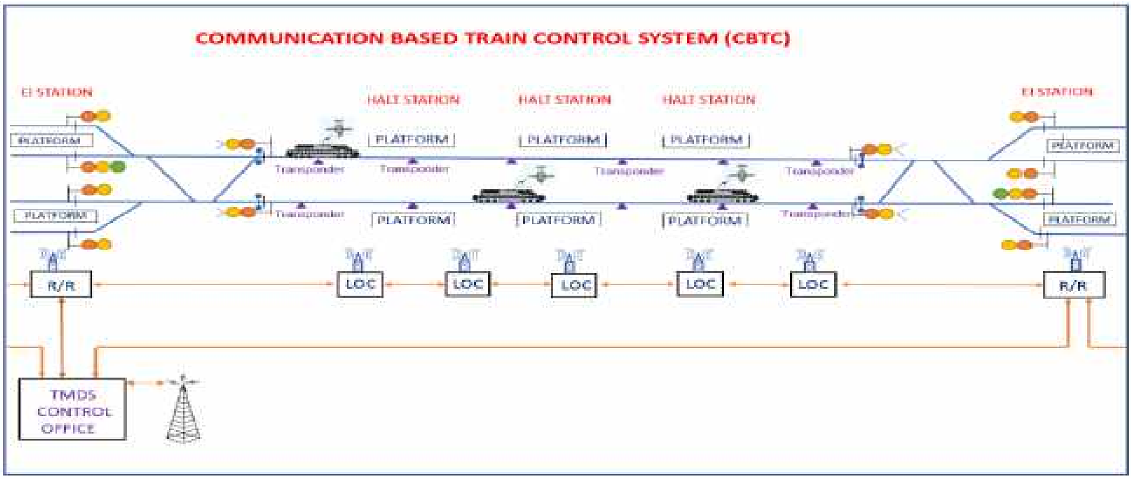
Horizon Years	2025	2031	2041
Rake requirement	51	65	78
Coach requirement	306	390	468

SIGNALING AND TELECOMMUNICATION

Train control requirements of the Sub-urban network are planned to be achieved by adopting Continuous Automatic Train Control (CATC) based on the Communication Based Train Control (CBTC) System. The CBTC system offers following advantages:

i) High reliability, better availability and less prone to failures.
ii) Easier to maintain.
iii) Provides higher traffic capacity.
iv) They are reported to be more energy sufficient systems compared to DTG signalling.
v) Adaptable to any Grade of Automation and scalable too.

FIGURE 0.19 COMMUNICATION BASED TRAIN CONTROL SYSTEM



MAINTENANCE DEPOT AND WORKSHOP

The Maintenance facilities for the Corridors Chikkabanavara - Baiyyappanahalli (Corridor-2), Kengeri - White Field (Corridor-3) and Heelalige - Rajankunte (Corridor-4) are proposed to be provided at Jnanabharathi and for Bengaluru City - Devanahalli (Corridor-1), near Devanahalli.

All the rakes will be serviced at maintenance Depot cum workshop for the scheduled inspections, major schedules viz Periodical overhaul (POH) and major unscheduled repairs. The main depot will also house Operation Control Centre (OCC), Administrative Building, maintenance facilities for Civil – track, buildings, water supply; Electrical – traction, E&M; Signalling& Telecomm.; Automatic Fare Collection etc. apart from 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.

For starting the morning services, some rakes will have to be kept at terminal stations and stabling facilities for the remaining rakes will have to be provided at the depots. Following aspects of Depot are covered:

- Conceptual design of Stabling lines, Inspection Shed and Workshop to provide maintenance facilities and stabling facilities for the Rolling Stock.
- Operational and functional safety requirements.
- Ancillary buildings for other maintenance facilities.
- Electrical & Mechanical Services, power supply system etc.
- Location for Depot cum Workshop

The rake induction and withdrawal from depot to the open line will have to be so planned that the headway of open line is not affected. For the purpose, facilities for simultaneous receipt and dispatch of trains from depot to open line should be created. The stabling area should be interlocked with the open line so that the induction of train from the stabling can be done without loss of time. The rake washing can be done at automatic coach washing plant provided at the entry of depot i.e. before rake is placed on stabling lines.

The other movements in the depot, viz from the stabling to the inspection shed or workshop and vice versa may be non-interlocked. An ART (accident relief train) line and 2 emergency re-railing lines will be 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 except trains under maintenance would be in the service. However during the off-peak hour in daytime, approximately half of the trains will be withdrawn from the service. To economize on the air-conditioning energy, 50% of the

total stabling lines would be under covered stabling shed. There would be pathways between the stabling lines, which are necessary for the "Safe to Run" examination and to facilitate the workers to move trolleys for the sweeping work. The scheduled inspections are envisaged to be carried out during the day off-peak hours and night.
The stabling and the yard layout would be at grade level for least power requirements in shunting movements and to avoid accidental rolling of Rolling Stock resulting into accidents and damages to the property.

The servicing requirement is to be determined from the Rolling Stock manufacturer. Depending upon manufacturer's requirements, servicing facilities may be provided to include the ability to carry out the inspection, maintenance, overhaul and repair of the rolling stock fleet, including the following components:

- Body;
- Bogies;
- Wheels
- Traction motors;
- Electrical components;
- Electronics; PA/ PIS
- Mechanical components;
- Batteries;
- Rolling stock air conditioning;
- Brake modules;
- Vehicle doors, windows and internal fittings.

The proposed arrangement for stabling and maintenance facilities of all the corridors is given in **Table 0.11.**

TABLE 0.11: MAINTENANCE DEPOT FOR ALL CORRIDORS

Infrastructure	Corridor-1	Corridor-2	Corridor-3	Corridor-4
	Devanahalli Depot	Jnanabharathi Depot		
Stabling Lines	29 lines of 6 car	14 lines of 6 car	13 lines of 6 car	21 lines of 6 car
Inspection Lines	6 lines	4 lines		
Workshop Lines	3 lines	3 lines		

TABLE 0.12: STABLING LINE REQUIREMENTS

Corridor		
KSR Bengaluru City - Devanahalli	Stabling Requirements	48
Chikkabanavara– Baiyyappanahalli	Inside Depot for Maintenance +POH	6
Kengeri - White Field	Stabling Lines in Depot	42
	Stabling Lines at Terminal stations	4
Heelalige - Rajankunte	Stabling Requirements	29
	Inside Depot for Maintenance +POH	4
	Stabling Lines in Depot	28
	Stabling Lines at Terminal stations	4

FIGURE 0.20: JNANABHARATHI DEPOT LAYOUT FOR CORRIDOR-2, 3 & 4

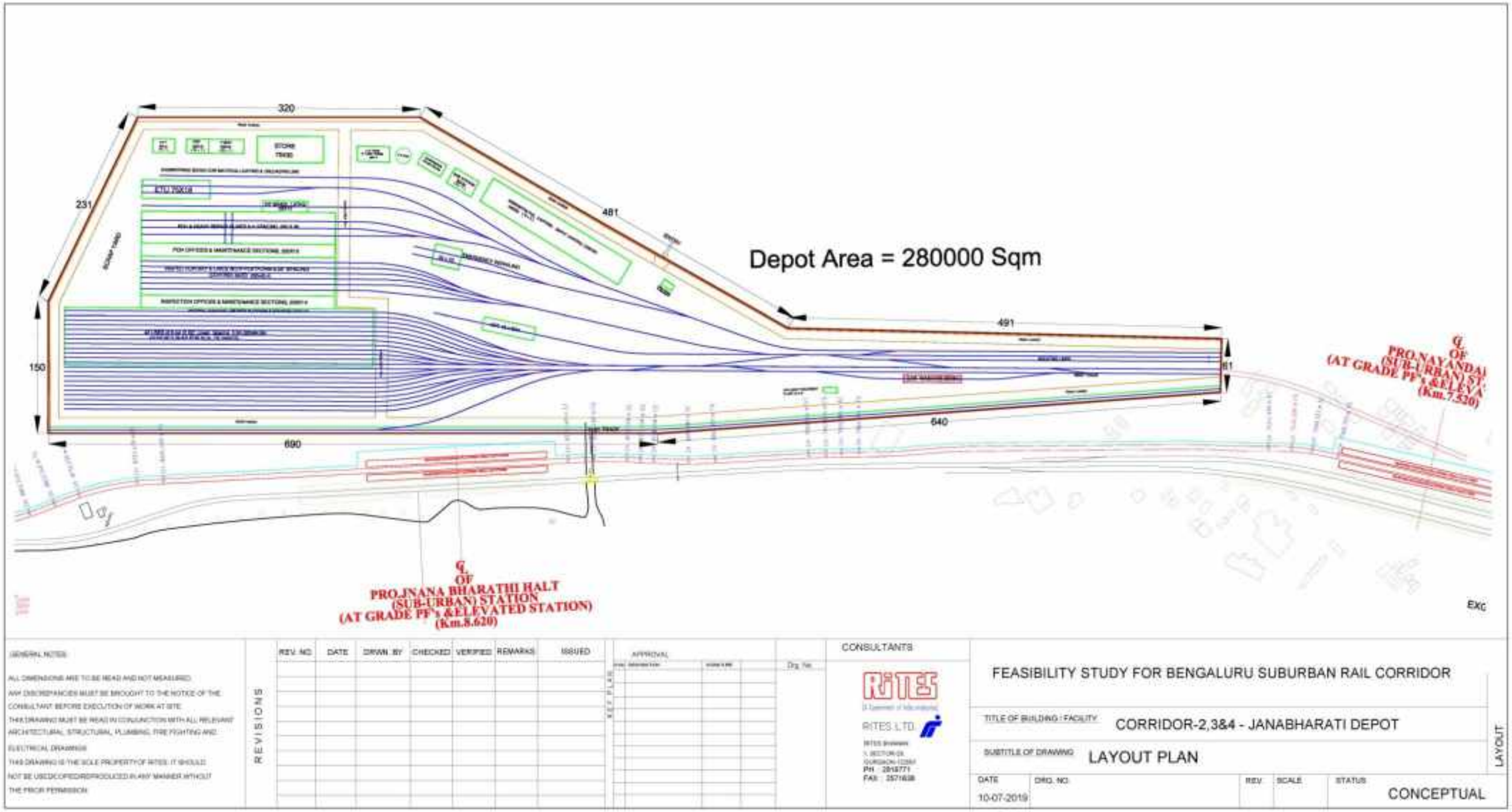
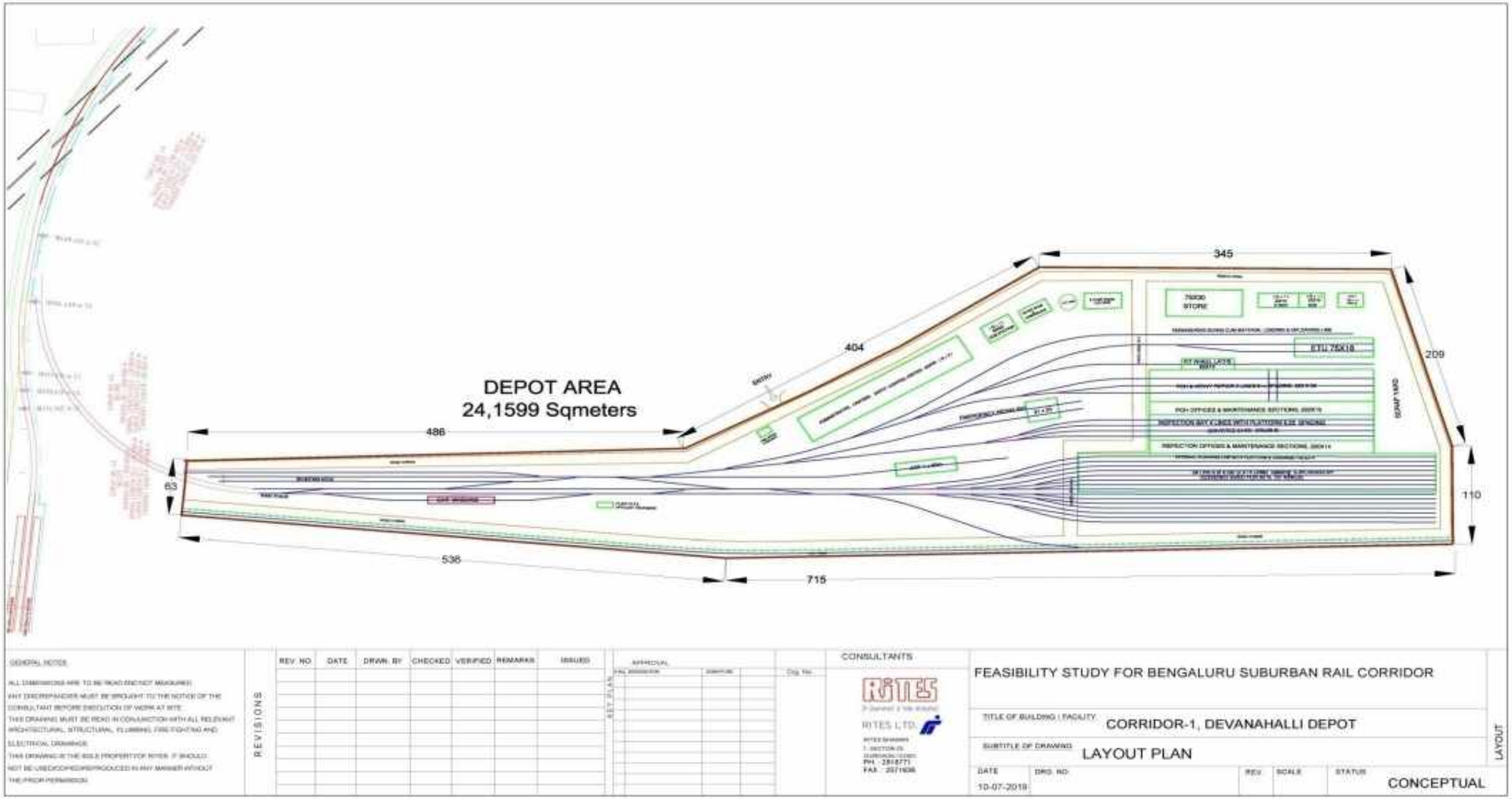


FIGURE 0.21: DEPOT LOCATION FOR CORRIDOR-1 NEAR DEVANAHALLI



DISASTER MANAGEMENT MEASURES

The main objectives of the DMP are as follows:

- Save life and alleviate suffering
- Provide help to stranded passengers / commuters and arrange their prompt evacuation
- In-still a sense of security amongst all concerned by providing accurate information
- Protect Sub-urban Rail & IR property
- Expedite restoration of train operations
- Lay down the actions required to be taken by staff, in the event of any disaster in the corridors of Sub-urban train services, to ensure handling of crisis situation in co-ordinated matter.
- To ensure that all the officials who are responsible to deal with the situation are thoroughly conversant with their duties and responsibilities, in advance. It is also important that these officials and workers are adequately trained to avoid any kind of confusion and chaos at the time of actual situation and to enable them to discharge their responsibilities with alertness and promptness.
- A detailed Disaster Management Manual need to be prepared with action plan and duties of the Officials during any disaster arising over sub-urban rail system.
- Exclusive locomotive of diesel or battery operated, should be available at least one in each corridor so that same will be moved on any emergency of power failure or disabled train.
- A self-propelled Road cum rail car or Accident relief train should be available in good fettle at the depots in readiness to move on any emergency arising over the corridors. The car should be well equipped with tools and machineries to handle any situation of track failures derailments etc.

RECOMMENDATIONS

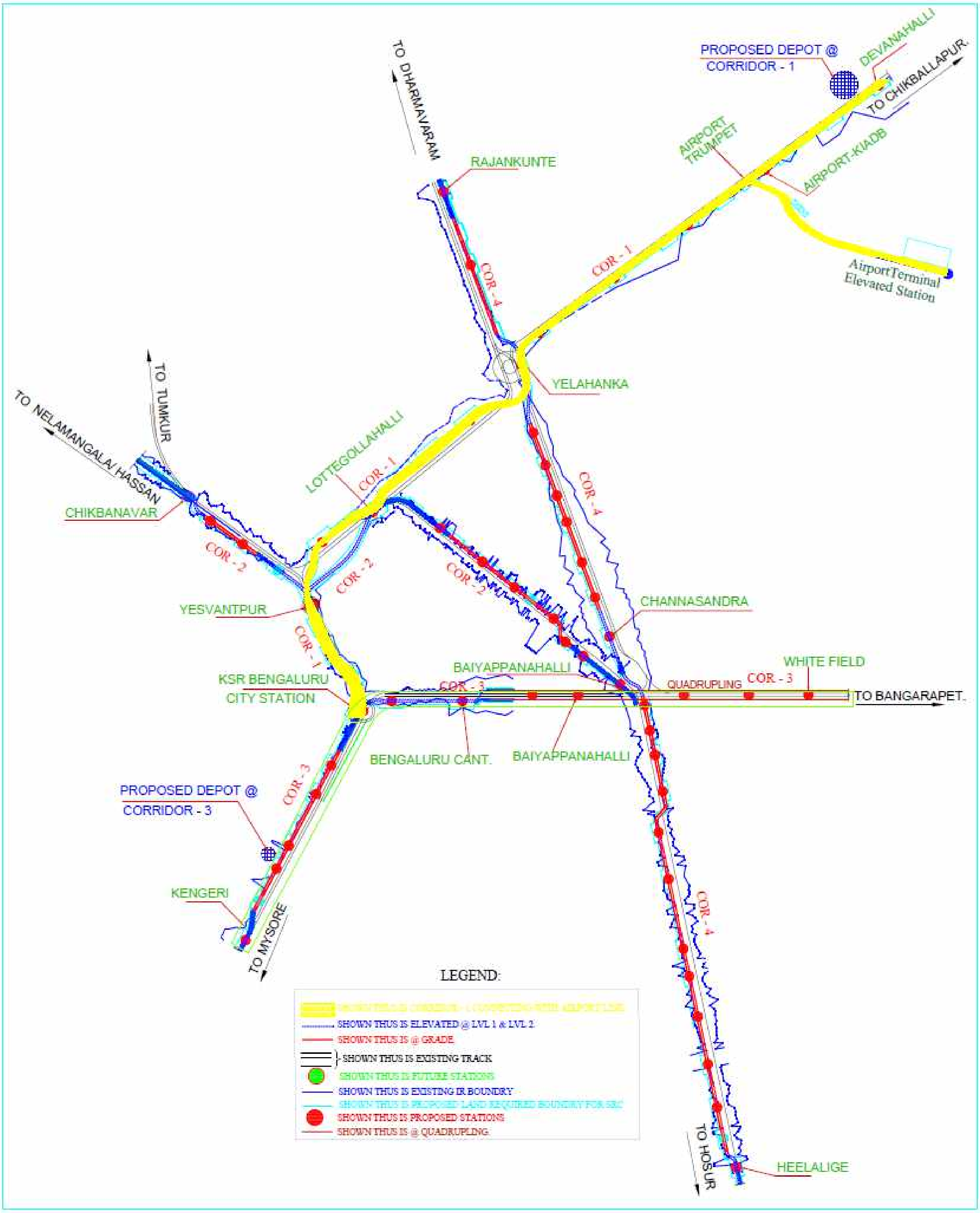
- The GoK& SPV in association with SDMA need to formulate an integrated DMA to facilitate a cohesive approach to comprehensively address all aspects of disaster management.
- SPV & SDMA should have infrastructure of relief equipment, facilities in hospitals and initiate effective measures to maintain the relief equipment fully equipped and in a state of operational readiness.
- The SPV &SDMA should, on priority, address the issue of operational constraints imposing speed restrictions, positioning of relief / medical vans, etc., to optimize response time, which is the essence of any response mechanism.

- SPV &SDMA should quickly provide effective communication system for transmission of real time information from the disaster site, which in turn is essential for assessing the gravity of the disaster and in organizing rescue and relief.
- SPV &SDMA need to constitute dedicated teams and initiate tangible measures to hasten the pace of providing specialized training in order to develop a trained team to handle the disaster.
- SPV need to enhance surveillance mechanism in the railway stations and institute an effective mechanism to prevent unauthorized entry into station premises.
- Since the sub-urban system tracks are aligned parallel to the existing IR tracks SPV should ensure while designing and executing the structures it should be in conformity with the IRS Bridge Rules A&C slip No. 48 dated 22.06.2017.

AIRPORT CONNECTIVITY

- RITES Ltd. of the opinion that direct connectivity to airport from Bengaluru City Station will serve central and northern parts of Bengaluru.
- This link will be of about 5.5 km length with about 0.50 km as elevated, and 5.00 km at grade. This will have only one elevated station at the airport above the parking.
- The Approximate cost of the airport connectivity is about ₹ 251.90 Crore, The approximate area of land required is 15.96 Acres, however the land cost has not been considered as it is Govt. land.

Figure 0.22: PROPOSED AIRPORT LINK



CAPITAL EXPENDITURE AND FINANCIAL ANALYSIS

COST ESTIMATES

Cost estimate for Bengaluru Suburban Rail corridors has been prepared covering civil, electrical, signalling and telecommunications works, rolling stock etc. at June' 2019 price level.

While preparing the capital cost estimates, various items have been grouped under three major heads on the basis of (i) Route km length of alignment, (ii) Number of units of that item and (iii) Item being an independent entity. All items related with alignment, construction, permanent way, Traction, Signalling & Telecommunication, whether in main lines or in maintenance depot have been estimated at rate per Route km basis.

In order to arrive at realistic cost of various items, costs have been assessed on the basis of recently awarded rates of Bengaluru Metro, various rates benchmarked by Ministry of Housing and Urban Affairs (MoHUA), various DPRs of Indian Railways and other projects with similar technology have also been considered and suitable escalation factor has been applied to bring these costs to June' 2019 price level.

Basic cost is exclusive of various taxes and duties viz. custom duty, State GST, Centre GST etc. and details of taxes and duties are worked out separately. Current rates of various taxes and duties have been taken into consideration.

The total Cost including private land, GST comes out to be ₹ 14,615.26 Crore.

TABLE 0.13: CAPITAL COST ESTIMATE

Total length = **152.01** Km

Elevated = 59.415 Km, At-Grade = 75.545 Km, and Quadrupling = 17.05 Km

Total Stations = **62** No's,

Elevated = 21 No's (including 4 common stations), At-Grade = 36 No's (including 5 in Quadrupling), Future Stations = 5 No's, (Elevated = 1 No. and At-grade = 4 No's)

June, 2019 Price Level, (₹ in Crore)

S. No.	Item	Unit	Rate (₹ In Crore)	Qty.	Amount (₹ In Crore)
2.0	**Alignment and Formation:**				
2.1	Elevated section including viaduct length in station (including cost of Rain water harvesting)	Route Km	39.60	59.42	2,352.83
2.2	At Grade section including Station length	Route Km	10.00	75.55	755.45

S. No.	Item	Unit	Rate (₹ In Crore)	Qty.	Amount (₹ In Crore)
2.3	Box Pushing under ROB for two tracks	Each	1.15	16.00	18.40
2.4	Elimination of Level Crossings	Each	30.00	23.00	690.00
2.6	At-grade entry to Depot	Route Km	10.00	0.75	7.50
2.7	Boundary wall for At Grade track (One side only)	Km	0.28	69.19	19.37
	Sub Total (2)				**3,843.56**
3.0	**Station Buildings**				
3.1	**Elevated stations Including Viaduct, finishes (205m long)** :				
a	Civil works	Per station	36.96	17.00	628.32
b	EM works	Per station	8.21	17.00	139.57
3.2	**Common Elevated stations in different corridors:**				
a	Civil works	Per station	25.87	4.00	103.49
b	EM works	Per station	5.75	4.00	22.99
3.4	**At Grade Station - (205m long):**				
a	Civil works	Per station	18.48	31.00	572.88
b	EM works	Per station	4.11	31.00	127.26
3.5	**Existing At-grade stations in Quadrupling:**				
a	Civil works	Per station	4.62	5.00	23.10
b	EM works	Per station	0.82	5.00	4.11
3.6	**Lifts & Escalators**				
a	Lifts*	Each	0.47	114.00	53.58
b	Escalators*	Each	0.73	171.00	124.83
	Sub Total (3)				**1,800.12**
4.0	**Depot and OCC Building** :				
4.1	Civil Works including boundary wall	LS			175.00
4.2	EM Works + M&P + General Works	LS			120.00
	Subtotal (4)				**295.00**
5.0	**P-Way:**				
5.1	Ballast-less track for elevated Section	Route Km	6.60	59.42	392.14
5.2	Ballasted track for At-grade section	Route Km	3.90	75.55	294.63
5.3	Ballasted track for Depot	Track Km	1.95	20.40	39.78
	Subtotal (5)				**726.54**
6.0	**Traction & power supply incl. OHE, ASS etc. :**				
6.1	Elevated section	Route Km	7.50	59.42	445.61
6.2	At Grade section	Route Km	7.50	75.55	566.59
6.3	For Depot	Track Km.	2.00	18.90	37.80

S. No.	Item	Unit	Rate (₹ In Crore)	Qty.	Amount (₹ In Crore)
				Subtotal (6)	**1,050.00**
7.0	**Signaling and Telecom.** :				
7.1	Signaling	Route Km	4.40	134.96	593.82
7.2	Signaling On-board equipment	Per Train	1.70	36.00	61.20
7.3	Telecommunication	Per station	4.50	57.00	256.50
7.4	Automatic fare collection*	Per station	3.50	57.00	199.50
7.5	Platform Screen Doors (PSD)*	Per station	4.40	57.00	250.80
				Sub Total (7)	**1,361.82**
8.0	**R&R (Hutments)** :				
8.1	Social cost of R&R (Hutments)	LS			50.00
				Sub Total (8)	**50.00**
9.0	**Misc. Utilities, road works, Topographic Surveys, Geotechnical Investigation, Barricading, Tree Cutting and replanting, other civil works such as signages, Environmental protection and traffic management**				
9.1	Civil Works	Route Km	1.35	134.96	182.20
9.2	EM Works	Route Km	0.90	134.96	121.46
				Sub Total (9)	**303.66**
10.0	**Capital Expenditure on Security**:				
10.1	Civil works	Route Km	0.30	134.96	40.49
10.2	EM works	Route Km	0.07	134.96	9.45
				Sub Total (10)	**49.94**
11.0	**Staff Quarters:**				
11.1	Civil works & EM Woks	LS			25.00
				Sub Total (11)	**25.00**
12.0	**Airport Connectivity:**				
12.1	Airport Connectivity	LS			273.96
				Sub Total (12)	**273.96**
13.0	**Total of all items except Land**				**9,779.60**
14.0	**General Charges @5% including design charges**				**488.98**
15.0	**Rolling Stock (3.66m wide)**	Each	9.25	216.00	1,998.00
				Sub Total (15)	**1,998.00**
16.0	**Total including General Charges and Rolling Stock but excluding land**				**12,266.58**
17.0	**Contingency @ 3% (excluding land)**				**368.00**
18.0	**Gross Total including Contingencies (excluding land cost)**				**12,634.57**

S. No.	Item	Unit	Rate (₹ In Crore)	Qty.	Amount (₹ In Crore)
19.0	**Central GST & Basic Customs duty**				**1,060.27**
20.0	**State GST**				**920.42**
21.0	**Total Cost including GST**				**14,615.26**
1.0	**Land :**				
1.2	Permanent - State Govt.				
a	State Govt. (for running section and stations)	Ha	LS	7.62	0.00
b	State Govt. (Maintenance Depots)	Ha	LS	47.85	0.00
1.2	Permanent - Private				
a	Private Open Land (for running section and stations)	Ha	LS	28.64	748.69
b	Private Built-up land (for running section and stations)	Ha	LS	12.52	671.12
1.3	Rly Land	Ha	LS	132.30	0
				Sub Total	**1,419.81**

***ITEMS CAN BE TAKEN UNDER PPP. TOTAL COST OF THESE ITEMS IS ₹. 841 CRORE INCLUDING GST AT JUNE 2019 PRICE LEVEL**

OPERATION AND MAINTENANCE COST

The Operation and Maintenance cost for Bengaluru Suburban Corridors is worked under three major heads:

- Staff cost
- Maintenance cost which includes expenditure towards upkeep and maintenance of the system and consumables and
- Energy cost

The replacement costs are provided for meeting the cost on account of replacement of equipment due to wear and tear. With the nature of equipment proposed to be provided for the corridor, it is expected that about 25% of the equipment comprising Electrical and 50% of Signaling, Telecom, AFC and PSD would require replacement/ rehabilitation after 20 years.

The replacement cost for Bengaluru suburban rail corridors is ₹ 3354.46 for year 2045. The replacement cost has been worked out considering an escalation factor of 5% per annum.

The year wise total Operation and Maintenance cost for the SPV for the corridors of Bengaluru suburban rail corridor is indicated in **TABLE 0.14**.

TABLE 0.14: OPERATION & MAINTENANCE COST

Year	Staff Cost	Maintenance Expenses	Energy Charges	Lease Charges for Rolling Stock	Maintenance Charges for Rolling Stock	GST on Lease Charges for Rolling Stock	GST on Maintenance Charges for Rolling Stock	Total O&M
2025	173	168	157	403	127	73	23	1124
2026	182	176	169	403	133	73	24	1160
2027	191	185	182	403	140	73	25	1198
2028	200	195	195	403	147	73	26	1238
2029	210	204	209	403	154	73	28	1281
2030	221	214	224	403	162	73	29	1326
2031	232	225	240	403	170	73	31	1373
2032	243	236	255	403	178	73	32	1421
2033	255	248	272	403	187	73	34	1472
2034	268	261	289	403	197	73	35	1526
2035	282	274	307	403	206	73	37	1582
2036	296	287	327	360	217	65	39	1590
2037	310	302	347	360	228	65	41	1653
2038	326	317	369	360	239	65	43	1718
2039	342	333	392	360	251	65	45	1788
2040	359	349	417	360	264	65	47	1861
2041	377	367	443	360	277	65	50	1938
2042	396	385	471	360	290	65	52	2019
2043	416	404	500	360	305	65	55	2105
2044	437	425	531	360	320	65	58	2195
2045	459	446	564	360	336	65	61	2290
2046	482	468	599	109	353	20	64	2093
2047	506	492	636	109	371	20	67	2199
2048	531	516	675	109	389	20	70	2309
2049	558	542	716	109	409	20	74	2426
2050	585	569	760	109	429	20	77	2549
2051	615	598	807	109	451	20	81	2679
2052	645	627	856	109	473	20	85	2815
2053	678	659	908	109	497	20	89	2959
2054	712	692	963	109	522	32	53	3082

ECONOMIC ANALYSIS

APPROACH AND METHODOLOGY FOR ECONOMIC ANALYSIS

The economic appraisal has been carried out within the broad framework of Social Cost – Benefit Analysis Technique. It is based on the incremental costs and benefits and involves comparison of project costs and benefits in economic terms under the "with" and "without" project scenario. In the analysis, the cost and benefit streams arising under the above project scenarios have been estimated in terms of market prices and economic values have been computed by converting the former using appropriate shadow prices.

This has been done to iron out distortions due to externalities and anomalies arising in real world pricing systems. The annual streams of project costs and benefit have been compared over the analysis period of 30 years to estimate the net cost / benefit and to calculate the economic viability of the project in terms of EIRR & ENPV. The sensitivity analysis has been carried out to see the impact of change in critical parameters in the range of 5% to 15% on EIRR.

TABLE 0.15: SENSITIVITY ANALYSIS FOR EIRR

S. No.	Factor	Range		
		5%	10%	15%
1	Cost overruns due to delay or other factors	18.32	17.68	17.08
2	Increase in Maintenance Cost	18.89	18.76	18.63
3	Reduction in Ridership	18.38	17.73	17.08
4	Reduction in benefits	18.15	17.27	16.36
5	Combination of reduction in benefits and increase in cost	17.48	16.03	14.65

FINANCIAL ANALYSIS

PROJECT STRUCTURE

Bangalore suburban rail project is proposed to be implemented on Equity funded SPV model with equal contribution from central (20%) and state government (20%) and rest from multilateral agencies (60%). However, for potential private participation through leasing of rolling stock is also contemplated.

The SPV shall provide fixed infrastructure (Civil assets, Electrical assets, S&T assets) and shall be responsible for collection of revenue, operation & maintenance of assets (excluding rolling stock) and management of infrastructure incl. stations while a private entity shall procure & finance the required Rolling Stock and also be responsible for providing train operators, maintenance of rolling stock and management of maintenance depots (Operation & Maintenance obligations). In lieu of its investment the private entity shall be entitled to received Lease Charges (towards financing of procurement cost) and Maintenance Charges (towards Operation & Maintenance obligations).

It is pertinent to note here that, although DMRC had tried to bid out the provisioning of rolling stock on lease basis, it could not successfully award the contract on account of high price. Therefore, as a step of necessary precaution, it is recommended that a provision for procurement of Rolling Stock by SPV may be kept in case the proposed leasing model does not span out.

CAPITAL COSTS

The main components of the project cost include land costs, R&R, Infrastructure costs, General Charges & Design Charges (@5% on cost excluding land) and Contingencies (@3% on cost excluding land), Central GST & Basic custom duty and State GST.

TABLE 0.16: CAPITAL COST OF THE PROJECT

S. No.	Description	Amount (₹ in Crore)
1	**Land Cost and R&R**	**1470**
1.1	Land	1420
1.2	R&R	50
2	**Infrastructure Cost (excl. Rolling Stock)**	**10759**
3	**State GST**	**681**
4	**Central GST & Basic custom duty**	**662**
	Estimated Cost of Project (June 2019 price level)	**13572**

The Capital Cost in above table is excluding the cost of Rolling Stock, taxes and contingencies on RS (**"Rolling Stock Component"**), which is estimated at ₹. 2,418 Crore at June 2019 price levels. It is proposed to take Rolling Stock on lease basis as a potential alternate source of financing.

The Project is proposed to have a construction period of 6 years but the payments are expected to spill over to the 7th year, hence the capital expenditure excluding land and

R&R is assumed to be in the ratio of 5:15:20:20:20:15:5. Land shall be acquired during the first 2 years with expenditure for acquiring land and R&R in the ratio of 50:50. The operations would start from the year 2025 (i.e. FY 2025-26). Escalation (on all items excluding cost of land and R&R) is considered from 2020 at 5% per annum from June-2019. The completion cost of the project (without IDC) is calculated as given in **Table 0.17.**

TABLE 0.17: **COMPLETION COST OF THE PROJECT (W/O IDC)**

								(₹ in Crores)
Completed Project Cost	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**Total**
Phasing of Infrastructure, State Taxes & Central Taxes	5%	15%	20%	20%	20%	15%	5%	100%
Phasing of Cost of Land and R&R	50%	50%	0%	0%	0%	0%	0%	100%
Escalation Factor[1]	1.00	1.04	1.09	1.15	1.21	1.27	1.33	
Infrastructure Cost (with escalation)	538	1681	2353	2471	2595	2044	715	12397
Central Taxes (with escalation)	33	103	145	152	160	126	44	763
Completed Cost excluding Cost of Land & State Taxes	571	1784	2498	2623	2755	2170	759	13160
Cost of Land and R&R (no escalation)	735	735	0	0	0	0	0	1470
State Taxes (with escalation)	34	106	149	157	165	129	45	785
Completed Cost including Cost of Land & State Taxes	**1340**	**2625**	**2647**	**2780**	**2920**	**2299**	**804**	**15415**

Considering phasing and escalation on Rolling Stock component similar as Infrastructure component, the completed cost of Rolling Stock component works out to be ₹. 2785 Crore.

O&M COSTS

The O&M Costs for the suburban rail system will include costs towards staff, maintenance expense, energy charge, Lease Charges for Rolling Stock, Maintenance Charges for Rolling Stock, GST on Lease and Maintenance Charges and have been worked out as detailed in previous sections for the operation period i.e. from year 2025 to year 2054 and is brought out in **TABLE 0.22**.

[1]Escalation factor from 2020 onwards is calculated as (1+5%) ^ $^{\text{(April \{year\} – June 2019) (in years)}}$. For example, escalation factor applicable for FY 2020 is (1+5%) ^$^{\text{(April 2020 – June 2019)}}$= 1.05^$^{(9/12)}$ = 1.05^$^{0.75}$ = 1.04.

TABLE 0.18: O&M COSTS

(₹ in Crores)

Year	Staff Cost	Maintenance Expenses	Energy Charges	Lease Charges for Rolling Stock	Maintenance Charges for Rolling Stock	GST on Lease Charges for Rolling Stock	GST on Maintenance Charges for Rolling Stock	Total O&M
2025	173	168	157	403	127	73	23	1124
2031	232	225	240	403	170	73	31	1373
2041	377	367	443	360	277	65	50	1938
2054	712	692	963	109	522	32	53	3082

TRAFFIC

Traffic is worked out based on the trip length, generation and distribution and annual ridership (in millions) is worked out as shown in Table.0.19.

TABLE 0.19. RIDERSHIP DETAILS

Year	2025	2031	2041	2051
Ridership (In Lakhs)	9.84	13.41	17.61	23.11

REVENUES

FARE-BOX REVENUE

Fare-box revenue or revenue generated from collection of fares, is based on the traffic data from above para (C) and a proposed fare structure starting from ₹. 13 (for less than 3 Kms. trip) to ₹ 100 (for more than 60 Kms trip) at 2025 price levels and escalated at 10% every two years. Fare box revenues as calculated is shown below in **Table 0.20.**

TABLE 0.19: FARE BOX REVENUES

Revenue Stream	Total Revenues (Fare box) (in ₹. Crore)			
	2025	2031	2041	2051
Revenue from Fare-box	1281	2389	5162	10922

NON-FARE BOX REVENUE

Non fare box revenue could be from commercial development and advertisement at station buildings, leasing of parking rights at stations, advertisement on trains and tickets, advertisements within stations and parking lots, advertisements on viaducts, columns and other structures, co-branding rights to corporate, film shootings and special events on sub urban rail premises.

The major sources of non-fare box revenue are:

- Station Commercials
- Advertisement on Station/ skywalk etc.
- Station & Train naming rights'

TABLE 0.20: NON FARE BOX REVENUE ASSESSMENT

S. No.	Revenue Generating Proposal	Total Revenue Generation - (₹ Cr)	Phasing of Proposal	Probable Stakeholders
1	Rental Revenue from Retail-Commercial Activities at Concourse Level	**28.56**	Starting from 2025	Fast moving retail item brands: Retail F&B, Book Stores, Café's, Pharmacy, Banks (ATMs)
2	Revenue from Selling Stations' Semi-Naming Rights.	**40.00**	Starting from 2025	Private Companies/ Organizations; Advertising Agencies
3	Advertising Revenue	**20.00**	Starting from 2025	Private Companies/ Organizations; Advertising Agencies
4	Advertisement on Trains	**3.60**	Starting from 2025	Private Companies/ Organizations; Advertising Agencies
4	Advertisement Revenue from Skywalks	**5.00**	Starting from 2025	Private Companies/ Organizations; Advertising Agencies

Based on the preliminary revenue assessment, about 93.57 Crore is realizable in the year 2019. Further escalation of 10% in every three years is considered.

FINANCIAL INTERNAL RATE OF RETURN (FIRR):

The Financial Internal Rate of Return (FIRR) has been worked out on the basis of the cash flows accruing to the project from the ticketing and other sources. The FIRR with fare-box and non-fare box revenue along with VCF (without sale of rights) is **10.74%.**

ALTERNATE SOURCES FOR FINANCING

INTRODUCTION

Since, the suburban rail like any infrastructure project requires large capital outlay and resources having long gestation period (current project 6 years). The rate of return required by the private sector is typically higher at 14% or more for such projects considering the risks involved. Since the current project offers lesser IRR than that required by private entity, it is proposed that the initial capex be made available through government budgetary allocations and mix of equity and debt via a Special Purpose Vehicle (SPV).

However, it is desirable to augment the resources through alternate sources of finances given the constraints of government treasury. These alternate sources can be explored once the initial risk of construction and requirement of large capital outlay has been assumed by the SPV and subsequent project becomes commercially viable for the private entity.

Some of the forms of PPP that can be explored by the SPV are described below:

1. **O&M PPP**

   Fixed infrastructure by SPV, operation & maintenance of the Sub-urban system is in the hands of private entity. Fixed annual payment shall be paid in such arrangement.

2. **Leasing of Rolling Stock and its maintenance (Wet Lease)**

   Fixed infrastructure by SPV, operational independence with SPV, maintenance of the sub-urban system is in the hands of private entity. Availability based payment shall be paid in such arrangements.

   Besides above the SPV can also employ innovative contracting tools involving private sector that hold great potential as established with various MRTS Rail projects in the country, such as Lifts & Escalators on O&M Model, AFC – Advanced systems that can be bid out with branding and Platform Screen Door – Can be taken up as O&M model. Since these components are essential in the overall suburban infrastructure construction, these will need to be worked out at the time of taking up the implementation of the project.

PROPERTY DEVELOPMENT ON RAILWAY LAND

Property development across the world is currently being utilized for augmenting the resources; this is usually done by developing real estate on the land parcels available with the SPV/ IR. Indian Railways (SWR) has about 380.0 Acre of land that can be utilized for the property development. This land is located at various locations of the city along the rail and station area.

Indian Railways / SWR may monetize the land by way of leasing. The land parcels are situated as:

1) Vacant land parcels of Land adjacent to station and rail network.
2) Land with old structures such as quarters, utilities that can be redeveloped
3) Station areas where the current or proposed stations are located
4) Track areas where there are tracks, pit lines, etc.

TABLE 0.21: AVAILABILITY OF LAND

Sl. No.	Station	Vacant Land for commercial exploitation (in Acres)	Area above Railway Track (in Acres)	Total Area (in Acres)
1.	SBC	60.13	50.09	110.22
2.	YPR	132.96	34.81	167.764
3.	BNC	23.21	21.22	44.43
4.	YNK	8.13	17.73	25.86
5.	BYPL	14.32	8.33	22.65
6.	KJM	1.68	8.43	10.11
7.	WFD	10.7	6.88	17.58
8.	CSDR	23.86	7.19	31.05
9.	HEB	36.66	14.55	51.21
10.	MWM	0.00	4.18	4.18
11.	BAND	4.95	13.41	18.36
12.	LOGH	0.82	2.43	3.25
13.	KGI	4.01	7.02	11.03
14.	HLE	24.89	4.64	29.53
15.	NYH	2.85	4.31	7.16

Sl. No.	Station	Vacant Land for commercial exploitation (in Acres)	Area above Railway Track (in Acres)	Total Area (in Acres)
16.	DHL	13.04	2.22	15.26
17.	NMGA	14.35	8.09	22.44
18.	BAW	4.24	6.40	10.64
Total		**380.795**	**221.929**	**602.724**

Development on these parcels of land offers challenges of varying degree as the corridor traverses the city of varying development potential. The prices of land and built up area are also varying. Property development or real estate development is dictated by the location, economic condition of the surrounding, the size of the parcel and mainly the regulations determined by the master Plan documents. Further, the criteria for attractiveness comes from the size of the land parcel, whether it is contagious, it has good access, frontage and as well as supporting external infrastructure.

Vacant lands and redevelopment:

The Vacant lands which are of considerable size and potential can be developed with the partnership of the private players.

Redevelopment of the lands can be taken up with private participation but the substantial costs for redevelopment are expended. The Higher FAR framework will allow for re-organizing and redevelopment of the property by housing the existing function within smaller land component and developing the rest optimally.

Integrated Station with Land:

The lands adjacent to the station that may be smaller in size and are dependent on the station improvement/Development can be developed in an integrated manner along with the station. The concourse area of the proposed stations can be also put for rentals according to the passenger movement and real estate market conditions. The investment will be along with the station development and may be guided one developed along with the project phasing. This will allow for rentals from leasing activity.

Vacant Land Parcels

The following stations have been identified for possibility of real estate development. Few structures may require relocation to realize full potential of real estate at these locations:

TABLE 0.22: STATIONS FOR REAL ESTATE DEVELOPMENT

S. No.	Description	Land parcel code	Area in Sqm	Planning Authority
1	KSR Bengaluru City - KSR - Opp Krishna Mill	SBC - C	12140.60	BDA
2	Cantonment Station	BNC- A and B	49,836	BDA
3	Yeshwanthpur	YPR –A & YPR- B	109,296	BDA
4	Channasandra	CSDR – A & CSDR -B	62,758	BDA
5	Baiyyappanahalli	BYP-A,B,C,D	55312	BDA
6	Chikkabanavara	BAW – B	3765	BDA
7	Devanahalli	DHL	30,644	BIAPPA

The vacant area that is available for immediate exercise is about: 323751.6 Sqm or 79.97 Acres of Land. Based on the Guideline value for the standalone vacant land parcels at the locations - SBC, BNC, YPR, CSDR, BYPL, BAW, DHL, the valuation of the land are as follows:

TABLE 0.23: VALUATION OF LAND

Sl. No.	Name of Station	Description	Area		Value (Lease basis)	Land Value (INR)	Ext. Devpt. Infra (₹ in Crores)	Net Value (₹ in Crore)
			Acres	Sq. Mtr				
1	SBC	Krishna Mill	3.00	12140.60	161500.00	1960706900.00	0.00	196.07
2	YPR	Site A	17.00	68816.00	44000.00	3027904000.00	15.00	
		Site B	10.00	40480.00	44000.00	1781120000.00		465.90
3	BNC	Site A	12.11	49036.00	94800.00	4648612800.00	0.00	464.86
4	CSDR	Site A	3.69	14950.00	35600.00	532220000.00	0.00	
		Site B	11.81	47808.00	35600.00	1701964800.00		223.42
5	BAW	Site B	0.93	3765.00	17500.00	65887500.00	0.00	6.59
6	BYPL	A, B, C, D	13.66	55312.00	10700.00	591838400.00	5.00	54.18
7	DHL	Site A	7.57	30644.00	13557.60	415459094.40	0.00	41.55
Total						**1472.57**	**20.00**	**1452.57**

For about 79.78 Acres or 3,22,951.60 Sqm – INR 1452 Cr

TABLE 0.24: VALUE OF LAND ON REDEVELOPMENT PARCELS

SL. NO.	NAME OF STATION	DESCRIPTION	AREA		VALUE (LEASE BASIS)	LAND VALUE (INR)	EXT. DEVPT. INFRA (IN CRORES)	NET VALUE (IN CRORE)
			ACRES	SQ. MTR				
1	SBC	Site A	15.00	60720.00	120000.00	7286400000.00	25.00	
		Site B	17.86	72297.28	120000.00	8675673600.00		1571.21
2	BNC	Site B	2.87	11622.00	100000.00	1162200000.00	7.50	599.08
Total								**2170.29**

For land about – 35.731 Acres or 144639.28 Sqm – the value is about 2170.29 Crore. The total value of Land for the above based on prevailing guideline value is about INR 3622.86 Crore.

FUNDING PLAN: EQUITY SHARING MODEL (SPV MODEL)

Under this model, a Special Purpose Vehicle (SPV) will be set up as a joint venture between Central Government and Government of Karnataka for the implementation of the project and for its subsequent Operation &Maintenance. Under this arrangement Government of India and Government of Karnataka shall make equal equity contribution and run the SPV as a commercial enterprise as a joint venture of GOI & GOK. As per the prevalent practice in MRTS projects, Central Government may contribute upto 20% of the project cost excluding land and R&R, Central and state taxes as its equity contribution. An equal amount will be contributed by the State Government aggregating the total equity to 40%. In addition to equity, GoI will also fund the cost of Central GST and Basic Customs Duty, similarly GOK will fund the cost of land including R&R, state GST and Interest during construction. Rolling Stock will be procured by Lessor (private party) and hence not considered in the funding plan for the SPV.

With the equal ownership of the SPV, both the governments nominate their representatives as members of the Board of Directors, which in turn select functional directors. Such a SPV has a benefit of independent management under the aegis of Indian Companies Act, 2013. Delhi Metro Rail Corporation, Chennai &Bengaluru metro corporations are examples of success of such SPV. For balance 60%, loan from bilateral/ multilateral agencies such as JICA can be explored. The loan terms for JICA ODA loan are provided in **TABLE 0.25.**

TABLE 0.25: JICA-ODA LOAN TERMS

Particulars	Values
Interest Rate % p.a	1.4%
Loan Period	40
Moratorium	10
Repayment Start Year	2029
Repayment End Year	2058

The funding pattern developed under this model (SPV) is placed in **TABLE 0.26**.

TABLE 0.26: CONTRIBUTION UNDER SPV MODEL

Particulars	Amount (₹ in Cr)	% Share
Equity by GoI	2479	20.0%
Equity by Govt. of Karnataka	2479	20.0%
Soft Loan from bilateral/multilateral funding agencies	7439	60.0%
Total Cost	**12397**	**100.00%**
Sub-Ordinate Debt for Ccentral GST & Basic Customs Duty by GoI	763	-
Sub-Ordinate Debt for land and R&R by Govt. of Karnataka	1470	-
Sub-Ordinate Debt for State GST by Govt. of Karnataka	785	-
Sub-Ordinate Debt for IDC for JICA ODA Loan @1.4% by Govt. of Karnataka	353	-
Total Cost	**15768**	-

The loan amortization schedule is provided in **TABLE 0.27.**

TABLE 0.27: LOAN AMORTIZATION SCHEDULE

(₹ in Crores)

Year	Opening Balance	Withdrawn Amount	Principal Repayment	Interest (@1.4% of Opening Balance)	Closing Balance	Interest During Construction (IDC)
2019	0	323	0	2	323	2
2020	323	1008	0	12	1331	12
2021	1331	1412	0	29	2743	29
2022	2743	1483	0	49	4226	49

(₹ in Crores)

Year	Opening Balance	Withdrawn Amount	Principal Repayment	Interest (@1.4% of Opening Balance)	Closing Balance	Interest During Construction (IDC)
2023	4226	1557	0	70	5783	70
2024	5783	1226	0	90	7009	90
2025	7009	430	0	101	7439	101
2026	7439	0	0	105	7439	
2027	7439	0	0	105	7439	
2028	7439	0	0	105	7439	
2029	7439	0	286	102	7152	
2030	7152	0	286	98	6866	
2031	6866	0	286	94	6580	
2032	6580	0	286	90	6294	
2033	6294	0	286	86	6008	
2034	6008	0	286	82	5722	
2035	5722	0	286	78	5436	
2036	5436	0	286	74	5150	
2037	5150	0	286	70	4864	
2038	4864	0	286	66	4577	
2039	4577	0	286	62	4291	
2040	4291	0	286	58	4005	
2041	4005	0	286	54	3719	
2042	3719	0	286	50	3433	
2043	3433	0	286	46	3147	
2044	3147	0	286	42	2861	
2045	2861	0	286	38	2575	
2046	2575	0	286	34	2289	
2047	2289	0	286	30	2003	
2048	2003	0	286	26	1717	
2049	1717	0	286	22	1430	
2050	1430	0	286	18	1144	
2051	1144	0	286	14	858	
2052	858	0	286	10	572	
2053	572	0	286	6	286	
2054	286	0	286	2	0	
Total		**7439**	**7439**	**2023**		**353**

0.12 RECOMMENDATIONS

- The project has good EIRR &FIRR and may be considered for implementation in order to take care of City's long term traffic needs.
- The corridors under the present assignment may be extended beyond their proposed terminal station to nearest important town in order to cater some additional catchment.
- The direct connectivity to Kempegowda International Airport through suburban rail system is also recommended, as it will serve central and northern parts of Bengaluru.
- Additional sources of revenue including commercial development needs to be explored to support the project.
- SWR may consider appointing financial, legal and institutional consultants to take up the project implementation forward.
- The implementation of Corridors may be taken up in phases and the priority of corridors is given below:

  1) KSR Bengaluru City to Devanahalli
  2) Baiyyappanahalli to Chikkabanavara
  3) Heelalige to Rajankunte
  4) Kengeri to Whitefield

- The study is restricted only within the Bengaluru Urban limits. However, based on the patronage and the ridership along the corridors, the corridors may be extended in future to the nearest towns as listed below:

  i. Corridor – 1 (KSR Bengaluru City –Devanahalli) – may be extended up to Chikkaballapura on Northern side of the city.
  ii. Corridor – 2 (Baiyyappanahalli – Chikkabanavara) – may be extended up to Tumakuru on North – Western side.
  iii. Corridor – 3 (Kengeri – Whitefield) – may be extended up to Ramanagara on South Western side and up to Mallur/Bangarpet on North Eastern side.
  iv. Corridor–4 (Heelalige–Rajankunte) – may be extended up to Doddaballapura on Northern side and up to Hosur on Heelalige side.

- Items like Automatic Fare Collection (AFC) gates, Lifts, Escalators and Platform Screen Doors (PSD) can be taken under PPP model.
- During construction, SPV may explore the procurement of Rolling stock requirement under PPP model.

1. INTRODUCTION

1.1 BACKGROUND

Bengaluru is the fifth largest metropolis in India and is one of the fastest growing cities in Asia. It is also the capital of Karnataka. It is globally recognized as IT capital of India and also as a well-developed industrial city. The city which was originally developed as a Garden City over the years, slowly transformed into an industrial and software hub of India. Emergence of IT sector has overshadowed other areas of development and has metamorphosed the city into a global hub. The establishment of the IT hubs on the outskirts has converted the city and its surroundings into Silicon Valley of India. It has also caused an urban sprawl around, to some extent lop sided towards south and east.

Bengaluru has become a commercial, administrative and military centre for the Region because of its salubrious climate and cosmopolitan nature of people. It was also known as pensioner's paradise with well-developed residential areas, roads with well grown trees, good commercial establishments, shopping malls etc. Despite such growth it is trying to maintain its character of garden city. The city continues to attract India's best and brightest human capital, given its undisputed status as the knowledge capital of India.

1.2 PROBLEMS & ISSUES

Bengaluru population has been growing faster. There has been a phenomenal growth in the population of vehicles as well, especially the two and four wheelers in this period due to rising household incomes. In the absence of adequate public transport system, people are using the personalized modes which is not only leading to congestion on limited road network but also increasing environmental pollution. An average citizen of Bengaluru spends more than 240 hours stuck in traffic every year. Such delays result in loss of productivity, reduced air quality, reduced quality of life, and increased costs for services and goods.

The analysis of collected data from primary and secondary sources has brought the following major issues regarding the transport system of Bengaluru.

- Road network capacity is inadequate. Most of the major roads are four lane or less, with limited scope for widening. This indicates the need for judicious use of available road space. The junctions are closely spaced and many junctions in core area are with 5 arms. This makes traffic circulation difficult. There is need to optimise the available capacity by adopting transport system management measures and by making use of intelligent transportation systems.

- Traffic composition on roads indicate very high share of two wheelers and cars. V/C ratios on most of the roads are more than 1. Overall average traffic speed is about 12 Kmph in peak hour. This not only indicates the need of augmenting road capacity but also to plan high capacity mass transport systems on many corridors.

- Outer cordon has high through traffic to the city. These points to the need of road bypasses not only for Bengaluru Metropolitan Area (BMA) but also for Bengaluru Metropolitan Region (BMR). High goods traffic also indicates the need of freight terminals at the periphery of the city.

- Bengaluru is characterised by mutation corridors where residential areas also has commercial activities. In view of this, there is high pedestrian traffic not only in core area but also in other areas of the city. Footpath facilities are generally not adequate and their condition is deteriorating. Therefore up gradation of their facilities is very important. Share of cycle traffic has declined over the years. This mode of transport needs to be promoted by providing cycle tracks along the roads.

- Parking is assuming critical dimensions in Bengaluru. Parking facilities need to be augmented substantially. In the long run, city-wide public transport system needs to provide not only to reduce congestion on roads but also to reduce parking demand.

- BMA Master Plan has provided for densification of existing areas, Mutation corridors, hi-tech areas etc in various parts of the city. This likely to have a major impact on traffic demand. The transport network including mass transport system needs to be planned taking the proposed development in to consideration.

- Major developments have been proposed in the suburban towns of Bengaluru by BMRDA in the BMR. This is likely to increase interaction between Bengaluru and these suburban towns. Thus, there will be need to provide commuter rail services to these towns from Bengaluru.

1.3 DEMOGRAPHIC AND SOCIO ECONOMIC CHARACTERISTICS

Population of Bengaluru has been growing at over 3% per annum since independence. The city, which had a population of 1.6 lakh in 1901, reached 61 lakh in 2001. With a decadal growth rate of 49%, Bengaluru was one of the fastest-growing Indian metropolises for the decade 1991 – 2001. As per 2011 census, the Bengaluru Metropolitan Area (BMA) is estimated to have population of about 85 lakh. The present population is estimated at 120 lakh.

Bengaluru has the second highest literacy rate (87%) for an Indian metropolis. The city's workforce structure is predominantly non-agrarian and only minimum of Bengaluru's workforce being engaged in agriculture-related activities.

1.4 TRANSPORT NETWORK

1.4.1 ROAD NETWORK CHARACTERISTICS

Bengaluru is endowed with a radial pattern of road network converging in the core area of the city. The total road network of the city consists of arterial/sub-arterial roads. The road network in the central parts of the city has developed over the last few centuries and has inadequate Right-of-Way. There is also a Ring Road (Outer Ring Road of about 62 Km) which cuts across the various radial roads. An Intermediate Ring Road has been constructed in fragments in the south-east part of the city between Koramangala and Old Airport Road.

1.4.2 RAIL NETWORK

Bengaluru is an important and major junction on the South-Western railway network. There are five major railway stations in Bengaluru – Kranti Veera Sangolli Rayanna, Bengaluru City Station, Bengaluru Cantonment Railway Station, Yeshwantpur Railway Station and Krishnarajapuram Railway Station. Bengaluru is served by 5 radial rail corridors viz.

- B. G. line from Chennai on east
- B. G. line from Mumbai – Pune on north-west
- B. G. line from Guntakal on the north
- B. G. line from Salem / Thiruvananthapuram from east
- B. G. line from Mysuru from south-west

Though at present these rail corridors serve only intercity traffic, a small number of conventional and DEMU / MEMU short distance passenger trains run in morning and evening hours to nearby (satellite) towns like Tumakuru, Chikkaballapura, Bangarpet, Hosur and Mandya to serve the daily office-going commuters.

Till the beginning of 2010, no rail corridors were operated as regular intra-urban commuter corridors. However, in 2010, the Government of Karnataka in association with South Western Railway (SWR) introduced train services from Yeshwantpur to Hosur and Yeshwantpur to Kempegowda International Airport (KIA) at Devanahalli on trial basis.

1.4.3 METRO RAIL NETWORK

Metro Rail network popularly called as “**Namma Metro”** became operational in 2017. Phase I of **Namma Metro** covering a length 42 km. traverses from Nagasandra to Yelachenahalli (North South corridor) and from Baiyyappanahalli to Mysuru Road (East West Corridor). The Phase-2 is under construction. **Namma Metro**, as a Public Transport System is attracting considerable commuters.

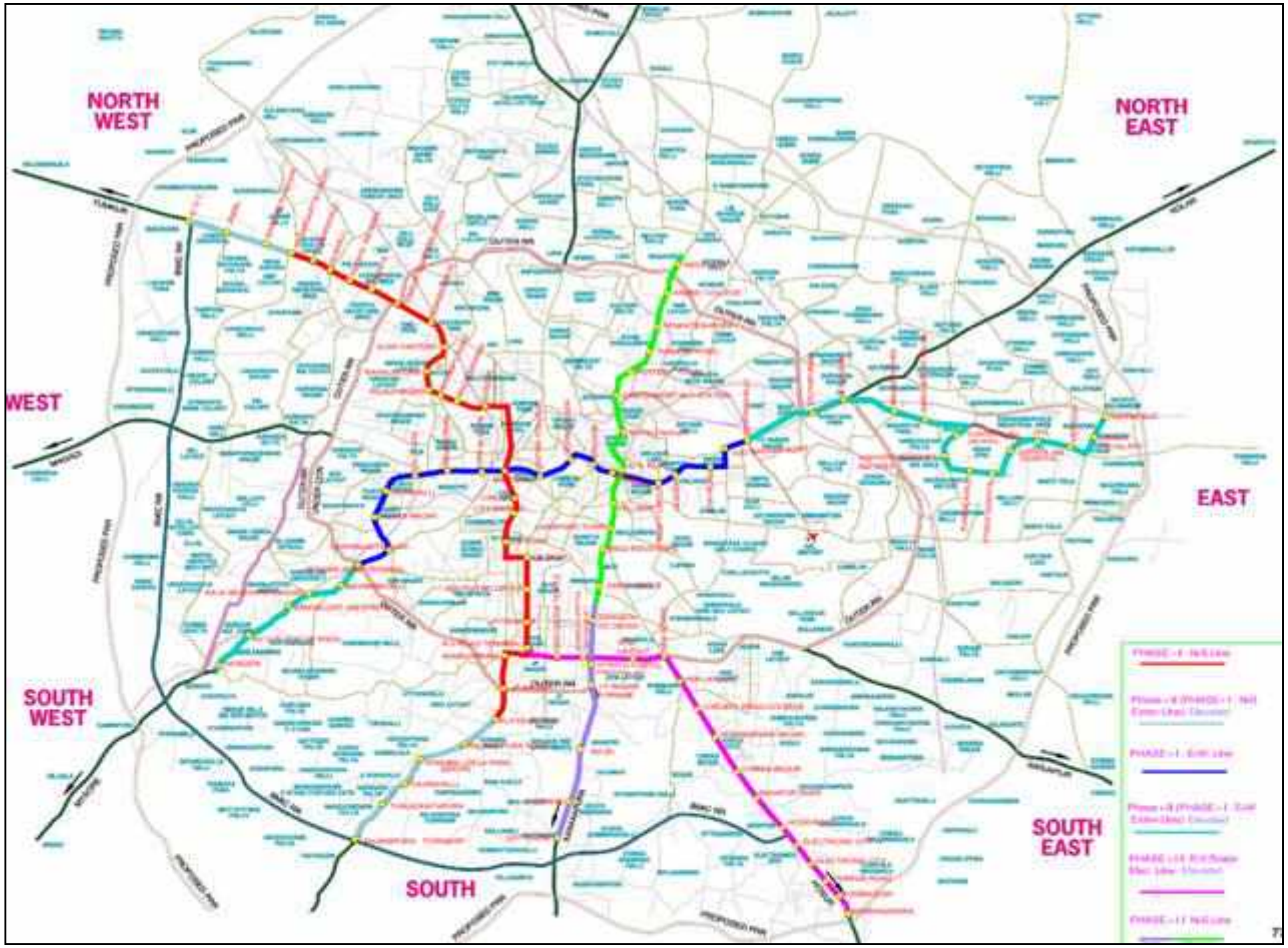
The map showing the road network and Phase-1 Metro corridors are shown in **FIGURE 1.1**

1.4.4 AIRPORT

The earlier HAL Airport located about 11 Km from city centre towards the east of the city and adjacent to the Hindustan Aeronautic Ltd. (HAL) was opened to passenger traffic in 1947. The present Kempegowda International Airport (KIA) located near Devanahalli became operational in May 2008. The Kempegowda International Airport is located north of the City at a distance of 40 Km from the city centre.

The NH-44 (Ballari Road) is the only main road link connecting city to the Kempegowda International Airport. Thus the only public transport connecting the airport from different parts of the city are “Vayu Vajra” bus services operated by Bengaluru Metropolitan Transport Corporation. Apart from this, the Intermediate Public Transport mainly comprising of private taxis is the other mode of transport available to Kempegowda International Airport.

FIGURE 1.1: BENGALURU MAP SHOWING ROAD NETWORK & NAMMA METRO CORRIDORS



1.5 NEED FOR STUDY

The rapid urbanization has contributed to the haphazard growth of the city. The urban infrastructure growth is unable to cope up with the expansion of the city, resulting in traffic congestion and daily commuting becoming a horrendous task for the residents.

To increase the share of public transport in Bengaluru, GoK and Railways had commissioned many studies through RITES Ltd., for introduction of Commuter Rail Services (CRS) in Bengaluru. The studies analysed the existing rail network and suggested improvements / augmentation by way of doubling / quadrupling etc.

However, to run Commuter Rail System in Bengaluru, separate tracks need to be provided, which may involve land acquisition. The land acquisition is generally a costly and time consuming affair and hence, most of the earlier proposals remained non-starter.

The increase in the volume of personalized vehicles like two-wheelers and cars has made riding a nightmare. Therefore, it was decided by Railways to explore the possibility of introducing / enhancing the Commuter Rail Services (also called Sub-Urban Train Services) in Bengaluru, with minimum land acquisition. Towards this end, Railways entrusted the work of examining the Pre-Feasibility of Elevated Rail cum Road corridor along the existing rail network of Bengaluru.

1.6 PRE FEASIBILITY STUDY

Prefeasibility study Report submitted to South Western Railway in November 2017. Considering the following three options:

- Option-1 : Elevated Rail cum Road corridor
- Option-2: Additional Rail corridor in the entire section, road corridor only a circular portion.
- Option-3: Additional Rail corridor only.

1.6.1 OPTION-1: ELEVATED RAIL CUM ROAD CORRIDOR

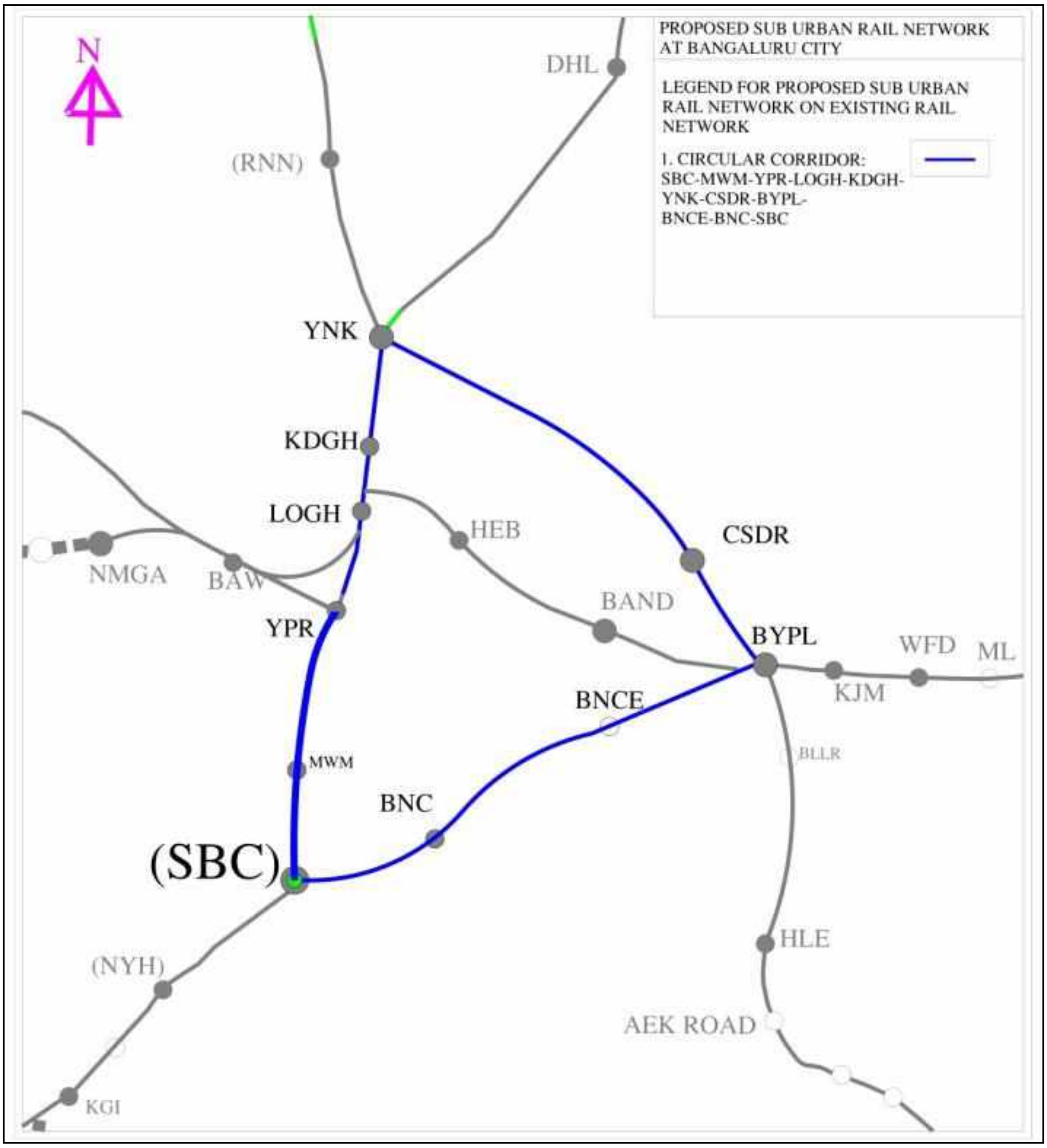
The elevated Rail-cum-Road corridor has been examined over the entire 161 Km of length which includes circular portion of 61 Km and radials of 100 Km. The Elevated corridor contemplated in the study consists of:

- Circular Corridor connecting KSR Bengaluru City – Malleswaram – Yeshwantpur – Lottegollahalli – Kodigehalli – Yelahanka – Channasandra – Baiyyappanahalli – Bengaluru East – Bengaluru Cantonment – KSR Bengaluru City

- One Diagonal corridor connecting Kodigehalli – Hebbal – Banaswadi – Baiyyappanahalli
- Radial corridors – Kengeri – KSR Bengaluru City, Nelamangala – Chikkabanavara – Yeshwantpur, Yelahanka – Rajankunte, Yelahanka – Devanahalli, Baiyyappanahalli – Whitefield, Baiyyappanahalli – Heelalige.

The corridors are shown in **FIGURE 1.2.**

FIGURE 1.2:ELEVATED RAIL CUM ROAD CORRIDOR



1.6.2 OPTION-2: ADDITIONAL RAIL CORRIDOR IN THE ENTIRE SECTION AND ROAD CORRIDOR ONLY IN CIRCULAR PORTION

This option was examined and it is observed that Elevated Rail-cum-Road corridor restricted to circular portion of 61 Km connecting KSR Bengaluru City- Yeshwantpur – Yelahanka – Channasandra – Baiyyappanahalli – Bengaluru Cantonment – KSR Bengaluru City. Additional rail corridors (2 tracks) for sub-urban traffic was considered for the full identified 161 Km. The track will be either At-grade or elevated as per land availability. In this option, elevated road structure would have to be ramped down to the nearest available major road point around the corridor.

1.6.3 OPTION-3: ADDITIONAL RAIL CORRIDOR ONLY

This option involves additional rail corridor only i.e. 3rd & 4th lines in the entire section - either At-Grade or Elevated, depending on the availability of land. The option mainly recommends providing 2 additional lines for Sub-urban train on a single column elevated rail structure on one side of existing double line track where land availability is a constraint for 3rd & 4th lines, at ground level. The option of providing 3rd & 4th lines At-Grade can be explored where land is available. In case there is only a single line, then suburban tracks has been proposed after leaving space for one additional/future line.

1.7 CENTRALISED TRAFFIC CONTROL

To handle Sub-urban Train Services effectively on 4 lines in different corridors, automatic Signaling and CTC will be ideal.

1.8 SPECIAL PURPOSE VEHICLE (SPV)

Finances for the Sub-urban Train Services are to be mobilized from real estate, GoK and Railways. A separate SPV named as BSRC – Bengaluru Sub-urban Rail Corporation was proposed to be formed to manage finances and to co-ordinate with different agencies for Project execution.

1.9 PRESENT ASSIGNMENT

As discussed in earlier paragraphs, Option-3 is the most feasible and practical option for implementation. Option-3 consists mainly of “Additional Rail Corridor only” with 3rd and 4th lines in the entire section either At-Grade or elevated, depending on land availability.

SWR vide their Acceptance letter No.W.496/BNC/ERRN-02 dated 27.04.2018 & TOR has accepted the proposal of Option-3. Accordingly, the work of Feasibility Study for Elevated Rail Corridor for Bengaluru was awarded to M/s RITES Ltd.

The Study was taken up and the Draft Feasibility Report was submitted to South Western Railways (SWR) on 30.11.2018. Based on the observations of SWR and K-RIDE the Final Report was submitted to SWR on 11.01.2019.

Certain observations on the Final Report of January 2019 was made by Ministry of Finance (MoF) which was communicated to RITES Ltd. by SWR vide their letter dated 07.06.2019. Based on the observations communicated, the configuration of corridors has since been modified and details reworked.

1.9.1 TOR FOR PROPOSED FEASIBILITY STUDY

A) Detailed feasibility study shall be carried out on option 3 where railway land is available along with provision of elevated corridors on single column (for 2 tracks) on one side of the existing running lines at other locations. The study shall specifically examine all technical, operational and site constraints including but not limited to items listed out in TOR.

B) Proposed study shall cover site constraints such as;

1) Crossing of ROBs / FOB / Metro tracks by the elevated corridors.

2) Availability and acquisition of Government or Private land at locations where railway land is inadequate.

3) Identifying existence of cables and other utilities like pipe lines etc., alongside railway track which need to be relocated.

4) Requirement of line blocks (including power blocks) for execution of elevated corridor.

5) Constraints regarding execution of works in restricted/congested areas including leading of material and temporary requirement of land for casting depot, material storage etc. Possible remedy to overcome these constraints and cost involved.

6) Measures required for safety of existing services during construction process.

1.9.2 TECHNICAL ISSUES:

A) <u>CIVIL ENGINEERING</u>

a. The required specifications / standards to which the Suburban system should be planned.

b. Permissible gradient for raising / lowering Elevated Corridors from ground level / across obstructions such as Road Over Bridges / Foot Over Bridges / Metro Elevated

Corridors, etc. (in the Pre-feasibility Report, M/s RITES had presumed 1 in 40 gradient, the feasibility of which needs to be re-established with reference to current rules of running of passenger trains).

c. Signalling system required to ensure safety of the trains at proposed gradient.

d. Minimizing gradient locations to avoid repeated changes of grade.

e. Defining other parameters such as maximum curvature and type of track on elevated structure. In case ballast less track is proposed, type of ballast less track.

f. Optimal speed of trains considering Rolling stock, Gradients and Track structure.

g. Engineering Survey through LIDAR/DRONES or other means to all be carried out to assess the feasibility of additional lines/tracks. Survey shall be done for details such that following deliverables are provided to Railway.

- A plan showing horizontal alignment of proposed track at suitable scale. Existing tracks/structures/Railway boundary shall be marked on this plan so that Railway is in a position to confirm feasibility of the proposal.
- A plan showing vertical alignment of the proposed track at suitable scale. Existing structures such as ROB, FOB, adjacent buildings, etc. to be marked on the plan. Future plan for such structures to be confirmed from the State Government and incorporated in the Report.
- Engineering survey through LIDAR/DRONES of all the station yards shall be done. A plan shall be prepared after survey showing existing tracks/facilities and proposed additional facilities.

h. Detailed scheme of integration of the Elevated Corridor at Junction stations, particularly at bigger stations viz. KSR Bengaluru City, Yeshwantpur, Yelahanka and Baiyyappanahalli, along with requirement of additional platforms with their locations and layout.

i. Requirement and technical feasibility of Rail flyovers as proposed in the Report at Baiyyappanahalli and any additional flyover.

j. Requirement and planning of 4th Coaching Terminal in addition to existing terminals at KSR Bengaluru City and Yeshwantpur stations and the upcoming Baiyyappanahalli Coaching Terminal.

k. Impact and consequences of derailment and accident on the elevated corridor and relief and rescue operations both on elevated corridor and existing network once columns are erected for the elevated corridor.

l. Location and movement of Relief equipment.

m. Approach constraints for Railway stations for proposed Commercial development for funding/part funding of the Suburban Project (it is to be seen whether the approaches are adequate to take the additional traffic arising out of the proposed Commercial development which may include Hotels, Malls, Commercial Complexes, etc.). Areas adjacent to Railway Stations to be explored for suitable modifications to facilitate approaches to the stations.

n. Feasibility and technical aspects of Commercial development of the Stations including circulating areas as well as airspace over the stations.

B) OPERATIONAL

a. Survey needs to be done with regard to the likely traffic in the proposed corridors including existing Suburban services considering other modes of transports being developed by the State Government.

b. Future suburban rail traffic and projections for the next 20 years.

c. Possibility of meeting the additional demand by conversion of conventional rakes to MEMU rakes of 16 coach each to be examined.

d. Review of comprehensive Transport Plan for Bengaluru – Modal share of public transport viz. rail mode, metro, bus, auto, personal cars, etc. – assess the future demand for each stream of traffic for the next 20 years

e. Feasibility and justification for the gradients for reaching the elevated structure and for coming down to be commensurate or rather concurrent with conventional rakes to permit long distance services to use the elevated structure for more flexibility in operations.

f. GR and SR provisions for gradients in yards and approaches to be catered for. Operational constraints and their effect on the line capacity if any with the proposed gradient to be examined.

g. To examine the possibility of running long distance trains on the suburban network.

h. MEMU /EMU maintenance and terminal facilities to be planned for 20 car lengths keeping in view future requirements.

i. De-congestion of existing terminals for augmentation of sub-urban services. Possibility of acquiring Binny Mill Land vital to decongest SBC station and freezing action on the same.

j. Electrification and provision of automatic signaling and modern communication facilities on the identified corridors.
k. Mode of operation and control – CTC etc.

C) <u>OTHERS</u>

a. To include detailed feasibility study of all the corridors and items contained in the earlier Study carried out by M/s RITES including preparation of Cost Estimates, Station Planning, Inter-Modal Integration, Maintenance facilities, etc.
b. Take-into account the existing Planning/ sanctions i.e. doubling/ Tripling / Quadrupling.
c. To provide Plans showing horizontal and vertical alignment, indicative Section of the Elevated Corridors as in item A (f) and Scheme of Integration with the existing Stations / Yards, etc.
d. Include required data collections for field studies and site visits including Survey by Drones, etc.
e. Requirement and feasibility of additional stations.
f. Preparation of Abstract Cost Estimates and ROR.
g. While assessing the rate of return include factors like:
    - Exploitation of commercial space, including sky space.
    - Various operational concessions being granted to such major urban infrastructure by government bodies.
    - Financing pattern and funding of metro infrastructures in line with National Urban Transport Policy of MOUD.
    - Policy guidelines for taking up suburban Rail system on Indian Railways.
    - Modes of financing – JV, SPC etc.

1.10 COMPOSITION OF REPORT

The present Feasibility Report has been finalised based on the observations communicated on the Feasibility Report submitted on January, 2019 by Railway Board.

The Report has 12 chapters including this introductory chapter and covers all items of the scope. Some of the items will however, be further discussed with client officials and suitably incorporated in the Final Report.

Chapter 2 of the Report deals with Travel Demand Modelling and Ridership Assessment on the complete transport network in various horizon years. Chapter 3 presents the Planning for alignment as well as the station locations. Various utilities that are likely to get affected due to the Project are identified in Chapter 4. Station Planning and Architecture is presented in Chapter 5. Intermodal integration and dispersal planning is covered in Chapter 6. Construction Planning is presented in Chapter 7. Chapter 8 covers all aspects relating to System Design including Rolling Stock, Traction, Signaling, AFC, and maintenance facilities. Disaster Management is covered in Chapter 9. Airport connectivity is Chapter 10, Costing and Financials for the project are presented in Chapter 11 and the Conclusions and Recommendations are listed in Chapter 12.

2. TRANSPORT DEMAND ANALYSIS

2.1 STUDY AREA

The study area includes Bengaluru Metropolitan Area (BMA area) of about 1306 Sq.km. (including part BMICAPA area – 65.31 Sq.km.) and adjoining areas around Bengaluru International Airport Area Planning Authority (BIAAPA). Adjoining BIAAPA area has been included in the study area as public transport corridors are connecting Kempegowda International Airport and some of the localities where proposed development have been listed out in BIAAPA Master Plan. The horizon year for the study is 2041. The effect of traffic coming from outside Bengaluru and using Bengaluru's transport system has also been taken into account.

2.1.1 ROAD NETWORK CHARACTERISTICS

Bengaluru's road network length exceeds 3,000 km and consists of ring roads, arterial roads, sub-arterial roads and residential streets. The city road network is mainly radial, converging in the center. The road network in the central parts of the city has developed organically over the last few centuries and has inadequate right-of-way. There is a Core Ring Road and also Outer Ring Road of about 62 Km which cuts across the various radial roads. An Intermediate Ring Road has been constructed in fragments at south-east of the city between Koramangala and Old Airport Road.

Some of the National Highways which pass through Bengaluru include:

- NH – 48 connecting to Delhi and Chennai
- NH – 44 connecting to Varanasi and Kanyakumari
- NH – 948 connecting Bengaluru to Coimbatore

The following are the State Highways in Bengaluru:

- SH – 17 connecting Mysuru
- SH – 9 connecting Hindupur via Yelahanka and Doddaballapur
- SH – 86 connecting Mysore via Kanakapura

B.V.K. Iyengar Road is the retail hub of Bengaluru, while MG Road, Commercial Street and Brigade Road are important shopping, recreation and corporate areas. Road network capacity is inadequate and most of the major roads are with four lanes or less with limited scope of widening.

2.1.2 REGIONAL RAIL NETWORK

Bengaluru is an important and a major junction on the South-Western railway network. There are three major railway stations in Bengaluru - City Railway Station, Cantonment Railway Station and Yeshwantpur Railway Station. Bengaluru is served by 5 radial rail corridors.

- B.G. line from Chennai on east
- B.G. line from Mumbai-Pune on north-west
- B.G. line from Guntakal on the north
- B.G. line from Salem / Thiruvananthapuram from east
- B.G. line from Mysuru from south-west

Though at present these rail corridors serve only intercity traffic, a small number of conventional short distance passenger trains are run in morning and evening hours to nearby (satellite) towns like Tumakuru, Chikkaballapur, Bangarpet, Hosur and Mandya to serve the commuters.

Government of Karnataka in association with South Western Railways has introduced train services from Yeshwantpur to Hosur and Yeshwantpur to Kempegowda International Airport (KIA) at Devanahalli on trial basis.

2.1.3 BENGALURU METRO RAIL NETWORK

A rapid transit system called the Namma Metro is being built in stages. At present, Phase 1 covering a length of 43 km on two lines i.e. Mysore Road to Baiyyappanahalli and Nagasandra to Yelachenahalli. Both the lines are under operation and catering about 4.4 Lakh of daily ridership. The Phase 2, 2A & 2B are under implementation.

2.1.4 KEMPEGOWDA INTERNATIONAL AIRPORT (KIA)

The present Kempegowda International Airport (KIA) located near Devanahalli became operational in May 2008. The Kempegowda International Airport is located north of the City at a distance of 40 Km from the city centre.

The NH-44 (Ballari Road) is the only main road link connecting city to the BIA. Thus the only public transport connecting the airport from different parts of the city are the bus services operated by BMTC. Apart from this, the IPT comprising of private taxis are the other modes of transport available to BIA. Direct flights from Bengaluru fly to destinations in Asia, the Middle East and Europe.

2.1.5 BUS TRANSPORT SYSTEM

The city has one of the better run city bus transport systems in the country. BMTC has 40 depots in and around Bengaluru city. The daily ridership is approximately 50 Lakh passengers. BMTC operates 578 City and 1756 Sub-Urban routes per day. BMTC is catering to the transport services in city and suburban areas of Bengaluru in a radius of about 40.4 km and the area of operation is expanded from 3527 Sqkm. to 5130 Sqkm. It has established state of the art commuter friendly modernized bus stations at Shivaji Nagar, Shanti Nagar and MCTC. Kempegowda Bus Station at Subhash Nagar is also modernized with improved commuter amenities. The other major terminal of BMTC operating in the city is located at K R Market.

In order to increase the frequency of services and to provide direction-oriented services in place of the destination oriented services, 27 high density trunk corridors (Grid Routes) were identified and services offered along these routes. However, due to poor patronage for these services, these were withdrawn and BIG10 services have been started along 12 major corridors in and around the City and its sub-urbs mainly along Hosur Road, Bannerghatta Road, Sarjapura Road, Kanakapura Road, Mysore Road etc. These buses are run on a direction based concept where the commuter takes the next (high frequency, every 15 minutes) bus in his/her direction of travel, and if need be, makes a changeover to another bus to reach the destination. The service terminates on different points on the radius of the city core, to avoid congesting the city centre.

BMTC has now added a few more buses to its fleet under the JNNURM. The plans of adding new depots, new bus stations, commuter amenity centres, bus shelters, GPS system etc. are being implemented by BMTC in phases. A few Traffic & Transit Management Centres (TTMC) have been constructed at some locations of the City and a few are planned for future also.

2.1.6 INTERMEDIATE PUBLIC TRANSPORT

Auto rickshaws and taxis are the IPT facility available in Bengaluru. Autos are the popular form of transport and can be called common man’s taxi in Indian cities and towns. Apart from the autos, regular small cars (Maruti Omni vans and Indica diesel cars) and Ola cabs as taxis are provided by several operators commonly referred to as City Taxis or call Taxis. The autos are also used for education and other trips and to a large extent by the visitors to the city. The drivers tend to take advantage of the vehicle’s size and manoeuvrability and criss-cross in traffic contributing a lot to traffic indiscipline and delays to overall traffic flow.

2.1.7 DATABASE FOR THE STUDY

The transport network maps of the Study Area and land-use proposals were studied in depth to assess the scope and requirement of future transport infrastructure. The data available with various Government departments relating to traffic and travel characteristics was collected and compiled for use in the Study.

The primary surveys included Road Network Inventory, Speed and Delay Survey, Traffic Volume Surveys, Origin and Destination Survey, Outer cordon surveys, Bus and Shared Auto Passenger Survey, Rail Terminal Survey and Household Travel Surveys.

The traffic volume data was compiled, both, in terms of vehicles and passengers. Origin-Destination (O-D) matrices for public and private transport, for various trip purposes was prepared for base year and projected for various horizon years.

Planning parameters consisting of population, employment and number of resident workers for the zone system for the base year (2018) and for the horizon years (2025, 2031 & 2041) have been quantified.

A road network map with all roads of ROW, 12m and above was developed and integrated with traffic zone system.

2.1.8 ZONING SYSTEM

The entire study area has been divided into 198 internal urban & 17 zones of Bengaluru International Airport Area Planning Authority and 10 external traffic zones. The traffic zone system maps are shown in **Figure 2.1** and **Figure 2.2**.

FIGURE 2-1: TRAFFIC ZONE SYSTEM OF BMA

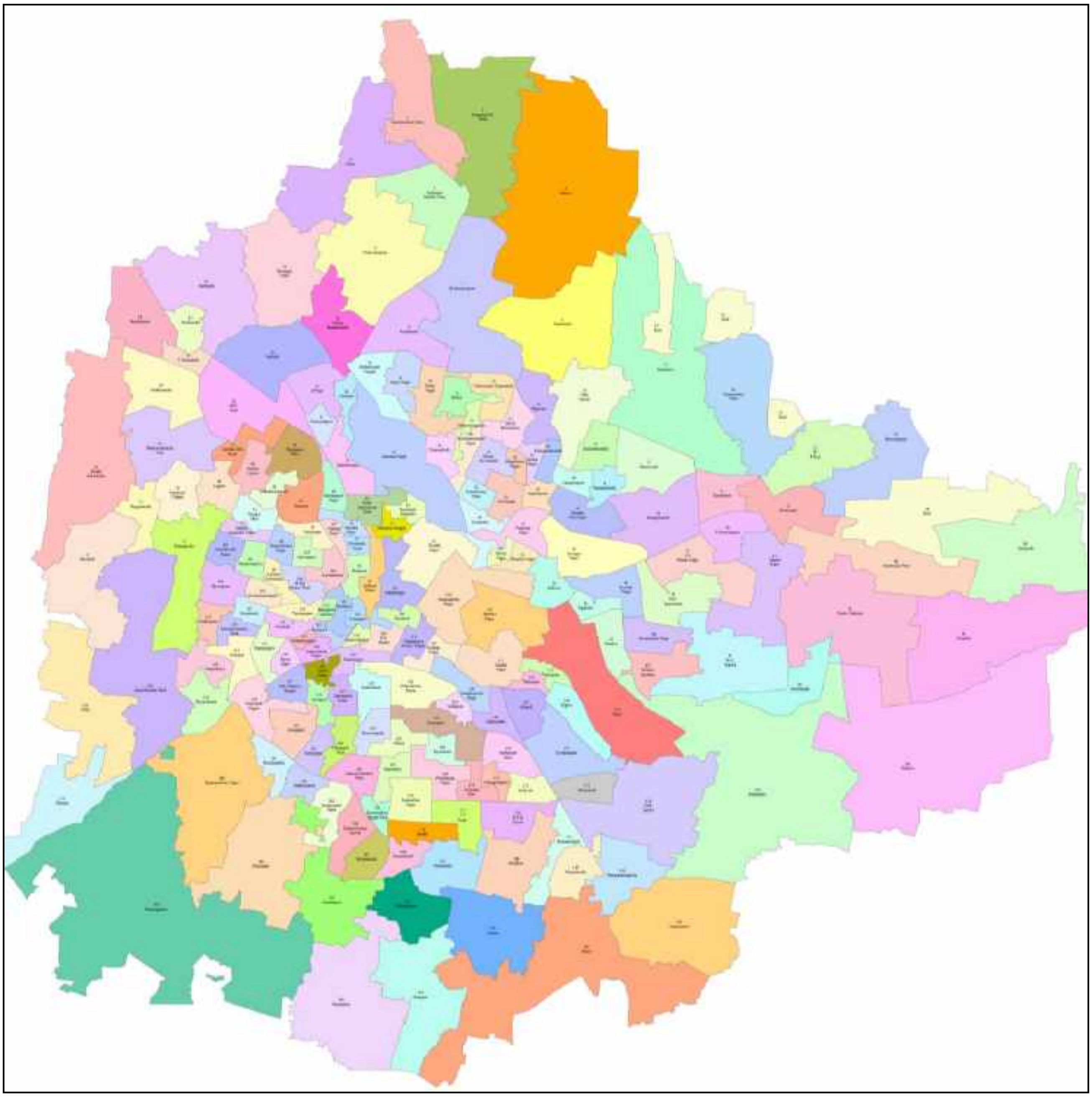
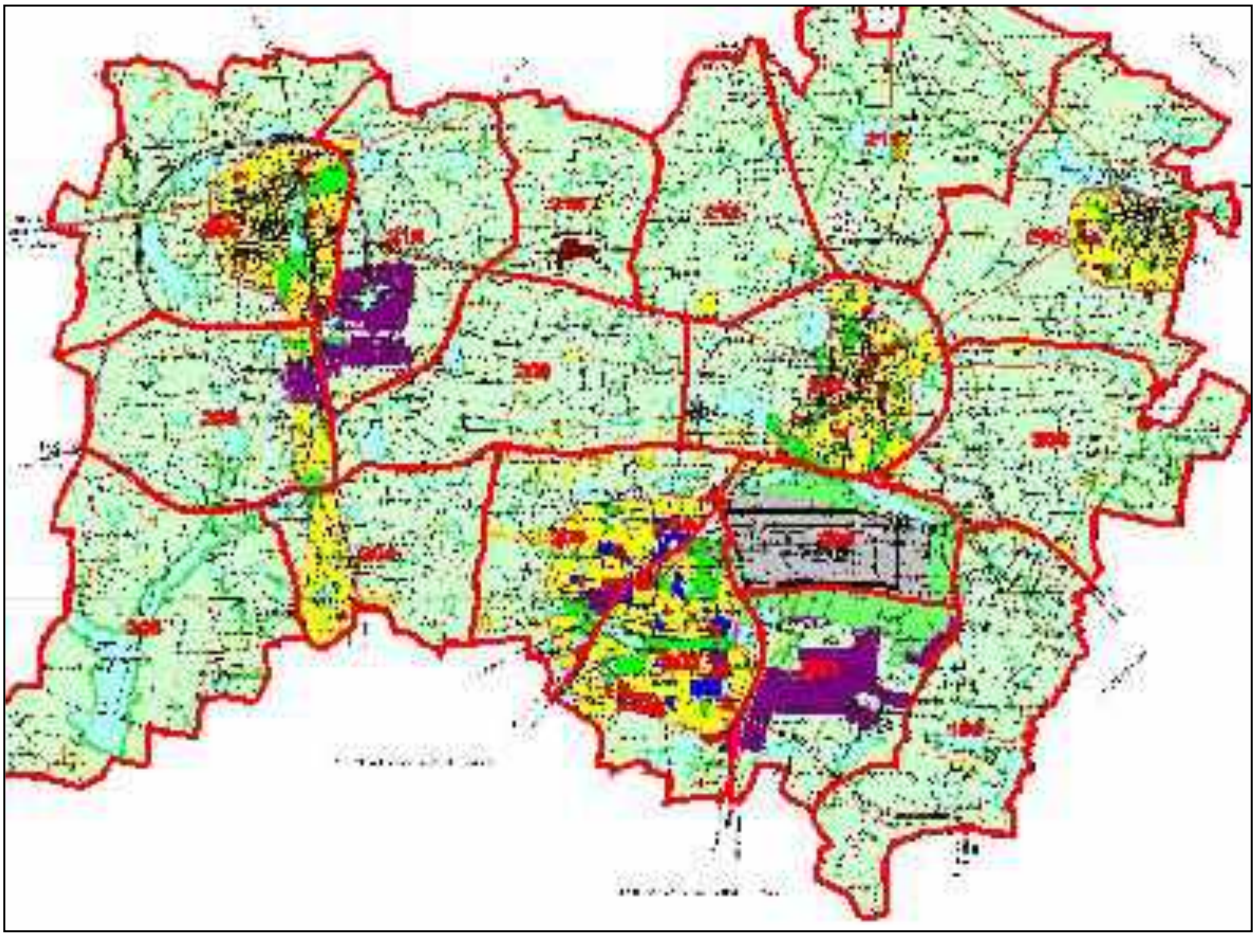


FIGURE 2-2: TRAFFIC ZONE SYSTEM OF BIAAPA



2.2 PRIMARY SURVEYS

2.2.1 SOCIO-ECONOMIC CHARACTERISTICS

The following outputs were derived from the analysis of the household survey.

- Zone wise distribution of the households according to household size and vehicle ownership
- Zone wise distribution of the individuals by their occupation and education level
- Distribution of trips by mode and purpose
- Distribution of trips by trip length

i. Distribution of Household By Size

Distribution of households according to its family size is presented in **TABLE 2-1** and **FIGURE 2-3.** The table indicates that about 8% of the households have upto 2 member and about 16% of the households belong to the category of households which have 5-6 persons per household. Majority of households

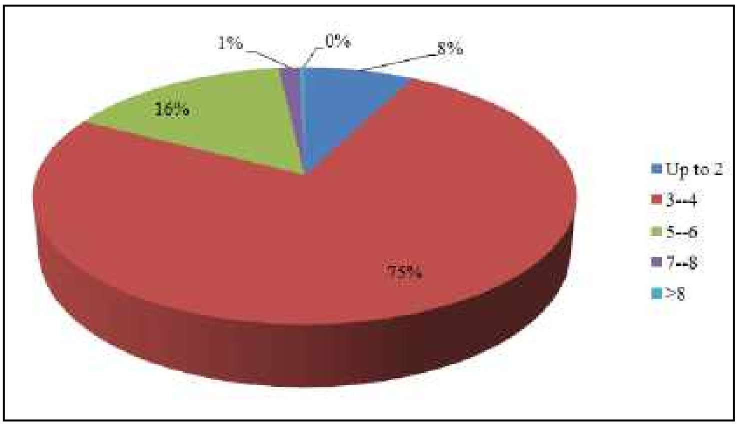
(75%) have between 3 to 4 persons per households. The average household size is 3.7.

TABLE 2-1: DISTRIBUTION OF HOUSEHOLDS ACCORDING TO SIZE

S. No.	Household by No. of Members	No. of Households	(%)age
1	Up to 2	780	7.7
2	3-4	7619	74.9
3	5-6	1584	15.6
4	7-8	152	1.5
5	>8	32	0.3
Total		**10167**	**100.0**

Source: RITES Primary Surveys – 2015

FIGURE 2-3: DISTRIBUTION OF HOUSEHOLDS ACCORDING TO SIZE



ii. Distribution of Household By Vehicle Ownership

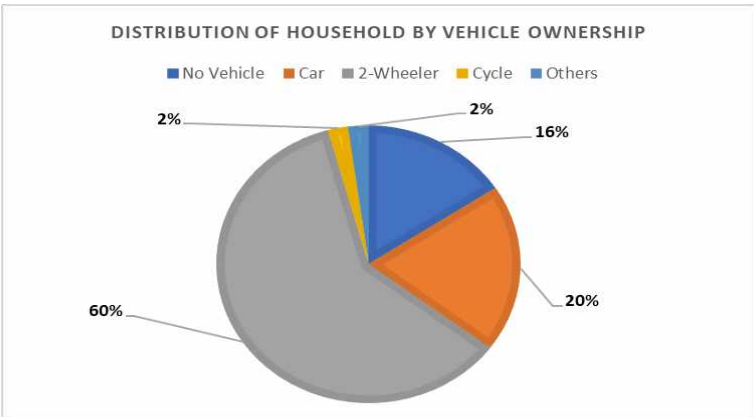
Distribution of households owning vehicles is presented in **TABLE 2-2** and **FIGURE 2-4.** It is observed that about 60% of households have 2-Wheeler while 19.6% of household have car and only 2.2% have Cycle.

TABLE 2-2: DISTRIBUTION OF HOUSEHOLDS ACCORDING TO VEHICLE OWNERSHIP

S No.	Type of Vehicle	Number of Households	(%)age
1	No Vehicle	1938	15.7
2	Car	2408	19.6
3	2-Wheeler	7438	60.4
4	Cycle	267	2.2
5	Others	263	2.1
Total		**12314**	**100.0**

Source: RITES Primary Surveys – 2015

FIGURE 2-4: DISTRIBUTION OF HOUSEHOLDS ACCORDING TO VEHICLE OWNERSHIP



iii. Distribution of Individual by Occupation

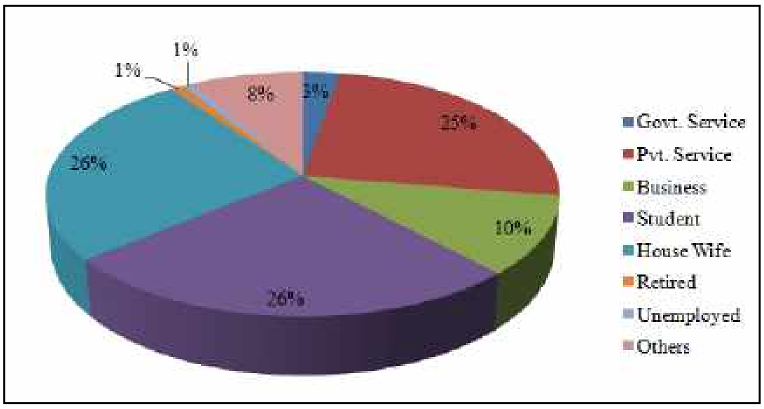
Distribution of individuals of sampled households according to their occupations is presented in **TABLE 2-3** and in **FIGURE 2-5.** It is observed that 38% of individuals are engaged in occupations like (Govt. Service, Pvt. Service & Business). The number of students and housewives is accounted for about 26%.

TABLE 2-3: DISTRIBUTION OF INDIVIDUALS BY OCCUPATION

S. No.	Occupation	No of Individuals In Sampled Households	Percentage (%)
1	Govt. Service	1034	2.7
2	Pvt. Service	9477	24.9
3	Business	3961	10.4
4	Student	9905	26.0
5	House Wife	9940	26.1
6	Retired	371	1.0
7	Unemployed	275	0.7
8	Others	3129	8.2
Total		**38092**	**100.0**

Source: RITES Primary Surveys – 2015

FIGURE 2-5: DISTRIBUTIONS OF INDIVIDUALS BY OCCUPATION



iv. Distribution of Individuals by Education

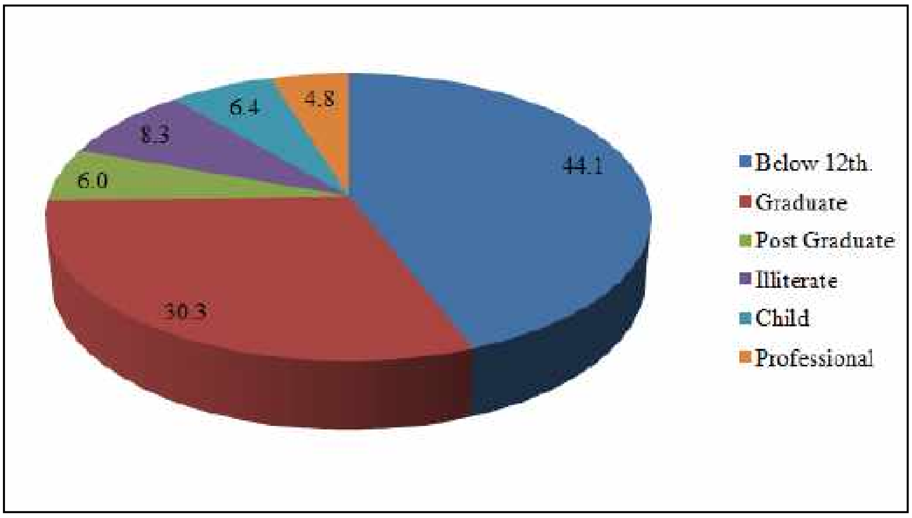
Distribution of individuals of sampled households according to their education is presented in **TABLE 2-4** and in **FIGURE 2-6**. It is observed that about 44% of individuals are non-matriculates, matriculates or intermediate (12th) pass. Graduates and post-graduates account for nearly 26%.

TABLE 2-4: DISTRIBUTIONS OF INDIVIDUALS BY EDUCATION

S. No.	Education	No. of Individuals In Sampled Households	(%)age
1	Below 12th	16817	44.1
2	Graduate	11553	30.3
3	Post Graduate	2278	6.0
4	Illiterate	3168	8.3
5	Child	2440	6.4
6	Professional	1836	4.8
Total		**38092**	**100.0**

Source: RITES Primary Surveys – 2015

FIGURE 2-6: DISTRIBUTIONS OF INDIVIDUALS BY EDUCATION



2.2.2 TRAVEL CHARACTERISTICS

i. Distribution of Trips by Mode of Travel

Distribution of trips according to mode of travel is given in **Table 2.5, Table 2.6, Table 2.7** and **Table 2.8.** It is observed that about 26% of the trips are walk trips. However, the trips performed by 2 wheelers are about 27% and 32% trips are performed by public transport modes including bus, minibus, school bus chartered bus and metro. The trips performed by auto rickshaw and taxis are about 7%. Per capita trip rate including walk is 1.24 and for motorized trips is 0.91.

TABLE 2-5: MODAL SPLIT - 2015 (INCLUDING WALK TRIPS)

S. No.	Mode	No of Trips	(%)age
1	Car	870571	7.0%
2	2-Wheeler	3353560	26.9%
3	Auto/ Taxi	855186	6.9%
4	Bus	3964859	31.8%
7	Metro	29000	0.2%
8	Cycle	83744	0.7%
9	Walk	3313389	26.6%
Total		**12470309**	**100%**

Source: RITES Primary Surveys – 2015

FIGURE 2-7: MODAL SPLIT - 2015 (INCLUDING WALK TRIPS)

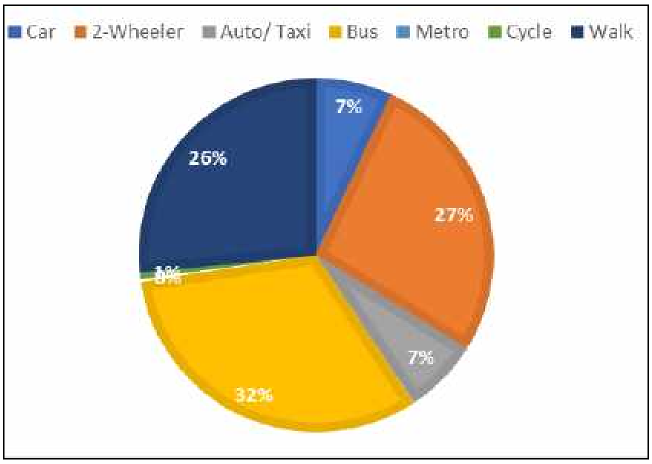
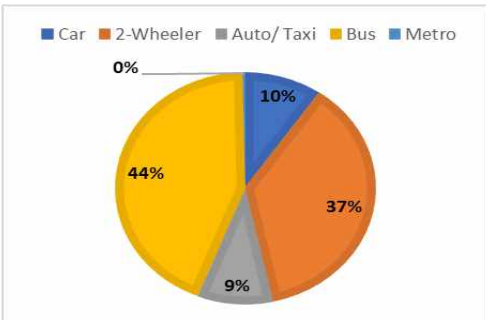


TABLE 2-6: MODAL SPLIT - 2015 (MOTORISED TRIPS)

S. No.	Mode	No of Trips	(%)age
1	Car	870571	9.6%
2	2-Wheeler	3353560	37.0%
3	Auto/ Taxi	855186	9.4%
4	Bus	3964859	43.7%
5	Metro	29000	0.3%
Total		**9073176**	100.0%

Source: RITES Primary Surveys – 2015

FIGURE 2-8: MODAL SPLIT - 2015 (MOTORISED TRIPS)



ii. Purpose wise Distribution of Trips

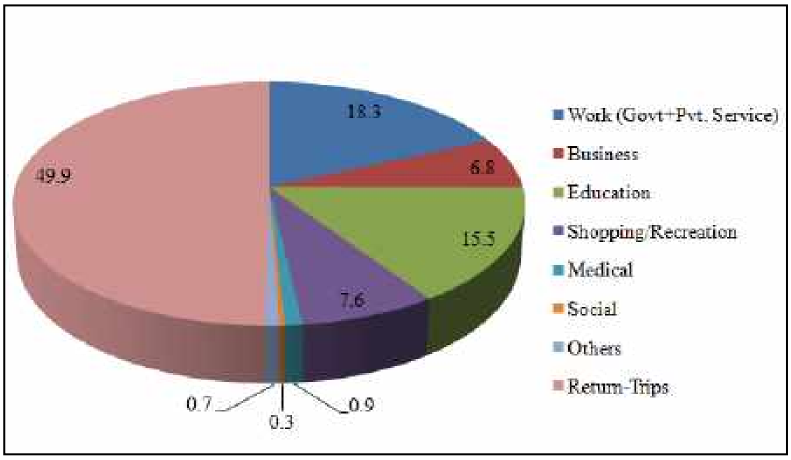
TABLE 2-7 and **FIGURE 2-9** gives the purpose wise distribution of the trips. It is observed from the table that about 25% of the trips are performed for work and business purpose together, where as 15% trips are education and about 10% trips which includes shopping, social, health and recreation.

TABLE 2-7: PURPOSE WISE DISTRIBUTION OF TOTAL TRIPS

S. No.	Purpose	No of Trips	(%)age
1	Work (Govt.+ Pvt. Service)	2292057	18.3
3	Business	844160	6.8
4	Education	1932514	15.5
5	Shopping/Recreation	952965	7.6
6	Medical	118652	1.0
7	Social	40197	0.3
8	Others	87255	0.7
9	Return-Trips	6202509	49.7
Total		**12470309**	**100.0**

Source: RITES Primary Surveys – 2015

FIGURE 2-9: PURPOSE WISE DISTRIBUTION OF TOTAL TRIPS



iii. Mode wise Distribution by Trip Length

Mode wise distribution of average trip length is presented in **TABLE 2-8.** Average trip length for walk is 2.0 Km, for 2-wheeler 8.1 km, for car and taxi is 12.2 km and 12.7 km respectively and for Bus it is about 9.7 km.

TABLE 2-8: MODE WISE AVERAGE TRIP LENGTH

S. No.	Mode	Average Trip Length (Km)
1	Car	12.8
2	Taxi	13.1

S. No.	Mode	Average Trip Length (Km)
3	Shared Taxi	15.4
4	2- Wheelers	8.0
5	Auto	6.0
6	Bus	10.7
7	Mini Bus	10.7
8	School Bus	5.1
9	Chartered Bus	15.1
10	Cycle	2.6
11	Walk	1.0

Source: RITES Primary Surveys – 2015

2.2.3 HOUSEHOLD OPINION SURVEY

Household opinion survey was carried out to obtain preference of commuters about shifting to good public transport system. The respondents were asked their willingness to pay extra fare and time saving with respect to their existing mode of transport used.

TABLE 2-9 shows that about 96% of respondent households are willing to shift to a good public transport system where as about 4% of households want to use their existing mode of travel.

TABLE 2-9: WILLINGNESS TO SHIFT TO GOOD PUBLIC TRANSPORT SYSTEM

S. No.	Response	No of Households (Surveyed)	Percentage (%)
1	Yes	9252	91.0
2	No	915	9.0
Total		**10167**	**100.0**

Source: RITES Primary Surveys – 2015

2.3 EXISTING AND PROPOSED LANDUSE DISTRIBUTION

One of the important aspects of traffic demand modelling exercise is the estimation of base and horizon year landuse parameters. Base year land-use parameters population, employment and student enrolment have been taken from 2011 Census Data, and data collected from Bengaluru Development Authority (BDA), Bruhat Bengaluru Mahanagara Palike (BBMP), BIAAPA and Town Planning Organisation etc. Landuse parameters for various horizon years have been estimated as envisaged in the BDA Draft Master Plan 2031 for Bengaluru Metropolitan area and BIAAPA Master Plan 2021 area.

In addition to this, detailed discussions with various officials of Bruhat Bengaluru Mahanagara Palike (BBMP), Bengaluru Development Authority

(BDA), Bengaluru Metro Rail Corporation Ltd. (BMRCL), KIADB, Bengaluru International Airport Area Planning Authority (BIAAPA) and Karnataka – Udyog Mitra (KU Mitra) have been carried out. Their views on direction of city growth and anticipated population & employment growth across different sectors for various horizon years have been taken into account. A preliminary reconnaissance was also carried out by RITES team to make an assessment of the present level of development in various zones of the study area.

2.3.1 BASE YEAR POPULATION

The population of Bengaluru Metropolitan Area and BIAAPA area for year 2011 has been taken from Census data of year 2011. As per the census of India the population of Bengaluru city is about 84.5 lakh and BIAAPA Area population is about 5 lakhs in 2011.

Base year (2018) population estimation for the study area has been worked out on the basis of Census 2011 figures, divisional growth trends and Master Plan of Bengaluru. Based on these factors, the population for the base year 2018 has been estimated as 120 Lakh.

2.3.2 FUTURE GROWTH SCENARIO

The core area of Bengaluru is saturated to an extent and hence may see a little appreciation in the growth of population but Core area i.e., Gandhi Nagar, Shivaji Nagar, Chikkapete, Cottonpete, Binnipete, Kempapura Agrahara, KR Market & Chamarajapet etc will continue to attract a large number of people for their employment, shopping, trading, education, medical, tourism and other requirements.

Planning authorities have proposed new planning area to accommodate rising population and provide upgraded scale of services to its inhabitants towards East in Whitefield Hoodi area, North-east in Hennur & Thanisandra, North-West in Tumakuru Road, Yelahanka & along Doddaballapur Road, along Outer Ring Road, West in Magadi Road, South-East in Sarjapura Road. In addition, KIADB is planning Software park, Hard ware park, Aerospace, Socio-Economic zone, Finance City, Apparel Park near KIA (Kempegowda International Airport). The area around Outer Ring Road, Sarjapura road, ITPL main road, Doddaballapur Road and Devanahalli are considered the most potential areas as per development point of view.

The city limits are expanding very fast, as numerous new organized and unorganized residential colonies have mushroomed.

The ward wise population for the years 2018, 2025, 2031 and 2041 of study area have been assumed to grow according to the residential density pattern and the landuse plan.

Numerous development projects i.e., residential & commercial are proposed in study area. The proposed growth of population and economy is expected to generate high travel demand. The study area has been considered in area wise based on existing level of saturation in growth as follows.

1. Core area-1 : Central Zones where Growth reached to an extent
2. Core Area-2 : Areas where moderate scope for growth
3. Outer Ring Road (ORR) : Zones adjoining to Existing Outer Ring Road
4. Outer Area -1 : Zones in between ORR & Extreme outer Zones
5. Outer Area -2 : Extreme outer Zones
6. BIAAPA Area : Areas in and around airport site covering Doddaballapur, Devanahalli and Vijayapura towns

The decadal Area-wise population growth rate in study area is shown in **TABLE 2-10** and projected population for horizon years 2018, 2025, 2031 and 2041 are shown in **TABLE 2-11.**

TABLE 2-10: DECADAL POPULATION GROWTH RATES STUDY AREA (BMA & BIAAPA)

Population Growth rate (Area-wise)				
S. No.	Area Description	Annual Growth rate (%)		
		2025	2031	2041
1	Core Area-1	1	0.5	0.5
2	Core Area-2	3	1.5	0.5
3	Area adjoining Outer Ring Road	3	1.8	1
4	Outer Ring Road -1 (wards in between ORR & Extreme outer wards)	5	5	2.5
5	Outer Ring Road -2 (Extreme outer wards)	4	4.5	3.5
6	BIAAPA Area	4	4.5	3.5

TABLE 2-11: PROJECTED POPULATION OF STUDY AREA 2011 TO 2041

S. No	Year	Population (Lakh)
1	2011	90
2	2018	120
3	2025	152
4	2031*	180
5	2041	215

**Draft Master Plan (2031) Population Suitably Considered*

The zone wise distribution of estimated population of the study area for various horizon years viz. 2018, 2025, 2031 & 2041 is given in **TABLE 2-12.**

TABLE 2-12: ZONE WISE DISTRIBUTION OF POPULATION

Traffic Zone	Traffic Zone Name	Population				
		2011	2018	2025	2031	2041
1	Kempegowda Ward	34783	45772	61400	79958	112789
2	Chowdeswari Ward	36602	48166	64611	84140	118687
3	Atturu	58129	76494	102610	133625	188492
4	Yelahanka Satellite Town	41986	59079	83129	111401	142603
5	Jakkuru	52025	68461	91836	119594	168699
6	Thanisandra	71855	101107	142268	190653	244052
7	Byatarayanapura	72154	101528	142860	191446	245067
8	Kodigehalli	47546	66902	94138	126154	161487
9	Vidyaranyapura	57195	80479	113242	151755	194260
10	Dodda Bommasandra	36396	51213	72062	96569	123617
11	Kuvempu Nagar	37128	48858	65539	85349	120393
12	Shettihalli	61071	80365	107804	140388	198032
13	Mallasandra	41482	54587	73225	95358	134512
14	Bagalakunte	65113	85684	114939	149680	211139
15	T Dasarahalli	33042	46493	65421	87670	112225
16	Jalahalli	37959	53412	75156	100717	128926
17	J P Park	49610	69806	86787	96592	106697
18	Radhakrishna Temple Ward	35122	49420	61442	68383	75538
19	Sanjaya Nagar	32491	45718	56839	63261	69879
20	Ganga Nagar	27361	38500	47865	53272	58846
21	Hebbala	32516	45753	56883	63309	69933
22	Vishwanath Nagenahalli	51592	72595	90254	100451	110960
23	Nagavara	60483	85106	105808	117762	130082
24	HBR Layout	58967	82972	103156	114810	126822
25	Horamavu	95368	134192	188822	253040	323912
26	Ramamurthy Nagar	47358	62320	83597	108865	153565
27	Banasavadi	51268	72139	89687	99820	110263
28	Kammanahalli	47074	66238	82350	91654	101243
29	Kacharkanahalli	33588	47262	58758	65397	72238
30	Kadugondanahalli	45748	60201	71874	78590	82609
31	Kushal Nagar	41936	55185	65885	72041	75725
32	Kaval Bairasandra	39334	51761	61797	67571	71027
33	Manorayanapalya	47926	63067	75295	82331	86542
34	Gangenahalli	24308	31988	38190	41758	43894
35	Aramane Nagara	36738	48345	57718	63112	66339

Traffic Zone	Traffic Zone Name	Population				
		2011	2018	2025	2031	2041
36	Mattikere	37036	48737	58186	63624	66877
37	Yeshwanthpura	41107	54094	64582	70617	74228
38	HMT Ward	36879	51892	73018	97851	125258
39	Chokkasandra	59289	83426	117388	157311	201372
40	Dodda Bidarakallu	72794	95792	128497	167337	236045
41	Peenya Industrial Area	57814	81350	114468	153398	196362
42	Lakshmi Devi Nagar	41352	58186	72340	80513	88937
43	Nandini Layout	51200	72044	89568	99688	110117
44	Marappana Palya	40212	52916	63176	69080	72612
45	Malleswaram	34196	45000	53725	58745	61749
46	Jayachamarajendra Nagar	31449	41385	49409	54026	56789
47	Devara Jeevanahalli	42135	55447	66197	72383	76085
48	Muneshwara Nagar	35814	47129	56267	61524	64671
49	Lingarajapura	37955	49946	59630	65202	68537
50	Benniganahalli	49094	64604	77130	84338	88651
51	Vijnanapura	46159	64950	80750	89873	99275
52	K R Puram	35168	46279	62079	80843	114037
53	Basavanapura	48585	63935	85763	111686	157544
54	Hudi	50191	66048	88598	115378	162752
55	Devasandra	33946	47765	59384	66094	73008
56	A Narayanapura	43443	61129	75998	84584	93434
57	C V Raman Nagar	58815	77397	92403	101037	106204
58	New Tippasandara	43983	57879	69101	75558	79422
59	Maruthi Seva Nagar	40362	53114	63412	69337	72883
60	Sagayarapuram	35334	46497	55512	60700	63804
61	S K Garden	38050	50071	59779	65365	68708
62	Ramaswamy Palya	34394	45260	54036	59085	62107
63	Jayamahal	21728	28593	34136	37326	39235
64	Rajamahal Guttahalli	31118	40949	48889	53457	56191
65	Kadu Malleshwar Ward	35609	46859	55944	61172	64300
66	Subramanya Nagar	35709	46991	56102	61344	64481
67	Nagapura	34574	45497	54318	59394	62432
68	Mahalakshimpuram	44615	58710	70094	76643	80563
69	Laggere	57077	80313	99849	111130	122757
70	Rajagopal Nagar	61479	86507	121724	163122	208810
71	Hegganahalli	66314	93310	131297	175951	225232
72	Herohalli	62272	81946	109924	143149	201926
73	Kottegepalya	68922	96980	120571	134193	148232
74	Shakthi Ganapathi Nagar	43844	57696	68882	75319	79171

Traffic Zone	Traffic Zone Name	Population				
		2011	2018	2025	2031	2041
75	Shankar Matt	48734	64131	76565	83719	88001
76	Gayithri Nagar	33236	43736	52216	57096	60015
77	Dattatreya Temple	33388	43936	52455	57357	60290
78	Pulikeshinagar	28835	37945	45302	49535	52068
79	Sarvagna Nagar	37291	49072	58587	64062	67338
80	Hoysala Nagar	35228	46358	55346	60518	63612
81	Vijnana Nagar	57062	80292	99823	111101	122725
82	Garudachar Playa	49631	69836	98266	131686	168569
83	Kadugodi	43942	57825	77567	101013	142488
84	Hagadur	50556	66528	89242	116217	163935
85	Dodda Nekkundi	63083	88764	124900	167378	214258
86	Marathahalli	39768	55958	69569	77429	85530
87	HAL Airport	39926	52540	62727	68588	72096
88	Jeevanbhima Nagar	38251	50336	60095	65711	69071
89	Jogupalya	33793	44469	53091	58052	61021
90	Halsoor	35090	46176	55129	60281	63363
91	Bharathi Nagar	32689	43016	51357	56156	59028
92	Shivaji Nagar	37506	40212	42265	43549	45776
93	Vasanth Nagar	22815	30023	35844	39194	41198
94	Gandhinagar	31208	33459	35168	36236	38089
95	Subhash Nagar	37693	49601	59219	64752	68064
96	Okalipuram	38110	50150	59874	65469	68817
97	Dayananda Nagar	35721	47006	56120	61365	64503
98	Prakash Nagar	32913	43311	51709	56541	59432
99	Rajaji Nagar	33084	43536	51978	56834	59741
100	Basaveshwara Nagar	30333	39916	47655	52109	54773
101	Kamakshipalya	30051	39545	47212	51624	54264
102	Vrisabhavathi Nagar	50893	66972	79957	87428	91899
103	Kaveripura	53532	70444	84103	91962	96665
104	Govindaraja Nagar	26873	35363	42220	46165	48526
105	Agrahara Dasarahalli	28355	37313	44548	48711	51202
106	Dr. Raj Kumar Ward	24181	31821	37990	41540	43665
107	Shivanagara	36461	47980	57283	62636	65839
108	Sriramamandir	33866	44565	53206	58178	61153
109	Chickpete	33292	35694	37516	38656	40633
110	Sampangiram Nagar	27504	36193	43211	47249	49665
111	Shantala Nagar	22995	30260	36127	39503	41523
112	Domlur	30638	40318	48135	52633	55324
113	Konena Agrahara	38108	50148	59871	65465	68813

Traffic Zone	Traffic Zone Name	Population				
		2011	2018	2025	2031	2041
114	Agaram	36916	48579	57998	63417	66661
115	Vannarpet	37060	48768	58224	63665	66921
116	Nilasandra	48534	63867	76251	83376	87640
117	Shanthi Nagar	42095	55394	66135	72314	76012
118	Sudham Nagara	28784	37878	45222	49448	51976
119	Dharmaraya Swamy Temple	27076	35630	42538	46513	48892
120	Cottonpete	37344	40038	42082	43361	45578
121	Binnipete	37354	40049	42094	43372	45590
122	Kempapura Agrahara	40032	42920	45111	46482	48859
123	Vijayanagar	40331	53073	63363	69284	72827
124	Hosahalli	37347	49146	58675	64158	67439
125	Marenahalli	21171	27860	33261	36369	38229
126	Maruthi Mandir ward	29319	38582	46062	50367	52942
127	Mudalapalya	43729	57544	68702	75121	78963
128	Nagarabhavi	35780	47084	56213	61466	64609
129	Jnana Bharathi ward	68132	95869	134897	180774	231407
130	Ullalu	58199	76586	102734	133786	188719
131	Nayandahalli	42785	60203	74847	83303	92019
132	Attiguppe	41487	54594	65179	71270	74915
133	Hampi Nagar	35113	46206	55165	60320	63405
134	Bapuji Nagar	49484	65118	77743	85008	89355
135	Padarayanapura	37599	49478	59071	64591	67894
136	Jagajivanaramnagar	38639	50846	60705	66377	69772
137	Rayapuram	36039	47425	56620	61911	65077
138	Chalavadipalya	24801	32636	38964	42605	44784
139	K R Market	29344	31461	33067	34072	35814
140	Chamrajapet	32213	34537	36300	37403	39316
141	Azad Nagar	38825	51091	60997	66697	70108
142	Sunkenahalli	34666	45618	54463	59552	62598
143	Vishveshwara Puram	32462	42718	51000	55766	58618
144	Siddapura	34879	45898	54798	59918	62982
145	Hombegowda Nagara	38309	50412	60186	65810	69176
146	Lakkasandra	30667	40356	48180	52682	55377
147	Adugodi	34299	45135	53886	58922	61935
148	Ejipura	47004	61854	73847	80747	84877
149	Varthuru	54625	71883	96425	125571	177130
150	Bellanduru	80180	105511	141535	184316	259996
151	Koramangala	38316	50421	60197	65822	69189
152	Suddagunte Palya	39997	52633	62838	68710	72224

Traffic Zone	Traffic Zone Name	Population				
		2011	2018	2025	2031	2041
153	Jayanagar	38151	50204	59938	65539	68891
154	Basavanagudi	32640	42952	51280	56072	58939
155	Hanumanth Nagar	36982	48666	58102	63531	66780
156	Srinagar	41379	54452	65010	71084	74720
157	Gali Anjenaya Temple ward	34653	45601	54443	59530	62574
158	Deepanjali Nagar	45928	60438	72156	78899	82934
159	Kengeri	40771	53652	71970	93723	132206
160	Rajarajeshwari Nagar	56897	80060	112652	150965	193248
161	Hosakerehalli	46805	65859	81880	91130	100665
162	Girinagar	43195	56842	67863	74204	77999
163	Katriguppe	45572	59970	71597	78287	82291
164	Vidyapeeta ward	43483	57221	68315	74699	78519
165	Ganesh Mandir ward	25998	34212	40845	44662	46946
166	Karisandra	27040	35583	42482	46452	48827
167	Yediyur	32756	43105	51462	56271	59149
168	Pattabhiram Nagar	28353	37311	44545	48707	51198
169	Byrasandra	32066	42197	50378	55086	57903
170	Jayanagar East	33927	47739	59351	66057	72968
171	Gurappanapalya	48991	68935	85704	95387	105366
172	Madivala	42624	59976	74566	82990	91672
173	Jakkasandra	33521	47167	58641	65266	72094
174	HSR Layout	63033	88694	110269	122727	135567
175	Bommanahalli	43585	61328	76247	84861	93739
176	BTM Layout	52250	73521	91405	101732	112375
177	J P Nagar	28846	40589	50463	56164	62040
178	Sarakki	31034	43668	54290	60424	66746
179	Shakambari Nagar	25871	36403	45258	50371	55641
180	Banashankari Temple ward	42171	59339	73773	82108	90698
181	Kumaraswamy Layout	47182	66390	82539	91864	101475
182	Padmanabha Nagar	41037	57743	71789	79900	88259
183	Chikkalsandra	43364	61018	75860	84431	93264
184	Uttarahalli	57209	80499	113270	151793	194307
185	Yelchenahalli	46943	66054	82121	91399	100961
186	Jaraganahalli	38294	53884	66991	74559	82360
187	Puttenahalli	49207	69239	86082	95807	105831
188	Bilekhalli	49884	70192	98767	132357	169428
189	Hongasandra	68554	96462	135732	181894	232840
190	Mangammanapalya	65890	92714	130458	174826	223792
191	Singasandra	71004	93436	125338	163222	230241

Traffic Zone	Traffic Zone Name	Population				
		2011	2018	2025	2031	2041
192	Begur	80037	105323	141283	183987	259532
193	Arakere	58355	82111	115539	154833	198200
194	Gottigere	51911	68311	91634	119332	168329
195	Konankunte	57335	80676	113519	152127	194735
196	Anjanapura	45608	60017	80508	104842	147891
197	Vasanthpura	62057	87320	122869	164656	210773
198	Hemmigepura	50440	66376	89038	115950	163559
199	Budigere	30191	39729	53294	69402	97899
200	Huvinayakanahalli	14391	18938	25403	33082	46665
201	Aiport Township	17689	23278	31225	40663	57359
202	Aiport City-1	19754	25995	34870	45410	64055
203	Aiport City-2	20427	26881	36058	46957	66238
204	Maragondanahalli	14076	18523	24847	32358	45644
205	Budumanahalli	20422	26874	36049	46946	66221
206	Naganayakanahalli	24622	32401	43463	56600	79840
207	Devanahalli	33660	44294	59417	77377	109148
208	Doddachamanahalli	22972	30230	40551	52807	74490
209	Byarasandra	20158	26527	35583	46339	65365
210	Vijayapura	57900	76192	102206	133099	187749
211	Vemkatagirikote	26355	34681	46522	60584	85460
212	Sonnenahalli	17588	23145	31047	40431	57032
213	Ramanthapur	10079	13263	17792	23169	32683
214	Konaghatta	26352	34677	46517	60577	85450
215	Doddaballapur	123847	162974	218617	284696	401592
Total		**8944158**	**11989489**	**15176082**	**18007395**	**21490045**

2.3.3 EMPLOYMENT DISTRIBUTION

Total employment of study area has been estimated on the basis of total population and work force participation rate (WFPR). As per Census -2011, WFPR in Bengaluru is 43 %. The total employment for different horizon years and the respective work force participation rate is given in **TABLE 2-13.**

TABLE 2-13: EMPLOYMENT & WFPR 2018 – 2041

S. No.	Year	Population	Employment	WFPR %
1	2018	11989489	5138647	43%
2	2025	15176082	6554027	43%
3	2031	18007395	7907534	44%
4	2041	21490045	9436993	44%

The base year zone wise distribution of employment has been worked out on the basis of household, work centre data, preliminary reconnaissance survey of land use and details given in land use plans.

The horizon year employment has been distributed in various traffic zones based on the land-use given in Draft Master Plan–2031.

Study area employments for various horizon years are estimated as 65.5 Lakh (2025), 79.0 Lakh (2031) and 94.4 Lakh (2041).

TABLE 2-14 shows zone wise employment distribution in the study area for various horizon years viz. 2025, 2031 & 2041.

TABLE 2-14: ZONE WISE DISTRIBUTION OF EMPLOYMENT

Traffic Zone	Traffic Zone Name	Employment			
		2018	2025	2031	2041
1	Kempegowda Ward	11174	16156	22375	29672
2	Chowdeswari Ward	14218	18965	24597	31170
3	Atturu	27022	35327	44742	56232
4	Yelahanka Satellite Town	56985	69213	80515	91954
5	Jakkuru	20372	30526	43637	60331
6	Thanisandra	33050	45086	58979	69141
7	Byatarayanapura	19723	31370	46169	56923
8	Kodigehalli	12719	22314	35853	48079
9	Vidyaranyapura	15675	24683	36100	44187
10	Dodda Bommasandra	19122	25328	32314	37461
11	Kuvempu Nagar	15111	19948	25624	32292
12	Shettihalli	17810	25504	35266	46234
13	Mallasandra	17249	22665	28987	36437
14	Bagalakunte	22152	30484	40686	52381
15	T Dasarahalli	25095	31048	37275	41947
16	Jalahalli	43158	50510	57548	62916
17	J P Park	23835	28780	31557	33480
18	Radhakrishna Temple Ward	11946	15354	17402	18763
19	Sanjaya Nagar	22144	25515	27239	28498
20	Ganga Nagar	20182	23053	24483	25544
21	Hebbala	71463	79649	84041	90696
22	Vishwanath Nagenahalli	16754	21746	24769	26769
23	Nagavara	31005	46260	60313	78843
24	HBR Layout	37831	50744	60842	73918
25	Horamavu	24513	42281	65374	84362

Traffic Zone	Traffic Zone Name	Employment			
		2018	2025	2031	2041
26	Ramamurthy Nagar	20017	26838	34745	44301
27	Banasavadi	34426	39734	42461	44449
28	Kammanahalli	15692	20254	23005	24830
29	Kacharkanahalli	19004	22409	24246	25548
30	Kadugondanahalli	19982	23550	25572	26336
31	Kushal Nagar	13112	15963	17654	18356
32	Kaval Bairasandra	17300	20377	22120	22777
33	Manorayanapalya	13493	17060	19365	20804
34	Gangenahalli	11538	13508	14612	15017
35	Aramane Nagara	19900	23076	24822	25437
36	Mattikere	25466	33358	39456	46455
37	Yeshwanthpura	100730	123056	143918	170120
38	HMT Ward	65875	73794	80539	85754
39	Chokkasandra	34399	47259	61580	74364
40	Dodda Bidarakallu	26853	36244	47525	60600
41	Peenya Industrial Area	47272	66089	88168	112849
42	Lakshmi Devi Nagar	18759	22859	25191	26795
43	Nandini Layout	19953	24967	27908	29893
44	Marappana Palya	18638	21861	23672	24345
45	Malleswaram	57245	66983	73900	80850
46	Jayachamarajendra Nagar	53250	58905	61568	62094
47	Devara Jeevanahalli	14496	17466	19207	19911
48	Muneshwara Nagar	10999	13418	14857	15455
49	Lingarajapura	16199	19128	20794	21428
50	Benniganahalli	16798	25674	34617	45644
51	Vijnanapura	15724	21582	25676	29623
52	K R Puram	66062	77029	85097	98764
53	Basavanapura	18040	32519	55247	84974
54	Hudi	18270	32374	51332	76098
55	Devasandra	12544	17231	20594	24069
56	A Narayanapura	20380	25393	28518	31280
57	C V Raman Nagar	21357	26294	29420	31423
58	New Tippasandara	24529	31956	38237	45350
59	Maruthi Seva Nagar	18221	21416	23219	23893
60	Sagayarapuram	11257	13676	15108	15699
61	S K Garden	9665	12074	13541	14178
62	Ramaswamy Palya	11063	13427	14823	15399
63	Jayamahal	14315	16399	17513	17876
64	Rajamahal Guttahalli	11250	13487	14789	15309

Traffic Zone	Traffic Zone Name	Employment			
		2018	2025	2031	2041
65	Kadu Malleshwar Ward	11332	14467	16578	18193
66	Subramanya Nagar	14135	17501	19694	21312
67	Nagapura	10484	15507	19458	23864
68	Mahalakshimpuram	19695	23190	25169	25915
69	Laggere	26366	32034	35247	37459
70	Rajagopal Nagar	16942	26631	38899	47592
71	Hegganahalli	22018	32688	45764	55141
72	Herohalli	20554	28499	38295	49479
73	Kottegepalya	27996	34766	38706	41378
74	Shakthi Ganapathi Nagar	13141	16076	17828	18561
75	Shankar Matt	15133	18438	20401	21215
76	Gayithri Nagar	9444	11628	12939	13495
77	Dattatreya Temple	9676	12671	14832	16667
78	Pulikeshinagar	15872	18385	19763	20245
79	Sarvagna Nagar	11763	14306	15813	16437
80	Hoysala Nagar	16602	19447	21043	21631
81	Vijnana Nagar	17365	22867	26232	28444
82	Garudachar Playa	40742	62929	87301	116328
83	Kadugodi	23735	40912	57953	81597
84	Hagadur	68421	84981	98836	120517
85	Dodda Nekkundi	47986	72464	99395	130323
86	Marathahalli	65216	73913	78842	85778
87	HAL Airport	44368	51254	55498	58717
88	Jeevanbhima Nagar	17214	23356	28428	34171
89	Jogupalya	11864	14266	15669	16234
90	Halsoor	22247	28238	32494	36907
91	Bharathi Nagar	19807	22802	24422	24970
92	Shivaji Nagar	74383	79817	86350	96774
93	Vasanth Nagar	24382	31579	37198	43959
94	Gandhinagar	106782	112670	119092	129445
95	Subhash Nagar	29138	33103	35173	35804
96	Okalipuram	21820	25210	27058	27696
97	Dayananda Nagar	13761	16397	17918	18516
98	Prakash Nagar	13193	15664	17082	17631
99	Rajaji Nagar	70913	81726	89033	95966
100	Basaveshwara Nagar	23563	26763	28433	28940
101	Kamakshipalya	21423	24437	26030	26533
102	Vrisabhavathi Nagar	15327	18740	20775	21626
103	Kaveripura	12003	15264	17282	18177

Traffic Zone	Traffic Zone Name	Employment			
		2018	2025	2031	2041
104	Govindaraja Nagar	7680	9449	10511	10962
105	Agrahara Dasarahalli	6710	8466	9545	10020
106	Dr. Raj Kumar Ward	7622	9271	10248	10653
107	Shivanagara	9384	11702	13113	13721
108	Sriramamandir	10322	12603	13961	14527
109	Chickpete	32632	36080	39506	44882
110	Sampangiram Nagar	77195	90321	100105	110770
111	Shantala Nagar	30811	39847	48176	58767
112	Domlur	63282	75642	86740	100009
113	Konena Agrahara	17359	24630	30574	37591
114	Agaram	25726	34213	42870	53693
115	Vannarpet	11408	13913	15403	16021
116	Nilasandra	13226	16370	18268	19079
117	Shanthi Nagar	50132	60266	67228	74310
118	Sudham Nagara	8611	10536	11686	12167
119	Dharmaraya Swamy Temple	7007	8731	9779	10232
120	Cottonpete	9396	12800	16442	21864
121	Binnipete	11887	15314	18914	24336
122	Kempapura Agrahara	9091	9720	10118	10570
123	Vijayanagar	54819	64616	71646	78700
124	Hosahalli	15044	17854	19465	20089
125	Marenahalli	8784	10397	11319	11672
126	Maruthi Mandir ward	9996	12056	13264	13754
127	Mudalapalya	13478	16436	18194	18925
128	Nagarabhavi	24139	27618	29471	30068
129	Jnana Bharathi ward	24379	35438	48810	58445
130	Ullalu	17695	25058	34311	44764
131	Nayandahalli	17056	24347	30339	37392
132	Attiguppe	13482	16343	18033	18726
133	Hampi Nagar	14463	17130	18655	19241
134	Bapuji Nagar	18995	22642	24748	25574
135	Padarayanapura	9362	11726	13171	13800
136	Jagajivanaramnagar	11148	13700	15230	15876
137	Rayapuram	8999	11268	12653	13255
138	Chalavadipalya	6748	8353	9323	9738
139	K R Market	76020	79446	82778	88109
140	Chamrajapet	46517	47022	47338	47702
141	Azad Nagar	9708	12153	13646	14295
142	Sunkenahalli	10338	12655	14039	14618

Traffic Zone	Traffic Zone Name	Employment			
		2018	2025	2031	2041
143	Vishveshwara Puram	19494	22456	24060	24602
144	Siddapura	13246	15805	17284	17867
145	Hombegowda Nagara	19097	22275	24043	24684
146	Lakkasandra	27002	30494	32285	32797
147	Adugodi	25867	33675	39697	46650
148	Ejipura	12760	15801	17638	18424
149	Varthuru	23963	43807	66608	97421
150	Bellanduru	45933	69439	95217	130620
151	Koramangala	87835	110037	126362	146139
152	Suddagunte Palya	12226	14923	16528	17196
153	Jayanagar	42222	48065	51376	53290
154	Basavanagudi	32876	39629	44122	48494
155	Hanumanth Nagar	10964	13430	14904	15523
156	Srinagar	18475	21735	23577	24268
157	Gali Anjenaya Temple ward	10613	12951	14342	14922
158	Deepanjali Nagar	17218	20570	22511	23279
159	Kengeri	46619	60781	76100	99174
160	Rajarajeshwari Nagar	38364	48424	59206	67251
161	Hosakerehalli	36395	41344	43766	45580
162	Girinagar	22124	25755	27768	28490
163	Katriguppe	24536	31161	35811	40400
164	Vidyapeeta ward	21723	25335	27343	28070
165	Ganesh Mandir ward	15713	18093	19380	19816
166	Karisandra	11421	16189	19915	24194
167	Yediyur	15641	18303	19793	20340
168	Pattabhiram Nagar	41236	45785	47967	48440
169	Byrasandra	25685	29131	30921	31457
170	Jayanagar East	24420	27967	29749	31063
171	Gurappanapalya	18885	27438	33775	41068
172	Madivala	33182	37690	39895	41547
173	Jakkasandra	13326	19000	23020	27556
174	HSR Layout	47805	59492	69671	82906
175	Bommanahalli	44693	54599	63571	76051
176	BTM Layout	58287	66561	71025	76288
177	J P Nagar	35224	40918	44242	48598
178	Sarakki	10097	13099	14918	16121
179	Shakambari Nagar	9643	12168	13662	14664
180	Banashankari Temple ward	17258	21403	23812	25447
181	Kumaraswamy Layout	16802	21393	24132	25959

Traffic Zone	Traffic Zone Name	Employment			
		2018	2025	2031	2041
182	Padmanabha Nagar	13602	17577	19977	21568
183	Chikkalsandra	11960	16122	18704	20384
184	Uttarahalli	23338	34062	46735	57025
185	Yelchenahalli	14297	20203	24382	28360
186	Jaraganahalli	11931	15628	17882	19365
187	Puttenahalli	13401	18121	21054	22962
188	Bilekhalli	14436	27302	45270	63328
189	Hongasandra	18161	33524	51947	68243
190	Mangammanapalya	27848	43305	60698	76618
191	Singasandra	88521	118494	147398	191654
192	Begur	23119	44468	68178	98304
193	Arakere	20638	33656	48993	62746
194	Gottigere	15126	21666	29964	39287
195	Konankunte	18655	27859	39178	47286
196	Anjanapura	14236	20022	27249	35440
197	Vasanthpura	15684	25376	37829	46604
198	Hemmigepura	13849	20165	28288	37347
199	Budigere	15333	21253	28991	42040
200	Huvinayakanahalli	7474	14895	27443	53863
201	Aiport Township	11105	19126	31826	58838
202	Aiport City-1	11166	20528	37285	69434
203	Aiport City-2	8862	18105	35357	67629
204	Maragondanahalli	4431	7887	12855	21104
205	Budumanahalli	7651	11969	17809	27197
206	Naganayakanahalli	4558	9307	16251	26394
207	Devanahalli	10435	21356	40908	75554
208	Doddachamanahalli	8600	13252	19482	29328
209	Byarasandra	20396	24730	29806	39146
210	Vijayapura	20469	32446	48165	72865
211	Vemkatagirikote	10736	15845	22526	32980
212	Sonnenahalli	7586	11553	16881	25761
213	Ramanthapur	5765	8769	12873	20403
214	Konaghatta	16335	23155	33541	57342
215	Doddaballapur	58234	82264	113965	164809
Total		**5138647**	**6554027**	**7907534**	**9436993**

2.3.4 STUDENT ENROLMENT DISTRIBUTION

The base year (2018) student enrolment is 26.6 Lakh worked out on the basis of number of student in each type of institutions i.e., schools, undergraduate colleges, engineering colleges, medical, dental, polytechnic & universities for Bengaluru.

Student enrolment for the year 2025 has been estimated on the basis of the zone wise student enrolment 2018. Existing student enrolment 2018 has been projected with the same growth rate of population for the years 2025, 2031 & 2041.

For the year 2025 though the exact distribution of educational institutions for the new areas has not been identified. However, enrolment has been estimated on the basis of student enrolment 2018 already available and proportion of population. The overall enrolment has been taken as 22.0%.

The estimated distribution of student enrolment by traffic zones for the year 2018, 2025, 2031 and 2041 are represented in **TABLE 2-15**. Accordingly for the overall estimated population of 215 Lakh, an student enrolment of 48.4 Lakh has been worked out for the year 2041.

TABLE 2-15: ZONE WISE DISTRIBUTION OF STUDENT ENROLMENT

Traffic Zone	Traffic Zone Name	Student Enrolment			
		2018	2021	2031	2041
1	Kempegowda Ward	6299	9160	12822	18462
2	Chowdeswari Ward	6431	9421	13280	19199
3	Atturu	8091	12601	18796	28038
4	Yelahanka Satellite Town	26616	32847	38874	46101
5	Jakkuru	16155	21076	26476	35423
6	Thanisandra	12114	19192	28532	38243
7	Byatarayanapura	8731	15377	24787	34268
8	Kodigehalli	11005	16055	22263	28926
9	Vidyaranyapura	7500	12850	20298	27859
10	Dodda Bommasandra	9622	13626	18400	23595
11	Kuvempu Nagar	5532	8456	12399	18328
12	Shettihalli	8932	13721	20212	29954
13	Mallasandra	37881	43789	48255	57289
14	Bagalakunte	16403	22216	28999	39906
15	T Dasarahalli	15585	19951	24491	29752
16	Jalahalli	13503	18060	23130	28824
17	J P Park	4668	7461	9619	11752

Traffic Zone	Traffic Zone Name	Student Enrolment			
		2018	2021	2031	2041
18	Radhakrishna Temple Ward	5575	7734	9305	10989
19	Sanjaya Nagar	5075	7065	8516	10067
20	Ganga Nagar	10288	12474	13860	15635
21	Hebbala	15755	18654	20407	22791
22	Vishwanath Nagenahalli	4933	7844	10088	12313
23	Nagavara	11181	15030	17772	20796
24	HBR Layout	9112	12715	15346	18155
25	Horamavu	9451	17934	30432	42800
26	Ramamurthy Nagar	16521	21159	26071	34353
27	Banasavadi	7090	10155	12424	14802
28	Kammanahalli	8158	11109	13229	15540
29	Kacharkanahalli	4725	6739	8227	9791
30	Kadugondanahalli	6168	8127	9516	10763
31	Kushal Nagar	3865	5397	6528	7518
32	Kaval Bairasandra	9493	11801	13337	14770
33	Manorayanapalya	9684	12216	13933	15516
34	Gangenahalli	33982	39598	42891	46203
35	Aramane Nagara	19477	23214	25530	27784
36	Mattikere	16532	19837	21913	23917
37	Yeshwanthpura	36182	42508	46300	50063
38	HMT Ward	6415	10073	14867	19866
39	Chokkasandra	8672	14339	22050	29958
40	Dodda Bidarakallu	7499	12816	20702	32076
41	Peenya Industrial Area	23433	30676	38488	47389
42	Lakshmi Devi Nagar	3690	6004	7800	9563
43	Nandini Layout	9874	13167	15498	18089
44	Marappana Palya	5076	6747	7941	9006
45	Malleswaram	57981	67398	72882	78418
46	Jayachamarajendra Nagar	7835	9717	10965	12131
47	Devara Jeevanahalli	7640	9736	11173	12491
48	Muneshwara Nagar	3425	4752	5728	6583
49	Lingarajapura	4780	6357	7481	8487
50	Benniganahalli	4541	6337	7661	8821
51	Vijnanapura	4552	7167	9177	11178
52	K R Puram	23706	28072	31778	38798
53	Basavanapura	8328	12274	17400	25243
54	Hudi	4432	7995	13482	21270
55	Devasandra	3709	5659	7143	8642
56	A Narayanapura	6499	9136	11069	13122

Traffic Zone	Traffic Zone Name	Student Enrolment			
		2018	2021	2031	2041
57	C V Raman Nagar	18755	22885	25559	28095
58	New Tippasandara	11993	14779	16611	18332
59	Maruthi Seva Nagar	7650	9708	11112	12402
60	Sagayarapuram	4157	5581	6605	7516
61	S K Garden	3602	5006	6040	6945
62	Ramaswamy Palya	2677	3862	4752	5522
63	Jayamahal	23714	27742	30130	32515
64	Rajamahal Guttahalli	4681	6087	7070	7960
65	Kadu Malleshwar Ward	2905	4150	5081	5889
66	Subramanya Nagar	6283	8031	9234	10334
67	Nagapura	11611	14127	15747	17288
68	Mahalakshimpuram	33160	39115	42721	46278
69	Laggere	9776	13343	15911	18705
70	Rajagopal Nagar	5546	10933	19012	26943
71	Hegganahalli	9232	15507	24137	32946
72	Herohalli	7544	12240	18924	28740
73	Kottegepalya	10412	14604	17674	20939
74	Shakthi Ganapathi Nagar	4509	6179	7397	8473
75	Shankar Matt	10894	13625	15456	17156
76	Gayithri Nagar	26941	31710	34583	37425
77	Dattatreya Temple	2698	3862	4733	5488
78	Pulikeshinagar	25364	29798	32456	35094
79	Sarvagna Nagar	12921	15694	17474	19171
80	Hoysala Nagar	12322	14958	16650	18263
81	Vijnana Nagar	10082	13674	16249	19067
82	Garudachar Playa	12338	17708	24203	31226
83	Kadugodi	8223	11866	16486	23630
84	Hagadur	4638	8251	13766	21623
85	Dodda Nekkundi	11826	18190	26395	35014
86	Marathahalli	15929	19189	21232	23889
87	HAL Airport	27637	32662	35718	38725
88	Jeevanbhima Nagar	17235	20672	22830	24914
89	Jogupalya	7933	9882	11184	12396
90	Halsoor	28635	33700	36749	39766
91	Bharathi Nagar	2983	4172	5051	5820
92	Shivaji Nagar	17099	18487	19475	21160
93	Vasanth Nagar	19135	22504	24530	26536
94	Gandhinagar	40325	43118	45088	48512
95	Subhash Nagar	30098	35439	38659	41843

Traffic Zone	Traffic Zone Name	Student Enrolment			
		2018	2021	2031	2041
96	Okalipuram	5427	7103	8282	9346
97	Dayananda Nagar	5591	7237	8383	9423
98	Prakash Nagar	9035	11129	12504	13798
99	Rajaji Nagar	107595	124379	133988	143788
100	Basaveshwara Nagar	14104	16894	18642	20331
101	Kamakshipalya	16620	19779	21730	23633
102	Vrisabhavathi Nagar	4653	6507	7877	9073
103	Kaveripura	4142	5981	7364	8559
104	Govindaraja Nagar	3471	4599	5403	6123
105	Agrahara Dasarahalli	2256	3240	3977	4615
106	Dr. Raj Kumar Ward	4244	5426	6240	6984
107	Shivanagara	3727	5113	6125	7017
108	Sriramamandir	7483	9367	10632	11807
109	Chickpete	6908	7621	8134	8989
110	Sampangiram Nagar	62407	72331	78059	83873
111	Shantala Nagar	28211	32937	35723	38516
112	Domlur	8692	10684	11989	13216
113	Konena Agrahara	10416	12834	14423	15917
114	Agaram	27281	32185	35156	38085
115	Vannarpet	5701	7393	8575	9645
116	Nilasandra	4397	6159	7462	8600
117	Shanthi Nagar	8529	10756	12265	13659
118	Sudham Nagara	9855	11978	13343	14642
119	Dharmaraya Swamy Temple	10675	12881	14281	15625
120	Cottonpete	7490	8274	8838	9777
121	Binnipete	7873	8681	9262	10231
122	Kempapura Agrahara	3603	4165	4577	5241
123	Vijayanagar	77649	90135	97377	104705
124	Hosahalli	4335	5831	6908	7867
125	Marenahalli	3892	4953	5680	6346
126	Maruthi Mandir ward	8603	10551	11823	13022
127	Mudalapalya	4940	6672	7923	9033
128	Nagarabhavi	36199	42405	46099	49780
129	Jnana Bharathi ward	13449	20407	29272	38636
130	Ullalu	5424	9596	15938	24990
131	Nayandahalli	5344	7855	9737	11678
132	Attiguppe	3328	4771	5851	6787
133	Hampi Nagar	4752	6259	7327	8285
134	Bapuji Nagar	3938	5655	6942	8055

Traffic Zone	Traffic Zone Name	Student Enrolment			
		2018	2021	2031	2041
135	Padarayanapura	6772	8636	9915	11087
136	Jagajivanaramnagar	3668	5095	6144	7065
137	Rayapuram	3428	4760	5741	6600
138	Chalavadipalya	1835	2674	3308	3855
139	K R Market	10495	11400	12046	13141
140	Chamrajapet	43474	46474	48589	52267
141	Azad Nagar	6401	8238	9511	10669
142	Sunkenahalli	2675	3866	4761	5534
143	Vishveshwara Puram	19007	22576	24772	26918
144	Siddapura	5053	6600	7687	8666
145	Hombegowda Nagara	9929	12279	13831	15285
146	Lakkasandra	9580	11704	13082	14387
147	Adugodi	4937	6453	7518	8480
148	Ejipura	7344	9507	11015	12383
149	Varthuru	9973	14475	20224	29088
150	Bellanduru	12231	18577	27082	39910
151	Koramangala	41820	48921	53131	57338
152	Suddagunte Palya	16919	20349	22514	24597
153	Jayanagar	114277	132173	142435	152890
154	Basavanagudi	50594	58874	63712	68585
155	Hanumanth Nagar	4565	6086	7175	8146
156	Srinagar	3407	4860	5944	6885
157	Gali Anjenaya Temple ward	2840	4054	4962	5749
158	Deepanjali Nagar	5387	7235	8564	9747
159	Kengeri	24786	29637	33912	41845
160	Rajarajeshwari Nagar	20946	27852	35473	44064
161	Hosakerehalli	6106	8875	10939	13082
162	Girinagar	4133	5734	6911	7943
163	Katriguppe	7115	9211	10673	11999
164	Vidyapeeta ward	3873	5442	6605	7619
165	Ganesh Mandir ward	6728	8321	9373	10359
166	Karisandra	3561	4707	5520	6250
167	Yediyur	2642	3783	4637	5377
168	Pattabhiram Nagar	6245	7820	8878	9859
169	Byrasandra	4408	5795	6774	7655
170	Jayanagar East	13146	15889	17620	19851
171	Gurappanapalya	7347	10322	12504	14821
172	Madivala	15000	18317	20447	23131
173	Jakkasandra	3250	5146	6605	8053

Traffic Zone	Traffic Zone Name	Student Enrolment			
		2018	2021	2031	2041
174	HSR Layout	15310	19630	22583	26019
175	Bommanahalli	12222	15350	17437	19939
176	BTM Layout	21056	25351	28040	31539
177	J P Nagar	44971	50185	52710	57248
178	Sarakki	7318	9427	10875	12549
179	Shakambari Nagar	2454	3913	5038	6153
180	Banashankari Temple ward	62857	70234	73833	80242
181	Kumaraswamy Layout	13711	17137	19410	22157
182	Padmanabha Nagar	5254	7672	9480	11351
183	Chikkalsandra	3904	6333	8217	10068
184	Uttarahalli	11113	16934	24377	32224
185	Yelchenahalli	3958	6569	8605	10589
186	Jaraganahalli	11419	14225	16078	18330
187	Puttenahalli	4033	6762	8894	10965
188	Bilekhalli	7108	11851	18341	24980
189	Hongasandra	5674	11604	20638	29442
190	Mangammanapalya	9030	15246	23822	32564
191	Singasandra	31392	38900	46275	59195
192	Begur	8249	14095	22766	35272
193	Arakere	9414	15107	22692	30546
194	Gottigere	11613	16108	21532	30118
195	Konankunte	8530	14029	21485	29144
196	Anjanapura	9854	13769	18540	26056
197	Vasanthpura	7164	12831	20933	29060
198	Hemmigepura	4331	7893	13418	21234
199	Budigere	3594	5930	9171	13929
200	Huvinayakanahalli	1535	2632	4185	6441
201	Aiport Township	2123	3492	5390	8180
202	Aiport City-1	2537	4081	6192	9319
203	Aiport City-2	3791	5476	7625	10944
204	Maragondanahalli	4754	6046	7506	9951
205	Budumanahalli	2230	3793	5995	9199
206	Naganayakanahalli	1887	3695	6403	10208
207	Devanahalli	3805	6392	10014	15305
208	Doddachamanahalli	2675	4447	6916	10532
209	Byarasandra	2072	3603	5783	8937
210	Vijayapura	4492	8749	15112	24064
211	Vemkatagirikote	4061	6174	8968	13189
212	Sonnenahalli	1620	2937	4852	7590

Traffic Zone	Traffic Zone Name	Student Enrolment			
		2018	2021	2031	2041
213	Ramanthapur	869	1618	2720	4285
214	Konaghatta	2863	4877	7721	11853
215	Doddaballapur	12457	21832	35248	54602
	Total	**2661301**	**3388992**	**4053692**	**4840546**

2.3.5 SUMMARY

Population of Study Area expected to increase from 120 Lakh in the year 2018 to 215 Lakh by the year 2041.

The work force participation rate in the Study Area varies between 43% and 44%. Total employment in Study Area is expected to increase from 51.6 Lakh in 2018 to 94.4 Lakh in 2041.

The student enrolment rate in the Study Area is 22%. Total student enrolment in Study Area is expected to increase from 26.6 Lakh in 2018 to 48.4 Lakh in 2041.

The substantial increase in area of office / commercial / industrial and other activities expected to grow in Bengaluru City and adjoining BIAAPA area. This will mean a large increase in employment in Study area. This will attract large traffic. Therefore, adequate and good quality citywide mass public transport system will need to be provided to meet this expected demand.

2.4 RIDERSHIP ASSESSMENT

The following steps are involved in traffic demand analysis towards estimation of ridership on Mass Rapid Transit System:

i. **Preparation of Database**: Involves collection of secondary data (studies done earlier, census data, Master Plan, land use parameters etc.) and primary surveys (traffic and travel surveys).

ii. **Development of Transport Demand Models**: The process consists of development of formulae (or models), enabling forecast of travel demand.

iii. **Estimation of Land use Parameters**: Land use parameters (viz., population, employment) are estimated for the horizon years in order to assess the future travel demand.

iv. Ridership Assessment on Rail Based Mass Rapid Transit System

2.4.1 ASSUMPTIONS FOR TRANSPORT DEMAND FORECASTING

i. The following network has been considered to assess the Ridership on Sub-Urban Rail System:

- Road Network (ROW more than 12 m)
- Existing Indian Rail Network within the Study Area
- Bengaluru Metro Phase 1, Phase 2, 2A & 2B
- Sub-Urban Rail Corridors

ii. The existing fare levels of Bengaluru metro have been considered for Metro system.

iii. Existing fare levels of BMTC have been considered for Bus system

iv. Existing fare levels of BMTC have been modified and considered for Sub-Urban Rail System

v. Inter-city passenger to / from the study area will grow at the growth rate of 3%.

vi. The special generator passenger traffic of airport and railway stations in Bengaluru is expected to grow at 4% per annum.

vii. Inter-city goods traffic is expected to grow at 3% per annum up to 2041.

viii. Intra-city goods traffic is expected to grow at 2% per annum up to 2041.

2.4.2 TRANSPORT DEMAND FORECAST FOR SUB-URBAN RAIL CORRIDORS

The following network have been considered for the Ridership Assessment:

i. Bengaluru Bus system operated by BMTC in the entire study area

ii. Bengaluru Metro Phase 1, 2, 2A & 2B Corridors:

- Anjanapura – Yelachenahalli– Nagasandra – BIEC (34.12 Km)
- Kengeri – Mysore Road – Baiyyappanahalli – White Field (40.4 Km)
- RV Road Terminal – Bommasandra (18.7 Km)
- Gottigere – Nagawara (20 Km)
- KR Puram – Silk Board (16.5 Km)
- KR Puram – Nagawara – Hebbal – Kogilu Cross – Airport Terminal (36.4 Km)

iii. Sub-Urban Rail Corridors:

- Corridor 1 : KSR Bengaluru City – Yelahanka – Devanahalli
- Corridor 2 : Baiyyappanahalli – Yeshwantpur – Chikkabanawar
- Corridor 3 : Kengeri – KSR Bengaluru City – White Field
- Corridor 4 : Heelalige – Yelahanka – Rajankunte

Considering the above assumptions and calibrated / validated traffic demand model, forecasting of transport demand has been carried out for Sub-Urban Rail network in the year 2025, 2031 & 2041. The Daily Station loads and Peak Hour Section loads are given from **TABLE *2-16*** to **TABLE 2-31**.

TABLE 2-16: STATION LOADS ON CORRIDOR-1 IN 2025

KSR BENGALURU CITY (SBC) - DEVANAHALLI (DHL)							
S.No.	Station Name	SBC - DHL		DHL - SBC		TOTAL	
		BOARD	ALIGHT	BOARD	ALIGHT	BOARD	ALIGHT
1	KSR BENGALURU CITY	34181	0	0	40795	34181	40795
2	SRIRAMPURA	6899	6511	7981	9299	14880	15810
3	MALLESWARAM	23841	9073	10174	23355	34015	32428
4	YESHWANTPUR	20944	13851	13841	19711	34785	33562
5	MUTHYALANAGAR	18724	11711	13863	15916	32587	27628
6	LOTTEGOLAHALLI	21057	30727	29233	21135	50290	51863
7	KODIGEHALLI	13053	19012	19509	15193	32563	34205
8	JUDICIAL LAYOUT	32423	14592	15723	33674	48146	48266
9	YELAHANKA	12102	30838	31639	12271	43741	43109
10	NITTE MEENAKSHI	2894	10736	12300	2892	15193	13628
11	BETAHALASURU	1037	1327	1327	1001	2364	2328
12	DODDAJALA	8045	12670	13564	7907	21609	20577
13	AIRPORT TRUMPET	1732	5212	5368	1882	7099	7093
14	AIRPORT KIADB	2597	16413	16063	2823	18660	19235
15	DEVANAHALLI	0	16856	17268	0	17268	16856
TOTAL		**199529**	**199529**	**207854**	**207854**	**407382**	**407383**

TABLE 2-17: STATION LOADS ON CORRIDOR-2 IN 2025

BAIYAPPANNAHALLI (BYPL) - CHIKKABANAVAR (BAW)							
S.No.	Station Name	BYPL - BAW		BAW- BYPL		TOTAL	
		BOARD	ALIGHT	BOARD	ALIGHT	BOARD	ALIGHT
1	BAIYYAPPANAHALLI TERMINAL	13180	0	0	12779	13180	12779
2	KASTURI NAGAR	4673	8488	8230	5170	12903	13657
3	SEVANAGAR	10834	4728	5379	11554	16212	16282
4	BANASWADI	6192	4558	4916	6928	11109	11486
5	KAVERI NAGAR	14976	7880	8405	14637	23381	22517
6	NAGAWARA	14221	20375	20356	12613	34576	32987
7	KANAKANAGARA	5218	9572	8368	5354	13586	14926
8	HEBBAL	4786	6508	6356	4928	11142	11436

BAIYAPPANNAHALLI (BYPL) - CHIKKABANAVAR (BAW)							
S.No.	Station Name	BYPL - BAW		BAW- BYPL		TOTAL	
		BOARD	ALIGHT	BOARD	ALIGHT	BOARD	ALIGHT
9	LOTTEGOLAHALLI	6885	7248	7130	10791	14015	18039
10	YESHWANTPUR	20672	11167	15331	22738	36003	33905
11	JALAHALLI	18964	1053	1439	22013	20403	23066
12	SHETTIHALLI	8904	22002	25607	8416	34511	30418
13	MYDARAHALLI	2425	14189	12147	2324	14572	16513
14	CHIKKABANAVAR	0	14163	16579	0	16579	14163
TOTAL		**131930**	**131931**	**140243**	**140244**	**272174**	**272174**

TABLE 2-18: STATION LOADS ON CORRIDOR-3 IN 2025

KENGERI (KGI) - WHITE FIELD (WFD)							
S.No.	Station Name	KGI - WFD		WFD - KGI		TOTAL	
		BOARD	ALIGHT	BOARD	ALIGHT	BOARD	ALIGHT
1	KENGERI	32154	0	0	37513	32154	37513
2	RV COLLEGE	7114	11128	11488	6472	18602	17600
3	JNANABHARATI	3264	18208	15410	4970	18674	23179
4	NAYANDAHALLI	3294	7168	10140	1904	13434	9073
5	KRISHNADEVARAYA	6679	3001	1250	6147	7929	9148
6	JAGAJEEVANRAM NAGAR	4704	6322	5822	4528	10526	10850
7	KSR BENGALURU CITY	15366	11149	12485	16947	27851	28097
8	KUMARAPARK (BDA)	2967	11595	16389	3707	19356	15302
9	BENGALURU CANTT.	12046	6305	8467	13103	20513	19408
10	BENGALURU EAST	5544	11155	12349	3675	17893	14830
11	BAIYYAPPANAHALLI	3782	5795	3941	3844	7723	9639
12	KRISHANRAJAPURAM	8079	4664	4661	7996	12740	12660
13	HOODI	699	8156	7981	699	8680	8855
14	WHITE FIELD	0	1044	1124	0	1124	1044
TOTAL		**105691**	**105691**	**111507**	**111507**	**217198**	**217198**

TABLE 2-19: STATION LOADS ON CORRIDOR-4 IN 2025

HEELALIGE (HLE) - RAJANKUNTE (RNN)							
S.No.	Station Name	HLE - RNN		RNN - HLE		TOTAL	
		BOARD	ALIGHT	BOARD	ALIGHT	BOARD	ALIGHT
1	HEELALIGE	4617	0	0	4617	4617	4617
2	BOMMASANDRA	4328	29	87	4328	4415	4357
3	SINGENA AGRAHARA	3462	115	173	3462	3636	3578
4	HUSKUR	13720	491	346	12913	14066	13403
5	AMBEDKAR NAGAR	9147	606	519	8608	9666	9214
6	KARMELRAM	13124	21173	20437	14863	33561	36036
7	BELANDUR ROAD	3296	11301	12099	3721	15395	15022
8	MARATHAHALLI	12748	6684	7108	12160	19856	18845
9	KAGADASPURA	6293	16473	16962	6312	23254	22785
10	BENNIGANAHALLI	8732	3913	3971	8222	12703	12135

HEELALIGE (HLE) - RAJANKUNTE (RNN)							
S.No.	Station Name	HLE - RNN		RNN - HLE		TOTAL	
		BOARD	ALIGHT	BOARD	ALIGHT	BOARD	ALIGHT
11	CHANNASANDRA	15830	6563	6562	14686	22392	21249
12	HORAMAVU	19827	11161	11369	17454	31196	28614
13	HENNUR	29589	18396	16928	26064	46517	44460
14	TANNISANDRA	15299	39129	35521	15146	50820	54275
15	RK HEGDE NAGAR	11304	20667	19716	10401	31020	31068
16	JAKUR	4937	7673	3948	5062	8885	12735
17	YELAHANKA	4554	11123	11658	4219	16212	15342
18	MUDDENAHALLI	5034	3344	3283	5034	8317	8379
19	RAJANKUNTE	0	7000	6585	0	6585	7000
TOTAL		**185841**	**185841**	**177272**	**177272**	**363113**	**363113**

TABLE 2-20: STATION LOADS ON CORRIDOR-1 IN 2031

KSR BENGALURU CITY (SBC) - DEVANAHALLI (DHL)							
S.No.	Station Name	SBC - DHL		DHL - SBC		TOTAL	
		BOARD	ALIGHT	BOARD	ALIGHT	BOARD	ALIGHT
1	KSR BENGALURU CITY	43118	0	0	51774	43118	51774
2	SRIRAMPURA	8151	7917	9638	11308	17788	19225
3	MALLESWARAM	29190	10496	12112	28569	41302	39065
4	YESHWANTPUR	22290	17727	17698	20902	39988	38628
5	MUTHYALANAGAR	23085	13281	16002	19749	39086	33029
6	LOTTEGOLAHALLI	25773	38928	36764	25019	62537	63947
7	KODIGEHALLI	20089	21795	20661	26046	40750	47841
8	JUDICIAL LAYOUT	40424	19628	25952	41396	66376	61025
9	YELAHANKA	16504	41743	42645	16854	59149	58598
10	NITTE MEENAKSHI	5736	11678	14024	5729	19759	17407
11	BETAHALASURU	1839	1838	1838	1839	3677	3677
12	DODDAJALA	13852	20919	21659	13850	35511	34769
13	AIRPORT TRUMPET	2812	6474	6511	3165	9323	9639
14	AIRPORT KIADB	4218	24362	24279	4747	28496	29109
15	DEVANAHALLI	0	20294	21164	0	21164	20294
TOTAL		**257079**	**257079**	**270946**	**270946**	**528026**	**528026**

TABLE 2-21: STATION LOADS ON CORRIDOR-2 IN 2031

BAIYAPPANNAHALLI (BYPL) - CHIKKABANAVAR (BAW)							
S.No.	Station Name	BYPL - BAW		BAW- BYPL		TOTAL	
		BOARD	ALIGHT	BOARD	ALIGHT	BOARD	ALIGHT
1	BAIYYAPPANAHALLI TERMINAL	17953	0	0	17714	17953	17714
2	KASTURI NAGAR	5640	10044	10026	5887	15666	15930
3	SEVANAGAR	12750	6121	6939	14931	19690	21052
4	BANASWADI	7336	5330	6686	7656	14022	12985

BAIYAPPANNAHALLI (BYPL) - CHIKKABANAVAR (BAW)							
S.No.	Station Name	BYPL - BAW		BAW- BYPL		TOTAL	
		BOARD	ALIGHT	BOARD	ALIGHT	BOARD	ALIGHT
5	KAVERI NAGAR	18802	10020	10200	17946	29002	27966
6	NAGAWARA	18361	25226	24813	16607	43173	41833
7	KANAKANAGARA	6325	11829	10506	6401	16830	18229
8	HEBBAL	5128	8413	8206	5422	13334	13835
9	LOTTEGOLAHALLI	7697	9528	9276	11952	16973	21481
10	YESHWANTPUR	27212	12871	17288	30087	44500	42958
11	JALAHALLI	25227	1573	1668	28772	26895	30344
12	SHETTIHALLI	12891	28786	33745	13156	46636	41942
13	MYDARAHALLI	2611	19971	17237	2524	19848	22495
14	CHIKKABANAVAR	0	18222	22466	0	22466	18222
TOTAL		**167934**	**167934**	**179054**	**179054**	**346988**	**346988**

TABLE 2-22: STATION LOADS ON CORRIDOR-3 IN 2031

KENGERI (KGI) - WHITE FIELD (WFD)							
S.No.	Station Name	KGI - WFD		WFD - KGI		TOTAL	
		BOARD	ALIGHT	BOARD	ALIGHT	BOARD	ALIGHT
1	KENGERI	42294	0	0	49693	42294	49693
2	RV COLLEGE	10195	15777	16287	8456	26482	24233
3	JNANABHARATI	3958	24147	20170	6269	24128	30417
4	NAYANDAHALLI	3983	8933	12981	2471	16964	11404
5	KRISHNADEVARAYA	7954	3554	1579	7356	9533	10910
6	JAGAJEEVANRAM NAGAR	5553	7644	7081	5263	12634	12906
7	KSR BENGALURU CITY	18921	13495	15075	19124	33996	32619
8	KUMARAPARK (BDA)	4322	14359	18857	5019	23179	19378
9	BENGALURU CANTT.	13763	8380	10702	15042	24465	23422
10	BENGALURU EAST	8115	12060	13482	6089	21598	18149
11	BAIYYAPPANAHALLI	4452	7966	6051	4540	10503	12506
12	KRISHANRAJAPURAM	11866	6283	6275	12033	18142	18316
13	HOODI	942	12073	11946	942	12888	13015
14	WHITE FIELD	0	1648	1811	0	1811	1648
TOTAL		**136319**	**136319**	**142298**	**142298**	**278617**	**278617**

TABLE 2-23: STATION LOADS ON CORRIDOR-4 IN 2031

HEELALIGE (HLE) - RAJANKUNTE (RNN)							
S.No.	Station Name	HLE - RNN		RNN - HLE		TOTAL	
		BOARD	ALIGHT	BOARD	ALIGHT	BOARD	ALIGHT
1	HEELALIGE	8000	0	0	8000	8000	8000
2	BOMMASANDRA	7500	50	150	7500	7650	7550
3	SINGENA AGRAHARA	6000	200	300	6000	6300	6200
4	HUSKUR	16999	850	600	16070	17599	16920
5	AMBEDKAR NAGAR	11332	1050	900	10713	12232	11763

HEELALIGE (HLE) - RAJANKUNTE (RNN)							
S.No.	Station Name	HLE - RNN		RNN - HLE		TOTAL	
		BOARD	ALIGHT	BOARD	ALIGHT	BOARD	ALIGHT
6	KARMELRAM	16817	26752	26124	17775	42940	44527
7	BELANDUR ROAD	4013	14139	15173	4453	19186	18592
8	MARATHAHALLI	18578	8952	9429	18405	28006	27357
9	KAGADASPURA	9763	20980	22288	9665	32052	30645
10	BENNIGANAHALLI	11208	5913	5979	10310	17187	16223
11	CHANNASANDRA	20967	10200	10199	19687	31166	29887
12	HORAMAVU	26348	16156	16502	23245	42850	39401
13	HENNUR	44388	22176	20603	39152	64990	61328
14	TANNISANDRA	25471	60753	56841	25917	82312	86669
15	RK HEGDE NAGAR	15894	34123	31250	14956	47144	49078
16	JAKUR	7177	12026	6004	7350	13180	19375
17	YELAHANKA	7030	15031	15952	5969	22981	21000
18	MUDDENAHALLI	6106	4442	4335	6106	10442	10549
19	RAJANKUNTE	0	9798	8643	0	8643	9798
TOTAL		**263590**	**263590**	**251272**	**251272**	**514862**	**514862**

TABLE 2-24: STATION LOADS ON CORRIDOR-1 IN 2041

KSR BENGALURU CITY (SBC) - DEVANAHALLI (DHL)							
S.No.	Station Name	SBC - DHL		DHL - SBC		TOTAL	
		BOARD	ALIGHT	BOARD	ALIGHT	BOARD	ALIGHT
1	KSR BENGALURU CITY	55435	0	0	67213	55435	67213
2	SRIRAMPURA	9051	9015	10747	14146	19797	23160
3	MALLESWARAM	34695	11301	14417	33879	49112	45180
4	YESHWANTPUR	27169	23047	23142	25653	50311	48700
5	MUTHYALANAGAR	27020	15257	18445	23233	45465	38490
6	LOTTEGOLAHALLI	35105	43823	41651	39279	76757	83102
7	KODIGEHALLI	29956	22780	27684	37275	57640	60056
8	JUDICIAL LAYOUT	50049	31188	37620	50913	87670	82102
9	YELAHANKA	36748	50398	50402	37504	87150	87902
10	NITTE MEENAKSHI	13523	16250	20774	13481	34297	29731
11	BETAHALASURU	4157	3082	3082	4157	7238	7239
12	DODDAJALA	20793	40271	42317	20793	63110	61064
13	AIRPORT TRUMPET	4236	9476	9788	4236	14024	13712
14	AIRPORT KIADB	6354	48598	48258	6354	54612	54952
15	DEVANAHALLI	0	29804	29788	0	29788	29804
TOTAL		**354291**	**354291**	**378115**	**378115**	**732406**	**732406**

TABLE 2-25: STATION LOADS ON CORRIDOR-2 IN 2041

BAIYAPPANNAHALLI (BYPL) - CHIKKABANAVAR (BAW)							
S.No.	Station Name	BYPL - BAW		BAW- BYPL		TOTAL	
		BOARD	ALIGHT	BOARD	ALIGHT	BOARD	ALIGHT
1	BAIYYAPPANAHALLI TERMINAL	23487	0	0	23102	23487	23102
2	KASTURI NAGAR	6452	11407	11646	6609	18098	18016
3	SEVANAGAR	14880	7461	8689	15279	23569	22740
4	BANASWADI	8159	6202	7660	9281	15819	15483
5	KAVERI NAGAR	20936	11936	12987	21131	33923	33067
6	NAGAWARA	25902	28147	28624	23868	54526	52015
7	KANAKANAGARA	8177	15050	13818	8268	21994	23318
8	HEBBAL	5961	11275	11409	6424	17371	17699
9	LOTTEGOLLAHALLI	10000	14073	13180	13579	23179	27652
10	YESHWANTPUR	34371	16296	18037	36345	52408	52641
11	JALAHALLI	35736	3031	2007	38784	37743	41814
12	SHETTIHALLI	16691	35050	37587	18598	54278	53647
13	MYDARAHALLI	3146	27610	23920	3070	27066	30680
14	CHIKKABANAVAR	0	26359	34774	0	34774	26359
TOTAL		**213897**	**213897**	**224337**	**224337**	**438234**	**438234**

TABLE 2-26: STATION LOADS ON CORRIDOR-3 IN 2041

KENGERI (KGI) - WHITE FIELD (WFD)							
S.No.	Station Name	KGI - WFD		WFD - KGI		TOTAL	
		BOARD	ALIGHT	BOARD	ALIGHT	BOARD	ALIGHT
1	KENGERI	55449	0	0	64306	55449	64306
2	RV COLLEGE	13915	23615	24378	10322	38293	33937
3	JNANABHARATI	4402	29938	23676	7186	28079	37124
4	NAYANDAHALLI	4488	10378	15114	3168	19602	13545
5	KRISHNADEVARAYA	8528	3767	2384	8089	10912	11856
6	JAGAJEEVANRAM NAGAR	5844	8270	7719	5710	13563	13979
7	KSR BENGALURU CITY	21973	16002	18273	20402	40245	36403
8	KUMARAPARK (BDA)	5932	15752	19676	6718	25608	22471
9	BENGALURU CANTT.	14955	11619	13990	15641	28945	27260
10	BENGALURU EAST	10835	12811	14029	9553	24864	22364
11	BAIYYAPPANAHALLI	5159	10029	8192	5088	13351	15117
12	KRISHANRAJAPURAM	14982	7481	7306	15244	22287	22725
13	HOODI	1162	15825	15545	1162	16707	16986
14	WHITE FIELD	0	2136	2305	0	2305	2136
TOTAL		**167623**	**167622**	**172586**	**172587**	**340209**	**340209**

TABLE 2-27: STATION LOADS ON CORRIDOR-4 IN 2041

HEELALIGE (HLE) - RAJANKUNTE (RNN)							
S.No.	Station Name	HLE - RNN		RNN - HLE		TOTAL	
		BOARD	ALIGHT	BOARD	ALIGHT	BOARD	ALIGHT
1	HEELALIGE	14400	0	0	14400	14400	14400
2	BOMMASANDRA	13500	90	270	13500	13770	13590
3	SINGENA AGRAHARA	10800	360	540	10800	11340	11160
4	HUSKUR	21865	1530	1080	20665	22945	22195
5	AMBEDKAR NAGAR	14576	1890	1620	13776	16196	15666
6	KARMELRAM	22038	35251	34736	23284	56774	58535
7	BELANDUR ROAD	4325	18348	19997	4777	24322	23125
8	MARATHAHALLI	23407	12765	13286	23743	36692	36508
9	KAGADASPURA	12125	26001	26352	11988	38477	37988
10	BENNIGANAHALLI	14104	8295	8363	13362	22467	21657
11	CHANNASANDRA	24750	13903	13902	22907	38651	36810
12	HORAMAVU	28268	20197	20788	26990	49055	47187
13	HENNUR	49688	30673	27883	45559	77571	76232
14	TANNISANDRA	32653	68380	65528	32864	98181	101245
15	RK HEGDE NAGAR	21361	41002	40625	18338	61986	59340
16	JAKUR	13630	16642	8603	13897	22233	30539
17	YELAHANKA	12234	24530	26010	10010	38244	34541
18	MUDDENAHALLI	7633	7038	6816	7633	14449	14671
19	RAJANKUNTE	0	14462	12095	0	12095	14462
TOTAL		**341357**	**341357**	**328493**	**328493**	**669850**	**669849**

TABLE 2-28: SECTION LOADING ON CORRIDOR-1 FOR 2025, 2031 & 2041

KSR BENGALURU CITY (SBC) - DEVANAHALLI (DHL)			2025		2031		2041	
S.No.	STATION NAME		DIR 1	DIR 2	DIR 1	DIR 2	DIR 1	DIR 2
1	KSR BENGALURU CITY	SRIRAMPURA	5869	7005	6899	8284	8870	10754
2	SRIRAMPURA	MALLESWARAM	5937	7231	6936	8551	8875	11298
3	MALLESWARAM	YESHWANTPUR	8470	9494	9927	11184	12618	14412
4	YESHWANTPUR	MUTHYALANAGAR	9707	10524	10658	11697	13278	14814
5	MUTHYALANAGAR	LOTTEGOLAHALLI	10911	10877	12226	12296	15160	15580
6	LOTTEGOLAHALLI	KODIGEHALLI	9198	7933	10121	8817	13765	12800
7	KODIGEHALLI	JUDICIAL LAYOUT	8207	10499	9848	12879	14913	19135
8	JUDICIAL LAYOUT	YELAHANKA	11267	11775	13176	13750	17931	18862
9	YELAHANKA	NITTE MEENAKSHI	8042	8444	9137	9623	15747	16798
10	NITTE MEENAKSHI	BETAHALASURU	6718	6858	8187	8296	15311	15631
11	BETAHALASURU	DODDAJALA	6674	6808	8187	8296	15483	15803
12	DODDAJALA	AIRPORT TRUMPET	5875	5845	7056	7047	12366	12359
13	AIRPORT TRUMPET	AIRPORT KIADB	4979	4922	6020	6005	10850	10793
14	AIRPORT KIADB	DEVANAHALLI	2894	2965	3247	3386	4769	4766
MAX.PHPDT			11775		13750		19135	

TABLE 2-29: SECTION LOADING ON CORRIDOR-2 FOR 2025, 2031 & 2041

BAIYAPPANNAHALLI (BYPL) - CHIKKABANAVAR (BAW)			2025		2031		2041	
S.No.	STATION NAME		DIR 1	DIR 2	DIR 1	DIR 2	DIR 1	DIR 2
1	BAIYYAPPANAHALLI TERMINAL	KASTURI NAGAR	2263	2194	2873	2834	3758	3696
2	KASTURI NAGAR	SEVANAGAR	1600	1672	2168	2172	2885	2890
3	SEVANAGAR	BANASWADI	2661	2734	3229	3451	4072	3785
4	BANASWADI	KAVERI NAGAR	2942	3089	3550	3606	4385	4524
5	KAVERI NAGAR	NAGAWARA	4161	4159	4955	4845	5825	5827

BAIYAPPANNAHALLI (BYPL) - CHIKKABANAVAR (BAW)			2025		2031		2041	
S.No.	STATION NAME		DIR 1	DIR 2	DIR 1	DIR 2	DIR 1	DIR 2
6	NAGAWARA	KANAKANAGARA	3101	2826	3856	3532	5466	5066
7	KANAKANAGARA	HEBBAL	2353	2310	2976	2875	4366	4178
8	HEBBAL	LOTTEGOLAHALLI	2069	2073	2450	2430	3516	3381
9	LOTTEGOLAHALLI	YESHWANTPUR	2006	2701	2157	2858	2384	2965
10	YESHWANTPUR	JALAHALLI	3620	4695	4452	5706	5676	6934
11	JALAHALLI	SHETTIHALLI	6721	9009	8316	10923	11229	13858
12	SHETTIHALLI	MYDARAHALLI	4473	4551	5773	6029	8292	9060
13	MYDARAHALLI	CHIKKABANAVAR	2432	2847	2915	3595	4217	5564
MAX.PHPDT			9009		10923		13858	

TABLE 2-30: SECTION LOADING ON CORRIDOR-3 FOR 2025, 2031 & 2041

KENGERI (KGI) - WHITE FIELD (WFD)			2025		2031		2041	
S.No.	STATION NAME		DIR 1	DIR 2	DIR 1	DIR 2	DIR 1	DIR 2
1	KENGERI	RV COLLEGE	5521	6442	6767	7951	8872	10289
2	RV COLLEGE	JNANABHARATI	4831	4768	5874	5738	7320	6920
3	JNANABHARATI	NAYANDAHALLI	2270	2978	2644	3514	3234	4281
4	NAYANDAHALLI	KRISHNADEVARAYA	1605	1563	1852	1832	2292	2370
5	KRISHNADEVARAYA	JAGAJEEVANRAM NAGAR	2237	2405	2556	2757	3053	3363
6	JAGAJEEVANRAM NAGAR	KSR BENGALURU CITY	1960	2183	2221	2466	2665	3041
7	KSR BENGALURU CITY	KUMARAPARK (BDA)	2683	3761	3089	4074	3621	4502
8	KUMARAPARK (BDA)	BENGALURU CANTT.	1205	1585	1483	1859	2049	2429
9	BENGALURU CANTT.	BENGALURU EAST	2191	2381	2345	2554	2583	2693
10	BENGALURU EAST	BAIYYAPPANAHALLI	1212	874	1714	1371	2267	1897
11	BAIYYAPPANAHALLI	KRISHANRAJAPURAM	875	872	1151	1129	1488	1400
12	KRISHANRAJAPURAM	HOODI	1459	1443	2045	2050	2688	2670
13	HOODI	WHITE FIELD	179	193	264	290	342	369
MAX.PHPDT			6442		7951		10289	

TABLE 2-31: SECTION LOADING ON CORRIDOR-4 FOR 2025, 2031 & 2041

HEELALIGE (HLE) - RAJANKUNTE (RNN)			2025		2031		2041	
S.No.	STATION NAME		DIR 1	DIR 2	DIR 1	DIR 2	DIR 1	DIR 2
1	HEELALIGE	BOMMASANDRA	739	739	1280	1280	2304	2304
2	BOMMASANDRA	SINGENA AGRAHARA	1427	1417	2472	2456	4450	4421
3	SINGENA AGRAHARA	HUSKUR	1962	1944	3400	3368	6120	6062
4	HUSKUR	AMBEDKAR NAGAR	4117	3990	5984	5843	9374	9196
5	AMBEDKAR NAGAR	KARMELRAM	5491	5292	7629	7413	11403	11141
6	KARMELRAM	BELANDUR ROAD	4202	4380	6039	6077	9289	9309
7	BELANDUR ROAD	MARATHAHALLI	2912	3036	4419	4362	7046	6874
8	MARATHAHALLI	KAGADASPURA	3877	3840	5959	5798	8748	8547
9	KAGADASPURA	BENNIGANAHALLI	2183	2097	4164	3779	6528	6249
10	BENNIGANAHALLI	CHANNASANDRA	2997	2812	5012	4472	7458	7048
11	CHANNASANDRA	HORAMAVU	4504	4123	6735	5990	9193	8489
12	HORAMAVU	HENNUR	5899	5099	8365	7068	10485	9482
13	HENNUR	TANNISANDRA	7646	6532	11919	10036	13527	12310
14	TANNISANDRA	RK HEGDE NAGAR	3834	3278	6274	5089	7811	7084
15	RK HEGDE NAGAR	JAKUR	2336	1783	3357	2481	4668	3518
16	JAKUR	YELAHANKA	1894	1960	2582	2697	4186	4364
17	YELAHANKA	MUDDENAHALLI	842	770	1301	1100	2219	1805
18	MUDDENAHALLI	RAJANKUNTE	1120	1054	1568	1383	2314	1935
MAX.PHPDT			**7646**		**11919**		**13527**	

2.4.3 Summary of Transport Demand Forecast for Sub-Urban Rail System

Total Daily Ridership on the study corridors for the years 2025, 2031 and 2041 is expected to be 9.84 Lakh passenger trips, 13.41 Lakh passenger trips and 17.60 passenger trips respectively. The corridor wise daily Ridership and Interchanges for 2025, 2031 and 2041 are shown in **TABLE 2-32 and TABLE 2-33** respectively**.**

TABLE 2-32: DAILY RIDERSHIP OF SUB-URBAN RAIL SYSTEM IN 2025, 2031 AND 2041

CORRIDOR NAME	DAILY BOARDING			DAILY TRIPS		
	2025	2031	2041	2025	2031	2041
Corridor 1 (KSR Bengaluru City - Devanahalli)	407382	528026	732406	282154	378901	536046
Corridor 2 (Baiyappanahalli - Chikkabanawar)	272174	346988	438234	203317	266316	341561
Corridor 3 (Kengeri - White Field)	217198	278617	340209	164180	219644	271906
Corridor 4 (Heelalige - Rajankunte)	363113	514862	669850	334724	476304	611005
TOTAL	**12,59,867**	**16,68,492**	**21,80,698**	**9,84,374**	**13,41,165**	**17,60,518**

TABLE 2-33: DAILY INTERCHANGE OF SUB-URBAN RAIL SYSTEM IN 2025, 2031 AND 2041

CORRIDOR NAME	DAILY INTERCHANGE		
	2025	2031	2041
Corridor 1 (KSR Bengaluru City - Devanahalli)	125229	149125	196360
Corridor 2 (Baiyappanahalli - Chikkabanawar)	68857	80673	96673
Corridor 3 (Kengeri - White Field)	53019	58973	68303
Corridor 4 (Heelalige - Rajankunte)	28389	38558	58845
TOTAL	**2,75,493**	**3,27,328**	**4,20,180**

3. GROUND SURVEY AND ALIGNMENT

3.1 ENGINEERING SURVEY

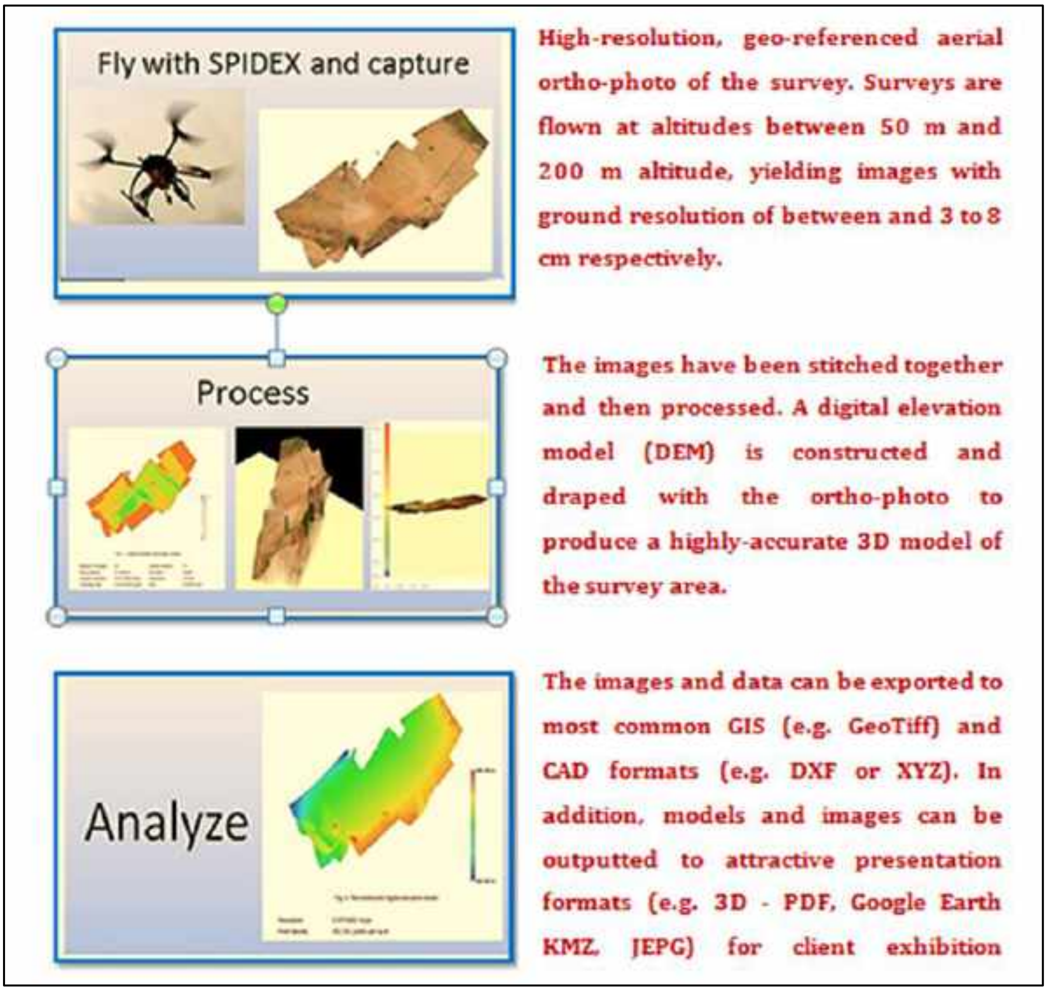
3.1.1 CORRIDORS

The Suburban Rail network proposed around Bengaluru city has been planned as 4 independent corridors:

1) Corridor – 1: KSR Bengaluru City to Devanahalli
2) Corridor – 2 : Baiyyappanahalli to Chikkabanavara
3) Corridor – 3 : Kengeri to Whitefield
4) Corridor – 4 : Heelalige to Rajankunte

The survey process is explained through **Figure 3.1.**

FIGURE 3.1: SURVEY WORK FLOW



3.1.2 PRE-SURVEY

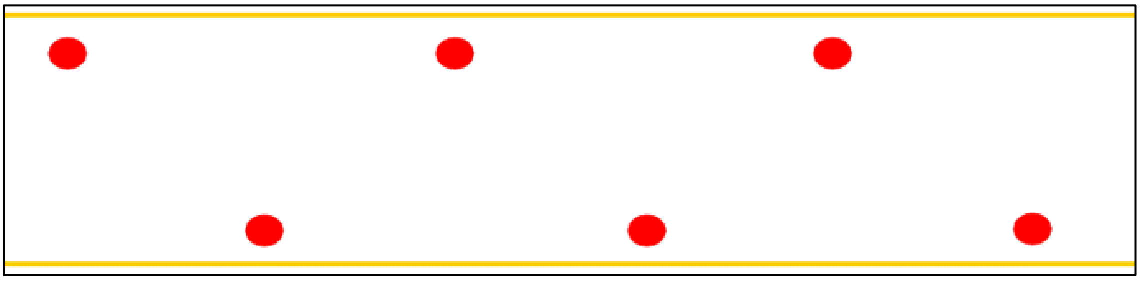
- Establishment of Temporary Ground Control Point (GCP) :

  Ground Control Points (GCPs) are points of known coordinates in the area of interest. Their coordinates have been measured with traditional surveying methods or have been obtained from other sources (LiDAR, older maps of the area, Web Map Service). They increase significantly the absolute accuracy of the project.

- Number and distribution of ground control points (GCPs) in corridor mapping :

  Corridor mapping includes project areas that are significantly larger in one dimension than another, e.g. railways, roads, rivers; etc. It was recommended that corridor projects include ground control points (GCPs) to ensure an accurate reconstruction. The minimum number of GCPs required for a corridor project depends on the same factors as many other types of projects, including the relative accuracy of the image geolocation, the amount of image overlap, and the length and width of the corridor.

FIGURE 3.2: GROUND CONTROL POINT



3.1.3 GCP CO-ORDINATE SYSTEM

A coordinate system is a set of numbers and parameters that is used in order to define the position of any object in the 2D or 3D space. The chosen GCP coordinate system depends on the need of the end-user. Usually the coordinate systems can be:

- Global coordinate systems: They are defined using 3D ellipsoid coordinates (latitude, longitude, altitude).
- National coordinate systems: They are usually defined using a projection defined for a specific country (X, Y, altitude).
- Local coordinate systems: They are defined using a projection. The user sets the origin and orientation where it is most convenient (X, Y, altitude).

  As per the plan for pre-survey work is create the flight mission and stabilize the ground control points. As per the accuracy requirement it was decided to establish 4 GCP points per km and 644 ground control points in total (GCPs) were established and the reading for the same has been taken in RTK Mode.

FIGURE 3.3: GPS CO-ORDINATE SYSTEM

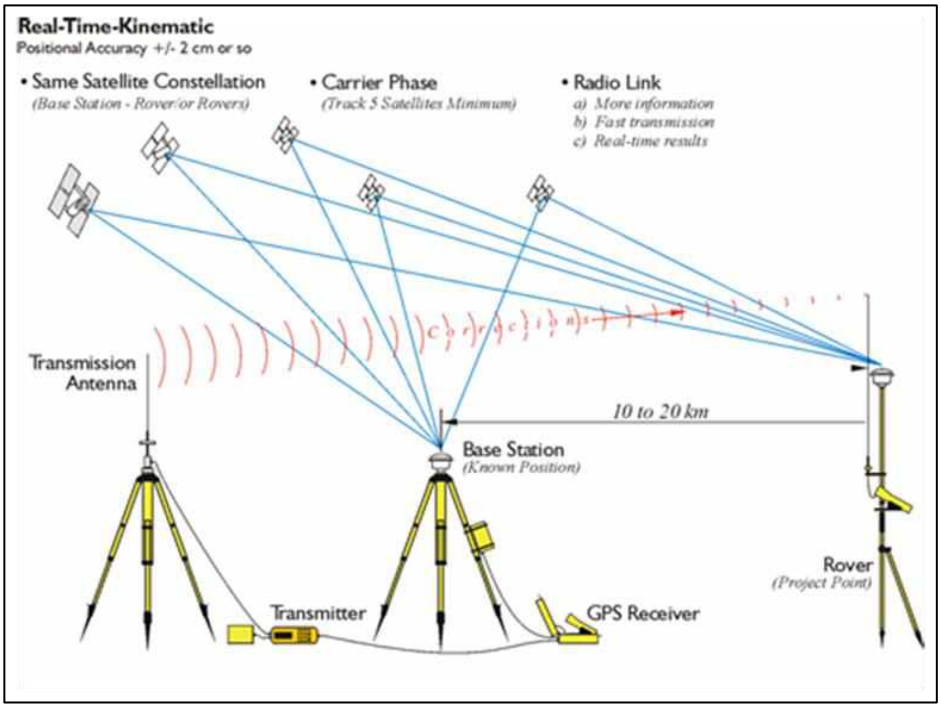
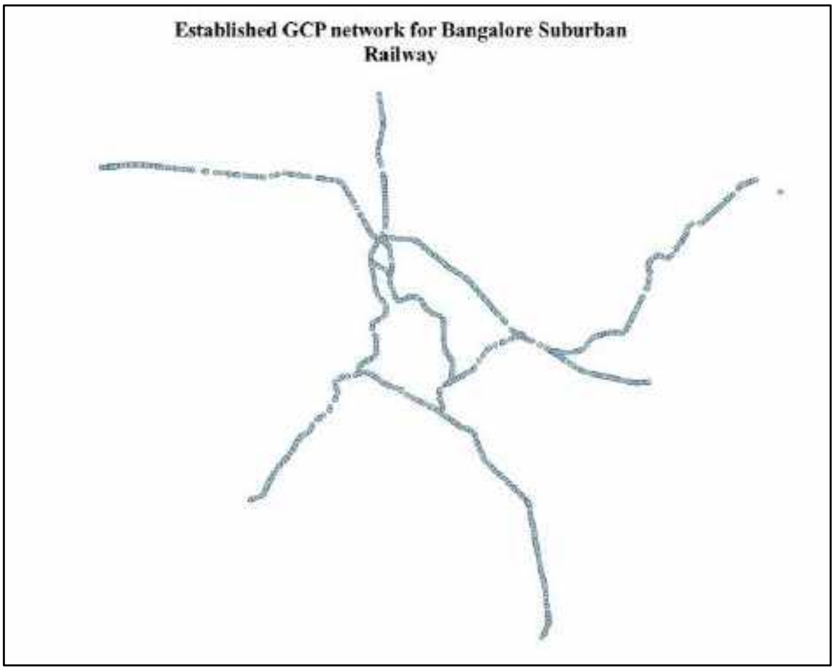


TABLE 3.1: GCP TABLES

GCP	X(m)	Y(m)	Z(m)
1	462292.389	1813980.868	15.411
2	462104.548	1813939.19	16.280
3	461742.199	1813890.192	14.694
4	461459.176	1813831.702	14.541

FIGURE 3.4: GCP OBSERVATION USING DGPS

FIGURE 3.5: GCP NETWORK FOR BENGALURU SUBURBAN NETWORK



3.1.4 IMAGE ACQUISITION

The procedure of the image acquisition and processing of UAV is started by the flight planning. The mission is normally planned in the Pix4D capture software using grid option. Flight height and camera angle which will determine the capturing size of the image and object details. The drone flew over the corridor length according to the flight path.

FIGURE 3.6: FLIGHT PATH OF DRONE

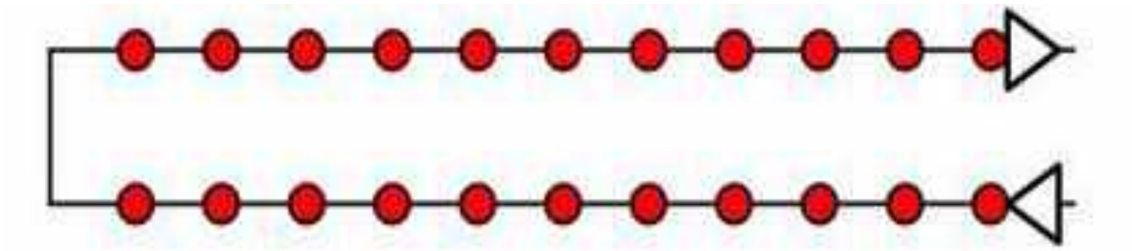


TABLE 3.2: IMAGERY ACQUISITION CRITERIA

Components	Description
Coverage area	Approximate 1KM² (tile size)
Pixel size /Resolution	3-4 cm
Flight Height	Not more than 200 ft.
Camera Sensor	20 megapixels and above
Photography condition	Ground must be free of fog, snow, haze, dust
Overlapping	80 % forward overlap and 70 % side overlap

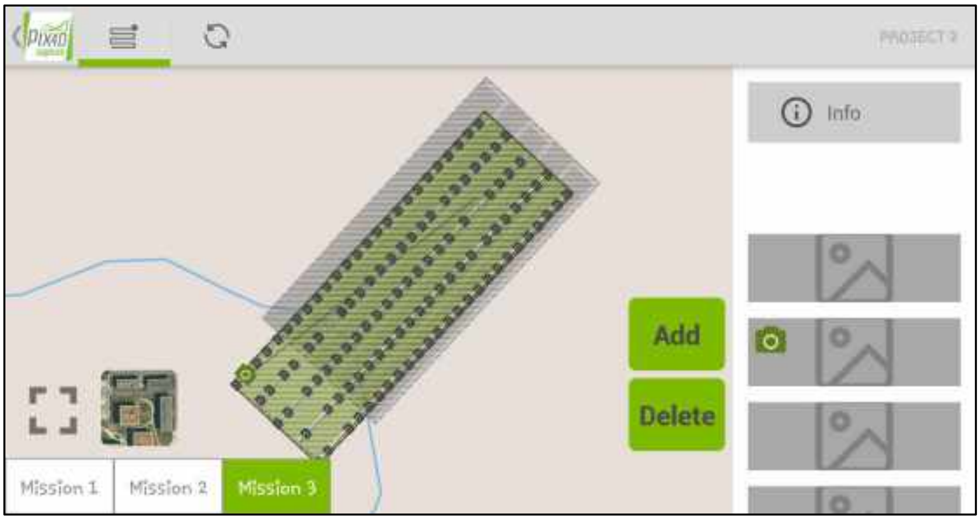
3.1.5 DRONE

DJI phantom 4 pro drone is used for the aerial survey which specification is presented below.

FIGURE 3.7:AERIAL SPECIFICATION

	DJI Phantom 4
Weight	48.7 oz
Max Speed	45 MPH
Flight Time	28 mins
Camera	4K, 30 fps
Obstacle avoid	Yes
Follow me	Yes
Return home	Yes

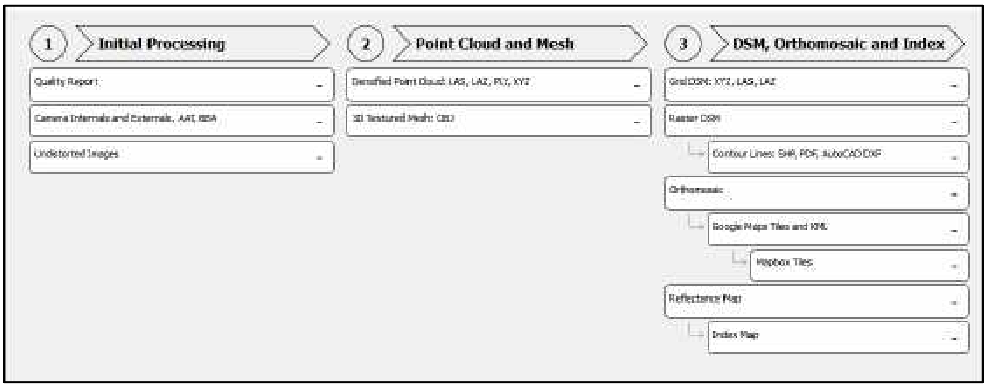
FIGURE 3.8 MISSION PLANNING SOFTWARE



3.1.6 IMAGE PROCESSING AND ORTHO-RECTIFICATION

The total number of flight mission for this project is around 322 missions. The flight mission created as per the corridor length. The total length of the corridor width is 200m. Each mission has same mission flight parameters. Another key consideration of data processing software is a Pix4d desktop. Image captured from the drone to be processed using this software to can generate a high-resolution ortho-mosaic image. The final orthophoto has 2.5cm ground sampling distance (GSD).

FIGURE 3.9 IMAGE PROCESSING WORK FLOW



3.1.7 OUT PUTS

RITES have collected the information pertaining to existing infrastructure from the concerned railway departments of SWR. Further RITES have examined physically by travelling across the track by trolley and by way of drone survey and prepared the existing master plan for the entire 160 Kms route length within Bengaluru city limits.

FIGURE 3.10: ORTHOMOSAIC / DEM

FIGURE 3.11: DIGITIZED OUTPUT WITH RAILWAY BOUNDARY AND CHAINAGE

3.1.8 METHODOLOGY FOR DRONE SURVEY:

The survey findings have been integrated with existing data available with Railways and established the master plan for the entire study area for about 160.00 Kms within Bengaluru city limits.

To serve the purpose of above, the Drone based survey has been conducted with highly qualified and suitable experts to boost the productivity at a short period. This data collection was done.

- Image acquisition with GSD resolution using Drone technology
- Image Processing and Ortho Rectification
- Base Map preparation with rectified image.

The above have been acquired through

1. **Stereo image acquisition using Drone Technology (4Cms GSD or better resolution)**

- Establishing of Ground Control Network for drone survey: Identification and marking of Ground Control Points within the railway premises with the double frequency of DGPS (Digital Global Positioning)
- Monumentation of G.C.P: Required number of Ground Control Points (GCP) shall be marked on the ground using DGPS.
- Aerial Imaginary Acquisition Using Drone: Aerial photography data acquisition using UAV

2. **Image Processing and Ortho- rectification**

- Pre-Processing and ortho rectification of imagery
- Pre-processing of acquired Images.
- Digital surface models, digital terrain model generation
- Ortho-Rectification of satellite Images
- The ground control points established and DEM created should be used for ortho rectification imagery

3. **Base map preparation:**

- Heads-up digitization using 2D features capturing technology from ortho-rectified images
- Creation of data layers with necessary attributes of various existing features all along the track.
- Field verification of features to ensure complete accuracy.

FIGURE 3.12: TYPICAL VIEW OF THE DRONE IMAGE

3.2 MAJOR CONSTRAINTS

Based on the output of the Engineering Survey and data collected during the trolley inspection along the existing Rail network, a master plan of the entire network has been prepared incorporating the existing infrastructure such as tracks, roads, building, ROBs, RUBs, FOBs, Metro lines, and H.T. line crossings etc. On detailed study, it is found that the following are the major constraints for aligning the Sub-urban Rail Corridors:

- Limited ROW of railway land all along the existing tracks,
- Existence of ROBs, RUBs and Metro alignment, crossing the proposed route and the horizontal clearance from the existing track and limited ROW at those locations.
- Crossing of High tension power lines
- Encroachment of Railway land
- Existence of temples within Railway ROW
- Space constraints at the location of LC are within the city limits.

The Alignment has been proposed duly considering the above constraints.

3.3 PLANNING AND DESIGN NORMS

3.3.1 PLANNING PARAMETERS

- The Suburban corridor shall consist of BG tracks (1676 mm) running parallel to one side existing At-grade IR tracks with centre to centre spacing of 5.30m. When elevated, the track spacing between two tracks shall be maintained at 4.725m (as per standards of Delhi Metro Rail System) and the viaduct width of 10.9m is being proposed. All vertical and lateral clearances, standards and turnouts will conform to the standards laid down by Indian Railways, SOD – 2004.
- The proposed Sub-urban alignment at grade is kept at a distance of 7.8m from IR line and the inter distance between Sub Urban tracks is 5.30m.
- Elevated alignment is kept at a distance of 8.5m from IR line to centre of the viaduct and the inter distance between tracks is 4.725m.
- The design speed adopted is 90 Kmph.
- Track structure on the main line will be for broad gauge with 60-kg UIC wear resistant rails. On elevated corridor, the track will be of ballast-less type (BLT) and At-grade alignment, the track will be provided with 350 mm ballast cushion, on PSC sleepers 1660 nos./Km.

3.3.2 GEOMETRIC DESIGN PARAMETERS

A) Horizontal Curves

- The minimum adopted curve radius for main running lines is 200m for At-grade / elevated section. In exceptional cases, for elevated section, the radius of 175 m has been adopted at some locations.
- Radius of curves at stations shall be 1000m and in exceptional cases, it can be of 875m.
- Cant deficiency (Cd) allowed may not exceed 100 mm and the Actual Cant (Ca) may not normally exceed 125 mm

B) Transition Curves

- The transition curve length calculation has been carried out as per the formula given below and the maximum of the three has to be considered

L = 0.008x actual cant x Maximum speed

L= 0.008x cant deficiency x maximum speed

L =0.72x actual cant

Note: Wherever the transition to full length not possible, the IR standards need to be followed. (2/3 of transition)

C) Safe speed on curves

- The safe speed on curves is determined by the formula:

V safe = 0.27 *Sqrt(R (Ca + Cd))

Where,

V safe	=	Safe speed in kmph
R	=	Radius in m
Ca	=	Applied Cant in mm
Cd	=	Cant deficiency in mm

D) Vertical curves

Minimum radius of vertical curves at change of grade points (wherever change of grade is steeper than 0.4%) to be adopted, is 3000m in normal circumstances and 2500m in exceptional situations. There should be no overlap between vertical curves and transition curves. The minimum length of vertical curves is to be 20 m.

E) Gradients

On main line tracks, following criteria/guidelines has been adopted.

- At stations - Level or 1 in 1000 for Elevated stations and existing grades for At–grade stations and maintain IR norms.
- In mid-section, the gradients, not steeper than 2.0%, in exceptional situations the steepest gradient may go up to 2.5% for elevated section
- At-grade in mid-section locations, the Gradient will be at par with existing Main Line Tracks.

F) Points and Crossings

All turn outs/crossovers on the main lines and other running lines should be 1 in 12 type CMS weldable turnouts. Points and crossings in depot/yard lines can be 1 in 8.5 types. No part of points and crossing length should fall on a transition curve or a vertical curve.

G) Depot yards

Yard lines should normally be flat/level; gradient may not be steeper than 1 in1200. Curves in yard may be non-canted and non-transitioned, with radii not less than 175 m. Stabling lines should have a clear standing length of 230m for one rake length or 460m for two rake lengths.

TABLE 3.3: SALIENT FEATURES OF THE DESIGN NORMS

Sl.No.	ITEM DESCRIPTION	SALIENT FEATURES
1	Tracks	BG Tracks (1676mm)
2	Centre to Centre Spacing of existing IR tracks At-grade	5.30m
3	Centre to Centre Spacing of Proposed tracks in elevated structure	4.725m
4	Width of Proposed Viaduct	10.9m for two tracks
5	Distance of Proposed At-grade nearest Sub-urban track from centre line of nearest IR track	7.8m
6	Distance of Proposed Centre line of viaduct from Centre line of nearest IR track	8.5m
7	Design Speed	90 Kmph
8	Types of track proposed	(a) Ballast-less track for elevated structure.
		(b) Ballast cushion of 350mm for At-grade track

Sl.No.	ITEM DESCRIPTION	SALIENT FEATURES
9	Horizontal Curves	Minimum radius of 200mm for At-grade/elevated
10	Radius of curves	1000m at stations
11	Cant Deficiency	Not to exceed 100mm
12	Actual Cant	Not to exceed 125mm
13	Vertical Curves	(a) Radius of vertical curve is 3000m (normal circumstances) & 2500m in exceptional circumstances
		(b) Minimum length shall be 20m
14	Gradient	(a) Elevated station -Level (or) 1 in 1000, At-grade – Existing grade
		(b) At mid sections - Not Steeper than 2 % (May be 3% for elevated section in exceptional situation)
		(c) At par with existing IR tracks in mid locations At- grade
15	Turnouts/Crossovers	(a) Main lines/ other running lines 1 in 12
		(b) Depot/Yard lines 1 in 8.5
16	Depot Yards	(a) Lines are normally flat/level in yards , may not be steeper than 1 in 1200
		(b) Curves in yards shall have radii not less than 175mm
		(c) Stabling lines shall have clear standing length of 350m for one rake length

3.3.3 ALIGNMENT CONSIDERATIONS

Following considerations have been kept while proposing alignment:

- The alignment has been proposed generally within railways Right of Way, in order to minimize acquisition of private land/properties.
- Alignment proposed is along one side and generally parallel to the existing tracks.
- Since crossing over of alignment involves additional cost, as well as disturbance to the train operations, bare minimum crossings have been proposed.
- Track centres have been kept 4.725m for elevated sections and 5.30m for the At-grade sections.

- Height of deck has been generally kept 15.0m, above existing rail level, in order to provide adequate clearance over existing ROBs, FOBs and to accommodate elevated station box.
- Wherever minimum height of deck needs to be increased, due to higher road level on the ROB, same has been increased by down/upgrade in approaches.
- Thickness of elevated deck girder will generally vary from 2.45m to 2.75m depending upon span design.
- The Formation width as adopted in the project is given below.
  - Bridge & Viaduct = 10.9 m (Double Track)
  - At-grade double track = 13.15m (5.3 + 7.85)
- Alignment and stations have been planned keeping provision for 9 car trains i.e. 205m length.
- Based on the land availability and other constraints probable cross section have been developed and these are presented in the following figures.

TABLE 3.4: ALIGNMENT CONSIDERATIONS

Sl.No.	ITEM DESCRIPTION	SALIENT FEATURES
1	Alignment	(a) Proposed along parallel to existing IR tracks.
		(b) Proposed within Railway ROW to minimize the private land acquisition.
2	Crossings	Bare minimum crossing proposed to reduce cost & avoid disturbances to train operations of IR.
3	Height of Deck	15.0m to be maintained above existing rail level.
4	Thickness of Elevated Deck Girder	Varies from 2.45m to 2.75m (based on span design)

FIGURE 3.13: TYPICAL VIADUCT CROSS-SECTION

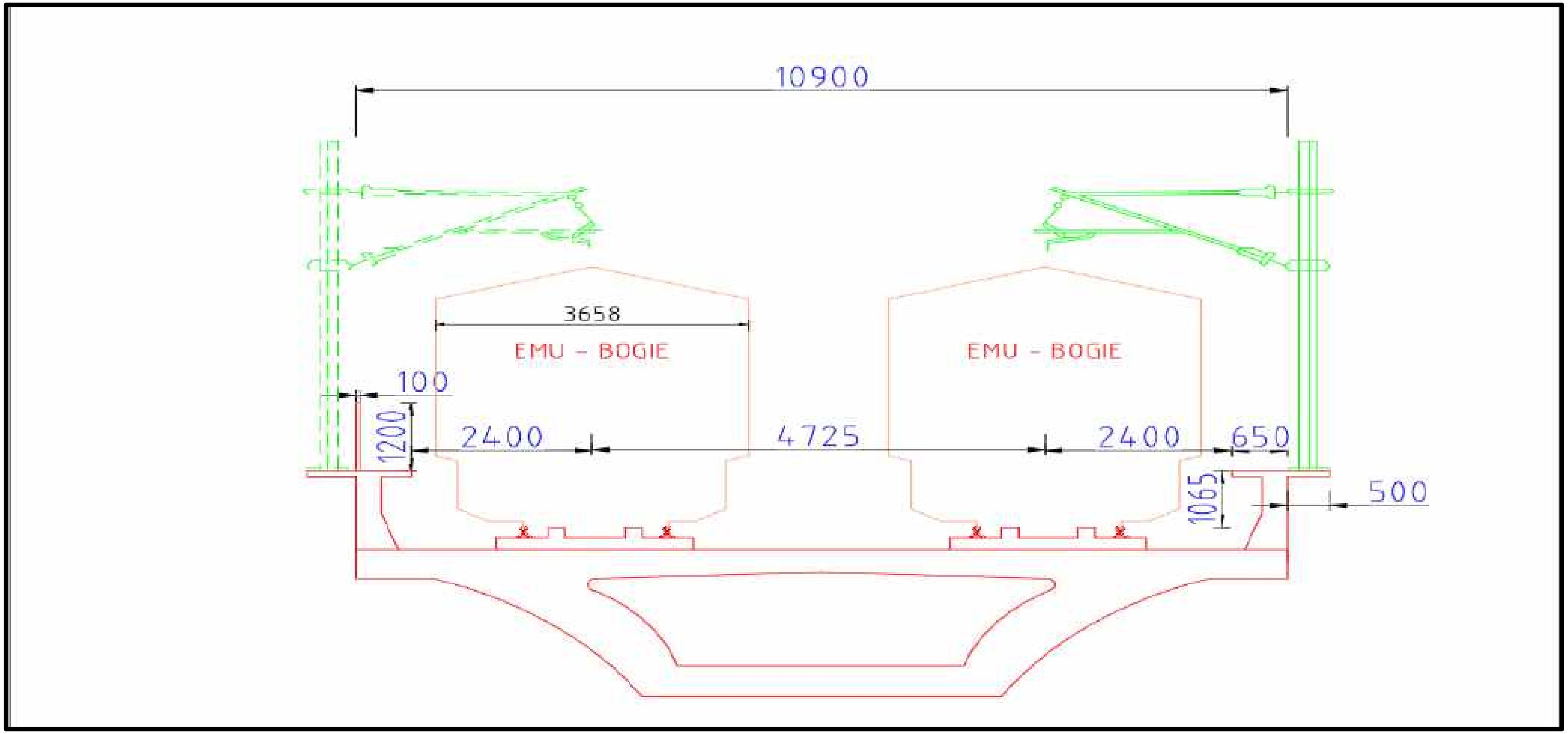


FIGURE 3.14: AT-GRADE CROSS SECTION

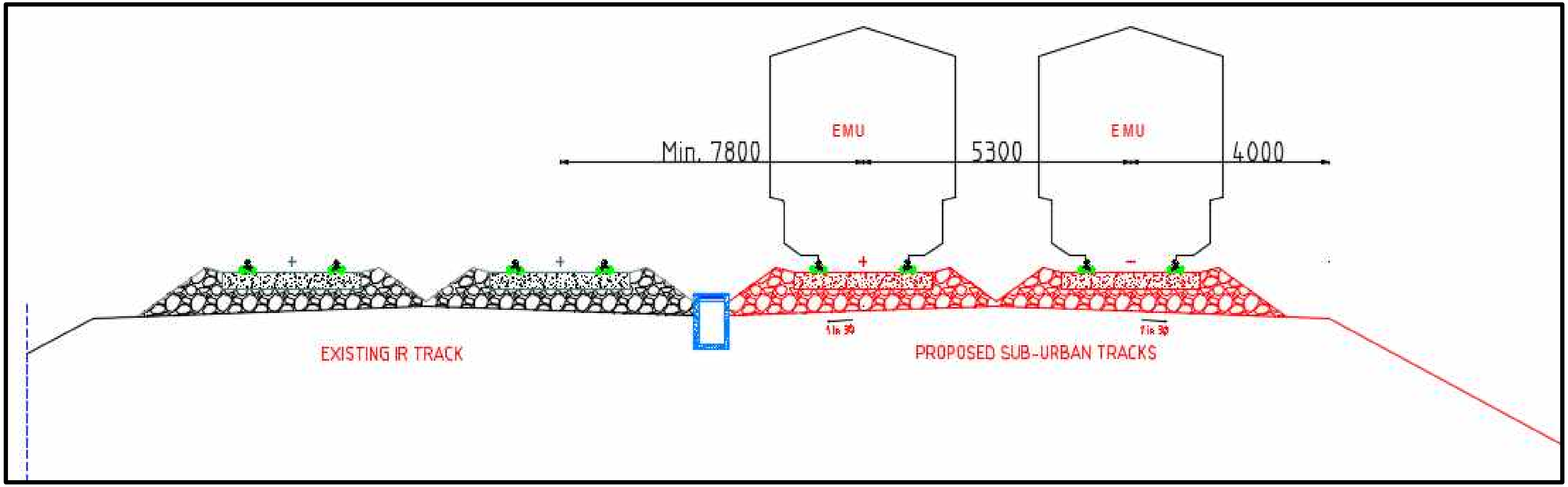


FIGURE 3.15: ELEVATED CROSS SECTION (SINGLE VIADUCT)

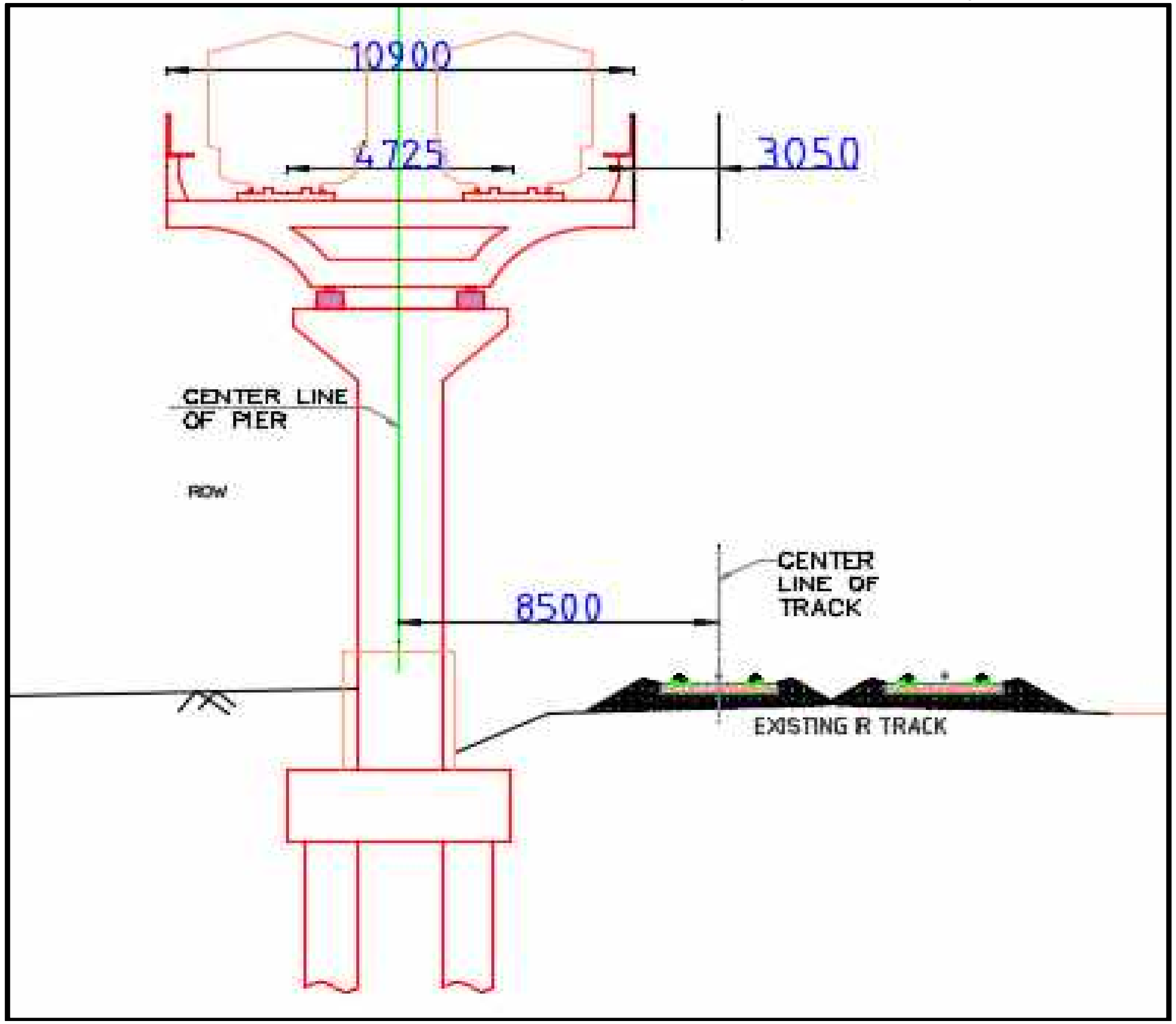
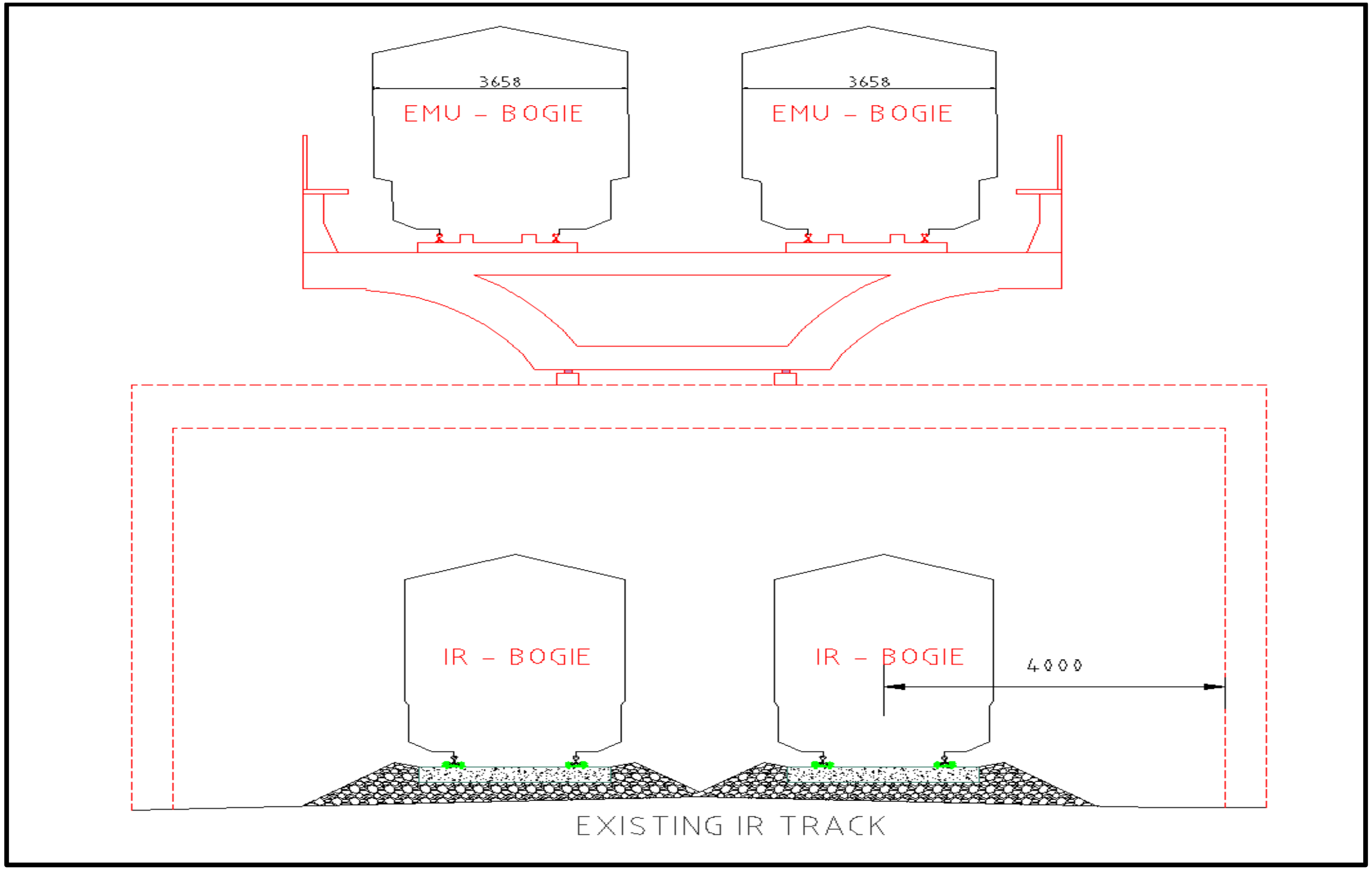


FIGURE 3.16: SECTION OF PORTAL ARRANGEMENT



3.4 VIADUCT

Design of Viaduct & Pier and its details are listed below:

- SPAN :31 m (9x3+2x2 segments in straight)
  : 25 m (7x3+2x2 segments in curves)
- VIADUCT : (M60): 10.9 m width – 2.4-2.5m height (Double Track)
- HEIGHT OF PIER : 6.0-9.0m Normal / 15.0m Special (RL-RL 10 m)
- PIER Dia : 2.5m (Two tracks)
- REINFORCEMENT : 60 no 32mmØ
- CONCRETE : M40

The multiple pile construction can be done for a double track viaduct.

3.5 CORRIDOR – 1: KSR BENGALURU CITY TO DEVANAHALLI

3.5.1 CORRIDOR DETAILS

- The total route length of this corridor is 41.400 Km. This corridor passes through Yeshwantpura terminal at Km 5.74 and Yelahanka junction at Km 18.38. Yeshwantpura station is a major passenger terminal. Yelahanka is a major junction connected to Devanahalli, Channasandra, Rajankunte and Yeshwantpura.
- In this corridor, total 15 stations are proposed out of which 7 stations are elevated and 7 stations are At-grade and one future elevated station.
- Out of the 7 stations proposed At-grade, the platforms are At-grade while the concourse is elevated.
- The list of stations proposed along this stretch is given below:

TABLE 3.5: LIST OF STATIONS OF CORRIDOR-1

Sl. No.	Station	Elevated Platform	At-grade Platform	Status
1	KSR Bengaluru City	✓ (Repeated)		Existing IR station (Interchange)
2	Srirampura	✓		**Future**
3	Malleswaram	✓		Existing IR station
4	Yeshwantpura	✓ (Level 1)		Existing IR station (Interchange)
5	Muthyalanagar	✓		New

Sl. No.	Station	Elevated Platform	At-grade Platform	Status
6	Lottegollahalli	✓ (Level 1)		Existing IR station (Interchange)
7	Kodigehalli		✓	Existing IR station
8	Judicial layout		✓	New
9	Yelahanka	✓		Existing IR station
10	Nitte Meenakshi		✓	New
11	Bettahalasuru		✓	Existing IR station
12	Doddajala		✓	Existing IR station
13	Airport Trumpet		✓	New
14	Airport KIADB		✓	New
15	Devanahalli	✓		Existing IR station (Interchange)
	Total	**8**	**7**	

- **KSR BENGALURU CITY STATION** (0 Km) is proposed with Elevated platform and Elevated Station building. This is the starting station for this corridor. The platforms are proposed above existing IR platform 6 or 7. It serves as an interchange station for Corridors nos. (1) and (3) of Sub-urban network and also connects to IR Bengaluru terminal.
- **SRIRAMPURA STATION** (1.45 Km) is an elevated platform with elevated station **(Future)** building. The inter distance from KSR Bengaluru City is 1.40 Km. In this section the proposed elevated Sub-urban alignment runs on RH side of the existing IR track. This station is a new station.
- **MALLESWARAM STATION** (2.85 Km) is an elevated station with elevated platform. The inter distance from Srirampura station is 1.40 Km. In this section the proposed Elevated Sub-urban alignment runs on RH side of IR lines up to km 1/700 and cross the IR line at Km: 1/700. Further, it proceeds towards Malleswaram on LH side of IR line. At this location there exists At-grade IR station.
- **YESHWANTPURA STATION** (5.74 Km) is an elevated station at level-1 with elevated platform. The platform and station are proposed above existing platforms No.1 to4. The inter distance from Malleswaram station is 2.89 Km. This station is an interchange station for Corridor Nos. (1) and (2). In this section the proposed elevated alignment runs on LH side of IR line up to Yeshwantpura station.

- **MUTHYALANAGAR STATION** (8.32 Km) is an elevated station with elevated platform. The inter distance from Yeshwantpura is 2.58 Km. In this section the proposed elevated alignment runs on RH side of IR line duly crossing the IR line at Km: 6/250. The proposed doubling between Yeshwantpura and Baiyyappanahalli by SWR also runs on RH side at the location. Doubling has also been considered while fixing the alignment of suburban. Both doubling and Sub-urban runs on RH side of the stretch up to Km 8.050. The proposed alignment crosses IR line at Km 8.050 and runs on LH side of IR line up to Muthyalanagar station. Muthyalanagar station is a new station.
- **LOTTEGOLLAHALLI STATION** (10.02 Km) is an elevated station at Level-1 with elevated platform. This station is an interchange station for Corridor (1) and (2). The proposed alignment of Corridor (2) will be at level (2). The inter distance from Muthyalanagar station is 1.700 Km. In this section the proposed elevated alignment runs LH side of IR line up to Km 9.75. Further the alignment runs above the IR line up to Km 10.20. The proposed platforms and stations are above existing IR station.
- **KODIGEHALLI STATION** (Km 12.78) is an elevated station with At-grade platforms. The inter distance from Lottegollahalli station is 2.76 Km. In this section the proposed elevated alignment runs on LH side up to Km 12.30 and further At-grade on LH side till it reaches Kodigehalli station. Kodigehalli is an existing IR station.
- **JUDICIAL LAYOUT STATION** (Km 14.96) is an elevated station and At-grade platforms. The inter distance from Kodigehalli station is 2.18 Km. In this section At-grade alignment runs on LH side of IR lines. This is a new station.
- **YELAHANKA JUNCTION** (Km 18.38) is a major junction of IR. The inter distance from Judicial Layout station is 3.42 Km. The proposed station and platforms are elevated at Level (1) on platform (1) of IR station towards Dharmavaram end. In this section At-grade alignment runs on LH side up to Km 15.100. From Km 15.100 both tracks run on LH side of IR lines as elevated and it crosses Yeshwantpura-Yelahanka line at Km: 16.700 towards RH side and further crosses Channasandra-Yelahanka line at Km:16.900 and enters Yelahanka station at Level (1) up to Km 18.38. This station serves as interchange station for corridors (1) and (4).
- **NITTE MEENAKSHI STATION** (Km 21.330) is an elevated station with At-grade platforms. Distance from Yelahanka station is 2.95 Km. In this section, elevated alignment runs up to Km 20.93 and further continues At-grade alignment on RH side of IR line. This is a proposed new station.
- **BETTAHALASURU STATION** (Km 26.12) is an elevated station with At-grade platforms. Distance from NITTE Meenakshi station is 4.79 Km. In this section,

At-grade alignment runs up to Bettahalasuru on RH side of IR lines. This is existing IR halt station.

- **DODDAJALA STATION** (Km 30.070) is an elevated station with At-grade platforms. Distance from Bettahalasuru station is 3.95 Km. In this section, At-grade alignment runs up to Doddajala station on RH side of IR lines. At Doddajala IR station exists.
- **AIRPORT TRUMPET STATION** (Km 34.22) is an elevated station with At-grade platforms. Inter station distance from Doddajala station is 4.15 Km. In this section, At-grade alignment runs up to Airport Trumpet station on RH side of IR lines. This is proposed new station.
- **AIRPORT KIADB STATION** (Km 36.15) is an elevated station with At-grade platforms. Inter distance from Airport Trumpet station is 1.93 Km. In this section At-grade alignment runs on RH side of IR track. This is a new station.
- **DEVANAHALLI STATION** (Km 41.40) is an elevated station with elevated platforms. This is the last station of the corridor. The inter distance from Airport KIADB station is 5.25 Km. In this section the proposed At-grade track runs on RH side of IR line up to Km 40.55. Further elevated alignment runs up to Devanahalli station. It is proposed for cut and connect at Km 36.350 and 40.900 with IR line due to space constraints at ROB-236-A

NOTE: Shunting neck facility is provided at End stations.

- Thus, in corridor-1, terminal stations viz, KSR Bengaluru City & Devanahalli are elevated. The total length of elevated section is 18.98 Km and that of At-grade is 22.42 Km. the corridor also has interchange stations at Yeshwantpura, Lottegollahalli and Yelahanka.

TABLE 3.6: CORRIDOR – 1 BREAKUP

Between Stations	Elevated (2 tracks on one side)	At-grade (2 tracks on one side)
KSR Bengaluru City Station – Srirampura	1.45	0
Srirampura -Malleswaram	1.40	0
Malleswaram – Yeshwantpura	2.89	0
Yeshwantpura – Muthyalanagar	2.58	0
Muthyalanagar - Lottegollahalli	1.70	0
Lottegollahalli – Kodigehalli	2.28	0.48
Kodigehalli – Judicial Layout	0	2.18
Judicial Layout – Yelahanka	3.28	0.14
Yelahanka – Nitte Meenakshi	2.55	0.40
Nitte Meenakshi – Bettahalasuru	0	4.79
Bettahalasuru – Doddajala	0	3.95
Doddajala – Airport Trumpet	0	4.15
Airport Trumpet – Airport KIADB	0	1.93
Airport KIADB – Devanahalli	0.85	4.40
	18.98	**22.42**

TABLE 3.7: CURVE DETAILS OF CORRIDOR-1

CURVE DATA					
NO.	RADIUS	DELTA	LENGTH	TANGENT	ALIGNMENT
C1	475.000	12.957	107.421	53.940	SBC-DHL
C2	300.000	2.914	15.258	7.631	SBC-DHL
C3	300.000	2.876	15.058	7.531	SBC-DHL
C4	580.000	1.723	17.437	8.719	SBC-DHL
C5	3250.000	2.032	115.249	57.630	SBC-DHL
C6	1250.000	4.317	94.182	47.113	SBC-DHL
C7	850.000	21.579	320.130	161.984	SBC-DHL
C8	400.000	1.752	12.232	6.116	SBC-DHL
C9	300.000	3.882	20.324	10.166	SBC-DHL
C10	800.000	10.043	140.226	70.293	SBC-DHL
C11	350.000	23.692	144.726	73.412	SBC-DHL
C12	240.000	5.256	22.015	11.015	SBC-DHL
C13	312.153	3.359	18.300	9.153	SBC-DHL
C14	300.000	3.160	16.544	8.274	SBC-DHL
C15	800.000	4.806	67.109	33.574	SBC-DHL
C16	607.000	8.655	91.689	45.932	SBC-DHL
C17	900.000	21.512	337.912	170.969	SBC-DHL
C18	900.000	11.300	177.494	89.036	SBC-DHL
C19	437.000	2.260	17.239	8.620	SBC-DHL
C20	437.000	2.523	19.240	9.621	SBC-DHL
C21	285.000	18.614	92.591	46.707	SBC-DHL
C22	300.000	17.918	93.817	47.294	SBC-DHL
C23	218.000	110.214	419.346	312.579	SBC-DHL
C24	436.000	11.715	89.143	44.728	SBC-DHL
C25	437.500	4.879	37.258	18.640	SBC-DHL
C26	260.000	8.502	38.581	19.326	SBC-DHL
C27	800.000	15.116	211.053	106.143	SBC-DHL
C28	425.000	54.853	406.877	220.547	SBC-DHL
C29	370.000	0.920	5.943	2.971	SBC-DHL
C30	350.000	5.006	30.582	15.301	SBC-DHL
C31	200.000	9.285	32.410	16.241	SBC-DHL
C32	275.000	10.392	49.877	25.007	SBC-DHL

CURVE DATA					
C33	10000.000	0.022	3.752	1.876	SBC-DHL
C34	900.000	25.026	393.104	199.738	SBC-DHL
C35	300.000	4.210	22.044	11.027	SBC-DHL
C36	300.000	4.354	22.798	11.405	SBC-DHL
C37	300.000	4.310	22.566	11.288	SBC-DHL
C38	300.000	4.287	22.444	11.227	SBC-DHL
C39	875.000	31.750	484.878	248.840	SBC-DHL
C40	300.000	3.659	19.161	9.584	SBC-DHL
C41	325.000	5.381	30.521	15.272	SBC-DHL
C42	450.000	5.504	43.227	21.630	SBC-DHL
C43	434.000	5.449	41.274	20.653	SBC-DHL
C44	875.000	7.239	110.543	55.345	SBC-DHL
C45	425.000	33.438	248.031	127.660	SBC-DHL
C46	437.500	3.635	27.757	13.883	SBC-DHL
C47	330.000	1.898	10.930	5.465	SBC-DHL
C48	425.000	4.348	32.252	16.134	SBC-DHL
C49	325.000	3.314	18.796	9.401	SBC-DHL
C50	450.000	3.541	27.808	13.909	SBC-DHL
C51	450.000	3.902	30.642	15.327	SBC-DHL
C52	325.000	2.432	13.796	6.899	SBC-DHL
C53	325.000	2.788	15.816	7.909	SBC-DHL
C54	325.000	3.608	20.465	10.236	SBC-DHL
C55	325.000	3.705	21.018	10.513	SBC-DHL
C56	300.000	26.199	137.177	69.809	SBC-DHL
C57	775.000	21.152	286.108	144.701	SBC-DHL
C58	400.000	5.239	36.576	18.301	SBC-DHL
C59	400.000	3.875	27.050	13.530	SBC-DHL
C60	300.000	5.558	29.103	14.563	SBC-DHL
C61	300.000	6.605	34.585	17.312	SBC-DHL
C62	400.000	28.341	197.856	100.996	SBC-DHL
C63	650.000	26.024	295.227	150.204	SBC-DHL
C64	1500.000	5.854	153.246	76.690	SBC-DHL
C65	800.000	17.412	243.111	122.500	SBC-DHL
C66	335.000	62.989	368.288	205.244	SBC-DHL

CURVE DATA					
C67	350.000	4.899	29.928	14.973	SBC-DHL
C68	350.000	4.520	27.609	13.812	SBC-DHL
C69	450.000	4.147	32.572	16.293	SBC-DHL
C70	450.000	4.119	32.350	16.182	SBC-DHL
C71	750.000	17.967	235.186	118.566	SBC-DHL
C72	300.000	4.076	21.341	10.675	SBC-DHL
C73	300.000	4.344	22.743	11.377	SBC-DHL
C74	350.000	0.961	5.871	2.936	SBC-DHL
C75	350.000	25.664	156.772	79.723	SBC-DHL
C76	375.000	45.748	299.418	158.205	SBC-DHL
C77	450.000	24.806	194.828	98.965	SBC-DHL
C78	360.000	50.261	315.798	168.869	SBC-DHL
C79	325.000	2.638	14.961	7.482	SBC-DHL
C80	375.000	2.807	18.371	9.187	SBC-DHL
C81	350.000	75.518	461.311	271.085	SBC-DHL
C82	800.000	5.128	71.604	35.826	SBC-DHL
C83	800.000	1.074	15.000	7.500	SBC-DHL
C84	1000.000	2.397	41.832	20.919	SBC-DHL
C85	3000.000	1.960	102.609	51.309	SBC-DHL
C86	170.000	1.553	4.608	2.304	SBC-DHL
C87	170.000	1.487	4.412	2.206	SBC-DHL
C88	300.000	3.218	16.847	8.426	SBC-DHL
C89	300.000	3.626	18.986	9.496	SBC-DHL
C90	550.000	18.030	173.072	87.257	SBC-DHL
C91	380.000	61.570	408.348	226.391	SBC-DHL
C92	300.000	0.439	2.296	1.148	SBC-DHL
C93	300.000	5.436	28.465	14.243	SBC-DHL
C94	300.000	11.188	58.578	29.382	SBC-DHL
C95	442.000	14.830	114.400	57.522	SBC-DHL
C96	515.000	31.525	283.362	145.367	SBC-DHL
C97	466.000	5.309	43.178	21.605	SBC-DHL
C98	500.000	29.386	256.444	131.109	SBC-DHL
C99	360.000	0.850	5.341	2.670	SBC-DHL
C100	360.000	12.161	76.413	38.350	SBC-DHL

CURVE DATA					
C101	360.000	5.068	31.846	15.933	SBC-DHL

TABLE 3.8: DETAILS OF LAND REQUIREMENT FOR CORRIDOR-1

CORRIDOR -1 (SBC-YPR-YNK-DHL)										
SBC-YPR										
S.No	**KM (IR)**		**SECTION**	**LHS / RHS**	**Additional Land Requirement**				**Property details**
	From	**To**			**Total (Sqm)**	**Vacant Land (Sqm)**	**Road (Sqm)**	**Built up (Sqm)**	
1	0.85	0.90	KSR Bengaluru City to Yesvanthpur	RHS	205	0	100	105	Road & built up
2	1.20	1.35			1049	0	270	779	Road & built up
3	1.35	1.65			1228	0	500	728	Road & built up
4	1.70	2.20		LHS	1740	0	900	840	Road & built up
5	2.20	2.60			1259	0	250	1009	Road & built up
6	2.60	2.90			1572	0	500	1072	Railway parallel road
7	3.60	4.00			1639	0	1639	0	Railway parallel road
8	4.05	4.20			438	0	438	0	Road
9	4.90	5.05			351	50	0	301	Buildings
YPR - YNK										
10	8.10	8.4	Yesvanthpur to Yelahanka	RHS	931	671	0	260	Vacant/built up
11	8.45	8.9			1397	1347	50	0	Vacant & cross road
12	11.80	11.9		LHS	207	207	0	0	Vacant
13	12.60	12.85		RHS	1651	1651	0	0	Vacant
14	16.30	16.6		LHS	1267	1267	0	0	Vacant
15	18.25	18.6		LHS& RHS	4064	3414	400	250	vacant/road/ buildings
16	18.62	1.65			9939	9179	260	500	Overlap to DHL line
YNK - DHL										
17	3.25	3.55	Yelahanka to Devanahalli	RHS	2145	1355	0	790	vacant/ built-up
18	5.80	6.1			562	562	0	0	Vacant land
19	6.60	7.1			1198	1078	120	0	Rajankunte-Doddaballapura Road
20	7.10	7.8			2203	2153	50	0	Agricultural land

CORRIDOR -1 (SBC-YPR-YNK-DHL)									
21	8.60	8.7			64	64	0	0	Vacant land
22	9.40	9.85			840	840	0	0	Agricultural land
23	9.85	10.1			382	382	0	0	Vacant land
24	10.80	11.15			1105	0	1105	0	Kuccha road
25	12.85	12.9			56	0	56	0	JSS Road
26	12.90	13.2			376	0	376	0	Kuccha road
27	13.20	13.5			471	471	0	0	Vacant land
28	13.50	13.70			307	307	0	0	Vacant land
29	13.34	14.95			3349	3349	0	0	vacant
30	15.20	16.20			6287	5047	1240	0	Vacant/Agricultural land
31	16.20	16.90			7987	7987	0	0	Vacant/Agricultural land
32	17.30	17.60			959	959	0	0	vacant
TOTAL					**57228**	**42340**	**8254**	**6634**	

Note: The additional area required beyond the Railway boundary is worked out keeping the clear distance of 6.10m and 4.0m from the C/L of the extreme proposed track for elevated double track and At-grade respectively.

TABLE 3.9: LIST OF ROB'S

Section	No. of ROB's	Details of ROB	Railway Kilometre (Approx.)		Recommended Proposal
			From	To	
KSR Bengaluru City – Yelahanka - Devanahalli	12	Metro line	Km:2/100	Km:2/200	
		ROB-418	Km:2/200	Km:2/300	
		ROB-416A	Km:3/500	Km:3/600	
		ROB-414A	Km:4/600	Km:4/700	
		ROB	Km:8/000	Km:8/100	
		ROB-587A	Km:9/100	Km:9/200	
		ROB-529A	Km:9/800	Km:9/900	
Yelahanka - Devanahalli		ROB	Km:12/000	Km:12/100	Additional boxes to be inserted - proposed
		ROB-236A	Km:16/100	Km:16/200	Additional boxes to be inserted - proposed
		ROB	Km:18/800	Km:18/900	Additional vents proposed

TABLE 3.10: LIST OF FOB'S OF CORRIDOR-1

Section	No of FOBs	Railway Details of FOB	Railway Kilometre (Approx.)	
			From	To
KSR Bengaluru City – Yeshwantpura	6	417A	Km: 2/600	Km: 2/700
		417	Km: 2/820	Km: 2/900
		416D	Km: 3/200	Km: 3/300
Yeshwantpura-Yelahanka		413A	Km: 5/300	Km: 5/400
		FOB	Km:17/800	Km:17/900
		FOB	Km:18/000	Km:18/100
Yelahanka - Devanahalli		NIL		

TABLE 3.11: LIST OF LC'S FOR CORRIDOR-1

Sl.No.	Between Stn.	LC No.	Railway KM.	Remarks
1.	KSR Bengaluru City - Yeshwantpura	2	4/200 – 300	Elevated Track
2.	Yeshwantpura – Yelahanka	5	8/600 – 700	Elevated Track
3.	Yeshwantpura – Yelahanka	9	11/300 – 400	Elevated Track
4.	Yelahanka – Devanahalli	2	4/00 – 100	To be eliminated
		4	6/800 – 900	To be eliminated
		10	12/400 – 500	To be eliminated
		15	19/700 – 800	To be eliminated
		16	20/400 – 500	Sanctioned for ROB/RUB
		17	21/100 – 200	To be eliminated
		18	21/900 – 22/000	To be eliminated

3.6 CORRIDOR – 2: BAIYYAPPANAHALLI TERMINAL - CHIKKABANAVARA

3.6.1 CORRIDOR DETAILS

Total length of this corridor is 25.01 Km. this corridor passes through Banaswadi, Hebbal, Lottegollahalli, Yeshwantpura passenger Terminal. In this corridor the proposed elevated track from Lottegollahalli to Yeshwantpura runs on the median of road and the distance is 2.785 Km. at Yeshwantpura, loco pilot has to change the driving cab for further movement towards Chikkabanavara.

In this Corridor total 14 stations are proposed out of which 6 stations elevated and 6 stations are At-grade and 2 nos. are Future At-grade stations.

The List of Stations and type of structure is given in the table below:

TABLE 3.12: LIST OF STATIONS OF CORRIDOR-2

Sl. No.	Station	Elevated Platform	At grade Platform	Status
1	Baiyyappanahalli Panel		✓	New
2	Kasturi Nagar		✓	New
3	Sevanagar	✓		New
4	Banaswadi	✓		Existing

Sl. No.	Station	Elevated Platform	At grade Platform	Status
5	Kaveri Nagar		✓	New **(Future)**
6	Nagavara		✓	New
7	Kanakanagar		✓	New
8	Hebbal	✓		Existing
9	Lottegollahalli (common for corridor-2 & 1)	✓ (Repeated in C1)		Existing (Interchange)
10	Yeshwantpura (Common for C2 & C1)	✓ (Repeated in C1)		Existing (Interchange)
11	Jalahalli		✓	New **(Future)**
12	Shettyhalli		✓	New
13	Myadarahalli		✓	New
14	Chikkabanavara	✓		Existing
	Total	**6**	**8**	

- **BAIYYAPPANAHALLI TERMINAL** (Km 0.00) is an elevated station with At-grade platforms. This is a proposed new station At-grade on Salem line. This is a terminal station.
- **KASTURI NAGAR STATION** (Km 1.14) is an elevated station with At-grade platforms. Inter station distance from Baiyyappanahalli Terminal station is 1.14 Km. In this section, At-grade alignment runs on LH side up to Kasturi Nagar Station. This is a proposed new station.
- **SEVANAGAR STATION** (Km 3.16) is an elevated station with elevated platforms. Inter station distance from Kasturinagar station is 2.02 Km. In this section At-grade alignment runs on LH side of IR line up to Km 1.730. Further Elevated track runs on LH side of IR line up to 2.85 Km. Then it crosses to RH side and runs up to Sevanagar. This is a proposed new station.
- **BANASWADI STATION** (Km 4.17) is an elevated station with elevated platforms. Distance from Sevanagar station is 1.01 Km. In this section, the proposed elevated alignment runs on RH side of IR lines up to Banaswadi Station. The proposed Sub-urban line and platforms are on RH side of existing platforms no. 2 & 3 of existing IR station Banaswadi.
- **KAVERI NAGAR STATION** (Km 5.47) is an elevated station with At-grade platforms. Inter station distance from Banaswadi station is 1.30 Km. In this section, elevated alignment runs on RH side of IR line up to Km 4.75 and further At-grade up to Kaveri Nagar. This is a proposed new station **(Future)**.

- **NAGAVARA STATION** (Km 7.17) is an elevated station with At-grade platforms. Inter station distance from Kaveri Nagar station is 1.70 Km. In this section, At-grade alignment runs on RH side of IR lines. This is a proposed new station.
- **KANAKANAGAR STATION** (Km 8.69) is an elevated station with At-grade platforms. Distance from Nagavara station is 1.52Km. In this section, At-grade alignment runs on RH side of IR lines. This is a proposed new station.
- **HEBBAL STATION** (Km 11.63) is an elevated station with elevated platforms. Distance from Kanakanagar station is 2.94 Km. In this section At-grade alignment runs on RH side up to Km 11.18 and further Elevated track runs on RH side up to Hebbal Station. This is existing IR station.
- **LOTTEGOLLAHALLI STATION** (Km 14.35) is an elevated station with platforms located at level (2). Distance from Hebbal station is 2.72 Km. The elevated alignment runs on RH side of IR line up to Km 12.75. Further it cross to LH side of IR line and runs up to Km 14.00. Once again the elevated track crosses to RH side and runs up to Lottegollahalli station. At Lottegollahalli the platforms are at level (2). At level (1) corridor (1) platforms are proposed. IR lines and platforms are At-grade. This station serves as inter change station for corridors (2) and (1).
- **YESHWANTPURA STATION** (Km 17.135) is an elevated station at level-1 with elevated platforms. Distance from Lottegollahalli station is 2.785 Km. This serves as Intermediate Terminal for this corridor as there is a change in direction towards Chikkabanavara station. In this section elevated alignment runs above IR line up to Km: 14.75 and it crosses to LH side of IR line, deviates from IR lines and runs on the median of the road up to Km 16.700. It crosses IR line at Km 16.700 and runs above the IR tracks up to proposed Yeshwantpura Suburban station. The proposed Sub-urban station for corridors (2) and (1) is on platform no (1) to (4) of IR Yeshwantpura station. At Yeshwantpura station the loco pilot will interchange the cab to facilitate in reverse direction movement towards Chikkabanavara.
- **JALAHALLI STATION** (Km 20.24) is an elevated station with At-grade platforms. Distance from Yeshwantpura station is 3.105 Km. In this section elevated track runs in level (1) up to Km 18.200 and rises to level (2) to facilitate crossing of Corridor (1) at 18.75 Km and ROB at 19.100 Km. Further it resends gradually and reaches At-grade at Km 20.020. Further it runs on LH side of IR line on grade up to Jalahalli station. This is a proposed new station **(Future)**.
- **SHETTYHALLI STATION** (Km 21.46) is an elevated station with At-grade platform. Distance from Jalahalli station is 1.22 Km. In this section, At-grade alignment runs on LH side of IR lines. This is a proposed new station.

- **MYADARAHALLI STATION** (Km 23.75) is an elevated station with At-grade platform. Distance from Shettyhalli station is 2.29 Km. In this section, At-grade alignment runs on LH side of IR line up to Myadarahalli station. This is a proposed new station.
- **CHIKKABANAVARA STATION** (Km 25.010) is an elevated station with elevated platforms. Distance from Myadarahalli station is 1.26 Km. In this section At-grade alignment runs on LH side of IR track up to Km 23.950. Further it runs on elevated track up to 24.65 Km and crosses IR line and run on RH side up to Chikkabanavara station. This is an existing IR station.

  Thus this corridor has two interchange stations at Lottegollahalli and Yeshwantpura station for Corridors (1) and (2).

TABLE 3.13: BREAKUP - CORRIDOR-2

Between Stations	Elevated (2 track on one side)	At-grade(2 track on one side)
Baiyyappanahalli – Kasturinagar	0	1.14
Kasturinagar – Sevanagar	1.43	0.59
Sevanagar – Banaswadi	1.010	0
Banaswadi – Kaverinagar	0.58	0.72
Kaverinagar – Nagavara	0	1.70
Nagavara – Kanakanagar	0	1.52
Kanakanagar – Hebbal	0.45	2.49
Hebbal – Lottegollahalli	2.72	0
Lottegollahalli – Yeshwantpura	2.785	0
Yeshwantpura – Jalahalli	2.870	0.235
Jalahalli – Shettyhalli	0	1.22
Shettyhalli – Myadarahalli	0	2.29
Myadarahalli – Chikkabanavara	1.06	0.200
	12.905	**12.165**

TABLE 3.14: CURVE DETAILS OF CORRIDOR-2 (BYAPPANAHALLI TERMINAL-CHIKABANAVARA)

CURVE DATA					
NO.	RADIUS	DELTA	LENGTH	TANGENT	ALIGNMENT
C1	300.000	4.788	25.071	12.543	BYPL-CBR
C2	300.000	5.397	28.259	14.140	BYPL-CBR
C3	800.000	43.456	606.753	318.808	BYPL-CBR
C4	1200.000	3.563	74.626	37.325	BYPL-CBR
C5	600.000	2.875	30.108	15.057	BYPL-CBR
C6	600.000	2.879	30.153	15.079	BYPL-CBR
C7	1750.000	18.082	552.283	278.457	BYPL-CBR
C8	250.000	11.446	49.941	25.054	BYPL-CBR

CURVE DATA					
C9	250.000	11.808	51.523	25.853	BYPL-CBR
C10	330.000	20.013	115.266	58.226	BYPL-CBR
C11	800.000	5.976	83.439	41.757	BYPL-CBR
C12	350.000	4.680	28.587	14.302	BYPL-CBR
C13	350.000	4.091	24.991	12.501	BYPL-CBR
C14	833.384	2.063	30.000	15.002	BYPL-CBR
C15	1000.000	1.624	28.340	14.171	BYPL-CBR
C16	280.000	86.728	423.833	264.450	BYPL-CBR
C17	400.000	4.482	31.287	15.651	BYPL-CBR
C18	300.000	4.243	22.217	11.114	BYPL-CBR
C19	300.000	3.870	20.266	10.137	BYPL-CBR
C20	980.000	49.496	846.584	451.741	BYPL-CBR
C21	450.000	31.698	248.955	127.753	BYPL-CBR
C22	285.000	16.804	83.588	42.096	BYPL-CBR
C23	600.000	20.287	212.441	107.344	BYPL-CBR
C24	470.000	68.886	565.073	322.332	BYPL-CBR
C25	470.000	3.553	29.143	14.576	BYPL-CBR
C26	470.000	14.511	119.037	59.839	BYPL-CBR
C27	866.853	1.983	30.000	15.002	BYPL-CBR
C28	832.340	2.065	30.000	15.002	BYPL-CBR
C29	256.524	4.467	20.000	10.005	BYPL-CBR
C30	267.683	4.281	20.000	10.005	BYPL-CBR
C31	400.000	11.595	80.945	40.611	BYPL-CBR
C32	546.644	5.241	50.000	25.017	BYPL-CBR
C33	964.648	1.782	30.000	15.001	BYPL-CBR
C34	968.497	1.775	30.000	15.001	BYPL-CBR
C35	390.000	40.278	274.165	143.022	BYPL-CBR
C36	250.000	5.928	25.866	12.944	BYPL-CBR
C37	250.000	9.305	40.601	20.345	BYPL-CBR
C38	430.000	48.747	365.838	194.815	BYPL-CBR
C39	1000.000	23.961	418.199	212.201	BYPL-CBR
C40	900.000	10.376	162.983	81.715	BYPL-CBR
C41	360.000	65.362	410.678	230.945	BYPL-CBR
C42	300.000	20.011	104.776	52.927	BYPL-CBR
C43	300.000	18.882	98.865	49.885	BYPL-CBR
C44	350.000	17.047	104.136	52.455	BYPL-CBR
C45	550.000	14.353	137.779	69.252	BYPL-CBR

CURVE DATA					
C46	590.000	2.881	29.663	14.835	BYPL-CBR
C47	590.000	2.994	30.829	15.418	BYPL-CBR
C48	300.000	1.999	10.465	5.233	BYPL-CBR
C49	300.000	2.017	10.561	5.281	BYPL-CBR
C50	850.000	14.356	212.968	107.045	BYPL-CBR
C51	840.000	2.032	29.790	14.897	BYPL-CBR
C52	750.000	2.340	30.627	15.316	BYPL-CBR
C53	450.000	4.383	34.425	17.221	BYPL-CBR
C54	600.000	18.634	195.137	98.438	BYPL-CBR
C55	850.000	21.613	320.630	162.243	BYPL-CBR
C56	650.000	2.545	28.875	14.440	BYPL-CBR
C57	650.000	2.845	32.277	16.142	BYPL-CBR
C58	425.972	2.018	15.000	7.501	BYPL-CBR
C59	591.631	1.453	15.000	7.500	BYPL-CBR
C60	800.000	10.031	140.060	70.210	BYPL-CBR
C61	750.000	8.924	116.817	58.527	BYPL-CBR
C62	220.000	14.894	57.187	28.756	BYPL-CBR
C63	220.000	14.649	56.249	28.279	BYPL-CBR

TABLE 3.15: DETAILS OF LAND REQUIREMENT FOR CORRIDOR-2

CORRIDOR -2 (BAW-YPR-BYPL T)										
BAW - YPR										
S.No	KM (IR)		SECTION	LHS / RHS	Additional Land Requirement				Property details
	From	To			Total (Sqm)	Vacant Land (Sqm)	Road (Sqm)	Built up (Sqm)	
1	7.20	6.70	Chikkabanavara to Yeshwanthpur	LHS	4700	4500	200	0	Vacant & road
2	4.90	4.30			5250	5190	60	0	Vacant & road
3	3.64	2.85			8739	8489	250	0	Vacant & road
4	2.85	2.20		LHS & RHS	18167	17167	1000	0	Vacant & road
YPR - BYPL T									
5	222.30	220.22	Yeshwanthpur to Lottegollahalli	LHS & RHS	33896	2970	27026	3900	Vacant, road & buildings

CORRIDOR -2 (BAW-YPR-BYPL T)									
6	219.60	218.40	Lottegollahalli to Baiyyappanahalli Terminal	LHS	7914	1614	800	5500	Vacant, road & buildings
7	218.50	218.00			3150	2850	300	0	vacant & road area
8	218.10	217.90		RHS	619	0	619	0	road
9	217.90	217.30		LHS & RHS	7607	6857	750	0	Vacant & road area
10	217.40	217.10			5520	5220	300	0	Vacant & road area
11	216.60	215.85		RHS	3380	600	0	2780	Vacant & built-up area
12	215.85	215.50			1519	1319	200	0	NALLAH
13	215.25	215.00			1909	0	0	1909	Built-up area
13a	215.00	214.85			464	0	200	264	Road & built-up
14	214.80	214.15			8381	2700	162	5519	vacant, road & buildings
14a	214.15	214.00			335	335	0	0	vacant land
14b	213.90	213.75			486	0	486	0	Road
14c	213.70	213.45			912	0	912	0	Road
14d	213.30	213.2			350	0	350	0	Road
15	213.15	212.85			2485	1865	620	0	Vacant & road area
15c	212.60	212.50			346	346	0	0	Vacant land
16	212.40	212.10			1782	0	0	1782	Built-up area
16a	212.00	211.90			501	501	0	0	Vacant area
16b	211.90	211.70			1142	0	1142	0	Road
17	211.60	211.00			6644	6644	0	0	Vacant area
17d	210.50	210.45			261	261	0	0	Vacant area
17e	210.30	210.10			1023	883	140	0	Vacant &

CORRIDOR -2 (BAW-YPR-BYPL T)									
									road area
18	210.05	209.75			6937	4857	0	2080	Vacant & built-up area
18a	209.60	209.40			1492	750	0	742	Vacant & built-up area
18c	209.40	209.3			566	566	0	0	Vacant area
19	209.30	208.75			8228	0	1200	7028	Built-up & road
19a	208.70	208.60			217	217	0	0	Vacant area
20	208.50	207.55			8532	5232	1500	1800	Vacant & built-up area
20a	207.25	207.10		LHS	158	158	0	0	Vacant area
20b	206.10	206.00			75	75	0	0	Road
21	205.80	205.60			243	0	0	243	Built-up area
TOTAL					**153930**	**82166**	**38217**	**33547**	

TABLE 3.16: LIST OF ROB'S ALONG CORRIDOR-2

Section	No of ROB's	Details of ROB	Railway Kilometre (Approx.)		Recommended Proposal
			From	To	
Baiyyappanahalli Panel- Lottegollahalli- Yeshwantpura	6	ROB 567A	KM.216/738	Km:216/738	-
		ROB 541A	KM:210/356	KM:210/376	
		ROB 535A	KM:208/740	KM:208/770	
Yeshwantpura - Chikkabanavara		ROB 407A	KM:9/500	KM:9/600	
		ROB 408B	Km:8/800	KM:8/900	
		ROB-410A	KM:08/100	KM:08/200	

TABLE 3.17: LIST OF FOB'S ALONG CORRIDOR-2

Section	No of FOBs	Details of FOB	Railway Kilometre (Approx.)	
			From	To
Baiyyappanahalli Panel-Lottegollahalli - Yeshwantpura	2	538A	KM: 209/540	KM: 209/550
Yeshwantpura - Chikkabanavara		402A	KM: 8/200	KM: 8/300

TABLE 3.18: LIST OF LC'S ALONG CORRIDOR-2

Sl.No.	Between Stn.	LC No.	Railway KM.	Remarks
1.	Chikkabanavara – Yeshwantpura	6	12/00 – 100	Sanctioned for RUB
2.	Yeshwantpura – Lottegollahalli -	-		
3.	Lottegollahalli– Baiyyappanahalli Terminal	152	219/600 – 700	Elevated Track
		150	218/400 – 500	Elevated Track
		148	217/800 – 900	Elevated Track
		144A	214/400 – 500	To be eliminated
		144	213/800 – 900	To be eliminated
		143	213/200 – 300	To be eliminated
		142	212/600 – 700	Sanctioned for ROB
		141	212/300 – 400	To be eliminated
		140	211/900 – 212/000	To be eliminated
		137	208/200 – 300	Elevated Track

3.7 CORRIDOR – 3: KENGERI –KSR BENGALURU – BENGALURU CANTT - WHITEFIELD

3.7.1 CORRIDOR DETAILS

- The total route length of this corridor is 35.52 Km, out of which the section between Kengeri and Bengaluru Cantt is proposed for Sub-urban corridor. The distance between Kengeri and Bengaluru Cantt (merging point of quadrupling at Km: 349/700) is 18.47 Km. From Km: 349/700 after Bengaluru Cantt Station up to Whitefield a length of 17.05Km At-grade quadrupling lines will be used by Sub-Urban trains. The quadrupling of this stretch is in progress and being executed by SWR. It is likely to be completed in another two years' time. The quadrupling stretch is having 5 existing stations.
- In this corridor of length 18.47 Km, 9 stations are proposed. Out of these 9 stations, 4 stations are elevated and 4 stations are At-grade and one future At-grade station. Out of 4 elevated stations proposed in this corridor 1 is new station and 3 are existing stations. Out of 5 At-grade stations, 3 are existing stations with platforms At-grade and concourse elevated and 2 new stations including one future. Over the quadrupling section all the 5 stations are taken as At-grade. The details of the stations and their structure are given in **Table 3.19**.

TABLE 3.19: STATION LIST OF CORRIDOR-3 (KENGERI TO BENGALURU CANTT)

S. No.	Station	Elevated Platform	At-grade Platform	Status
1	Kengeri	✓		Existing
2	RV college		✓	New **(Future)**
3	Jnanabharathi		✓	Existing

S. No.	Station	Elevated Platform	At-grade Platform	Status
4	Nayandahalli		✓	Existing
5	Krishnadevaraya		✓	Existing
6	Jagajeevanramnagar		✓	New
7	KSR Bengaluru City	✓		Existing
8	Kumara Park	✓		New
9	Bengaluru Cantt	✓		Existing
	Total	4	5	

TABLE 3.20: QUADRUPLING STATION LIST OF CORRIDOR-3 (BENGALURU CANTT-WHITEFIELD)

S. No.	Station	Elevated Platform	At-grade Platform	Status
1	Bengaluru East	-	✓	Existing
2	Baiyyappanahalli	-	✓	Existing
3	Krishnarajapuram	-	✓	Existing
4	Hoodi	-	✓	Existing
5	White Field	-	✓	Existing
TOTAL		0	5	-

The following sections describe the alignment from Kengeri to Bengaluru Cantt.

- **KENGERI STATION** is a terminal station (0.00 Km) for this corridor with elevated station above the existing platforms. At this station, the existing amenities like parking and circulating area can be utilized if agreed by IR.
- **RV COLLEGE STATION** (1.95 Km) is proposed At-grade which is located at a distance of 1.95 Km from Kengeri. From Kengeri, the elevated Sub-urban track runs on LH side of existing IR line up to Km 1.29, and then At-grade up to R.V. College. It is proposed to construct new station (Future) along with platforms and amenities.
- **JNANABHARATHI STATION** (3.65 Km) is proposed to be provided with At-grade platform and elevated station building. It is located at a distance of 1.70 Km from R V College Station. The proposed track runs on LH side of IR lines. Due to existing temple at Km 3.25 the proposed alignment is taken beyond temple. There exists an IR station at this location.

- **NAYANDAHALLI STATION** (4.75 Km) is proposed At-grade platforms with Elevated station building and is 1.1 Km away from Jnanabharathi station. The proposed track runs on LH side. The platforms are provided on either side of Sub-urban lines. There exists an IR station at this location on RH side.
- **KRISHNADEVARAYA STATION** (7.55 Km) is proposed with At-grade platforms and Elevated station building. There exists an IR station at this location. The inter distance from Nayandahalli station is 2.80 Km. In this section, the proposed At-grade track runs on LH side of IR line.
- **JAGAJEEVANRAMNAGAR STATION** (3.12 Km) has proposed with At-grade platforms and elevated station building. Inter distance from Krishnadevaraya station is 1.60 Km. The track in this section runs At-grade on LH side of IR lines. It is a new Sub-urban station.
- **KSR BENGALURU CITY STATION** (12.110Km) is proposed with Elevated platforms and elevated station building. The proposed station is an interchange station for Corridor (1) and Corridor 3. The inter distance from Jagajeevanramnagar station is 2.96 Km. The proposed Elevated station is located between platforms (6) and (7) of IR station. In this station elevated track runs on LH side of IR line and crosses it at Km 11.70 and runs towards platform 5&6.
- **KUMARA PARK STATION (BDA)** (13.95 Km) is proposed with Elevated platforms and elevated station building. Inter distance from KSR Bengaluru City station is 1.84 Km. In this section, the Elevated track runs on LH side of existing IR lines up to Km: 13.700 and crosses the IR line at Km: 13.700. Further the proposed alignment runs on RH side of IR line. It is a new station building.
- **BENGALURU CANTONMENT STATION** (Km 16.90) is proposed with Elevated platforms and station building. Inter distance from Kumara park (BDA) station is 2.95 Km. In this section, Sub-urban elevated track runs on RH side of IR lines up to Bengaluru Cantonment station. The proposed Suburban tracks join At-grade with proposed Quadrupling at Km 349/700. The proposed station building is located at vacant land near MCO office duly considering IR proposals for expansion of Bengaluru Cantt Station.

  Thus, the total length of elevated section is 10.40 Km and that of At-grade is 8.07 Km (KSR Bengaluru City – Cantonment).

The following sections describe the alignment from Bengaluru Cantt to Whitefield (Km: 18.47 –Km: 35.52, Total length -17.05km).

- **BENGALURU EAST** (Km 19.17): It is an existing IR station. The inter distance from Bengaluru Cantt. Station is 2.27 Km. The proposed quadrupling track runs At-grade.

- **BAIYYAPPANAHALLI** (Km 23.28): It is an existing IR station. The inter distance from Bengaluru East station is 4.110 Km. The proposed quadrupling track runs At-grade.
- **KRISHNARAJAPURAM** (Km 25.87): It is an existing IR station. The inter distance from Baiyyappanahalli station is 2.59 Kms. The proposed quadrupling track runs At-grade.
- **HOODI (Km 30.65)** is an existing IR station. The inter distance from Krishnarajapuram is 4.78 Km. The proposed quadrupling tracks runs At-grade.
- **WHITEFIELD** (Km 35.52): It is an existing IR station. The inter distance from Krishnarajapuram is 4.87 Kms. The proposed quadrupling track runs At-grade.

TABLE 3.21: BREAKUP OF TRACK SYSTEM FOR CORRIDOR-3

Between stations	Elevated (2 track on one side)	At-grade (2 track on one side)
Kengeri – R V College	1.29	0.66
R V College – Jnanabharathi	0	1.70
Jnanabharathi – Nayandahalli	0	1.10
Nayandahalli– Krishnadevaraya	0	2.80
Krishnadevaraya–Jagajeevanramnagar	0	1.60
Jagajeevanramnagar – KSR Bengaluru City	2.75	0.21
KSR Bengaluru City Station – Kumara park (BDA)	1.84	0
Kumara park (BDA) – Bengaluru Cantonment	2.95	0
Bengaluru Cantonment- Merging Point	1.57	0
Total Length	**10.40**	**8.07**

TABLE 3.22: CURVE DETAILS FOR CORRIDOR-3
(KENGERI - BENGALURU CANTONMENT)

CURVE DATA					
NO.	**RADIUS**	**DELTA**	**LENGTH**	**TANGENT**	**ALIGNMENT**
C1	340.000	29.465	174.849	89.404	KGI-BNC
C2	500.000	1.948	17.000	8.501	KGI-BNC
C3	500.000	2.414	21.062	10.533	KGI-BNC
C4	500.000	2.401	20.953	10.478	KGI-BNC
C5	350.000	4.171	25.476	12.744	KGI-BNC
C6	350.000	4.590	28.036	14.025	KGI-BNC
C7	270.000	14.875	70.098	35.247	KGI-BNC
C8	330.000	16.107	92.769	46.692	KGI-BNC

CURVE DATA					
C9	280.000	14.202	69.404	34.881	KGI-BNC
C10	280.000	11.330	55.368	27.775	KGI-BNC
C11	600.000	2.726	28.543	14.274	KGI-BNC
C12	600.000	2.865	30.000	15.003	KGI-BNC
C13	2300.000	1.236	49.624	24.813	KGI-BNC
C14	500.000	8.876	77.461	38.808	KGI-BNC
C15	750.000	1.517	19.861	9.931	KGI-BNC
C16	500.000	8.246	71.964	36.044	KGI-BNC
C17	600.000	4.042	42.332	21.175	KGI-BNC
C18	450.000	1.819	14.284	7.143	KGI-BNC
C19	600.000	31.935	334.419	171.677	KGI-BNC
C20	500.000	5.313	46.362	23.198	KGI-BNC
C21	250.000	14.190	61.917	31.118	KGI-BNC
C22	300.000	6.092	31.898	15.964	KGI-BNC
C23	600.000	30.360	317.923	162.788	KGI-BNC
C24	600.000	1.114	11.665	5.833	KGI-BNC
C25	600.000	2.366	24.774	12.389	KGI-BNC
C26	667.052	1.718	20.000	10.001	KGI-BNC
C27	869.843	1.317	20.000	10.000	KGI-BNC
C28	400.000	5.702	39.804	19.918	KGI-BNC
C29	400.000	7.555	52.743	26.410	KGI-BNC
C30	500.000	0.348	3.033	1.516	KGI-BNC
C31	500.000	2.504	21.854	10.929	KGI-BNC
C32	500.000	2.745	23.955	11.980	KGI-BNC
C33	200.000	46.372	161.868	85.662	KGI-BNC
C34	200.000	7.148	24.953	12.492	KGI-BNC
C35	400.000	10.707	74.751	37.485	KGI-BNC
C36	500.000	6.744	58.854	29.461	KGI-BNC
C37	300.000	0.878	4.597	2.299	KGI-BNC
C38	300.000	2.414	12.641	6.321	KGI-BNC
C39	200.000	18.331	63.988	32.270	KGI-BNC
C40	300.000	17.604	92.174	46.453	KGI-BNC
C41	310.000	23.401	126.610	64.200	KGI-BNC
C42	180.000	80.008	251.354	151.060	KGI-BNC

CURVE DATA					
C43	981.655	1.167	20.000	10.000	KGI-BNC
C44	1536.210	0.746	20.000	10.000	KGI-BNC
C45	1100.000	5.463	104.872	52.476	KGI-BNC
C46	500.000	13.190	115.105	57.808	KGI-BNC
C47	300.000	24.616	128.891	65.456	KGI-BNC
C48	2500.000	3.555	155.100	77.575	KGI-BNC
C49	300.000	17.127	89.677	45.176	KGI-BNC
C50	300.000	30.902	161.803	82.922	KGI-BNC
C51	280.000	14.947	73.047	36.732	KGI-BNC
C52	280.000	16.022	78.300	39.407	KGI-BNC
C53	300.000	4.494	23.530	11.771	KGI-BNC
C54	300.000	6.576	34.431	17.234	KGI-BNC
C55	295.000	69.674	358.733	205.314	KGI-BNC
C56	350.000	18.369	112.211	56.591	KGI-BNC
C57	300.000	22.299	116.758	59.127	KGI-BNC
C58	300.000	2.235	11.702	5.852	KGI-BNC
C59	300.000	9.382	49.122	24.616	KGI-BNC
C60	295.000	41.598	214.177	112.054	KGI-BNC
C61	295.000	19.464	100.216	50.595	KGI-BNC
C62	295.000	3.797	19.550	9.779	KGI-BNC
C63	295.000	3.201	16.479	8.242	KGI-BNC
C64	750.000	24.794	324.551	164.856	KGI-BNC

FIGURE 3.17: SBC STATION ALIGNMENT

FIGURE 3.18: TEMPLE AVOID

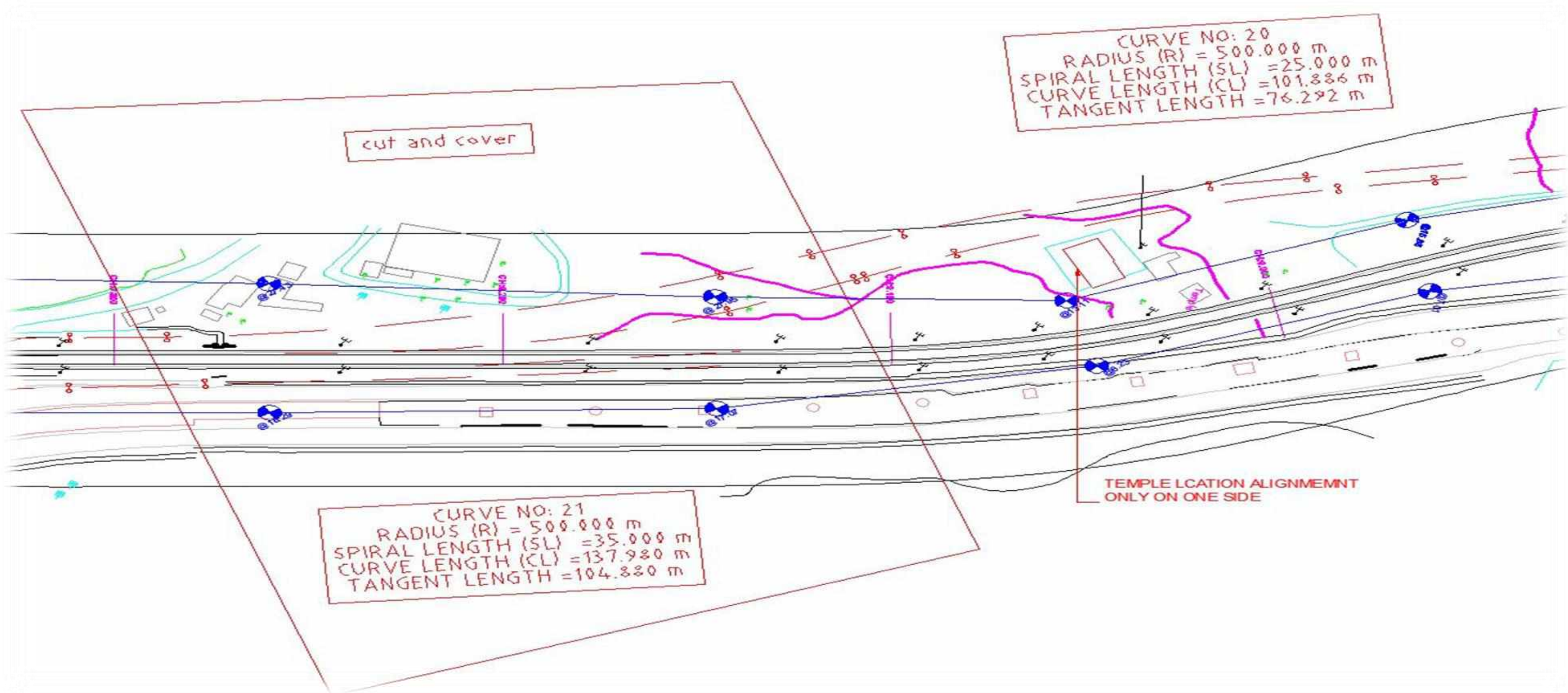


TABLE 3.23: DETAILS OF LAND REQUIREMENTFOR CORRIDOR-3

CORRIDOR -3 (KGI-SBC-BNC)

S.No	KM (IR) From	KM (IR) To	SECTION	LHS / RHS	Additional Land Requirement Total (Sqm)	Vacant Land (Sqm)	Road (Sqm)	Built up (Sqm)	Property details
KGI - SBC									
1	11.90	11.30	Kengeri to KSR Bengaluru City	LHS	3199	0	1999	1200	road/buildings
2	11.30	10.40			4152	4152	0	0	vacant area
3	10.50	9.70			9446	6861	585	2000	vacant/road/ buildings
4	9.20	6.50			35331	26191	770	8370	vacant/road/ buildings
5	6.00	4.90			1675	411	70	1194	vacant/road/ buildings
6	4.90	4.00			9000	4770	1040	3190	vacant/road/ buildings
7	4.00	3.60			1548	456	100	992	vacant/road/ buildings
8	3.50	2.80			1000	0	85	915	road/buildings
9	2.80	2.20			703	0	0	703	buildings
10	2.10	1.60			2171	0	0	2171	buildings
SBC-BNC									
11	335.5	335.4	KSR Bengaluru City to Bengaluru Cantonment	LHS	936	0	936	0	Road
12	355.2	354.43			6245	0	1025	5220	Road/buildings
13	354.4	353.8		RHS	5500	250	400	4850	Vacant/road/ buildings
14	353.9	352.1			13244	0	3310	9934	Road/buildings
TOTAL					**94150**	**43091**	**10320**	**40739**	

Note: The additional area required beyond the Railway boundary is worked out keeping the clear distance of 6.10m, and 4.0m from the C/L of the extreme proposed track for elevated double track, and At-grade respectively.

TABLE 3.24: LIST OF ROB'S ALONG CORRIDOR-3

Section	No. of ROB's	Details of ROB	Railway Kilometre (Approx.) From	Railway Kilometre (Approx.) To	Recommended Proposal
Kengeri – KSR Bengaluru City	**3**	ROB-431	Km: 3/200	Km: 3/300	Additional Vents proposed
		ROB-438	Km: 5/200	Km: 5/300	Additional Vents proposed
		Metro Crossing	Km: 5/200	Km: 5/300	-

Section	No. of ROB's	Details of ROB	Railway Kilometre (Approx.)		Recommended Proposal
			From	To	
KSR Bengaluru City – Bengaluru Cantonment	NIL				

TABLE 3.25: LIST OF FOB'S ALONG CORRIDOR-3

Section	No. of FOBs	Details of FOB	Railway Kilometre (Approx.)	
			From	To
Kengeri – KSR Bengaluru City	2	445B	Km: 7/400	Km: 7/500
		458A	Km: 12/000	Km: 12/100
KSR Bengaluru City – Whitefield	8	822A	Km: 332/400	Km: 332/500
		832B	Km: 342/000	Km: 342/100
		835B	Km: 344/850	Km: 344/900
		839A	Km: 348/820	Km: 348/822
		839E	Km: 349/143	Km: 349/145
		841A	Km: 350/406	Km: 350/408
		844A	Km: 351/663	Km: 351/665
		867B	Km: 355/500	Km: 355/600

TABLE 3.26: LIST OF LC'S ALONG CORRIDOR-3

Sl.No.	Between Stn.	LC No.	Railway KM.	Remarks
1.	Kengeri– KSR Bengaluru City	10	10/900 – 11/000	Sanctioned for RUB
		9	9/300 – 400	To be eliminated
		2	1/900 – 2/000	Elevated Track
2.	KSR Bengaluru City – Cantonment	NIL		

3.8 CORRIDOR –4: HEELALIGE TO RAJANKUNTE

3.8.1 CORRIDOR DETAILS

Total route length of this proposed corridor is 46.24 Km. This corridor passes through, Carmelaram, Belandur Road, Benniganahalli, Channasandra, Yelahanka Junction, and Benniganahalli. Total 19 stations are proposed along this corridor, out of which 4 stations are with Elevated platforms and 14 stations are with At-grade platforms and one future At-grade station. The details are as below:

TABLE 3.27: LIST OF STATIONS OF CORRIDOR-4

S.No.	Station	Elevated Platform	At grade Platform	Status
1.	Heelalige	✓		Existing
2.	Bommasandra		✓	New **(Future)**
3.	Singena Agrahara		✓	New
4.	Huskuru		✓	New
5.	Ambedkar Nagar		✓	New
6.	Carmelaram		✓	Existing
7.	Belandur Road		✓	Existing
8.	Marathahalli		✓	New
9.	Kaggadasapura		✓	New
10.	Benniganahalli		✓	New (Inter change)
11.	Channasandra	✓		Existing
12.	Horamavu		✓	New
13.	Hennur		✓	New
14.	Tanisandra		✓	New
15.	Hegde Nagara		✓	New
16.	Jakkur		✓	New
17.	Yelahanka (Common for Corridors-1 & 4)	✓(Level-1/ Repeated in C1)		Existing (Interchange)
18.	Muddenahalli		✓	New
19.	Rajankunte	✓		Existing
	Total	**4**	**15**	

- **HEELALIGE STATION** (Km 0.00) is proposed as elevated station with elevated platforms. This is a terminal station for the proposed corridor No. (4) with shunting operation facility. At Heelalige, IR station exists and proposed elevated track and platforms are above the existing platforms on portal system.
- **BOMMASANDRA STATION** (Km 1.48) is an elevated station with At-grade platforms. Inter station distance from Heelalige station is 1.48 Km. In this section elevated alignment runs on LH side of IR lines up to Km: 1.19. Further At-grade alignment runs up to Bommasandra station on LH side of IR line. This is a proposed new future station.

- **SINGENA AGRAHARA STATION** (Km 3.00) is an elevated station with At-grade platform. Inter station distance from Bommasandra station is 1.52Km. In this section At-grade alignment runs on LH side of IR line up to Singena Agrahara. This is a proposed new station.
- **HUSKURU STATION** (Km 5.00) is an elevated station with At-grade platforms. Distance of this station is 2.00 Km from Singena Agrahara. In this section, At-grade alignment on LH side of IR lines runs up to Huskuru station. This is a proposed new station.
- **AMBEDKARNAGAR STATION** (Km 9.00) is an elevated station with At-grade platforms. Distance from Huskuru station is 4.00 Km. In this section, At-grade alignment runs on LH side of IR line. This is a proposed new station.
- **CARMELARAM STATION** (Km 10.40) is an elevated station with At-grade platforms. Inter station distance from Ambedkar station is 1.40 km. In this Section At-grade alignment runs on LH side of IR lines. At Carmelaram IR station exists.
- **BELANDUR ROAD STATION** (Km 13.69) is also an elevated station with At-grade platforms. Distance from Carmelaram station is 3.29 Km. In this section, At-grade alignment runs on LH side of IR line. It is a proposed new station with IR halt station.
- **MARATHAHALLI STATION** (Km 15.85) is an elevated station with At-grade platforms. Distance from Belandur Road station is 2.16 Km. In this section, At-grade alignment runs on LH side of IR lines. This is a proposed new station.
- **KAGGADASAPURA STATION** (Km 20.700) is an elevated station with At-grade platforms. Distance from Marathahalli station is 4.85 Km. In this section At grade alignment runs on LH side of IR track up to Km 16.100 and further as elevated track on LH side up to 16.910 and cross to RH side of IR track. The Elevated track runs on RH i.e. up to Km 17.700. Further track runs At-grade up to Kaggadasapura station. This is a proposed new station.
- **BENNIGANAHALLI STATION** (Km 22.650) is an elevated station with At-grade platforms. Inter station distance from Kaggadasapura station is 1.95 Km. In this section, At-grade alignment runs on RH side of IR track up to Benniganahalli station. It is new proposed station. This station is an interchange station for Corridors 2 & 4.
- **CHANNASANDRA STATION** (Km 24.45) is an elevated station with elevated platforms. Inter station distance from Benniganahalli Station is 1.80 Km. In this section Elevated alignment runs up to Channasandra station on LH side of IR track. This is an existing IR station.

- **HORAMAVU STATION** (Km 26.10) is an elevated station with At-grade platforms. Distance from Channasandra station is 1.65 Km. Alignment runs elevated from Channasandra station up to Km 25.84 on LH side of IR lines. Further it continues At-grade up to Horamavu station.
- **HENNUR STATION** (Km 27.660) is an elevated station with At-grade platforms. Inter station distance from Horamavu station is 1.56 Km. In this section At-grade alignment runs on LH side of IR lines. This is a proposed new station.
- **TANISANDRA STATION** (Km 30.960) is an elevated station with At-grade platforms. Inter station distance from Hennur station is 3.30 Km. In this section, At-grade alignment runs on LH side of IR line. This is a proposed new station.
- **HEGDENAGAR STATION** (Km 32.64) is an elevated station with At-grade platforms. Distance from Tanisandra station is 1.68 Km. In this Section, At-grade alignment runs on LH side of IR line. This is a proposed new station.
- **JAKKUR STATION** (Km 33.91) is an elevated station with At-grade platforms. Distance from Hegdenagar station is 1.27 Km. In this section At-grade alignment runs on LH side of IR lines. This is a new proposed station.
- **YELAHANKA STATION** (Km 37.825) is an elevated station with elevated platforms at level (1) above IR platform No.1. Inter station distance from Jakkur Station is 3.915 Km. In this section, At-grade alignment runs up to Km 34.160 on LH side of IR lines and further elevated alignment continues on LH side of IR lines up to Km 35.800.Further alignment shifts toward RH side of IR line at level (2) and proceeds up to Yelahanka station on RH side and reaches Yelahanka station at Level (1). This station serves as an Interchange station for corridors 1 & 4.
- **MUDDENAHALLI STATION** (Km 42.730) is an elevated station with At-grade platforms. Inter station distance from Yelahanka station is 4.905 Km. In this section, Elevated alignment runs on RH side of IR line up to Km 39.920. Further At grade alignment runs on RH side of IR line up to Muddenahalli station. This is a new station.
- **RAJANKUNTE STATION** (Km 46.240) is an elevated station with elevated platform. Inter station distance from Muddenahalli station is 3.51 Km. In this section At-grade alignment runs on RH side of IR up to Km 44.690 and elevated alignment runs on RH side and IR up to Km 44.690 and elevated alignment runs on RH side & IR up to Rajankunte station. This station is a terminal station for Corridor (4).

Thus, in corridor-4 also, terminal stations are elevated. There are 2 interchange stations, one at Benniganahalli and second one at Yelahanka.

TABLE 3.28: CORRIDOR - 4 BREAKUP

Between Stations	Elevated (2 track on one side)	At-grade(2 track on one side)
Heelalige - Bommasandra	1.19	0.29
Bommasandra- Singena Agrahara	0	1.52
Singena Agrahara - Huskuru	0	2.00
Huskuru - Ambedkar Nagar	0	4.00
Ambedkar Nagar - Carmelaram	0	1.40
Carmelaram - Belandur	0	3.29
Belandur - Marathahalli	0	2.16
Marathahalli-Kaggadasapura	1.60	3.25
Kagadasapura –Benniganahalli	0	1.95
Benniganahalli– Channasandra	1.80	0
Channasandra - Horamavu	1.390	0.26
Horamavu - Hennur	0	1.56
Hennur –Tanisandra	0	3.30
Tanisandra - Hegde Nagar	0	1.68
Hegde Nagar-Jakkur	0	1.27
Jakkur - Yelahanka	3.665	0.25
Yelahanka –Muddenahalli	2.095	2.81
Muddenahalli – Rajankunte	1.55	1.96
TOTAL	**13.29**	**32.95**

TABLE 3.29: CURVE DETAILS OF CORRIDOR-4 (HEELALIGE – RAJANAKUNTE)

CURVE DATA					
NO.	**RADIUS**	**DELTA**	**LENGTH**	**TANGENT**	**ALIGNMENT**
C1	225.000	3.563	13.993	6.999	HEL-RNN
C2	205.000	5.624	20.123	10.070	HEL-RNN
C3	1500.000	2.641	69.139	34.576	HEL-RNN
C4	1500.000	2.762	72.298	36.156	HEL-RNN
C5	500.000	3.491	30.468	15.239	HEL-RNN
C6	600.000	3.312	34.684	17.347	HEL-RNN
C7	300.000	5.215	27.308	13.663	HEL-RNN
C8	300.000	5.341	27.967	13.994	HEL-RNN
C9	1250.000	9.450	206.165	103.317	HEL-RNN
C10	2500.000	1.856	80.978	40.493	HEL-RNN
C11	1500.000	2.274	59.546	29.777	HEL-RNN
C12	300.000	6.254	32.746	16.389	HEL-RNN

CURVE DATA					
C13	300.000	4.627	24.229	12.121	HEL-RNN
C14	300.000	5.302	27.760	13.890	HEL-RNN
C15	300.000	5.464	28.607	14.314	HEL-RNN
C16	300.000	3.198	16.743	8.374	HEL-RNN
C17	300.000	3.081	16.134	8.069	HEL-RNN
C18	300.000	6.195	32.437	16.235	HEL-RNN
C19	300.000	6.154	32.222	16.127	HEL-RNN
C20	3500.000	0.044	2.671	1.336	HEL-RNN
C21	300.000	1.801	9.432	4.716	HEL-RNN
C22	300.000	1.959	10.257	5.129	HEL-RNN
C23	3500.000	0.307	18.766	9.383	HEL-RNN
C24	5000.000	0.036	3.113	1.557	HEL-RNN
C25	300.000	6.006	31.449	15.739	HEL-RNN
C26	300.000	5.983	31.326	15.677	HEL-RNN
C27	300.000	3.888	20.355	10.182	HEL-RNN
C28	300.000	5.869	30.732	15.380	HEL-RNN
C29	500.000	0.277	2.416	1.208	HEL-RNN
C30	300.000	1.667	8.728	4.364	HEL-RNN
C31	1200.000	1.548	32.431	16.217	HEL-RNN
C32	1500.000	1.147	30.030	15.016	HEL-RNN
C33	300.000	6.252	32.738	16.385	HEL-RNN
C34	300.000	5.271	27.599	13.809	HEL-RNN
C35	250.000	3.676	16.037	8.021	HEL-RNN
C36	300.000	4.502	23.571	11.791	HEL-RNN
C37	50000.000	0.194	169.248	84.624	HEL-RNN
C38	3000.000	0.290	15.198	7.599	HEL-RNN
C39	500.000	0.679	5.926	2.963	HEL-RNN
C40	500.000	0.664	5.794	2.897	HEL-RNN
C41	500.000	3.782	33.001	16.506	HEL-RNN
C42	300.000	0.124	0.648	0.324	HEL-RNN
C43	300.000	6.914	36.200	18.122	HEL-RNN
C44	500.000	1.795	15.663	7.832	HEL-RNN

CURVE DATA					
C45	5000.000	0.090	7.843	3.921	HEL-RNN
C46	800.000	17.381	242.691	122.285	HEL-RNN
C47	1000.000	0.275	4.805	2.403	HEL-RNN
C48	300.000	5.557	29.095	14.559	HEL-RNN
C49	300.000	6.853	35.884	17.964	HEL-RNN
C50	250.000	6.314	27.551	13.789	HEL-RNN
C51	250.000	6.195	27.030	13.528	HEL-RNN
C52	400.000	5.489	38.322	19.175	HEL-RNN
C53	400.000	5.137	35.864	17.944	HEL-RNN
C54	300.000	6.177	32.345	16.188	HEL-RNN
C55	300.000	5.798	30.358	15.192	HEL-RNN
C56	1200.000	0.075	1.571	0.786	HEL-RNN
C57	5000.000	0.162	14.117	7.059	HEL-RNN
C58	1500.000	0.111	2.900	1.450	HEL-RNN
C59	400.000	2.554	17.833	8.918	HEL-RNN
C60	300.000	3.706	19.407	9.707	HEL-RNN
C61	900.000	49.548	778.300	415.364	HEL-RNN
C62	5000.000	0.091	7.964	3.982	HEL-RNN
C63	300.000	6.324	33.111	16.572	HEL-RNN
C64	300.000	6.373	33.371	16.703	HEL-RNN
C65	300.000	6.956	36.420	18.233	HEL-RNN
C66	300.000	6.957	36.427	18.236	HEL-RNN
C67	554.000	6.455	62.416	31.241	HEL-RNN
C68	300.000	10.564	55.315	27.736	HEL-RNN
C69	300.000	6.114	32.013	16.022	HEL-RNN
C70	300.000	6.079	31.830	15.930	HEL-RNN
C71	285.000	58.335	290.168	159.068	HEL-RNN
C72	285.000	31.212	155.254	79.606	HEL-RNN
C73	300.000	4.783	25.042	12.528	HEL-RNN
C74	300.000	3.997	20.929	10.469	HEL-RNN
C75	450.000	5.978	46.954	23.498	HEL-RNN
C76	450.000	6.567	51.578	25.817	HEL-RNN

CURVE DATA					
C77	850.000	33.171	492.107	253.165	HEL-RNN
C78	450.000	5.817	45.687	22.863	HEL-RNN
C79	450.000	5.515	43.315	21.674	HEL-RNN
C80	445.000	5.562	43.202	21.618	HEL-RNN
C81	445.000	5.563	43.204	21.619	HEL-RNN
C82	300.000	6.035	31.598	15.814	HEL-RNN
C83	300.000	6.033	31.590	15.810	HEL-RNN
C84	300.000	5.909	30.940	15.484	HEL-RNN
C85	300.000	5.902	30.902	15.465	HEL-RNN
C86	1500.000	6.969	182.460	91.343	HEL-RNN
C87	660.000	12.897	148.563	74.597	HEL-RNN
C88	1700.000	4.205	124.764	62.410	HEL-RNN
C89	300.000	5.883	30.805	15.416	HEL-RNN
C90	300.000	7.011	36.708	18.377	HEL-RNN
C91	300.000	6.080	31.836	15.933	HEL-RNN
C92	300.000	6.069	31.775	15.903	HEL-RNN
C93	300.000	6.101	31.946	15.988	HEL-RNN
C94	300.000	6.162	32.263	16.147	HEL-RNN
C95	300.000	7.280	38.117	19.084	HEL-RNN
C96	300.000	8.364	43.795	21.936	HEL-RNN
C97	300.000	4.087	21.400	10.704	HEL-RNN
C98	300.000	6.439	33.714	16.875	HEL-RNN
C99	350.000	6.127	37.429	18.732	HEL-RNN
C100	350.000	6.342	38.742	19.391	HEL-RNN
C101	490.000	20.191	172.678	87.244	HEL-RNN
C102	437.500	0.621	4.745	2.373	HEL-RNN
C103	500.000	1.366	11.918	5.959	HEL-RNN
C104	330.000	3.759	21.652	10.830	HEL-RNN
C105	330.000	4.090	23.554	11.782	HEL-RNN
C106	200.000	5.186	18.104	9.058	HEL-RNN
C107	437.500	11.059	84.445	42.354	HEL-RNN
C108	30.000	6.136	3.213	1.608	HEL-RNN

CURVE DATA					
C109	320.000	0.257	1.436	0.718	HEL-RNN
C110	500.000	2.460	21.465	10.734	HEL-RNN
C111	500.000	3.147	27.459	13.733	HEL-RNN
C112	250.000	1.790	7.812	3.906	HEL-RNN
C113	345.000	6.706	40.382	20.214	HEL-RNN
C114	304.725	6.675	35.501	17.771	HEL-RNN
C115	900.000	18.229	286.334	144.387	HEL-RNN
C116	500.000	5.280	46.075	23.054	HEL-RNN
C117	500.000	5.302	46.267	23.150	HEL-RNN
C118	300.000	5.204	27.248	13.633	HEL-RNN
C119	300.000	5.238	27.425	13.722	HEL-RNN
C120	500.000	2.714	23.687	11.846	HEL-RNN
C121	500.000	2.530	22.080	11.042	HEL-RNN
C122	875.000	15.030	229.526	115.426	HEL-RNN
C123	300.000	6.822	35.721	17.882	HEL-RNN
C124	300.000	6.773	35.465	17.753	HEL-RNN

TABLE 3.30: DETAILS OF LAND REQUIREMENT OF CORRIDOR-4

CORRIDOR -4 (RNN-YNK-HLE)									
RNN-YNK									
S. No	**KM (IR)**		**SECTION**	**LHS / RHS**	**Additional Land Requirement**				**Property details**
	From	**To**			**Total (Sqm)**	**Vacant Land (Sqm)**	**Road (Sqm)**	**Built up (Sqm)**	
1	24.3	23.3	Rajankunte to Yelahanka	RHS	6393	6393	0	0	Vacant Land/Agricultural land
2	23.3	21.8			8314	8314	0	0	Vacant Land
3	21.2	18.6			6925	6232	693		Vacant land/Road
3A	18.6	17.5			6013	1500	4513	0	Vacant land/Road
YNK - CSDR - BYPL (A)									
4	14.1	13.3	Yelahanka to Channasandra to Baiyyappanahalli (A) - panel	LHS	4404	0	4404	0	Road
5	13.3	11.7			9787	8817	970	0	Vacant land/Road
6	11.6	11.2			4448	898	3550	0	Vacant land/Road
7	10.8	9.3			9978	9048	930	0	Vacant land/Road

CORRIDOR -4 (RNN-YNK-HLE)									
8	7.9	6.4			9554	5554	200	3800	Buildings, cross road & vacant area
9	6.4	6.3			362	0	0	362	Buildings
10	5.0	4.7			2086	0	0	2086	Buildings
11	4.4	4.2			601	601	0	0	Vacant area
12	4.1	3.5			1486	586	0	900	partly vacant & built up
13	2.1	1.5		RHS	7407	6307	1100	0	Road & vacant area
BYPL (A) -HLE									
14	205.4	205.1	Baiyyappana halli (A) - panel to Heelalige	RHS	8700	3000	850	4850	Buildings, road & vacant area
15	203.7	202.6			3790	2440	0	1350	vacant & built up
16	200.7	199.8			4788	2938	0	1850	vacant & built up
17	199.6	197.4		LHS	24114	3600	1700	18814	Buildings, road & partly vacant
18	197.2	196.8			3686	3686	0	0	Vacant area
19	195.6	194.4			4247	3797	0	450	Vacant land & partly buildings
20	194.3	192.9			14900	8400	0	6500	Vacant land & buildings
21	192.2	191.2			9037	8037	0	1000	Vacant land & buildings
22	190.5	190.2			670	670	0	0	Vacant land
23	189.3	188.5			3369	3369	0	0	Vacant land
24	187.6	186.6			7239	5739	0	1500	Vacant land & buildings
25	186.4	185.5			9913	8913	200	800	Vacant land & buildings
26	184.4	184			6031	5731	300	0	Vacant land & road
27	183.5	183.2			2294	2294	0	0	Vacant land
28	183.0	182.6		RHS	1929	1929	0	0	Vacant land
TOTAL					**182465**	**118793**	**19410**	**44262**	

TABLE 3.31: LIST OF ROB'S ALONG CORRIDOR-4

Section	No of ROB's	Details of ROB	Railway Kilometre (Approx.)		Remarks
			From	To	
Heelalige–Baiyyappanahalli Panel	10	ROB-524A	Km:203/800	Km:203/900	Additional Boxes proposed
		ROB-516	Km:198/700	Km:198/800	Horizontal clearance exists
		ROB	Km:192/700	Km:192/600	Horizontal Clearance exists
		ROB	Km:183/400	Km:183/500	Under Construction
Baiyyappanahalli Panel - Channasandra - Yelahanka		ROB	Km: 1/600	Km: 1/700	-
		ROB-547	Km:3/500	Km:3/600	-
		ROB	Km:6/500	Km:6/600	Additional Boxes proposed
Yelahanka - Rajankunte		ROB-520A	Km:14/500	Km:14/600	Additional boxes to be inserted - proposed
		ROB-519	Km:15/680	Km:15/900	
		ROB	Km:24/500	Km:24/600	

TABLE 3.32: LIST OF FOB'S ALONG CORRIDOR-4

Section	No of FOBs	Details of FOB	Railway Kilometre (Approx.)	
			From	To
Heelalige-Baiyyappanahalli Panel -Yelahanka	3	547A	Km: 3/120	Km: 3/130
		515A	Km: 16/100	Km: 16/200
		515B	Km: 16/340	Km: 16/350
Yelahanka-Rajankunte	1	497A	Km:26/740	Km:26/750

TABLE 3.33: LIST OF LC'S ALONG CORRIDOR-4

Sl.No.	Between Stn.	LC No.	Railway KM.	Remarks
1.	Heelalige – Baiyyappanahalli	125	185/600 700	To be eliminated
2.		126	187/100 – 200	To be eliminated
3.		127	187/600 – 700	To be eliminated
4.		130	191/600 – 700	To be eliminated
5.		132	193/300 – 400	To be eliminated
6.		133	197/800 – 900	To be eliminated
7.		134	199/800 – 900	To be eliminated
8.		136	203/100 – 200	Sanctioned for ROB
9.	Channasandra – Yelahanka	6	5/800 – 900	To be eliminated
10.		9	11/600 – 700	Sanctioned for RUB
		10	12/800 – 900	To be eliminated
	Yelahanka – Rajankunte	15	18/300 – 400	Elevated Track
		17	19/800 – 900	To be eliminated
		20	23/000 - 100	To be eliminated

3.9 LAND AVAILABILITY

The proposed Suburban alignment is running all along the existing IR lines in all the four corridors. In corridor 2 i.e. from Baiyyappanahalli Panel to Chikkabanavara, on the stretch from Yeshwantpura to Lottegollahalli, the proposed alignment is an elevated structure and runs above the existing road.

Railway land boundary details were obtained from SWR Division and plotted on the base map to demark railway land all along the Sub-urban Rail corridor. At locations where records were not made available by SWR, the edge of clear open land on either side of the existing IR line is considered as railway land. Trolley inspection was conducted to correlate the information such as horizontal and vertical clearance at critical locations such as ROBs, RUBs and Metro alignment, based on the map prepared. Based on the site inspection and data collected from SWR, the available land and additional land requirements have been identified.

- **Between Kengeri and Bengaluru Cantt stations**, adequate land is not available within the Railway Right of Way, to construct columns for supporting viaduct. The constraints between Bengaluru Cantt and Whitefield stations are more challenging as quadrupling is already sanctioned to expand the existing rail network in between these stations. After the quadrupling is considered for the execution, the land left for the Sub-urban corridor in this section is a great challenge as the railway boundary necessitating to look into alternative option in this stretch. However, the stretch between BNC and WFD station is not part of the RITES study area.
- **Between Kengeri and KSR Bengaluru City station**, there are ROB's at two locations -one at Metro line crossing at Deepanjali Nagar and the second one at Goripalya near Vijaya Nagar. Metro alignment beyond Nayandahalli towards Kengeri, and temple complexes at three locations adjacent to existing tracks are biggest challenges.
- The land available between **KSR Bengaluru City and Yeshwantpura station** is less between the outer most line and railway boundary. This restriction in land availability has resulted in carefully designing the alignment, duly considering the standard railway norms. Special consideration also needs to be given to the metro alignment crossing the existing Railway tracks near Malleswaram station.
- **Between Yeshwantpura and Lottegollahalli**, there are only 2 lines at present and adequate land is not available. Moreover, there is a proposed doubling from Yeshwantpura to Hosur (being taken up by SWR) and also proposed Sub-urban corridors (1) and (2) are interchanging.
- **Between Lottegollahalli and Baiyyappanahalli Panel on Salem section**, at present only single line is running and one more line for doubling is sanctioned. After considering the doubling, two additional lines for suburban rail network is

proposed At-grade from Lottegollahalli to Lingarajapura ROB. The Lingarajapura ROB near Banaswadi Railway station is surrounded with private buildings and thickly populated. Further there is no sufficient land available at Banaswadi station and just after Banaswadi station, the existing ROB at Sevanagar is also a major constraint to run the track At-grade. The defence land is secured with boundary wall all along the section from the Banaswadi to Kasturinagar. Considering these constraints, elevated corridor has been proposed at these locations.

- Other constraints include the presence of a large number of encroachments on railway land along the existing Corridor, non-availability of enough land to locate columns, existing railway structures directly above the Rail track at number of locations and non-availability of required circulating area for the new stations.

TABLE 3.34: SUMMARY OF LAND REQUIREMENT

(SUMMARY OF PRIVATE LAND TO BE ACQUIRED - CORRIDOR WISE)

CORRIDOR		FROM	TO	TOTAL KM	TOTAL AREA IN SQM	Vacant Land (Sqm)	Road (Sqm)	Built up (Sqm)
CORRIDOR - 1	SBC-YPR-LOGH-YNK-DHL	0.00	41.40	41.40	57228	42340	8254	6634
CORRIDOR - 2	BAW-YPR-LOGH-BYPL (T)	0.00	25.01	25.01	153930	82166	38217	33547
CORRIDOR - 3	KGI-SBC-BNC (WFD)	0.00	18.47	18.47	94150	43091	10320	40739
CORRIDOR - 4	HLE-BENNIGANAHALLI-CSDR-YNK-RNN	0.00	46.24	46.24	182465	118793	19410	44262
Total Route length		**131.12**		**131.12**	**487773**	**286390**	**76201**	**125182**
		Total area in acres			**120.53**	**70.77**	**18.83**	**30.93**

TABLE 3.35: TOTAL LAND REQUIREMENTS FOR SUB-URBAN NETWORK

Sl. No	Description	Area (Acres)	
		Area	**Total**
1	**<u>State Govt. land</u>** Land requirement for Airport Connectivity	15.96	15.96
2	State Govt. Land (Roads)	18.829	137.069
3	Depots	118.26	
4	Railway Land	327.0	327.0
5	Private Land (Built up)	30.93	101.687
6	Private Land (vacant)	70.757	

4. UTILITIES

4.1 UTILITIES AND SERVICES

A 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. exist all along the proposed alignment.

Apart from the above utilities, South Western Railway's huge network of Traction Power cables, Traction Power Installations, DC and AC traction substations, SPs and SSPs, Signal & Telecommunication cables, traction OHE masts and structures, Signal posts, power supply cubicles, location boxes etc. are spread along and across the entire alignment.

The proposed corridor has been planned mostly within Railway's ROW and the some of the utility services and Railways vital installations are encountered at number of locations.

These utility services are essential and have to be maintained in working condition 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 sensitive Sub-urban services and direct impact on the commuters, besides setback in construction and project implementation schedule. Meticulous planning, therefore, will be necessary in tackling the issue of protection / diversion of these utility services and as well as Railway's vital installations.

The proposed corridors are elevated and at-grade. They are as Follows;

a) **Corridor 1**. - Kranthi Veera Sangolli Rayanna Bengaluru station to Devanahalli (About 41.48 Kms), (Via Yeshwanthpur – Lottegollahalli – Yelahanka).

b) **Corridor 2**. – Baiyyappanahalli Terminal To Chikkabanavara (About 25.00 Kms), (Via Banaswadi – Lottegollahalli – Yeshwanthpur)

c) **Corridor 3.** – Kengeri to Bangalore Cantonment (About 18.27 Kms). (Via Kranthi Veera Sangolli Rayanna Station).

d) **Corridor 4.** - Heelalige to Rajankunte (About 46.13 Kms), (Via Benniganahalli – Channasandra – Yelahanka).

4.2 CONCERNED ORGANISATIONS/ DEPARTMENTS

The details of various utilities have been collected from concerned organisations **(TABLE 4.1).**

TABLE 4.1: ORGANIZATION/ DEPARTMENT RESPONSIBLE FOR UTILITIES

S.No.	ORGANIZATION/ DEPARTMENT	UTILITY SERVICES
1.	BESCOM	Underground Electrical cables
2.	Vodafone	OFC cables Including Telecom cables.
3.	Defence	Other cables including telecom cables.
4.	BWSSB.	Storm water drainages, Water Pipe Lines
5.	Gail (Gas Pipe)	Gas or Oil Pipe lines.
6.	KPTCL	UG Cables Electrical cables, H.V power transmission Lines
7.	Reliance Jio Infocom.	OFC cables Including Telecom cables.
8.	BSNL	OFC cables Including Telecom cables.

4.3 DIVERSION OF UNDERGROUND UTILITIES

While planning for diversion of underground utility services viz. sewer lines, water pipelines, cables, etc., during construction of corridor, following issues need to be clearly taken care of:

- 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 RCC 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 arrangements of the viaduct and layout of piles in the foundation will be suitably adjusted to ensure that no foundation needs to be constructed at the location, where utility is crossing the proposed alignment.
- For the at-grade alignment, utilities running along like electrical / S&T cables, etc. may need to be diverted.

Keeping in view the above, the diversion /relocation of these installations has to be planned. The diversion of S&T and power supply cables has been planned by keeping provision of new cables in dedicated cable ducts separately prior to commencement of any construction activity.

4.4 ELEVATED AND AT-GRADE STRETCHES

In the elevated & At-grade stretch, the alignment is running mostly along the railway track on one side of the existing track with in railway boundary.

The major sewer / drainage lines and water mains running across the alignment and likely to be affected due to location of pier foundations, are proposed to be taken care of by relocating column supports of viaduct by change in the span configuration or by suitably adjusting the layout of pile foundations. Where, this is not feasible, utilities will be suitably diverted.

Details of storm water drains, sewers lines and water pipe lines, are listed in **Table 4.2** to **TABLE 4.5**.

TABLE 4.2: CORRIDOR-1, KSR BENGALURU CITY TO DEVANAHALLI

S. No.	From Chainage	To Chainage	Affected length in (m)	Position w.r.t. Alignment	Remarks
1.	0.70	1.25	55	Along the Drain (One Side)	B
2.	1.90	2.30	40	Along the Drain (One Side)	B
3.	3.30	3.45	15	Along the Drain (One Side)	B
4.	3.75	3.90	15	Along the Drain (One Side)	B
5.	4.30	4.65	35	Along the Drain (One Side)	B
6.	7.85	-	-	Across the Alignment	A
7.	8.25	8.70	45	Along the Alignment one side	B
8.	10.55	10.75	20	Along the Alignment one side	B
9.	10.85	11.40	55	Along the Alignment one side	B
10.	11.70	-	-	Across the alignment	A
11.	13.35	13.85	50	Along the Alignment one side	B
12.	14.25	16.85	260	Along the Alignment partially one side & partially both side	B
13.	17.30	18.45	115	Along the Alignment one side	B
14.	19.05	21.95	290	Along the Alignment one side	B
15.	27.45	-	-	Across the Alignment	

S. No.	From Chainage	To Chainage	Affected length in (m)	Position w.r.t. Alignment	Remarks
16.	28.25	31.85	360	Along the Alignment & Across Alignment .Partially one side & Partially both side	B
17.	37.20	37.40	20	Along the Alignment one side	B
18.	37.95	38.85	90	Along the Alignment one side	B
19.	39.20	39.50	30	Along the Alignment one side	B
20.	39.85	40.10	25	Along the Alignment one side	B
21.	40.60	41.70	110	Along the Alignment one side	B

A. Drains running parallel/across the alignment are proposed to be diverted away from the alignment or supported properly before work is taken in hand at each location.

B. Sewer lines running parallel/across the alignment are not proposed for diversion. But due care will be taken to avoid any damage to above lines.

TABLE 4.3: CORRIDOR-2, BAIYYAPPANAHALLI TERMINAL TO CHIKKABANAVARA

S. No.	From Chainage	To Chainage	Affected length in (m)	Position w.r.t. Alignment	Remarks
1	5.45	-	-	Culvert, Across Alignment	A
2	5.60	-	-	Culvert, Across Alignment	A
3	5.50	5.85	35	Drain One side	B
4	5.90	5.95	5	Culvert, Across Alignment	A
5	6.05	6.15	10	drain one side	B
6	6.15	7.00	85	Partially one side & partially both sides	B
7	7.05	7.15	10	Along the drain with culvert	B
8	7.20	7.45	25	Along the drain on one side	B
9	7.45	-		Culvert, Across Alignment	A
10	7.6	7.85	25	Along the drain	B
11	7.95	-		Along the drain & culvert	B
12	8.15	8.35	20	Along the drain on one side	B
13	8.65	-		Culvert, Across Alignment	A
14	8.8	-		Culvert, Across Alignment	A
15	8.95	9.05	10	Along the drain on one side	B
16	9.70	-		Along the drain	B
17	9.95	-		Along the culvert	B
18	10.1	-		Along the culvert	B
19	10.3	-		Along the culvert	B
20	10.6	-		Along the culvert	B
21.	10.825	-		Along the culvert	
22	13.35	13.50	15	Along the drain & culvert	B
23	14.85	14.95	10	Along the drain & culvert	B

A. Drains running parallel/across the alignment are proposed to be diverted away from the alignment or supported properly before work is taken in hand at each location.

B. Sewer lines running parallel/across the alignment are not proposed for diversion. But due care will be taken to avoid any damage to above lines.

TABLE 4.4: CORRIDOR-3, KENGERI TO BANGALORE CANTONMENT {VIA-KSR}

S. No.	From Chainage	To Chainage	Affected length in (m)	Position w.r.t. Alignment	Remarks
1.	12	12.1	-	2.75m Across alignment 1.5m wide	A
2.	9/300	-	200mts	About 200 mts. length drain	B
3.	9/800	-	-	Across the Alignment	A
4.	10/200	10/450	150mts	Along the Alignment	B
5.	10/300	11/050	170mts	Along the Alignment	B
6.	10/900	11/500	200mts	Along the Alignment	B
7.	11/700	12/200	300mts	Along the Alignment	B
8.	11/900	12/450	550mts	Along the Alignment	B
9.	13/700	13/750	50 mts.	Both side of alignment	B
10.	14/450	16/200	1900mts	Along the Alignment	B
11.	17/50	17/250	200mts	Along the Alignment	B

A. Drains running parallel/across the alignment are proposed to be diverted away from the alignment or supported properly before work is taken in hand at each location.

B. Sewer lines running parallel/across the alignment are not proposed for diversion. But due care will be taken to avoid any damage to above lines.

TABLE 4.5: CORRIDOR-4, HEELALIGE TO RAJANKUNTE

S.No.	From Chainage	To Chainage	Affected length in (m)	Position w.r.t Alignment	Remark
1.	0.05	0.85	35	Partially drain both side	B
2.	1.25	-	-	culvert	A
3.	1.35	-	-	culvert	A
4.	2.40	-	-	culvert	A
5.	2.55	-	-	culvert	A
6.	2.65	-	-	culvert	A
7.	2.90	2.95	5	Drain	B
8.	3.00	-	-	culvert	A
9.	3.75	-	-	culvert	A
10.	5.75	-	-	culvert	A
11.	5.95	-	-	culvert	A
12.	6.10	-	-	culvert	A
13.	7.4	-	-	culvert	A
14.	11.60	11.75	15	Partially Drain both side	A
15.	11.95	12.45	50	Partially Drain both side	A

S.No.	From Chainage	To Chainage	Affected length in (m)	Position w.r.t Alignment	Remark
16.	12.65	-	-	culvert	A
17.	14.35	-	-	culvert	A
18.	14.85	15.10	25	Drain both side	B
19.	15.40	16.8	140	Drain both side	B
20.	17.85	18.00	15	Drain	B
21.	22.05	22.20	15	Drain both side	B
22.	22.45	-	-	Culvert	A
23.	23.5	-	-	Culvert	A
24.	24.85	25.95	-	Drain Partially both side	B
25.	26.95	28.10	-	Partially both side	B
26.	28.35	28.80	-	One side	B
27.	29.05	32.35	-	Both Side partially	B
28.	32.85	34.1	-	Both Side partially	B
29.	39.45	44.55	-	Both Side partially	B

A. Drains running parallel/across the alignment are proposed to be diverted away from the alignment or supported properly before work is taken in hand at each location.

B. Sewer lines running parallel/across the alignment are not proposed for diversion. But due care will be taken to avoid any damage to above lines.

4.5 SOUTH WESTERN RAILWAY TRACTION SUPPLY

4.5.1 OHE TRACTION

South Western Railway’s entire Traction Power Supply installations are 220KV/25KV, power supply to traction, general lighting stations, workshops, PRS, S&T installations are like Auxiliary Transformers of 25kV/230 Volts spread along both sides of the proposed alignment.

4.5.2 RELOCATION PHILOSOPHY

During construction activities, any probability of cable damages cannot be ruled out. Therefore, it is recommended to divert the entire cable network of power cables in a **Dedicated Cable Duct** for Power Cables prior to commencement of construction activities.

There are two feeders for 22kv cables and shall be laid in ducts on either side (East and West) of the existing SWR‘s tracks. The Ducts will have provision for spare capacity.

Power Cables (BESCOM & KPTCL)

At several places Electrical cables are crossing the alignment below the ground. The list of such lines along with their locations is indicated in **Table 4.6 to Table 4.11**.

TABLE 4.6: ELECTRICAL CABLES

	KSR Bengaluru City - Kengeri			
S.No.	**KV**	**Position of Cable**	**Chainage**	**Section**
1	11	UG	10/100-200	KSR Bengaluru City - Kengeri
2	66	UG (6 runs of single core 630 sq mm in individual HDPE pipes = 3 spare pipes)	6/700-800 6/500-600	KSR Bengaluru City - Nayandahalli
3	66	UG (3*1C-1000 sq mm)	8/400-500	Jnanabharathi - Nayandahalli
4	66	UG	6/500-600	KSR Bengaluru City - Nayandahalli
5	11	UG	10/100-200	KSR Bengaluru City - Kengeri
6	11	UG	TM 356/18-19	KSR Bengaluru City - Nayandahalli

TABLE 4.7: KSR BENGALURU CITY – WHITEFIELD

S.No.	KV	Position of Cable	Chainage	Section
1	11	UG	348/600-700	Bengaluru East - Krishnarajapuram
2	11	UG	341/800-900	Near Krishnarajapuram
3	11	UG	344/100-200	Baiyyappanahalli - Krishnarajapuram
4	11	UG	344/700-800	Baiyyappanahalli - Krishnarajapuram
5	11	UG (2 runs of 3 c 400 sq mm)	340/26-27	Krishnarajapuram - Whitefield
6	11	UG (4 runs of 3 c 400 sq mm)	334/000-100	Krishnarajapuram - Whitefield
7	11	UG (2 runs of 3 c 400 sq mm)	344/200-300	Baiyyappanahalli - Krishnarajapuram
8	11	UG (2 runs of 3 c 240 sq mm)	341/700-800	Krishnarajapuram - Whitefield
9	220	UG	354/800-900	KSR Bengaluru City - Bengaluru Cantonment
10	66	UG	355/400-500	KSR Bengaluru City - Bengaluru Cantonment
11	66	UF(6R 1C 1000 sq mm)	355/400-500	KSR Bengaluru City - Bengaluru Cantonment
12	66	UG[(3+1)*1*630]	341/100-200	Krishnarajapuram - HOODI
13	11	UG	8/2/2009	Krishnarajapuram - Channasandra
14	11	UG (4 runs of 3 c 400 sq mm)	334/000-100	Krishnarajapuram - Whitefield

S.No.	KV	Position of Cable	Chainage	Section
15	11	UG	334/8	Whitefield -SGT
16	11	UG	334/8-335/000	Whitefield - Krishnarajapuram
17	11	UG (2 runs of 3 c 400 sq mm)	340/26-27	Krishnarajapuram - Whitefield
18	11	UG (2 runs of 3 c 240 sq mm)	341/700-800	Krishnarajapuram - Whitefield
19	11	UG	341/800-900	near Krishnarajapuram
20	11	UG	344/100-200	Baiyyappanahalli-Krishnarajapuram
21	11	UG (2 runs of 3 c 400 sq mm)	344/200-300	Baiyyappanahalli - Krishnarajapuram
22	11	UG	344/700-800	Baiyyappanahalli - Krishnarajapuram
23	11	UG	348/600-700	Bengaluru East - Krishnarajapuram
24	220	UG	354/800-900	KSR Bengaluru City - Bengaluru Cantonment
25	66	UG	355/400-500	KSR Bengaluru City - Bengaluru Cantonment

TABLE 4.8: HEELALIGE – BAIYYAPPANAHALLI – LOTTEGOLLAHALLI

S. No.	KV	Position of Cable	Chainage	Section
1	11	UG	208/200-300	Baiyyappanahalli - Banaswadi
2	440V	UG	208/200-300	Baiyyappanahalli - Banaswadi
3	66	UG	205/200-300	Baiyyappanahalli -BLRR
4	66	UG	203/700-800	Baiyyappanahalli -BLRR
5	11	UG(6R 3C 400sq mm)	208/300-400	Baiyyappanahalli - Banaswadi
6	11	UG(6R 3C 400sq mm)	203/700-800	Baiyyappanahalli - Banaswadi
7	11	UG cable(4 runs 3 core 400 sq mm)	210/300-400	Banaswadi - Hebbal
8	66	UG cable(4 runs of single core 240 sq mm)	210/300-400	Banaswadi - Hebbal
9	11	UG	400/8-9	Banaswadi -BLRR
10	11	UG	405/10-11	Banaswadi
11	11	UG	411/12-412/13	Hebbal - Banaswadi

TABLE 4.9: BAIYYAPPANAHALLI – YELAHANKA – RAJANAKUNTE

S. No.	KV	Position of Cable	Chainage	Section
1	11	UG	9/600-700	Yelahanka - Channasandra
2	11	UG	17/700-800	Yelahanka -RNN
3	11	UG	15/400-500	Yelahanka - Channasandra
4	11	UG	15/600-700	Yelahanka - Channasandra

S. No.	KV	Position of Cable	Chainage	Section
5	11	UG	9/700-800 near-THSA	Yelahanka - Baiyyappanahalli
6	11	UG	4/800-900	Yelahanka - Channasandra
7	66	UG 630 sq mm <6 runs>	7/500-600	Yelahanka - Channasandra
8	11 KV (2*3c400)	UG	19/800-900	Yelahanka -Rajankunte
9	11	UG	15/400-500	Yelahanka - Channasandra
10	11	UG	15/600-700	Yelahanka - Channasandra
11	11	UG	4/800-900	Yelahanka - Channasandra
12	66	UG	7/500-600	Yelahanka - Channasandra
13	11	UG	9/600-700	Yelahanka - Channasandra
14	11	UG	9/700-800	Yelahanka -Baiyyappanahalli
15	66	UG	3/800-900	Channasandra - Yelahanka
16	11	UG	4/800-900	Yelahanka - Channasandra

TABLE 4.10: KSR BENGALURU CITY – YELAHANKA

S. No.	KV	Position of Cable	Chainage	Section
1	11	UG	13/100-200	Yeshwantpur-Yelahanka
2	220	UG	0/500-600	KSR Bengaluru City -Malleswaram
3	11	UG	9/100-200	Yeshwantpur - Lottegollahalli
4	66 KV	UG	0/500-600	KSR Bengaluru City - Yeshwantpur
5	66	UG(6R 1C 1000 sq mm)	0/400-500	KSR Bengaluru City - Yeshwantpur
6	66	UG cable (3 runs of single core 1000 sq mm)	4/200-300	KSR Bengaluru City - Yeshwantpur
7	11	UG	9/000-100	Yeshwantpur - Lottegollahalli
8	220	UG	*/500-600	KSR Bengaluru City -Malleswaram
9	66 KV	UG	0/500-600	KSR Bengaluru City - Yeshwantpur
10	11	UG	16/13-14	Yelahanka - Yeshwantpur
11	11	UG	13/100-200	Yeshwantpur - Yelahanka
12	11	UG	9/000-100	Yeshwantpur - Lottegollahalli

TABLE 4.11: YELAHANKA – DEVANAHALLI

S. No.	KV	Position of Cable	Chainage	Section
1	11	UG	11/200-300	Doddajala-Yelahanka
2	11	UG	14/200-300	Doddajala -Devanahalli
3	66	UG	14/300-400	Doddajala - Devanahalli
4	11	UG	8/300-400	Yelahanka - Devanahalli
5	11	UG	17/100-200	Doddajala - Devanahalli
6	11	UG	18/700-800	Doddajala - Devanahalli
7	11	UG (3C 400 sq mm)	12/400-500	Devanahalli -Yelahanka
8	11	UG	11/200-300	Doddajala -Yelahanka
9	11	UG	14/200-300	Doddajala - Devanahalli
10	11	UG	14/300-400	Doddajala - Devanahalli

S. No.	KV	Position of Cable	Chainage	Section
11	66	UG	17/100-200	Doddajala - Devanahalli
12	11	UG	17/200-400	Doddajala - Devanahalli
13	11	UG	18/700-800	Doddajala - Devanahalli
14	11	UG	9/19/2010	Doddajala - Devanahalli
15	11	UG	8/300-400	Yelahanka - Doddajala

All the above cables belong to BESCOM/KPTCL and running across the alignment are proposed to be diverted away from the alignment, supported properly and due care to be taken to avoid any damage to above lines, before work is taken up at each location

4.6 SIGNAL AND TELECOMMUNICATION UTILITY

The underground network of S&T cables is spread over the entire alignment on both the sides and across the tracks. A large number of these cables will be affected.

The alignment of the proposed elevated corridor is mostly within Railways ROW. It is seen that the network of S&T cables will be encountered frequently during construction activities and relocation of the cables will become necessary.

4.6.1 RELOCATION PHILOSOPHY

In order to rule out any probability of S&T cable damage, a **Dedicated Cable Duct for only S&T cables** is recommended and proposed along the corridor to accommodate all types of S&T cables and to divert all S&T cable network prior to commencement of construction activities.

4.7 GAS PIPE LINES

The gas pipelines belonging to GAIL, running along and across the alignment, these gas pipe lines carry highly inflammable gas. Hence special care is to be taken during construction of proposed corridor. The gas pipe lines exist in Elevated section as well as At-grade sections.

Gas pipe lines running parallel/across the alignment are proposed to be diverted away from the alignment or supported properly before work is taken up at each location.

Gas pipe lines running parallel/across the alignment are not proposed for diversion. But due care will be taken to avoid any damage to above lines.

Gas pipe lines running across the alignment are likely to be affected due to location of pier foundations, which are proposed to be taken care by relocating column supports of viaduct by changing the span or by suitably adjusting the layout of pile foundations. At the time of project execution, the GAIL authorities should be contacted for necessary diversions and sufficient care needs to be taken to ensure their safety.

4.8 ABOVE GROUND UTILITIES (POWER SUPPLY INSTALLATION & OVER HEAD ELECTRIFICATION)

4.8.1 SOUTH WESTERN RAILWAY'S ELECTRICAL AND S&T UTILITY

South Western Railway's entire Traction Power Supply installations are with 220kv/25kv Single phase AC. The power supply from proposed 4 nos. Traction sub stations, 8 nos. SSP (substation and paralleling post) and 4 nos. SP (sectioning and paralleling post) General lighting stations, workshops, PRS, colonies, S&T installations are spread along both sides of the proposed alignment, Installed with Auxiliary Transformers of 25kv/230V.

4.8.2 RELOCATION PHILOSOPHY

The power supply installations getting affected will have to be relocated in the vicinity only.

Relocation of the affected Traction and other installations will have to be done in such a way that:

- power supply and Signaling supply does not get affected
- no changes are made in the system configuration
- Relocation to be in the vicinity of the affected ones.

A) Power Supply Installations (PSI)

Keeping in view the sensitive, the affected Power supply installations and 220KV/25 KV system in the Traction substations, SSPs, SPs and OHE will be relocated at the same chainage/ in the vicinity of the affected ones. The details of affected PSI, their relocations and the cost of relocation have been arrived at accordingly.

B) OHE

Few OHE masts will involve minor modifications such as slewing, adjustments, minor modifications, relocation of Masts and structures etc. needing crane and wiring train operation under local traffic and power blocks. The cost of such modifications to OHE under Power blocks conditions will be at higher than the normal rates.

4.9 HV POWER TRANSMISSION LINES

There are numbers of multi circuits HV Power Transmission lines. These are crossing the Railway tracks at several locations. Due to the proposed elevated alignment, these power line crossings will get affected and will therefore need to be suitably modified to achieve the statutory clearances as per IE Rules and provisions of the Indian Railway's Regulations for Power lines crossing Electrified Railway tracks.

The Power supply authorities to be advised to furnish cost estimates for modifications to these lines.

These Power lines are feeding power to Bengaluru City and Region and any modification to these power lines involves:

a) Additional land beyond their ROW
b) Long outages-about a month's duration for each line.
c) Very high cost of modification.

5 STATION PLANNING AND ARCHITECTURE

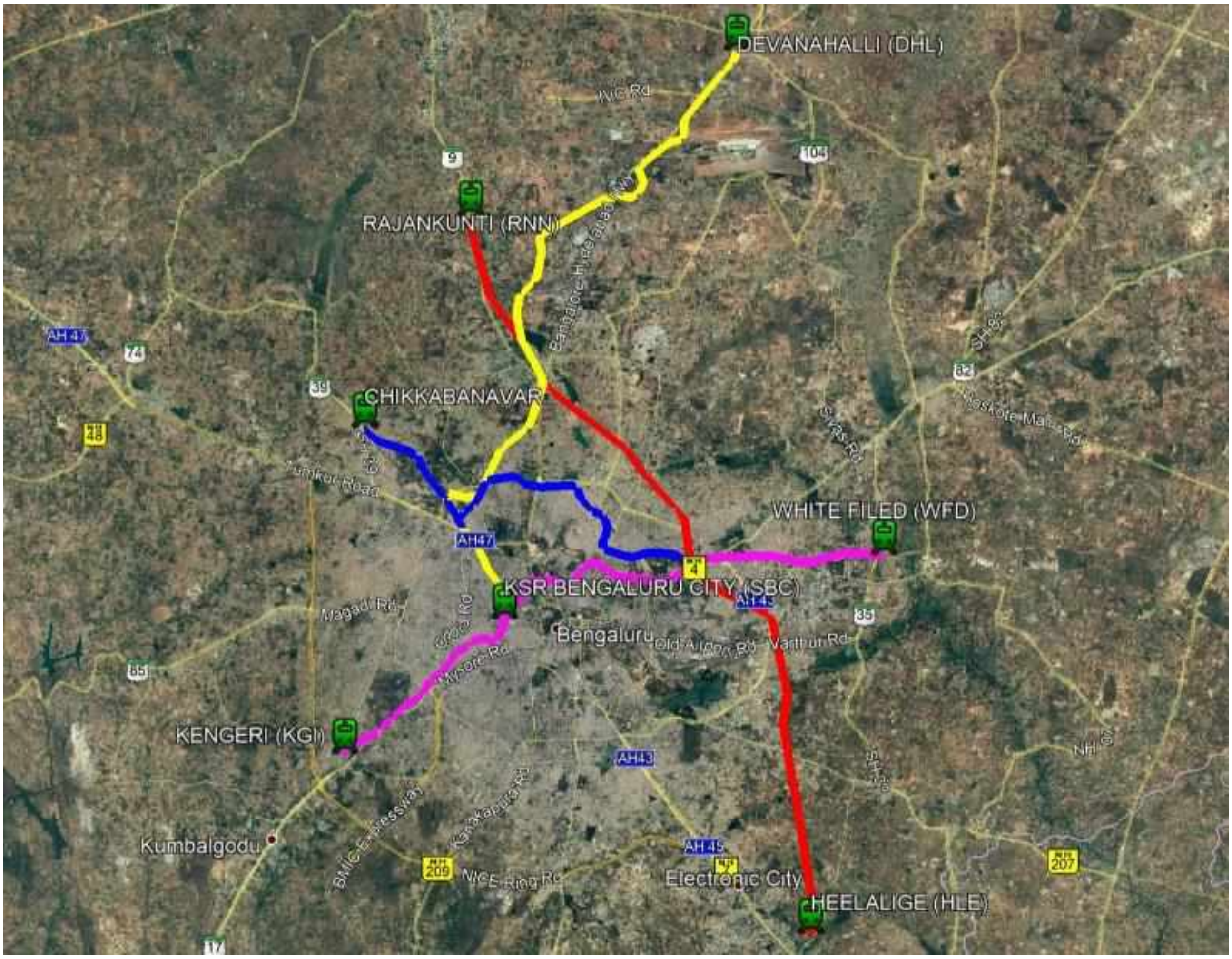
5.1 GENERAL

Out of 62 stations, 6 typical stations of different categories have been identified for planning and intermodal integration, the details of which are presented in **Table 5.1.** and **Figure 5.1.**

TABLE 5.1: DETAILS OF SIX IDENTIFIED STATIONS

S. NO.	NAME OF THE STATION	CORRIDOR NAME	INTERCHANGE TYPE	PLATFORM TYPE (PROPOSED)
1.	Kengeri Station	Kengeri – White Field	Rail - Metro	Two side platform (Elevated)
2.	KSR Bengaluru City Station	Kengeri – White Field and KSR Bengaluru City - Devanahalli	Rail – Rail and Rail - Metro	Two side and one Island platform (Elevated)
3.	Bengaluru Cantonment	Kengeri – White Field	-	Two side platform (Elevated) on curve
4.	Lottegollahalli	KSR Bengaluru City to Devanahalli & Baiyyappanahalli to Chikkabanavara	Rail - Rail	Two side platforms (Elevated) on two levels (i.e. four tracks are crossing)
5.	Muthyalanagar	KSR Bengaluru City – Yelahanka - Devanahalli	-	Two side platform (Elevated)
6.	Chikkabanavara	Baiyyappanahalli – Yeshwantpur – Chikkabanavara	Bus/IPT	Two side platform (Elevated)

FIGURE 5.1: PROPOSED SUBURBAN RAIL CORRIDORS IN BENGALURU



5.2 STATION PLANNING NORMS

5.2.1 SALIENT FEATURES OF A TYPICAL STATION

1. The stations are divided into public and non-public areas (those areas where access is restricted). The public areas are further subdivided into paid and unpaid areas.
2. The platform level has adequate assembly space for passengers for both normal operating conditions and a recognised abnormal scenario.
3. The platform level in elevated stations is about 15 m, and upto 21 m above ground level.
4. The concourse contains automatic fare collection system in a manner that divides the concourse into distinct areas. The 'unpaid area' is where passengers gain access to the system, obtain travel information and purchase tickets. On passing through the ticket gates, the passenger enters the 'paid area', which includes access to the platforms.

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

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

7. Station entrances are located with particular reference to passenger catchment points and physical site constraints.

8. Office accommodation, operational areas and plant room space is required in the non-public areas at each station. The functions of such areas are given in **TABLE 5.2.**

TABLE 5.2: STATION ACCOMMODATION

1. Station Control Room	2. Cleaner's Room
3. Station Master's Office	4. Security Room
5. Information & Enquiries	6. First Aid Room
7. Ticket Office	8. Miscellaneous Operations Room
9. Ticket Hall Supervisor & Excess Fare Collection (Passenger Office)	10. Platform Supervisor's Booth
11. Cash and Ticket Room	12. Traction Substation
13. Staff Area	14. Fire Tank and Pump Room
15. Staff Toilets	16. Commercial Outlets and Kiosks
17. Station Store Room	18. UPS and Battery Room
19. Refuse Store	20. Signalling / Communication Room

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

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

- Minimum distance of travel to and from the platform and between platforms for transfer between lines.
- Adequate capacity for passenger movements.

- Safety and security, including a high level of protection against accidents.

11. Following requirements have been taken into account:
    - Minimum capital cost is incurred consistent with maximising passenger attraction.
    - Minimum operating costs are incurred consistent with maintaining efficiency and the safety of passengers.
    - Flexibility of operation including the ability to adapt to different traffic conditions, changes in fare collection methods and provision for the continuity of operation during any extended maintenance or repair period, etc.
    - Provision of good visibility of platforms, fare collection zones and other areas, thus aiding the supervision of operations and monitoring of efficiency and safety.
    - Provision of display of passenger information and advertising.
12. The number and size of staircases/ escalators are determined by checking the capacity against peak passenger flows rates for both normal and emergency conditions such as delayed train service, fire etc.
13. In order to transfer passengers efficiently from street to platforms and vice versa, station planning has been based on established principles of pedestrian flow and arranged to minimise unnecessary walking distances and cross-flows between incoming and outgoing passengers**.**
14. Passenger handling facilities comprise of stairs/ escalators, lifts and ticket gates required to process the peak traffic from street to platform and vice-versa (these facilities also enable evacuation of the station under emergency conditions, within a set safe time limit).

5.2.2 PASSENGER AMENITIES

Passenger amenities such as ticketing counters/ automatic ticket vending machines, ticketing gate, etc. are provided in the concourse. Uniform numbers of these facilities have been provided for system wide uniformity, although the requirement of the facilities actually varies from station to station. The same applies to provision of platform widths and staircase/ escalators. For ensuring adequacy of platform area, stair widths and requirement additional of emergency evacuation stairs, a maximum accumulation of passengers in the station has been considered to be comprising of waiting passengers at the platform (including one missed headway) 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.

5.2.3 CONCOURSE

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

5.2.4 TICKETING GATES

Ticketing gates' requirement has been calculated taking the gate capacity as 40 persons per minute per gate. At least two ticketing gates shall be provided at a station even if the design requirement is satisfied with only one gate.

The numbers of gates is based on the peak hour traffic per station. It always includes one more gate in case of breakdown. The gate design depends on;

- Check in and check out (distance/ fare): implying bi-directional gates
- Fare media: smart card, magnetic or paper ticket.

The most popular gates are with sliding glass panels ("pavel" design): as in the following photo;

Special gates have to be foreseen and designed for;

- Disabled persons' access,
- Customers with luggage,
- Customers with strollers

Elevated BTS AFC gates – Bangkok

5.2.5 TICKET COUNTERS AND TICKET VENDING MACHINES (TVMS)

It is proposed to deploy manual ticket issuing in the beginning of the operation. At a later stage, automatic TVMs would be used for which space provision has been made in the concourse. Capacity of manual ticket vending counters is taken as 10 passengers per minute and it is assumed that only 40% of the commuters would purchase tickets at the stations while performing the journey. The rest are expected to buy prepaid tickets. Accordingly, the requirement of ticket counters has been calculated and the same provided for in the plans.

Automatic TVMs are proposed to be located in the ticket hall. They must be protected during the night (if the ticket hall is open).

The number of TVMs required is governed by the peak hour passengers' 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.

It is proposed to provide 7 to 10 TVMs for stations with high traffic and 2 to 5 TVMs for other stations.

MTR Wall mounted TVM with maintenance corridor in the back – Hong Kong

Shinjuku Station Tokyo

Ticket Office

The number of Ticket Offices is determined by the passenger traffic and the operation policy. The Ticket Office can also be used to inform passengers. It is recommended to plan for a minimum of 2 ticket offices per station in the stations with high traffic, and a minimum of 1 ticket office per station in the stations with low traffic

At the start of revenues services, temporary ticket office should be implanted, available to customers for creating and entering information (like name, address) as required depending upon the fare media selected.

	
France SNCF Ticket Booths - Paris	MTR Ticket booths BoH - Hong Kong

5.2.6 PLATFORMS

A uniform island platform of 12 m width is proposed for the elevated stations. For the two side platforms of 6m width (including entry/exit) each have been proposed. These platform widths also have been checked for holding capacity of the platform for worst-case scenario.

5.2.7 STAIRS, ESCALATORS AND LIFTS FOR NORMAL AND EMERGENCY OPERATIONS

Provision has been made for escalators in the paid area i.e. from concourse to platforms. On each platform, at least one escalator has been proposed. In addition, two staircases with a minimum combined width of 6 m are provided on each platform connecting to the concourse. These stairs and escalator together provide an escape capacity adequate to evacuate maximum accumulated passengers in emergency from platforms to concourse in 4 minutes. Lifts have been provided one each on either platform, to provide access for elderly and disabled. Since the level difference between the road and the concourse is about 8 m, it is proposed to provide escalators and lifts in addition to stairs for vertical movement of passengers from street to concourse.

5.2.8 PASSENGER INFORMATION KIOSKS

Passenger Information Kiosks are provided in the unpaid and paid areas of the concourse.

5.2.9 COMMERCIAL PROGRAMS

A) Advertising areas

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 advertising in transit systems include;

- A high level of passenger traffic:
- Maximum of space and maximum of repetitions: minimum space for posters is around 150 positions to be efficient on the entire network (that means a minimum of 6 positions per station)
- Importance of light and the treatment of light to see the posters
- Advertising sales agency to manage the advertising space.

The different possibilities of advertising spaces include;

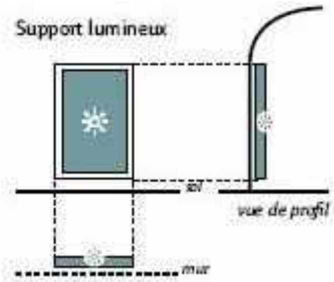
- On the platforms (20% of the spaces on the platform could be used for advertising).
- On the walls beside the escalators:

- On the walls of the first level of the stations
- Inside the rolling stock (specific dedicated areas)
- On the rolling stocks: train wearing advertisement campaign (train is used as an advertising medium for one campaign)

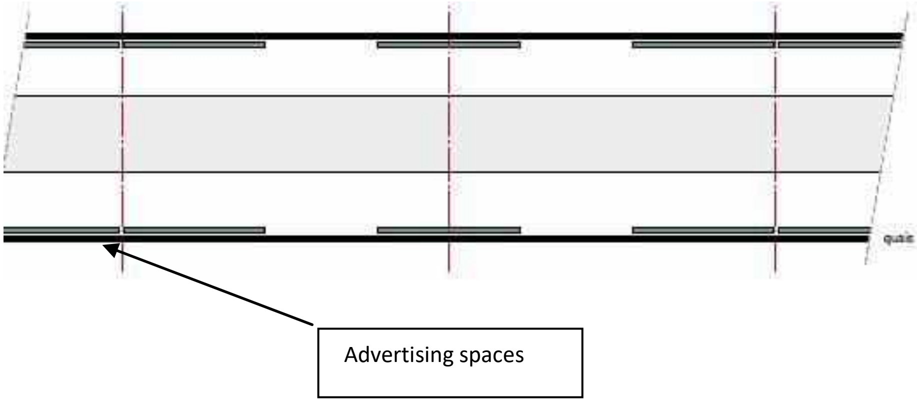
- The entire station can be used as an advertising medium for one campaign
- New technologies can be used especially on the platforms: LCS screens (about 8m²) with projection. It implies cables have to be set up in the stations and on the platforms. The screens include sensors to calculate the number of passengers who pass and see the poster. The screen can also communicate with mobile phones.

Rules about the advertising space:

- Advertising spaces must be seen by the customers on the platforms, as illustrated below;



- On the platforms, a symmetry position can be set up, as illustrated below;



B) Commercial Areas for Retail Shops

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. The different area possibilities for location of retail shops are:

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

On the platforms

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

Inside the stations (before the tool zone)

- Spaces 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.

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.

5.2.10 OPERATIONAL ROOMS

A) Operation Rooms Related To Public

Station Master Control Room

The station master control room is required to control and monitor the stations' equipments (fire fighting systems, ventilation, etc.). It is generally located in the ticket hall of each station. It is recommended that the operator can easily access any part of the station from this office. This room is fitted with a dialog box for passenger information.

Ticket Office

The number of Ticket Offices is defined by the passenger traffic and the operation policy. The Ticket Office can also be used to inform passengers. If the main Ticket Office is located next to the Station master control room, it will be fitted with a self-closing door between these two rooms. The room will require special protection (as armoured glass, metal doors, etc.).

Ticket Vending Machines (TVM) and TVM back-store room

Automatic TVM are located in the ticket hall. The type of TVM will be defined in accordance with the fare policy. For security reasons, the Ticket Vending Machines should be equipped with a back store room.

Security Room

This room is located in each station and is used by the security staff. It is preferable that this room is located in the ticket hall, in the public operation area allowing watching over the public. This room could be fitted with specific equipments in relation to the role of security staff.

First aid room

First aid room isn't a specific operation room but will be located in every station. This room could also be used as a detention room if it is needed.

Safety Precautions

- Manual call point for giving fire alarm signal if fire is discovered.
- Follow the instructions given by Suburban Rail Staffs.
- Use nearest staircase to reach street level.
- Take care when walking to exit.
- Do not use Lift in case of fire.

Passenger amenities

Toilets for public are not specific operation rooms but will be provided at all stations in accordance with the technical provisions of the project.

Space requirement synthesis

Office / Room	Number of rooms	Area in m^2
Station master control room	1 per station	20
Ticket Office in stations with low traffic	1 per station	12 to 20
Ticket Office in stations with high traffic	2 per station	20 to 25
TVM back-store	Depending on the no. of TVMs	4
Security room	1 per station	14
First Aid / Detention if needed	1 per station	20
Men Toilets for public	1 per station	15
Women toilets for public	1 per station	15

B) Operation Rooms Related To Staff Use Only

Safe deposit

In each station where tickets will be sold, a safe deposit room located next to the main ticket office is to be provided. For security reasons, it is recommended to collect cash every day from the ticket office and at regular intervals from the ticket vending machines of the station. 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.

In case enough space is not available to have a separate room, Safe Deposit can be located in the ticket office. In this case, a "protective wall" will be required in the ticket office, in order to obstruct the visibility of cash handling from the public.

In each safe room, there will be a safe box. The room will require special protection (as armoured glass, metal doors, etc.).

Male and female locker and rest rooms

These rooms shall be close to the staff operation areas. Males & females shall have separate access, in the non-public operation area. The area of these rooms will depend on the number of employees in each station.

Male and female staff toilet

It is recommended to fit the stations with specific toilets for the employees. Separate male and female toilets shall be provided in each station. Sanitary features shall include at least toilet and washbasin.

Operation storage room

The operation storage room is to be provided to store any kind of items required for operation purpose.

Cleaning and garbage rooms

Cleaning and garbage rooms are not specific operation rooms but must be located in every station. These rooms shall be close to each other. Hot and cold water shall be available in the cleaning room.

Space requirement synthesis

Office / Room	No. of rooms	Area in m^2
Safe deposit	1 per station	10
Male locker room (*)	1 per station	15 or 20 (1)
Male staff toilets (*)	1 per station	15
Female locker room (*)	1 per station	15 or 20 (1)
Female staff toilets (*)	1 per station	15
Rest room / kitchen	1 per station	15
Operation storage room	1 per station	20
Cleaning room	1 per station	10
Garbage room	1 per station	10

NOTE:
(*) The accurate areas of these rooms depend on the number of staff to use this facility.
(1) The staff locker room could be combined.

C) Operation Rooms In Terminals Or Intermediate Terminals

Operation supervisor office

This office is located in terminal or specific stations; it is assigned to the operation supervisor in charge of train drivers or operation of a group of stations of the line (defined by operation policy). It is preferable to locate this room at the platform level.

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 located at the platform level and include:

- Train drivers dispatch office,
- Training room / emergency room,
- Operation storage room,
- Male and female locker rooms separated,
- Male toilets,
- Female toilets,
- 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. The room should be located next to the operation supervisor Office.

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 will be located into the public area in a station with high traffic. The lost and found location will require a public zone and a restricted room dedicated to lost objects.

Space requirement synthesis

Office / Room	Number of rooms	Area in m^2
Operation manager office	1 per terminal	20
Train drivers dispatch office	1 per terminal	20
Training room / emergency room	1 per terminal	30
Operation storage room	1 per terminal	20
Train drivers locker	1 per terminal	12
Male toilets	1 per terminal	3
Female toilets	1 per terminal	3
Rest room	1 per terminal	15
Lost and found Room	1 in City Gate station	40

5.2.1 TECHNICAL ROOMS

Technical Room Requirements

S. No.	Room Name	Min. Area (m^2)	Remarks
1	Station Control Room	20	
2	Misc. Operations	28	
3	Ticket Office	12	Number related to traffic
4	Audit / Cash Storage Room	20	
5	Security Room	16	
6	First Aid Room	9	
7	Cleaners Room	8	
8	Female Staff Toilet	9	
9	Male Staff Toilet	12	
10	Signalling Equipment Room SM	49	
11	Signalling Equipment Room LG	20	

S. No.	Room Name	Min. Area (m²)	Remarks
12	Telecoms Equipment Room	49	
13	UPS Room (SIG/TEL)	27	
14	UPS Room (Station)	27	
15	Refuse Store Room	9	Street level
16	Staff / Train Crew Room (Ladies)	12	
17	Staff / Train Crew Room (Gents)	12	
18	Tank / Pump Room	90	Street level
19	Diesel Generator Room	49	Street level
20	Gas Bottle Room	9	
21	SSS Transformer / Switch Room	90	
22	TSS Transformer / Switch Room	120	only half no. of stns
23	Station Store Room	20	(x2)
24	Ladies Toilet (Public)	9	*if public toilets required
25	Gents Toilet (Public)	12	*if public toilets required
26	Toilet (Handicapped)	3	*if public toilets required

5.2.11 DESIGN CRITERIA FOR PASSENGER MOVEMENT FACILITIES

A) Escalator Requirements

Standards, Codes and Regulations

The following regulations and standards shall form the basis for the design of escalator system.

- 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

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. In the case of adjacent escalators, it should be possible to dismantle or put back in place all parts of either escalator without stopping or interfering with the operation of the adjacent unit.

Escalators will have inclination angle of 30 degree (EN 115).

Truss will be a non-oscillating and distortion-free welded structure of angle steel or lattice girder sections. The deflection of the loaded truss should be less than 1/1000 of the distance 'L' between support beams based on a passenger load of 5 KN/m^2. (EN 115 para 5.1, 5.4)

Escalators will be equipped with protective barriers, where necessary.

Interfacing requirements

The following escalators interface will be monitored by the SCADA and abnormal conditions will be alarmed:

- Incoming power lines healthy.
- Direction status.
- Running
- Fault
- Emergency

B) Elevator Requirements

Standards, Codes and Regulations

The following regulations and standards will form the basis for the design of elevator system.

- 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

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.

The design of the lift will take into consideration fire prevention, elimination of dust and dirt traps, and easy access for cleaning and routine maintenance.

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 drive machine, its associated machinery and all necessary control equipment of lifts at stations will be installed within the lift shaft without any lift machine room. Intercom will be provided inside the lift car to communicate with the Station Operation Room of the station where lifts are installed.
The levelling 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 standard.

Interfacing requirements

The following shall be monitored by the SCADA and abnormal conditions will be alarmed:

- Incoming power lines healthy
- Direction status
- Running
- Fault
- Emergency Status.

Stairs Requirements

- Provide central handrail when stair width is 4.5 m or more.
- Risers per flight: 3 minimum, 12 maximum
- All Steps in a flight of stairs should have the same dimensions
- Tread width of steps will be 300mm
- Riser will be 130mm(for suburban station)
- Length of intermediate landing: lesser of 2m or width of stairs
- Handrail: 0,9m high, 50mm diameter, 45mm clearance to wall.
- No open risers shall be allowed.
- Step noses will be rounded and colour contrasted
- Minimum Stair width for public use: 1500mm
- Minimum Stair width for emergency evacuation: 1100mm

Corridors

Minimum width:

- Unidirectional movement: 1.8 m
- Bi-directional movement: 2.0 m
- Where length is more than 30 m: 3.0 m
- For staff 1.2 m

Ramps

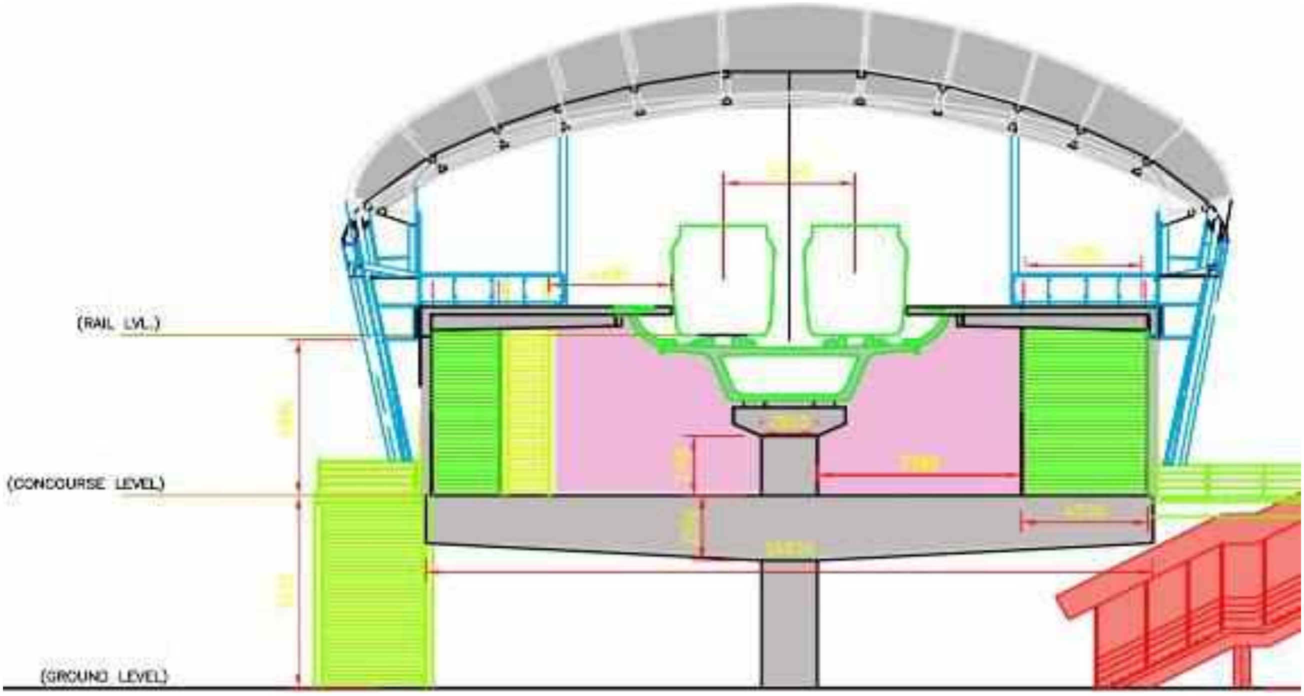
- Preferred gradient: 1:20
- Maximum gradient: 1:12
- Minimum width:
  Unidirectional movement: 1.2 m
  Bi-directional movement: 1.5 m
- For ramp exceeding 10 m, rest platform: 1.8m long

5.3 STRUCTURAL FEASIBILITY

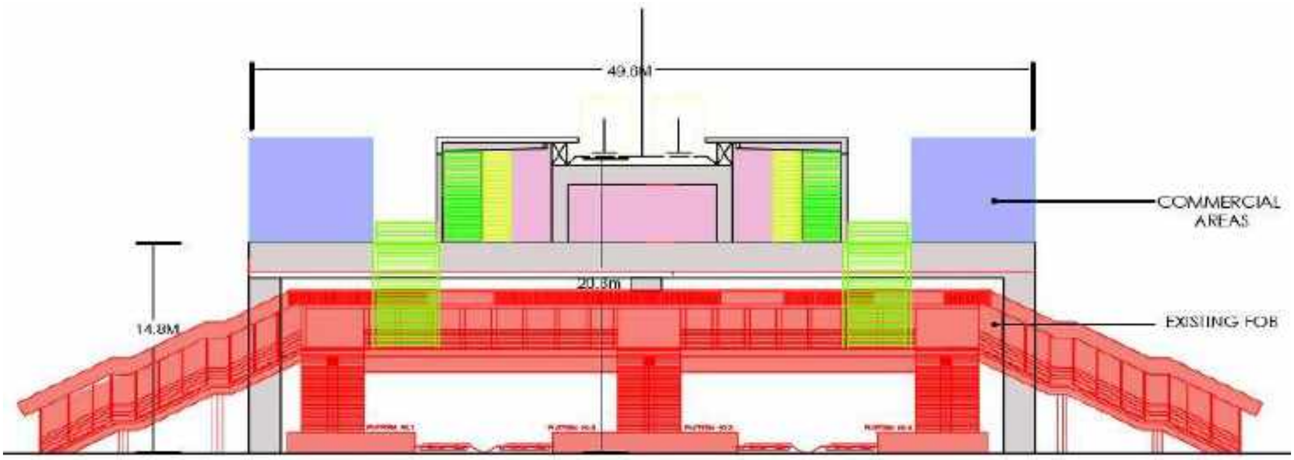
5.3.1 APPROACH FOR ELEVATED STATION

For elevated station buildings, there are two possible major structural principles:

1) Single pier with two symmetrical cantilevered beams, where one distinct advantage is the limited impact on the ground level; however the available width of the station cannot be more than 26m.

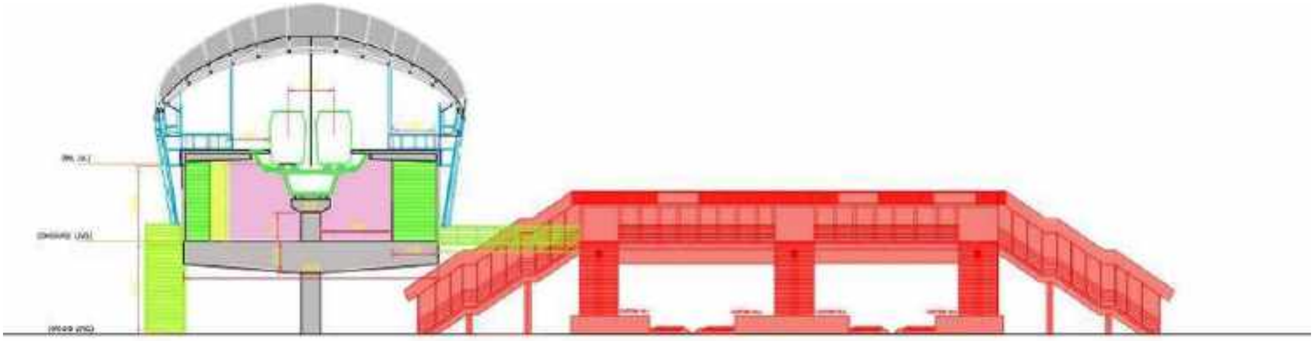


2) Portal structure with several supports (at least three), where the station width could be wider than 26 m; but in that case, it will have wider impacts on the tracks (ground) level, due to the more numbered portal supports. Effectively, a wider concourse means more capacity for commercial development.

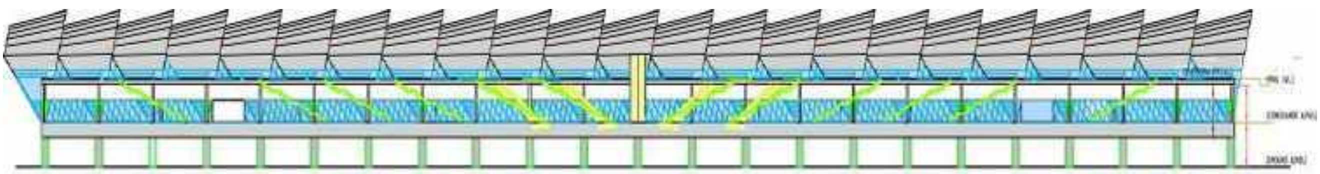


TYPICAL CROSS SECTION FOR CONCOURSE ABOVE FOB LEVEL (PORTAL SYSTEM)

In both cases, the vertical position of the stations has to be further studied. If the station concourse is to be at the existing FOB level, there will two major problems. One is the inter-mixing of the flow of passengers arriving from the existing network of FOB, into the new concourse. Specially, if we move the existing ticket office from the ground level, and install it on the new concourse, the effect of inter-mixing flow between the two different passenger profiles will be chaotic. The second problem occurs when the new concourse covers the middle platform of the ground level; where it will be very difficult, even impossible to ensure the connection between this platform and the new concourse. Consequently, the station location should be staggered in the transverse or longitudinal direction.

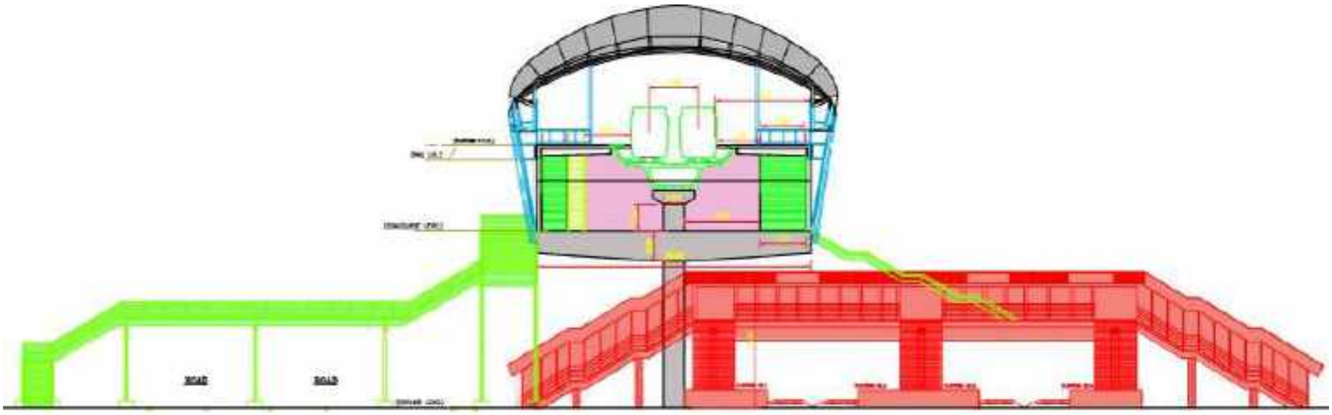


CROSS SECTION AT FOB LEVEL

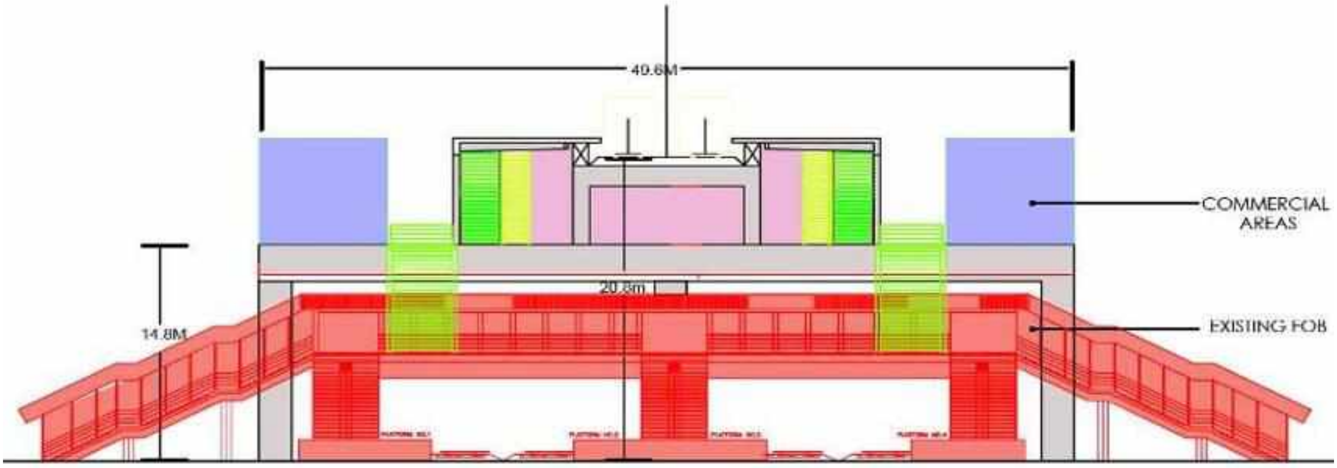


LONGITUDINAL SECTION AT FOB LEVEL

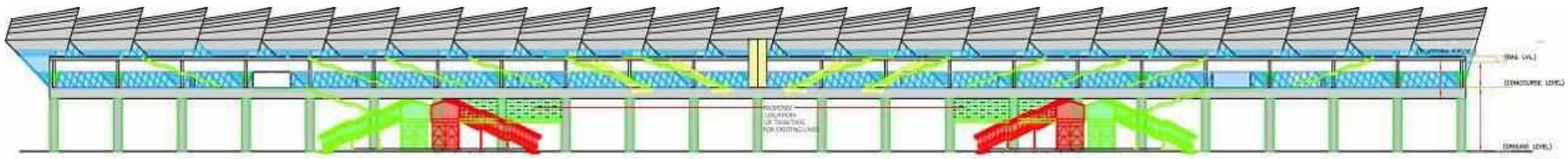
If the station concourse is above the FOB level (and occasionally ROB in some cases), then it permits a more flexible arrangement where the two flows (existing and new) could be clearly separated. The congestion resulting from the relocation of existing ticket office can be avoided, by installing it at the existing FOB level, under the new concourse. It will also enable retaining the current function of the existing network and provision of a new set of entrance and exit for the new stations. This could either be clubbed with or separated from the existing FOB, without altering their functions.



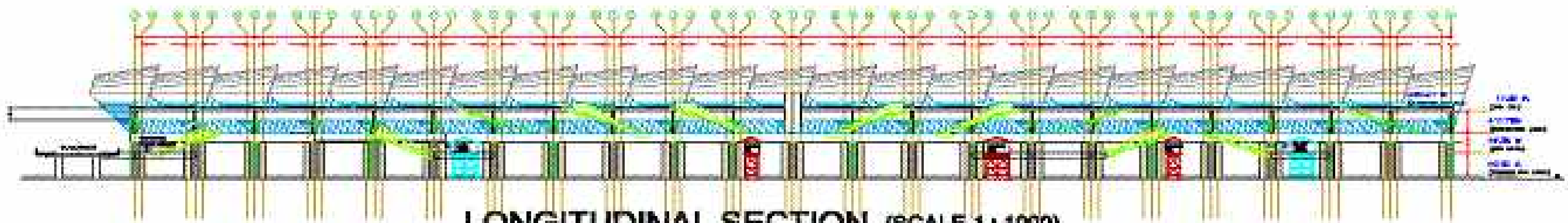
CROSS SECTION ABOVE FOB LEVEL



TYPICAL CROSS SECTION FOR CONCOURSE ABOVE FOB LEVEL (PORTAL SYSTEM)



LONGITUDINAL SECTION ABOVE FOB LEVEL



LONGITUDINAL SECTION (SCALE 1 : 1000)

Accordingly, for all the elevated stations, portal structure principle is recommended.

CONCOURSE ARRANGEMENT

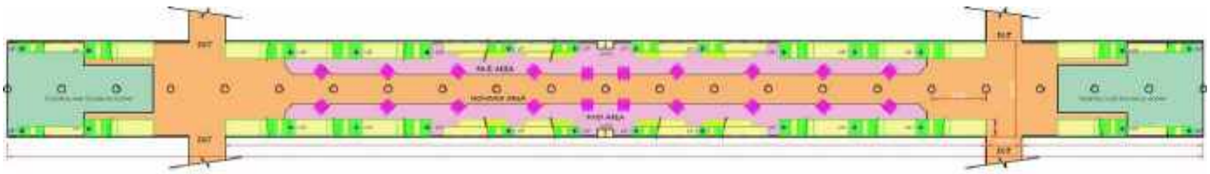
Two types of layout can be proposed for the concourse arrangement.

Portal structure (26m wide)

1) Two unpaid area on each end and staggered AFC lines in two sides of the paid area: the number of 40 AFC gates can be reached in that case.

CONCOURSE LEVEL PLAN (OPTION 1)

2) Two paid area on each side of the concourse, and one single non-paid area: a larger number of AFC gate can be arranged, and the layout is very flexible in terms of adjusting the number of gates. In addition, this layout spreads out the passenger flow (boarding and alighting) along the concourse length, and will better absorb the peak effect.



CONCOURSE LEVEL PLAN (OPTION 2)

Accordingly, the option 1 is preferred, as it provides more wide spaces at centre for passenger's movements and it is more feasible option for 205m long concourse.

5.4 CONCEPTUAL PLANNING FOR SELECTED TYPICAL STATIONS

5.4.1 KENGERI STATION

This is the first elevated suburban station of corridor Kengeri to White Field and has two side platform. The overall size of the station is 205m x 26m. At Northern side, it has two entry/exit, parallel to the station and approach from ground to concourse level. At Southern side one entry/exit placed in open space on ground, parallel to the station. At Southern side a connection with existing FOB is shown at unpaid concourse area. The station has two unpaid and one paid area at concourse level. The elevated station is on portal frame. The station planning is presented in **Figure 5.2**, **Figure 5.3, Figure 5.4** and **Figure 5.5.**

FIGURE 5.2: KENGERI SUBURBAN STATION (CONCOURSE LEVEL PLAN)

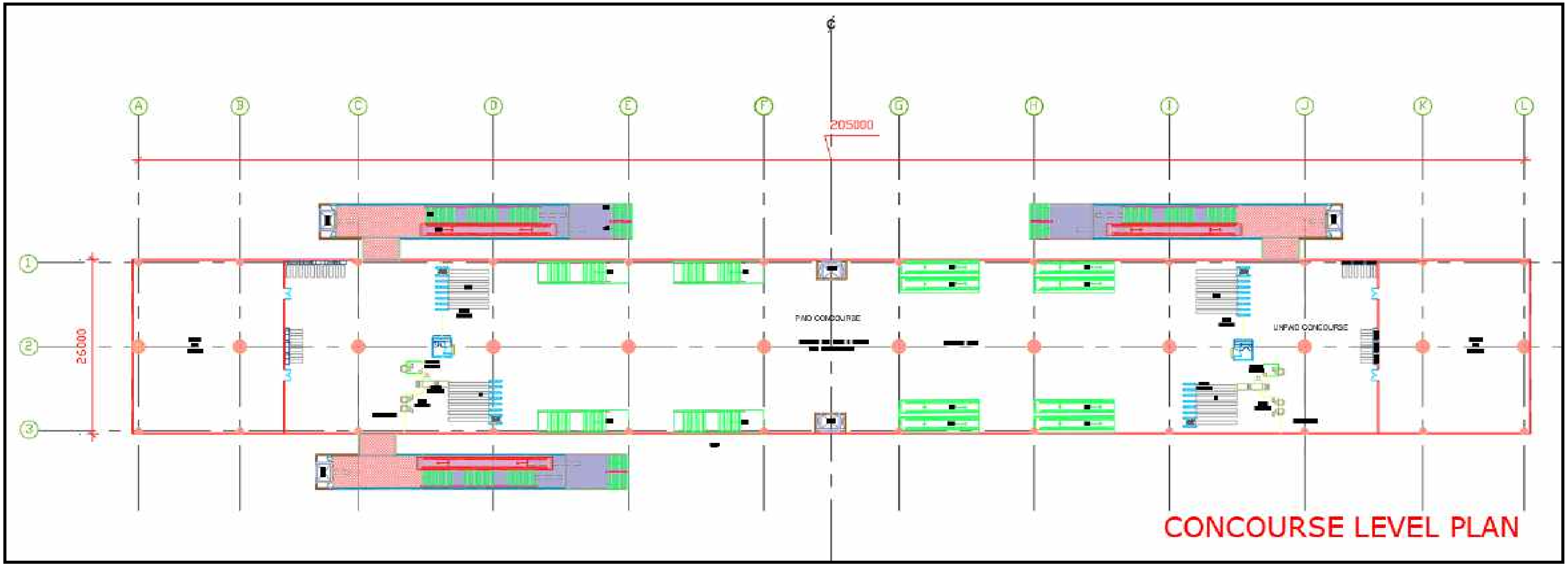


FIGURE 5.3 KENGERI SUBURBAN STATION (PLATFORM LEVEL PLAN)

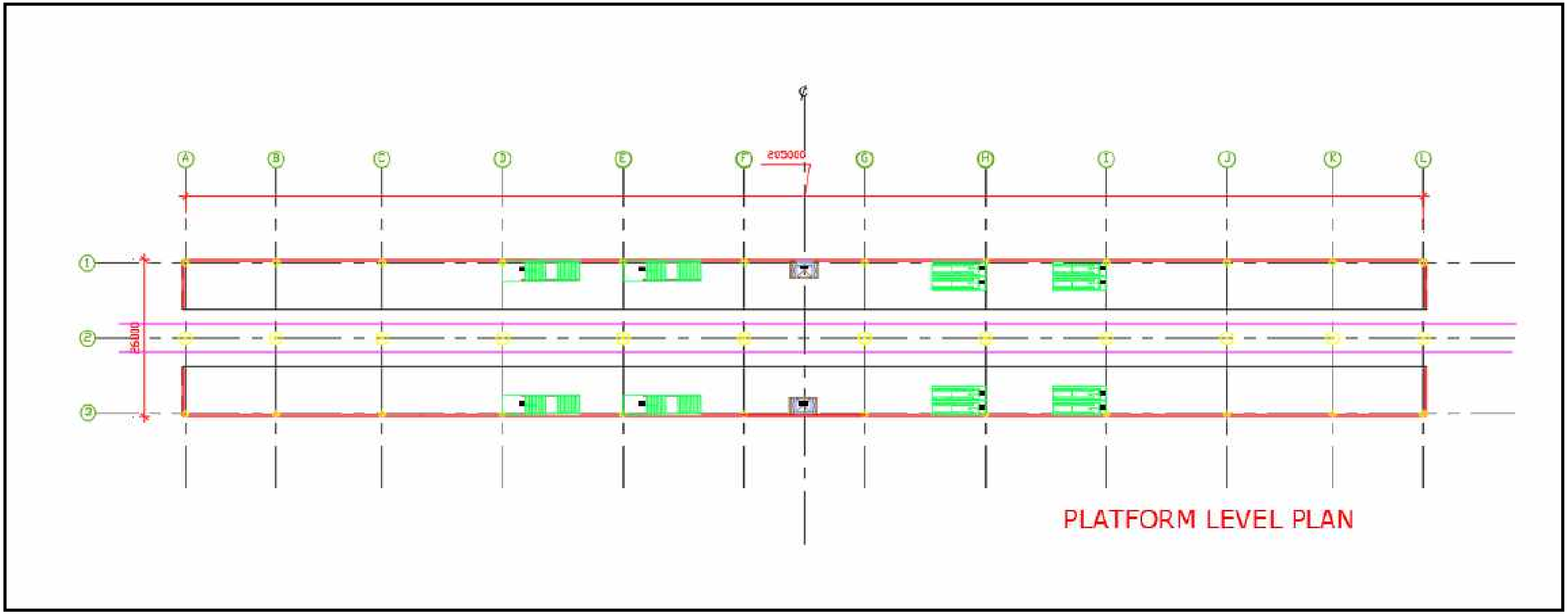


FIGURE 5.4: KENGERI SUBURBAN STATION (CROSS-SECTION)

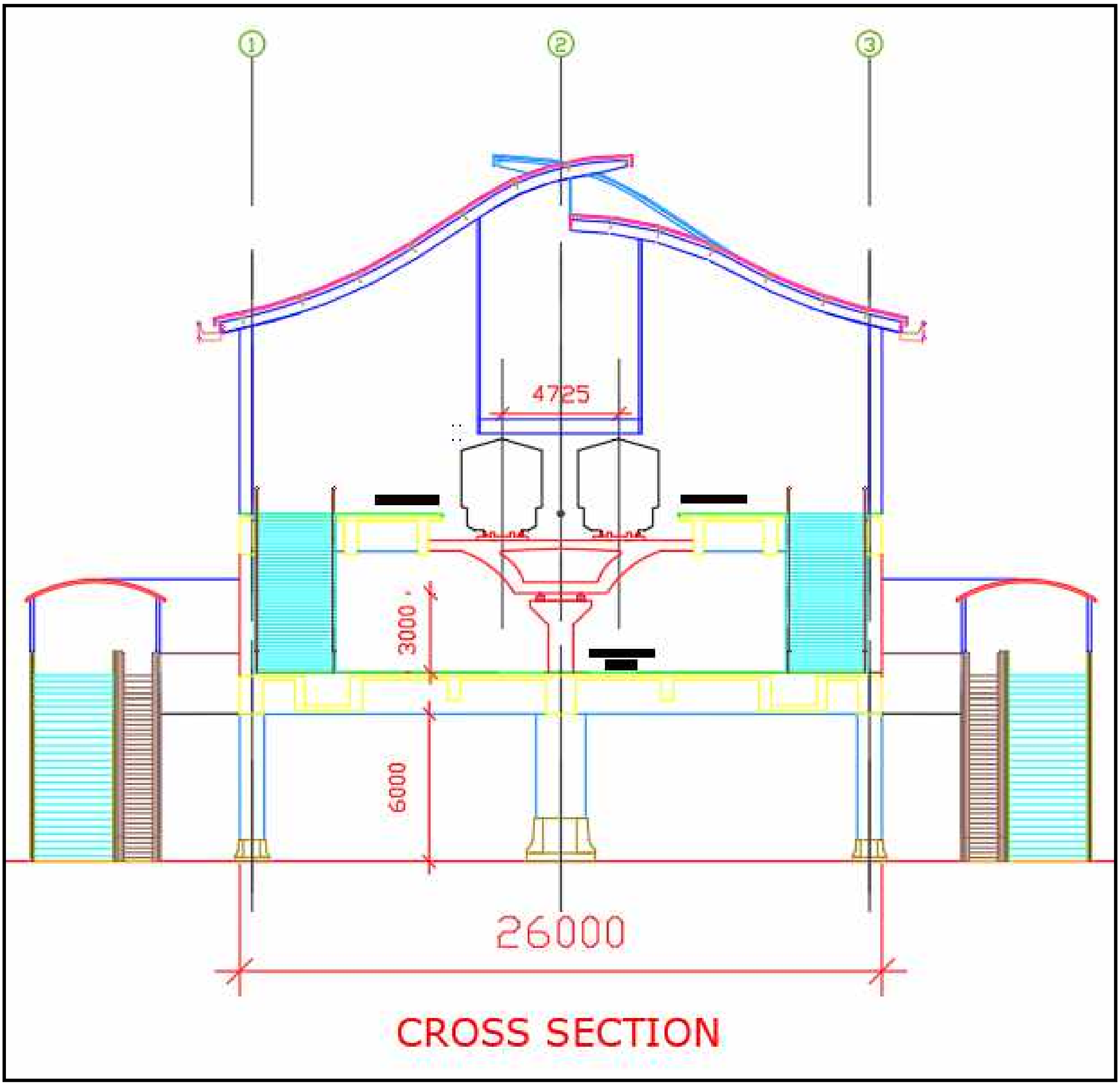


FIGURE 5.5: PROPOSED KENGERI SUBURBAN STATION ON SITE

	
Kengeri Existing Suburban Station	**Existing Platform of Kengeri Station**

	
Existing FOB of Kengeri Station	**Existing Platform of Kengeri Station**

5.4.2 KSR BENGALURU CITY STATION

There are two side and one island platform for this proposed elevated station are planned for four lines. At this location, two lines are for KSR Bengaluru City to Devanahalli corridor and two lines are for Kengeri to White Field. The first one is started from this location. The length of the station is taken as 205m. One entry/exit at Northern side is placed to access passengers from left side and also passengers from Metro station. Southern side connectivity shall be placed at suitable place either outside of the existing station or on a suitable platform i.e. first platform of the existing station. Centre connectivity will be with existing FOB. These connectivity will be through paid area so ticketing and AFC gates are provided there. Another connectivity will be with existing FOB some distance away from the station building. These connectivity will be from unpaid concourse area with existing FOB. The station planning is presented in **Figure 5.6, Figure 5.7, Figure 5.8** and **Figure 5.9.**

FIGURE 5.6: PROPOSED KSR BENGALURU CITY STATION CONCOURSE LEVEL PLAN

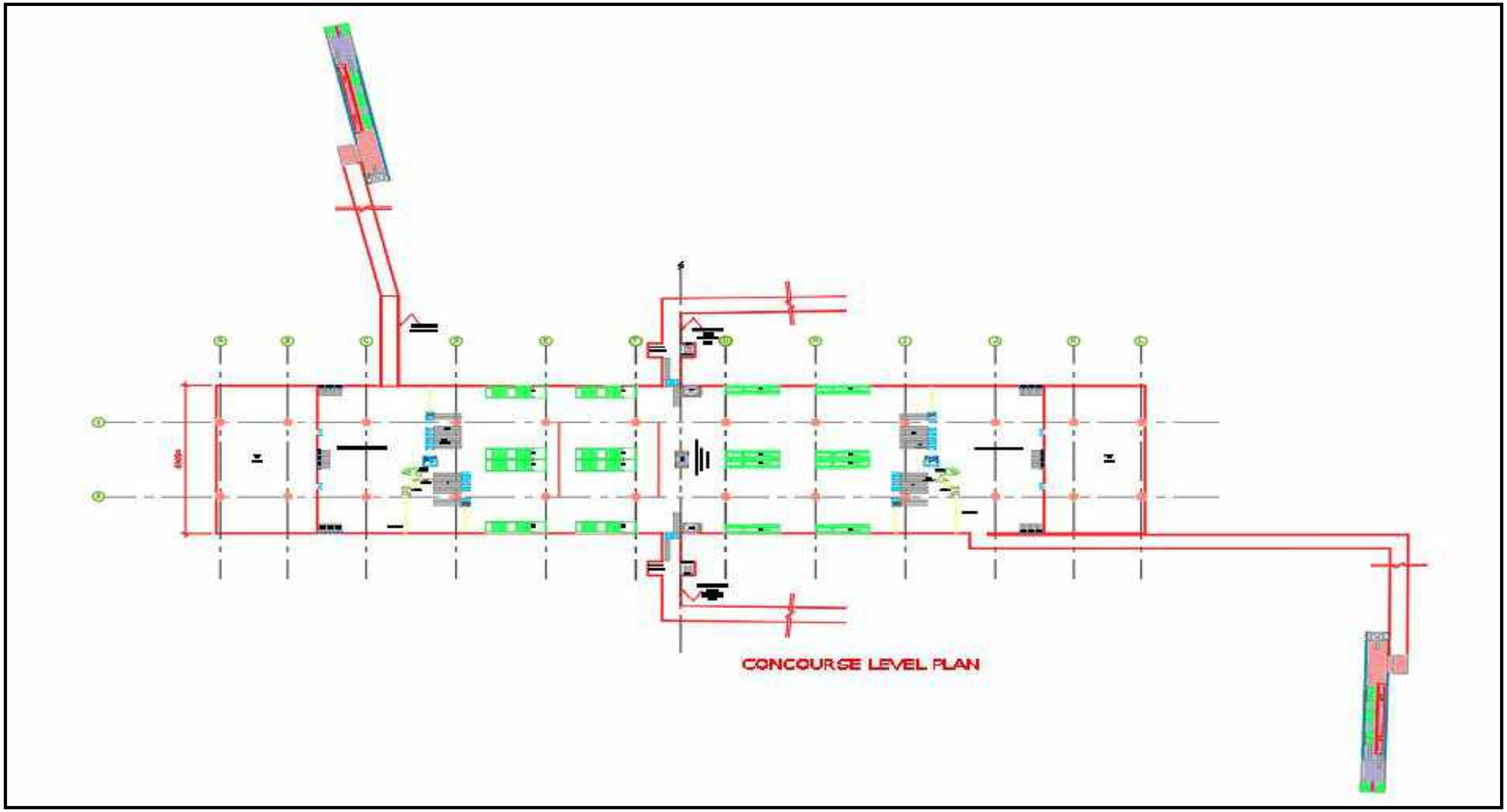


FIGURE 5.7: PROPOSED KSR BENGALURU CITY STATION PLATFORM LEVEL PLAN

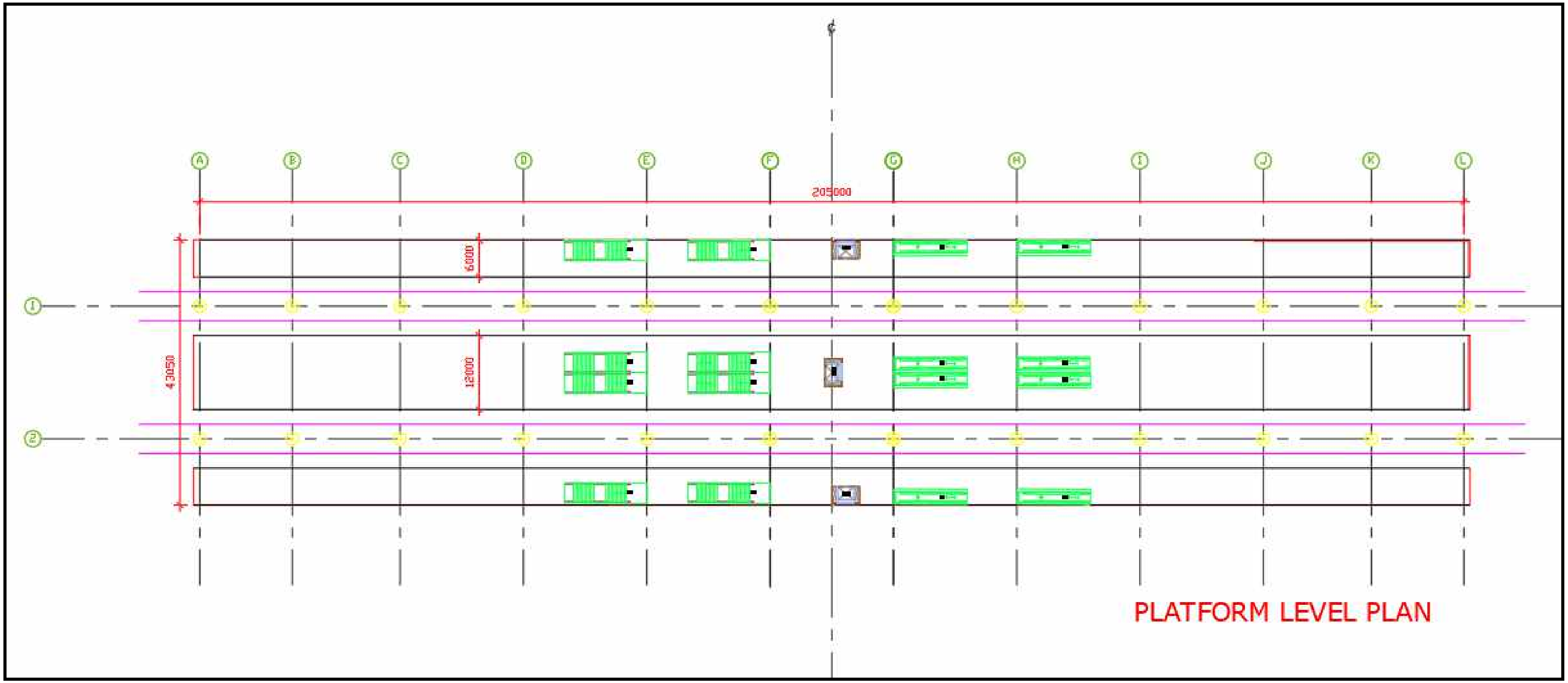


FIGURE 5.8: PROPOSED KSR BENGALURU CITY STATION CROSS SECTION

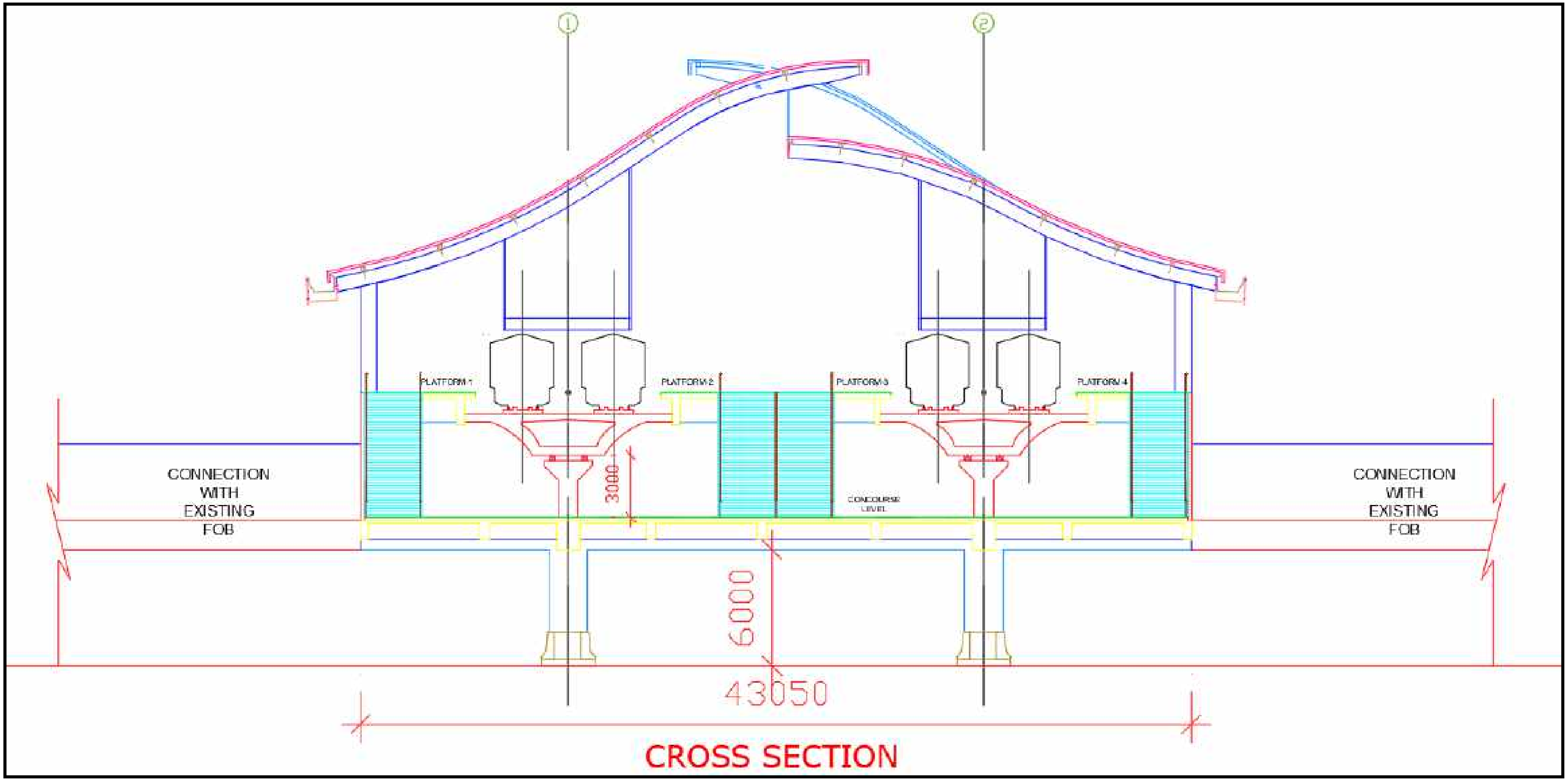
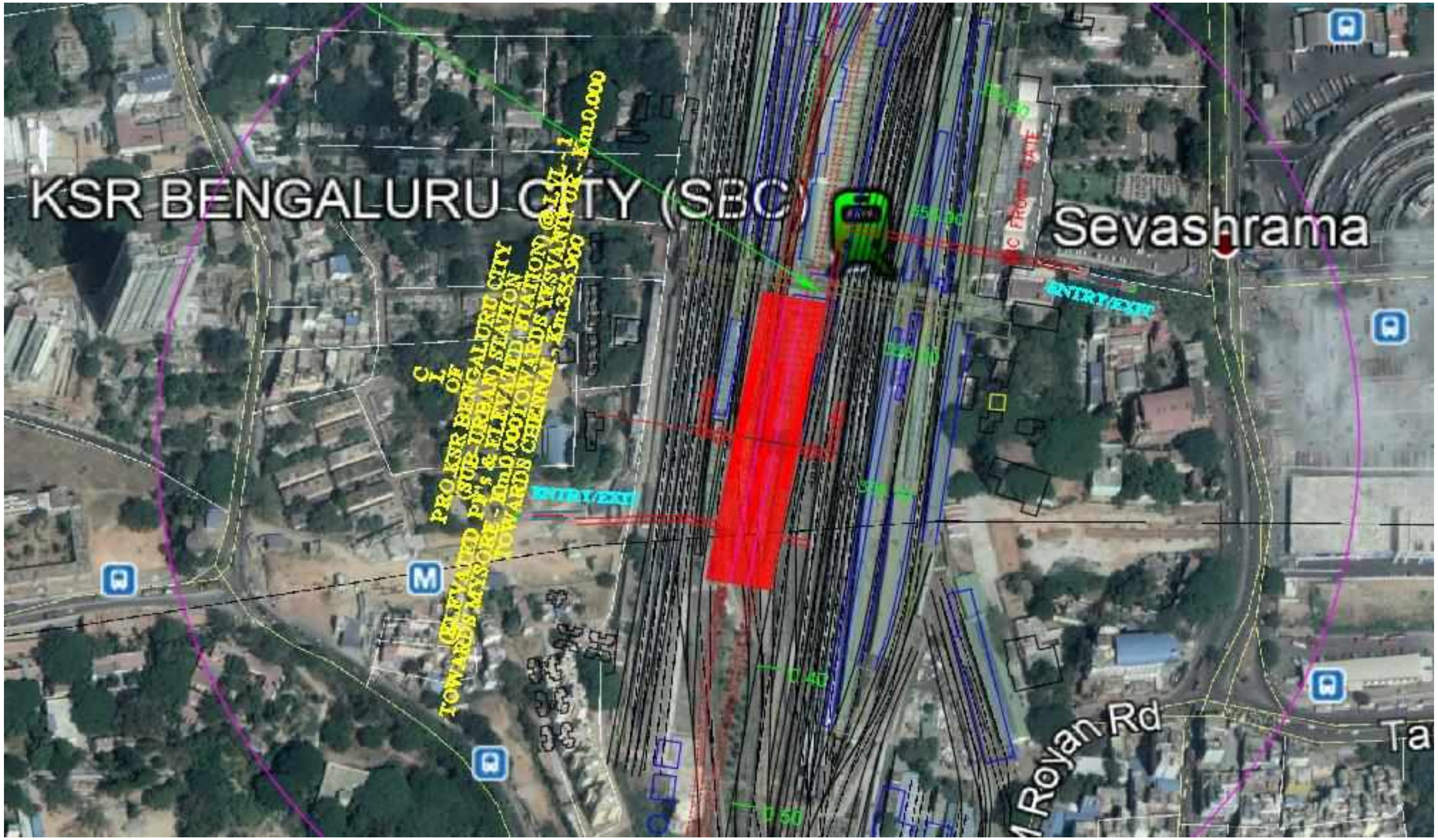


FIGURE 5.9: PROPOSED KSR BENGALURU CITY STATION ON SITE



	
Existing Bengaluru City Station(SBC)	**Entrance Lobby of Bengaluru City Station(SBC)**
	
Existing Platform of Bengaluru City Station(SBC)	**Back side of the SBC Station showing staircase connectivity with FOB**
	
Existing FOB of Bengaluru City Station(SBC)	**Underpass connectivity of Bengaluru City Station(SBC)**

5.4.3 BENGALURU CANTONMENT STATION

Bengaluru Cantonment is existing station of Kengeri to White Field corridor. The proposed station is slightly away from existing one. It is in curve. The proposed station is elevated, concourse is at first level and two side platforms at second level. Front side connectivity is from ground but another side connectivity is through proposed FOB. One side it connect with existing Bengaluru Cantonment station and another side it may be connect with future FOB. The station planning is presented in **Figure 5.10, Figure 5.11, Figure 5.12** and **Figure 5.13.**

FIGURE 5.10: PROPOSED BENGALURU CANTONMENT STATION CROSS SECTION

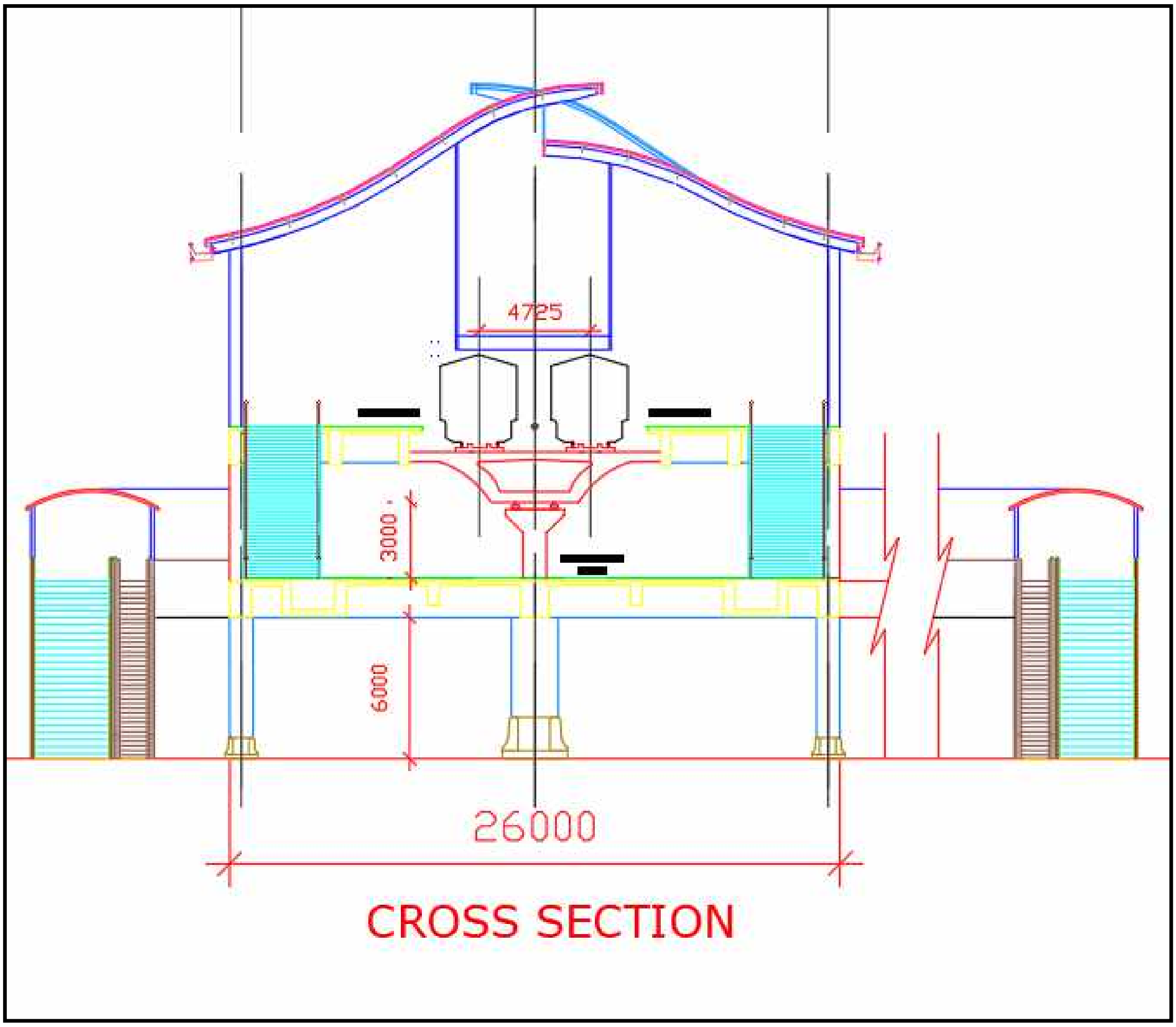


FIGURE 5.11: PROPOSED BENGALURU CANTONMENT STATION (CONCOURSE LEVEL PLAN)

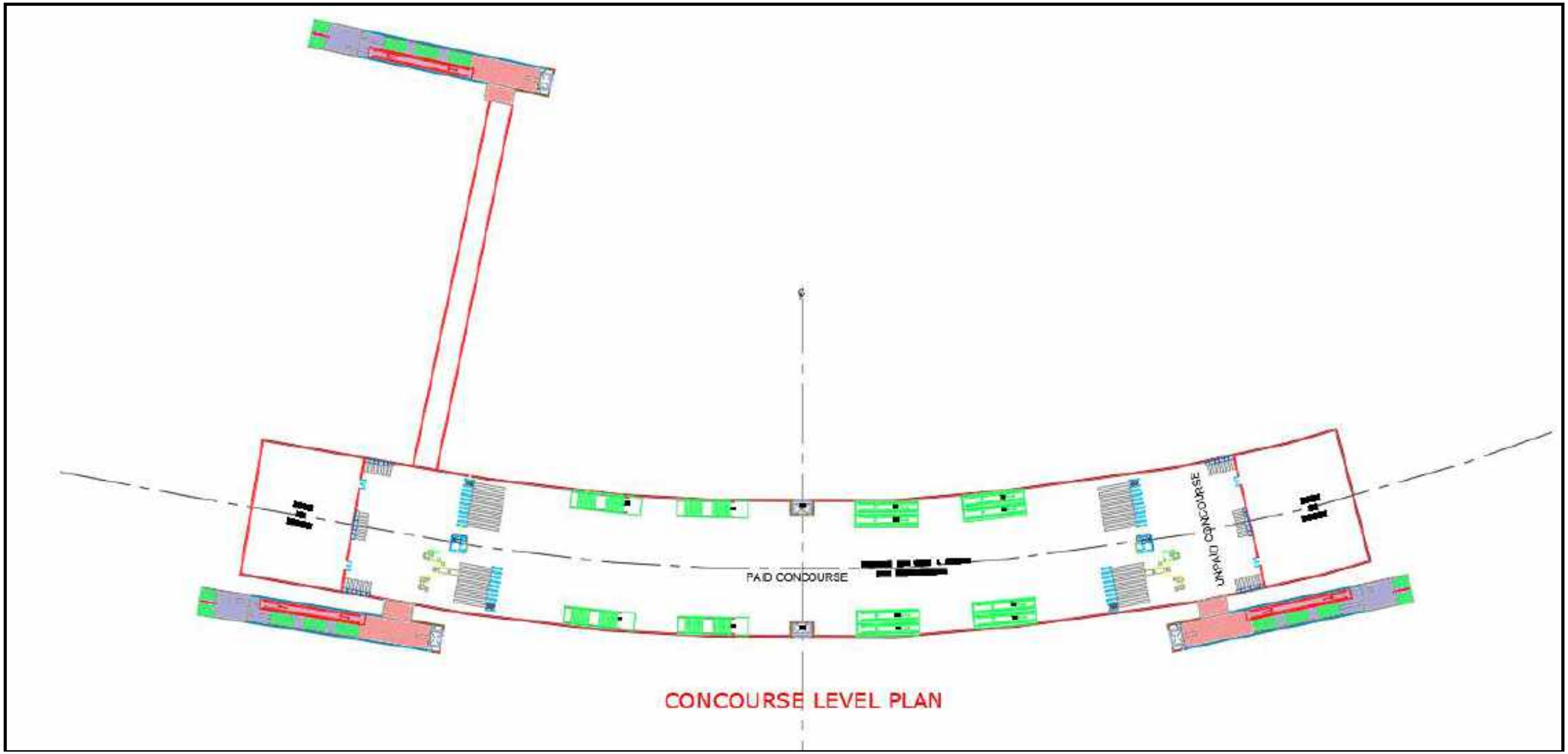


FIGURE 5.12: : PROPOSED BENGALURU CANTONMENT STATION (PLATFORM LEVEL PLAN)

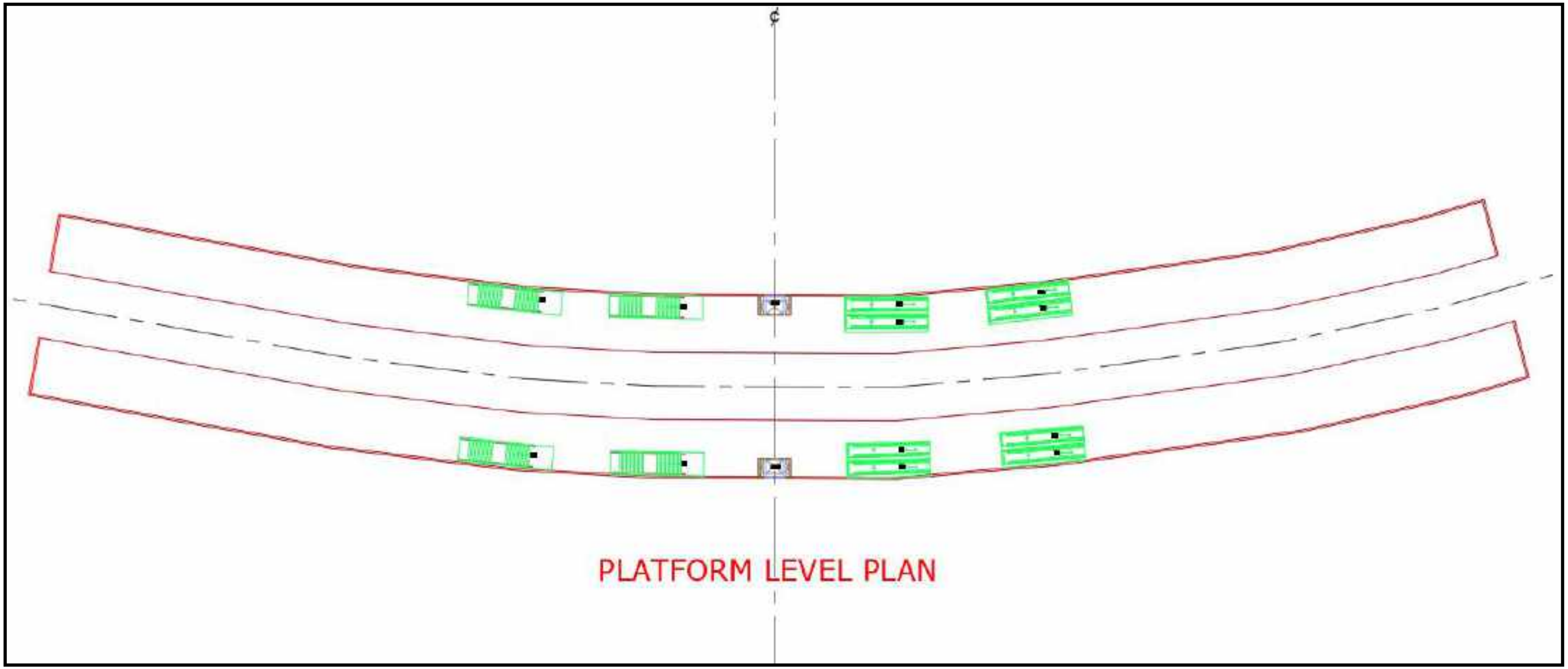


FIGURE 5.13: PROPOSED BENGALURU CANTONMENT STATION ON SITE

Existing Bengaluru Cantonment Station(BNC)

Existing Parking at Bengaluru Cantonment Station(BNC)

Existing Platform of Bengaluru Cantonment Station(BNC

Other side Entry/exit of Bengaluru Cantonment Station(BNC)

5.4.4 LOTTEGOLLAHALLI STATION

This station has connectivity of two corridors Bengaluru City to Devanahalli & Baiyyappanahalli to Chikkabanavara. Lottegollahalli Station is a three level elevated station. First level concourse, 2nd level two side platforms and again 3rd level another two side platforms are proposed here. The Land and property acquisition will be required for construction of this station and its entry/exit. The station planning is presented in **Figure 5.14, Figure 5.15, Figure 5.16 Figure 5.17** and **Figure 5.18.**

FIGURE 5.14 : PROPOSED LOTTEGOLLAHALLI STATION (CONCOURSE LEVEL PLAN)

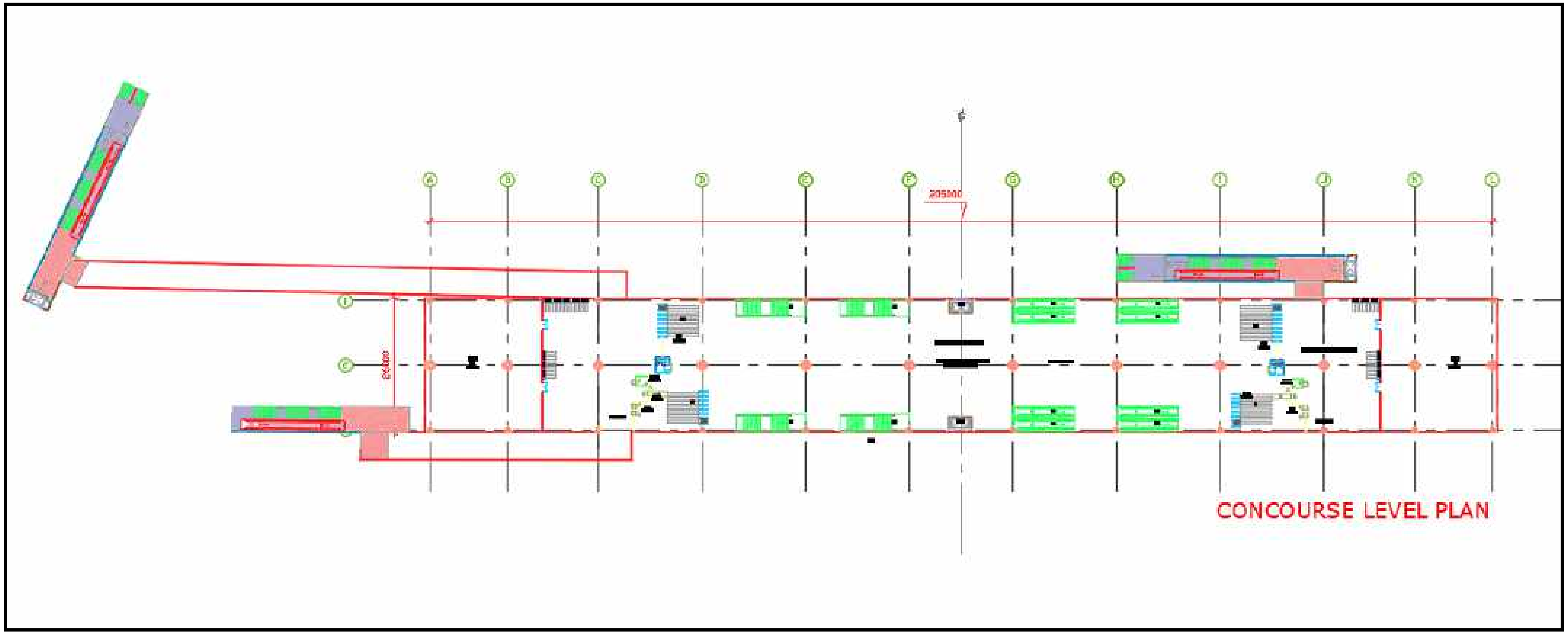


FIGURE 5.15: PROPOSED LOTTEGOLLAHALLI STATION (FIRST PLATFORM LEVEL PLAN)

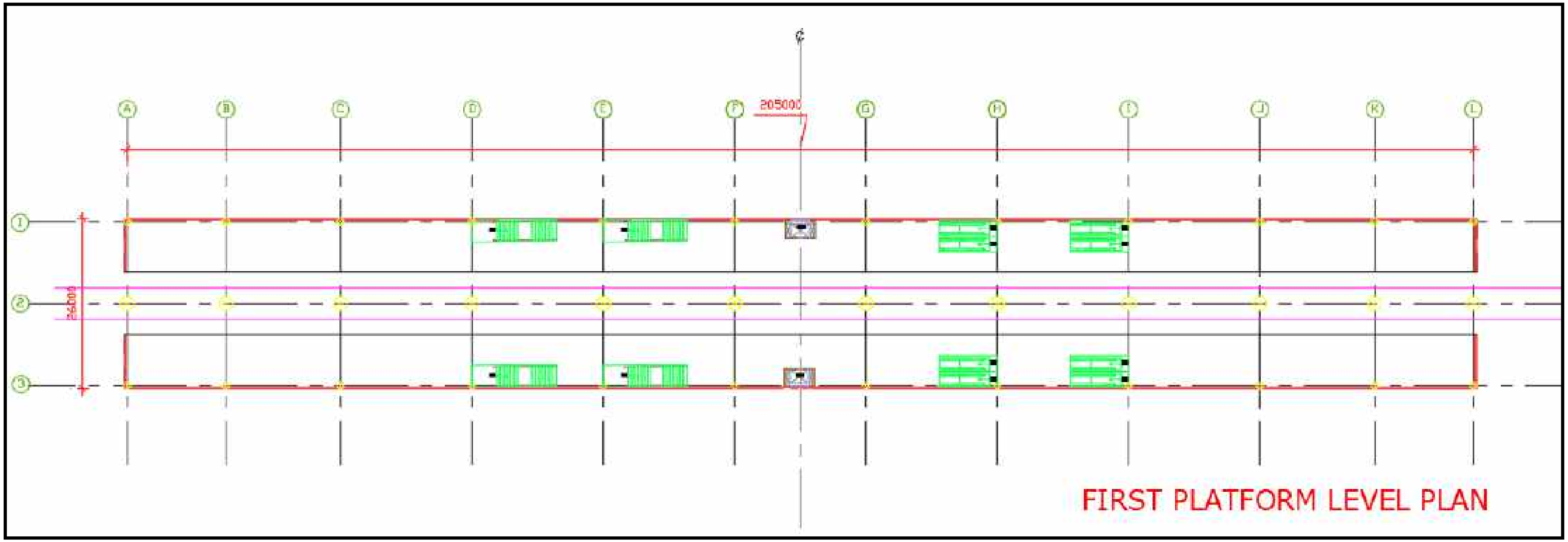


FIGURE 5.16: PROPOSED LOTTEGOLLAHALLI STATION (SECOND PLATFORM LEVEL PLAN)

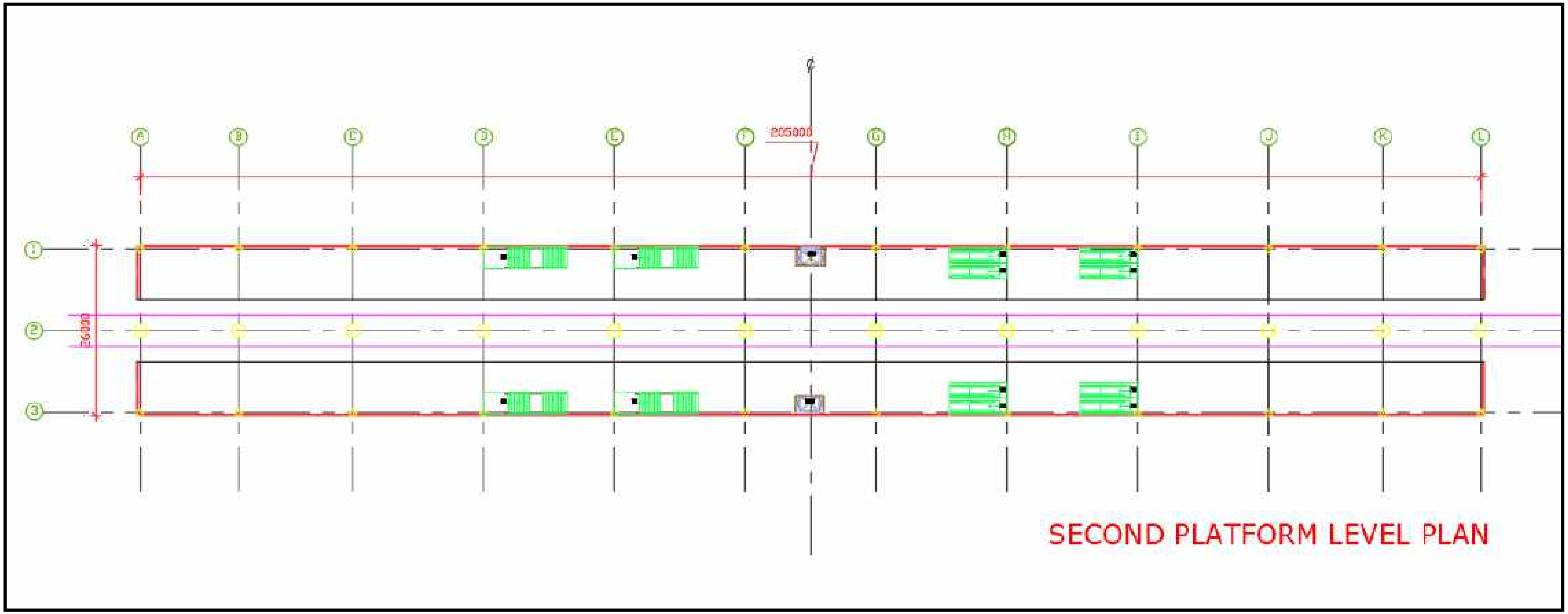


FIGURE 5.17: PROPOSED LOTTEGOLLAHALLI STATION (CROSS SECTION)

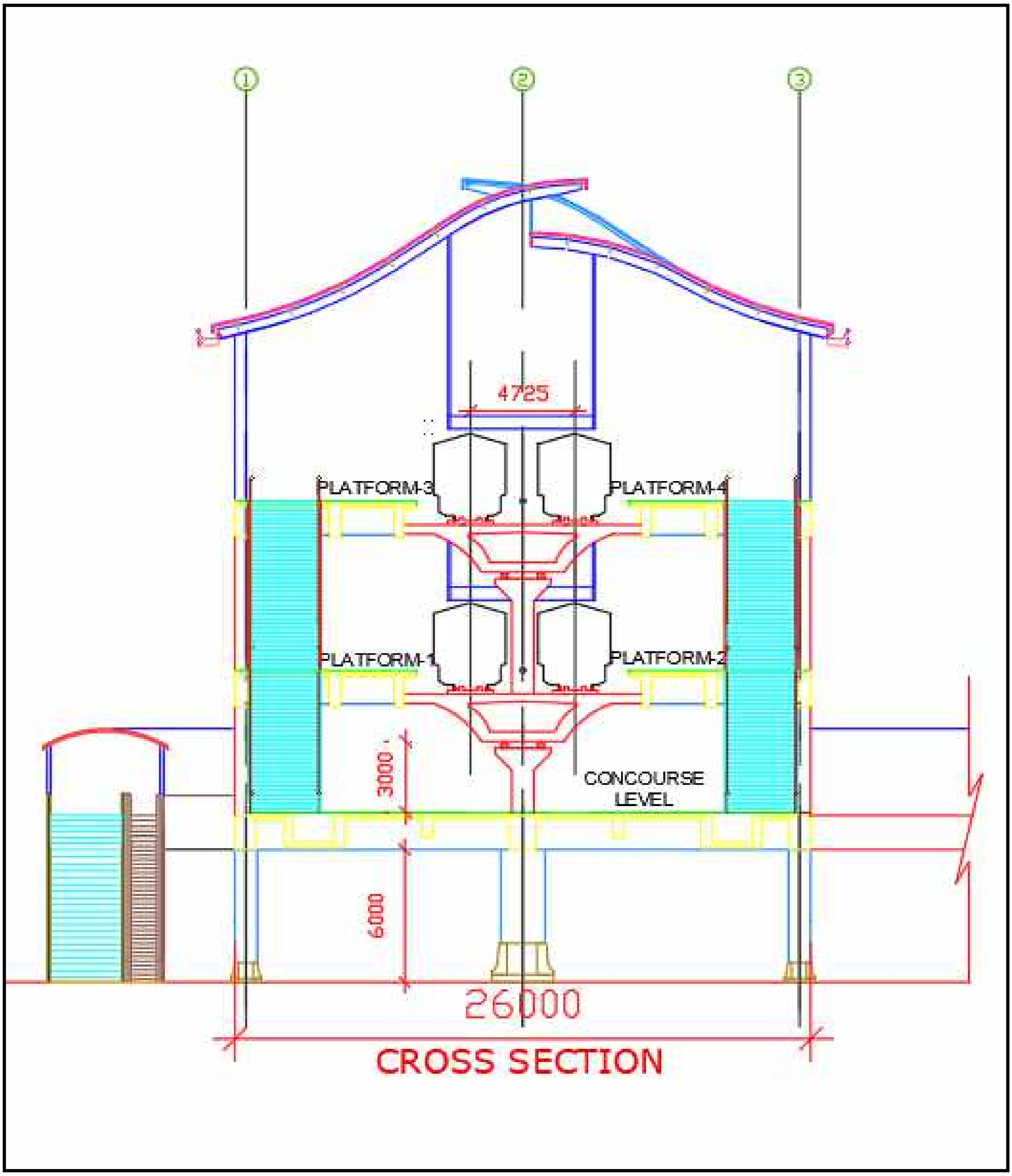
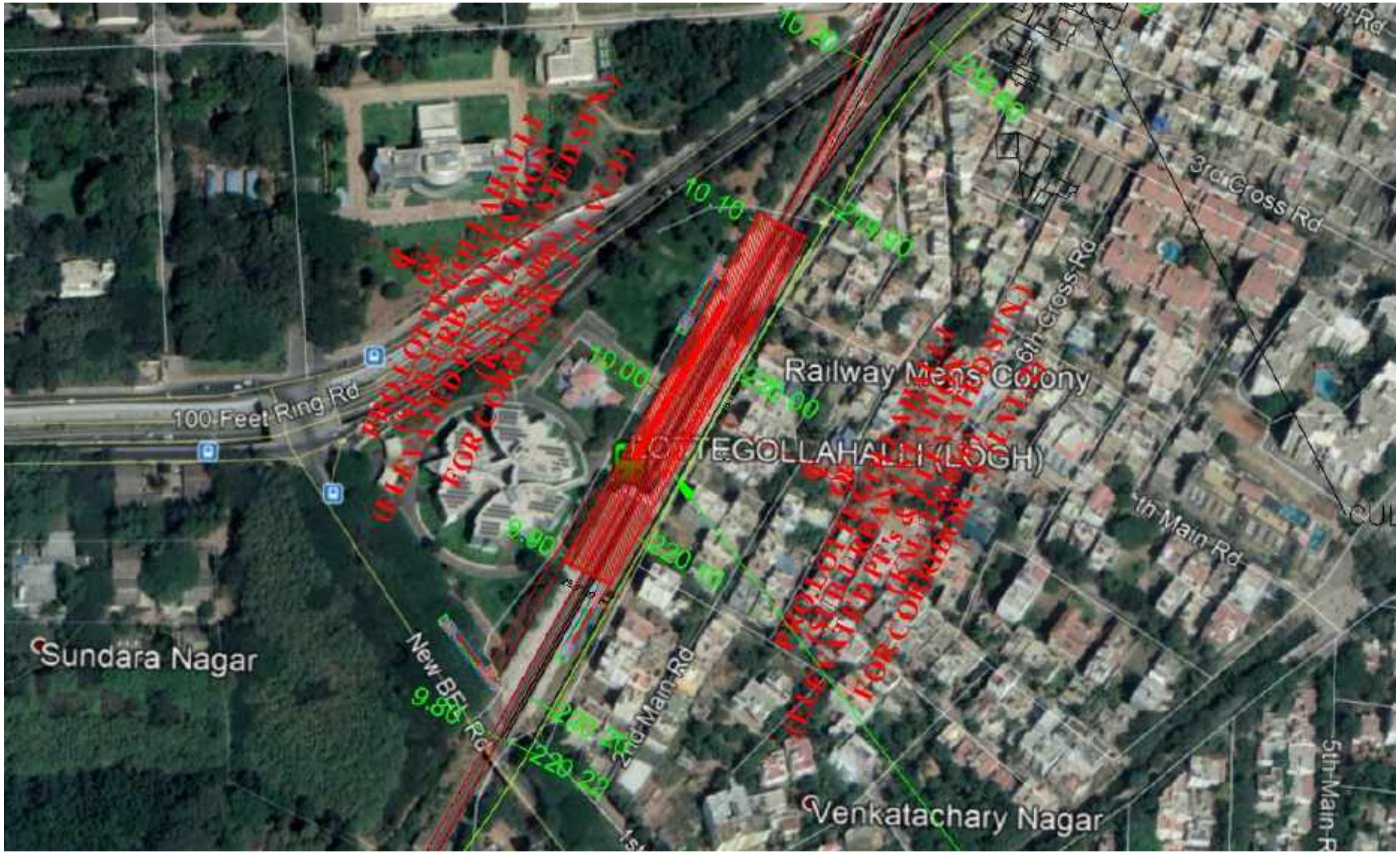


FIGURE 5.18 : PROPOSED LOTTEGOLLAHALLI STATION ON SITE



	
Existing Lottegollahalli Station	**Existing Parking at Lottegollahalli Station**
	
Existing Lottegollahalli inner view	**Another side of Lottegollahalli station**

5.4.5 MUTHYALANAGAR STATION

The station is on corridor KSR Bengaluru City to Devanahalli and it is a proposed station. The station has two side platform. The overall size of the station is 205m x 26m. At Northern side, it has two entry/exit, parallel to the station and approach from ground to concourse level. At Southern side one entry/exit placed in open space on ground. The station has two unpaid and one paid area at concourse level. The elevated station is on portal frame. The station planning is presented in **Figure 5.19, Figure 5.20, Figure 5.21** and **Figure 5.22.**

FIGURE 5.19 : PROPOSED MUTHYALANAGAR STATION (CONCOURSE LEVEL PLAN)

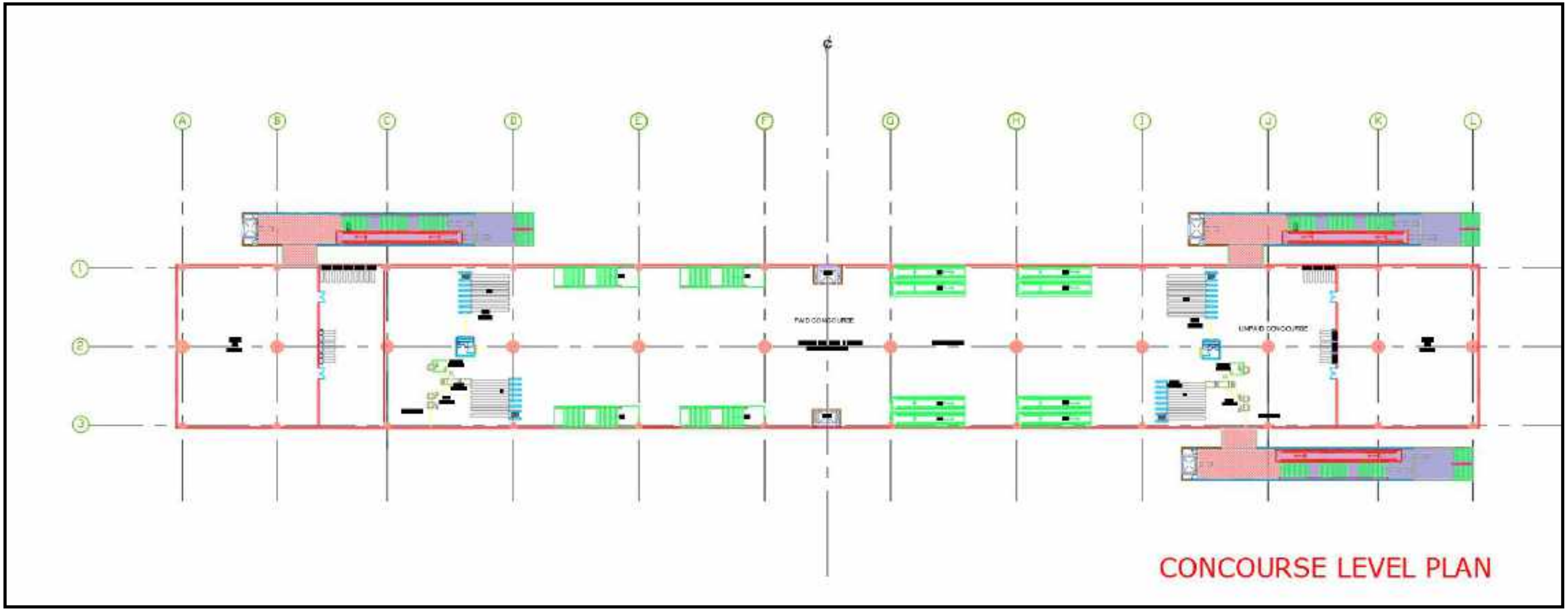


FIGURE 5.20: PROPOSED MUTHYALANAGAR STATION (PLATFORM LEVEL PLAN)

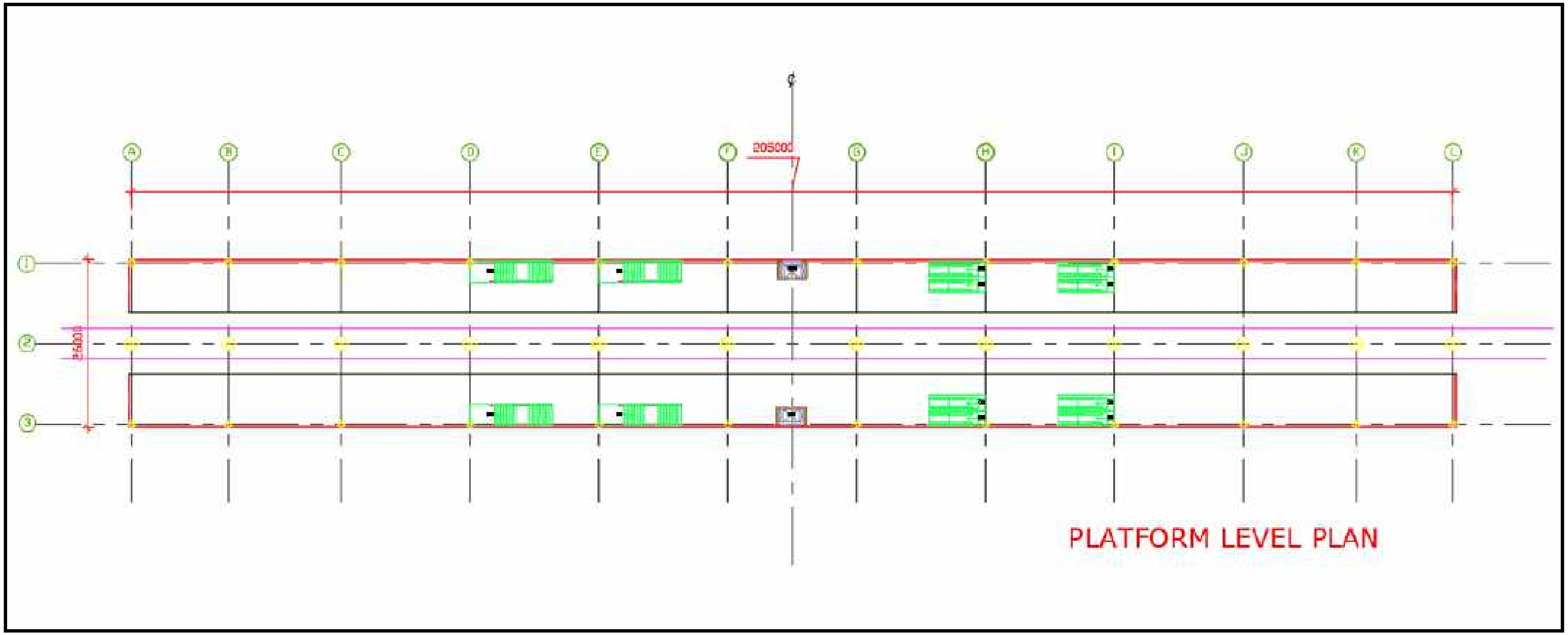


FIGURE 5.21: PROPOSED MUTHYALANAGAR STATION (CROSS-SECTION)

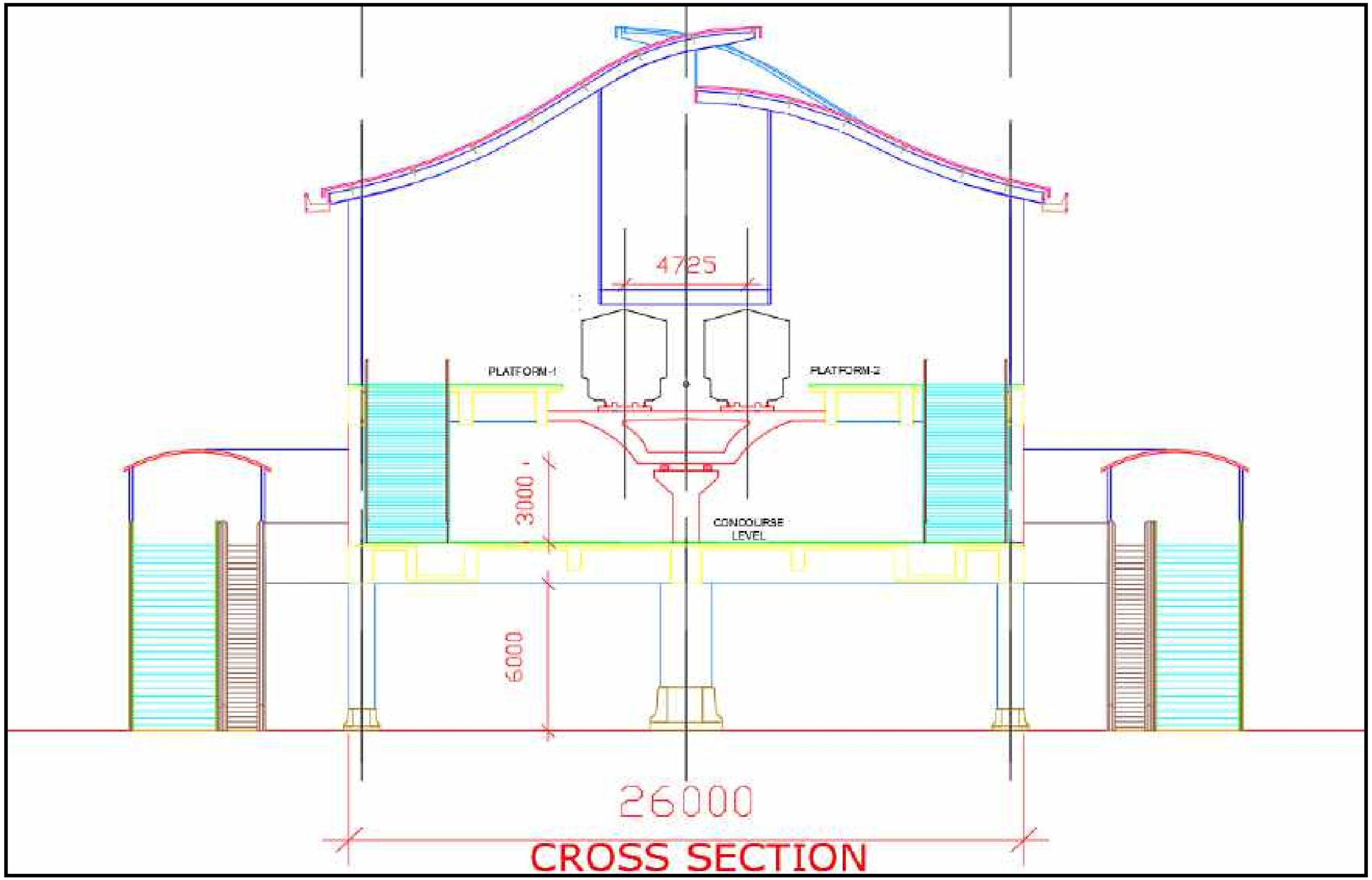


FIGURE 5.22 : PROPOSED MUTHYALANAGAR STATION ON SITE

	
Proposed Station Location	**Existing Underpass near Muthyalanagar Station**
	
Access Road to station	**Narrow Access Road to station**

5.4.6 CHIKKABANWARA STATION

This is the elevated suburban station of corridor Baiyyappanahalli to Chikkabanavara. The station has two side platform. The overall size of the station is 205m x 26m. At Northern side, it has two entry/exit, parallel to the station and approach from ground to concourse level. At Southern side, it has one entry/exit parallel to the station. The station has two unpaid and one paid area at concourse level. The elevated station is on portal frame. The station planning is presented in **Figure 5.23, Figure 5.24, Figure 5.25** and **Figure 5.26.**

FIGURE 5.23: PROPOSED CHIKKABANWARA STATION (CONCOURSE LEVEL PLAN)

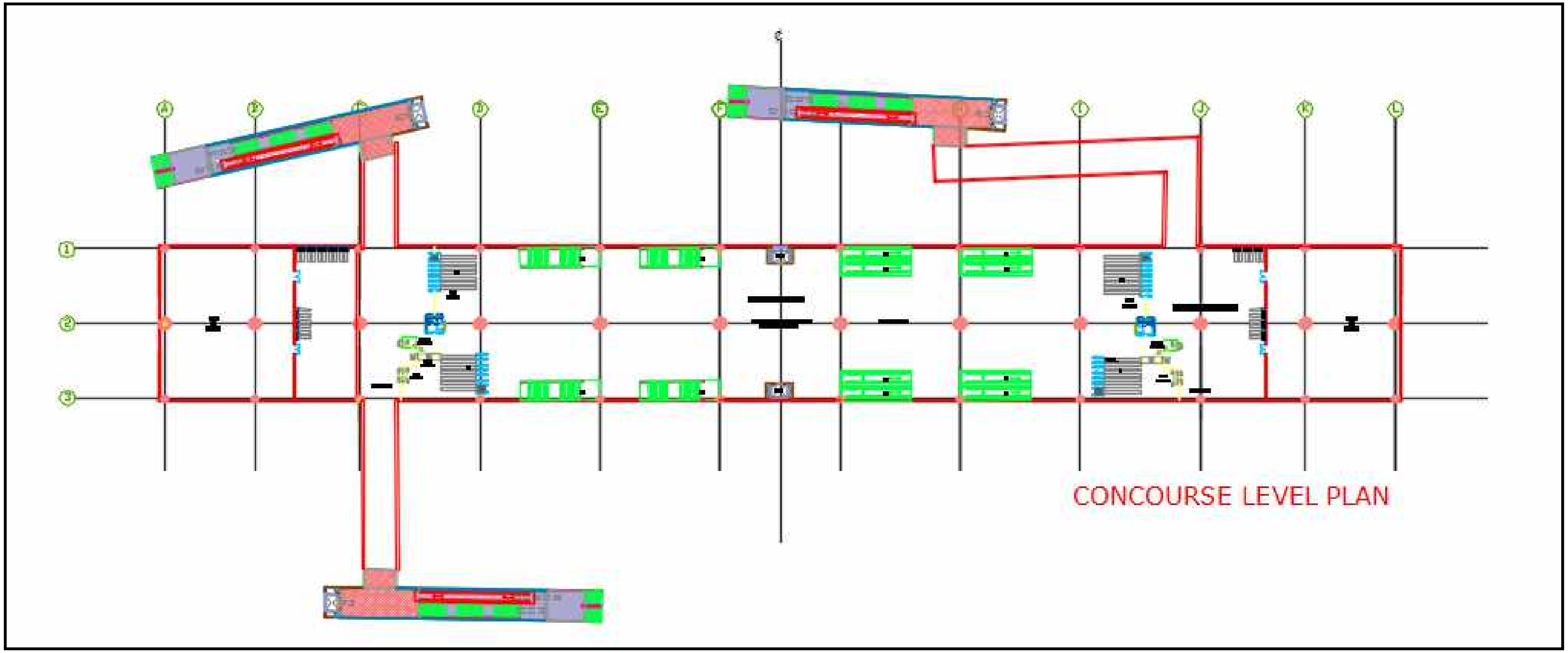


FIGURE 5.24: PROPOSED CHIKKABANWARA STATION (PLATFORM LEVEL PLAN)

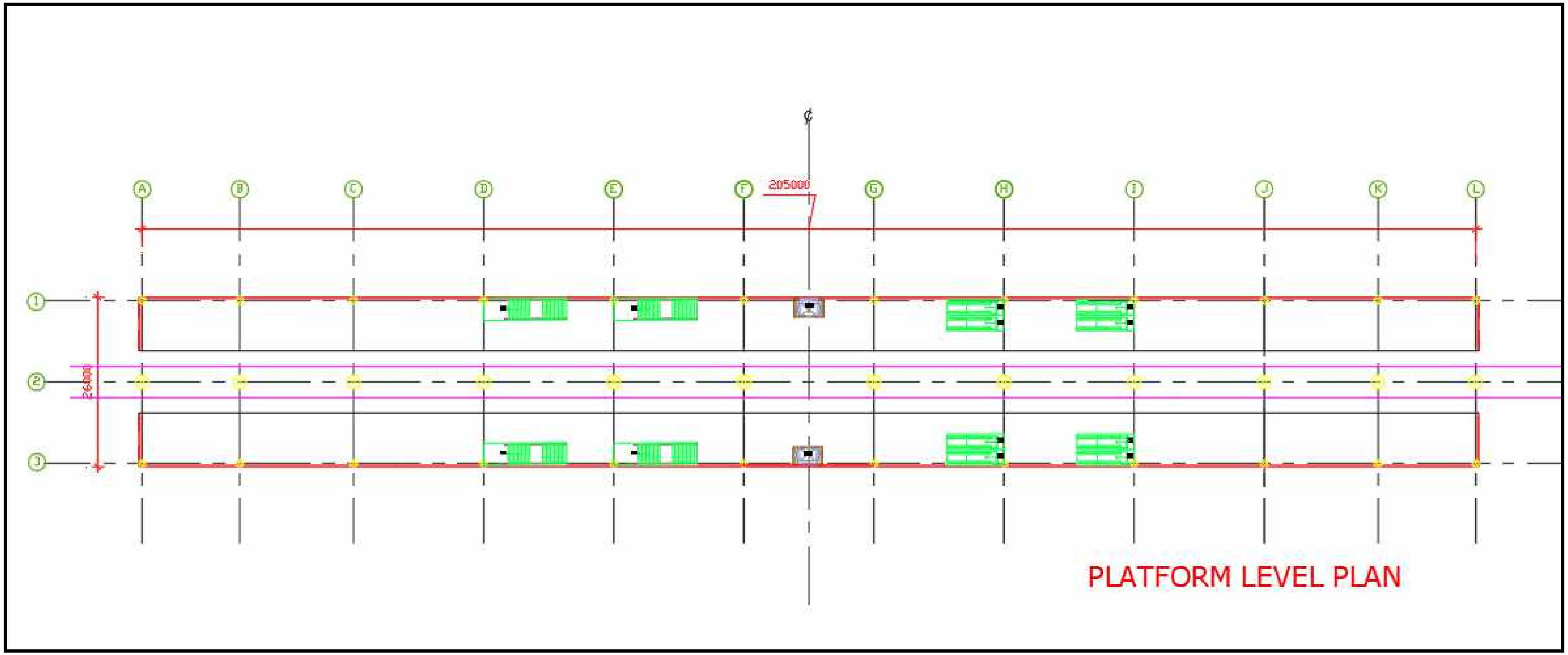


FIGURE 5.25: PROPOSED CHIKKABANWARA STATION (CROSS-SECTION)

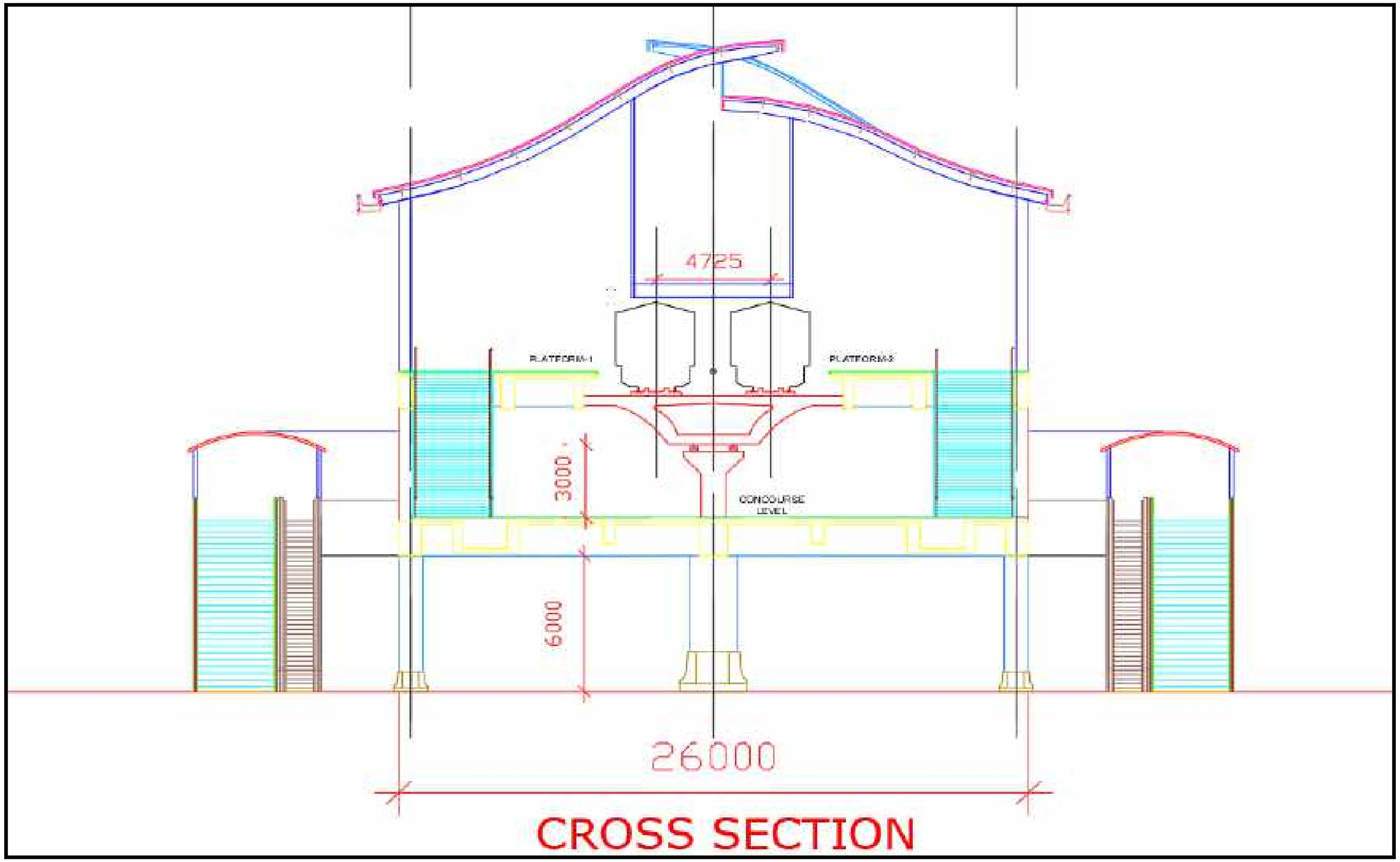


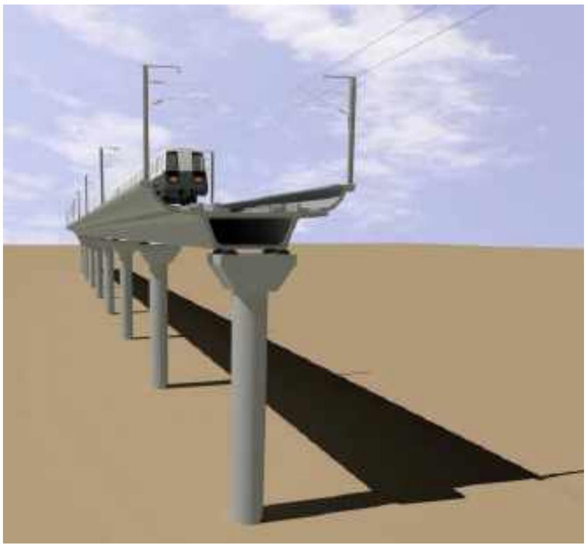
FIGURE 5.26 : PROPOSED CHIKKABANWARA STATION ON SITE

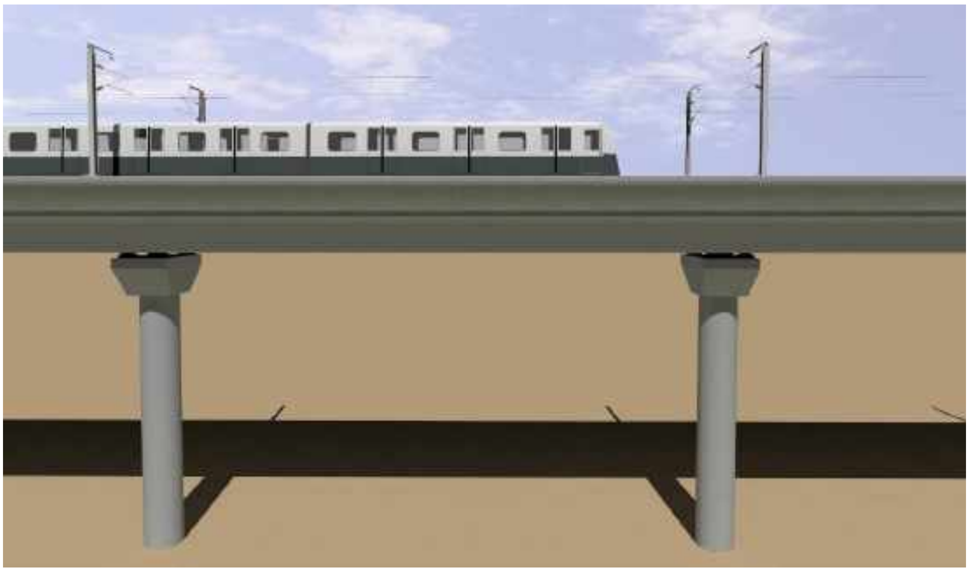
	
Existing Chikkabanavara Station	**Existing Parking at Chikkabanavara Station**
	
Existing Chikkabanavara inner view	**Existing FOB of Chikkabanavara station**

5.5 ARCHITECTURAL DEFINITIONS

5.5.1 VIADUCT ARCHITECTURE

The viaduct profile is designed to satisfy engineering and aesthetic criteria. It is slightly curved in order to lighten the feeling of a massive civil work, very visible from all side. It will be painted in order to provide a uniform appearance from outside, and to enhance the curb smoothness.



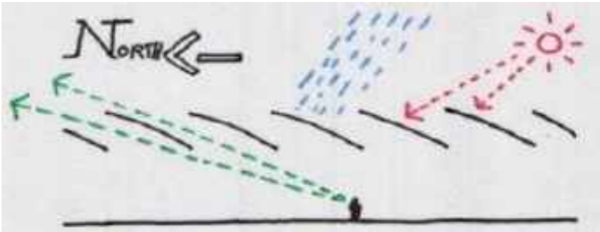


5.5.2 ROOF AND ELEVATIONS

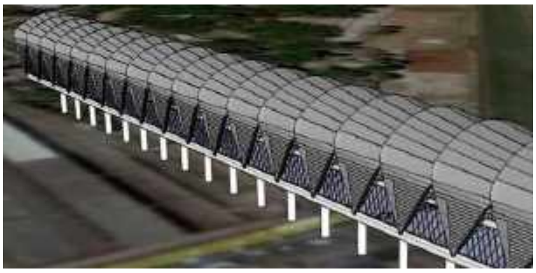
The roof is the most visible part of the station from the surroundings. At about 20 to 26 m height, the roof will be the iconic signature of the station identity. It has to reflect the modern and contemporary values of the new line, while being human scaled and properly sized to offer visual comfort for users.

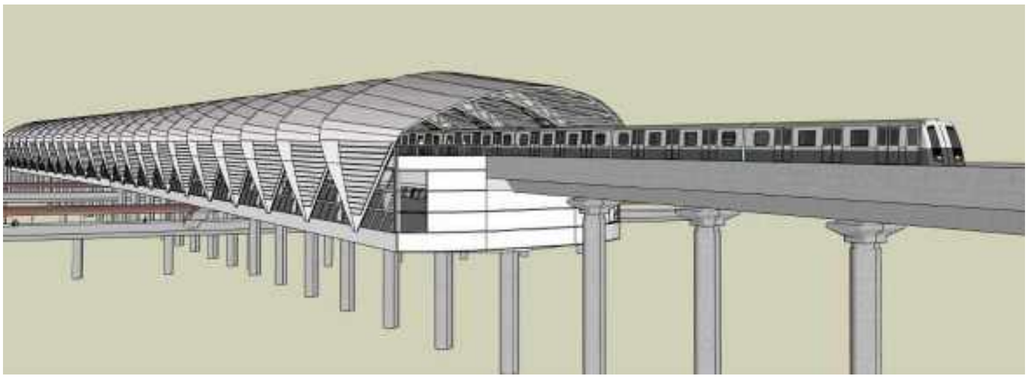
Two types of roof concept for elevated stations are proposed;

The single shell: A set of triangle modules of 15 m span, slightly inclined on the top, and chasing the soft northern light, while being closed to the south side, to protect from the sunlight and harsh shower of monsoon season.

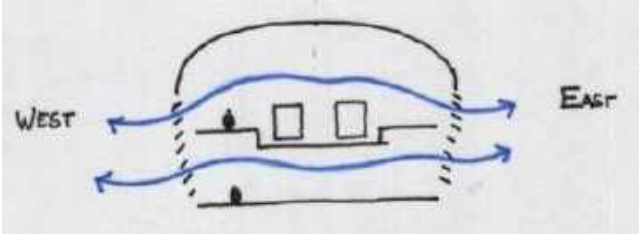


In addition, the modular pattern could be easily adapted to the curvy layout of many of elevated structures.

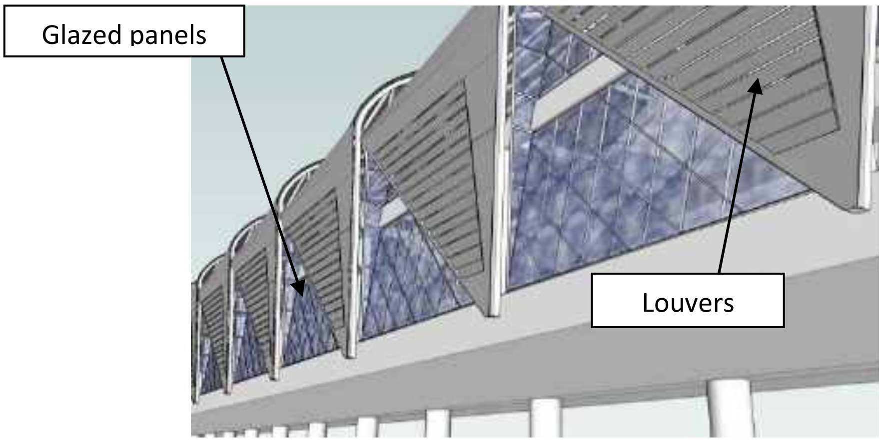


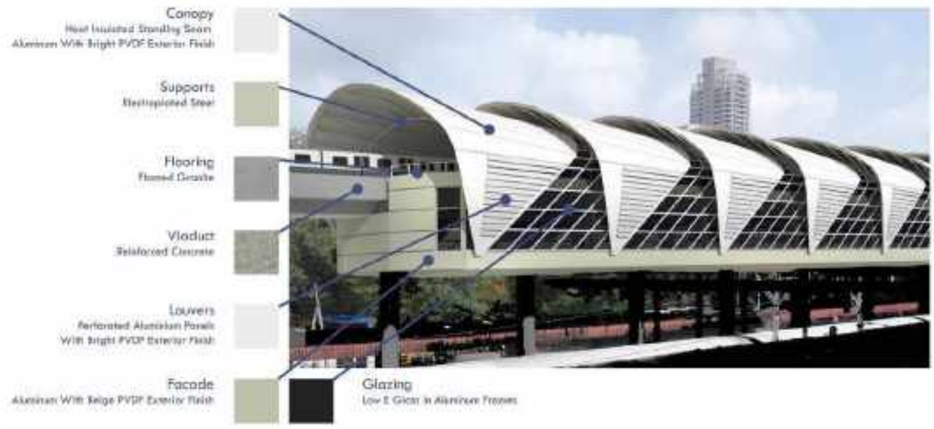


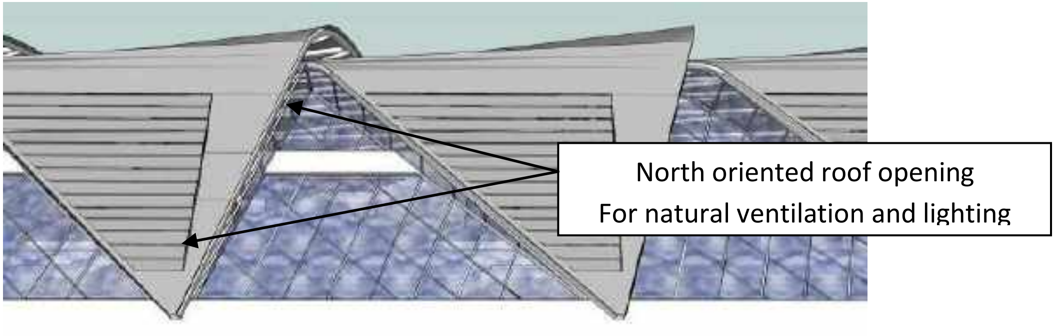
Natural ventilation on platforms and concourse area is ensured through louvers embodied in the lateral side of each module.



In the spare space between two modules, a glazed façade could be erected to protect laterally from the elements. Further detailing during implementation can improve some of the opacity of the glazed panels to the natural light and air flows.



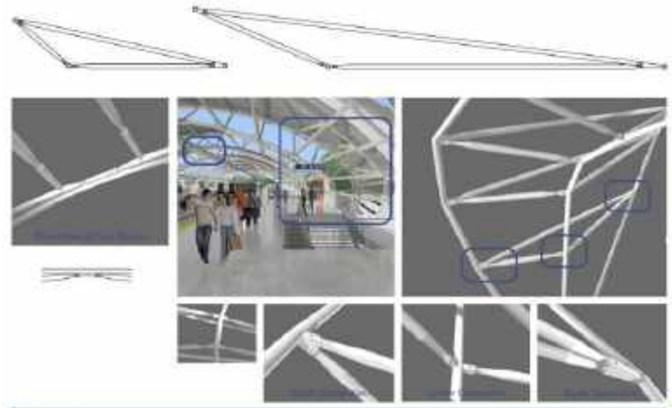




Platform View to North

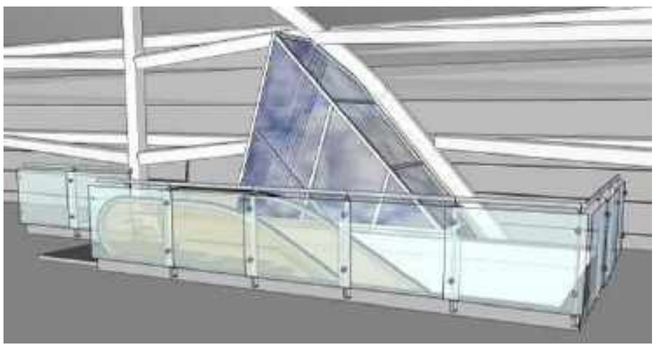
Platform View to South

The void between two roof modules will be occupied by a glazed façade which also laterally protects the concourse underneath.



The alternate rhythm of open and closed panels regulates the light and the natural air flow.

Thus, the station offers a comfortable platform space for the high profile passengers expected to use the new train service for their daily commute.

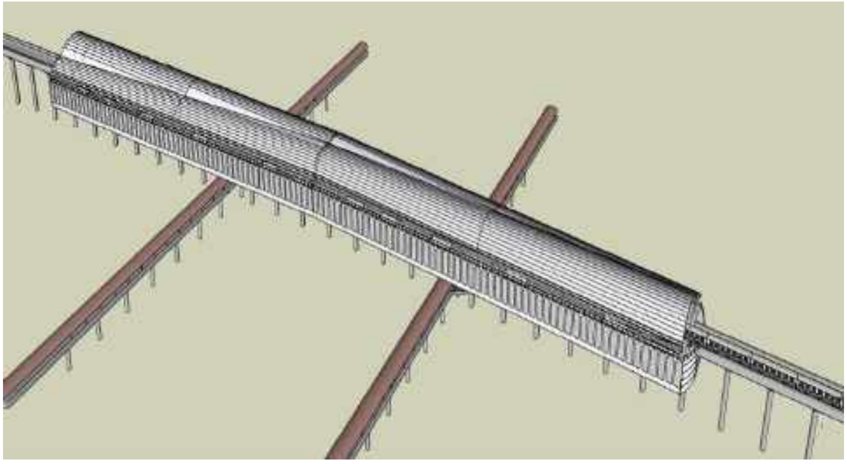


Vertical circulations adjacent to the façade follow the rhythm of glazed façade. It ensures a continuous view to the surroundings.

MRT Exhibition Station in Singapore : A high Cost Example of Signature Roof

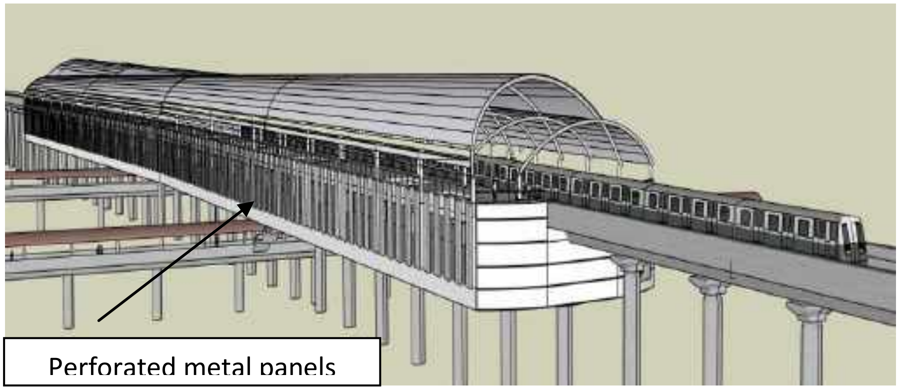
The Merging Loop option is a second version proposed for transit station. The concept represents a figure of cross connection, and dynamism of exchange between two systems.

The merging loop applied in Andheri, Mumbai



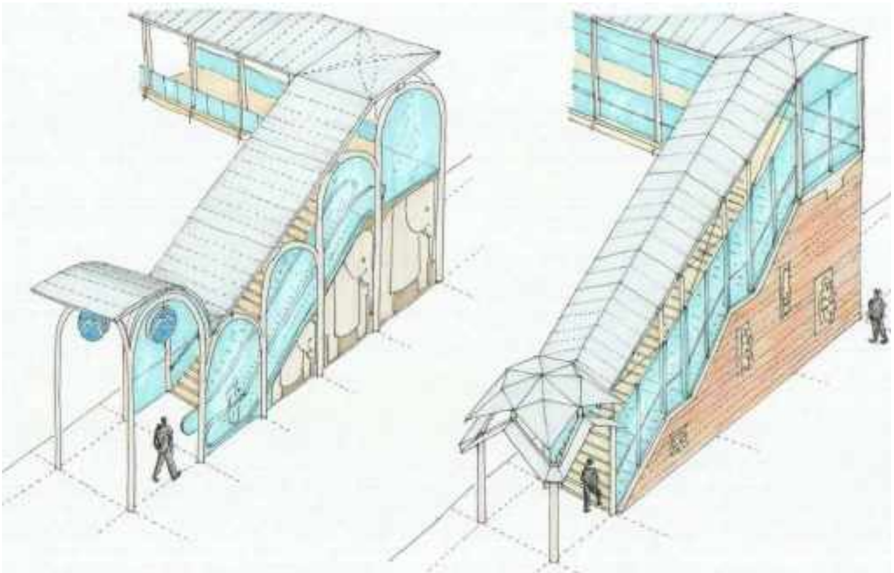
Bird eye view of the Merging Loop option

The concourse elevation will be designed with vertical perforated panels, in order to ensure the same level of natural ventilation and lighting than the single shell option.



Perforated metal panel, for the concourse elevation in the merging Loop option

Similarly, entrances for above ground stations should provide lateral protection from the rain and wind, while being part of the urban scenery. They might be identifiable, but in fusion with the urban fabric.



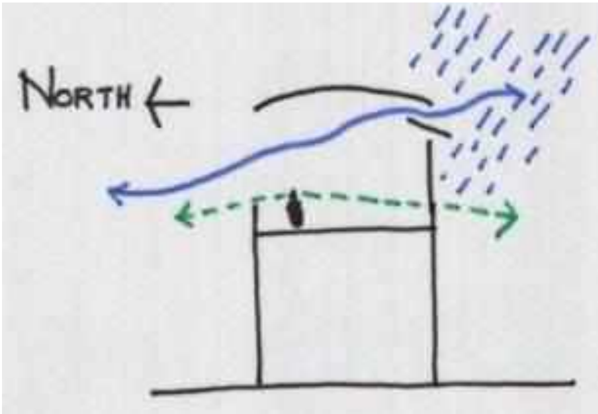
BTS entrance-Bangkok

5.5.3 FOOT OVER BRIDGES

New FOBs would be entrance and exit gates for the elevated sections of the proposed corridors. In that regard, they have to provide all the necessary comfort, and space quality required for such a level of service.

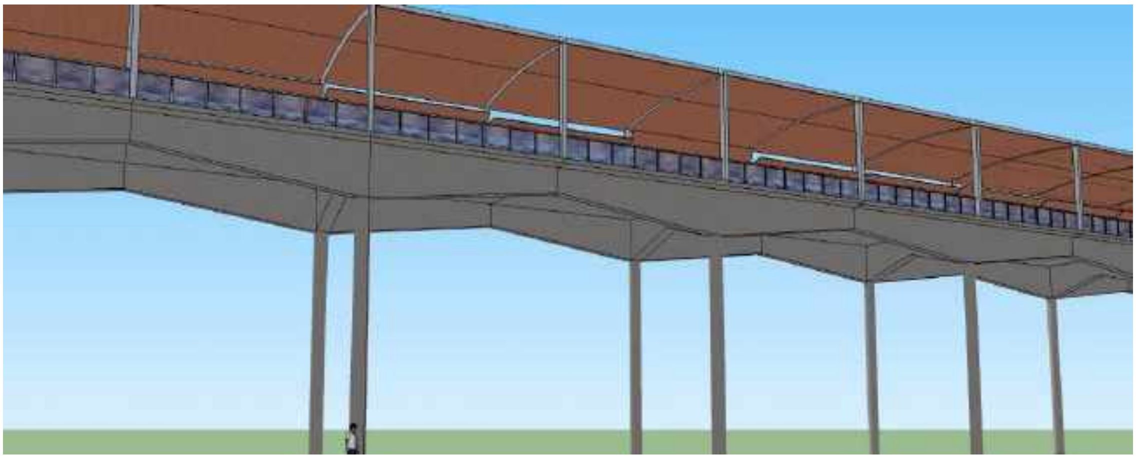
The width is sufficient to provide a maximum of comfort for passengers flow. Architectural concept of this structure is based on open view from the footbridge to track yard, in order to avoid the claustrophobic sensation of an enclosed corridor.

The south elevation is glazed to a certain height, to protect from the elements; and open in the upper part to ensure natural ventilation.

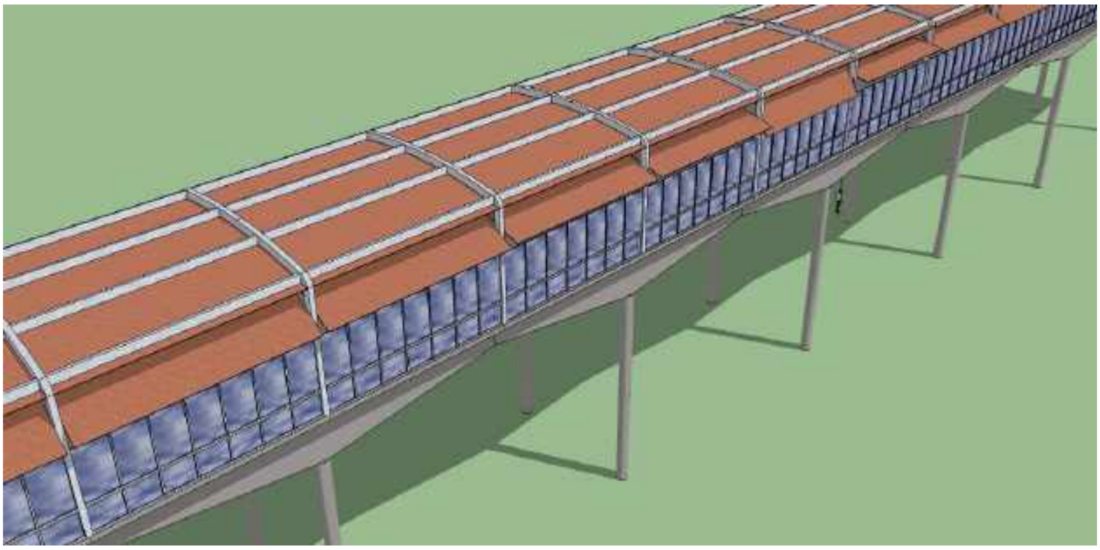


Interior view of FOB at upper level

North elevation of FOB from Track yard level

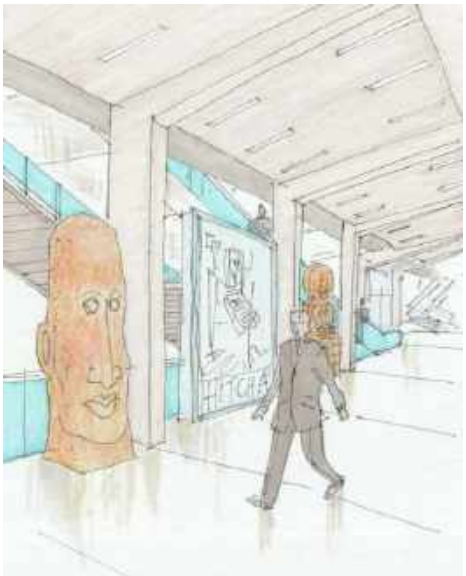


North elevation of FOB from Track yard level



Bird eye view of FOB's South elevation

5.5.1 FINISHES



The choice of finishing materials is intended to satisfy the following criteria:

- The material should be locally and readily available.
- The material should be strong and should be able to withstand rough use.
- The material should be economical and easy on maintenance.

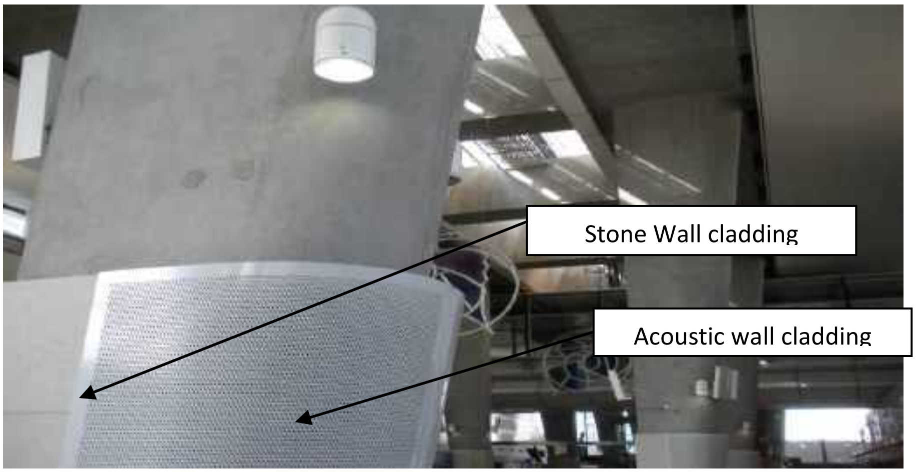
The proposed finishes on various elements in different spaces are:

Floor Finishes:

Space	Floor Finish
Public spaces	Vitrified tiles / polished Granite stone.
Public Staircases	Flamed granite treads and polished granite risers.
Fire escape (internal) and Utility rooms	Polished Kota stone.
Operational Rooms:	
Signalling rooms	False Floor
Electrical Rooms	IPS with surface hardener.

Wall Finishes:

Space	Wall Finish
Inside Rooms	Plaster with distemper / emulsion paint.
Public Areas	Polished Granite, Stainless Steel, Vitrified tiles and paint at levels.
External	Sand stone at lower level and washed grit at upper level.



Acoustic wall cladding could be combined with stone, above the structure bare facia.

Ceiling Finishes:

Space	Ceiling Finish
Public Areas	Lay-in-modular-tiles of sheet metal are proposed for easy removal and fixing during maintenance even by 'non-experts'.
Operational Rooms: Signalling & UPS	Lay-in-modular-tiles in mineral fibre have been proposed.

Acoustic panels with open joints to allow leakage point to be identified, if any above - recommended for the Concourse area.

Perforated metal panel are proposed to be used for the finishes of the inner face of the platform roof.

Finishes in the Public Toilets

Building Element	Finish
Walls	Ceramic tiles Dado with painted plaster on top.
Floors	Matt finish ceramic tiles.
Ceilings	Painted plaster

6. INTERMODAL INTEGRATION AND DISPERSAL FACILITIES

6.1. CONCEPT

6.1.1. INTRODUCTION

A public transit system will be able to function seamlessly if there is convenient and efficient intermodal integration. The suburban rail network will have to be provided with enhanced convenience of interchanging facility with other transport modes for better mobility and reduction in travel time for commuters. Interchange facility with secondary/intermediate transport modes is important for seamless transfer of commuters. Intermodal integration is planned to provide first and last mile connectivity for commuters.

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

Intermodal integration depends on many factors such as nature of station (terminal or en route), its catchment, availability of access/dispersal modes, and interchange with other mass transport, distance from station, trip length and destination. This includes planning for roads, footpaths/pedestrian facilities, bus stops, IPT stands, parking for different modes, pick and drop areas etc.

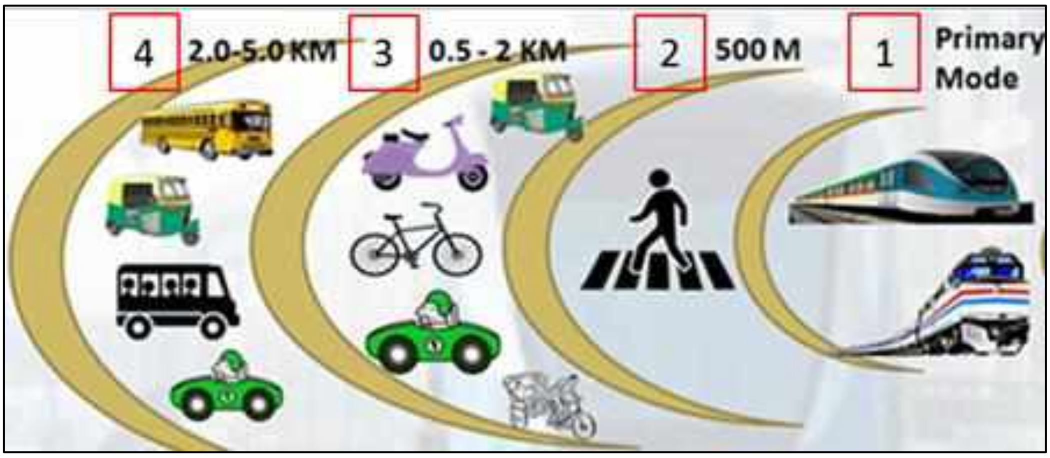
The proposed system will be accessed by passengers coming from different areas by different modes. In order to provide seamless connectivity, the system has to be well integrated with:

- Other transit modes (metro, bus, etc.)
- Pedestrian facilities
- Public modes (IPT, PT, NMT)
- Private modes (bicycle, two and four wheelers)
- Parking facility for Park and Ride

6.1.2. MODE AND ITS CATCHMENT

The proposed system can be connected to multiple modes depending on the catchment area it has to cater to. Primary transit modes must be integrated with each other for a seamless travel experience. The preferable mode choice to be opted for access/dispersal to/from the nearest station to the surrounding neighborhood can be classified based on the distance of catchment from the station area (**FIGURE 6.1**).

FIGURE 6.1: INTERMODAL INTEGRATION WITH DIFFERENT MODES IN THE CATCHMENT AREA



a. INTEGRATION WITH MODES OF URBAN TRANSPORT (DIRECT INTERCHANGE)

Integration of the suburban system can be provided with major urban transport modes like railways, metro, airport, bus station/terminal, etc. It is preferable to connect the other major transport system(s) with the suburban system for serving a larger catchment. The integration with railway station, bus terminal and airport help serve the city wide catchment.

b. CONNECTIVITY TO IMMEDIATE CATCHMENT OF 500M

The idea behind providing a good connectivity of station area by footpaths and walkways is to encourage pedestrian movement. The catchment within 500m should have good connectivity for pedestrians through footpaths, skywalks, etc. For smooth movement of pedestrian, all the footpaths in the suburban station influence zone should be considered to be upgraded along with skywalks (wherever necessary).

c. CONNECTIVITY WITHIN 500M - 2KM

In absence of proper feeder modes and network, commuters tend to shift towards private modes. Therefore, feeder planning should be done in a way that there is minimal requirement and use of private modes. Each station should be planned with the provision of infrastructure that supports the use of feeder public transport over private modes. However, planning for private vehicle pick/drop and parking should also be done for inclusive planning.

Auto Rickshaws/Mini Buses

IPTs are one of the main modes of commuter transport over short and medium distances. It is therefore, imperative that suitable bays for boarding and alighting of commuters are proposed near the entry/exits of the stations.

Bicycle

Commuters within 2km radius from the station area can use bicycle as mode to commute if provided with proper infrastructure and parking facility.

Private modes

Commuters should be able to access the station by means of private vehicles like two and 4-wheelers. Therefore, proper pick and drop bays should be provided in the station area. The road geometry and network must be proper for easy access to station area. Station should also be planned with private vehicle parking in order to facilitate park & ride.

d. CONNECTIVITY WITHIN 2 – 5KM

Mini Bus

If commuters are to be attracted towards using suburban system from areas within 5km radius, proper feeder bus network needs to be planned. The bus service must be of high quality and the network should be well planned. The bus stops should be close to the station entry/exit to increase footfall.

Auto Rickshaws and Private modes

The provision for these modes needs to be made in the station area as the probability of using these modes increases as the distance from the station area increases.

6.1.3. PRINCIPLES OF INTEGRATION

The planning principles taken into account for intermodal integration at the station locations are as follows:

- Seamless connectivity to and from catchment area of the station - Passenger movement from the station area to the nearby land use to be seamless i.e. obstruction free movement.

- Integration with all possible modes including other mass transport systems - The transit system is to be well integrated with other transit modes, PT modes, IPT modes, private modes and walk.

- There should be an integrated ticketing system to simplify the transfer between different transport modes. Smart Card ticketing facilitates a genuinely seamless multimodal transport system.

- Priority to pedestrians followed by public transport - To provide convenient and safe access to pedestrians to the station area and vicinity and to promote walkability.

- Minimizing pedestrian/vehicle conflict - Proper design of circulation area adjoining the station building to ensure rapid/ efficient dispersal of the passengers and avoiding conflicts between pedestrian and vehicular traffic.

- Provision of pick/drop and parking facilities for all modes- Station area with adequate parking space, designated space for embarking and disembarking for vehicular traffic (pick-drop zones) and feeder modes like bus, IPTs and NMT.

- Disabled friendly design considerations

6.1.4. MEASURES FOR PLANNING PROPER INTEGRATION

The following measures are taken while planning intermodal integration facilities so as to obtain the desirable results.

1. **Augmentation of Road Geometry & Footpaths:**

   - By utilization of complete RoW to cater to the future traffic volume. The existing road shoulder areas and service lanes may be augmented/ strengthened, wherever possible.

   - By providing continuous, encroachment free and well maintained footpath on major roads near station locations.

2. **Seamless connectivity/Effective Passenger Interchange with Feeder Modes:**

   - By proper planning and design of station circulation in order to ensure rapid/efficient dispersal of passengers, avoiding conflict between pedestrians and vehicular traffic.

   - By provision of well-planned station entry/exit keeping in view the major growth centers/activity areas and integrate the station with existing/ proposed bus stops/bus bays, pick-drop zones and IPT services within walking distance.

   - By provision of demarcated pick and drop zones and bays for feeder modes like buses, IPT near the station.

- By providing off street parking wherein adequate land is available for encouraging park and ride. The existing on-street parking can be moved to these parking lots for availability of total carriageway for vehicular movement.

3. **Uninterrupted Traffic Flow/Smooth Traffic Conditions:**

- By relocation of vendors/hawkers and parking for unobstructed movement of pedestrians and vehicles, wherever possible.

4. **Pedestrian & Disabled Friendly Design:**

- By facilitating passenger interchange with linkages like subways, skywalks, covered walkways etc. in order to reduce the passenger travel time and pedestrian load on the roads.
- By provision of well-designed junctions and intersections with proper pedestrian crossings. Design table top crossings wherever possible, otherwise ramps with gentle slope may be designed for pedestrians and wheelchair users. Tactile paths and strips may be provided in the design to facilitate the visually impaired.
- By providing proper road markings, traffic signages, Zebra crossings and pedestrian signals to provide safe and uninterrupted pedestrian movement.

6.2. PROPOSED SUBURBAN RAIL CORRIDORS

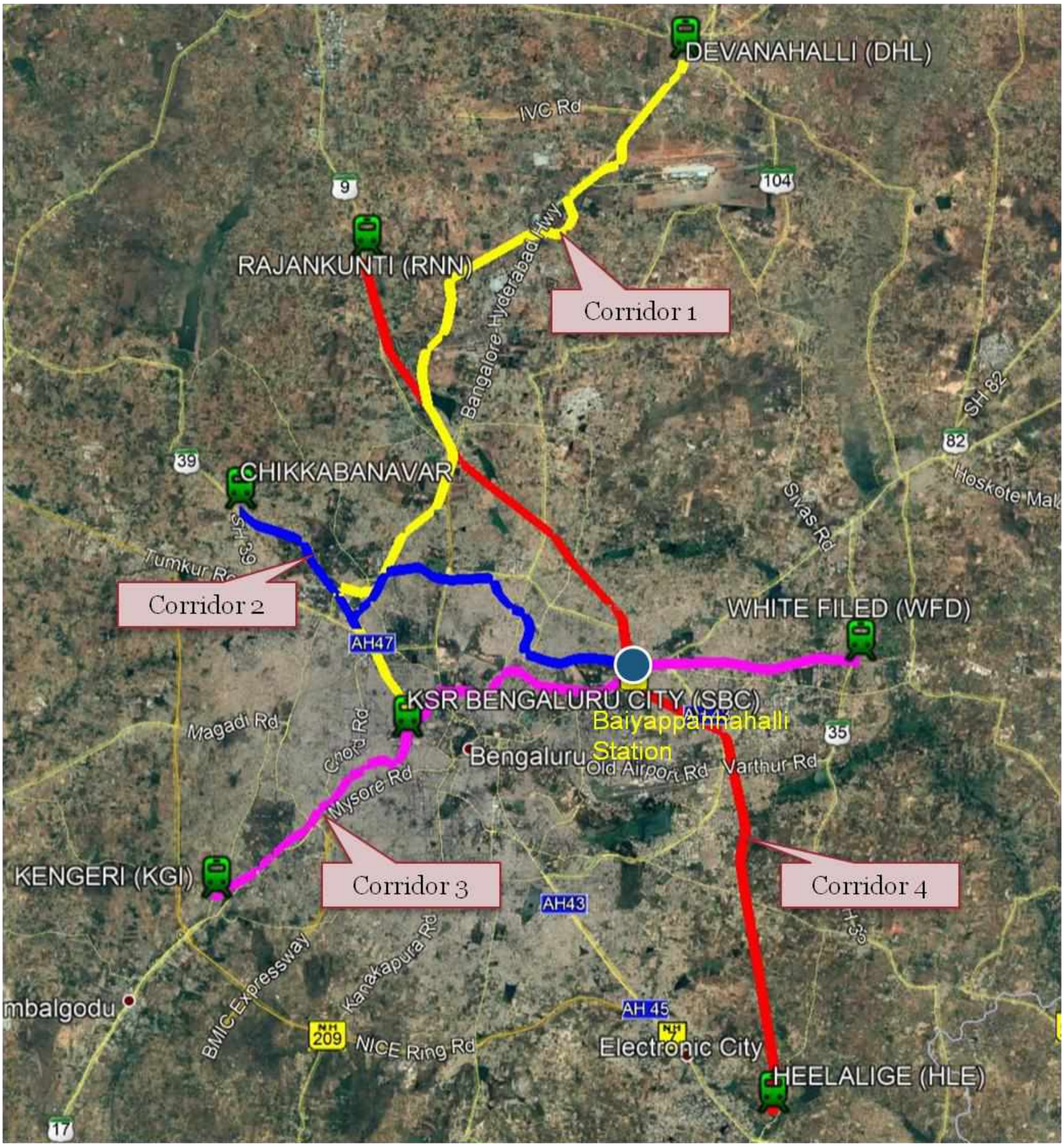
Proposed Bengaluru Suburban Rail Network has four corridors with total length of 147 Km. It mainly serves the long distance trains and suburban services to some extent. For enhancing the suburban services, two dedicated tracks have been proposed along the suburban rail network exclusively for suburban services. The proposed system will be broad guage and trains will be running on high frequency. The proposed system will have different fare structure with Automatic Fare Collection System.

There are about 6 important stations namely,

1. SBC
2. YPR
3. YNK
4. KJM
5. WFD
6. BNC

that will have interchange facilities between SRC – IR and 10 stations having SRC - Metro interchange. The map showing suburban network is given in **FIGURE 6.2**.

FIGURE 6.2: MAP SHOWING PROPOSED SUBURBAN RAIL NETWORK



Out of total 62 stations, 6 typical stations of different categories have been identified for planning and intermodal integration **(TABLE 6.1).**

TABLE 6.1: DETAILS OF IDENTIFIED STATIONS FOR INTERMODAL INTEGRATION

S. NO.	STATION NAME	CORRIDOR NAME	INTERCHANGE TYPE
1	Kengeri Station	Kengeri - Whitefield	Rail - Metro
2	Bengaluru City Station	Kengeri - Whitefield and Bengaluru City - Devanahalli	Rail-Rail & Rail - Metro
3	Bengaluru Cantonment Station	Kengeri - Whitefield	-
4	Lottegollahalli Station	Bengaluru City - Devanahalli and Baiyappannahalli - Chikkabanawara	Rail-Rail
5	Muthyalanagar	Bengaluru City - Devanahalli	-
6	Chikkabanawara	Baiyappannahalli - Chikkabanawara	

6.3. EXISTING TRAFFIC DISPERSAL ARRANGEMENTS

The existing mode-wise traffic dispersal facilities at the identified stations are presented in **TABLE 6.2.**

It is observed that apart from the walk, Buses and IPTs in the form of autos/ taxis are the other modes of traffic dispersal. Private vehicles and drop-offs also form a significant component of the feeder trips. The pictorial depiction of traffic dispersal and related issues are presented in the following sections.

TABLE 6.2: EXISTING MODE WISE TRAFFIC DISPERSAL FACILITIES AT IDENTIFIED STATIONS

Station	Side	Modes			
		Walk	Bus	Auto/ Taxi	Private Vehicles
Kengeri Station	East	No facility	No facility	No facility	No facility
	West	Footpath along Station Access Road	No Bus Stop	On street Auto Stand	Off Street Parking for 2-wheelers
KSR Bengaluru City Station	East	• Pedestrian Subway for connecting Bus terminal & Metro station • Footpathsat Station entries	• Kempegowda Bus terminal • BMTC Bus terminal	Off Street Auto/ Taxi Stand	Off Street Parking
	West	FOB connection to City Railway Station Metro Station	No facility	No facility	No facility
Bengaluru Cantonment Station	East	Footpath along Station Access Road	On street Bus Stop	On street Auto/ Taxi Stand	Off Street Parking for 2-wheelers & cars
	West	No facility	No facility	On street Auto Stand	Off Street Parking for 2-wheelers
Lottegollahalli Station	East	No facility	No facility	On street Auto Stand	On Street Parking for 2-wheelers & cars
	West	No facility	No facility	No facility	No facility
Muthyalanagar (Proposed)	East	No facility	No facility	No facility	No facility
	West	No facility	No facility	On street Auto	No facility
Chikkabanavara	East	No facility	No facility	No facility	No facility
	West	No Footpath along Station Access Road	On street Bus Stop	Off Street Auto/ Taxi Stand	Off Street Parking for 2-wheelers & cars

6.3.1. KENGERI STATION

Kengeri Station is the existing terminal station of the corridor Kengeri to Whitefield. The main access to the station is from west side through Kengeri Main Road. The access from east side is through minor roads. The major abutting land use surrounding the station is residential followed by institutional land use like SJR Kengeri Public School, Sheshadripuram College, Surana Management College etc. Kengeri Lake is located in close proximity to the station.

The proposed station will have interchange with Kengeri Metro station which is under constructed on the extension of E-W line.**(FIGURE 6.3)**

FIGURE 6.3: MAP SHOWING LOCATION OF KENGERI STATION

ISSUES

- The connectivity to the station from east side is poor.
- On-street parking of private vehicles and autos is observed on the carriageway and footpath of the main access road which reduces the carriageway capacity.
- Encroachments is also observed on the main carriageway

The existing pictures of Kengeri station and its surroundings are presented in **FIGURE 6.4.**

FIGURE 6.4: EXISTING PICTURES OF KENGERI STATION

	
Main Station Building on West Side	On-street parking of two wheelers & autos on station access road
	
Off-street parking of two wheelers	Access to station from east side
	
Under-constructed metro station near Kengeri railway station	BMTC bus terminal near metro station

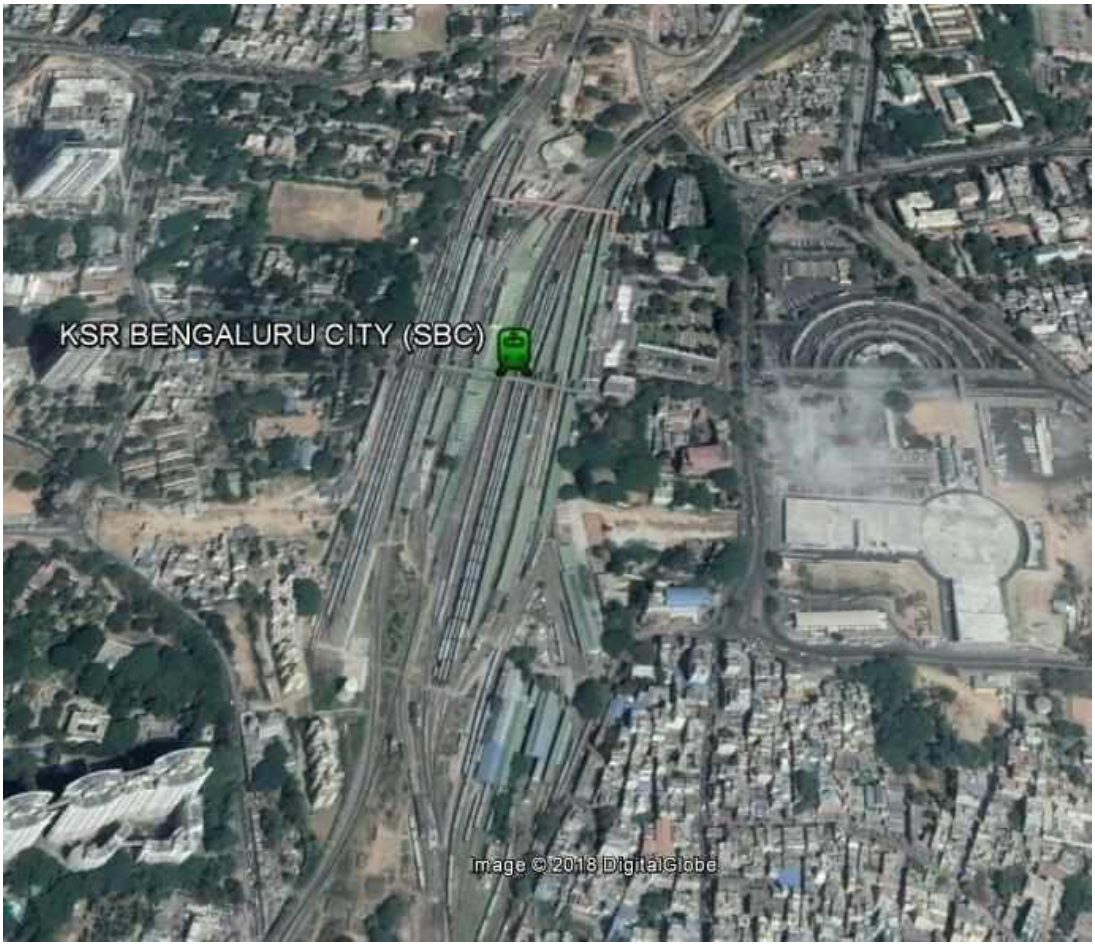
6.3.2. KSR BENGALURU CITY STATION

Bengaluru City station is a terminal station of the corridor 1 (KSR Bengaluru City - Devanahalli) and also lies along the corridor 3 (Kengeri - Whitefield). It is an interchange station of corridor 1 and 3. The station is accessible from east side through Gubbi Totadappa Chattra Road. There is no vehicular connectivity from west side.

Two metro stations are located in vicinity of the station. One is City Railway Station Metro Station on the west side which lies along Purple line metro (Mysore road to Baiyappanahalli) and other one is Majestic Metro Station on the east side which lies along Green line metro (Nagasandara to Yelachenahalli). Kempegowda Bus terminal and BMTC bus terminal & depot are located in front of the station where intercity and intracity buses terminate.

The predominant landuse on east side of the station is commercial and residential followed by public & semi-public on west side of the station. The map showing location of KSR Bengaluru City Station is presented in **FIGURE 6.5**.

FIGURE 6.5: MAP SHOWING LOCATION OF KSR BENGALURU CITY STATION



ISSUES

- There is a poor connectivity to the station from west side along with lack of pedestrian facilities
- On-street parking of private vehicles and autos is observed on the carriageway of the main access road.
- Heavy encroachments is observed on the carriageway of station access road.

The existing pictures of KSR Bengaluru City station and its surroundings are presented in **FIGURE 6.6.**

FIGURE 6.6: EXISTING PICTURES OF KSR BENGALURU CITY STATION

Access Road to Station from east side

Pedestrian Subway connecting Railway station with metro station and Bus terminal

Majestic Metro station in front of railway station

Bus terminal in front of railway station

FOB connection to City railway station metro station

Access to station from west side

6.3.3. BENGALURU CANTONMENT STATION

Bengaluru Cantonment Station lies along corridor 3 (Kengeri to Whitefield). The station is accessible through Cantonment Station Road from south side and Millers Road from north side.

The predominant land use along north side of the station is residential and public and semi-public land use along south side. The public land use includes Veterinary Hospital, Church of South India Hospital, HKBK Degree College, Stadium etc. The map showing location of Bengaluru Cantonment Station is presented in **FIGURE 6.7.**

FIGURE 6.7: MAP SHOWING LOCATION OF BENGALURU CANTONMENT STATION

ISSUES

- Pick drop of Autos and taxis is occurred on the access road. There is no segregation of pick drop.
- At grade pedestrian crossing to reach the station from car parking area increases the pedestrian vehicular conflicts.

The existing pictures of Bengaluru Cantonment station and its surroundings are presented in **FIGURE 6.8.**

FIGURE 6.8: EXISTING PICTURES OF BENGALURU CANTONMENT STATION

	
Access Road to station from south side	Car parking area in front of the station
	
Taxi stand in front of the station	Station Access from north side
	
Access Road to station from north side with on street parking	Off street parking for two wheelers

6.3.4. LOTEGOLLAHALLI STATION

Lotegollahalli is an interchange station of corridor 1 (KSR Bengaluru City - Devanahalli) and corridor 2 (Chikkabanawara - Baiyappanahalli). The station is only accessible through minor road from the east side. There is no vehicular and pedestrian access from west side.

The predominant land use along east side of the station is residential and industrial land use along west side. Bharat Electronics Limited (BEL) Nalanda Campus is located in front of the station. The map showing location of Lotegollahalli Station is presented in **FIGURE 6.9.**

FIGURE 6.9: MAP SHOWING LOCATION OF LOTEGOLLAHALLI STATION

ISSUES

- No vehicular and pedestrian access to the station from Outer Ring Road on west side.
- Station Access Road is very narrow on the east side which hinders the smooth traffic flow
- On street parking of cars and two wheelers is observed on the access road

The existing pictures of Lotegollahalli station and its surroundings are presented in **FIGURE 6.10**

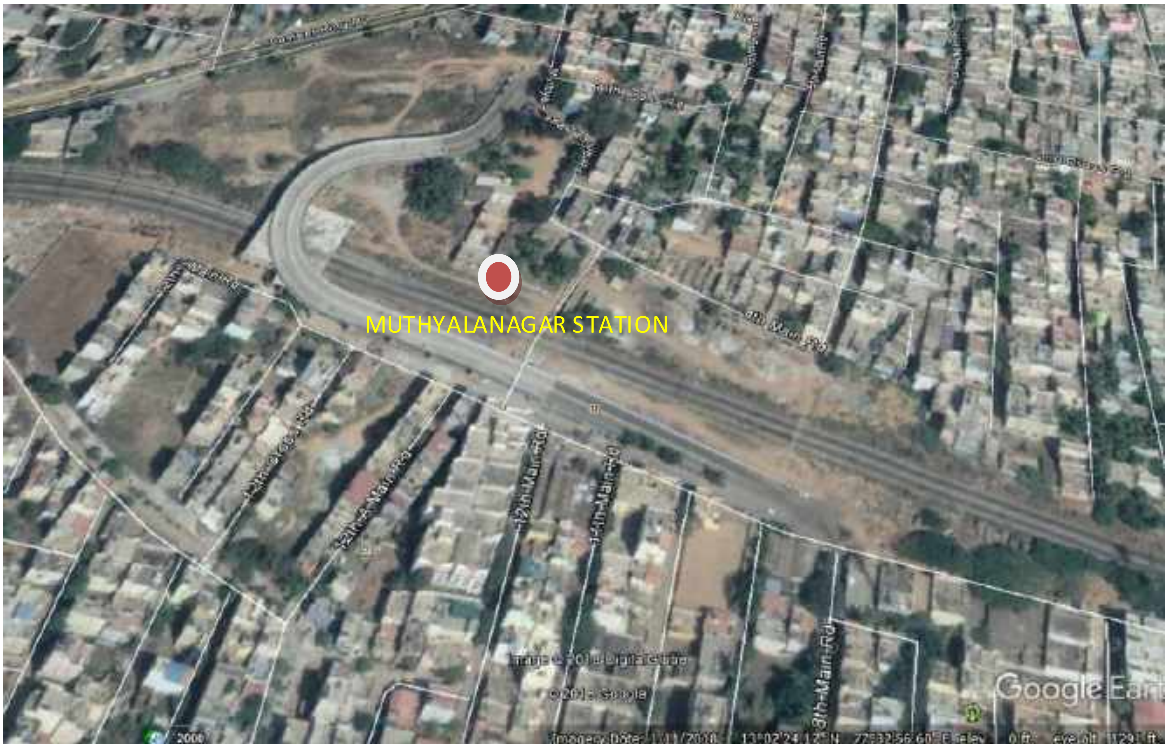
FIGURE 6.10: EXISTING PICTURES OF LOTEGOLLAHALLI STATION

	
Only access to station from east side	On street parking of two wheelers along access road
	
BEL Campus on west side but no access given from this side	Narrow access road from east side
	
Foot Over Bridge at the station	On street Car parking along access road

6.3.5. MUTHYALANAGAR STATION

Muthyalanagar station is a proposed station along corridor 1 (KSR Bengaluru City - Devanahalli). The proposed station is accessible through 19th Cross Road from the west side and 1st A Cross Road from east side. The predominant land use along both the side of the station is residential. The map showing location of Muthyalanagar Station is presented in **FIGURE 6.11.**

FIGURE 6.11: MAP SHOWING LOCATION OF MUTHYALANAGAR STATION



ISSUES

- Narrow access roads to proposed station
- Lack of footpath along the station access road
- Existing underpass is very narrow which restrict the smooth traffic flow

The existing pictures of Muthyalanagar station and its surroundings are presented in **FIGURE 6.12.**

FIGURE 6.12: EXISTING PICTURES OF MUTHYALANAGAR STATION LOCATION

Proposed Station Site

Access Road to station from east side

Existing Underpass connecting east and west side

Narrow Access Road to station from west side

6.3.6. CHIKKABANVARA STATION

Chikkabanawara is an existing station along Corridor 2 (Baiyappannahalli - Chikkabanawara). The station is accessible through Hesarghatta Main Road from west side and through some minor road from east side. The predominant land use along both the side of station is residential. The map showing location of Chikkabanawara Station is presented in **FIGURE 6.13.**

ISSUES

- There is a poor connectivity from east side of the station. Station access road is Kutcha road with bad condition.
- No access/ dispersal facilities planned on east side of the station
- Lack of pedestrian facilities along station access roads

FIGURE 6.13: MAP SHOWING LOCATION OF CHIKKABANAWARA STATION

The existing pictures of Chikkabanawara station and its surroundings are presented in**FIGURE 6.14.**

FIGURE 6.14: EXISTING PICTURES OF CHIKKABANVARA STATION

	
Station access road from east side	Off street parking on west side of the station
	
Station access road from west side	Encroachments observed on station access road from west side

6.4. PROPOSED TRAFFIC DISPERSAL AND CIRCULATION PLANS

The stations on the proposed Corridors will be suitably integrated with the existing sub-urban stations. With the increase in passenger traffic dispersing via the road network for their feeder trips, it is vital that adequate traffic dispersal facilities are available at these integrated stations in terms of capacity of roads, footpaths/ pedestrian facilities, bus stops, IPT stands, Pick-Drop Areas and Parking to cater to the projected requirements.

The proposed conceptual traffic circulation and intermodal integration plans around the six identified stations are presented in the subsequent sections.

6.4.1. KENGERI STATION

The main access to the station is from west side through Kengeri Main Road which is about 12m wide. At present, pick drop and parking of autos and private vehicles is occurring on the access road. Therefore, pick drop and parking of autos and private vehicles have been proposed on the existing 2 wheeler parking area.

From the east side, station is accessible through minor roads with 7- 9 m width. One way movement of vehicles has been proposed to reach the station. Pick drop bays have been provided in front of the station building. Parking for private vehicles has been proposed on the vacant land in front of the station building. BMTC Bus terminal and under-construction Metro station are located 500 m away from Kengeri station. The station has been proposed to be integrated with metro station and bus terminal. A skywalk has been proposed to connect the proposed station with metro station and bus terminal.

The conceptual intermodal integration plan for Kengeri Station is shown in **Annexure 6.1**.

6.4.2. KSR BENGALURU CITY STATION

KSR Bengaluru City station is a major station in the city for serving long distance trains and it is also an interchange of two corridors of suburban services. Proper integration of all the modes accessing and dispersing the station is very essential to ensure efficient traffic dispersal and circulation around the station areas.

The vehicular connectivity to the station is provided only from east side. Parking facility is given in front of the station building for private vehicles and IPTs (Auto and taxis). The pick drop bays for private vehicles (cars & two wheelers), Auto and taxis have been provided in addition to parking. Multilevel Parking has been proposed on the existing car parking area.

There is no vehicular connectivity to the station from west side. The access to the station has been provided through Old Mysore Road. The pedestrian walkway has been proposed to reach the entry of proposed elevated station. The pick drop, bus bays, auto/ taxi stand has been proposed over the vacant land towards south of the station. The pick drop area has been proposed to be connected to the elevated station through FOB.

There are two existing metro stations in the vicinity of the station. One metro station (City Railway Station) is already connected to the existing station through FOB. The proposed station building is given on the west side of the existing station and concourse of the proposed station is connected to the existing station. There is an existing pedestrian subway connecting the station with Majestic Metro station and bus terminal. There is an existing skywalk which connects the metro station with bus terminal. It is proposed to extend this skywalk to connect the existing FOB.

The conceptual intermodal integration plan for Bengaluru City Station is shown in **Annexure 6.2**.

6.4.3. BENGALURU CANTONMENT STATION

Bengaluru Cantonment Station is getting access from both east and west side. The station is accessible through Millers Road from west side and Cantonment Station Road from east side.

There is an existing parking area given towards east side of the station which has been proposed for Multilevel Parking. The pick drop bays for cars, autos and taxis has been proposed in front of the station building along with bus bay. Auto and Taxi Stand has also been proposed along with parking for two wheelers. Since Multilevel parking is given on other side of the road so the existing and proposed station has been proposed to be connected to the parking area through FOB.

There is an existing parking for two wheelers only and pick drop of autos and the same have been retained.

The conceptual intermodal integration plan for Bengaluru Cantonment Station is shown in **Annexure 6.3**.

6.4.4. LOTTEGOLLAHALLI STATION

The station is accessible only through east side. The access road is very narrow and has two way movement. Due to limited ROW, the access road may not be widened. Therefore, only pick drop has been proposed near the proposed entry towards south of station.

At present, Outer Ring Road is passing near the west side of the station but no access has been given from that side. The access has been proposed from the Outer Ring Road with pick and drop and auto stand.

The south side entry of the station is proposed to be connected with new BEL road through pedestrian walkway.

The conceptual intermodal integration plan for Lottegollahalli Station is shown in **Annexure 6.4**.

6.4.5. MUTHYALANAGAR STATION

This is a proposed station accessible through 19th cross road on west side. The existing ROB connecting Outer Ring Road provides access to the proposed station on east side. Only pick drop and auto/ taxi stand has been proposed on the east side of the station due to space constraints.

On the west side, the pick drop and auto/taxi stand along with parking have been proposed over the vacant land abutting the railway track. The pedestrian walkway has been proposed adjacent to the existing underpass to access the station entry.

The conceptual intermodal integration plan for Muthyalanagar Station is shown in **Annexure 6.5**.

6.4.6. CHIKKABANAWARA STATION

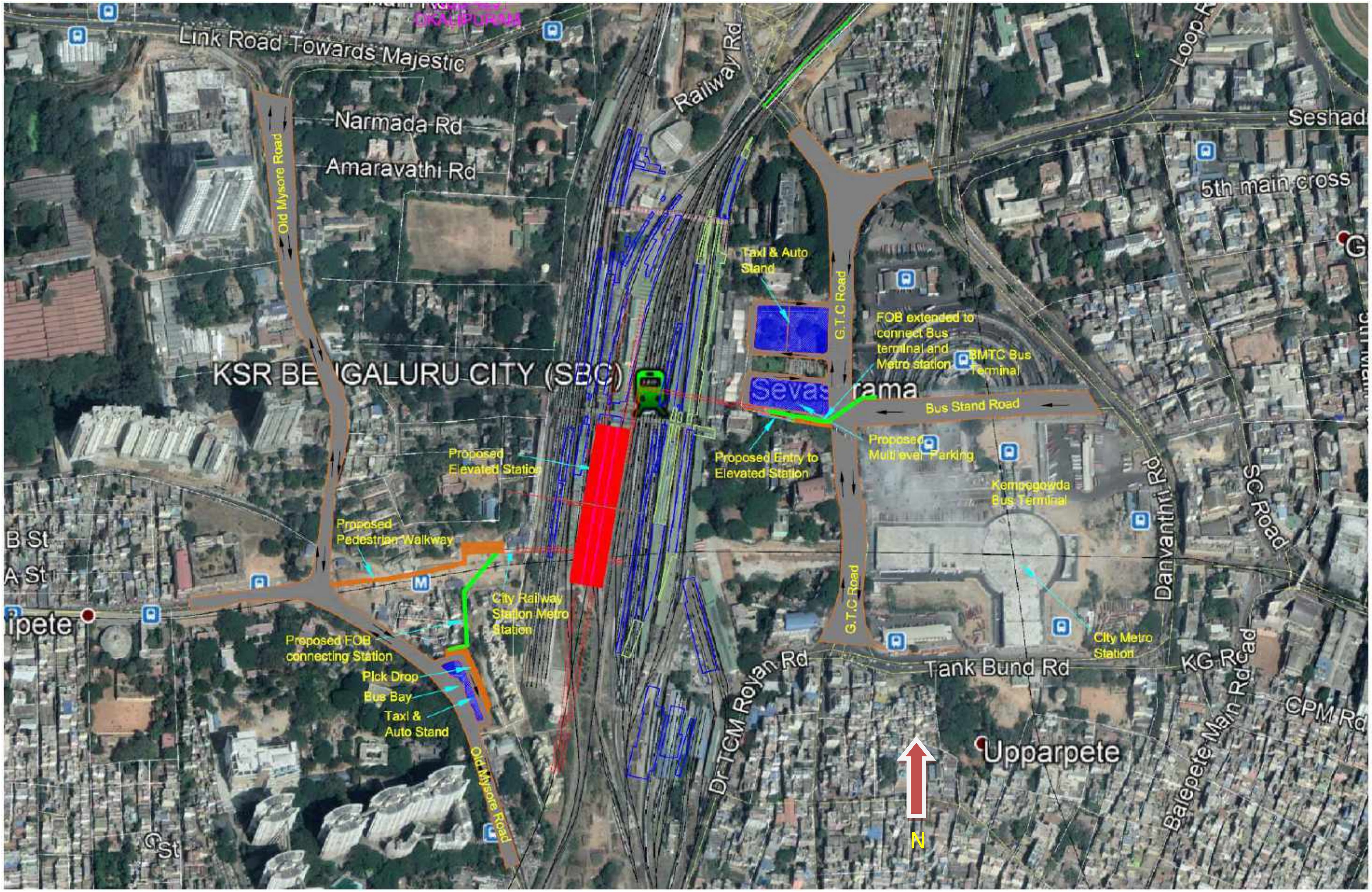
The station is accessible through Kutcha Road from east side. Therefore, east side road has been proposed to be strengthened. Only pick drop and auto stand are proposed on the east side due to space constraint.

The access road to the station on west side connects the Hesarghatta Main Road. The access road is proposed to be widened to 9 m. The pick drops, auto/ taxi stand, car and 2 wheeler parking are proposed on the vacant land near the station. In addition, bus bays are proposed on Hesarghatta Main Road.

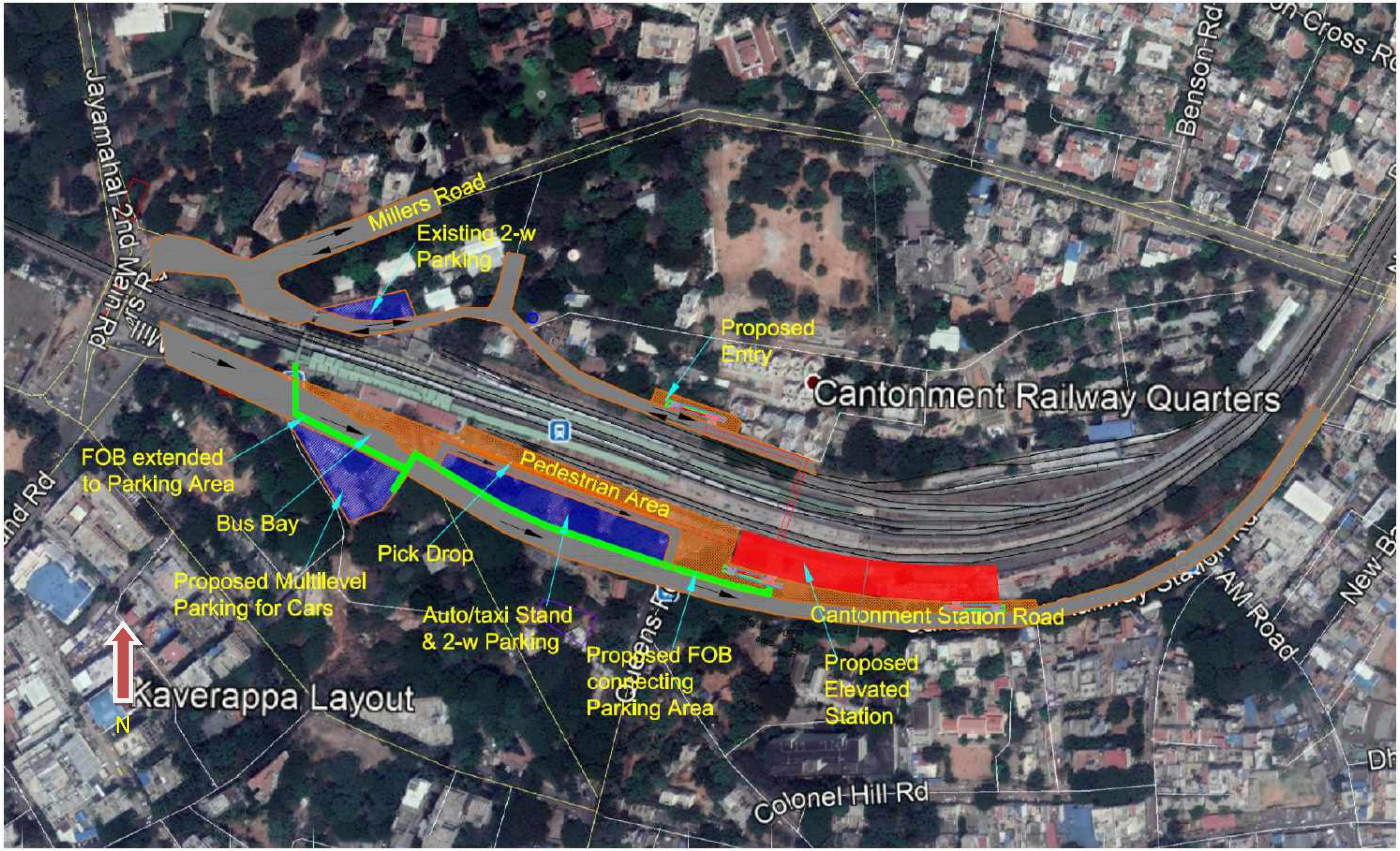
The conceptual intermodal integration plan for Chikkabanawara Station is shown in **Annexure 6.6**.

ANNEXURE 6.1: CONCEPTUAL INTERMODAL INTEGRATION PLAN AT KENGERI STATION

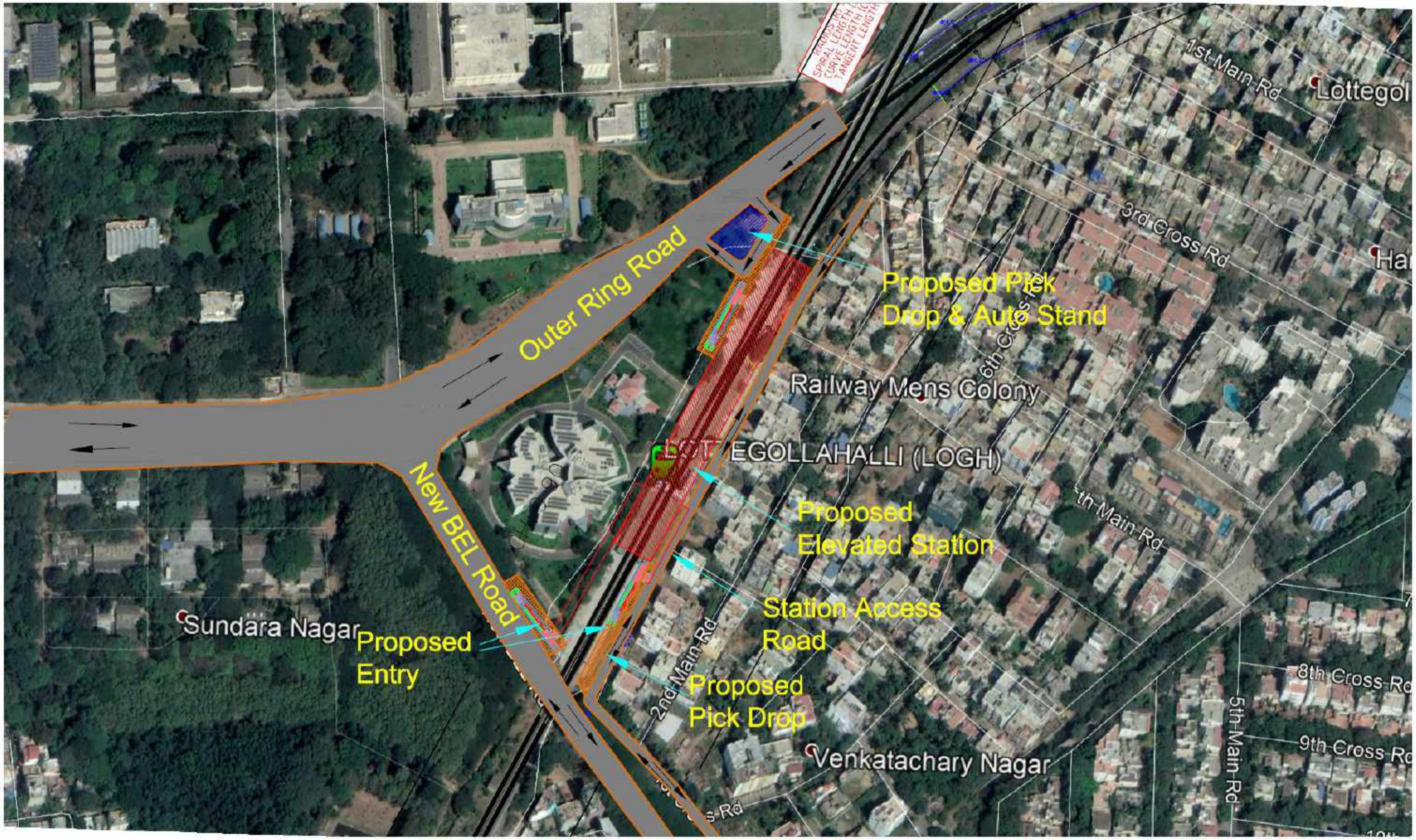
ANNEXURE 6.2: CONCEPTUAL INTERMODAL INTEGRATION PLAN AT KSR BENGALURU CITY STATION



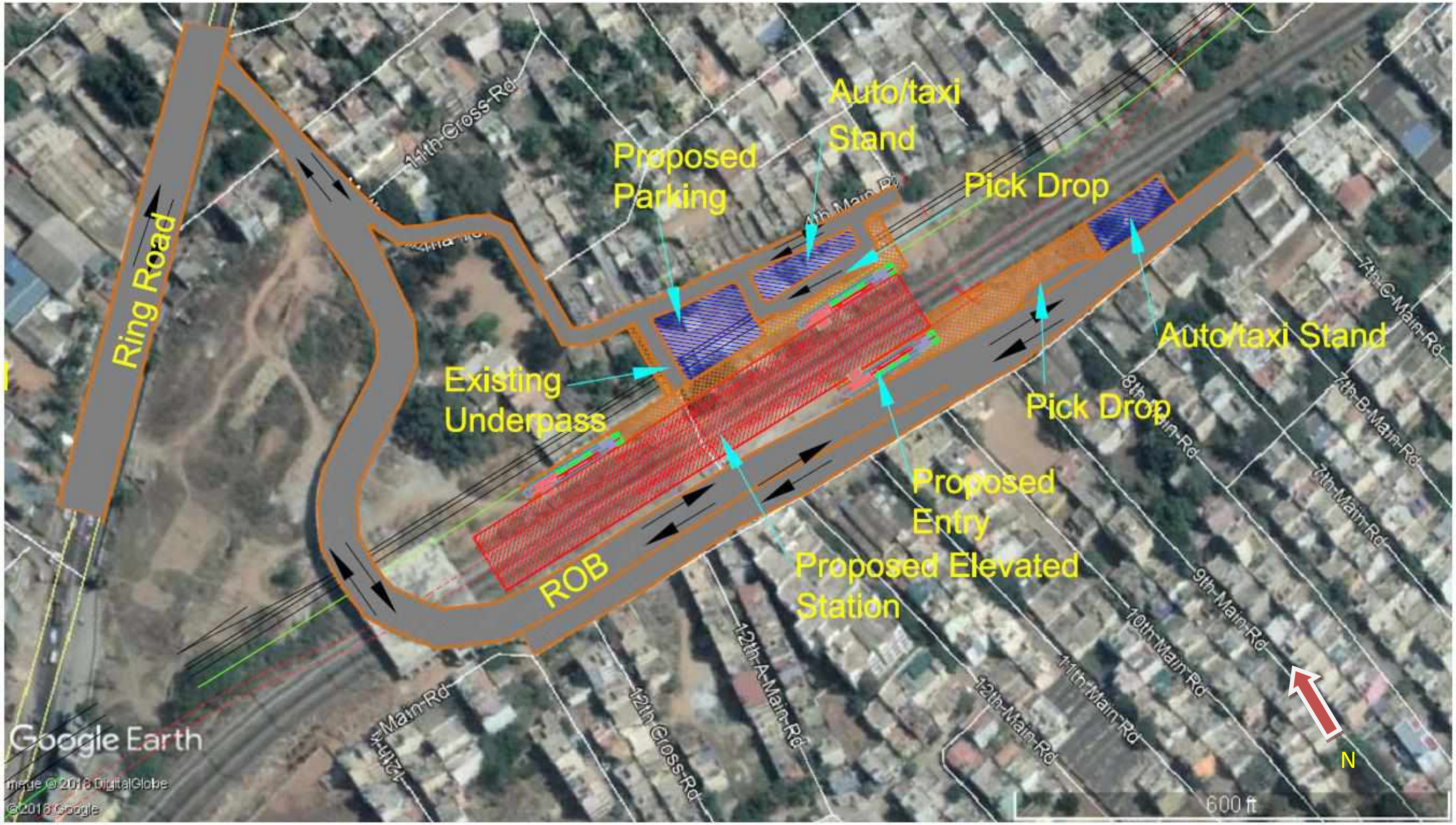
ANNEXURE 6.3: CONCEPTUAL INTERMODAL INTEGRATION PLAN AT BENGALURU CANTONMENT STATION



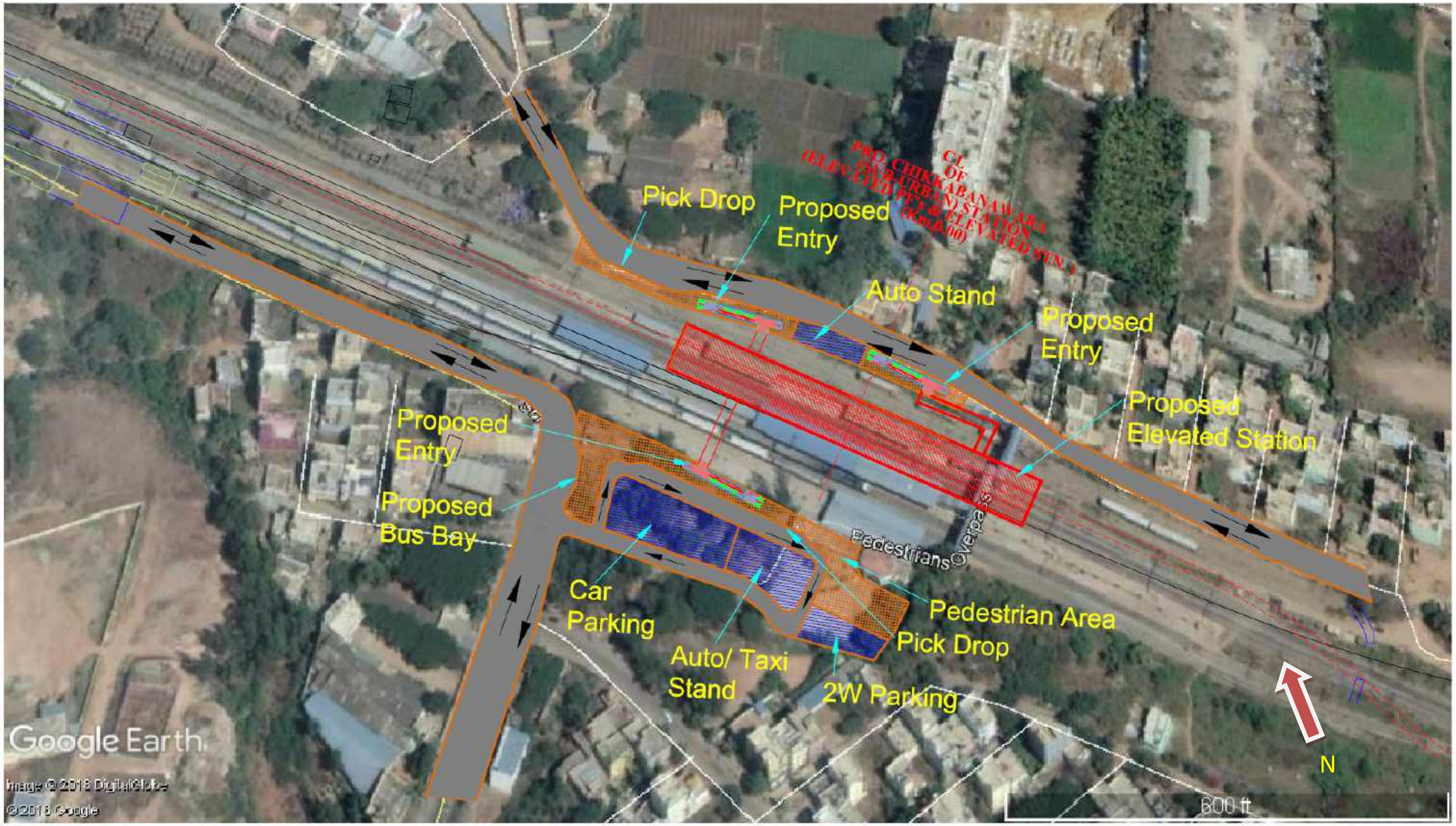
ANNEXURE 6.4: CONCEPTUAL INTERMODAL INTEGRATION PLAN AT LOTTEGOLLAHALLI STATION



ANNEXURE 6.5: CONCEPTUAL INTERMODAL INTEGRATION PLAN AT MUTHYALANAGAR STATION



ANNEXURE 6.6: CONCEPTUAL INTERMODAL INTEGRATION PLAN AT CHIKKABANAWARA STATION



7. CONSTRUCTION PLANNING

7.1 APPROACH

- The entire proposed network of Suburban rail of 148.17 kms is divided into four corridors as discussed in the earlier chapters. The planning for construction is to be made keeping in view the following:
  - As the proposed alignment is running parallel to the existing IR lines, planning of construction of sub-urban lines to be finalized strictly in consultation with the Railways, keeping in view the operation of existing trains, safety aspects etc.
  - The construction activity may be taken up in phases to minimize the operational constraints / line blocks.
  - At places of space constraints, mainly at LCs / Stations / ROBs / RUBs etc., traffic diversion shall be taken up in consultation with concerned State Govt Agencies (viz, BBMP, Traffic Police etc.).
  - As the construction is of huge magnitude, resource planning for men and material has to be done meticulously.
  - More than 60% of proposed alignment is within the metropolitan city limits. Hence, shift wise construction is essential to avoid peak hour road traffic as materials and equipment has to be brought to the construction site only by road.
- RITES team made several visits to the project corridors to check the existing conditions along the existing rail network. Detailed survey has been conducted to know the exact extent of the railway land and also the space available between the railway boundary and the center line of outer most IR track. Based on this survey and data collected during various site visits, methodology for construction has to be taken up separately for elevated and At– grade corridors.

7.2 ELEVATED

7.2.1. SPAN CONFIGURATIONS

Based on the prevailing site conditions, loading, etc., a typical span length of 31 m has been proposed along the elevated stretches of the respective corridors. Moreover, as the alignment has to be as far as possible within the Railway ROW, it is impossible to avoid the existing FOBs and ROBs etc. Generally, a span configuration of 31m has been adhered to all along the proposed alignment but it is only at some locations of ROBs, FOBs and other Obligatory points some non standard spans (eg. 25m, 34m etc.) or special structures have been proposed.

7.2.2. FOUNDATION SYSTEMS

Considering the space restrictions and the assumption that the hard rock level is encountered at a depth 8–10 mts from the existing ground, pile foundation is proposed with socketing into the hard rock. Two types of pile foundations are proposed, depending upon the availability of construction space:

- Multiple Pile
- Mono pile

A) MULTIPLE PILE

Bored piles of 1.2m diameter are envisaged. The piles would be arranged in group of four and the maximum pile cap dimension would be 5.0m x 5.0m. Moreover, construction space of at least 8.0m width would be required for piling. The multiple pile groups shall be provided only in the stretch where the aforesaid width is available for construction without any disturbance to the adjoining structures and Railway operations.

B) MONOPILE

This type of pile foundation, as the name suggests, consists of a single larger diameter pile. The diameter of mono pile is envisaged to vary from 2m to 2.5m depending on the difference between the rock level and the rail level and the pile cap dimension shall be 3.0m x 3.0m. The construction space required would be 5m in width. Mono pile is proposed at locations of space restrictions or to avoid infringement with existing railway structures and utilities. If however, at the time of construction, the relocation of existing structures and shifting of utilities is approved by the railways and the width for construction of foundation is enough for group of piles, the mono pile foundation can be replaced by multiple pile foundation.

7.2.3. PIER AND PIER CAPS

Keeping in mind the aesthetics, the piers for typical viaduct shall be circular, diameter of which varies from 2.0m to 3.0m depending on the rail, ground and rock level. The width at the top of the pier cap is kept to be equal to the bottom width of the box girder and gradually decreases to diameter of pier over a depth of 2.5 m where it meets the pier.

7.2.4. SUPER STRUCTURE

Viaduct consists of segmental box girder of 10.9m width, 2.4 to 2.5m (depth) for double track, 5.50m width, 1.8 to 2.00 depth for single track.

FIGURE 7.1: PROPOSED TYPICAL VIADUCT WITH MULTIPLE PILES

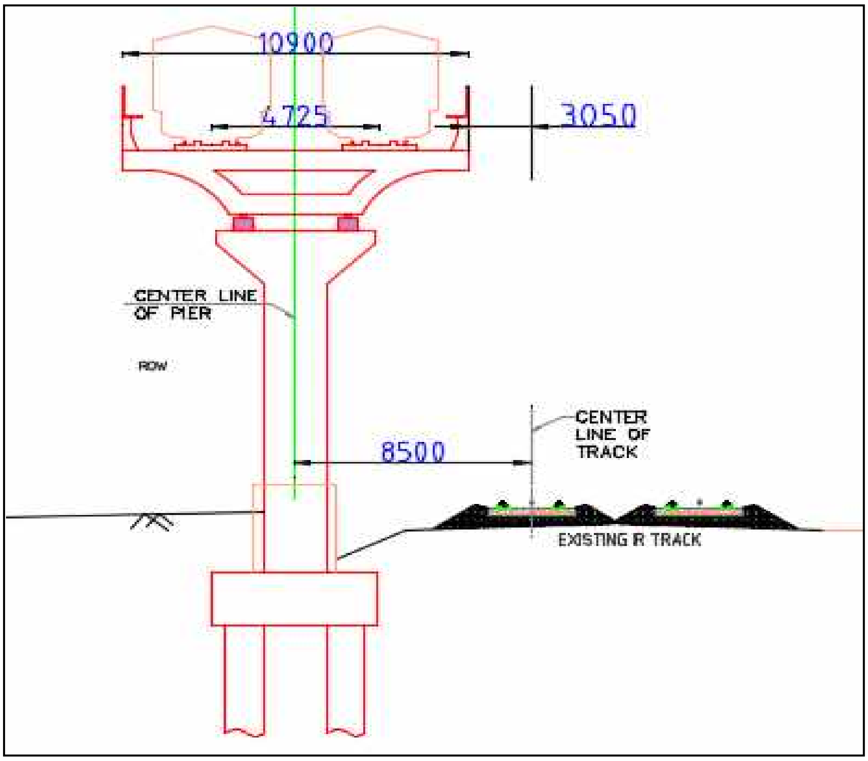


FIGURE: 7.2: PROPOSED TYPICAL VIADUCT WITH MONOPILE

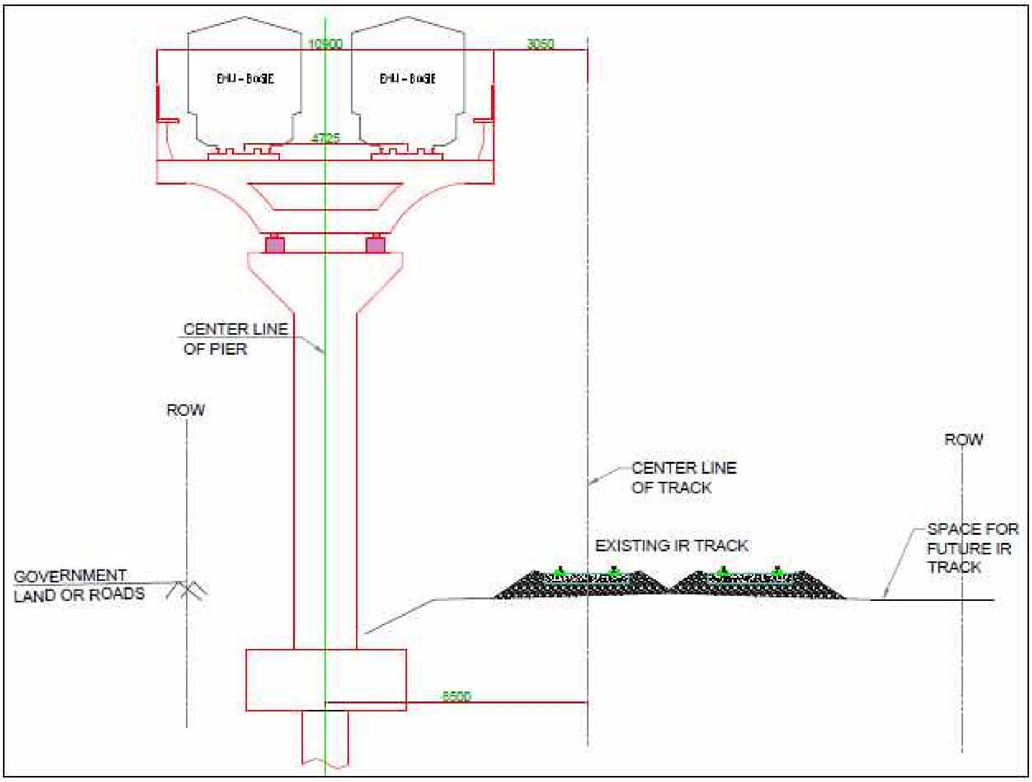
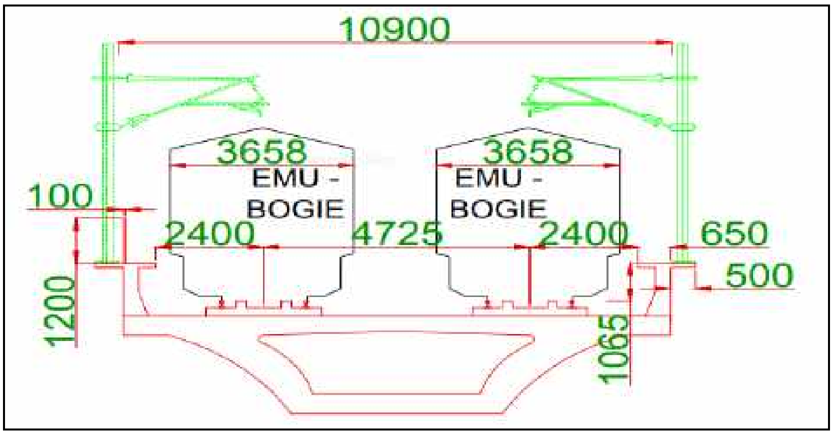


FIGURE 7.3: TYPICAL PROPOSED SECTION

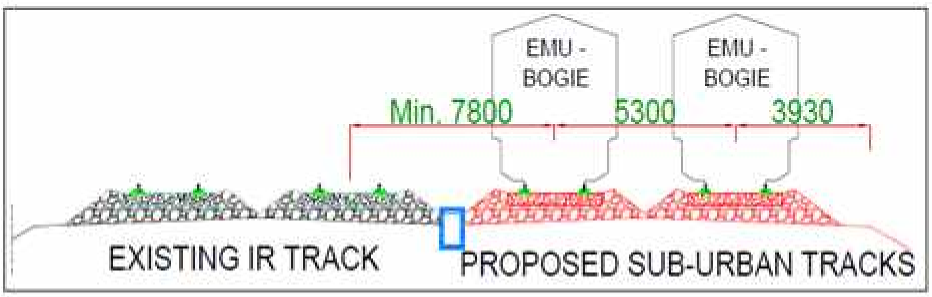


Generally, it is planned to align the proposed sub-urban tracks as At Grade along the existing IR lines as the same will reduce the cost of construction as well as period of construction. This also facilitates ease of maintenance.

In addition, sub-urban lines alignment is proposed on one side of existing IR lines duly leaving other side of IR lines for future requirement of Railways.

For proposed At grade sub-urban alignment, a minimum distance of 7.80m is proposed from center line of nearest IR track to center line of sub-urban line in terms of Railway Board Letter No 2011/CE-II/Form/Misc dated 11.9.2015.

FIGURE 7.4: TYPICAL SECTION (ONE SIDE) AT-GRADE



7.3 SEQUENCE AND METHODOLOGY OF CONSTRUCTION

7.3.1. VIADUCT

A) Substructure and Foundation Construction Method (Typical / Viaduct) for Multiple Pile Foundation

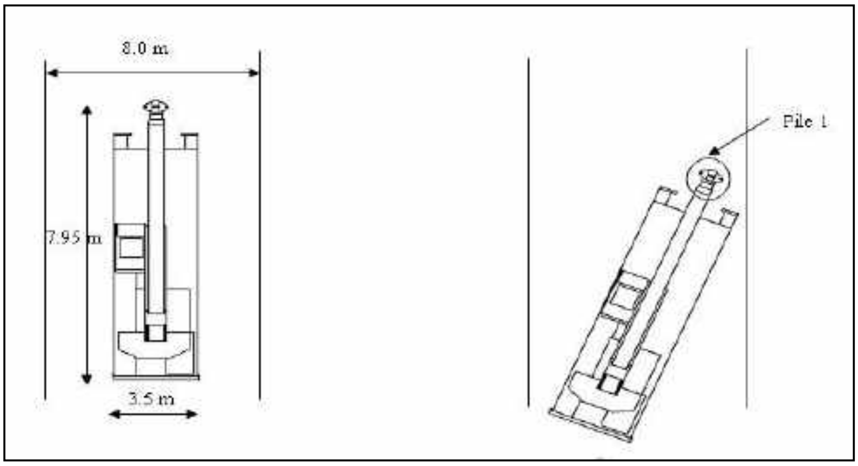
The construction method of Multiple Pile foundation and Substructure is as explained below:

- Stage 1 – Pile rig enters the location from the nearest access.

- Stage 2 – Piling rig aligns itself parallel to the longitudinal axis of the alignment and places itself at the center of the foundation. The boom of the rig is made vertical.
- Stage 3 – Rotation of piling rig by 45º for drilling of pile 1 (**FIGURE 7.5**)
- Stage 4– After completing Pile 1, the rig realigns itself parallel to the longitudinal axis
- Stage 5 – Placing of reinforcement cage for pile 1
- Stage 6 - concreting of pile 1 up to the cut-off level
- Stage 7 – Repeat stages 1 to 6 for other piles and complete the pile group.
- Stage 8 – Cutting of piles, placing of starter bars for pier, reinforcement for pile cap and concreting of pile cap
- Stage 9 – completion of reinforcement and fixing of Formwork for pier and concreting of pier
- Stage 10 - Installation and fixing of Formwork for pier cap
- Stage 11 - Casting for pier cap

The Construction method is explained in the following Figures:

FIGURE 7.5: PROPOSED PILING RIG ARRANGEMENT AT SITE



The construction method of Mono pile foundation and Substructure is as explained below:

- Stage 1 – Pile rig enters the location from the nearest access
- Stage 2 – Piling rig aligns itself parallel to the longitudinal axis of the alignment and places itself at the center of the foundation
- Stage 3 – Drilling of Pile
- Stage 4 – Placing of reinforcement cage for pile and placing of starter bars for pier

- Stage 5 - concreting of pile up to the cut-off level
- Stage 6 – completion of reinforcement and fixing of Formwork for pier and concreting of pier
- Stage 7 - Installation and fixing of Formwork for pier cap
- Stage 8 - Casting for pier cap

The Construction method is explained in the following Figures:

FIGURE 7.6: STAGE 3

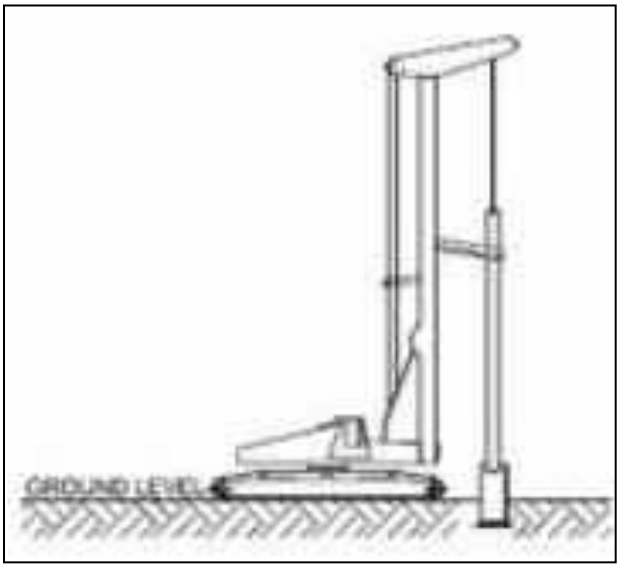


FIGURE 7.7: STAGE 4

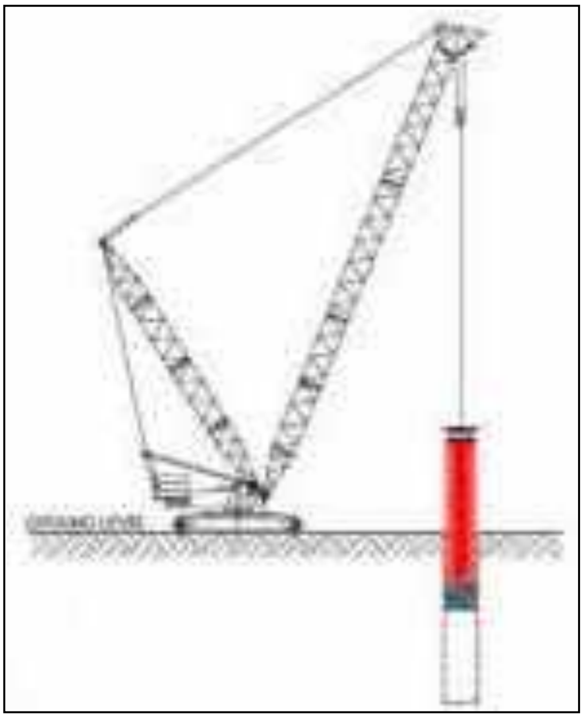


FIGURE 7.8: STAGE 5

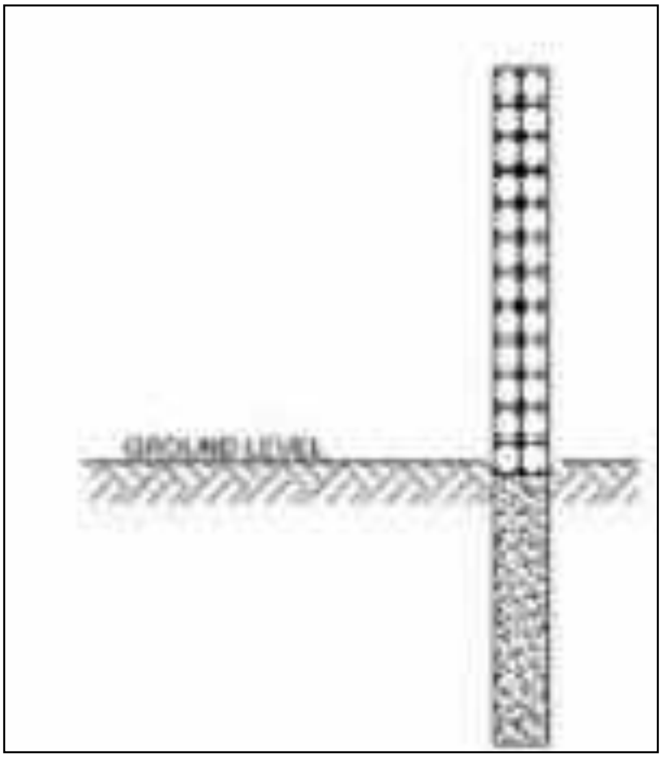


FIGURE 7.9: STAGE 6, 7 AND 8

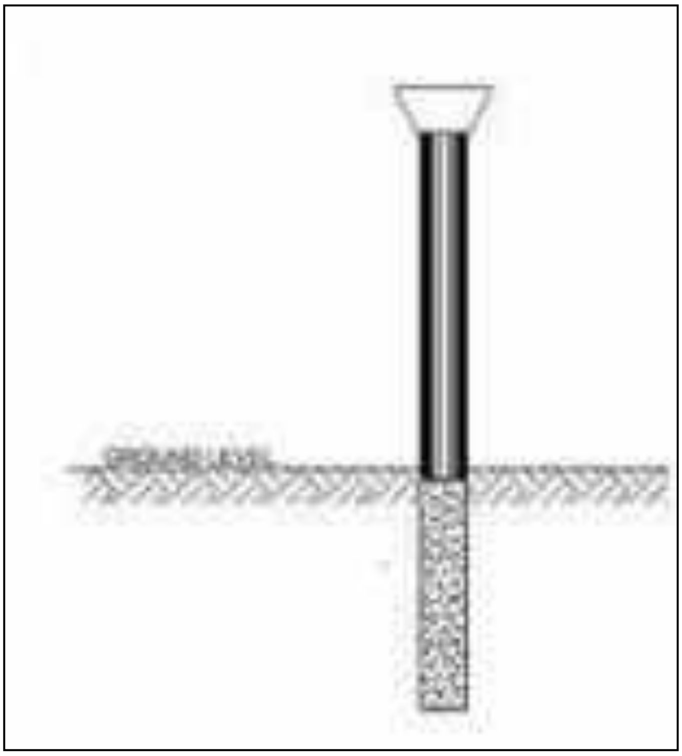
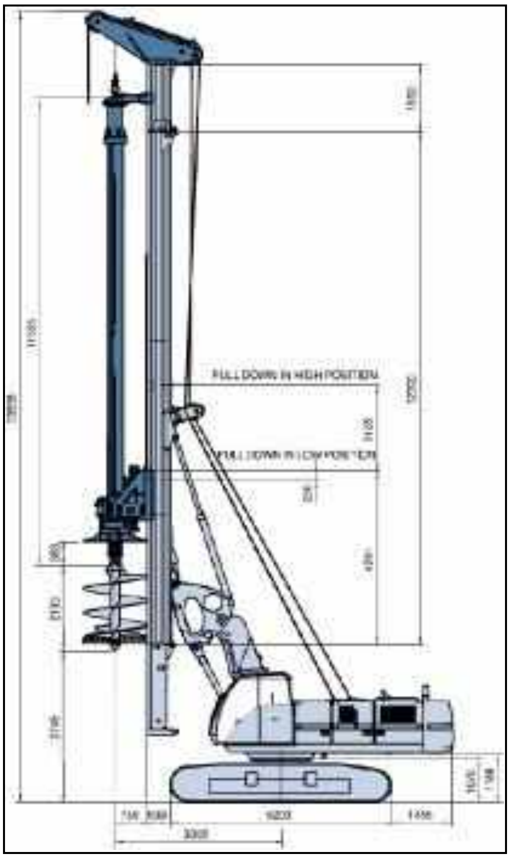


FIGURE 7.10: FOUNDATIONANDSUB-STRUCTURECONSTRUCTIONMETHOD

FIGURE 7.11: EQUIPMENT FOR CONSTRUCTION OF MULTIPLE AND MONO PILE FOUNDATION



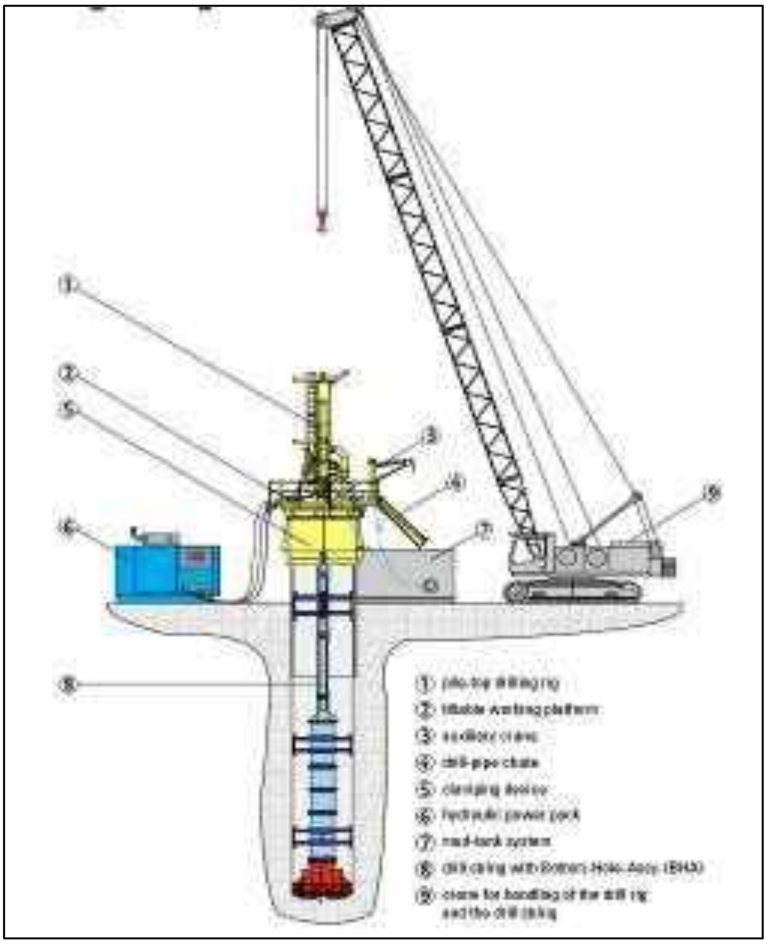
Alternatively, the mono pile can be done by pile top method developed by WIRTH.

The principle is as follows:

- Compressed air is injected into the drill pipe below water level, slightly above the cutting head. The air rising and expanding within the drill pipe greatly reduces the density of the internal fluid column, creating a differential pressure between the fluid outside of drill pipe and fluid inside the drill pipe. Due to the higher density of the outer column, the solids pass from the drill hole, through the suction cutting head opening and rise up through the drill pipe. By Establishing the correct air/fluid flows within the drill pipe, the airlift principle is utilized for transporting the solids to the surface.
- The amount of differential pressure or the conveying capacity depends on the rate and volume of compressed air injected, the depth of injection and the delivery head.

The rig assembly is as shown in the **FIGURE 7.12.**

FIGURE 7.12: RIG ASSEMBLY



B) Superstructures Construction Methods (Typical Viaduct)

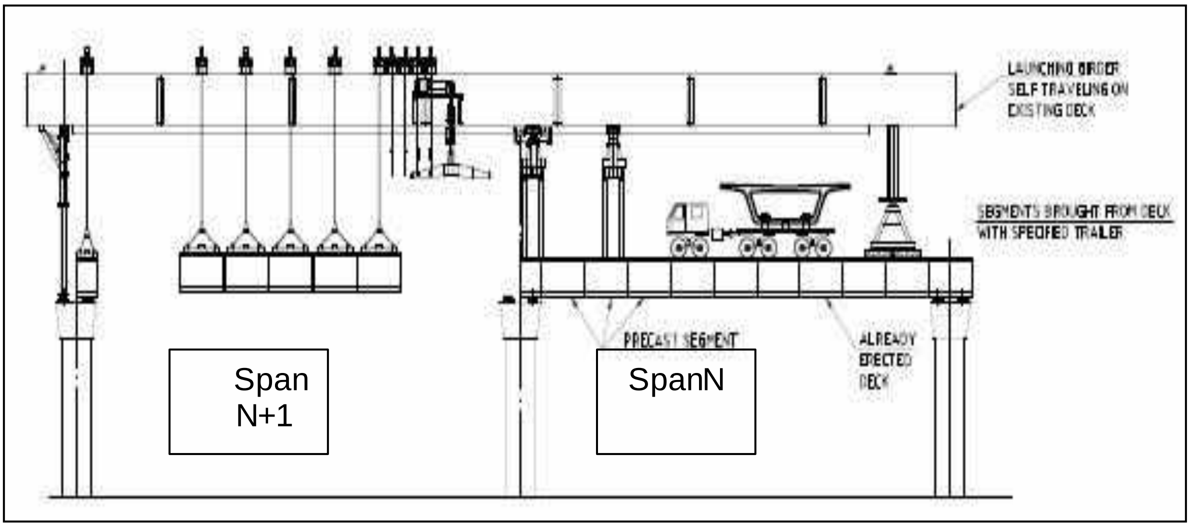
For the proposed design concept of super-structure, two alternative construction methods have been proposed and depend on the operability at a particular location.

Segmental built Span by Span

In order to avoid any disturbance to the rail traffic, it is proposed to launch and erect the segments from the already erected deck. Such areas, where the segment can be lifted on the erected deck have been identified and explained in **FIGURE 7.13.**The method is as explained below:

- Move the launching girder to span (N+1)
- Bring segments from span N (already erected deck)
- Glue all the segments together
- Stress the pre stressing tendons

FIGURE 7.13: SEGMENTAL SPAN BY SPAN ERECTION METHOD



The locations identified for casting yards for segmental construction activities include Channasandra and Yeshwantpura yard where sufficient vacant railway land is available. Further 4 maintenance depots are proposed by RITES and these proposed depots can also be used as casting yards if required.

The casting yards for segmental constructional activities have been identified within the city limits/along the proposed corridors as mentioned above. The segments cast at the casting yards, shall be transported to the site of execution, by road. Hence, necessary precautions shall be taken to ensure smooth and safe transportation to execution site with necessary help from the traffic police, as required.

7.4 ROAD TRAFFIC DIVERSION PLANNING

7.4.1. OBJECTIVE

The road traffic diversions have to be planned with the following objectives:

- To minimize disruption to the movement of traffic on roads adjacent to the proposed Corridor, especially near the existing station areas.
- To provide for uninterrupted access to all stations.
- To accommodate the existing bus/ IPT stands near the station areas for effective inter-modal dispersal.

7.4.2. CONCEPT

The project construction poses significant challenges in view of the multiple constraints of existing Railway tracks/ infrastructure, ROBs, FOBs in addition to the extremely limited road space in the vicinity for traffic movement. The proposed Corridor alignment and construction methodology/ sequence to be adopted should be to minimize affecting existing structures and disrupting the traffic flow in the vicinity. The Corridors are planned to be constructed largely within the Railway Boundary. At certain locations, lands/ properties contiguous to Railway Land are proposed to be acquired. At same locations the construction of the proposed Corridor and its Stations will involve the partial closure of existing roads for varying amounts of time.

7.4.3. TYPICAL CONSTRUCTION SEQUENCE AND TRAFFIC DIVERSIONS

The quantum of surface roads affected by the proposed project varies for the different levels of construction.

A) Elevated

It is proposed to construct the elevated sections on a combination of mono pile and multiple pile foundations. This may involve blockage of a minimum width of 5 m wide strip in case of mono pile and 8 m in case of multiple pile foundations for construction along the viaduct portion. However, as a safety measure, generally the entire 10.90 m deck width of the elevated portion will be barricaded on ground (with exceptions in very tight sections subject to the minimum width stated herein). An extra barricading width of 1.75 m towards road side would be desirable during night time for movement of equipment within the construction zone, and the same can be withdrawn during day time to maximize available road width for general traffic movement.

At station locations, the total width to be blocked for construction would be about 26 m, which will have to blocked in one go. However most of these would be over Railway Land, and therefore block only part of the adjacent roads in most of the cases.

FIGURE 7.14: ELEVATED DECK

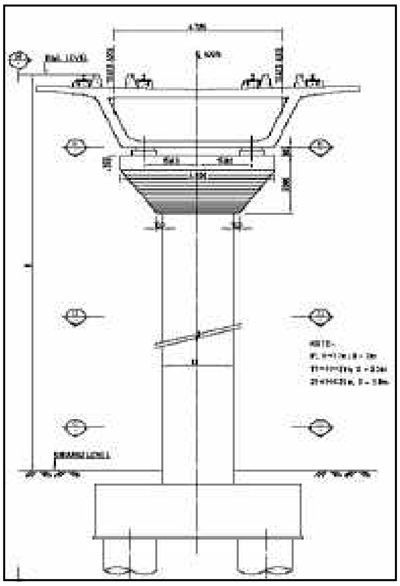
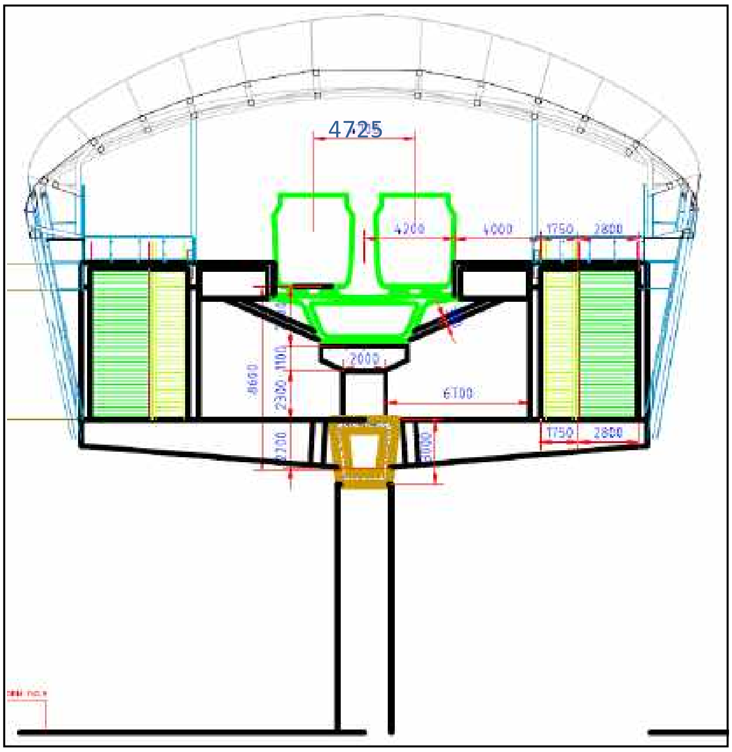


FIGURE 7.15: ELEVATED STATION – 26m



7.4.4. SITE SPECIFIC CONSTRUCTION SEQUENCE AND TRAFFIC DIVERSIONS

The quantum of surface roads affected by the proposed project varies for the different levels of construction. The capacity of the alternative road networks has been assessed for identifying the roads with spare capacity to carry the quantum of diverted traffic. IRC – 106 : 1990 recommends a lane capacity of 900 PCUs per hour which generally corresponds to V/C Ratio of 0.6 for urban roads. This translates into total capacity of 900/ 0.6 = 1500 PCUs per 3 m lane. Accordingly, a traffic capacity of 500 PCUs per hour per m carriageway width has been assumed for assessing the traffic capacity of the road network (although practical traffic capacities of around 1000 PCUs per hour per m carriageway width are also commonly observed in Indian cities like Mumbai and Delhi). Suitable Traffic circulation schemes have to be suggested so as not to exceed V/C Ratio of 1 on any road with the diverted traffic. The bus stops/ IPT stands, if affected by the diversion, will also have to be suitably planned at alternate locations near the station entry/ exit points.

7.5 TRAFFIC AND POWER BLOCKS/DIVERSION OF TRAINS

7.5.1. OBJECTIVE

The traffic and power blocks have to be planned with the following objectives:

- To minimize the diversion/cancellation of trains
- To utilize the available corridor blocks

7.5.2. CONCEPT

The proposed sub-urban corridor runs parallel to existing Railway tracks duly utilizing the available Railway land. The entire construction of sub-urban will have serious effect on running of trains. Thus proper construction methodology to be adopted to minimize the impact on running of trains.

7.5.3. BLOCK REQUIREMENTS/DIVERSION OF TRAINS

Diversion/Cancellation of trains is not envisaged during execution of sub-urban work

A) Elevated

The proposed sub-urban alignment is planned such way that the central line of pier/viaduct of sub-urban alignment is 8.50m from the center of nearest IR track. Further, the viaduct width is 10.9m for two tracks. Thus, the minimum distance from the center of nearest IR track to nearest viaduct edge is 3.05m.

As stated in the preceding paras, the minimum width required for piling work is 8m and 5m for multiple piles and mono pile respectively. Considering all these, 8.5m from center line of nearest IR track to center of pier/viaduct has been proposed. Thus the sub-urban work can be executed without affecting the train movement duly barricading at about 2.50 to 3.0m from the center of nearest IR track. However, as a precaution WHISTLE FREE caution shall be imposed

For super structure and crossing of IR tracks, no separate blocks are envisaged. Existing corridor blocks shall be utilized for launching of segments.

B) At Grade:

In all at grade locations, the center to center distance of nearest sub-urban and IR tracks is 7.80m in terms of Railway Board Letter No 2011/CE-II/Form/Misc. dated 11.9.2015. Thus the sub-urban work can be executed without affecting the train movement duly barricading at about 2.50 to 3.0m from the center of nearest IR track. However, as a precaution WHISTLE FREE caution shall be imposed

8 SYSTEM DESIGN & MAINTENANCE FACILITIES

8.1 ROLLING STOCK

8.1.1 INTRODUCTION

Unlike the cities of Mumbai, Kolkata and Chennai, Bengaluru does not have an exclusive suburban rail network to cater to the need of passengers. Conventional trains and recently DEMU/MEMU trains are being run to meet the demand of the commuters coming from the outskirts and nearby towns.

The suburban rail system with BG track is proposed along the existing SWR network on different sections of Bengaluru Division. Due to the space and land constraints, the track and stations are to be planned at different grades; some on elevated and others at grade. For the grade, gauge and mobility conditions, BG Metro Train sets (EMU) rakes are found to be the best suitable to meet the requirement. A study on trains run on different suburban system of Indian cities was made and found BG Metro Train sets (EMU) – RS 13 series, which is manufactured at M/s BEML, Bengaluru, is the most suitable for Bengaluru Suburban Rail system.

TABLE 8.1: ROLLING STOCK CHARACTERSTICS

Train speed – Designed	90 kmph
Acceleration at peak load on tangent track	0.82 M/Sec.Sq.
Deceleration with Full service Brake	1.00 M/Sec.Sq
Emergency brake	1.3 M/Sec.Sq
Jerk rate	0.82 M/Sec.Sq
Service brake response time	2.0 Sec
Emergency Brake response time	1.5 sec. Max.
SB and EB release time	2.0 Sec.

8.1.2 THE SUB SYSTEMS

i) Vehicle Body – Car body including interiors
ii) Bogie & Suspension
iii) Propulsion and HV System.
iv) Aux Power Supply system
v) Brake & Pneumatic Systems
vi) Door System
vii) HVAC System
viii) PA & PIS System
ix) Train Management System (TMS)
x) CCTV system
xi) Electrical and Control Equipment

xii) Gangway and Coupler

8.1.3 GENERAL REQUIREMENTS

i) Reliability,
ii) System Safety during operation
iii) Interface with other systems
iv) Maximum availability
v) Maintainability
vi) Electro Magnetic Compatibility
vii) Quality assurance
viii) Noise and Vibration in allowable limits.
ix) Complying to Fire and Toxicity Standards
x) Hazard limits
xi) Flood proofing (Runs at 10 Kmph through water level up to a depth of 75 mm above Rail level)

8.2 TRACTION/POWER SUPPLY

8.2.1 TRACTION AND STATIONS

All the 62 stations over the four corridors need to be provided with KPTCL power supply. Apart from this, supply from 25 KV traction also needs to be tapped for uninterrupted power supply for signalling and station emergency lighting. As an emergency, alternate backup system like invertors and DG sets also have to be integrated. All the supply is independent of the existing IR power supply.

8.2.2 INTEGRATED POWER SUPPLY

The power **supply** to the stations has to be integrated to ensure uninterrupted power supply which is very much essential for the proposed signalling system (CBTC) over the Suburban Rail System.

8.2.3 SOURCE OF POWER SUPPLY

The Power supply proposed for the 4 corridors is through TSS (Traction Sub Stations).

The four TSS have been identified:

Corridor – 1 :- Yelahanka (SU YNK)
Corridor – 2 :- Hebbal (SU HEB)
Corridor – 3 :- Bengaluru Cantonment (SU BNC)
Corridor – 4 :- Benniganahalli (SU BNGH)

The incoming supply 220 KV with double circuit, proposed to be taken from existing KPTCL 220 KV Sub stations for all the 4 Corridors are indicated below:

Corridor – 1	:- Puttenahalli	(4 KM with 13 Towers)
Corridor – 2	:- Anchepalya	(10 KM with 31 Towers)

Corridor – 3 :- Subramanyapura/ Vrushabhavathy Valley (15 KM with 46 towers),
Corridor – 4 :- Hoodi/Hosakote (8 KM with 25 Towers).

In addition to the Subramanyapura KPTCL GSS, there is one more 220 KV KPTCL GSS at Vrushabhavathy Valley, which is also nearer to Kengeri. Further, it is also understood from KPTCL that one more 220 KV GSS (Gas Insulated type) is being planned from KPTCL at Kumbalagodu. When once this gets commissioned, Supply from this GSS would be more feasible compared to the proposals made as above. Details will be worked out considering the actual availability of the KPTCL Source and also the probable Voltage Drop expected during actual Design stage.

8.2.4 LAND REQUIREMENT

TSS, SSP and SPs

The Area requirement for TSS, SSP and SPs are furnished as under.

- 4 TSS is 22000 Sq.m (5500 Sq.m x 4 = 22000.00 Sq.m)
- 9 SSPs is 897.12 Sq.m (99.68 Sq.m x 9 = 897.12 Sq.m)
- 5 SPs is 498.40 Sq.m (99.68 Sq.m x 5 = 498.4 Sq.m)

OHE Maintenance Depots

- 2 Major OHE Maintenance depots is 3200 Sq.m (1600 Sq.m x 2 = 3200.00 Sq.m).
- 2 Minor OHE Maintenance depots is 1250 Sq.m (625 Sq.m x 2 = 1250.00 Sq.m).

General Power Supply for all Station Buildings

It is proposed to avail General Power Supply for all the Station Buildings at 11 KV for various General Lighting Load, Power Utilities such as HVAC, Lifts and Escalators etc by grouping 2 to 3 stations as per proposed station alignment and also depending on the availability of existing BESCOM / KPTCL Sources. Accordingly, the Area requirement for General Power Supply for all Station Buildings with 11 KV power Supply are furnished as under.

- Corridor 1:- Proposed 11 KV Substations – 8 Nos = 8 X 90 Sq.m = 720.00 Sq.m
- Corridor 2:- Proposed 11 KV Substations – 7 Nos = 7 X 90 Sq.m = 630.00 Sq.m
- Corridor 3:- Proposed 11 KV Substations – 7 Nos = 7 X 90 Sq.m = 630.00 Sq.m
- Corridor 4:- Proposed 11 KV Substations – 10 Nos = 10 X 90 Sq.m = 900.00 Sq.m

For Erection of 220 KV Towers in Public land for extending 220 KV Power Supply from KPTCL / BESCOM Power Grid to Proposed TSS

The Area requirement for General Power Supply for all Station Buildings with 11 KV power Supply are furnished as under.

- Corridor 1:- Proposed 220 KV Towers – 13 Nos = 13 X 900 Sq.m = 11700.00 Sq.m
- Corridor 2:- Proposed 220 KV Towers – 31 Nos =31 X 900 Sq.m = 27900.00 Sq.m
- Corridor 3:- Proposed 220 KV Towers – 46 Nos = 46 X 900 Sq.m = 41400.00 Sq.m
- Corridor 4:- Proposed 220 KV Towers – 25 Nos = 25 X 900 Sq.m = 22500.00 Sq.m

A total of **134225.52 Sq.m.** of land is proposed for erecting for **TSS, SSP and SPs, OHE Maintenance Depots and General Power Supply Substations for all Station Buildings** and Erection of 220 KV Towers for extending 220 KV Power supply from KPTCL Power Grid. The proposed list of locations of TSS, SP and SSPS is presented in **TABLE 8.2**.

TABLE 8.2: PROPOSED LIST OF LOCATIONS OF TSS,SP AND SSPS

S. No.	Station name	Station code	Chainage	Proposed		
				TSS	SSP	SP
CORRIDOR 1 (SBC-YPR-LOGH-YNK-DHL)						
1	KSR BANGALORE CITY	SU SBC	0.000		SU SBC SSP	
2	MUTHYALANAGARA	SU MUTY	8.320		SU MUTY SSP	
3	YELHANKA	SU YNK	18.380	SU YNK TSS		
4	DODDAJALA	SU DJL	30.070		SU DJL SSP	
5	DEVANAHALLI	SU DHL	41.400			SU DHL SP
CORRIDOR 2 (BYPL(T)-BAND-LOGH-YPR-BAW)						
1	KASTURINAGARA	SU KSTR	1.140		SU KSTR SSP	
2	HEBBAL	SU HEB	11.630	SU HEB TSS		
3	SHETTIHALLI	SU SETH	21.460		SU SETH SSP	
CORRIDOR 3 (KGI-SBC-BNC-WFD)						
1	KENGERI	SU KGI	0.000			SU KGI SP
2	KRISHNADEVARAYA	SU KNDV	7.550		SU KNDV SSP	
3	BENGALURU CANTONMENT	SU BNC	16.900	SU BNC TSS		
4	KRISHNARAJAPURAM	SU KJM	25.870		SU KJM SSP	
5	WHITEFIELD	SU WFD	35.520			SU WFD SP
CORRIDOR 4(HLE-CSDR-YNK-RNN)						
1	HEELALIGE	SU HLE	0.000			SU HLE SP
2	KARMELARAM	SU CRLM	10.400		SU CRLM SSP	
3	BENNIGANAHALLI	SU BNGH	22.650	SU BNGH TSS		
4	HEGDENAGAR	SU HGD	32.640		SU HGD SSP	
5	MODENAHALLI	SU MDNH	42.730			SU MDNH SP

8.2.5 RELIABLE POWER SUPPLY

To ensure an uninterrupted and reliable power supply, bridging with IR traction supply is recommended at convenient At grade locations.

a) In order to maintain the reliable power supply to the OHE in between two Traction Sub Stations, one SP (Sectioning and Paralleling Post) is to be provided to extend the supply from one TSS to another TSS by operating the Electrical Switch gear in SP by TPC (Traction Power Control) remotely. With this, Power supply can be extended from one corridor to another corridor.

b) In addition to this two manually operated Isolators are proposed for arranging at convenient locations (Normally Opened) for At grade locations by closing Isolator with a clear message and by exchanging PN (Private number) by Authorized officials from TPC.

c) Proposal also made by providing cross over from the existing track nearer to the proposed At grade Suburban track at three to four convenient locations.

8.2.6 OHE, PSI & RC INSTALLATIONS

a) TSS (Traction Sub Station) consists of PSI (power supply installations), Equipment Switch Gear and also Remote Control Equipment RTU (Remote Terminal Unit) Of SCADA Equipment.

b) SSP (Sub Sectioning and Paralleling post) consists of PSI Equipment Switch Gear and also Remote Control Equipment RTU (Remote Terminal Unit) Of SCADA Equipment.

c) SP (Sectioning and Paralleling Post) consists of PSI Equipment Switch Gear and also Remote Control Equipment RTU (Remote Terminal Unit) Of SCADA Equipment.

d) RCC (Remote Control Centre) is proposed with Master Station to control the OHE and PSI Switchgear provided at RTUs (TSSs and Switching Stations) through SCADA system.

e) TPC (Traction Power Control) is authorized to control the Power system to OHE and operating the above switch gear remotely.

The proposed Suburban trains Power supply controlling has to function along with the CBTC Signaling control and close coordination is recommended with IR TPC to act during any emergency.

8.3 TRAIN OPERATION PLAN

8.3.1 OPERATIONS PHILOSOPHY

Train operation plan for the proposed Bengaluru Suburban rail system has been envisaged based on the ridership assessment. The underlying operations philosophy is to provide Mass Rapid Transit services with optimal utilisation of fixed Infrastructure and Rolling Stock planning.

- Selecting frequency of Train services to provide sectional capacity commensurate with the demand during peak hours in the initial years to be increased afterwards due to increase in traffic demand.
- A minimum train service frequency during lean period so as to keep the service attractive during lean period also.
- 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.

8.3.2 SALIENT FEATURES

The train operation plan for the proposed corridors will be based on the following salient features:

- Running of services for 19 hours of the day (5 AM to Midnight) with a station dwell time of 30 seconds.
- Make up time of 5-10% (on the tangent track) with 8-12% coasting.
- Average speed shall be 33 km/h.

8.3.3 TRAFFIC DEMAND

Peak hour peak direction traffic demand (PHPDT) considered for the formulation of train operation plan is given in **TABLE 8.3**.

TABLE 8.3: YEAR WISE PHPDT FOR BENGALURU SUBURBAN CORRIDORS

Corridor	2025	2031	2041
Corridor 1 (Bengaluru City - Devanahalli)	11775	13750	19135
Corridor 2 (Baiyappanahalli - Chikkabanavar)	9009	10923	13858
Corridor 3 (Kengeri - White Field)	6442	7951	10289
Corridor 4 (Heelalige - Rajankunte)	7646	11919	13527

8.3.4 TRAIN FORMATION

To meet the above projected traffic demand, the 3.66 m wide coaches are considered for operation on Bengaluru suburban corridors. The composition and capacity details of the rolling stock/trainsets are given below:

a. Train Composition

The basic unit shall be a combination of one motor coach and one trailer coach.
One basic unit of 3 car = MC+ TC + MC
MC- Motor coach
TC- Trailer coach
3 car, 6 car and 9 car train compositions can be formed by suitable combination of basic 3 car units.

b. Train Capacity

The capacity of MC, DTC and one basic unit comprising of 3 cars with different density of standees is given in **TABLE 8.4.**

TABLE 8.4: CAPACITY OF ONE BASIC UNIT WITH DIFFERENT DENSITY OF STANDEES

	Passenger Capacity of Cars and one Basic unit of 3 cars		
Standees	MC (With 50 Seats + 2 Wheel chair)	DTC (With 43 Seats + 2 Wheel chair)	One unit of 3 cars (2MC+ 1DTC)
4 pass/m^2	277	247	802
5 pass/m^2	333	298	965
6 pass/m^2	390	349	1128
7 pass/m^2	446	399	1291

The capacity of trains with different compositions is given below in **TABLE 8.5**.

TABLE 8.5: CAPACITY OF TRAIN WITH DIFFERENT NUMBER OF CARS

	Passenger capacity of Train with no. of cars		
Standees	3-Cars	6-Cars	9-Cars
4 pass/m^2	802	1603	2405
5 pass/m^2	965	1930	2895
6 pass/m^2	1128	2256	3384
7 pass/m^2	1291	2582	3874

c. Headway

Considering the projected traffic demand, 6 car train composition with standees @6 passengers per sqm is considered for the formulation of train operation plan. The possibility of running the trains at different headways has been examined. The traffic capacity and demand have been matched by suitable regulation of headways. The train operation plan for the Bengaluru suburban rail corridors is envisaged with 6 car rake composition. However, the infrastructure is proposed to be designed for 9 car composition considering the future growth in traffic demand. To avoid any complexity in operation, independent operation has been proposed on the corridors. Based on the above, the headway and the capacity provided for different corridors is given in **TABLE 8.6**.

TABLE 8.6: HEADWAY AND CAPACITY PROVIDED ON THE CORRIDORS

Corridor	Item	2025	2031	2041
Corridor 1 (Bengaluru City - Devanahalli)	Cars/ Train	6	6	6
	Peak Period Headway (Sec)	600	514	400
	Trains/hr	6	7	9
	Capacity Provided	13548	15806	20322
	PHPDT	11775	13750	19135
Corridor 2 (Chikkabanavar - Baiyappanahalli)	Cars/ Train	6	6	6
	Peak Period Headway (Sec)	900	720	514
	Trains/hr	4	5	7
	Capacity Provided	9032	11290	15806
	PHPDT	9009	10923	13858
Corridor 3 (Kengeri - White Field)	Cars/ Train	6	6	6
	Peak Period Headway (Sec)	1200	900	720
	Trains/hr	3	4	5
	Capacity Provided	6774	9032	11290
	PHPDT	6442	7951	10289
Corridor 4 (Heelalige - Rajankunte)	Cars/ Train	6	6	6
	Peak Period Headway (Sec)	900	600	600
	Trains/hr	4	6	6
	Capacity Provided	9032	13548	13548
	PHPDT	7646	11919	13527

8.3.5 HOURLY TRAIN OPERATION PLAN

The hourly train operation plan for the suburban rail corridors for the year 2025, 2031 and 2041 is given in **TABLE 8.8**, **TABLE 8.9** and **TABLE 8.10.** No services are proposed between 0000 Hrs. to 0500 Hrs. which are reserved for maintenance of infrastructure and rolling stock.

TABLE 8.7: HOURLY TRAIN OPERATION PLAN FOR BENGALURU CITY - DEVANAHALLI

Time of Day	Year 2025		Year 2031		Year 2041	
	Headway (min)	Trains/hr	Headway (min)	Trains/hr	Headway (min)	Trains/hr
5 to 6	30.0	2	30.0	2	20.0	3
6 to 7	20.0	3	15.0	4	12.0	5
7 to 8	15.0	4	12.0	5	10.0	6
8 to 9	**10.0**	**6**	**8.6**	**7**	**6.7**	**9**
9 to 10	**10.0**	**6**	**8.6**	**7**	**6.7**	**9**
10 to 11	12.0	5	10.0	6	8.6	7

Time of Day	Year 2025		Year 2031		Year 2041	
	Headway (min)	Trains/hr	Headway (min)	Trains/hr	Headway (min)	Trains/hr
11 to12	15.0	4	15.0	4	12.0	5
12 to 13	20.0	3	15.0	4	12.0	5
13 to 14	30.0	2	30.0	2	20.0	3
14 to 15	20.0	3	15.0	4	12.0	5
15 to 16	15.0	4	15.0	4	12.0	5
16 to 17	12.0	5	10.0	6	8.6	7
17 to 18	**10.0**	**6**	**8.6**	**7**	**6.7**	**9**
18 to 19	**10.0**	**6**	**8.6**	**7**	**6.7**	**9**
19 to 20	12.0	5	10.0	6	8.6	7
20 to 21	15.0	4	15.0	4	12.0	5
21 to 22	20.0	3	15.0	4	12.0	5
22 to 23	30.0	2	20.0	3	15.0	4
23 to 24	30.0	2	30.0	2	20.0	3
Total No. of trains per direction per day		**75**		**88**		**111**

TABLE 8.8: HOURLY TRAIN OPERATION PLAN FOR CHIKKABANAVAR - BAIYAPPANAHALLI

Time of Day	Year 2025		Year 2031		Year 2041	
	Headway (min)	Trains/hr	Headway (min)	Trains/hr	Headway (min)	Trains/hr
5 to 6	60.0	1	30.0	2	30.0	2
6 to 7	30.0	2	20.0	3	15.0	4
7 to 8	20.0	3	15.0	4	12.0	5
8 to 9	**15.0**	**4**	**12.0**	**5**	**8.6**	**7**
9 to 10	**15.0**	**4**	**12.0**	**5**	**8.6**	**7**
10 to 11	20.0	3	15.0	4	10.0	6
11 to12	30.0	2	20.0	3	15.0	4
12 to 13	30.0	2	20.0	3	15.0	4
13 to 14	60.0	1	30.0	2	30.0	2
14 to 15	30.0	2	20.0	3	15.0	4
15 to 16	30.0	2	20.0	3	15.0	4
16 to 17	20.0	3	15.0	4	10.0	6
17 to 18	**15.0**	**4**	**12.0**	**5**	**8.6**	**7**
18 to 19	**15.0**	**4**	**12.0**	**5**	**8.6**	**7**
19 to 20	20.0	3	15.0	4	10.0	6
20 to 21	30.0	2	20.0	3	15.0	4
21 to 22	30.0	2	20.0	3	15.0	4
22 to 23	30.0	2	30.0	2	20.0	3

Time of Day	Year 2025		Year 2031		Year 2041	
	Headway (min)	Trains/hr	Headway (min)	Trains/hr	Headway (min)	Trains/hr
23 to 24	60.0	1	30.0	2	30.0	2
Total No. of trains per direction per day		**47**		**65**		**88**

TABLE 8.9: HOURLY TRAIN OPERATION PLAN FOR KENGERI - WHITE FIELD

Time of Day	Year 2025		Year 2031		Year 2041	
	Headway (min)	Trains/hr	Headway (min)	Trains/hr	Headway (min)	Trains/hr
5 to 6	60.0	1	60.0	1	30.0	2
6 to 7	30.0	2	30.0	2	20.0	3
7 to 8	30.0	2	20.0	3	15.0	4
8 to 9	**20.0**	**3**	**15.0**	**4**	**12.0**	**5**
9 to 10	**20.0**	**3**	**15.0**	**4**	**12.0**	**5**
10 to 11	30.0	2	20.0	3	15.0	4
11 to12	30.0	2	30.0	2	20.0	3
12 to 13	30.0	2	30.0	2	20.0	3
13 to 14	60.0	1	60.0	1	30.0	2
14 to 15	30.0	2	30.0	2	20.0	3
15 to 16	30.0	2	30.0	2	20.0	3
16 to 17	30.0	2	20.0	3	15.0	4
17 to 18	**20.0**	**3**	**15.0**	**4**	**12.0**	**5**
18 to 19	**20.0**	**3**	**15.0**	**4**	**12.0**	**5**
19 to 20	30.0	2	20.0	3	15.0	4
20 to 21	30.0	2	30.0	2	20.0	3
21 to 22	30.0	2	30.0	2	20.0	3
22 to 23	60.0	1	30.0	2	30.0	2
23 to 24	60.0	1	60.0	1	30.0	2
Total No. of trains per direction per day		**38**		**47**		**65**

TABLE 8.10: HOURLY TRAIN OPERATION PLAN FOR HEELALIGE - RAJANKUNTE

Time of Day	Year 2025		Year 2031		Year 2041	
	Headway (min)	Trains/hr	Headway (min)	Trains/hr	Headway (min)	Trains/hr
5 to 6	60.0	1	30.0	2	30.0	2
6 to 7	30.0	2	20.0	3	20.0	3
7 to 8	20.0	3	15.0	4	15.0	4
8 to 9	**15.0**	**4**	**10.0**	**6**	**10.0**	**6**
9 to 10	**15.0**	**4**	**10.0**	**6**	**10.0**	**6**

Time of Day	Year 2025		Year 2031		Year 2041	
	Headway (min)	Trains/hr	Headway (min)	Trains/hr	Headway (min)	Trains/hr
10 to 11	20.0	3	12.0	5	12.0	5
11 to12	30.0	2	15.0	4	15.0	4
12 to 13	30.0	2	20.0	3	20.0	3
13 to 14	60.0	1	30.0	2	30.0	2
14 to 15	30.0	2	20.0	3	20.0	3
15 to 16	30.0	2	15.0	4	15.0	4
16 to 17	20.0	3	12.0	5	12.0	5
17 to 18	**15.0**	**4**	**10.0**	**6**	**10.0**	**6**
18 to 19	**15.0**	**4**	**10.0**	**6**	**10.0**	**6**
19 to 20	20.0	3	12.0	5	12.0	5
20 to 21	30.0	2	15.0	4	15.0	4
21 to 22	30.0	2	20.0	3	20.0	3
22 to 23	30.0	2	30.0	2	30.0	2
23 to 24	60.0	1	30.0	2	30.0	2
Total No. of trains per direction per day		**47**		**75**		**75**

8.3.6 ROLLING STOCK REQUIREMENT

Requirement of coaches has been calculated as per following assumptions:

i) Headway during peak hours.

ii) Turn round time as 6 min at terminal stations.

iii) Traffic/Operational spares have been considered @5% of bare requirement to cater to operational exigencies on the corridor.

iv) Repair and maintenance has been estimated as 10% of total coach requirement (Bare+Traffic Reserve) based on Intermediate overhaul and periodic overhaul interval.

v) Schedule speed has been taken as 33 kmph.

Based on Train length and headway as decided above to meet Peak Hour Peak Direction Traffic Demand in different years, the rake requirement has been tabulated as follows:

TABLE 8.11: ROLLING STOCK REQUIREMENT FOR DIFFERENT CORRIDORS

Corridor	Time horizon Year	Train per hour	Section length km	Rake required	Bare Rake requirement	Traffic spare@ 5%	Maint. Spare @10%	Total rake requirement	Total Coach Requirement
Corridor 1 (KSR Bengaluru City - Devanahalli)	2025	6	41.5	16.3	17.0	1	2	20.0	120
	2031	7	41.5	19.0	19.0	1	2	22.0	132
	2041	9	41.5	24.4	25.0	1	3	29.0	174
Corridor 2 (Baiyappanahalli - Chikkabanavar)	2025	4	24.5	6.7	7.0	0	1	8.0	48
	2031	5	24.5	8.4	9.0	0	1	10.0	60
	2041	7	24.5	11.8	12.0	1	1	14.0	84
Corridor 3 (Kengeri - White Field)	2025	3	35.3	7.0	8.0	0	1	9.0	54
	2031	4	35.3	9.4	10.0	1	1	12.0	72
	2041	5	35.3	11.7	12.0	1	1	14.0	84
Corridor 4 (Heelalige - Rajankunte)	2025	4	46.1	12.0	12.0	1	1	14.0	84
	2031	6	46.1	18.0	18.0	1	2	21.0	126
	2041	6	46.1	18.0	18.0	1	2	21.0	126

The total number of rakes required for the Bengaluru Suburban rail corridors for different horizon years is given in **TABLE 8.12.**

TABLE 8.12 : TOTAL RAKES REQUIRED FOR BENGALURU SUBURBAN RAIL CORRIDORS

	2025	2031	2041
Rake Requirement	51	65	78
Coach Requirement	306	390	468

8.4 SIGNALLING & TELECOMMUNICATION

8.4.1 PROJECT BACKGROUND

The project involves to equip the proposed sub-urban corridor with state of the art proven Communication based Train Control system, computer-based interlocking (CBI/EI) system, automatic block working using axle counters and introduction of TMDS (Train Management and Dispatch System) facility.

- SBC-NYH-KGI (Two new lines to the .existing double line-12.80 Km)
- BYPL-KJM-WFD (Two new lines to the existing double line-12.5 Km)
- HLE-BYPL-BAND-HEB-LOGH (Two new lines to the existing single line-37.60 Km)
- YNK-RNN (Two new lines to the existing single line-8.755 Km)
- YNK-DHL-CBP (Two new line to the existing single line -46.00 Km)
- YPR-BAW (Two new lines to the existing double line-7.92 Km)
- A new Centralised dispatch office at BNC

8.4.2 PROPOSED EI STATIONS
(Terminal stations and block stations with approximately 10 km spacing)

- KENGERI
- KSR BANGALORE CITY
- BAIYYAPPANAHALLI
- WHITEFIELD
- LOTTEGOLLAHALLI
- YELAHANKA
- RAJANKUNTE
- HEELALIGE
- CARMELARM
- DEVANAHALLI

8.4.3 OPERATIONAL CONCEPT

a. Signalling and Train Control: Adoption of CBTC based signalling system.

Train control requirements if the Sub-urban network is planned to be achieved by adopting Continuous Automatic Train Control (CATC) based on the Communication Based Train Control (CBTC) System**(**

FIGURE 8.1). The train location is determined by continuous communication with central control. The Track circuits/Axle counters are installed as a fall back option and to manage non-equipped vehicle movements. This system includes Automatic Train Protection (ATP) and automatic Train operation (ATO) sub-systems using continuous bi-directional radio communication between track side and train and Automatic Train Supervision (ATS) sub systems.

The CBTC system offers following advantages:

i. High reliability, better availability and less prone to failures.

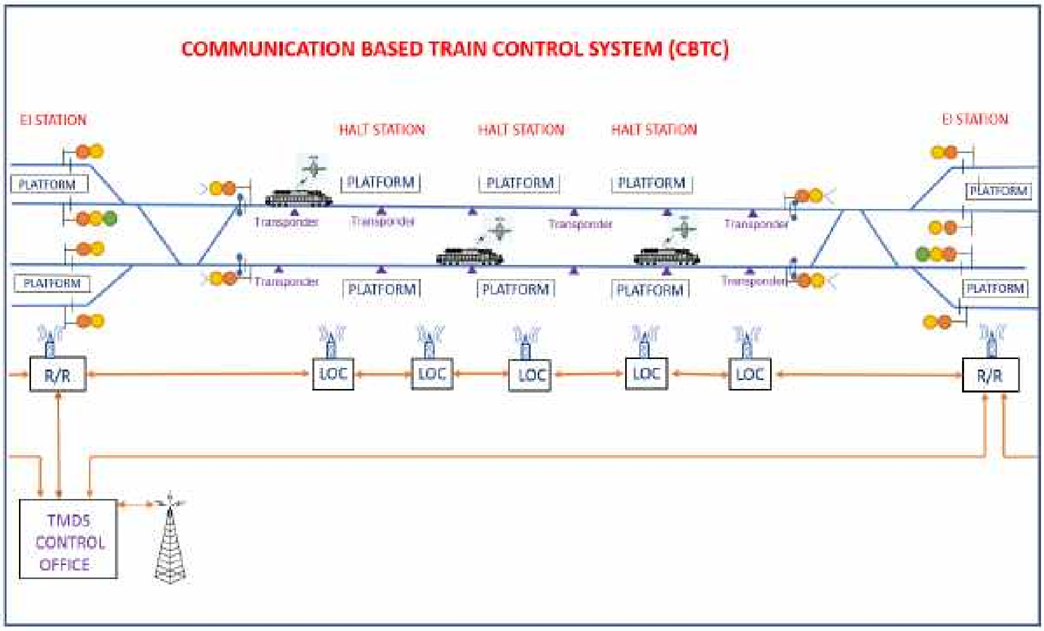
ii. Easier to maintain.

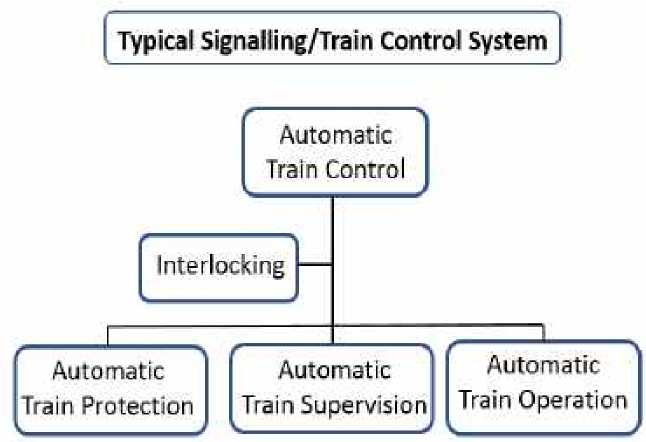
iii. Provides higher traffic capacity.

iv. They are reported to be more energy sufficient systems compared to DTG signalling.

v. Adaptable to any Grade of Automation and scalable too.

FIGURE 8.1 COMMUNICATION BASED TRAIN CONTROL SYSTEM





This will:

- Provide high level of safety ensuring continuous safe train separation and for bidirectional working.
- Eliminate accidents due to driver passing Signal at Danger by continuous speed monitoring and automatic application of brake in case of disregard of signal/ warning by the driver.
- Provides safety and enforces speed limit on section having permanent and temporary speed restrictions.
- Improve capacity with safer and smoother operations. Driver will have continuous display of Target Speed and other information in his cab enabling him to optimize the speed potential of the track section. It provides signal/ speed status in the cab even in bad weather.

- Improve maintenance of signalling and telecommunication equipments by providing new ways of monitoring system status of trackside and train borne equipments continuously and enabling preventive maintenance.

  A Signalling and train control system shall be designed to meet the required headway during peak hours. The signalling system shall also have secondary detection of trains through Axle counters/Track circuits. Radio for CBTC shall work in license free ISM band.

  The control of train operation will be done from a centralized Operation Control Centre (OCC) and will be supervised by Traffic Controller. The OCC shall have required facilities for setting of the route and clearing of the signals and other supervisory and control facilities. The Backup Control Centre shall also be provided at a suitable location geographically separated from the OCC.

b. System Description and Specifications:

i. Continuous Automatic Train Control

Continuous Automatic Train Control based on CBTC will consist of – Automatic Train Protection (ATP), Automatic Train Operation (ATO) and Automatic Train Supervision (ATS) sub systems. The train borne Automatic Train Control system will consist of Automatic train Operation (ATO) and Automatic train Protection (ATP). This will work on fixed block principle.

ii. Automatic Train Protection (ATP)

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

- Cab Signalling
- Moving Block
- Generation of track related speed profile based on continuous data from the track to train.
- Continuous monitoring of braking curve with respect to a defined target point.
- Monitoring of maximum permitted speed on the line and speed restriction in force.
- Detection of over speed with audio-visual warning and application of brakes, if necessary.
- Correct platform side opening of doors.

- Maintaining safe distance between trains.
- Prevention of side collision.
- Monitoring of stopping point.
- Monitoring of Direction of Travel and Rollback.

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

iii. Automatic Train Operation (ATO)

This system will operate the trains automatically from station to station within the safety envelope of ATP and open the train doors on the correct side. In conjunction with ATP/ATS, ATO can control the dwell time at stations and manage the train running in accordance with headway/ time table.

iv. Automatic Train Supervision (ATS)

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

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

- Automatic Route Setting
- Automatic Train Regulation
- Continuous Tracking of Train Position
- Display Panel & Workstation Interface
- Link to Passenger Information Display System for online information
- Computation of train Schedule and Timetable
- Issue special commands to train such as train hold, skip station etc.

8.4.4 TELECOMMUNICATION

Introduction:

The telecommunication system acts as the communication backbone for signalling systems and other systems. It also provides telecommunication services to meet operational and administrative requirements of Suburban work. Telecommunication system consists of following sub-systems:

i. Fibre optic transmission System (FOTS)- Main telecommunication Bearer

The main bearer of the bulk of the telecommunication network is proposed with optical fibre cable system.

Minimum SDH STM-4 based system shall be adopted with SDH nodes at every station and OCC. Access 2Mbps multiplexing system will be adopted for the lower level at each node, a fully IP based, high capacity(min 1 Gbps) highly reliable and fault tolerant Ethernet network (MAN/LAN) can be provided. Further small routers and switches shall be provided for LAN network stations.

- **Telephone Exchange**

  The system shall be IP based. The telephone extensions can be combination of IP, digital and analog**.** For an optimized cost effective solution, small exchanges of 30 port each shall be planned at each station and a 60 port exchanges at the terminal stations and depots shall be provided. The station exchanges will be connected to the OCC main exchange. The exchanges will serve the subscribers at all the stations and central control. The exchanges will be interconnected at the channel level on optical backbone. For the critical control communication, the Availability and Reliability should be high.

- **Mobile Radio Communication**

  Mobile radio communication system having 8 channels is proposed for on-line emergency communication between Railway operational staff, including drivers, dispatchers, shunting team members, train engineers and station controllers. The system shall be A based on Digital Trunk Radio Technology and TETRA International standard. All the stations, depots and OCC will be provided with fixed radio sets. Mobile communication facility for maintenance parties and security personnel will be provided with handheld sets.

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

  - **Passenger Announcement System**

    The system shall be capable of announcements from the local stations as well as from OCC. Announcement from OCC will have over-riding priority in all announcements. The system shall be linked to signalling system for automatic train actuated announcements.

- **Centralised Clock System**

  This will ensure an accurate display of time through a synchronisation system of slave clocks driven from a Master Clock at the OCC. The system will ensure identical display of time at all locations. Clocks are to be provided on platforms, concourse, Station Master's room, depots and other service establishments.

- **Passenger Information Display System**

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

- **Closed Circuit Television (CCTV)**

  CCTV system shall provide surveillance and recording function for the operations to monitor each station. All areas in stations where security, safety and crowd control purpose is necessary like Entry, concourse entry to lift, escalators, platforms, passage to operation rooms, entry to PFs from emergency stair case, External station area shall be covered by CCTV coverage. It shall be used extensively for platform surveillance, surveillance of all important location including depot locally and remotely and video recording locally and mirrored for video images retrieval.

  The surveillance of Trains shall be possible at a central location/OCC through a Broad Band Radio System (BBRS), which may make use of the track side infrastructure like poles provided for the Signalling/Train control system.

- **Network Monitoring & Management**

  For efficient and cost-effective maintenance of the entire communication network, it is proposed to provide a Network Management System (NMS), which will help in diagnosing faults immediately from a central location and attending the same with least possible delay, thus increasing the operational efficiency and reduction in manpower requirement for maintenance.

  The proposed NMS will be covering radio communication, Optical fibre transmission system, Telephone exchange and summary alarms of PA/PIDS, CCTV and clock and UPS systems.

8.4.5 STANDARDS

Standards proposed to be adopted for Telecommunication systems are shown in **TABLE 8.13**.

TABLE 8.13 : STANDARDS TO BE ADOPTED FOR TELECOMMUNICATION SYSTEMS

System	Standards
Transmission System	SDH or Etehrnet based MAN/LAN
Transmission Media	Optical Fibre system as the main bearer for bulk of the telecommunication network.
Telephone Exchange	IP EPABX of minimum 30 ports is to be provided at all stations, an Exchange of 60 ports to be provided at Terminal stations and Depot.
Train Radio system	Digital Train Radio (TETRA) communication between train operator of moving cars, stations, maintenance personnel, depots and central control.
Train destination indicator system	LED/LCD based boards with adequate visibility to be provided at convenient location at all stations to provide bilingual visual indication of the status of the running trains, and emergencies.
Centralized Clock system	Accurate display of time through a synchronized system of slave clocks driven from a master clock at OCC and sub-master clock in station/depots. This shall also be used for synchronization of other systems.
Passenger announcement systems	Passenger announcement systems covering all platform and concourse areas with local as well as Central announcement.
Video Surveillance	IP based High definition CCTV cameras with network video recorders at stations, Centralized management, video analytic features and video wall display.
Redundancy (Major system)	Redundancy on Radio base station equipment. Path redundancy for OFC by provisioning in ring configuration
Environmental conditions	All equipment rooms to be Air-conditioned.
Maintenance Philosophy	System to have as far as possible, automatic switching facility to alternate routes/circuits in the event of failure. Philosophy of preventive checks of maintenance to be followed. System network with NMS for diagnosing faults and co-ordination. Card/module level replacement shall be done in the field and repairs undertaken in the central laboratory/manufacturer's premises. Maintenance contract for hardware/software as necessary to manage the technology advancement.

8.5 MAINTENANCE FACILITIES

8.5.1 INTRODUCTION

The Maintenance facilities for the Corridors Chikkabanavar - Baiyappanahalli (Corridor-2), Kengeri - White Field (Corridor-3) and Heelalige - Rajankunte (Corridor-4) are proposed to be provided at Janabharathi and for Bengaluru City - Devanahalli (Corridor-1), near Devanahalli.

The proposed arrangement for stabling and maintenance facilities of all the corridors is given in **Table 8.14**.

TABLE 8.14: MAINTENANCE DEPOT FOR ALL CORRIDORS

Infrastructure	Corridor-1	Corridor-2	Corridor-3	Corridor-4
	Devanahalli Depot	Janabharathi Depot		
Stabling Lines	29 lines of 6 car	14 lines of 6 car	13 lines of 6 car	21 lines of 6 car
Inspection Lines	6 lines	4 lines		
Workshop Lines	3 lines	3 lines		

All the rakes will be serviced at maintenance Depot cum workshop for the scheduled inspections, major schedules viz Periodical overhaul (POH) and major unscheduled repairs. The main depot will also house Operation Control Centre (OCC), Administrative Building, maintenance facilities for Civil – track, buildings, water supply; Electrical – traction, E&M; Signalling & Telecomm.; Automatic Fare Collection etc. apart from 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.

For starting the morning services, some rakes will have to be kept at terminal stations and stabling facilities for the remaining rakes will have to be provided at the depots.

Rake composition for 3-cars and 6-cars are proposed with the basic units of 3-cars so that the train can be broken down into independent units of three cars each for the maintenance purposes.

This section provides conceptual design of the depot and will work as a guide for the detailed design later.

8.5.2 MAINTENANACE PHILOSOPHY

- Monitoring of the performance of equipment by condition monitoring of key parameters. The concept is to progressively evolve the need based maintenance regime, which can be suitably configured in the form of minor & major schedules.
- Unit replacement and to get essential repairs done by the OEMs, will be preferred. Since the cost is a constraint, certain activities of the workshop can be outsourced.
- Labour intensive procedures be kept to the minimum & emphasis laid on more automation with state of the art machinery to ensure quality with reliability.
- Multi skilling of the Maintenance staff to ensure quality and productivity in their performance.
- Energy conservation shall be given due attention

8.5.3 PLANNING OF THE MAINTENANCE FACILITIES SETUP

The projected Rolling Stock requirements for the corridor are as follows:

TABLE 8.15: ROLLING STOCK REQUIREMENTS

		2025	2031	2041
KSR Bengaluru City - Devanahalli	Headway (Sec)	600	514	400
	No. of Cars/Train	6	6	6
	Rakes Required	20	22	29
	Cars Required	120	132	174
Baiyappanahalli - Chikkabanavar	Headway (Sec)	900	720	514
	No. of Cars/Train	6	6	6
	Rakes Required	8	10	14
	Cars Required	48	60	84
Kengeri - White Field	Headway (Sec)	1200	900	720
	No. of Cars/Train	6	6	6
	Rakes Required	8	10	13
	Cars Required	48	60	78
Heelalige - Rajankunte	Headway (Sec)	900	600	600
	No. of Cars/Train	6	6	6
	Rakes Required	14	21	21
	Cars Required	84	126	126

8.5.4 ROLLING STOCK MAINTENANCE NEEDS

The servicing requirement is to be determined from the Rolling Stock manufacturer. Depending upon manufacturer's requirements, servicing facilities may be provided to include the ability to carry out the inspection, maintenance, overhaul and repair of the rolling stock fleet, including the following components:

- Body;
- Bogies;

- Wheels
- Traction motors;
- Electrical components;
- Electronics; PA/ PIS
- Mechanical components;
- Batteries;
- Rolling stock air conditioning;
- Brake modules;
- Vehicle doors, windows and internal fittings.

The modern, fully equipped facilities are proposed to be provided to meet these requirements efficiently and in full. The following maintenance schedule **(TABLE 8.16)** is recommended by RDSO in para (k) of SMI no. RDSO/PE/SMI/EMU/0037-2007(rev.0) dated April-2007, has been followed for conceptual design -

TABLE 8.16 : PERIODICITY OF MAINTENANCE SCHEDULES FOR RAKES

Schedule	Periodicity	
	As per SMI	With 10 days frequency
Trip Schedule (TI)	10 days	10 days
IA Inspection	45 days	40-50 days
IC Inspection	180 days	180-190 days
POH	18 months	18 months (540 days)

Legends Used:

TI:- Trip Inspection IA:- 45 days Inspection

IC:- 180 days Inspection POH:- 18 months Inspection

8.5.5 WASHING NEEDS OF ROLLING STOCK

To maintain high degree of cleanliness, following schedules **(TABLE 8.17)** are proposed:

TABLE 8.17: SCHEDULE OF CLEANING

S. No	Kind of Inspection	Maint. 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 & heavy cleaning on nominated stabling line

8.5.6 DEPOT CUM WORKSHOP

The layout plan of proposed Maintenance Depot cum Workshop has been evolved for maintenance and POH as per **TABLE 8.14**. The concept plan includes the following:

Operational Features

The rake induction and withdrawal from depot to the open line will have to be so planned that the headway of open line is not affected. For the purpose, facilities for simultaneous receipt and dispatch of trains from depot to open line needs to be created. The stabling area is to 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.

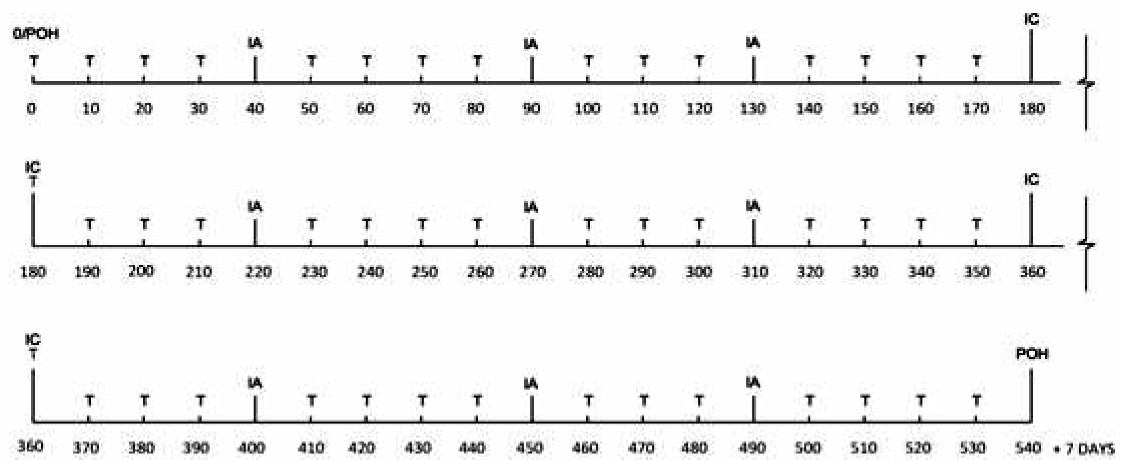
The other movements in the depot, viz from the stabling to the inspection shed or workshop and vice versa may be non-interlocked. An ART (accident relief train) line and 2 emergency rerailing lines will be provided from which emergency rescue vehicles can be dispatched to open line in the event of any emergency. To cater to the peak requirements, all trains except trains under maintenance would be in the service. However, during the off-peak hours, approximately half of the trains will be withdrawn from the service. To economize on the air-conditioning energy, 50% of the total stabling lines would be under covered stabling shed. There would be pathways between the stabling lines, which are necessary for the “Safe to Run” examination and to facilitate the workers to move trolleys for the sweeping work. The scheduled inspections are envisaged to be carried out during the day off-peak hours and night.

The stabling and the yard layout would be at grade level for least power requirements in shunting movements and to avoid accidental rolling of Rolling Stock resulting into accidents and damages to the property.

Conceptual layout plan of maintenance depot cum workshop is at **Annexure-I**and **Annexure-II**.

8.5.7 INFRASTRUCTURE FACILITIES PLANNED AT DEPOT

The sequence of rake inspection at every 10 days interval is given below:



As per the above frequency of inspections, periodicity of rakes visiting depot is given in **TABLE 8.18**.

TABLE 8.18 : RAKE VISIT PERIODICITY FOR DEPOT

Rake visits to Car Shed/Depot		
Schedule	**Total visits in 18 months**	**Average visits per year**
TI	43*	28.667
IA	9	6
IC	2	1.333
POH	1	0.667

*Includes one additional inspection in car shed after POH in workshop

To assess the number of lines required to maintain the rakes, following assumptions are made:

i) For Washing of rakes, an automatic washing plant will be proposed. Hence no separate washing line is needed exclusively for washing. However, one line will be provided for heavy cleaning (Manual cleaning of Floor, walls inside/outside and roof).

ii) In a day, two rakes are taken for Trip Inspection on a pit line.

iii) In a day, one rake is taken for IA schedule on a pit line.

iv) Pit line occupancy for IC schedule (Down time 16 hrs) is taken for two days.

v) Based on the number of holidays as given below, total number of working days is 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

TABLE 8.19 : TOTAL REQUIREMENT OF MAINTENANCE LINES IN CORRIDOR-I

Schedule	Schedule per rake per year	Total Arising per day for holding of 29 rakes	Line Occupancy	Lines Required	Lines Provided
Inspection Shed					
Trip Insp	28.67	2.77	2 rakes/ day	1.39	2
IA	6	0.58	1rakes/ day	0.58	0.5
IC	1.33	0.13	0.5 rakes/ day	0.26	0.5
Lines required for Inspection					3
Adjustment line for minor repair/testing after POH					**1**
Total Inspection Lines Provided					**4**
LINES NEEDED IN WORKSHOP					

Schedule	Schedule per rake per Year	Total Arising per Year	Time taken in Over haul	Number of lines needed	Lines required
POH	0.667	19.34	24	0.81	1
Lines required					1
Unscheduled Repair / Lifting /Wheel/Bogie sections etc.					**2**
Workshop Lines Provided					**3**

TABLE 8.20 : TOTAL REQUIREMENT OF MAINTENANCE LINES IN CORRIDOR-II, III & IV

Schedule	Schedule per rake per year	Total Arising per day for holding of 48 rakes	Line Occupancy	Lines Required	Lines Provided
Inspection Shed					
Trip Insp	28.67	4.59	2 rakes/ day	2.29	3
IA	6	0.96	1rakes/ day	0.96	1
IC	1.33	0.21	0.5 rakes/ day	0.43	1
Lines required for Inspection					5
Adjustment line for minor repair/testing after POH					1
Total Inspection Lines Provided					**6**
LINES NEEDED IN WORKSHOP					
Schedule	**Schedule per rake per Year**	**Total Arising per Year**	**Time taken in Over haul**	**Number of lines needed**	**Lines required**
POH	0.667	32.02	24	1.33	2
Lines required					2
Unscheduled Repair / Lifting /Wheel/Bogie sections etc.					1
Workshop Lines Provided					**3**

**All lines in workshop to be provided with lifting facility

Summary of requirement of lines inside depot during different years of train operations are presented in **TABLE 8.21**.

TABLE 8.21: SUMMARY OF REQUIREMENT OF LINES

Activities	2025	2031	2041
Trip Sch+IA+IC	3	3	3
Workshop	3	3	3
Total	6	6	6

8.5.8 PROVISION FOR STABLING LINES

As per the requirement of the rakes for different years, the requirement of the stabling to be catered in the depot, at the terminal stations and at enroute stations are summed up in **TABLE 8.22**.

TABLE 8.22: STABLING LINE REQUIREMENTS

Corridor		
KSR Bengaluru City - Devanahalli **Baiyappanahalli - Chikkabanavar** **Kengeri - White Field**	Stabling Requirements	48
	Inside Depot for Maintenance +POH	6
	Stabling Lines in Depot	42
	Stabling Lines at Terminal stations	4
Heelalige - Rajankunte	Stabling Requirements	29
	Inside Depot for Maintenance +POH	4
	Stabling Lines in Depot	28
	Stabling Lines at Terminal stations	4

8.5.9 DESIGN OF STABLING LINES

The length of two 6 cars Rolling Stock is approx 265 m. stabling lines are designed for 320 m length to cater for provision of the friction buffer stops and the signalling / interlocking needs; the breakup is as follows:

265 m (length of two 6 cars Rolling Stock) + 20 m +15 + 10+ 10 (length of the Buffer for two 6 cars Rolling Stock & signalling / interlocking needs and for clear distance between Rolling Stock &buffer, gap between two 6 car train, path ways at both ends) = 320 m.

Accordingly, stabling lines as well as inspection & workshop lines shall have 320 m & 220m length. The track centre in stabling lines would be 5.3m and in workshop and inspection lines will 8m & 6.25m respectively. Thus, sufficient space shall be provided to construct pathway in stabling area and in inspection shed to provide easy access for internal train cleaning / attention to equipments in passenger area.

WORKSHOP LINE: Working space for keeping 6 car basic unit, safe gap, pits for two car units and cross path inside this end of shed need approx. length of 220m.

INSPECTION LINE: Working space for keeping 6 car basic unit, safe gap, pits for two car units and cross path inside this end of shed need approx. length of 220m

ADMINISTRATIVE BUILDING: The Administrative Building for the depot is proposed to be located in Workshop cum Maintenance depot. An area of 180 x 30 m2 has been allocated in depot for the purpose and shown in the layout drawing.

Pit Wheel Lathe

A separate building is planned for housing pit wheel lathe in the 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.

8.5.10 AUTOMATIC COACH WASHING PLANT (AWP)

Provision to be made for Rolling Stock exterior surfaces to be washed using a fully automated Train Washing System with a throughput capacity of approximately six trains per hour. The AWP shall be situated at such a convenient point on the incoming route so that incoming trains can be washed before entry to the depot and undesirable movement/shunting over ingress and egress routes within the depot is avoided.

A test track of sufficient length is provided for the commissioning of the new trains, their trials and testing of the trains after the IOH and POH. It shall be equipped with signalling equipments. In compliance to safety norms, the boundary of the track shall be completely fenced to prevent unauthorized trespassing across or along the track.

8.5.11 POWER SUPPLIES

An auxiliary substation has been planned for catering to the power supply requirement of the main depot. Details of connected load, feeder may be worked out during detailed designing stage. The standby power supply will be proposed through silent DG set to supply all essential loads without over loading.

8.5.12 WATER SUPPLY, SEWERAGE AND DRAINAGE WORKS

In-house facilities should be developed for water supply for the entire depot cum workshop. Sewerage, storm water drainage may be given due care while designing the depot for efficient system functioning. Rainwater harvesting should be given due emphasis to charge the underground reserves.

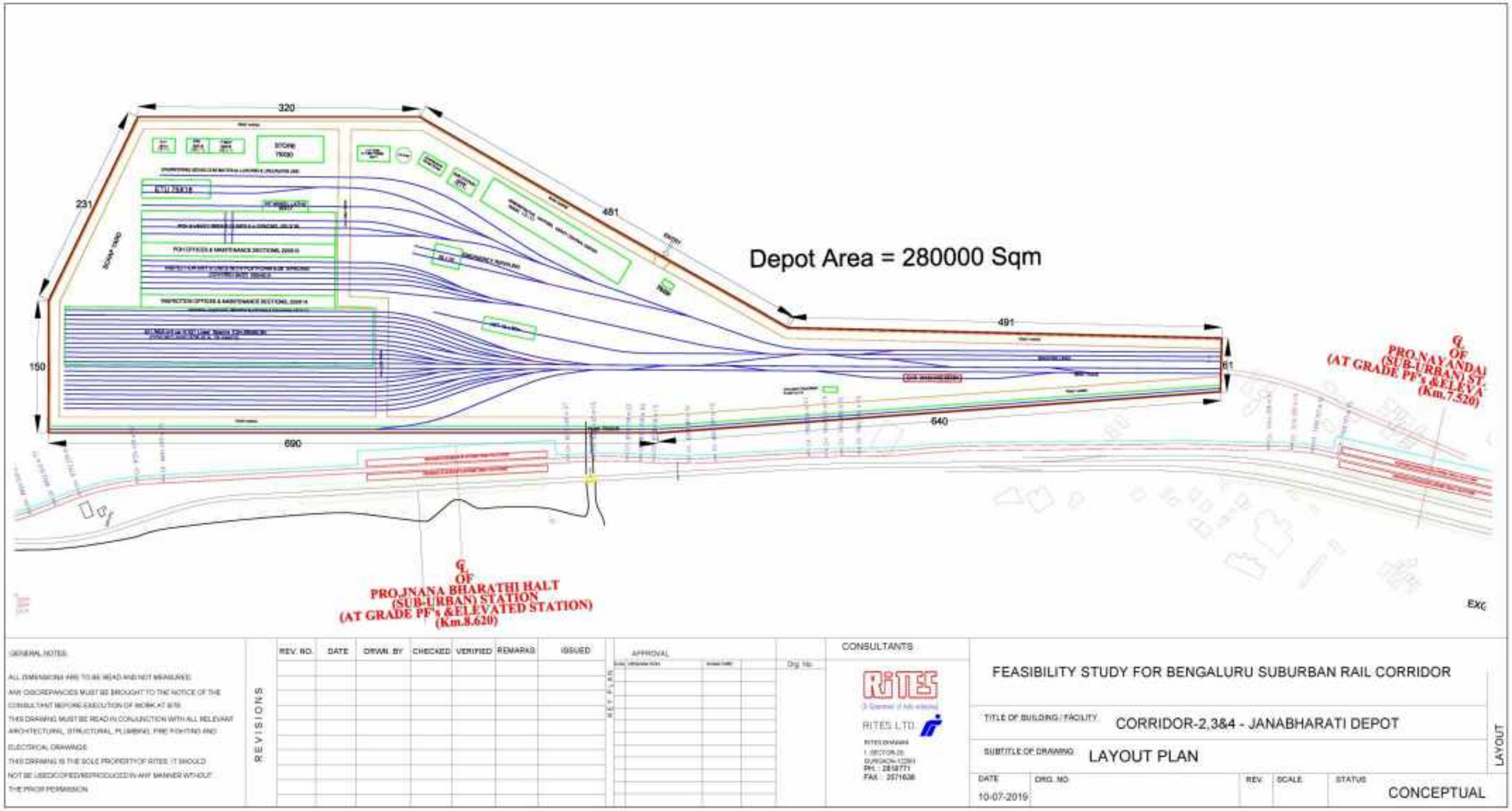
8.5.13 ENGINEERING TRAIN UNIT WORKSHOP

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 RS maintenance as shunting is also involved. Therefore, other vehicles like diesel locomotive, tower wagons, wagon for material trains etc may be housed and given required inspection attention in a separate shed called ETU workshop, for which 2 lines shall be provided in the main depot. However for the heavy lifting needs, these vehicles may be taken to main workshop for required attention.

8.5.14 PLANT AND MACHINERY

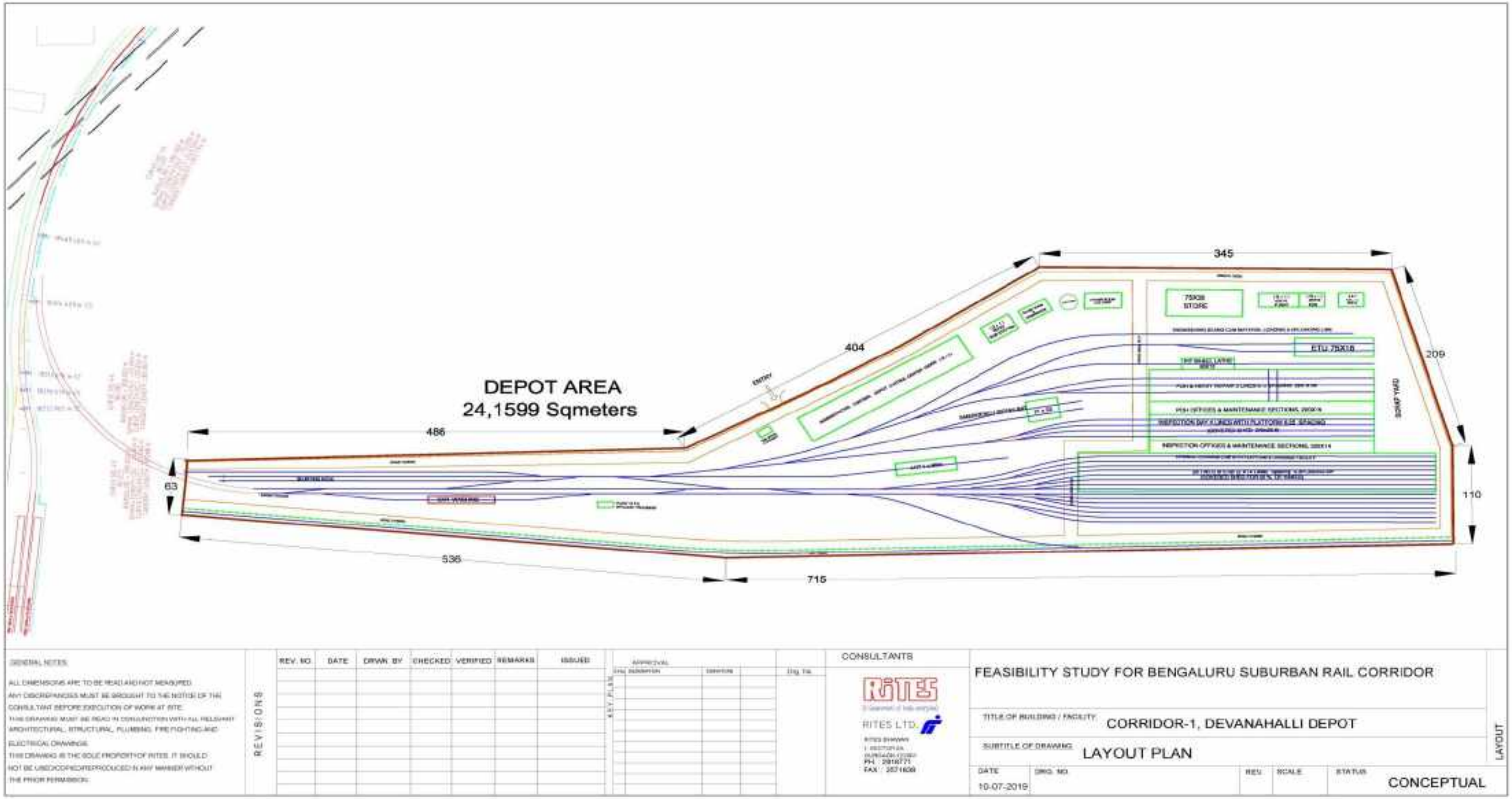
Requirement of major plants and machinery, which are vital for operational needs, is given in **Annexure-III**.

JANABHARATHI DEPOT LAYOUT FOR CORRIDOR-2, 3 & 4 *ANNEXURE-I*



DEPOT LOCATION FOR CORRIDOR-1 NEAR DEVANHALLI

ANNEXURE-II



ANNEXURE-III

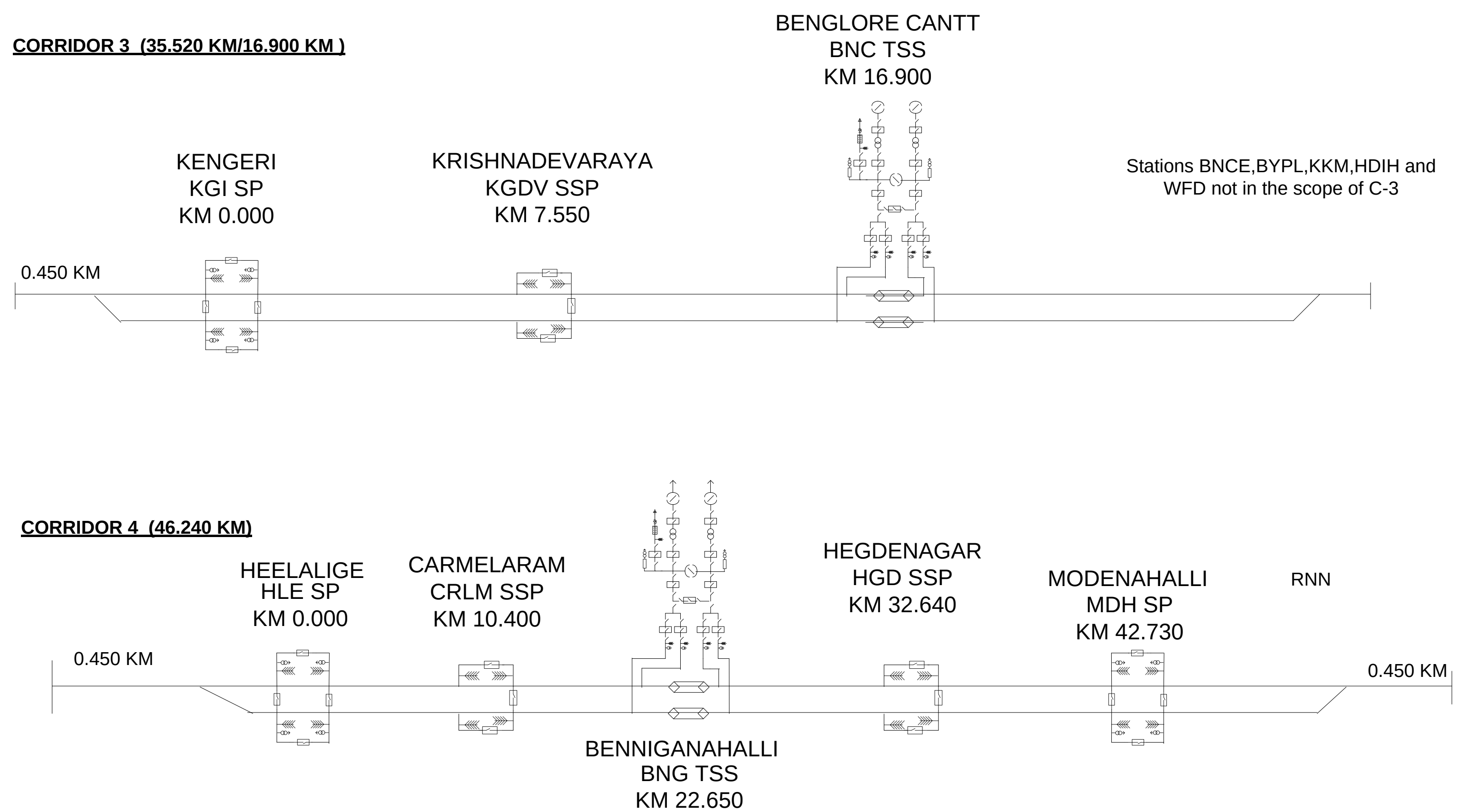
LIST OF MAJOR PLANT & MACHINERY FOR DEPOT

S.No.	PLANT & MACHINERY	Qty.
A.	**Material Handling**	
1	Travelling over head EOT cranes for workshop 35/10T	2
2	Travelling over head EOT cranes for inspection bay 2.0T	2
3	Travelling over head EOT cranes for ETU shed 5T	1
4	Jib crane for workshop 3 T	2
5	Synchronized pit jacks system for lifting (9 cars as one set)	1
6	Car body stands for keeping car shells	32
7	Dummy bogies	6
8	Mobile lifting jacks-15T	2
9	Mobile lifting jacks 10T	2
10	Battery powered Electric locomotive	2
11	OHE Inspection car	2
12	Road mobile Crane 5T cap	1
13	Fork lift trucks 3T cap	2
14	Pallet trucks	4
15	Pick up van	1
16	TATA Truck	2
B.	**Wheel shop**	
17	500T Hydraulic wheel press	1
18	Vertical boring m/c / Turret Lathe for wheel machining	1
19	Multipurpose Wheel Lathe/CNC surface wheel lathe	1
20	CNC Axle turning lathe/Axle journal turning & burnishing lathe	1
21	Axle UST inspection machine	2
22	Induction Heater	2
23	Bearing Extractor	4
C.	**Bogie shop**	
24	Bosch Tank : Bogie wash/cleaning plant (manual)	1
25	Bogie static load testing m/c	1

S.No.	PLANT & MACHINERY	Qty.
26	Shock absorber testing m/c	1
27	Spring scragging&testing m/c	1
28	Magnacheck crack detector	1
29	Glowcheck crack detector	1
D.	**Rotating m/cs**	
30	Air blow plant/Cleaning booth for Traction Motor	1
31	Baking Oven for traction motor drying	1
32	Dynamic balancing	1
E.	**Other m/cs**	
33	Under floor Pit wheel lathe, Chip crusher and conveyor, Electric tractor for movement over under floor wheel lathe	1
34	Automatic Washing plant for cars.	1
35	High-pressure washing pump for front and rear end cleaning of cars	2
36	Turn table for one car	1
37	Turntable for bogies	6
38	Driving Cab Simulator	1
39	Water de-mineralizing plant (Distillation plant)	2
40	Painting booth for separate parts	1
41	Floor cleaning machine	5
42	Welding equipments (Mobile welding, oxyacetylene, fixed arc welding)	5
43	Compressor 500Cfm, 10 kg/sq.cm for depot air supply	2
44	DG set 320 KVA	3
45	EMU Battery charger	2
F.	**Machine shop**	
46	Guillotine Shearing m/c	1
47	Shearing, punching & cropping	1
48	Universal tool cutter & grinder	1
49	Vertical surface grinder	1
50	Centre lathe 2m bed	1
51	Centre lathe 1m bed	1

S.No.	PLANT & MACHINERY	Qty.
52	Radial drill m/c	1
G.	**Test Benches/Instruments**	
53	Traction motor test console	1
54	Motor compressor test bench	1
55	Brake test bench	2
56	Speedometer test bench	2
57	Door test bench	2
58	Inverter test bench	1
59	Other test benches (MCB, RMPU etc.)	1
H.	**Furniture/material storage/Small tools**	
60	Vertical carousel storage system for DCOS store	1
61	Computer MMIS with LAN connectivity for depot	1
62	Storage racks	LS
63	Industrial furniture, work benches etc.	LS
64	Electric and pneumatic tools	LS
65	Measuring and testing equipments	LS
66	Tool kits	LS
67	Other small tools, machines &misc items etc	LS

ANNEXURE-IV



GENERAL POWER SUPPLY DIAGRAM OF 3 rd and 4 th CORRIDORS OF SUBURBAN RAIL SYSTEM AT BENGALURU

Scale:NTS

Note:
Arrangement for extended zone from corridor 2 & corridor 3 will be made at a suitable nearest location at YPR (Yeswanth pur)

9. DISASTER MANAGEMENT MEASURES

9.1 NEED FOR DISASTER MANAGEMENT MEASURES

9.1.1 Disaster is a sudden, calamitous event that seriously disrupts the functioning of a community or society and causes human, material and economic or environmental losses that exceed the community's or society's ability to cope using its own resources. Disasters are those situations which cause acute distress to public passengers and employees and outsiders and may be caused by internal or external factors. Alternatively, disaster can be defined as an occurrence disrupting the normal conditions of existence and causing a level of suffering that exceeds the capacity of adjustment of the affected community.

9.1.2 The effect of any disaster spread over in operational area of the Sub-urban Train services of Bengaluru and its surroundings is likely to be substantial as the Sub-urban Train Services deals with thousands of passengers daily in viaducts and stations. Disaster brings about sudden and immense misery to humanity, thereby disrupting the normal human life in the established social and economic patterns.

Disaster has the potential to cause large scale human suffering due to loss of life, loss of livelihood, damage to property, injury and hardship. Disasters may also cause destruction or damage to infrastructure, buildings and communication channels of Sub-urban Train services as also to the Indian Railways. Hence, there is a need to provide an efficient Disaster Management Plan (DMP).

9.2 OBJECTIVES OF DISASTER MANAGEMENT PLAN (DMP)

The main objectives of the DMP are as follows:

- ✓ Save life and alleviate suffering
- ✓ Provide help to stranded passengers / commuters and arrange their prompt evacuation
- ✓ Instil a sense of security amongst all concerned by providing accurate information
- ✓ Protect Sub-urban Rail & IR property
- ✓ Expedite restoration of train operations
- ✓ Lay down the actions required to be taken by staff, in the event of any disaster in the corridors of Sub-urban train services, to ensure handling of crisis situation in co-ordinated matter.

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

9.3 TYPES OF DISASTERS

The disasters may be broadly classified into 2 categories viz., Man-made and Natural:

- ✓ **Man**-made Disasters: This includes
- ✓ Terrorist attack
- ✓ Bomb threat / Bomb blast
- ✓ Hostage
- ✓ Release of chemical or biological gas in trains and stations
- ✓ Fire in station / buildings, power stations, Depots, elevated structures etc.
- ✓ Train accident and train collision / derailment of passenger carrying train(s)
- ✓ Sabotage and stampede
- ✓ **Natural Disaster**
- ✓ Earthquakes / Tremors
- ✓ Floods (due to unprecedented rains)

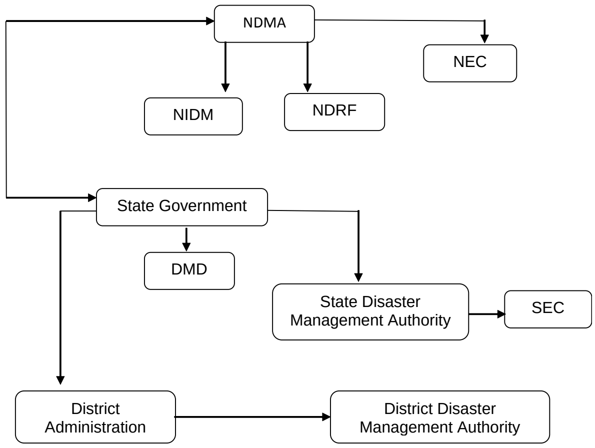
9.4 PROVISIONS UNDER DISASTER MANAGEMENT ACT, 2005

As per the Disaster Management Plan in Indian Railways, Zonal Railways will prepare Disaster Management Plans at Head Quarters and Divisional levels as per provisions of Disaster Management Act, 2005. These plans will encompass the National Policy of Disaster Management (NPDM) and guidelines issued by NDMA.

For ensuring uniformity and best possible use of information, effort needs to be made to format the plan under Divisional Disaster Management Plan, as the Sub-urban Train Services shall be under the purview of SPV formed by Government of Karnataka (GoK) and Ministry of Railways.

The Institutional Framework for the Disaster Management shall be as under:

FIGURE 9.1: INSTITUTIONAL FRAMEWORK FOR DISASTER MANAGEMENT



No Railway official is nominated either in the NEC or SEC, though they can be co-opted as per need.

9.5 NATIONAL DISASTER MANAGEMENT AUTHORITY (NMDA)

Establishment of National Disaster Management Authority:

i. With effect from such date as the Central Government may, by notification in the Official Gazette appoint in this behalf, there shall be established for the purposes of this Act (The Disaster Management Act, 2005), an authority to be known as the National Disaster Management Authority.

ii. The National Authority shall consist of the Chairperson and such number of other members, not exceeding nine, as may be prescribed by the Central Government and, unless the rules otherwise provide, the National Authority shall consist of the following:

   a) The Prime Minister of India, who shall be the Chairperson of the National Authority, Ex officio;

   b) Other members, not exceeding nine, to be nominated by the Chairperson of the National Authority.

iii. The Chairperson of the National Authority may designate one of the members nominated under clause (b) of sub-section (ii) to be the Vice-Chairperson of the National Authority.

iv. The term of office and conditions of service of members of the National Authority shall be such as may be prescribed.

9.6 STATE DISASTER MANAGEMENT AUTHORITY (SDMA)

9.6.1 ESTABLISHMENT OF STATE DISASTER MANAGEMENT AUTHORITY

a) The GoK, shall establish a State Disaster Management Authority (SDMA) for the State with such name as may be specified in the notification of the State Government.

b) 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:

- ✓ Chief Minister of the State, who shall be ex-officio chairperson
- ✓ Other members, not exceeding eight, to be nominated by the Chairperson of the State Authority
- ✓ Chairperson of State Executive Committee (SEC), ex-officio

c) The Chairperson of the State Authority may designate one of the members to be the Vice-Chairperson of the State Authority as per the Standard Institutional Framework of Disaster Management Act, 2005.

d) SPV would abide by the constitutional delegation stated above

e) The term of office and conditions of service of members of the State Authority shall be such as may be prescribed.

9.6.2 COMMAND AND CONTROL AT THE NATIONAL, STATE AND DISTRICT LEVEL

The mechanism to deal with natural as well as manmade disasters shall have a 4-tier structure as stated below:

A) National Crisis Management Committee (NCMC) under Chairmanship of Cabinet Secretary

B) Crisis Management Group (CMG) under Chairmanship of Union Home Secretary

C) State Level Committee under the Chairmanship of Chief Secretary

D) District Level Committee under the Chairmanship of District Magistrate

E) All agencies of the Government at the National, State & District levels will function in accordance with the guidelines and directions given by these committees.

9.6.3 PLANS BY AUTHORITIES AT DISTRICT LEVEL

Every office of the Government of India and of the GoK at the district level and the local authorities shall, subject to the supervision of the District Authority:

A) Prepare DMP setting out the following viz.,
   - ✓ Provisions for prevention and mitigation measures as provided in the District Plan and as assigned to the Department / 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.

B) Co-ordinate preparation and implementation of its plan with those of the other organisations at the district level including local authority, communities and other stake holders.

C) Regularly review and update the plan and

D) Submit a copy of DMP, and any amendment thereto, to the District Authority.

9.7 PROVISIONS AT SUB-URBAN TRAIN STATIONS / OTHER INSTALLATIONS

To prevent emergency situations and to handle effectively in case 'one arises', there needs to be following provisions for an effective system which can timely detect the threats and help suppress the same.

A) Fire Detection and Suppression System

B) Smoke Management

C) Environment Control System

D) Station Power Supply System

E) DG sets & UPS

F) Lighting System

G) Station Area lights

H) Seepage system

I) Water supply, Drainage system & Sewage system

J) Any other system deemed necessary

The above list is only suggestive and not exhaustive. Actual provisioning has to be done based on site conditions, other internal and external factors.

9.7.1 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
- 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 Chief Controller and Station Controller and take assistance from station staff as required.

D) Fire at Suburban 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 Sub-urban Train users or by Sub-urban Train passengers leaving the station area.

9.7.2 MEASURES IN CASE OF COLLISION OF TRAINS

In the event of a train collision involving Sub-urban 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 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 Local police.
- Mobilize the staff for evacuation of passengers and rendering of first aid to the injured and their hospitalization as required.
- Inform passenger waiting 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 State Disaster Management Team members.
- And other designated State 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.
- 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 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).

9.7.3 MEASURES IN CASE OF TRAIN DERAILMENT

A) Duties of Train Operator:

- The TO becoming aware that his train has derailed shall stop the train immediately if not, already stopped and secure the train.
- Inform passengers of the problem and action being taken.
- 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 Sub-urban Train departments, 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.
- 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).

9.7.4 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 Sub-urban Train 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.
- On receipt of information of any terrorist act on Sub-urban Trains, stations or on the Right of Way, OCC will take prompt action to get the entire Sub-urban Trains 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 passengers
- 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 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 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 concerned 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 announcements to be made to passengers in train and at station of the likely delay and evacuation procedures started. The entire Sub-urban Rail network shall remain closed till rescue and search operations have been completed. 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, he 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 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 a case of suspected release of poisonous gases. If gas release is detected in a train, TO will inform OCC and expeditiously to 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 Local 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.

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

9.8 PREPAREDNESS FOR DISASTER MANAGEMENT

When a new set of staff are to work in the Sub-urban Train System, the system being a technological complex system, proper training of staff is an essential requirement for disaster management. With a learning curve to improve and stabilize with time, intensive mock drills for the staff is very essential. This ensures proper training for them to become fully conversant with the action required to be taken to handle emergencies.

The staff also needs to be trained in appropriate communication skills while addressing passengers during "INCIDENT MANAGEMENT" to assure them about their well being, seeking their co-operation.

Thus, learning can be perfected only by doing Mock Drills. Hence, 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

Regular Mock Drills will thus instil confidence in the staff to deal with the crisis as and when it occurs.

Since the Sub-urban Rail System runs parallel to the existing IR network at grade and elevated, any disaster on Sub-urban or IR system could affect both the train operation. The Action Plan of SPV has to be applied for Sub-urban system, even if the disaster occurred on IR system and affecting the Sub-urban rail system. Relief assistance from either system should be utilized for early restoration of train operation. A separate co-ordinating team involving SPV and Railway officials need to be made to reach such crisis.

9.9 SECURITY MEASURES & ESSENTIALS OF SECURITY MANAGEMENT, SECURITY SYSTEM DESIGN PARAMETER

9.9.1 SECURITY MEASURES & ESSENTIALS OF SECURITY MANAGEMENT

Sub-urban Rail System is also a reliable mode of urban transportation system in India.

The inherent characteristics of Sub-urban system make it an ideal target for terrorists and miscreants. Sub-urban 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 Sub-urban 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 Sub-urban system for increasing its market share. Sub-urban railway administration must ensure that security model keeps pace with the rapid expansion of the Sub-urban and changing security scenario.

9.9.2 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 creates a sense of re-assurance which cannot fully be achieved by technology. For human factor to be more effective, staff has to be qualified, trained, well equipped and motivated. The staff members should be skillful, trained, drilled and experienced. The security risk assessment is the first step for understanding the needs and prioritizing resources. The organization of security should be clear and consistent. Security incidents, especially major ones, often happen without warning. Emergency and contingency plans must be developed, communicated and tested in advance. There are number of technologies which can be used to enhance security e.g. surveillance systems. The objectives of the security systems differ i.e., detection of the plan before an attack, deny the access for carrying out an attack and mitigation measures after an attack.

9.9.3 DIFFERENT PHASES OF SECURITY

There are three different phases associated with the security system in Sub-urban Rail System. 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.

9.9.4 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 the Sub-urban Rail Network of Bengaluru.

9.10 SECURITY SYSTEMS RECOMMENDED FOR SUB-URBAN TRAIN SERVICES IN BENGALURU

For providing an efficient security system in station areas, the following provisions are suggested:

i. CCTV coverage of all Sub-urban 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 crowded 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 crowded 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.

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 Sub-urban stations. Dog Kennels along with provision for dog handlers and MI room will also be provided by Sub-urban 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 Sub-urban 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 can look after 5-6 Sub-urban stations. 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.

9.11 INSPECTIONS / MAINTENANCE SCHEDULE

An effective inspection and maintenance schedule is required as a preventive measure. The system followed in Mumbai local trains may be planned duly training the staff for the inspections and maintenance works. Regarding maintenance of tracks, the daily corridor blocks during night hours and mega blocks on Sundays may be planned similar to the system followed in Mumbai local trains.

9.12 SPECIAL MEASURES FOR IR TRACKS

The Suburban rail system is aligned parallel to the existing IR lines. Hence all the structures of the Suburban system need adequate protection as per the prescribed norms of IR.

The following guide lines referred in Corrigendum Slip No.48 dated 22.06.2017 of IRS bridge rules issued by RDSO / Lucknow may be adopted. The following paras of the Corrigendum are appended below:

Para 2.16.4.1: Structures to be checked for accidental impact from derailed trains:

Para 2.16.4.1.1: Structures which need special measures to be taken regarding derailed vehicles:

- ✓ Buildings with regular occupancy offices/residences including amenities at railway stations (Occupancy more than 10)
- ✓ Buildings likely to be crowded usually or occasionally such as Shopping areas, theatres, auditorium etc.
- ✓ Structures supporting tracks, railway etc. carrying passengers.

- ✓ Structures carrying hazardous chemicals like oil, gas etc.
- ✓ Any other structure where risk analysis indicates a need for taking measures to protect the structures against derailment loads.

Para 2.16.4.1.1: The structures which usually don't need any special measures to be taken regarding derailed vehicles:

- ✓ Fencing /boundary walls etc.
- ✓ Masts, poles etc. for railway use such as indicators, OHE/signal structures etc.
- ✓ Platform cover shelters and other structures which do not normally have people on them.
- ✓ Ware houses and parking lots which are thinly occupied (occupancy less than or equal to 10)

Para 2.16.4.2 Distance upto which the Structures shall be considered vulnerable: The structures shall be considered vulnerable for a distance specified below:

Maximum Speed of Trains	Perpendicular distance of structure from center line of nearest track (Including duly protected ends of tracks) upto which structures shall be considered vulnerable
<=100 KMPH	4.1m + Maximum height of vehicle/3
>100 KMPH, <=160 KMPH	5.1m + Maximum height of vehicle/3
For track curvature exceeding 0.5 deg. An additional charges of 1m shall be provided	

Note: 1. For vehicles travelling at different speeds, the distance of vulnerability shall be worked out separately for different vehicles.

2. The height upto which the distance of structure is to be measured shall be upto the top of vertical part of the Maximum Moving Dimension diagram for the route.

Para 2.16.4.3 Design Measures for structures which are within distance specified in Para 2.16.4.2: All structures within the distance specified in para 2.16.4.2 are vulnerable to damage due to being hit by derailed vehicles. These structures shall be suitably designed as specified below:

Para 2.16.4.3.1: The structures considered vulnerable as per clause 2.16.4.1 but located near tracks having maximum speed 100 KMPH shall be considered adequately protected if the structure is supported on a platform (Can be an extension of foundation) with minimum height 0.76m above rail level, minimum length 3.6m and minimum thickness 0.8m , which extends minimum 1.2m below the surrounding ground and if the columns/piers of the structure are minimum 0.5m (measured from all possible directions of train impact) behind edge of the platform. It is desirable that the end of platform so provided is having proper shape (such as shape of cut-water of piers) to guide and deflect the derailed vehicle away from the structure.

Para 2.16.4.3.2: For locations with train speeds less than 50 KMPH, the structures considered vulnerable as per clause 2.16.4.1 shall be considered adequately protected if guard rail as per para 275 (1) of IRPWM is provided under the structure starting from a distance 30m ahead of the structure (To be measured from the start of guard rail to the start of structure) in the direction of travel of trains.

9.13 RECOMMENDATIONS

- ✓ The GoK & SPV in association with SDMA need to formulate an integrated DMA to facilitate a cohesive approach to comprehensively address all aspects of disaster management.
- ✓ SPV & SDMA should have infrastructure of relief equipments, facilities in hospitals and initiate effective measures to maintain the relief equipments fully equipped and in a state of operational readiness.
- ✓ The SPV & SDMA should, on priority, address the issue of operational constraints imposing speed restrictions, positioning of relief / medical vans, etc., to optimise response time, which is the essence of any response mechanism.
- ✓ SPV & SDMA should quickly provide effective communication system for transmission of real time information from the disaster site, which in turn is essential for assessing the gravity of the disaster and in organising rescue and relief.
- ✓ SPV & SDMA need to constitute dedicated teams and initiate tangible measures to hasten the pace of providing specialised training in order to develop a trained team to handle the disaster.
- ✓ SPV need to enhance surveillance mechanism in the railway stations and institute an effective mechanism to prevent unauthorised entry into station premises.

- ***Disaster management manual*** may be prepared and made readily available at all stations of Suburban rail corridors for ready reference and timely action by the staff / personnel of Suburban services / SPV personnel.
- Self-propelled road-cum-railcar – (or accident relief train equipped to handle any track failure or derailment of train) should be stabled in the depot sheds, manned round the clock to be moved in any emergency to the affected spot. The rail-cum road- car should be a multi-utility vehicle. Hence the following equipments are suggested to be readily available in the road-cum-railcar in good fettle:
- Track grinding equipment
- Rerailing equipment
- Auxiliary hand pump
- High pressure hoses
- Telescopic jacks
- Floodlights
- Traversing jack
- Rerailing bridge
- Pulling device
- Towing equipment
- Air compressor
- Vetter airbag

10. AIRPORT CONNECTIVITY

10.1 CONNECTIVITY OPTIONS

10.1.1. A suitable suburban rail link can get direct connectivity to airport at just corner of the airport boundary.

10.1.2. At present about 20000 staff are working at airport and it will be double by 2022 when the terminal-2 gets into operation. About 1.5 lakh four wheelers are moving everyday to airport at present and it may be double by 2022. Considering the huge volume of the traffic towards airport, rites had detailed discussions with concerned airport officials and connectivity to airport has been reviewed.

10.1.3. The existing rail network in Bengaluru city covers the catchment in a circular manner with radials as well as with diagonal routes. If this existing route can be developed with all modern facilities with fast running trains, then the traffic on road can be significantly reduced. The commuters can also be encouraged to use rail based public mode of transportation.

10.1.4. The maximum share of passengers as envisaged above is anticipated to reach through following existing sections by using various interchanges:

A) Corridor C1 from SBC-YPR-YNK-DHL will directly reach to airport with connectivity at Trumpet to Airport.

B) KGI-NYH-SBC (JUNCTION)-BYPL-WFD passengers on this Corridor will interchange at SBC from a) Sub-urban to Sub-urban; b) Sub-urban to Indian Railway; and c) Sub-urban to Metro and take Corridor C1 to reach Airport.

C) BAW (JUNCTION) - YPR (JUNCTION) – LOGH-BYPL passengers on this Corridor will interchange at YPR from a) Sub-urban to Sub-urban; b) Sub-urban to Indian Railway; and c) Sub-urban to Metro and take Corridor C1 to reach Airport.

D) HLE – CSDR-YNK-RNN Passengers will inter change at YNK from a) Sub-urban to Sub-urban; b) Sub-urban to Indian Railway go to the Airport through Corridor C1.

10.2 DISCUSSIONS WITH AIRPORT AUTHORITIES

10.2.1. It is noted from the discussions with the airport authorities on 24.09.2018 that, there is a proposal to establish an international exhibition cum convention centre in KIADB land which is adjacent to the airport boundary. This will further increase the traffic demand for suburban rail users.

By considering this aspect, Airport-KIADB suburban station is proposed at 18/400 in addition to the airport connectivity:

10.2.2. BMRCL is planning to connect Central Silk Board with KIA as a part of phase - 2A & 2B works. It is also understood that BIAL has agreed to bear Rs.1000.00 Crores towards the project. But the proposal serves Southern and Eastern parts of Bengaluru. The proposed suburban connectivity to the airport, will serve central and northern parts of Bengaluru.

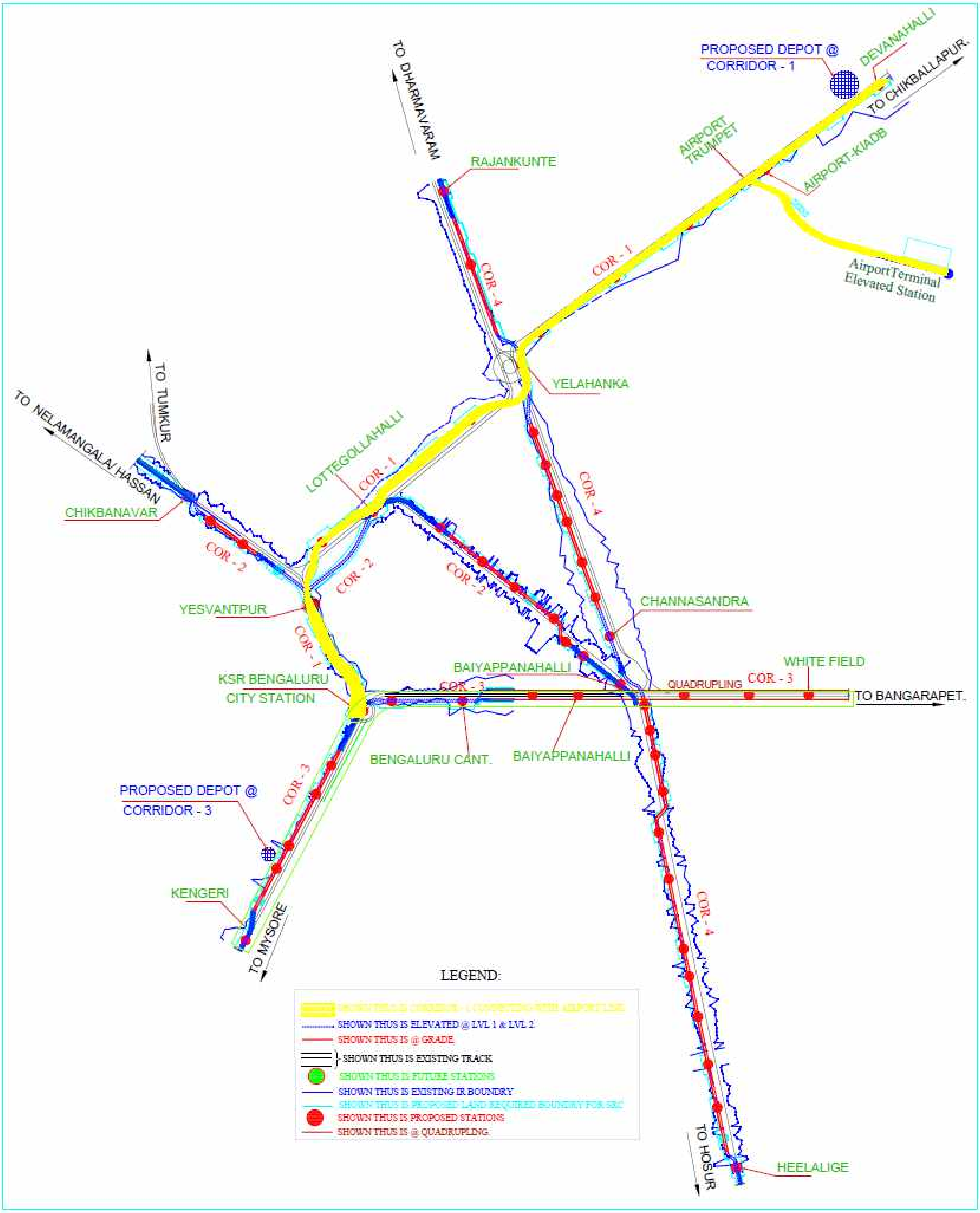
10.3 RECOMMENDED CONNECTIVITY

10.3.1. RITES Ltd of the opinion that direct connectivity to airport from Bengaluru City Station will serve central and northern parts of Bengaluru.

10.3.2. This link will be of about 5.5 km length with about 0.50 km as elevated, and 5.00 km at grade. This will have only one elevated station at the airport above the parking.

10.3.3. The Approximate cost of the airport connectivity is about Rs. 251.90 Crore, The approximate area of land required is 16.00 Acres, however the land cost has not been considered as it is Govt. land.

FIGURE 10.1: PROPOSED AIRPORT LINK WITH CORRIDOR-1



11. COSTING AND FINANCIALS

11.1 COST ESTIMATES

11.1.1 COVERAGE

Cost estimate for Bengaluru Suburban Rail Corridors has been prepared covering Civil, Electrical, Signalling and Telecommunications works, Rolling Stock etc. at June’ 2019 price level.

While preparing the Capital Cost Estimates, various items have been grouped under three major heads on the basis of (i) Route km length of alignment, (ii) Number of units of that item and (iii) Item being an independent entity. All items related with alignment, construction, permanent way, Traction, Signalling & Telecommunication, whether in main lines or in maintenance depot have been estimated at rate per Route km basis.

In order to arrive at realistic cost of various items, costs have been assessed on the basis of recently awarded rates of Bengaluru Metro, various rates benchmarked by Ministry of Housing and Urban Affairs (MoHUA), various DPRs of Indian Railways and other projects with similar technology have also been considered and suitable escalation factor has been applied to bring these costs to June’ 2019 price level.

Basic cost is exclusive of various taxes and duties viz. custom duty, State GST, Centre GST etc. and details of taxes and duties are worked out separately. Current rates of various taxes and duties have been taken into consideration.

11.1.2 LAND REQUIREMENT

Finalization of alignment, location of stations, entry/exits etc. has been done with the objective of keeping land requirement to the bare minimum. For this purpose, alignment, stations have been planned primarily in Railway land, unless and until it becomes unavoidable to plan these facilities in private land. Two Depots has been planned for the corridors in State Govt. land. The summary of land required on permanent basis is given in **TABLE 11.1.**

TABLE 11.1: LAND REQUIREMENT

Ownership	Area (In Ha)
Permanent Land	
Central Government - Indian Railways	132.30
State Government (i.e. Roads/RoW) & Airport link	14.10
State Government (Depot land – Jnanabharathi & Devanhalli)	47.85
Private Open Land (for running section and stations)	28.64
Private Built-up Land (for running section and stations)	12.52

THE DETAILS OF THE LAND REQUIRED AND THE VALUATION OF THE LAND IS COVERED IN THE ANNEXURE 1. COST OF STATE GOVT. LAND AND RAILWAY LAND HAS BEEN CONSIDERED FREE OF COST.

11.1.3 ALIGNMENT AND FORMATION

i) ELEVATED SECTION

Estimated rates of elevated section are based upon Bengaluru Metro/Rate Analysis which worked out to 39.60 Crore per Km.

ii) AT-GRADE SECTION

Estimated rates of At-grade section are based upon the rates of similar works of Indian Railways.

11.1.4 STATION BUILDING

As per ridership figures and train operation plan, 6-car train is able to meet the demand up to 2041. To cater the demand in future years as well, it is proposed to construct stations for 9-car at present stage, accordingly cost has been considered for 205m length (9-car train). As and when the demands pick up, frequency of trains can be increased.

i) ELEVATED STATION

Estimated rates of elevated station (Civil and EM works including finishes) are based upon rates standardized by Ministry of Housing and Urban Affairs (MoHUA), with 205 m length with concourse.

ii) AT-GRADE STATION

The At-grade stations are proposed with platforms at surface and con-course above it. Accordingly, rates of at-grade stations (civil works) has been considered as 50% of the elevated stations and for EM works rates has been kept equivalent to that of elevated station.

11.1.5 PERMANENT WAY

Estimated rates of Ballast-less and ballasted tracks for elevated and at-grade sections are based upon rates standardized by Ministry of Housing and Urban Affairs (MoHUA).

11.1.6 TRACTION & POWER SUPPLY

Estimated rates for traction and power supply for elevated and at-grade section are based upon rates standardized by Ministry of Housing and Urban Affairs (MoHUA).

11.1.7 SIGNALING & TELECOMMUNICATION

Estimated rates of Signalling and telecommunication for elevated and at-grade section are based upon rates standardized by Ministry of Housing and Urban Affairs (MoHUA).

11.1.8 ROLLING STOCK

Estimated rates of Rolling stock are taken from BEML. It is observed in most urban/suburban rail transit systems that ridership materialization in the initial years of operation is less than projected and takes time to reach the expected levels. Therefore, cost for 70% of the estimated no. of rakes has been considered. Additional rakes can be introduced depending upon actual ridership materialization.

11.1.9 CAPITAL COST ESTIMATE

The abstract of capital cost estimate is given in **Table 11.2.** Detailed capital cost estimate for Bengaluru Suburban Rail corridors is given in **TABLE 11.3**. The total Cost including private land and GST comes out to be **₹ 14,615.26** Crore including Airport Connectivity. The cost details of Airport connectivity is given in **Table 11.4.**

TABLE 11.2: ABSTRACT OF COST ESTIMATE

S. No.	Item	Amount (₹ In Crore)

S. No.	Item	Amount (₹ In Crore)
1.0	Land	1419.81
2.0	Alignment and Formation	3843.56
3.0	Station Buildings	1800.12
4.0	Depot and OCC Building	295.00
5.0	P-Way	726.54
6.0	Traction & power supply incl. OHE, ASS etc.	1,050.00
7.0	Signaling and Telecom.	1,361.82
8.0	R&R (Hutments)	50.00
9.0	Misc. Utilities, road works, Topographic Surveys, Geotechnical Investigation, Barricading, Tree Cutting and replanting, other civil works such as signage's, Environmental protection and traffic management	303.66
10.0	Capital Expenditure on Security	49.94
11.0	Staff Quarters	25.00
12.0	Airport Connectivity	273.96
13.0	**Total of all items except Land**	**9,779.60**
14.0	**General Charges @5% including design charges**	**488.98**
15.0	**Rolling Stock**	**1,998.00**
16.0	**Total including General Charges and Rolling Stock but excluding land**	**12,266.58**
17.0	**Contingency @ 3% (excluding land)**	**368.00**
18.0	**Gross Total including Contingencies (excluding land cost)**	**12,634.57**
20.0	**Central GST & Basic Customs duty**	**1,060.27**
21.0	**State GST**	**920.42**
22.0	**Total Cost including GST (excluding land cost)**	**14,615.26**

TABLE 11.3: CAPITAL COST ESTIMATE

Total length = **152.01** Km

Elevated = 59.415 Km, At-Grade = 75.545 Km, and Quadrupling = 17.05 Km

Total Stations = **62** No’s,

Elevated = 21 No’s (including 4 common stations), At-Grade = 36 No’s (including 5 in Quadrupling), Future Stations = 5 No's, (Elevated = 1 No. and At-grade = 4 No's)

June, 2019 Price Level, (₹ in Crore)

S. No.	Item	Unit	Rate (₹ In Crore)	Qty.	Amount (₹ In Crore)
2.0	**Alignment and Formation:**				
2.1	Elevated section including viaduct length in station (including cost of Rain water harvesting)	Route Km	39.60	59.42	2,352.83
2.2	At Grade section including Station length	Route Km	10.00	75.55	755.45
2.3	Box Pushing under ROB for two tracks	Each	1.15	16.00	18.40
2.4	Elimination of Level Crossings	Each	30.00	23.00	690.00

S. No.	Item	Unit	Rate (₹ In Crore)	Qty.	Amount (₹ In Crore)
2.6	At-grade entry to Depot	Route Km	10.00	0.75	7.50
2.7	Boundary wall for At Grade track (One side only)	Km	0.28	69.19	19.37
	Sub Total (2)				**3,843.56**
3.0	**Station Buildings**				
3.1	**Elevated stations Including Viaduct, finishes (205m long)** :				
a	Civil works	Per station	36.96	17.00	628.32
b	EM works	Per station	8.21	17.00	139.57
3.2	**Common Elevated stations in different corridors:**				
a	Civil works	Per station	25.87	4.00	103.49
b	EM works	Per station	5.75	4.00	22.99
3.4	**At Grade Station - (205m long):**				
a	Civil works	Per station	18.48	31.00	572.88
b	EM works	Per station	4.11	31.00	127.26
3.5	**Existing At-grade stations in Quadrupling:**				
a	Civil works	Per station	4.62	5.00	23.10
b	EM works	Per station	0.82	5.00	4.11
3.6	**Lifts & Escalators**				
a	Lifts*	Each	0.47	114.00	53.58
b	Escalators*	Each	0.73	171.00	124.83
	Sub Total (3)				**1,800.12**
4.0	**Depot and OCC Building** :				
4.1	Civil Works including boundary wall	LS			175.00
4.2	EM Works + M&P + General Works	LS			120.00
	Subtotal (4)				**295.00**
5.0	**P-Way:**				
5.1	Ballast-less track for elevated Section	Route Km	6.60	59.42	392.14
5.2	Ballasted track for At-grade section	Route Km	3.90	75.55	294.63
5.3	Ballasted track for Depot	Track Km	1.95	20.40	39.78
	Subtotal (5)				**726.54**
6.0	**Traction & power supply incl. OHE, ASS etc. :**				
6.1	Elevated section	Route Km	7.50	59.42	445.61
6.2	At Grade section	Route Km	7.50	75.55	566.59
6.3	For Depot	Track Km.	2.00	18.90	37.80
	Subtotal (6)				**1,050.00**

S. No.	Item	Unit	Rate (₹ In Crore)	Qty.	Amount (₹ In Crore)
7.0	**Signaling and Telecom.** :				
7.1	Signaling	Route Km	4.40	134.96	593.82
7.2	Signaling On-board equipment	Per Train	1.70	36.00	61.20
7.3	Telecommunication	Per station	4.50	57.00	256.50
7.4	Automatic fare collection*	Per station	3.50	57.00	199.50
7.5	Platform Screen Doors (PSD)*	Per station	4.40	57.00	250.80
				Sub Total (7)	**1,361.82**
8.0	**R&R (Hutments)** :				
8.1	Social cost of R&R (Hutments)	LS			50.00
				Sub Total (8)	**50.00**
9.0	**Misc. Utilities, road works, Topographic Surveys, Geotechnical Investigation, Barricading, Tree Cutting and replanting, other civil works such as signage, Environmental protection and traffic management**				
9.1	Civil Works	Route Km	1.35	134.96	182.20
9.2	EM Works	Route Km	0.90	134.96	121.46
				Sub Total (9)	**303.66**
10.0	**Capital Expenditure on Security**:				
10.1	Civil works	Route Km	0.30	134.96	40.49
10.2	EM works	Route Km	0.07	134.96	9.45
				Sub Total (10)	**49.94**
11.0	**Staff Quarters:**				
11.1	Civil works & EM Woks	LS			25.00
				Sub Total (11)	**25.00**
12.0	**Airport Connectivity:**				
12.1	Airport Connectivity	LS			273.96
				Sub Total (12)	**273.96**
13.0	**Total of all items except Land**				**9,779.60**
14.0	**General Charges @5% including design charges**				**488.98**
15.0	**Rolling Stock (3.66m wide)**	Each	9.25	216.00	1,998.00
				Sub Total (15)	**1,998.00**
16.0	**Total including General Charges and Rolling Stock but excluding land**				**12,266.58**
17.0	**Contingency @ 3% (excluding land)**				**368.00**
18.0	**Gross Total including Contingencies (excluding land cost)**				**12,634.57**
19.0	**Central GST & Basic Customs duty**				**1,060.27**

S. No.	Item	Unit	Rate (₹ In Crore)	Qty.	Amount (₹ In Crore)
20.0	**State GST**				**920.42**
21.0	**Total Cost including GST**				**14,615.26**
1.0	**Land :**				
1.2	Permanent - State Govt.				
a	State Govt. (for running section and stations)	Ha	LS	7.62	0.00
b	State Govt. (Maintenance Depots)	Ha	LS	47.85	0.00
1.2	Permanent - Private				
a	Private Open Land (for running section and stations)	Ha	LS	28.64	748.69
b	Private Built-up land (for running section and stations)	Ha	LS	12.52	671.12
1.3	Rly Land	Ha	LS	132.30	0
				Sub Total	**1,419.81**

***ITEMS CAN BE TAKEN UNDER PPP. TOTAL COST OF THESE ITEMS IS ₹. 841 CRORE INCLUDING GST AT JUNE 2019 PRICE LEVEL**

TABLE 11.4: CAPITAL COST OF AIRPORT CONNECTIVITY

Total length of corridor = **5.50** Km

Elevated = 0.50 km, At Grade = 5.0 Km

Total Stations = **2** No's, Elevated = 1 No., At-Grade = 1 No.

June, 2019 Price Level (₹ in Crore)

S. No.	Item	Unit	Rate (₹ In Crore)	Qty.	Amount (₹ In Crore)
2.0	**Alignment and Formation**				
2.1	Elevated section excluding viaduct length in station (including cost of Rain water harvesting)	Route Km	39.60	0.50	19.80
2.2	At Grade section including Station length	Route Km	10.00	5.00	50.00
2.3	Box Pushing under ROB for two tracks	Each	1.15	0.00	0.00
2.4	Elimination of Level Crossings	Each	30.00	0.00	0.00
2.6	At-grade entry to Depot	Route Km	10.00	0.00	0.00
2.7	Boundary wall for At Grade track (On Both side)	Km	0.28	9.59	2.69
	Sub Total (2)				**72.49**
3.0	**Station Buildings**				

S. No.	Item	Unit	Rate (₹ In Crore)	Qty.	Amount (₹ In Crore)
3.1	**Elevated stations Including Viaduct, finishes (205m long)**				
a	Civil works	Per station	36.96	1.00	36.96
b	EM works	Per station	8.21	1.00	8.21
3.2	**Common Elevated stations in different corridors**				
a	Civil works	Per station	25.87	0.00	0.00
b	EM works	Per station	5.75	0.00	0.00
3.4	**At Grade Station - (205m long)**				
a	Civil works	Per station	18.48	1.00	18.48
b	EM works	Per station	4.11	1.00	4.11
3.5	**Existing At-grade stations in Quadrupling**				
a	Civil works	Per station	4.62	0.00	0.00
b	EM works	Per station	0.82	0.00	0.00
3.6	**Lifts & Escalators**				
a	Lifts*	Each	0.47	4.00	1.88
b	Escalators*	Each	0.73	6.00	4.38
	Sub Total (3)				**74.02**
4.0	**Depot**				
4.1	Civil Works including boundary wall	LS			0.00
4.2	EM Works + M&P + General Works	LS			0.00
	Subtotal (4)				**0.00**
5.0	**P-Way**				
5.1	Ballast-less track for elevated Section	Route Km	6.60	0.50	3.30
5.2	Ballasted track for At-grade section	Route Km	3.90	5.00	19.50
5.3	Ballasted track for Depot	Track Km	1.95	0.00	0.00
	Subtotal (5)				**22.80**
6.0	**Traction & power supply incl. OHE, ASS etc.**				
6.1	Elevated section	Route Km	7.50	0.50	3.75
6.2	At Grade section	Route Km	7.50	5.00	37.50
6.3	For Depot	Track Km.	2.00	0.00	0.00
	Subtotal (6)				**41.25**
7.0	**Signaling and Telecom.**				
7.1	Signaling	Route Km	4.40	5.50	24.20
7.2	Signaling On-board equipment	Per Train	1.70	0.00	0.00

S. No.	Item	Unit	Rate (₹ In Crore)	Qty.	Amount (₹ In Crore)
7.3	Telecommunication	Per station	4.50	2.00	9.00
7.4	Automatic fare collection*	Per station	3.50	2.00	7.00
7.5	Platform Screen Doors (PSD)*	Per station	4.40	2.00	8.80
	Sub Total (7)				**49.00**
8.0	**R&R (Hutments)**				
8.1	Social cost of R&R (Hutments)	LS			0.00
	Sub Total (8)				**0.00**
9.0	**Misc. Utilities, road works, Topographic Surveys, Geotechnical Investigation, Barricading, Tree Cutting and replanting, other civil works such as signage, Environmental protection and traffic management**				
9.1	Civil Works	Route Km	1.35	5.50	7.43
9.2	EM Works	Route Km	0.90	5.50	4.95
	Sub Total (9)				**12.38**
10.0	**Capital Expenditure on Security**				
10.1	Civil works	Route Km	0.30	5.50	1.65
10.2	EM works	Route Km	0.07	5.50	0.39
	Sub Total (10)				**2.04**
11.0	**Staff Quarters**				
11.1	Civil works & EM Woks	LS			0.00
	Sub Total (11)				**0.00**
12.0	**Total of all items except Land**				**273.96**
13.0	**General Charges @5% including design charges**				**13.70**
14.0	**Rolling Stock (3.66m wide)**	Each	9.25	0.00	0.00
	Sub Total (14)				**0.00**
15.0	**Total including General Charges and Rolling Stock but excluding land**				**287.66**
16.0	**Contingency @ 3% (excluding land)**				**8.63**
17.0	**Gross Total including Contingencies (excluding land cost)**				**296.29**
18.0	**Central GST & Basic Customs duty**				**23.80**
19.0	**State GST**				**19.84**
20.0	**Total Cost including GST**				**339.94**
1.0	**Land**				
1.1	Permanent				

S. No.	Item	Unit	Rate (₹ In Crore)	Qty.	Amount (₹ In Crore)
a	State Government (Alignment including airport connectivity and depot at Jnanabharathi)	Ha	LS	6.48	0.00
b	Private (for running section and stations)	Ha	LS	0.00	0.00
c	Private land for depots	Ha	LS	0.00	0.00
d	Private Built-up land	Ha	LS	0.00	0.00
1.2	Temporary Casting Depot @6% per annum for 4 years (Binny Mill Land)	Ha	LS	0.00	0.00
	Sub Total				**0.00**
1.3	Rly Land	Ha	LS	0.00	0

11.1.10 TAXES AND DUTIES

Taxes and duties are worked out complete corridor. Current rates of various taxes and duties have been taken into consideration. Central and State taxes and duties are given in **TABLE 11.5**. The rate of taxes considered is given below:

Basic Customs Duty = 5.15%
CGST Customs Duty = 9.4635%
SGST Customs Duty = 9.4635%
Total Customs Duty = 24.077%
General IGST = 12.00%
General CGST = 6.00%
General SGST = 6.00%

TABLE 11.5: TAXES & DUTIES

S. No.	Description	Total cost without Taxes & duties (Cr.)	Custom Duty				GST			Total Taxes & Duties (Cr.)
			Basic Customs Duty (Cr.)	IGST (CGST portion) (Cr.)	IGST (SGST portion) (Cr.)	Total Customs Duty (Cr.)	CGST (Cr.)	SGST (Cr.)	Total GST (CGST & SGST) (Cr.)	
1	**Alignment & Formation**									
	Elevated & At-grade	3843.56	0.00	0.00	0.00	0.00	230.61	230.61	461.23	**461.23**
2	**Station Buildings**									
	At-grade station-civil works	595.98	0.00	0.00	0.00	0.00	35.76	35.76	71.52	**71.52**
	At-grade station-EM works	131.36	1.35	2.49	2.49	6.33	6.31	6.31	12.61	**18.94**
	Elevated station - civil works	731.81	0.00	0.00	0.00	0.00	43.91	43.91	87.82	**87.82**
	Elevated station-EM works	162.56	1.67	3.08	3.08	7.83	7.80	7.80	15.61	**23.43**
	Lifts & Escalators	178.41	1.84	3.38	3.38	8.59	8.56	8.56	17.13	**25.72**
3	**Depot and OCC**									
	Civil works	175.00	2.70	4.97	4.97	12.64	7.35	7.35	14.70	**27.34**
	EM and M&P works	120.00	1.24	2.27	2.27	5.78	13.44	13.44	26.88	**32.66**
4	**P-Way**	726.54	29.93	55.01	55.01	139.94	8.72	8.72	17.44	**157.38**
5	**Traction & power supply**									
	Traction and power supply	1050.00	21.63	39.75	39.75	101.12	37.80	37.80	75.60	**176.72**
6	**S and T Works**									
	S & T	911.52	37.55	69.01	69.01	175.57	16.41	16.41	32.81	**208.39**
	AFC & PSD	450.30	17.39	31.96	31.96	81.31	10.13	10.13	20.26	**101.58**

7	**R & R hutments**	50.00	0.00	0.00	0.00	0.00	3.00	3.00	6.00	**6.00**
8	**Misc.**									
	Civil works	182.20	0.00	0.00	0.00	0.00	10.93	10.93	21.86	**21.86**
	EM works	121.46	0.00	0.00	0.00	0.00	17.00	17.00	34.01	**34.01**
9	**Security**									
	Civil works	40.49	0.00	0.00	0.00	0.00	2.43	2.43	4.86	**4.86**
	EM works	9.45	0.00	0.00	0.00	0.00	1.32	1.32	2.65	**2.65**
10	**Staff quarters**									
	Civil works & EM works	25.00	0.00	0.00	0.00	0.00	1.50	1.50	3.00	**3.00**
11	**Airport Connectivity**	273.96	3.96	7.27	7.27	18.51	12.57	12.57	25.14	**43.65**
12	**Rolling stock**	1998.00	20.58	37.82	37.82	96.21	143.86	143.86	287.71	**383.92**
13	**General Charges**	488.98	0.00	0.00	0.00	0.00	44.01	44.01	88.02	**88.02**
14	**Total**	**12266.58**	**139.85**	**256.99**	**256.99**	**653.84**	**663.42**	**663.42**	**1326.85**	**1980.68**
Total taxes & Duties								**SAY**		**1980.68**
Rate of Taxes & Duties on Total cost without taxes & duties										**16.15%**
Total Central GST & Basic Customs duty										**1060.27**
Total State GST										**920.42**
Total Taxes & Duties										**1980.68**

11.2 OPERATION AND MAINTENANCE COST

The Operation and Maintenance cost for Bengaluru Suburban Corridors is worked under three major heads:

- Staff cost
- Maintenance cost which includes expenditure towards upkeep and maintenance of the system and consumables and
- Energy cost

11.2.1 STAFF COST

The O&M staff is assumed to be provided @ 12 persons per kilometer and the annual cost this account is estimated considering average staff salary of ₹. 7.3 Lakhs per annum in the year 2019. The escalation factor used for staff costs is 5% per annum to provide for growth in salaries. The staff cost for Bengaluru suburban rail corridors is ₹. 173 Crore for year 2025.

11.2.2 MAINTENANCE EXPENSES

Maintenance expenses are taken @ ₹. 0.85 Crores / km in the year 2019. Maintenance cost for Bengaluru Suburban rail corridors is ₹. 168 Crore for inception year i.e. 2025 considering escalation @ 5% p.a. for every year of operation.

11.2.3 ENERGY CHARGES

The energy consumption to meet the traction and non-traction power requirement is based on traffic demand for different horizon years. The cost of electricity is a significant part of O&M charges. The traction power tariff is taken @ ₹. 5.25 per kVAh in the year 2019, which is escalated @ 5% every year of operation. Annual energy consumption charges have been estimated as ₹. 157.48 Crores in year 2025, ₹. 239.79 Crores in 2031 and ₹. 442.83 Crores in 2041 for Bengaluru Suburban Rail corridors.

11.2.4 ADDITIONAL INVESTMENT

The project is considered for implementation on leasing model hence the requirements of Rolling Stock shall be the responsibility of the Lessor (private party), hence is not considered for FIRR computation of the SPV.

11.2.5 Replacement Cost

The replacement costs are provided for meeting the cost on account of replacement of equipments due to wear and tear. With the nature of equipment proposed to be provided for the corridor, it is expected that about 25% of the equipment comprising Electrical and 50% of Signaling, Telecom, AFC and PSD would require replacement/ rehabilitation after 20 years.

The replacement cost for Bengaluru suburban rail corridors is ₹. 3,354.46 Crore for year 2045. The replacement cost has been worked out considering an escalation factor of 5% per annum.

11.2.6 Lease And Maintenance Charges

The assessment of the financial implication by way of Leasing of Rolling Stock requires a detailed study of the proposed terms and conditions of the Leasing contract. However, for our analysis we have referred to the contractual framework of DMRC's EOI & RFP for selection of Lessor for Line-5 of its network. In lieu of its investment the Lessor shall be entitled to received Lease Charges (towards financing of procurement cost of the Rolling Stock) and Maintenance Charges (towards its Operation & Maintenance obligations).

The key parameters taken for calculation of Lease Charges and Maintenance Charges are provided in the table below:

Input Assumptions For Calculating Lease Charges

S. No	Parameter	Value
1.	Debt Equity Ratio	80:20
2.	Debt repayment tenure	15 years
3.	Cost of Debt	10.50%
4.	Target Pre-tax Equity IRR	18%
5.	Target Debt Service Coverage Ratio	1.2
6.	GST on Lease Charges	18%
7.	GST on Maintenance Charges	18%

Based on above assumptions, Lease Charges and Maintenance Charges have been calculated such that it provides a pre-tax Equity IRR of 18% to the Lessor. The Lease Charge has been worked and is as shown below:

Lease Charge	Value (₹ in Crore)
Year 2025 to Year 2035	403
Year 2036 to Year 2045	360
Year 2046 to Year 2054	109

These yearly slots have been identified based on additional rolling stock procurement required in subsequent years based on increased traffic.

For Maintenance Charges, it is estimated that the Lessor shall have to bear ₹. 0.37 Crore/km per annum and over this expense there is likely markup of 10% which will be charged to SPV and be recovered as Maintenance Charges.

Also, it may be noted that there are multiple key parameters on which the results are sensitive such as cost of procurement, cost of debt, expected returns, Lessor's expected revenues, foreign component in procurement, provision of mobilization advance, expectations about salaries, debt: equity ratio etc. which may vary from bidder to bidder and a probable scenario cannot be exactly ascertained.

The year wise total Operation and Maintenance cost for the SPV for the corridors of Bengaluru suburban rail corridor is indicated in **TABLE 11.6**.

TABLE 11.6: OPERATION & MAINTENANCE COST

Year	Staff Cost	Maintenance Expenses	Energy Charges	Lease Charges for Rolling Stock	Maintenance Charges for Rolling Stock	GST on Lease Charges for Rolling Stock	GST on Maintenance Charges for Rolling Stock	Total O&M
2025	173	168	157	403	127	73	23	1124
2026	182	176	169	403	133	73	24	1160
2027	191	185	182	403	140	73	25	1198
2028	200	195	195	403	147	73	26	1238
2029	210	204	209	403	154	73	28	1281
2030	221	214	224	403	162	73	29	1326
2031	232	225	240	403	170	73	31	1373
2032	243	236	255	403	178	73	32	1421
2033	255	248	272	403	187	73	34	1472
2034	268	261	289	403	197	73	35	1526
2035	282	274	307	403	206	73	37	1582

Year	Staff Cost	Maintenance Expenses	Energy Charges	Lease Charges for Rolling Stock	Maintenance Charges for Rolling Stock	GST on Lease Charges for Rolling Stock	GST on Maintenance Charges for Rolling Stock	Total O&M
2036	296	287	327	360	217	65	39	1590
2037	310	302	347	360	228	65	41	1653
2038	326	317	369	360	239	65	43	1718
2039	342	333	392	360	251	65	45	1788
2040	359	349	417	360	264	65	47	1861
2041	377	367	443	360	277	65	50	1938
2042	396	385	471	360	290	65	52	2019
2043	416	404	500	360	305	65	55	2105
2044	437	425	531	360	320	65	58	2195
2045	459	446	564	360	336	65	61	2290
2046	482	468	599	109	353	20	64	2093
2047	506	492	636	109	371	20	67	2199
2048	531	516	675	109	389	20	70	2309
2049	558	542	716	109	409	20	74	2426
2050	585	569	760	109	429	20	77	2549
2051	615	598	807	109	451	20	81	2679
2052	645	627	856	109	473	20	85	2815
2053	678	659	908	109	497	20	89	2959
2054	712	692	963	109	522	32	53	3082

11.3 ECONOMIC ANALYSIS

11.3.1 APPROACH AND METHODOLOGY FOR ECONOMIC ANALYSIS

The economic appraisal has been carried out within the broad framework of Social Cost – Benefit Analysis Technique. It is based on the incremental costs and benefits and involves comparison of project costs and benefits in economic terms under the "with" and "without" project scenario. In the analysis, the cost and benefit streams arising under the above project scenarios have been estimated in terms of market prices and economic values have been computed by converting the former using appropriate shadow prices.

This has been done to iron out distortions due to externalities and anomalies arising in real world pricing systems. The annual streams of project costs and benefit have been compared over the analysis period of 30 years to estimate the net cost / benefit and to calculate the economic viability of the project in terms of EIRR & ENPV.

11.3.2 EVALUATION ASSUMPTIONS

Project horizon comprises of the construction and operation period of the rail based transit project. The annual streams of project costs and benefit have been compared over the analysis period of 30 years to estimate the net cost / benefit and to calculate the economic viability of the project in terms of EIRR. The key assumptions used in the evaluation are listed in **TABLE 11.7.**

TABLE 11.7: KEY EVALUATION ASSUMPTIONS

Parameter	Assumption
Price Level	June 2019
Construction period	2019-2025
First year of operation	2025
Daily to annual factor	340

11.3.3 DEVELOPMENT OF ALTERNATIVE SCENARIOS

The development of the two scenario starts with estimating the traffic and the modal share in these scenarios for the system. **TABLE 11.8** gives the estimated traffic and modal share in different horizon years for Sub-Urban Rail. It can be seen that the total estimated demand in the year 2025 is about 138.36 Lakh which is expected to rise to about 233.76 Lakh in the year 2051. In the year 2025, Sub-Urban rail system is expected to cater to about 9.84 Lakh trips per day which is expected to rise to about 23.11 Lakh in the year 2051.

TABLE 11.8: ESTIMATED DEMAND AND MODAL SHARE IN 'WITH' AND 'WITHOUT' SCENARIO

Mode	Trips (With Sub-Urban Rail System)				Trips (Without Sub-Urban Rail System)			
	2025	2031	2041	2051	2025	2031	2041	2051
Metro	2300000	3000000	3400000	3853333	2300000	3000000	3400000	3853333
Bus	4903884	5645251	6756421	8077355	5254835	6126120	7381477	8889486
Car	853522	945308	1129932	1345178	997312	1139580	1388665	1689850
2 Wheelers	3954510	4524018	5413394	6467447	4300427	4995900	6031492	7277004
Auto	839763	929058	1110468	1321846	983480	1123200	1369100	1666481
Sub-Urban Rail	984374	1341165	1760518	2310994	-	-	-	-
Total	**13836053**	**16384800**	**19570733**	**23376154**	**13836053**	**16384800**	**19570733**	**23376154**

11.3.4 ESTIMATION OF ECONOMIC COST

The economic costs of the capital works and annual operation and maintenance costs have been calculated from the financial cost estimates by excluding:

- Price contingencies/price escalations
- Import duties and taxes
- Sunk costs
- Interest payment, principal payment and interest during construction period

The economic costs (**TABLE 11.9**) have been derived from financial costs using following shadow price factor for each component to take care of the distortions brought by above factors.

TABLE 11.9: FACTORS USED FOR ECONOMIC COSTS

S. No	Item	Factor
1	Capital Cost	0.83
2	Operations & Maintenance Cost	0.87

TABLE 11.10 give the capital and O&M costs of the system at June 2019 Price levels in economic terms respectively.

TABLE 11.10: ECONOMIC COSTS OF SUB-URBAN RAIL SYSTEM

Cost Component	(₹. in Crore)
Capital Cost Including Private land and R&R	14054.38
O&M Costs	
2025	457.91
2031	473.75
2041	491.65

11.3.5 ECONOMIC BENEFITS OF SUB-URBAN RAIL SYSTEM

Bengaluru Sub-Urban Rail System will yield tangible and non-tangible savings due to equivalent reduction in road traffic and certain socio-economic benefits.

The introduction of Sub-Urban Rail System will result in reduction in number of Buses, IPT, usage of private vehicles, air pollution and increase in the speed of road-based vehicles. This, in turn, will result in significant social benefits due to reduction in fuel consumption, vehicle operating cost and travel time of passengers. Reduction in accidents, pollution and road maintenance costs are the other benefits to the society in general. The benefit stream includes:

- Savings in Capital and operating cost (on present congestion norms) of carrying the total volume of passenger traffic by existing modes in case this Sub-Urban Rail System project is not taken up.
- Savings in operating costs of different modes due to de-congestion including those that would continue to use the existing transport network even after this Sub-Urban Rail System is introduced.
- Savings in time of commuters using this Sub-Urban Rail System over the existing transport modes because of faster speed of Sub-Urban Rail System.
- Savings in time of those passengers continuing on existing modes, because of reduced congestion on roads.
- Savings on account of prevention of accidents and pollution with introduction of this Sub-Urban Rail System.
- Savings in road infrastructure and development costs that would be required to cater to increase in traffic, in case this Sub-Urban Rail System is not introduced.

The Quantification of some of the social benefits has not been attempted because universally acceptable norms do not exist to facilitate such an exercise. However, it has been considered appropriate to highlight the same, as given below:

- Reduced road stress
- Better accessibility to facilities in the influence area
- Economic stimulation in the micro region of the infrastructure
- Increased business opportunities
- Overall increased mobility
- Facilitating better planning and up-gradation of influence area
- Improving the image of the city

Following factors have been used for converting project benefits to economic costs (**TABLE 11.11**).

TABLE 11.11: FACTORS USED FOR CONVERTING PROJECT BENEFITS IN TERMS OF ECONOMIC COSTS

S. No	Item	Factor
1	Savings in Capital & Operating Cost of Buses	0.83
2	Savings in Capital & Operating cost of Private Vehicles	0.83
3	Savings in Passenger Time	1.0
4	Savings in VOC	0.9
5	Savings in Accident Costs	0.9
6	Savings in Pollution Costs	1.0

11.3.6 INPUT PARAMETERS

Inputs used for Economic analysis have been collected from primary and secondary data sources. Vehicle Operating cost (VOC) and Value of Travel Time (VOT) are the two important parameters of Economic Analysis.

Various assumptions have been made, while assessing the economic benefits to the society on account of various factors after introduction of project. Following are the assumptions made for each of the factors as shown in **TABLE 11.12.**

TABLE 11.12: ASSUMPTIONS FOR VEHICLE OPERATING COST & VALUE OF TIME

S.No	Mode	VOC/Km.*(₹.)	Value of Time Passenger/Hour (₹.)
1	Metro	-	50
2	Bus	27.8	40
3	Car	6.7	95
4	2 Wheeler	2.0	50
5	3 Wheeler	3.3	40

*Source :*Figures updated to 2019 price level on the basis of Manual on Economic Evaluation of Highway Projects in India, IRC:SP:30-2009*

Other operational parameters required to assess the savings in VOC and VOT, accidents, pollution for the system in the year 2051 is presented in **TABLE 11.13**.

TABLE 11.13: MODE WISE OPERATIONAL PARAMETERS

Mode	Average Lead KM	Veh-KM/ Day*	Average Speed (Km/Hr)*		Occupancy
			Without MRTS	With MRTS	
Bus	10.70	200	13	15	55
Car	12.8	30	18	20	2.2
2wh	8.0	20	18	20	1.2
Auto	6.0	150	18	20	3.0

Source: RITES Primary Survey, Derived from Transport Demand model*

Other benefits that will accrue to the society include reduction in emission, savings due to reduction in accidents. The input for the benefit estimation from these parameters include the emission factors by vehicle category as given by CPCB (**TABLE 11.14)**, vehicle and accident statistics and cost of accidents (**TABLE 11.15**) in Bengaluru.

TABLE 11.14: MODE WISE EMISSION FACTORS (GRAM/KM)

Vehicle Type/ Pollutant	CO	HC	NOX	PM	CO2
2-wheeler	1.4	0.7	0.3	0.05	28.58
Auto	2.45	0.75	0.12	0.08	77.89
Cars (incl. cabs)	1.39	0.15	0.12	0.02	139.52
Bus (incl. BRT)	3.72	0.16	6.53	0.24	787.72
Treatment Cost (₹. /ton)	1,00,000	1,00,000	1,00,000	1,00,000	500

Source: Appraisal guidelines for Metro Rail Project Proposals MoHUA, GOI 2017

TABLE 11.15: COST OF ACCIDENTS

Type of Accident	Accident Cost (₹.)	
	(2004 prices)*	(2019 prices)**
Cost of fatal accident	437342	865907
Cost of major accident	64256	127222
Cost of damage to Two wheelers	2286	4526
Cost of damage to Car	9763	19330
Cost of damage to buses in road accidents	32818	64977

*Source: *Appraisal guidelines for Metro Rail Project Proposals MoHUA, GOI 2017*
***derived using escalation factor of 5%*

11.3.7 ESTIMATION OF PROJECT BENEFITS

Quantifiable benefits accrued to the society owing to implementation of the Sub urban rail project include:

- **TRAVEL TIME SAVINGS**
  - Travel Time Savings due to higher speed of this Sub-Urban Rail System project as compared to 'Without' project scenario.
  - Congestion reduction due to modal shift leads to fewer vehicles on roads. This also contributes to time savings of passengers travelling on other modes.

- **SAVINGS IN VEHICLE OPERATING COST**
  - Absence of vehicles on road due to modal shift passengers on this Sub-Urban Rail System
  - Smoother operations of passenger trips of other mode vehicles owing to reduced congestion on roads.

- **SAVINGS FROM ACCIDENT REDUCTION**
  - Reduction in fatal and injury accidents due less no of vehicles on roads
  - Savings in damage cost to vehicles involved in accidents.

- **SAVINGS FROM POLLUTION REDUCTION**
  - Absence of vehicles on road due to modal shift passengers on this Sub-Urban Rail System
  - Less pollution due to reduced congestion on roads.

- **SAVINGS IN ROAD INFRASTRUCTURE MAINTENANCE**
  - With less no of vehicles on roads, expenditure on road maintenance is expected to go down. In the absence of data, a lump-sum expenditure of ₹. 145 Crore / year has been assumed.

Above socio-economic benefits have been converted in money cost. With input from above tables, the accrued project benefits for Bengaluru Sub-Urban Rail System during the frame work period of 30 years have been summarized in **TABLE 11.16.**

TABLE 11.16: COMPARISONS OF SAVINGS IN HORIZON YEAR

S.NO	BENEFITS	MRTS	
		Amount	% Share
1	Travel Time Savings	2615	70.4
2	Savings in Vehicle Operating Cost	808.5	21.8
3	Savings from Accident, Pollution & Road maintenance Reduction	288.6	7.8
	Total	**3712**	**100**

It is clear from the table that benefits irrespective of the system benefits are mainly come from saving of travel time by Sub-Urban Rail System and road passengers (**70.4%**), VOC savings (**21.8%**), and Environmental benefit from emission reduction, accident reduction and road maintenance cost (together **7.8%**).

11.3.8 EIRR:

For deriving the values of economic indicators (EIRR, ENPV), cost and benefit stream has been constructed in terms of money value. The Toolkit on Finance and Financial Analysis 2013 by MoHUA, suggests that ENPV to be calculated on social cost of capital or government security rate. Accordingly, ENPV have been calculated on both the rates.

Metro Rail Policy 2017 prescribes 14% as acceptable EIRR rate for MRTS project, same has been considered as the social cost of capital. The government security rate in December'2017 is 8%. Accordingly, ENPV has been calculated based on these rates. The summary of the ENPV and EIRR is presented in **TABLE 11.17**. The cost and benefit streams for Sub-Urban Rail System is presented in **TABLE 11.18**.

TABLE 11.17: ECONOMIC RETURN PARAMETERS

S.NO	PARAMETER	
1	EIRR	19.01%
2	ENPV - Social cost of capital @14% - Government Security Rate@ 8%	 ₹. 3225 Crore ₹. 13381 Crore

TABLE 11.18: COST AND BENEFIT STREAM FOR SUB-URBAN RAIL SYSTEM (IN CRORE)

JUNE, 2019 PRICE LEVEL

Period	Capital Cost	O&M Cost	Addition Cost + Replacement Cost	Total Cost	Saving in Capital Cost of Reduced Buses	Saving in Capital Cost of Reduced of other vehicles	VOC Saving of all vehicles	Savings due to Decongestion Effect	Savings in Passenger time	Savings due to Less pollution	Savings due to Less number of accidents	Savings in Infrastructure Maintenance	Total Savings	Net Cash Flow (₹. in Crore)
2019-20	583.26													
2020-21	1749.77			1749.8										
2021-22	2333.03			2333.0									0.0	-2333.0
2022-23	2333.03			2333.0									0.0	-2333.0
2023-24	2333.03			2333.0									0.0	-2333.0
2024-25	1749.77			1749.8									0.0	-1749.8
2025-26	583.26	398.4		981.6	157.1	1733.0	476.1	25.7	1136.57	55.9	12.5	144.9	3741.7	2760.1
2026-27		400.7		400.7	9.3	106.8	497.7	26.2	1194.6	58.3	13.1	144.9	2050.9	1650.2
2027-28		403.0		403.0	9.3	106.8	520.3	26.8	1255.5	60.8	13.7	144.9	2138.0	1735.0
2028-29		405.3		405.3	9.3	106.8	543.9	27.3	1319.6	63.4	14.3	144.9	2229.4	1824.2
2029-30		407.6		407.6	9.3	106.8	568.6	27.9	1386.9	66.1	14.9	144.9	2325.3	1917.8
2030-31		409.9		409.9	9.3	106.8	594.4	28.5	1457.6	68.9	15.6	144.9	2426.0	2016.1
2031-32		412.2		412.2	9.3	106.8	621.3	29.1	1532.0	71.8	16.3	144.9	2531.5	2119.4
2032-33		413.7		413.7	9.3	106.8	637.3	29.6	1573.5	73.6	16.7	144.9	2591.7	2178.0
2033-34		415.3		415.3	9.3	106.8	653.7	30.2	1616.1	75.4	17.1	144.9	2653.5	2238.2
2034-35		416.8		416.8	9.3	106.8	670.6	30.7	1659.9	77.2	17.5	144.9	2716.9	2300.1
2035-36		418.4	289.7	708.1	240.6	2694.3	687.8	31.3	1704.8	79.1	18.0	144.9	5600.8	4892.7
2036-37		419.9		419.9	4.7	62.7	705.5	31.8	1751.0	81.1	18.4	144.9	2800.1	2380.2
2037-38		421.5		421.5	4.7	62.7	723.7	32.4	1798.4	83.1	18.9	144.9	2868.7	2447.2

Period	Capital Cost	O&M Cost	Addition Cost + Replacement Cost	Total Cost	Saving in Capital Cost of Reduced Buses	Saving in Capital Cost of Reduced of other vehicles	VOC Saving of all vehicles	Savings due to Decongestion Effect	Savings in Passenger time	Savings due to Less pollution	Savings due to Less number of accidents	Savings in Infrastructure Maintenance	Total Savings	Net Cash Flow (₹. in Crore)
2038-39		423.1		423.1	4.7	62.7	742.3	33.0	1847.1	85.1	19.4	144.9	2939.2	2516.1
2039-40		424.6		424.6	4.7	62.7	761.5	33.6	1897.1	87.2	19.9	144.9	3011.5	2586.8
2040-41		426.2		426.2	4.7	62.7	781.1	34.2	1948.4	89.3	20.4	144.9	3085.7	2659.5
2041-42		427.7		427.7	4.7	62.7	801.2	34.8	2001.2	91.5	20.9	144.9	3161.9	2734.1
2042-43		429.3		429.3	4.7	62.7	801.9	35.4	2055.5	93.8	21.4	144.9	3220.3	2791.0
2043-44		430.8		430.8	4.7	62.7	802.6	36.1	2111.2	96.1	22.0	144.9	3280.2	2849.4
2044-45		432.4		432.4	4.7	62.7	803.3	36.7	2168.4	98.5	22.5	144.9	3341.8	2909.4
2045-46		434.0	1255.3	1689.3	282.5	3258.8	804.1	37.4	2227.2	100.9	23.1	144.9	6878.9	5189.6
2046-47		435.5		435.5	8.4	109.3	804.8	38.0	2287.6	103.4	23.7	144.9	3520.1	3084.6
2047-48		437.1		437.1	8.4	109.3	805.5	38.7	2349.6	105.9	24.3	144.9	3586.7	3149.6
2048-49		438.6		438.6	8.4	109.3	806.3	39.4	2413.3	108.6	24.9	144.9	3655.0	3216.4
2049-50		440.2		440.2	8.4	109.3	807.0	40.1	2478.7	111.2	25.6	144.9	3725.2	3285.0
2050-51		441.8		441.8	8.4	109.3	807.7	40.8	2545.9	114.0	26.2	144.9	3797.3	3355.5
2051-52		443.3		443.3	8.4	109.3	808.5	41.5	2615.0	116.8	26.9	144.9	3871.2	3427.9
2052-53		444.9		444.9	8.4	109.3	809.2	42.3	2685.8	119.7	27.6	144.9	3947.2	3502.3
2053-54		446.4		446.4	8.4	109.3	809.9	43.0	2758.7	122.6	28.3	144.9	4025.1	3578.7
2054-55		448.0		448.0	8.4	109.3	810.7	43.8	2833.5	125.7	29.0	144.9	4105.2	3657.2
													EIRR	**19.01%**
													ENPV@14%	**3,225**

11.3.9 OUTCOME ON ECONOMIC VIABILITY

The project has EIRR more than 14%, indicating that the benefits to the society are more than the social cost of capital of 14%. It also meets the acceptable norm of MoHUA. **Thus, the project is economically viable and may be implemented.**

SENSITIVITY ANALYSIS

The sensitivity analysis has been carried out to see the impact of change in critical parameters in the range of 5% to 15% on EIRR and is presented in **Table 11.19**.

TABLE 11.19: SENSITIVITY ANALYSIS FOR EIRR

S. No.	Factor	Range		
		5%	10%	15%
1	Cost overruns due to delay or other factors	18.32	17.68	17.08
2	Increase in Maintenance Cost	18.89	18.76	18.63
3	Reduction in Ridership	18.38	17.73	17.08
4	Reduction in benefits	18.15	17.27	16.36
5	Combination of reduction in benefits and increase in cost	17.48	16.03	14.65

11.4 FINANCIAL ANALYSIS

11.4.1 PROJECT STRUCTURE

Bangalore suburban rail project is proposed to be implemented on Equity funded SPV model with equal contribution from central (20%) and state government (20%) and rest from multilateral agencies (60%). However, for potential private participation through leasing of rolling stock is also contemplated.

The SPV shall provide fixed infrastructure (Civil assets, Electrical assets, S&T assets) and shall be responsible for collection of revenue, operation & maintenance of assets (excluding rolling stock) and management of infrastructure incl. stations while a private entity shall procure & finance the required Rolling Stock and also be responsible for providing train operators, maintenance of rolling stock and management of maintenance depots

(Operation & Maintenance obligations). In lieu of its investment the private entity shall be entitled to received Lease Charges (towards financing of procurement cost) and Maintenance Charges (towards Operation & Maintenance obligations).

It is pertinent to note here that, although DMRC had tried to bid out the provisioning of rolling stock on lease basis, it could not successfully award the contract on account of high price. Therefore, as a step of necessary precaution, it is recommended that a provision for procurement of Rolling Stock by SPV may be kept in case the proposed leasing model does not span out.

11.4.2 CAPITAL COSTS

The main components of the project cost include land costs, R&R, Infrastructure costs, General Charges & Design Charges (@5% on cost excluding land) and Contingencies (@3% on cost excluding land), Central GST & Basic custom duty and State GST.

TABLE 11.20: CAPITAL COST OF THE PROJECT

S. No.	Description	Amount (₹ in Crore)
1	**Land Cost and R&R**	**1470**
1.1	Land	1420
1.2	R&R	50
2	**Infrastructure Cost (excl. Rolling Stock)**	**10759**
3	**State GST**	**681**
4	**Central GST & Basic custom duty**	**662**
	Estimated Cost of Project (June 2019 price level)	**13572**

The Capital Cost in above table is excluding the cost of Rolling Stock, taxes and contingencies on RS (**"Rolling Stock Component"**), which is estimated at ₹. 2,418 Crore at June 2019 price levels. It is proposed to take Rolling Stock on lease basis as a potential alternate source of financing.

The Project is proposed to have a construction period of 6 years but the payments are expected to spill over to the 7th year, hence the capital expenditure excluding land and R&R is assumed to be in the ratio of 5:15:20:20:20:15:5. Land shall be acquired during the first 2 years with expenditure for acquiring land and R&R in the ratio of 50:50. The operations would start from the year 2025 (i.e. FY 2025-26). Escalation (on all items excluding cost of land and R&R) is considered from 2020 at 5% per annum from June-2019. The completion cost of the project (without IDC) is calculated as given in **Table 11.21.**

TABLE 11.21: **COMPLETION COST OF THE PROJECT (W/O IDC)**

								(₹ in Crores)
COMPLETED PROJECT COST	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**Total**
Phasing of Infrastructure, State Taxes & Central Taxes	5%	15%	20%	20%	20%	15%	5%	100%
Phasing of Cost of Land and R&R	50%	50%	0%	0%	0%	0%	0%	100%
Escalation Factor[1]	1.00	1.04	1.09	1.15	1.21	1.27	1.33	
Infrastructure Cost (with escalation)	538	1681	2353	2471	2595	2044	715	12397
Central Taxes (with escalation)	33	103	145	152	160	126	44	763
Completed Cost excluding Cost of Land & State Taxes	571	1784	2498	2623	2755	2170	759	13160
Cost of Land and R&R (no escalation)	735	735	0	0	0	0	0	1470
State Taxes (with escalation)	34	106	149	157	165	129	45	785
Completed Cost including Cost of Land & State Taxes	**1340**	**2625**	**2647**	**2780**	**2920**	**2299**	**804**	**15415**

Considering phasing and escalation on Rolling Stock component similar as Infrastructure component, the completed cost of Rolling Stock component works out to be ₹. 2785 Crore.

11.4.3 O&M COSTS

The O&M Costs for the suburban rail system will include costs towards staff, maintenance expense, energy charge, Lease Charges for Rolling Stock, Maintenance Charges for Rolling Stock, GST on Lease and Maintenance Charges and have been worked out as detailed in previous sections for the operation period i.e. from year 2025 to year 2054 and is brought out in **TABLE 11.22**.

[1] Escalation factor from 2020 onwards is calculated as (1+5%) ^ $^{\text{(April \{year\} – June 2019) (in years)}}$. For example, escalation factor applicable for FY 2020 is (1+5%) ^$^{\text{(April 2020 – June 2019)}}$ = 1.05^$^{(9/12)}$ = 1.05^$^{0.75}$ = 1.04.

TABLE 11.22: O&M COSTS

(₹ in Crores)

Year	Staff Cost	Maintenance Expenses	Energy Charges	Lease Charges for Rolling Stock	Maintenance Charges for Rolling Stock	GST on Lease Charges for Rolling Stock	GST on Maintenance Charges for Rolling Stock	Total O&M
2025	173	168	157	403	127	73	23	1124
2026	182	176	169	403	133	73	24	1160
2027	191	185	182	403	140	73	25	1198
2028	200	195	195	403	147	73	26	1238
2029	210	204	209	403	154	73	28	1281
2030	221	214	224	403	162	73	29	1326
2031	232	225	240	403	170	73	31	1373
2032	243	236	255	403	178	73	32	1421
2033	255	248	272	403	187	73	34	1472
2034	268	261	289	403	197	73	35	1526
2035	282	274	307	403	206	73	37	1582
2036	296	287	327	360	217	65	39	1590
2037	310	302	347	360	228	65	41	1653
2038	326	317	369	360	239	65	43	1718
2039	342	333	392	360	251	65	45	1788
2040	359	349	417	360	264	65	47	1861
2041	377	367	443	360	277	65	50	1938
2042	396	385	471	360	290	65	52	2019
2043	416	404	500	360	305	65	55	2105
2044	437	425	531	360	320	65	58	2195
2045	459	446	564	360	336	65	61	2290
2046	482	468	599	109	353	20	64	2093
2047	506	492	636	109	371	20	67	2199
2048	531	516	675	109	389	20	70	2309
2049	558	542	716	109	409	20	74	2426
2050	585	569	760	109	429	20	77	2549
2051	615	598	807	109	451	20	81	2679
2052	645	627	856	109	473	20	85	2815
2053	678	659	908	109	497	20	89	2959
2054	712	692	963	109	522	32	53	3082

11.4.4 REVENUES

- **FARE-BOX REVENUE**

The primary source of revenue is the Fare Box revenue from the sale of tickets for the trips carried out by the passengers. The fare box revenue is calculated based on the projected ridership details and proposed fare structure as given in the following tables. Fares are given for year 2025 and it is escalated at 10% every 2 years. The estimated ridership is presented below in **TABLE 11.23**.

TABLE 11.23: RIDERSHIP DETAILS

Year	Daily Ridership (In Lakhs)
2025	9.84
2031	13.41
2041	17.61
2051	23.11

The trip distribution is presented in **TABLE 11.24.**

TABLE 11.24: TRIP DISTRIBUTION

RANGE (KM)	TRIP DISTRIBUTION			
	2025	**2031**	**2041**	**2051**
< 3	3.48%	3.48%	3.48%	3.48%
3-6	12.85%	10.75%	9.92%	9.92%
6-9	18.36%	18.76%	17.87%	17.87%
9-12	18.11%	18.11%	18.11%	18.11%
12-15	14.14%	13.73%	13.73%	13.73%
15-18	8.81%	8.65%	8.65%	8.65%
18-21	6.96%	7.12%	7.24%	7.24%
21-24	2.31%	2.47%	2.59%	2.59%
24-27	1.38%	1.54%	1.66%	1.66%
27-30	2.94%	3.10%	3.22%	3.22%
30-33	0.99%	1.15%	1.27%	1.27%
33-36	1.30%	1.46%	1.58%	1.58%
36-39	0.74%	0.90%	1.02%	1.02%
39-42	1.10%	1.26%	1.38%	1.38%
42-45	1.19%	1.35%	1.47%	1.47%
45-48	1.79%	1.95%	2.07%	2.07%
48-51	1.04%	1.20%	1.32%	1.32%
51-54	0.76%	0.92%	1.04%	1.04%
54-57	0.74%	0.90%	1.02%	1.02%
57-60	0.62%	0.70%	0.82%	0.82%
60-63	0.38%	0.47%	0.52%	0.52%
TOTAL	**100%**	**100%**	**100%**	**100%**

The Fare Structure proposed for Suburban Rail is as presented below in **TABLE 11.25**.

TABLE 11.25: FARE STRUCTURE

RANGE (KM)	FARES IN YEAR 2025 (IN ₹)
< 3	13
3-6	20
6-9	27
9-12	29
12-15	33
15-18	37
18-21	43
21-24	47
24-27	51
27-30	53
30-33	60
33-36	63
36-39	67
39-42	71
42-45	73
45-48	80
48-51	83
51-54	87
54-57	91
57-60	93
60-63	100

From the data as per above Tables 11.23, 11.24 and 11.25, fare box revenues are calculated and given below in **TABLE 1.26.**

TABLE 1.26: FARE BOX REVENUE

REVENUE STREAM	TOTAL REVENUES (FARE BOX) (₹ IN CRORES))			
	2025	**2031**	**2041**	**2051**
Revenue from Fare-box	1281	2389	5162	10922

- **NON-FARE BOX REVENUE**

Non-fare box revenue could be from commercial development and advertisement at station buildings, leasing of parking rights at stations, advertisement on trains and tickets, advertisements within stations and parking lots, advertisements on viaducts, columns and other structures, co-branding rights to corporate, film shootings and special events on sub urban rail premises. The major sources of non-fare box revenue are:

- Station Commercials
- Advertisement on Station / skywalk etc.
- Station & Train naming rights'

Based on the preliminary revenue assessment, about ₹ 93.57 Crores is realizable in the year 2019. Further escalation of 10% in every three years is considered.

1) **ADVERTISEMENT REVENUES ON STATION AND SKYWALKS:**

ADVERTISING REVENUE:
Revenue generation through advertising has turned out as a successful option for all MRTS networks in India. The following list gives an overview of revenue generated through advertisements by some of the Indian MRTS networks.

TABLE 11.27: ADVERTISING REVENUE GENERATED BY INDIAN MRTS NETWORKS

MRTS NETWORK	NO. OF OPERATIONAL STATIONS	ADVERTISING REVENUE (ROUNDED -OFF)	UNIT
Bengaluru Metro	41	5,000,000	₹ per Station per Year
Mumbai Metro	12	13,000,000	₹ per Station per Year
Delhi Metro	185	7,000,000	₹ per Station per Year

***Source**: secondary sources*

For Bengaluru, it is estimated about ₹ 20.0 Crore will be generated @ ₹ 0.50 Crore for 40 stations is adopted by Advertising at identified locations.

In addition, the branding of the trains with an average of ₹ 6.0 Lakh per train can generated about ₹ 3.6 Crore per year.

2) **SKYWALKS**
As the Stations require several Pedestrian cross overs in form of bridges and skywalks to connect to the other modes or across stations, it is possible to use the surface area along the skywalks for advertising.

Therefore, based on consideration of average revenue generation per meter length of skywalk, as per MMRDA's model, as well as assuming 10% escalation of revenue after every three years, the total potential revenue that can be generated by the end of year 2025 is about **₹ 5.0 Crore.**

3) **REVENUE FROM SELLING STATIONS' SEMI-NAMING RIGHTS**

The concept of selling semi-naming rights of Sub urban rail station to various commercial brands has been a huge hit in the recent past. Kochi, Bengaluru and Delhi Metro stations have recently observed high auctions of semi-naming rights of metro stations.

Benchmarking the case of Delhi Metro Rail Corporation (DMRC), the metro corporation has partially renamed 15 Metro stations by auctioning the naming rights to companies and public sector undertakings. According to data gathered, DMRC's revenue generated per station per year from selling semi-naming rights is valued at approx. ₹ 2.0 Crore.

For the Bengaluru Sub urban, it estimated based on the location of the stations, its branding and visibility value, about INR 20 Crore can be generated from 10 identified interchange and important stations. Another 10 Crore from the secondary stations that have very large footfall and branding value for 10 stations. Correspondingly, in order of significance, 0.50 Crore from 20 stations. The Total value from this activity in a year would amount to **₹ 40 Crore**.

4) **RENTALS FROM RETAIL IN CONCOURSE OF STATION**

Various passenger amenities and commercial retail can be developed in the station concourse areas, where there are large number of footfalls, suitable demand for such activity and the location of the station in a manner that they connect to other modes or other side to provide access. This offers potential for retail development. Accordingly, Station wise analysis has been carried out to provide for retail at the concourse.

TABLE 11.28: REVENUE POTENTIAL AT STATIONS

S. No.	STATIONS	EXISTING/NEW PROPOSED	CONCOURSE RENTAL ₹ PER SFT	CONCOURSE-COMMERCIAL AREA IN SQM	CONCOURSE RENTALS (₹)
1	Kengeri	Existing	25	1213.2	326350.8
2	Jnanabharathi Halt	Existing	25	758.25	203969.25
3	Nayandahalli	Existing	45	909.9	440573.58
4	Krishnadevaraya Halt	Existing	55	758.25	448732.35

S. No.	Stations	Existing/New Proposed	Concourse Rental ₹ per SFT	Concourse-commercial Area in Sqm	Concourse Rentals (₹)
5	KSR Bengaluru City JN	Existing	120	1819.8	2349725.76
6	Srirampura	New Proposed	55	606.6	358985.88
7	Yeshvanthapura	Existing	90	1516.5	1468578.6
8	Mathikere	New Proposed	55	909.9	538478.82
9	Jalahalli	New Proposed	30	606.6	195810.48
10	Tata Nagara	New Proposed	25	606.6	163175.4
11	Judicial Layout	New Proposed	40	909.9	391620.96
12	Yelahanka	Existing	70	1516.5	1142227.8
13	Nettie Meenakshi	New Proposed	25	758.25	203969.25
14	Airport	New Proposed	45	1516.5	734289.3
15	Devanahalli	Existing	30	909.9	293715.72
16	Behind BDA Land	New Proposed	60	909.9	587431.44
17	Bengaluru Cantonment	Existing	90	1516.5	1468578.6
18	Bengaluru East Station	Existing	45	909.9	440573.58
19	Banaswadi	Existing	45	909.9	440573.58
20	Kanaka Nagara	New Proposed	30	606.6	195810.48
21	Hebbal Station	Existing	70	909.9	685336.68
22	Pai Layout	New Proposed	30	606.6	195810.48
23	Kagadasapura	New Proposed	45	909.9	440573.58
24	Marathahalli	New Proposed	30	303.3	97905.24
25	Belandur	Existing	60	909.9	587431.44
26	Heelalige Station	Existing	30	1516.5	489526.2
27	Hoodi Halt	Existing	30	758.25	244763.1
28	Whitefield	Existing	60	909.9	587431.44
29	Krishnarajapuram Halt	Existing	60	606.6	391620.96
30	Baiyyappanahalli Junction	Existing	55	909.9	538478.82
31	Channasandra Station	Existing	55	909.9	538478.82
32	Horamavu	New Proposed	30	606.6	195810.48
33	Nelamangala Station	Existing	25	758.25	203969.25
34	Chikkabanavara	Existing	25	909.9	244763.1
35	Kaveri Nagar	New Proposed	30	303.3	97905.24
36	Airport terminal		45	1516.5	734289.3
				Monthly-INR	**18667265.76**

Annually, this works out to be **₹ 22.40 Crore per year**

TABLE 11.29: REVENUE FROM RENTALS - OTHER STATIONS

Rest of the stations	35
Average @ 15 % of the area	455
Average rental per sft	30
Total Rental per month	51,40,025
Total rental per year	**6,16,80,301**

It is estimated that **₹ 28.56 Crore** per year from retail in concourse area.

TABLE 11.30: NON FARE BOX REVENUE ASSESSMENT

S. No.	Revenue Generating Proposal	Total Revenue Generation - (₹ Cr)	Phasing of Proposal	Probable Stakeholders
1	Rental Revenue from Retail-Commercial Activities at Concourse Level	**28.56**	Starting from 2025	Fast moving retail item brands: Retail F&B, Book Stores, Café's, Pharmacy, Banks (ATMs)
2	Revenue from Selling Stations' Semi-Naming Rights.	**40.00**	Starting from 2025	Private Companies/ Organizations; Advertising Agencies
3	Advertising Revenue	**20.00**	Starting from 2025	Private Companies/ Organizations; Advertising Agencies
4	Advertisement on Trains	**3.60**	Starting from 2025	Private Companies/ Organizations; Advertising Agencies
5	Advertisement Revenue from Skywalks	**5.00**	Starting from 2025	Private Companies/ Organizations; Advertising Agencies

Based on the preliminary revenue assessment, about **₹ 93.57 Crore is realizable** as per 2019 price levels.

As worked out for the operation and maintenance period, the costs from these advertisements related revenues are as under

Year	2025	2031	2041	2051
Amount (₹ in Crores)	113	137	182	243

11.4.5 VCF APPLICATION FOR SUB-URBAN RAIL PROJECT, BENGALURU.

The Government of India has proposed the use of Value capture framework (VCF) as innovative finance for the MRTS and other transportation projects. Some of the tools available within the VCF are explored here:

LAND VALUE CAPTURE:

This method recovers all or some of the increase in land and property value as a result of public infrastructure provision. The new Value Capture Framework Policy mooted by the Government can enable the government to recover value generated by public infrastructure investments.

Other MRTS in the country such as the Delhi Metro Rail Corporation (DMRC) have also employed this financing method through property development. Hyderabad Metro has also used the land as concession for the development of Metro Project.

The excess Railway land available with SWR is proposed to be monetized through involvement of the private real estate developers. About 125 acres of identified land is proposed on a long lease model for 30/45/65 and 90-year period with floor area ratio of 5.0 have been proposed. The lease premium payable by the developer will be according the overall development schedule.

PREMIUM FLOOR AREA RATIO:

Currently, the Master Plan -2015 allows for the enhanced FAR of 4.0 around 150 m radius of the commissioned Sub urban rail Station to facilitate densification of the areas. This allows for increased development activity and transactions in these areas. This is useful for the areas that have large vacant lands and areas amenable for redevelopment.

The proposed (draft) Master Plan-2031 provides for a lower base FAR (for e.g.: 2.5) and allows purchase of additional rights (FSI) by the owners/developers of the land. The proceeds from the selling of rights would go to the dedicated urban Transportation fund. Further the funds can be shared between the Sub urban rail / Government and the BBMP in predefined ratio.

This proposal requires setting up of institutional mechanism for:

1. Zoning of the Master plan in accordance with city planning principles
2. Buying and selling of rights procedures- defined emitting and receiving zones for the development rights.
3. Pricing of the Rights – as the current system is driven by market and prevailing market guideline values given by the department of Stamps and registration.
4. Dovetailing with the existing Development rights of over 15.0 million square meters generated via road widening projects in the city.
5. Modifications to the Byelaws to allow for higher densification as the current rules, which are fairly liberal do not allow for utilization of FAR above 3.0 effectively.

Based on the project proposal for stations, 27 stations are located in areas where the densification and redevelopment potential exist. The land owners/ developers within the primary impact area of about 150 m around the station can be assumed to purchase a FAR of 1.0. (i.e.: 70650 Sqm) x 27 stations = 19,07,550 Sqm with average value of ₹ 2500 per Sqm , i.e. : INR 4,76,88,75,000 or about INR 475 Crores. About 60 % of this amount can be the Sub urban rail project share. This can be realized over the coming decade or so, as the process of development will take time. The 60 % translates to INR 286.13 Crores spread over the next 10 years post the necessary amendments to law and well laid procedures.

YEAR	RECEIPT (₹ IN CR)
2025	0
2026	0
2027	15
2028	18
2029	18
2030	26
2031	26
2032	35
2033	35
2034	38
2035	38
2036	38
2037	42
2038	42
2039	42

BETTERMENT LEVY:

A betterment levy can be levied on completed schemes undertaken by the authority and is supported by the law, especially the KMC Act and the BDA Act. As the TOD stipulates the impact zone of the transportation project, about 250 m around the stations can be declared as the area of impact and a levy be imposed on parcels of land. The same area with betterment levy of ₹. 700 per Sqm can be adopted for the revenue estimation, 52,98,750 Sqm translating to INR 3,70,91,25,000 or INR 370.91 Crore realized over the next decade.

YEAR	RECEIPT (₹ IN CR)
2025	0
2026	0
2027	22
2028	26
2029	29
2030	35
2031	39
2032	43
2033	43
2034	43
2035	43
2036	45
2037	45
2038	47
2039	47

LEVY OF FEES FOR CHANGE OF LAND USE

The TOD zones around the transportation project will have provisions of mixed land use. A nominal fee can be introduced to encourage mixed land use. A fee of ₹. 1500 per Sq. Mtr can be levied on the lands applying for change based on the Master Plan directions. An average mix of 25 % to 35 % of the area is considered for the non-residential land uses. The area is about 250 m around the stations i.e. 27 x 196250 Sq.Mtr, with about 25 % of area, i.e.: 13,24,687 Sq.Mtr with fee of ₹. 1500 per Sq.Mtr, resulting in ₹ 1,98,70,31,250 or ₹ 198.70 Crore. This will be over period of coming decade.

Year	Receipt (₹ in Cr)
2025	0
2026	0
2027	5
2028	9
2029	19
2030	19
2031	19
2032	19
2033	19
2034	19
2035	19
2036	19
2037	19
2038	19
2039	19

CESS ON APPROVAL OF NEW LAYOUTS:

The BDA is empowered to levy a cess and surcharge on development of new layouts within the Local planning Area. The other LPA within which the Sub Urban Rail traverse can also include the cess. The Cess is levied at the time of granting approval for development of land or buildings. The rate is usually less than 1/10th of the value of the land. An average of ₹. 15 per Sq.Mtr is adopted for the estimation purposes. The number of layouts coming in the BDA area is highly restricted due to the land supply. The new master plan intends to open up the Green belt areas in the north and the south western side of the city. In addition, layouts coming under the BIAPPA, NPA, Anekal can also be included. An area of about 6-8 sq.km of area per year will be developed given the current trends. This translates to about ₹ 22,23,00,000 or ₹ 222.30 Crore. About half of the proceeds, i.e. ₹ 110 Crore can be brought to the Rail project account on year on year basis.

Year	Receipt (₹ in Cr)
2025	0
2026	0
2027	110
2028	110
2029	110
2030	110
2031	110

YEAR	RECEIPT (₹ IN CR)
2032	110
2033	110
2034	110
2035	110
2036	110
2037	110
2038	110
2039	110

The above numbers are suggestive keeping the current trends of development. The revenue stream with above assumptions and calculations for a 15 year horizon starting from 2025 along two cases (with sale of rights and without sale of rights) are tabulated below in **Table 11.31** and **Table 11.32:**

TABLE 11.31: VALUE CAPTURE FINANCE (WITH SALE OF RIGHTS)

(₹ in Crores)

Sl.No	Description	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
1	Leasing of Railway land [2] (Vacant Lands)	1000	1000	1000	1200											
2	Sale of unused FSI from Railway (2.5 Million Sq.Mtr)	0	0	0	500	1500	1500	1500	1500	1500	1000	1000				
3	Sale of FSI from Stations (unutilised FSI of 3.5 of 5.0 FSI)	0	0	0	0	500	500	1000	1000	1000	500	500				
4	Land use changes around station areas (10 year)	0	0	5	9	19	19	19	19	19	19	19	19	19	19	19
5	Cess on approval of new layouts	0	0	110	110	110	110	110	110	110	110	110	110	110	110	110
6	Betterment levy on Station surround areas	0	0	22	26	29	35	39	43	43	43	43	45	45	47	47
	Total	**1000**	**1000**	**1137**	**1845**	**2158**	**2164**	**2668**	**2672**	**2672**	**1672**	**1672**	**174**	**174**	**176**	**176**

TABLE 11.32: VALUE CAPTURE FINANCE (WITHOUT SALE OF RIGHTS)

(₹ in Crores)

Sl.no	Description	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
1	Leasing of Railway land (Vacant Lands)	1000	1000	1000	1200											
2	Premium Floor Area Ratio (FAR)	0	0	15	18	18	26	26	35	35	38	38	38	42	42	42
3	Land use changes around station areas (10 year)	0	0	5	9	19	19	19	19	19	19	19	19	19	19	19
4	Cess on approval of new layouts	0	0	110	110	110	110	110	110	110	110	110	110	110	110	110
5	Betterment levy on Station surround areas	0	0	22	26	29	35	39	43	43	43	43	45	45	47	47
	Total	**1000**	**1000**	**1152**	**1363**	**176**	**190**	**194**	**207**	**207**	**210**	**210**	**212**	**216**	**218**	**218**

[2] Returns to SPV are calculated for both the scenarios where (i) Amount recovered from Leasing of railway land i.e. ₹ 4200 Crore are taken as source of VCF revenue and (ii) where the same is not considered as VCF Revenue. The comparison is shown in Table 11.33

11.4.6 FINANCIAL INTERNAL RATE OF RETURN (FIRR):

The Financial Internal Rate of Return (FIRR) has been worked out on the basis of the cash flows accruing to the project from the ticketing and other sources. The FIRR with fare-box and non-fare box revenue along with VCF (without sale of rights) is **10.74%.** The FIRR of the project over the 30-year period under various scenarios are listed below in **TABLE 11.33**:

TABLE 11.33: FIRR UNDER DIFFERENT SCENARIOS

S.No	Scenario	FIRR (Considering revenues from Railway land)	FIRR (w/o considering revenues from Railway land)
1.	Fare box & Advt. revenue	8.84%	8.84%
2.	Fare box	9.29%	9.29%
3.	Fare box, Advt. revenue and VCF revenue (without Sale of Rights) (“**Base Case**”)	10.74%	9.64%
4.	Fare box, Advt. revenue and VCF revenue (with Sale of Rights)	13.22%	11.97%

The details of FIRR calculations under scenario 3 (base case) are given in **TABLE 11.34**.

TABLE 11.34: FIRR CALCULATIONS

(₹ in Crores)

Year	Capital Cost	O&M Expenses	Replacement Cost	Total Yearly Expenditure	Fare Box Revenue	Non-Fare Box Revenue	Total Revenue	Net Cash Flows
2019	1340	0	0	1340	0	0	0	-1340
2020	2626	0	0	2626	0	0	0	-2626
2021	2647	0	0	2647	0	0	0	-2647
2022	2780	0	0	2780	0	0	0	-2780
2023	2919	0	0	2919	0	0	0	-2919
2024	2299	0	0	2299	0	0	0	-2299
2025	805	1124	0	1928	1281	1113	2394	466
2026	0	1160	0	1160	1355	1113	2468	1308
2027	0	1198	0	1198	1576	1265	2842	1643
2028	0	1238	0	1238	1668	1488	3155	1917
2029	0	1281	0	1281	1933	301	2233	953
2030	0	1326	0	1326	2046	315	2360	1035
2031	0	1373	0	1373	2389	331	2720	1348
2032	0	1421	0	1421	2460	344	2804	1383

(₹ in Crores)								
Year	Capital Cost	O&M Expenses	Replacement Cost	Total Yearly Expenditure	Fare Box Revenue	Non-Fare Box Revenue	Total Revenue	Net Cash Flows
2033	0	1472	0	1472	2790	344	3134	1661
2034	0	1526	0	1526	2872	361	3233	1708
2035	0	1582	0	1582	3254	361	3615	2033
2036	0	1590	0	1590	3351	363	3714	2124
2037	0	1653	0	1653	3789	382	4171	2518
2038	0	1718	0	1718	3902	384	4286	2567
2039	0	1788	0	1788	4432	384	4816	3028
2040	0	1861	0	1861	4564	182	4747	2886
2041	0	1938	0	1938	5162	182	5344	3406
2042	0	2019	0	2019	5304	182	5487	3468
2043	0	2105	0	2105	5993	201	6193	4088
2044	0	2195	0	2195	6158	201	6358	4163
2045	0	2290	3354	5644	6964	201	7164	1520
2046	0	2093	0	2093	7156	221	7376	5283
2047	0	2199	0	2199	8098	221	8318	6120
2048	0	2309	0	2309	8321	221	8542	6232
2049	0	2426	0	2426	9405	243	9648	7221
2050	0	2549	0	2549	9664	243	9907	7358
2051	0	2679	0	2679	10922	243	11165	8486
2052	0	2815	0	2815	11224	267	11491	8675
2053	0	2959	0	2959	12676	267	12943	9984
2054	0	3082	0	3082	13026	267	13293	10210
TOTAL	**15415**						**Project IRR**	**10.74%**

The FIRR for the project is indicative that the project is remunerative with range of **+8.84% to +13.22%** under various scenarios as brought out in Table 11.33.

Sensitivity Analysis

The sensitivity analysis has been carried out to see the impact of change in critical parameters in various ranges on FIRR and is presented in **Table 11.35.**

TABLE 11.35: Sensitivity Analysis For FIRR Under Base Case

S. No.	Factor	Range			
		-10%	-5%	5%	10%
1	Change in Capital Cost (excl. cost of rolling stock)	11.49%	11.10%	10.40%	10.08%
2	Change in Ridership	9.69%	10.23%	11.22%	11.68%

11.5 ALTERNATE SOURCES FOR FINANCING

11.5.1 INTRODUCTION

The suburban rail like any infrastructure project requires large capital outlay and resources having long gestation period (current project 6 years). The rate of return required by the private sector is typically higher at 14% or more for such projects considering the risks involved. Since the current project offers lesser IRR than that required by private entity, it is proposed that the initial capex be made available through government budgetary allocations and mix of equity and debt via a Special Purpose Vehicle (SPV).

However, it is desirable to augment the resources through alternate sources of finances given the constraints of government treasury. These alternate sources can be explored once the initial risk of construction and requirement of large capital outlay has been assumed by the SPV and subsequent project becomes commercially viable for the private entity.

Some of the forms of PPP that can be explored by the SPV are described below:

1. **O&M PPP**

   With the increase of mass transit rail systems in the country coupled with the steady development of the expertise for managing the services in the private sector, SPV may explore the possibility of provisioning of rolling stock, signalling systems etc. and also maintenance and operation by a private entity. This would also bring in the managerial efficiencies, and entrepreneurial spirit of the private sector in the delivery of service. In this arrangement, the entire operational independence is with the private entity with regards to frequency of trains, train timings, no. of coaches, etc. The private entity will be given a fixed annual payment during the O&M period.

2. **LEASING OF ROLLING STOCK AND ITS MAINTENANCE (WET LEASE)**

   In a pure O&M PPP as in (1), the operational independence is with private entity, however with the larger public policy in mind, it is desirable that the operation of the suburban trains remains with the SPV. For this the arrangement of PPP that can be explored is that the fixed infrastructure required for the sub-urban corridor would be constructed & financed by the SPV whereas the procurement & financing of rolling stock on lease along with its maintenance and provision of train operators be borne by the private entity. Availability based payments would be given to the operator during lease period. Notable example would be the leasing of Rolling Stock that the Delhi Metro Rail Corporation had attempted to bid in 2018-19.

The SPV can also employ tools of innovative contracting involving private sector that hold great potential as established with various MRTS Rail projects in the country, such as Lifts & Escalators on O&M Model, AFC – Advanced systems that can be bid out with branding and Platform Screen Door – Can be taken up as O&M model. Since these components are essential in the overall suburban infrastructure construction, these will need to be worked out at the time of taking up the implementation of the project

11.5.2 PROPERTY DEVELOPMENT ON RAILWAY LAND

Property development across the world is currently being utilized for augmenting the resources; this is usually done by developing real estate on the land parcels available with the SPV/ IR. Indian Railways (SWR) has about 380.0 Acre of land that can be utilized for the property development. This land is located at various locations of the city along the rail and station area.

Indian Railways / SWR may monetize the land by way of leasing. The land parcels are situated as:

1) Vacant land parcels of Land adjacent to station and rail network.
2) Land with old structures such as quarters, utilities that can be redeveloped
3) Station areas where the current or proposed stations are located
4) Track areas where there are tracks, pit lines, etc.

TABLE 11.36: AVAILABILITY OF LAND

SL. NO.	STATION	VACANT LAND FOR COMMERCIAL EXPLOITATION (IN ACRES)	AREA ABOVE RAILWAY TRACK (IN ACRES)	TOTAL AREA (IN ACRES)
1.	SBC	60.13	50.09	110.22
2.	YPR	132.96	34.81	167.764
3.	BNC	23.21	21.22	44.43
4.	YNK	8.13	17.73	25.86

SL. No.	STATION	VACANT LAND FOR COMMERCIAL EXPLOITATION (IN ACRES)	AREA ABOVE RAILWAY TRACK (IN ACRES)	TOTAL AREA (IN ACRES)
5.	BYPL	14.32	8.33	22.65
6.	KJM	1.68	8.43	10.11
7.	WFD	10.7	6.88	17.58
8.	CSDR	23.86	7.19	31.05
9.	HEB	36.66	14.55	51.21
10.	MWM	0.00	4.18	4.18
11.	BAND	4.95	13.41	18.36
12.	LOGH	0.82	2.43	3.25
13.	KGI	4.01	7.02	11.03
14.	HLE	24.89	4.64	29.53
15.	NYH	2.85	4.31	7.16
16.	DHL	13.04	2.22	15.26
17.	NMGA	14.35	8.09	22.44
18.	BAW	4.24	6.40	10.64
Total		**380.795**	**221.929**	**602.724**

Development on these parcels of land offers challenges of varying degree as the corridor traverses the city of varying development potential. The prices of land and built up area are also varying. Property development or real estate development is dictated by the location, economic condition of the surrounding, the size of the parcel and mainly the regulations determined by the master Plan documents. Further, the criteria for attractiveness comes from the size of the land parcel, whether it is contagious, it has good access, frontage and as well as supporting external infrastructure.

VACANT LANDS AND REDEVELOPMENT: The Vacant lands which are of considerable size and potential can be developed with the partnership of the private players.

Redevelopment of the lands can be taken up with private participation but the substantial costs for redevelopment are expended. The Higher FAR framework will allow for re-organizing and redevelopment of the property by housing the existing function within smaller land component and developing the rest optimally.

INTEGRATED STATION WITH LAND: The lands adjacent to the station that may be smaller in size and are dependent on the station improvement/Development can be developed in an integrated manner along with the station. The concourse area of the proposed stations can be also put for rentals according to the passenger movement and real estate market conditions. The investment will be along with the station development and may be guided one developed along with the project phasing. This will allow for rentals from leasing activity.

11.5.3 DEVELOPMENT POTENTIAL AND PROGRAM

To ascertain commercial development potential, real estate market of the project corridor area has been studied including types of real estate development possible, sustainability of demand of each type of commercial development based on supply and demand of each type; and capital and rental values of each type. The study has utilized both secondary and primary sources and methodology includes analysis of published real estate reports and discussions with real estate developers.

The following types of real estate development can take place are:

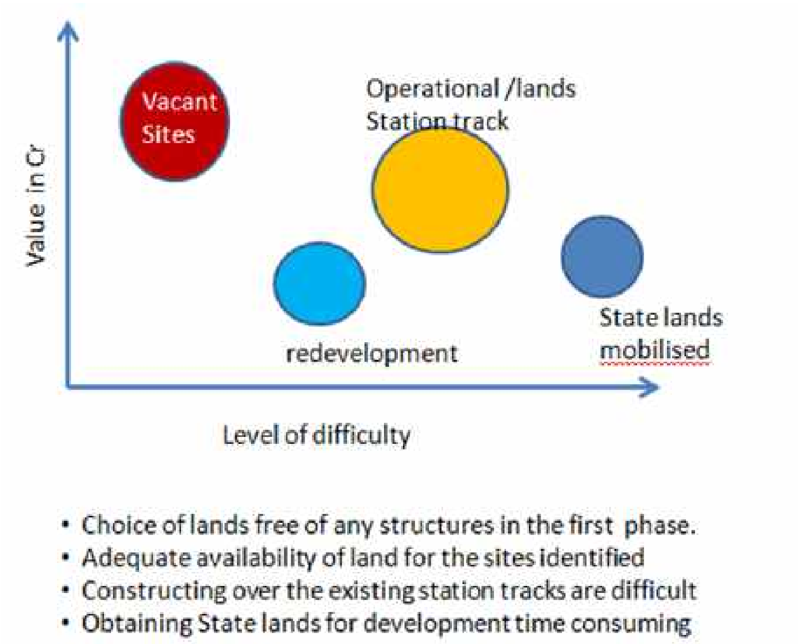
- Commercial (office)
- Retail (showrooms/shops)
- Residential
- Hospitality
- Warehousing

Only commercial offices and retail are suitable real estate types for lease periods of 30 years or more. Residential needs to be on outright sale or leased out for higher periods (65 years to 99 years) for successful absorption in the market while Hospitality leases can be for lower periods than 30 years but huge up-front capital expenditure in developing hotels and limited number of quality hotel operators limits absorption of hospitality space. Warehousing requires large spaces with lower rental yields and is not suitable for higher revenue realization on significant land parcels.

Commercial and retail are feasible types of real estate development in the airspaces (in station and over track situations) while Vacant and redevelopment land areas can contain residential development on identified land plots. Thus, commercial, retail and residential types have been studied in this real estate study to understand the rental and capital values obtainable.

The development potential in terms of revenue is mapped against the difficulty of development.

FIGURE 11.1: PRIORITIZATION OF LANDS FOR PROPERTY DEVELOPMENT



Based on the above criteria, the parcels of land have been categorized for the following development:

FIGURE 11.2: CATEGORIZATION OF LAND PARCELS

STAND ALONE PARCELS (78 Acres)	REDEVELOPMENT PARCELS (25 Acres)
SBC BNC YPR CSDR BYP DHL NMGA BAW	• SBC • BNC
AIR RIGHTS (8-10 Acres) Yelahanka Mathikere BYP Select Proposed stations	**INTEGRATED STATION (20 Acres)** • Hebbal • BAW • DHL • Banaswadi • WFD • HLE • NMGA

Selection criteria for land and its potential use categories

- Contagious land parcel & geometry
- Substantial size for market to be interested
- Good access
- Location advantage
- Vibrant Micro market
- Centrality- multimodal advantage – Commuters
- Potential for higher FAR utilization.

11.5.4 ESTIMATION OF VALUE BASED ON THE CATEGORIES OF LAND

VACANT LAND PARCELS

The following stations have been identified for possibility of real estate development. The vacant land parcels with station name and parcel code is given in **Table 11.32**. Few structures may require relocation to realize full potential of real estate at these locations:

TABLE 11.37: STATIONS FOR REAL ESTATE DEVELOPMENT

S. No.	DESCRIPTION	LAND PARCEL CODE	AREA IN SQM	PLANNING AUTHORITY
1	City Railway Station-KSR - Opp Krishna Mill	SBC - C	12140.60	BDA
2	Cantonment Station	BNC- A and B	49,836	BDA
3	Yeshwanthpur	YPR –A & YPR- B	109,296	BDA
4	Channasandra	CSDR – A & CSDR -B	62,758	BDA
5	Baiyyappanahalli	BYP-A,B,C,D	55312	BDA
6	Chikkabanavara	BAW – B	3765	BDA
7	Devanahalli	DHL	30,644	BIAPPA

The vacant area that is available for immediate exercise is about: 323751.6 Sqm or 79.97 Acres of Land.

Based on the location of the site and the road width available, the vacant lands have been subjected to the applicable zonal regulations with respect to the Floor area Ratio, Ground coverage, height and setbacks to determine the prefeasibility of development. The above identified sites require external infrastructure such as infrastructure, mainly roads for access and to develop optimally.

Based on the Guideline value for the standalone vacant land parcels at the locations –KSR Bengaluru City (SBC), Bengaluru Cantonment (BNC), Yeshwanthpur (YPR), Channasandra (CSDR), Baiyyappanahalli (BYPL), Chikkabanavara (BAW), Devanahalli (DHL), the valuation of the land are as follows:

TABLE 11.38: VALUATION OF LAND

SL. NO.	NAME OF STATION	DESCRIPTION	AREA		VALUE (LEASE BASIS)	LAND VALUE (INR)	EXT. DEVPT. INFRA (₹ IN CRORES)	NET VALUE (₹ IN CRORE)
			ACRES	SQ. MTR				
1	SBC	Krishna Mill	3.00	12140.60	161500.00	1960706900.00	0.00	196.07
2	YPR	Site A	17.00	68816.00	44000.00	3027904000.00	15.00	
		Site B	10.00	40480.00	44000.00	1781120000.00		465.90
3	BNC	Site A	12.11	49036.00	94800.00	4648612800.00	0.00	464.86
4	CSDR	Site A	3.69	14950.00	35600.00	532220000.00	0.00	
		Site B	11.81	47808.00	35600.00	1701964800.00		223.42
5	BAW	Site B	0.93	3765.00	17500.00	65887500.00	0.00	6.59
6	BYPL	A, B, C, D	13.66	55312.00	10700.00	591838400.00	5.00	54.18
7	DHL	Site A	7.57	30644.00	13557.60	415459094.40	0.00	41.55
Total						**1472.57**	**20.00**	**1452.57**

For about 79.78 Acres or 3,22,951.60 Sqm – INR 1452 Cr

TABLE 11.39: VALUE OF LAND ON REDEVELOPMENT OF PARCELS

SL. NO.	NAME OF STATION	DESCRIPTION	AREA		VALUE (LEASE BASIS)	LAND VALUE (INR)	EXT. DEVPT. INFRA (IN CRORES)	NET VALUE (IN CRORE)
			ACRES	SQ. MTR				
1	SBC	Site A	15.00	60720.00	120000.00	7286400000.00	25.00	
		Site B	17.86	72297.28	120000.00	8675673600.00		1571.21
2	BNC	Site B	2.87	11622.00	100000.00	1162200000.00	7.50	599.08
Total								**2170.29**

For land about – 35.731 Acres or 144639.28 Sqm – the value is about : 2170.29 Crore. The total value of Land for the above based on prevailing guideline value is about INR 3622.86 Crore.

TABLE 11.40: INTEGRATED STATION

SL. NO.	NAME OF STATION	DESCRIPTION	AREA		VALUE (LEASE BASIS)	LAND VALUE (INR)
			ACRES	SQ. MTR		
1	SBC	A	1.13	4574.00	17500.00	80045000.00
2	DHL	Site B	5.47	22132.00	30644.00	678213008.00
3	NMGA	Site B (half)	3.72	15062.00	10700.00	161163400.00
4	BAND	Site A (half)	4.95	20042.00	26100.00	523096200.00
5	HEB	A	4.74	19204.00	41500.00	796966000.00
6	WFD	A	10.70	43317.00	55700.00	2412756900.00
Land Area			**30.71**	**Total**		**465.22**

(BAND: Banaswadi, HEB: Hebbal, WFD: Whitefield, NMGA; Nelamangala)

11.5.5 SUMMARY

The value of the lands as per the Guideline value is as follows:

a) Vacant lands and redevelopment lands: ₹ 3622.86 Crore
b) Integrated Station development :₹ 465.22 Crore
c) The value that can be realized by the leasing can range between 3625 Crore and with a FAR of 5.0, additional 20 % increase in value upto 4350 Crore is estimated.
d) For integrated station development, the lands based on the geometry and area that can be leased is about 30 acre and this can yield about INR 465.22 Crore.
e) A total of about INR 4815 Crore can be raised through the leasing of the land.

11.5.6 INSTITUTIONAL FRAMEWORK FOR PROPERTY DEVELOPMENT

The Lands identified for the project belong to the Indian Railways (SWR) and they can be developed as per Indian Railways operational requirements and plans. The excess land belonging to Railways are vested with the Rail Land Development Authority, an authority under the statute dedicated to the commercialization of the railway land. (Amendment to Indian Railway Act, 2005). The RLDA is enabled as per the Act to enter into MoU / Agreements with Public, private sectors for the utilization and development/redevelopment of the lands. The powers are also vested with them for according concessions;

thereby models such as the Public Private partnership can be taken up by the RLDA. In this model, the excess land that can be put to the property development can be transferred to RLDA for development on lease basis with the help of the private sector. The RLDA stipulates a payment of premium and upfront payment from the private developer and this can be utilized as to financing the capital/OPEX. The long leases are up to 40 years for commercial development and up to 90 years for residential development. About 40 % of the proceeds from the revenue accrued from the property development will be transferred to the Indian Railways.

The extent of land and its equivalent value as proportion to the project needs to be determined. The State Government will provide the following:

1) Change of land use to the optimum use of land
2) Provide for Floor Area Ratio of 5.0
3) Provide necessary transport and traffic planning support in form of external roads, widening of roads and the municipal infrastructure.
4) Provide relaxation of the parking requirements /norms up to 30 % as these developments will be serviced by the Sub urban Rail networks.

SOME KEY STEPS FOR PROPERTY DEVELOPMENT

1) All the identified lands will have to be surveyed with total station and generate accurate topography, vegetation, etc.
2) The identified parcels must be demarcated properly with the boundary stones and with DGPS readings.
3) A dossier on the selected lands with its legal documentation and vetting of the same needs to be carried out.
4) All the railway land has some structures, the redevelopment parcels have quarters and other amenities that need to be redeveloped. The actual estate management and the need requirement for the Railways are to be established. This will guide the actual.
5) Detailed Commercial and financial studies have to be carried out to arrive at the reserve price for the lands for leasing.
6) The external infrastructure such as the power, water, Roads, etc. must be worked out in consultation with the other departments.
7) Interaction with the Local Planning Authority for the change of Land use and allowance of maximum FAR of 5.0 and subsequent formulation of the schemes.

8) Discussion with Private developers/PSU to be encouraged for marketing the Re/Development Opportunities.

11.6 FUNDING PLAN: EQUITY SHARING MODEL (SPV MODEL)

Under this model, a Special Purpose Vehicle (SPV) will be set up as a joint venture between Central Government and Government of Karnataka for the implementation of the project and for its subsequent Operation &Maintenance. Under this arrangement Government of India and Government of Karnataka shall make equal equity contribution and run the SPV as a commercial enterprise as a joint venture of GOI & GOK. As per the prevalent practice in MRTS projects, Central Government may contribute upto 20% of the project cost excluding land and R&R, Central and state taxes as its equity contribution. An equal amount will be contributed by the State Government aggregating the total equity to 40%. In addition to equity, GoI will also fund the cost of Central GST and Basic Customs Duty, similarly GOK will fund the cost of land including R&R, state GST and Interest during construction. Rolling Stock will be procured by Lessor (private party) and hence not considered in the funding plan for the SPV.

With the equal ownership of the SPV, both the governments nominate their representatives as members of the Board of Directors, which in turn select functional directors. Such a SPV has a benefit of independent management under the aegis of Indian Companies Act, 2013. Delhi Metro Rail Corporation, Chennai & Bengaluru metro corporations are examples of success of such SPV. For balance 60%, loan from bilateral/ multilateral agencies such as JICA can be explored. The loan terms for JICA ODA loan are provided in **TABLE 11.41**.

TABLE 11.41: JICA-ODA LOAN TERMS

PARTICULARS	VALUES
Interest Rate % p.a	1.4%
Loan Period	40
Moratorium	10
Repayment Start Year	2029
Repayment End Year	2058

The funding pattern developed under this model (SPV) is placed in **TABLE 11.42**.

TABLE 11.42: CONTRIBUTION UNDER SPV MODEL

PARTICULARS	AMOUNT (₹ IN CR)	% SHARE
Equity by GoI	2479	20.0%
Equity by Govt. of Karnataka	2479	20.0%
Soft Loan from bilateral/multilateral funding agencies	7439	60.0%
Total Cost	**12397**	**100.00%**
Sub-Ordinate Debt for Ccentral GST & Basic Customs Duty by GoI	763	-
Sub-Ordinate Debt for land and R&R by Govt. of Karnataka	1470	-
Sub-Ordinate Debt for State GST by Govt. of Karnataka	785	-
Sub-Ordinate Debt for IDC for JICA ODA Loan @1.4% by Govt. of Karnataka	353	-
Total Cost	**15768**	-

The loan amortization schedule is provided in **TABLE 11.43.**

TABLE 11.43: LOAN AMORTIZATION SCHEDULE

(₹ in Crores)

YEAR	OPENING BALANCE	WITHDRAWN AMOUNT	PRINCIPAL REPAYMENT	INTEREST (@1.4% OF OPENING BALANCE)	CLOSING BALANCE	INTEREST DURING CONSTRUCTION (IDC)
2019	0	323	0	2	323	2
2020	323	1008	0	12	1331	12
2021	1331	1412	0	29	2743	29
2022	2743	1483	0	49	4226	49
2023	4226	1557	0	70	5783	70
2024	5783	1226	0	90	7009	90
2025	7009	430	0	101	7439	101
2026	7439	0	0	105	7439	
2027	7439	0	0	105	7439	
2028	7439	0	0	105	7439	
2029	7439	0	286	102	7152	
2030	7152	0	286	98	6866	

(₹ in Crores)

Year	Opening Balance	Withdrawn Amount	Principal Repayment	Interest (@1.4% of Opening Balance)	Closing Balance	Interest During Construction (IDC)
2031	6866	0	286	94	6580	
2032	6580	0	286	90	6294	
2033	6294	0	286	86	6008	
2034	6008	0	286	82	5722	
2035	5722	0	286	78	5436	
2036	5436	0	286	74	5150	
2037	5150	0	286	70	4864	
2038	4864	0	286	66	4577	
2039	4577	0	286	62	4291	
2040	4291	0	286	58	4005	
2041	4005	0	286	54	3719	
2042	3719	0	286	50	3433	
2043	3433	0	286	46	3147	
2044	3147	0	286	42	2861	
2045	2861	0	286	38	2575	
2046	2575	0	286	34	2289	
2047	2289	0	286	30	2003	
2048	2003	0	286	26	1717	
2049	1717	0	286	22	1430	
2050	1430	0	286	18	1144	
2051	1144	0	286	14	858	
2052	858	0	286	10	572	
2053	572	0	286	6	286	
2054	286	0	286	2	0	
Total		**7439**	**7439**	**2023**		**353**

ANNEXURE -1: LAND DETAILS AND VALUATION

LAND VALUATION

The Private lands required for the project is valued by taking into the consideration of the Guideline value given by the Stamps and Registration Department. The land values adjacent to the private properties and the guidance value given are considered. Valuation is carried out on basis of segment and belt, i.e. the stretches with similar value adopted for the identified land parcels.

Depending on the proposed alignment and location of stations, small stretches of land with or without buildings that are required are identified corridor wise. Depending on the location of the land / building, guideline value i.e. capital value of land and built up is identified. The buildings are usually G+1, with moderate level of finishes. The corresponding value given by the Sub registrar office is adopted.

Illustration: Land stretch for the alignment

PRIVATE LAND REQUIREMENT:

CORRIDOR	SEGMENTS	TOTAL KM	LAND REQUIREMENT (SQM)			
			ROAD	BUILT-UP	VACANT LAND	TOTAL
CORRIDOR - 1	SBC-YPR-LOGH-YNK-DHL	41.40	8254	6634	42340	57228
CORRIDOR - 2	BAW-YPR-LOGH-BYPL (T)	25.01	38217	33547	82166	153930
CORRIDOR - 3	KGI-SBC-BNC (WFD)	35.52	10320	40739	43091	94150
CORRIDOR - 4	HLE-BENNIGANAHALLI-CSDR-YNK-RNN	46.24	19410	44262	118793	182465
Airport Connectivity			0	0	64610	64610
TOTAL LAND REQUIREMENT			**76201**	**125182**	**351000**	**552383**

The corridor wise details are provided in the following sections.

VALUATION OF PRIVATE LANDS ALONG CORRIDOR:

CORRIDORS	Segments	TOTAL KM	Vacant Land (Sqm)	Built up (Sqm)	Value of Vacant land (INR)	Value of Built-up (INR)	Total (INR)
CORRIDOR - 1	SBC-YPR-LOGH-YNK-DHL	41.40	42300	6634	533,015,510	429,411,450	962,426,960
CORRIDOR - 2	BAW-YPR-LOGH-BYPL (T)	25.01	82166	33547	3,003,431,020	1,472,940,690	4,476,371,710
CORRIDOR - 3	KGI-SBC-BNC (WFD)	35.52	43091	40739	1,561,040,340	3,299,782,900	4,860,823,240
CORRIDOR - 4	HLE-BENNIGANAHALLI-CSDR-YNK-RNN	46.24	118793	44262	2,389,392,240	1,509,081,160	3,898,473,400
Total Route length	**147.38 KM**	**148.17**	**286390**	**125182**	**7486879110**	**6711216200**	**14,198,095,310**

Total value as per Guidelines, value for the open and Built-up land is about INR 1419.81 Crore.

DEPOT LANDS:

The land for establishing the depot is at, Jnanabharathi & Devanahalli. It is proposed to mobilize the Devanahalli land of about 61.27 Acres and Jnanabharathi land of about 56.97 Acres by the State Government. The cost of the land is not considered as it is owned by the state government.

S. No.	Depot location	Area in Acres	Value/ Acre	Value (INR) in Crore
1	Devanahalli	61.27	0	0
2	Jnanabharathi	56.97	0	0

Mobilization of the Private Lands:

The alignment necessitates private lands to be utilized. The actual extents of the required land, ownership status will be established after the detailed engineering and Social Impact Assessment study. The private lands can be mobilized by the State by adopting suitable compensation model. Currently the Bengaluru Metro has adopted the KIADB Act provisions for the land acquisition and developed a suitable compensation model.

For large tracts of land for the depot purposes can be mobilized through innovative Land Pooling and Reconstitution tools within an urban planning method. This can help in overcoming the difficulty in awarding cash compensation and allow for development of the areas in a systematic manner. Greater densification of these areas can be attempted through a plan model. The state Government can explore these avenues for the land mobilization.

CORRIDOR – 1: KSR BENGALURU CITY TO DEVANAHALLI

S.No	Additional Land Requirement				GV for vacant Land	GV for Built-up Land	Values for vacant land	Values for Built-up	Area Name	Sub Registrar office
	Total (Sqm)	Vacant Land(Sq m)	Road (Sqm)	Built up (Sqm)						
1	205	0	100	105	30800	75000	0	7875000	Jakkarayanakere	Malleswaram SRO
2	1048	0	270	778	30800	75000	0	58350000	Jakkarayanakere	Malleswaram SRO
3	1228	0	500	728	41450	85250	0	62062000	Mantri Greens	Malleswaram SRO
4	1740	0	900	840	59200	85250	0	71610000	Srirampura	Malleswaram SRO
5	1259	0	250	1009	59200	85250	0	86017250	Srirampura	Malleswaram SRO
6	1572	0	500	1072	59300	72400	0	77612800	Subramanya Nagara/ Maruthi Extension	Rajaji Nagara SRO
7	1639	0	1639	0	59300	72400	0	0	Subramanya Nagara/ Maruthi Extension	Rajaji Nagara SRO
8	438	0	438	0	59300	72400	0	0	Subramanya Nagara/ Maruthi Extension	Rajaji Nagara SRO
9	351	50	0	351	65200	60400	3260000	21200400	Yeshwantpura	Yeshvanthapura SRO
10	930	670	0	260	59400	60400	39798000	15704000	Mathikere	Yeshvanthapura SRO
11	1397	1347	50	0	59400	60400	80011800	0	Mathikere	Yeshvanthapura SRO
12	207	207	0	0	27100	34100	5609700	0	Kodigehalli/TATA Nagar	Hebbal SRO

S.No	Additional Land Requirement				GV for vacant Land	GV for Built-up Land	Values for vacant land	Values for Built-up	Area Name	Sub Registrar office
	Total (Sqm)	Vacant Land(Sq m)	Road (Sqm)	Built up (Sqm)						
13	1651	1651	0	0	27100	34100	44742100	0	Kodigehalli	Bytarayanapura SRO
14	1267	1267	0	0	54000	33700	68418000	0	Allalasandra Judicial Layout	Yelahanka SRO
15	4064	3414	400	250	14300	26000.00	48820200	6500000	Yelahanka Station	Yelahanka SRO
16	9939	9179	260	500	14300	26000.00	131259700	13000000	Yelahanka Station	Yelahanka SRO
17	2145	1355	0	790	14000	12000.00	18970000	9480000	Govindapura	Yelahanka SRO
18	562	562	0	0	14000	12400.00	7868000	0	Nellukunte	Hesaragatta SRO
19	1198	1078	120	0	9500	22000.00	10241000	0	Bettahalasuru	Jala SRO
20	2203	2203	50	0	1900	12000.00	4185700	0	Bettahalasuru	Jala SRO
21	64	64	0	0	1900	12000.00	121600	0	Bettahalasuru	Jala SRO
22	840	840	0	0	2400	12040.00	2016000	0	Chennahalli/ Chikkajala	Jala SRO
23	381	381	0	0	2400	12040.00	914400	0	Chennahalli/ Chikkajala	Jala SRO
24	1105	0	1105	0	2400	12040.00	0	0	Chennahalli/ Chikkajala	Jala SRO
25	56	0	56	0	16000	12000.00	0	0	Doddajala	Jala SRO
26	376	0	376	0	16000	12000.00	0	0	Doddajala	Jala SRO
27	471	471	0	0	16000	12000.00	7536000	0	Doddajala	Jala SRO
28	307	307	0	0	16000	12000.00	4912000	0	Doddajala	Jala SRO
29	22.5	22.5	0	0	16000	12000.00	360000	0	Doddajala	Jala SRO
30	3348	3348	0	0	4150	12000.00	13894200	0	Yerthaganahalli	Jala SRO
31	6287	5047	1240	0	2770	12000.00	13980190	0	Yerthaganahalli	Jala SRO
32	7986	7986	0	0	2770	12000.00	22121220	0	Yerthaganahalli	Jala SRO

S.No	Additional Land Requirement				GV for vacant Land	GV for Built-up Land	Values for vacant land	Values for Built-up	Area Name	Sub Registrar office
	Total (Sqm)	Vacant Land(Sq m)	Road (Sqm)	Built up (Sqm)						
33	958	958	0	0	4150	12000.00	3975700	0	Yerthaganahalli	Jala SRO
TOTAL	**57228**	**42340**	**8254**	**6634**			**53,30,15,510**	**42,94,11,450**		

Total Value of Land for C1 Corridor is ₹ 96.25 Crore.

CORRIDOR – 2: BAIYYAPPANAHALLI TERMINAL TO CHIKKABANAVARA

S. No	Additional Land Requirement				GV for vacant Land	GV for Built-up Land	Values for vacant land	Values for Built-up	Area Name	Sub Registrar office
	Total (Sqm)	Vacant Land(Sq m)	Road (Sqm)	Built up (Sqm)						
1	4700	4500	200	0	7200	6000	32400000	0	Myadarahalli	
2	5250	5190	60	0	17700	23700	91863000	0	K G Halli	Peenya SRO
3	8739	8489	250	0	20000	32000	169780000	0	HMT Estate, Jalahalli	Peenya SRO
4	18160	17160	1000	0	20000	32000	343200000	0	Jalahalli	Peenya SRO
5	33896	2970	27026	3900	50000	59400	148500000	231660000	MSR Colony	Yeshwantpura SRO
6	7914	1614	800	5500	38000	59400	61332000	326700000	Devi Nagara, Lottegollahalli	Hebbal SRO
7	3150	2850	300	0	70000	42400	199500000	0	Bommasandra	Hebbal SRO
8	619	0	619	0	70000	42400	0	0	Bommasandra	Hebbal SRO
9	7607	6857	750	0	70000	42400	479990000	0	Bommasandra	Hebbal SRO
10	5520	5220	300	0	70000	42400	365400000	0	Bommasandra	Hebbal SRO

S. No	Additional Land Requirement				GV for Vacant Land	GV for Built-up Land	Values for Vacant Land	Values for Built-up	Area Name	Sub Registrar Office
	Total (Sqm)	Vacant Land(Sq m)	Road (Sqm)	Built up (Sqm)						
11	3380	600	0	2780	20000	30100	12000000	83678000	Guddadahalli	Kacharakanahalli SRO
12	1519	1319	200	0	33500	34700	44186500	0	Kanaka Nagara	Kacharakanahalli SRO
13	1909	0	0	1909	33500	34700	0	66242300	Kanaka Nagara	Kacharakanahalli SRO
13a	464	0	200	264	32300	37400	0	9873600	Vyalikaval HBCS	Kacharakanahalli SRO
14	8381	2700	162	5519	34000	37400	91800000	206410600	Shampura, Nagavara	Kacharakanahalli SRO
14a	335	335	0	0	34000	37400	11390000	0	Shampura, Nagavara	Kacharakanahalli SRO
14b	486	0	486	0	34000	37400	0	0	Shampura, Nagavara	Kacharakanahalli SRO
14c	912	0	912	0	34000	37400	0	0	Shampura, Nagavara	Kacharakanahalli SRO
14d	350	0	350	0	34000	37400	0	0	Shampura, Nagavara	Kacharakanahalli SRO
15	2485	1865	620	0	34000	37400	63410000	0	HBR Layout	Kacharakanahalli SRO
15c	346	346	0	0	34000	37400	11764000	0	HBR Layout	Kacharakanahalli SRO
16	1782	0	0	1782	34000	37400	0	66646800	HBR Layout	Kacharakanahalli SRO
16a	500	500	0	0	34000	37400	17000000	0	HBR Layout	Kacharakanahalli SRO
16b	1141	0	1141	0	34000	37400	0	0	HBR Layout	Kacharakanahalli SRO

S. No	Additional Land Requirement				GV for vacant Land	GV for Built-up Land	Values for vacant land	Values for Built-up	Area Name	Sub Registrar office
	Total (Sqm)	Vacant Land(Sqm)	Road (Sqm)	Built up (Sqm)						
17	6644	6644	0	0	44540	46000	295923760	0	Kariyannapalya, kadugondanahalli	Kacharakanahalli SRO
17a	260	260	0	0	44540	46000	11580400	0	Kariyannapalya, kadugondanahalli	Kacharakanahalli SRO
17e	1023	883	140	0	41500	46000	36644500	0	Lingarajapura	Halasuru SRO
18	6937	4857	0	2080	41500	46000	201565500	95680000	Lingarajapura	Halasuru SRO
18a	1492	750	0	742	41500	46000	31125000	34132000	Lingarajapura	Halasuru SRO
18c	566	566	0	0	41500	46000	23489000	0	Lingarajapura	Halasuru SRO
19	8227	0	1200	7027	49800	37070	0	260490890	Maruthi Nagara	Halasuru SRO
19a	216	216	0	0	49800	37070	10756800	0	Maruthi Nagara	Halasuru SRO
20	8531	5231	1500	1800	45540	46000	238219740	82800000	Bennigahalli	K R Puram SRO
20a	158	158	0	0	45540	46000	7195320	0	Bennigahalli	K R Puram SRO
20b	75	75	0	0	45540	46000	3415500	0	Bennigahalli	K R Puram SRO
21	243	0	0	243	35500	35500	0	8626500	Pai Layout, Bennigahalli	K R Puram SRO
TOTAL	**153930**	**82166**	**38217**	**33547**			**300,34,31,020**	**147,29,40,690**		

Total Value of Land for Corridor-2 is ₹ 447.63 Crore.

CORRIDOR – 3: KENGERI TO WHITEFIELD (VIA KSR AND CANTONMENT)

S. No	Additional Land Requirement				GV for vacant Land	GV for Built-up Land	Values for vacant land	Values for Built-up	Area Name	Sub Registrar office
	Total (Sqm)	Vacant Land(Sq m)	Road (Sqm)	Built up (Sqm)						
1	3199	0	1999	1200	37680	43060	0	51672000	Valagerehalli, KGI	Kengeri SRO
2	4152	4152	0	0	37680	43060	156447360	0	Valagerehalli, KGI	Kengeri SRO
3	9446	6861	585	2000	30140	35000	206790540	70000000	Muthuraya Nagara, Jnanabharathi	Kengeri SRO
4	35331	26191	770	8370	30140	35000	789396740	292950000	Muthuraya Nagara, Jnanabharathi	Kengeri SRO
5	1675	411	70	1194	35600	62500	14631600	74625000	BCC Layout, Deepanjali Nagara	Vijaya Nagara SRO
6	9000	4770	1040	3190	71100	50600	339147000	161414000	Bapuji Nagara, HBCS layout	Vijaya Nagara SRO
7	1548	456	100	992	67850	43000	30939600	42656000	Telecom Layout	Gandhi Nagara SRO
8	1000	0	85	915	67850	43000	0	39345000	Telecom Layout	Gandhi Nagara SRO
9	703	0	0	703	77500	35500	0	24956500	K P Agrahara, Cottonpet	Gandhi Nagara SRO
10	2171	0	0	2171	77500	35500	0	77070500	K P Agrahara, Cottonpet	Gandhi Nagara SRO
11	936	0	936	0	94750	94750	0	0	Railway parallel Road, Seshadripuram	Gandhi Nagara SRO
12	6245	0	1025	5220	94750	94750	0	494595000	Railway parallel Road, Seshadripuram	Gandhi Nagara SRO

S. No	Additional Land Requirement				GV for vacant Land	GV for Built-up Land	Values for vacant land	Values for Built-up	Area Name	Sub Registrar office
	Total (Sqm)	Vacant Land(Sq m)	Road (Sqm)	Built up (Sqm)						
13	5500	250	400	4850	94750	94750	23687500	459537500	Railway parallel Road, Seshadripuram	Gandhi Nagara SRO
14	13244	0	3310	9934	96900	152100	0	1510961400	M V Jayaram Road, Vasanth Nagar SRO	Gandhi Nagara SRO
TOTAL	**94150**	**43091**	**10320**	**40739**			**156,10,40,340**	**329,97,82,900**		

The total value of the lands are ₹ 486.08 Crore

CORRIDOR – 4: HEELALIGE TO RAJANKUNTE

S. No	Additional Land Requirement				GV for vacant Land	GV for Built-up Land	Values for vacant land	Values for Built-up	Area Name	Sub Registrar office
	Total (Sqm)	Vacant Land(Sq m)	Road (Sqm)	Built up (Sqm)						
1	6393	6393	0	0	9000	15500	57537000	0	Muddenahalli/Honnenahalli	Yelahanka SRO
2	8314	8314	0	0	17100	20000	142169400	0	Harohalli, YNK	Yelahanka SRO
3	6925	6232	693		12000	26400	74784000	0	Kenchenahalli, YNK	Yelahanka SRO
3A	6013	1500	4513	0	54000	33700	81000000	0	Yashoda Nagar,YNK	Yelahanka SRO
4	4404	0	4404	0	14300	12800	0	0	Kamakshamma Layout, YNK	Yelahanka SRO
5	9787	8817	970	0	35000	30100	308595000	0	Nehru Nagar, Jakkur	Byataranyapura SRO

S. No	Additional Land Requirement				GV for vacant Land	GV for Built-up Land	Values for vacant land	Values for Built-up	Area Name	Sub Registrar office
	Total (Sqm)	Vacant Land(Sq m)	Road (Sqm)	Built up (Sqm)						
6	4448	898	3550	0	29600	40600	26580800	0	Sampigehalli, Venkateshpura	Banaswadi SRO
7	9978	9048	930	0	16000	40600	144768000	0	R K Hegde Nagara,	Banaswadi SRO
8	9554	5554	200	3800	32560	37620	180838240	142956000	Vaddarapalya	Banaswadi SRO
9	362	0	0	362	32560	37620	0	13618440	Vaddarapalya	Banaswadi SRO
10	2086	0	0	2086	22000	35620	0	74303320	Horamavu	Banaswadi SRO
11	601	601	0	0	22000	35620	13222000	0	Horamavu	Banaswadi SRO
12	1486	586	0	900	36800	35600	21564800	32040000	B. Channasandra, Kasturi Nagara	Banaswadi SRO
13	7407	6307	1100	0	36800	35600	232097600	0	B. Channasandra, Kasturi Nagara	Banaswadi SRO
14	8700	3000	850	4850	56900	37400	170700000	181390000	Udaya Nagara	Mahadevapura SRO
15	3790	2440		1350	56900	37400	138836000	50490000	Udaya Nagara/Kagadasa pura	Mahadevapura SRO
16	4788	2938	0	1850	42700	52300	125452600	96755000	Doddanekundi	Mahadevapura SRO
17	24114	3600	1700	18814	31500	35600	113400000	669778400	Marathahalli	Varthur SRO
18	3686	3686	0	0	35600	39100	131221600	0	Panathur	Varthur SRO
19	4247	3797		450	26100	33200	99101700	14940000	Bhoganahalli	Varthur SRO
20	14900	8400	0	6500	7100	25000	59640000	162500000	Carmelaram	Varthur SRO
21	9037	8037		1000	8300	25000	66707100	25000000	Chikkanahalli	Sarjapura SRO
22	670	670	0	0	7200	23400	4824000	0	Avalahalli	Sarjapura SRO

S. No	Additional Land Requirement				GV for vacant Land	GV for Built-up Land	Values for vacant land	Values for Built-up	Area Name	Sub Registrar office
	Total (Sqm)	Vacant Land(Sq m)	Road (Sqm)	Built up (Sqm)						
23	3369	3369	0	0	7200	23400	24256800	0	Avalahalli	Sarjapura SRO
24	7239	5739	0	1500	7200	19700	41320800	29550000	Huskuru	Sarjapura SRO
25	9913	8913	200	800	7200	19700	64173600	15760000	Singena Agrahara	Sarjapura SRO
26	6031	5731	300	0	7200	19700	41263200	0	Singena Agrahara	Sarjapura SRO
27	2294	2294	0	0	6000	18300	13764000	0	Heelalige	Attibele SRO
28	1929	1929	0	0	6000	18300	11574000	0	Heelalige	Attibele SRO
TOTAL	**182465**	**118793**	**19410**	**44262**			**238,93,92,240**	**150,90,81,160**		

Total Value is INR 389.85 Crore

VALUATION OF THE INDIAN RAILWAYS LAND:

A strip of land used for transportation or transmission purposes (e.g., rail, highway, power, information, liquids) or the property rights of strip of land, for which the highest and best use is to provide economic or social benefit by making it possible to connect important end points, serve intermediate points along the way qualify as a corridor land. They are usually contagious and are characterized by the passage through areas of real estate development, institutional and natural features such as water bodies, Streams/ Nallah, Forests, etc.

The value of these lands is influenced by several factors such as the size, quality, use and the activity at the ends of the corridor. In the Indian Railway owned lands, the land has been assembled historically to form corridors serving mostly as the intercity linkages while passing through densely populated areas within the city. The lands are also characterized by linear stretches, with little depth and serve as backyard to the existing developments. The access to the lands itself is restricted by its use as rail corridor. The connecting roads to these lands from the surroundings are very sparse.

The land use for these stretches is given by the zoning regulations as “transportation and communication” and the uses are limited by these zoning clauses. The lands are also impacted by the environmental factors as Noise, Dust, and Visual etc.

As the utilization of the current corridor right of way does not constitute an assembly of a substitute corridor (forming a new one). The corresponding cost of proposed assembly as a substitute cannot be a benchmark to determine the value. Though theoretically, the cost of creating an ideal new corridor is the upper limit of value.

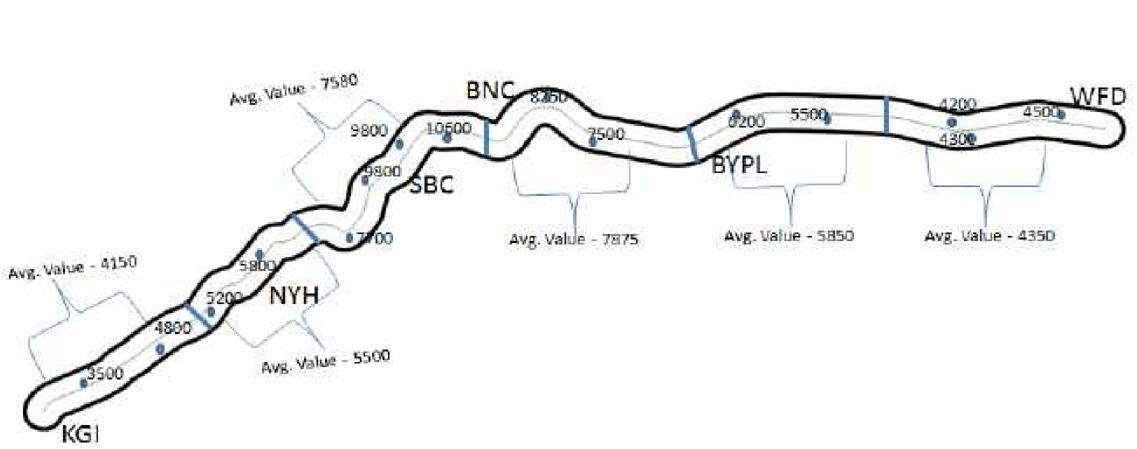
As the market is very limited, there is only one potential user, determining the value is further constrained. The lower limit of the value is often the value for alternative non corridor use. Such an alternative non corridor use is not available due to the earlier discussed aspects. Further in this case, the land is not being transacted in open market as it is lease basis.

Though the common acceptable method is the ATF (Across the Fence) valuation, there are other methods such as the

- Replacement cost approach
- Liquidation value (LV)
- Going concern value.

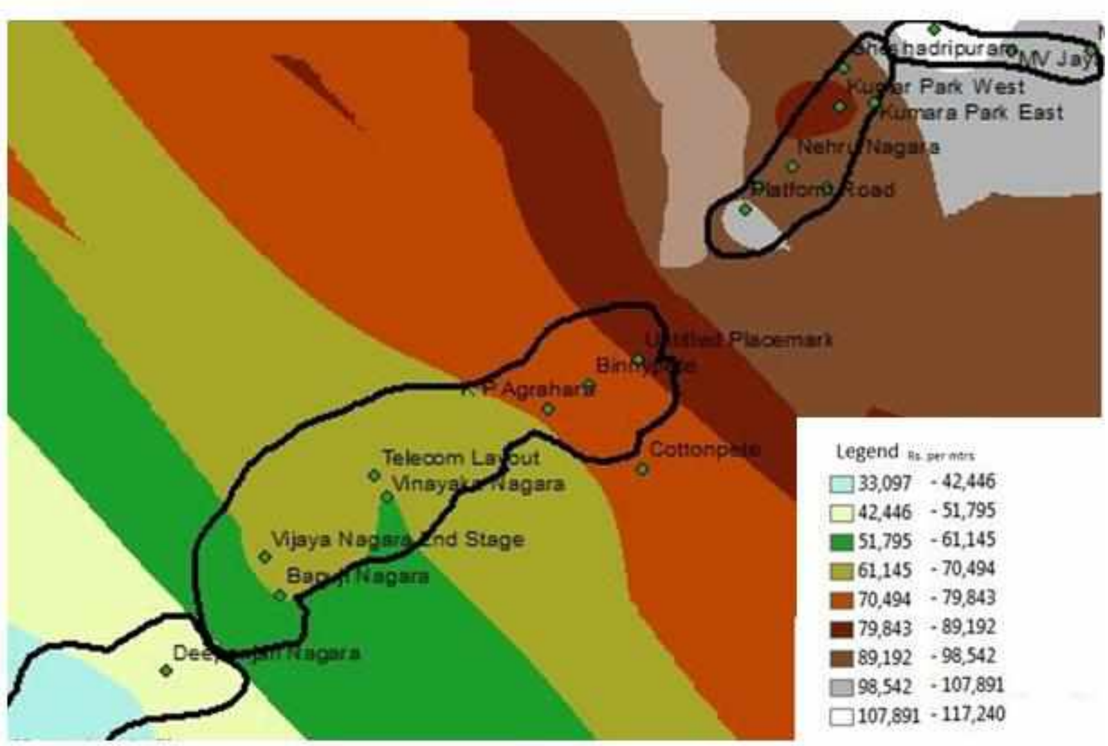
The ATF presumes the corridor is worth at least as much as the lands through which it passes. This ATF method is widely recognized as it mirrors the market for the highest and best use of the site i.e. continued corridor operation that the rail related activity will be carried upon and the land will be provided on lease basis.

CORRIDOR VALUES – ILLUSTRATION



The linear corridor is delineated into stretches coming under the similar value zone given by the Sub Registrar office. Two or more values in the segment and its buffer of 250 m which forms the adjacency to the corridor is taken for the land value determination. The values are then averaged. The area of the railway land dedicated to the sub urban network is then multiplied with the average value of the Land.

ILLUSTRATION –HEAT MAP OF THE LAND VALUES ALONG THE CORRIDOR.



The total land area along the segmented stretches is multiplied with the average land value adjacent to the segment for deriving value of the stretch of land. The Total value of the Land is about INR 4924.85 Crores.

DESCRIPTION- CORRIDOR	AREA IN ACRES	VALUE (INR) IN CRORES
C1	115.59	1648.13
C2	53.60	817.86
C3	42.12	1272.0
C4	115.50	1186.86
Total	**326.81**	**4924.85**

INDIAN RAILWAY LAND LEASE VALUE:

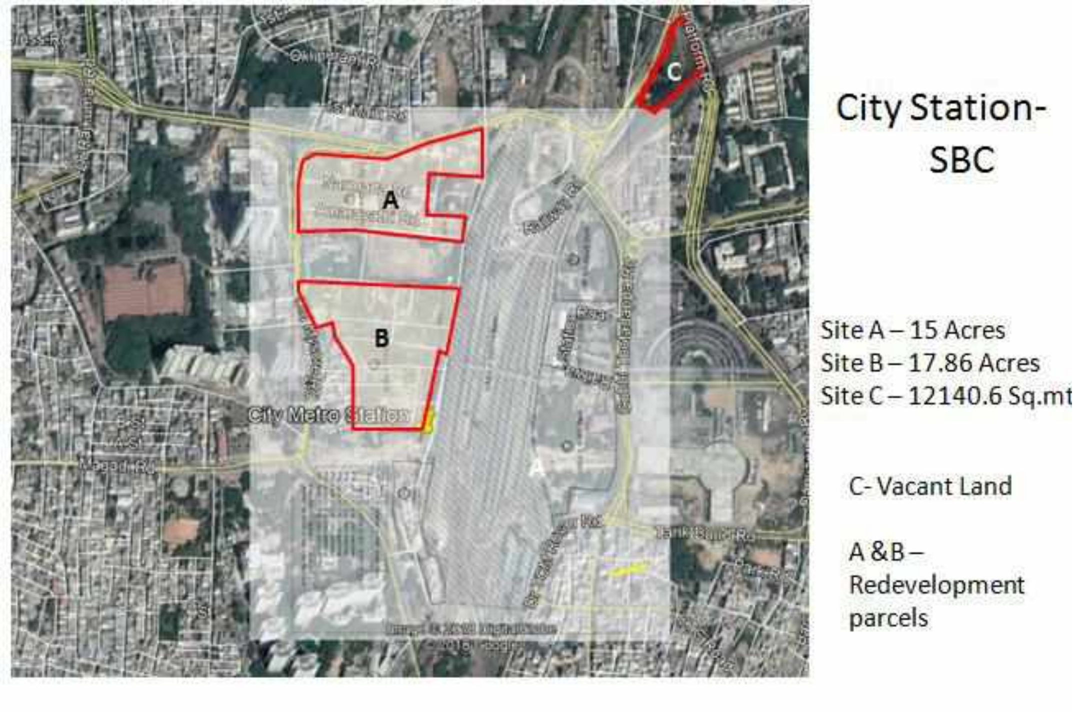
Indian Railways is following land lease model for 35 year period. As per the extent of Railway Board guidelines, in case of lease, the land value at 99 % of the value of the land is to be considered in addition to ₹ 1000/- per acre per annum. Thus, the total lease value of Railway land for 35 years lease period works out to be INR 4875.64 Crores i.e. (4924.85x0.99 + 35 x 1000x326.81).

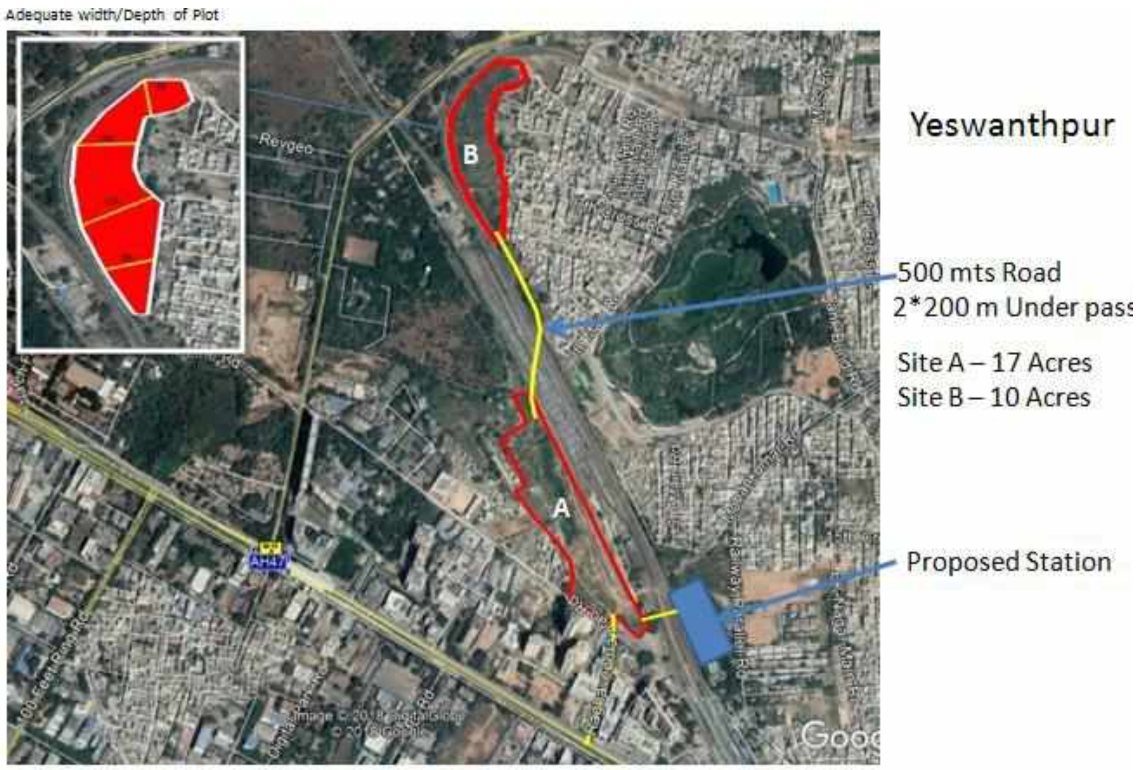
RAILWAY LAND WITHIN THE SUBURBAN RAIL NETWORK: VALUATION

CORRIDORS		AREA IN SQM	AVG VALUE PER SQ.MTR (INR)	AMOUNT (INR)	99% OF AVERAGE VALUE	EQ. AREA IN ACRES	ANNUAL LEASE RENTAL @ ₹ 1000 PER ACRE
CORRIDOR - 1	SBC-YPR-LOGH-YNK-DHL	467925	35222	16481254350	16316441807	115.59	115594.1
CORRIDOR - 2	BAW-YPR-LOGH-BYPL (T)	216986	37692	8178636312	8096849949	53.60	53603.26
CORRIDOR - 3	KGI-SBC-BNC (WFD)	170471	74617	12720034607	12592834261	42.11	42112.4
CORRIDOR - 4	HLE-BENNIGANAHALLI-CSDR-YNK-RNN	467564	25384	11868644576	11749958130	115.50	115504.9
TOTAL		**1322946**		**49248569845**	**48756084147**	**326.8147**	**326814.7**

The Railway land value is estimated at INR 4924.85 Crore.

ANNEXURE - LAND PARCELS FOR PROPERTY DEVELOPMENT
(ALL SKETCHES ARE NOT TO SCALE AND ORIENTED TO NORTH)





Cantonment

Site A – 49836 sq.mts
Site B – 11622 Sq.mts

Existing office

Channasandra -CSDR

Site A – 14950 Sq.mtr
Site B – 47808 Sq.mtr
Site C – 27577 Sq.mts

Site – A and Site B are selected vacant parcels

Parcel C – for construction purposes due to small depth of site

Baiyapanahalli - BYPL

Site A – 26591 Sq.mtr
Site B – 14709 Sq.mtr
Site C – 3739 Sq.mts
Site D – 10273 Sq.mts

Chikkabanawara - BAW

Site A – 4574 Sq.mtr
Site B – 3765 Sq.mtr

Site – B – vacant land parcel

Site A – for integrated develpment

Devanahalli

Site A – 30644 Sq.mtr
Site B – 22132 Sq.mtr

Site –A is vacant land parcel

Site –B is for Integrated Station development

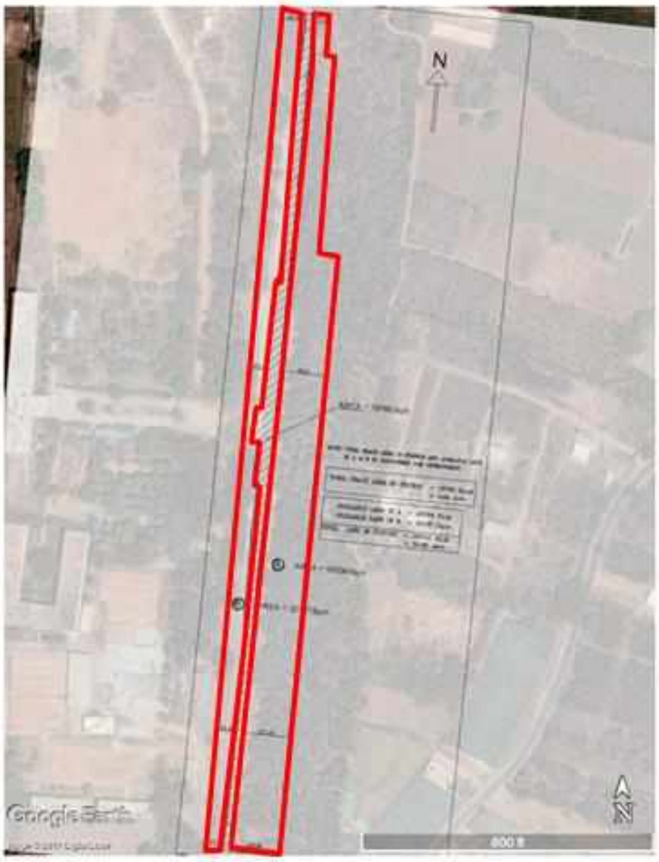
STATION LAND FOR INTEGRATED DEVELOPMENT:

The following parcels can be developed in integrated manner along with the station.

BANASWADI

Site A – 40084 Sq.mtr
Site B – 5617 Sq.mtr
Site C – 3739 Sq.mts
Site D – 8591 Sq.mts

Part of Site A is chosen for Integrated development



HEELALIGE - HLE

Site A – 68594 Sq.mtr
Site B – 32147 Sq.mtr

HEBBAL

Site A – 19204 Sq.mtr

Whitefield - WFD

Site A – 43317 Sq.mtr

12. CONCLUSIONS AND RECOMMENDATIONS

12.1 CONCLUSIONS

- Population of Study Area is expected to increase from 120 Lakh in the year 2018 to 215 Lakh by the year 2041. The work force participation rate in the Study Area varies between 43% and 44%. Total employment in Study Area is expected to increase from 51.6 Lakh in 2018 to 94.4 Lakh in 2041. The student enrolment rate in the Study Area is 22%. Total student enrolment in Study Area is expected to increase from 26.6 Lakh in 2018 to 48.4 Lakh in 2041. The substantial increase in area of office / commercial / industrial and other activities is expected in Bangalore City and adjoining BIAAPA area. This will mean a large increase in employment in Study area, which will attract significantly high traffic. Therefore, adequate, good quality and citywide mass public transport system needs to be provided to meet this expected demand.
- A four stage transport demand model has been developed for the study area. The land use parameters and complete transport network has been used as input to the model.
- Total Daily Ridership on the study corridors for the years 2025, 2031 and 2041 is expected to be 9.84 Lakh passenger trips, 13.41 Lakh passenger trips and 17.60 lakh passenger trips respectively.
- There are serious space constraints within Railway ROW for laying additional tracks with a number of private buildings at edge of the railway boundary on Kengeri-KSR Bengaluru City, also between KSR Bengaluru City and Bengaluru Cantonment stations. At some of the places temples are constructed either in Railway Boundary or just adjacent to railway boundaries on Kengeri-KSR Bengaluru City, Hebbal - Banaswadi and KSR Bengaluru City - Yeshwantpura sections.
- The proposed alignment and station details of the four corridors are as follows:

A. CORRIDOR – 1 (KSR Bengaluru City – Devanahalli via Yelahanka)

Total Length is 41.4 Km out of which elevated with two track on one side is 18.98 Km, at-grade two tracks on one side – 22.42 Km. Total stations are fifteen (15) out of which seven (07) Stations are at-grade and eight (08) stations are elevated including one Future elevated station at Srirampura and KSR Bengaluru City station which is repeated in Corridor 3.

B. CORRIDOR – 2 (Baiyyappanahalli - Chikkabanavara via Hebbal)

Total length is 25.01 Km out of which elevated with two track on one side is 12.92 Km and at-grade two tracks on one side – 12.09 Km. Total stations are fourteen four (14) out of which six (6) stations are elevated including YPR and LOGH stations which are repeated in Corridor 1 and eight (8) stations are at-grade including one future station at Jalahalli.

C. CORRIDOR – 3 (Kengeri – Whitefield via Bengaluru Cantonment & K R Puram)

Total Length is 35.52 Km out of which elevated section is 10.40 Km., At Grade is 8.07 km and quadrupling by SWR "At grade" is 17.05km. There are 9 stations from Kengeri to Bengaluru Cantt, out of which five (5) stations are at-grade including one future station at R.V. college and four (04) stations are elevated. There are five (5) stations between Bengaluru Cantt and White Field stations where quadrupling is being done by SWR.

D. CORRIDOR – 4 (Heelalige – Rajankunte via Channasandra & Yelahanka)

Total length is 46.24 Km out of which elevated with two track on one side is 15.23 Km and at-grade two tracks on one side – 31.01 Km. Total stations are twenty nine (19) out of which four (04) stations are elevated including one repeated station of YNK in Corridor 1 and fifteen five (15) stations are at-grade including one future station Bommasandra.

- A total of 62 stations are proposed including 5 repeated stations which are common in different corridors.

TABLE 12.1: CORRIDORS SUMMARY

S. No.	CORRIDORS	ELEVATED (2 TRACK ON ONE SIDE)	AT-GRADE (2 TRACKS ON ONE SIDE)	TOTAL LENGTH (IN KM)
1.	**C1**: KSR Bengaluru City – Devanahalli via Yelahanka	18.98	22.42	**41.40**
2.	**C2** : Baiyyappanahalli – Chikkabanavara via Banaswadi – Hebbal	12.905	12.105	**25.01**
3.	**C3** : Kengeri – Whitefield via Bengaluru Cantonment & K R Puram	10.4	8.07	**18.47***
4.	**C4** : Heelalige - Rajanakunte via Channasandra & Yelahanka	13.29	32.95	**46.24**
	TOTAL	**55.575**	**75.545**	**131.120**

Note:

** About 17.05 Km of quadrupling IR Line between Bengaluru Cantonment - Whitefield is not included in the total of Corridor 3.*

This corridor between Bengaluru Cantonment and Whitefield stations will become part of suburban network once suburban network becomes operational.

- The proposed elevated Corridor will be at a height of about 15m from existing rail level to bottom of viaduct due to the existence of a large number of FOBs and ROBs.
- The Private land of about 101.687 acres will have to be acquired for implementation of the project. The total Railway land required is about 326.9 acres.

- Broad gauge air-conditioned coaches of 3660 mm width have been recommended with 25KV AC, 50 HZ single phase traction system.
- CBCTC signaling system has been proposed to meet the high frequency operation requirement of horizon years as per the estimated traffic demand.
- The initial operations will be with 6 car rake with a headway varying from 12 minutes to 20 minutes.
- The services will run from 5 am to mid-night at a design speed of 90 km/h with a station dwell time of 30 seconds.
- Maintenance and stabling facilities are proposed at Devanahalli on Corridor-1 and near Jnanabharathi on Corridor-3.
- The total capital cost of the project including GST and Private Land cost is estimated at **₹. 14,615.26** Crore at June, 2019 price level.
- The O&M cost for the first year of operation is estimated at ₹. 1,124.00 Crore.
- The economic Internal Rate of Returns (EIRR) is estimated at 19.01%.
- The financial Internal Rate of Returns (FIRR)under different scenarios is estimated as below:

S.No	Scenario	FIRR (considering revenues from Railway land)	FIRR (w/o considering revenues from Railway land)
1.	Fare box & Advt. revenue	8.84%	8.84%
2.	Fare box	9.29%	9.29%
3.	Fare box, Advt. revenue and VCF revenue (without Sale of Rights) ("**Base Case**")	10.74%	9.64%
4.	Fare box, Advt. revenue and VCF revenue (with Sale of Rights)	13.22%	11.97%

12.2 RECOMMENDATIONS

- The project has good EIRR & FIRR and may be considered for implementation in order to take care of City's long term traffic needs.
- The corridors under the present assignment may be extended beyond their proposed terminal station to nearest important town in order to cater some additional catchment.

- The direct connectivity to Kempegowda International Airport through suburban rail system is also recommended, as it will serve central and northern parts of Bengaluru.

- Additional sources of revenue including commercial development needs to be explored to support the project.

- SWR may consider appointing financial, legal and institutional consultants to take up the project implementation forward.

- The implementation of Corridors may be taken up in phases and the priority of corridors is given below:
  1) KSR Bengaluru City to Devanahalli
  2) Baiyyappanahalli to Chikkabanavara
  3) Heelalige to Rajankunte
  4) Kengeri to Whitefield

- The study is restricted only within the Bengaluru Urban limits. However, based on the patronage and the ridership along the corridors, the corridors may be extended in future to the nearest towns as listed below:

  i. Corridor – 1 (KSR Bengaluru City – Devanahalli) – may be extended up to Chikkaballapura on Northern side of the city.

  ii. Corridor – 2 (Baiyyappanahalli – Chikkabanavara) – may be extended up to Tumakuru on North – Western side.

  iii. Corridor – 3 (Kengeri – Whitefield) – may be extended up to Ramanagara on South Western side and up to Mallur/Bangarpet on North Eastern side.

  iv. Corridor – 4 (Heelalige – Rajankunte) – may be extended up to Doddaballapura/ Gauribidanur on Northern side and up to Hosur on Heelalige side

- Items like Automatic Fare Collection (AFC) gates, Lifts, Escalators and Platform Screen Doors (PSD) can be taken under PPP model.

- During construction, SPV may explore the procurement of Rolling stock requirement under PPP model.