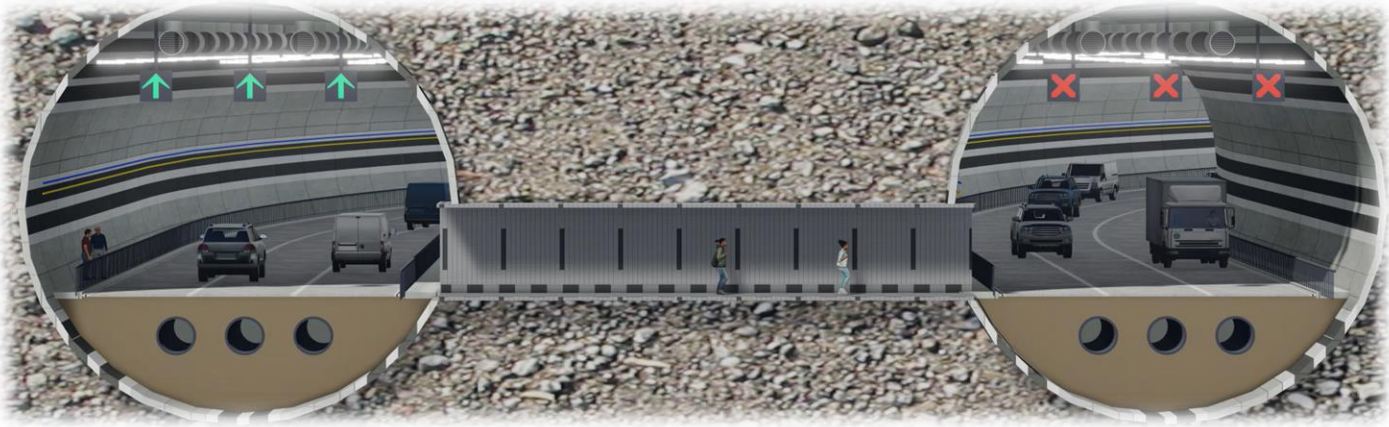
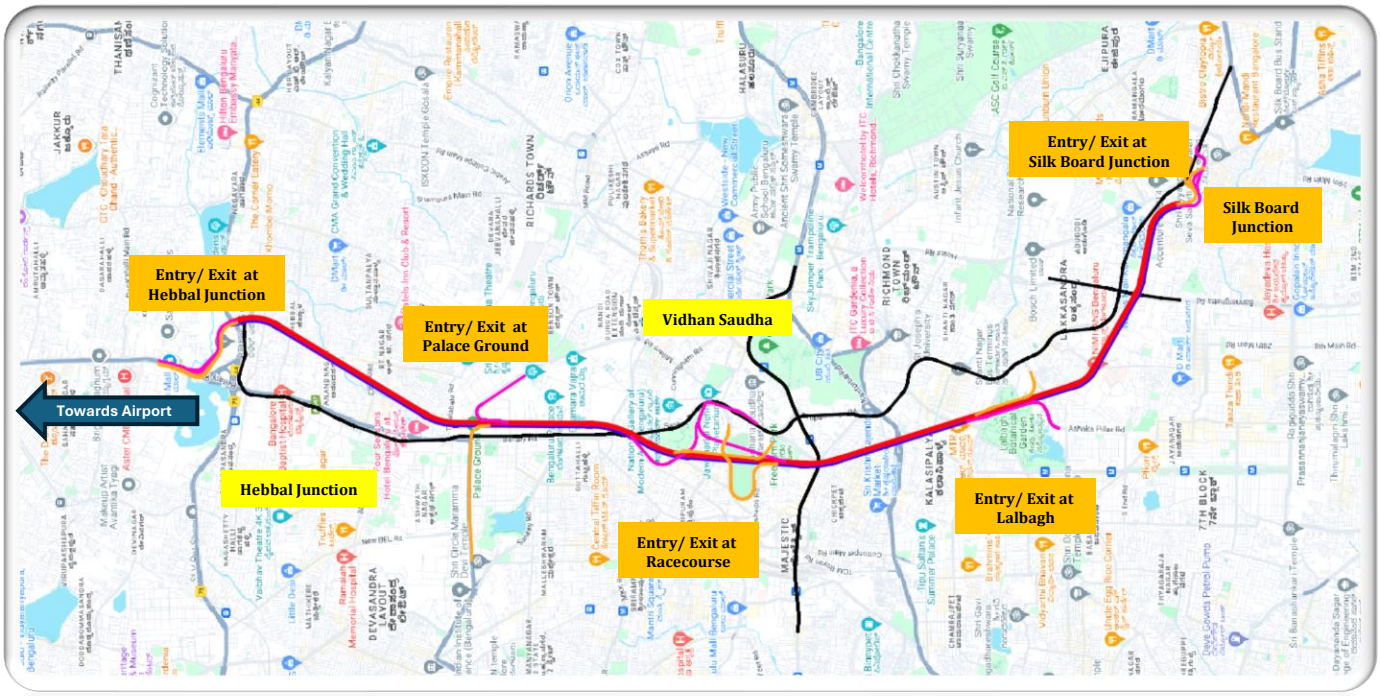
GOVERNMENT OF KARNATAKA



CONSULTANCY SERVICES FOR PREPARATION OF DPR FOR THE WORK OF CONSTRUCTION OF UNDERGROUND VEHICULAR TUNNEL FROM HEBBAL ESTEEM MALL JUNCTION TO SILK BOARD KSRP JUNCTION



DRAFT DETAILED PROJECT REPORT

VOLUME - I - MAIN REPORT WITH ANNEXURE

September 2024

Rodic
ENGINEERING. PASSION

RODIC CONSULTANTS PVT. LTD

BRUHAT BENGALURU MAHANAGARA PALIKE

DOCUMENT SUMMARY SHEET

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Date	24th September 2024	
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Project	**Consultancy services for preparation of DPR for the work of Construction of underground Vehicular Tunnel from Hebbal Esteem mall junction to Silk Board KSRP junction.**	
Report	***Main Report with Annexure***	

Name and Designation				
Owner	**Rodic Consultants Pvt. Ltd.**			
Prepared By	***Name & Designation***	***Remarks***	***Name & Designation***	***Remarks***
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Reviewed By	Mr. Adarsh Kumar Tiwari Project Co-Ordinator	Ok	Mr. Jagdish Sharma Asst. Vice President	Ok
Approved By	Dr H R Yadav Executive Director	Ok		

Revision Summary

Sl. No	Date	Modifications	Version	Remarks

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CHAPTER 1: EXECUTIVE SUMMARY

1.1 General

Bruhat Bengaluru Mahanagara Palike (BBMP) intends to Construct an Underground Vehicular Tunnel for the North – South Corridor starting from Hebbal Esteem Mall junction to Silk Board KSRP Junction.

In pursuance of the above, Rodic Consultants Pvt Ltd., New Delhi have been appointed as consultants to carry out Consultancy Services for Preparation of DPR for the work of Construction of Underground Vehicular Tunnel from Hebbal Esteem Mall junction to Silk Board KSRP junction.

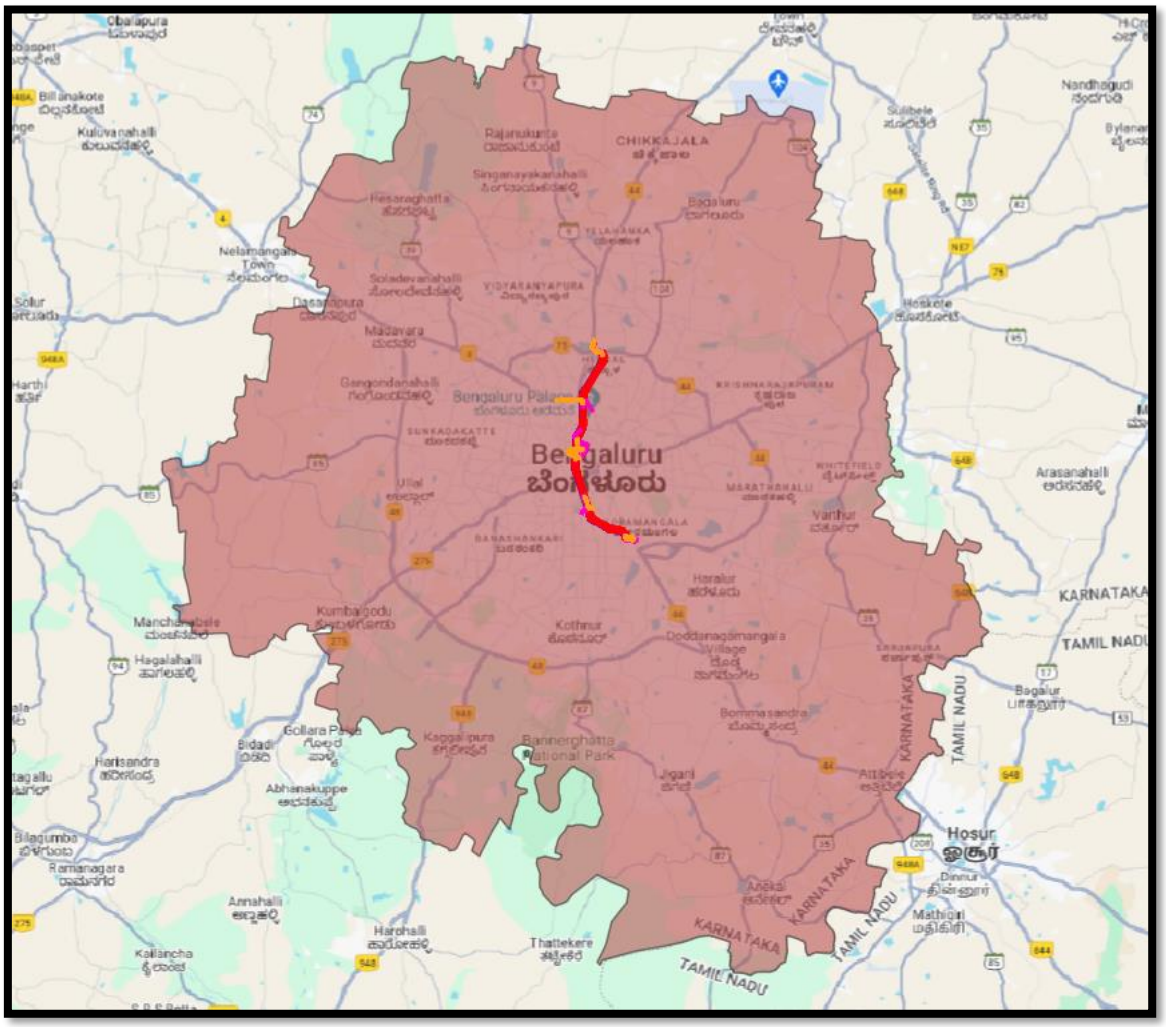


Figure 1: Project Location in Bangaluru Administrative Boundary

1.2 Project Background

Bengaluru is the fifth largest city in India with an estimated population of over 115 Lakhs (2011). The city limit, which was around 425 Sq Km in 2007 has increased to over 800 Sq Km in a span of years. Bengaluru's population has grown dramatically, and the city now ranks among the top metropolitan areas in the country, both in terms of population and in terms of economic activity. Bengaluru has undergone rapid urbanization and has transformed into one of the fastest growing economic centers of the world which has attracted millions of job-seeking individuals from different part of countries and world.

However, the city road networks have not seen major improvements either in terms of enhancement of existing roadway capacity or creation of new road networks to reduce traffic congestion. The present-day vehicle population in the city is around 85 Lakh with an average increase in number of vehicles at the rate

of 10% per annum.

Increasing traffic volume and its associated adverse impacts on traffic congestion and noise pollution is a key problem in Bengaluru. And without the intervention of planned construction to decongest the traffic hot spots along with promotion of use of metros, public transport the situation is likely to deteriorate further. Reference from CMP 2020 (by BMRCL and DULT) has been taken to integrate our traffic studies and simulations for forecasting the future demand model. Due to the poor level of services (mostly section in LOS F) of the present route of North – South corridor, the passenger travelling from North to South part & vice versa for work trip & travel trip faces huge congestion during travel. This leads to an increase in VOC (vehicle operation cost) & VOT (Value of time cost) accumulating higher economical loss.

For decongestion of the Bengaluru city, BBMP has assigned the work of "Consultancy services for preparation of Comprehensive Bengaluru city road infrastructure plan to decongest traffic and to prepare comprehensive traffic management plan for proposal of vehicular tunnel / Grade separator /Road widening in selected corridors in the State of Karnataka" to *M/S Altinok Consulting Engineering Inc. In Jv With M/S Lion Engineering Consultants Pvt. Limited*. The feasibility study has identified North South corridor as the high traffic density corridor of the Bangaluru city. The decongestion of North-South corridor has been suggested in the feasibility study by providing underground tunnel from Hebbal to Silk Board. The major problem statement identified in feasibility studies are as under:

- In peak hour and even most of the day the traffic runs at average speed of 15-20 Kmph
- The Level of Service is between LOS-E and LOS-F i.e., 15 to 20 Kmph resulting in huge loss of fuel
- The city roads have exhausted their lane capacity and there is no land available to widen the roads due to heavy built-up areas and higher price of land.

One of the corridors that has been taken up for this assignment is North South Corridor which we have studied. The road sections connecting the electronic city (Southern part) to Hebbal Junction (Northern Part) is **Hebbal Flyover- Mekri circle-Chalyuka circle-Lalbagh Botanical Garden-Silk Board Jn.** The corridor width varies from 4 lane to Six lane. From Hebbal Junction the Airport is connected through NH-4. The North South Corridor is a very important connection and due to traffic congestion, it chokes during peak hour resulting loss of travel time and increase in Vehicle operation cost.

1.3 Need of Tunnel

Bengaluru's population has grown dramatically in the last decade, and the city now ranks among the top metropolitan areas in the country, both in terms of population and in terms of economic activity. The city has undergone a rapid transformation into one of the most storied economic centers of the world and attracted millions of job-seeking migrants. Increasing traffic volumes and its associated adverse impacts on congestion and air quality is a key problem in Bengaluru and elsewhere in India and this situation is likely to deteriorate further. The proposed North-South corridor is planned to reduce the congestion levels on roads and reduce the travel time of people

The present North South corridor connects the north & south part of Bengaluru and feeds the traffic for work trips, airport trip, tourism trip etc. Most of the residents of the North and eastern part of the city are travelling through this corridor for work purposes to white field & electronic city area. The high traffic during peak hours congests the major junction point and the corridor on the preset route. The existing route traversing from Hebbal- Mekri Circle to Golf Course to Chalukya Circle to Lalbagh to Silk board junction. From that point the traffic divided towards Whitefield & electronic city. Due to longer trip length, people use private mode of communication for travelling to the offices and others outdoor activities. During the peak the average speed on the north south corridor is just 10 to 15 km/h. Apart from above the K R Circle, Mother dairy circle also used to be congested during the peak hours. The present Level of service, speed

and traffic density is as under-

Level of Service	Speed
The Present LOS is F	**Present travel speed is 15 Kmph.**

The city is growing at a fast pace and the per capita income is very good due to which people prefer private cars over public transport.

The present section from Hebbal to Golf Course, Golf Course to Chalukya Junction, Chalukya to Lal Bagh and Lal Bagh to Silk Board Junction is the main section running through the central part of Bengaluru city. The section traverses through most of the Government Offices, Official Residences of Members of Assembly, Vidhan Soudha and other prominent administrative blocks along with densely packed residential areas. The traffic from airport to Main city and through traffic also contributes to the of congestion of the North South Corridor.

The current road network capacity is already saturated. The capacity of the current road network needs to be increased to cater for the present and future traffic demand.

1.4 Project Benefits

The main objective of the project is to provide safe and efficient service levels to growing traffic movements and better connectivity between Silk board junction and Esteem mall junction. All road users will be benefited from the proposed improvement on account of comfort, safety and reduced vehicle operating costs. Community will accrue the benefit from proposed development project by way of improvement in the physical infrastructure; social infrastructure; development of economy; reduced pollution, vehicle maintenance, fuel saving; employment potential and other tangible benefits.

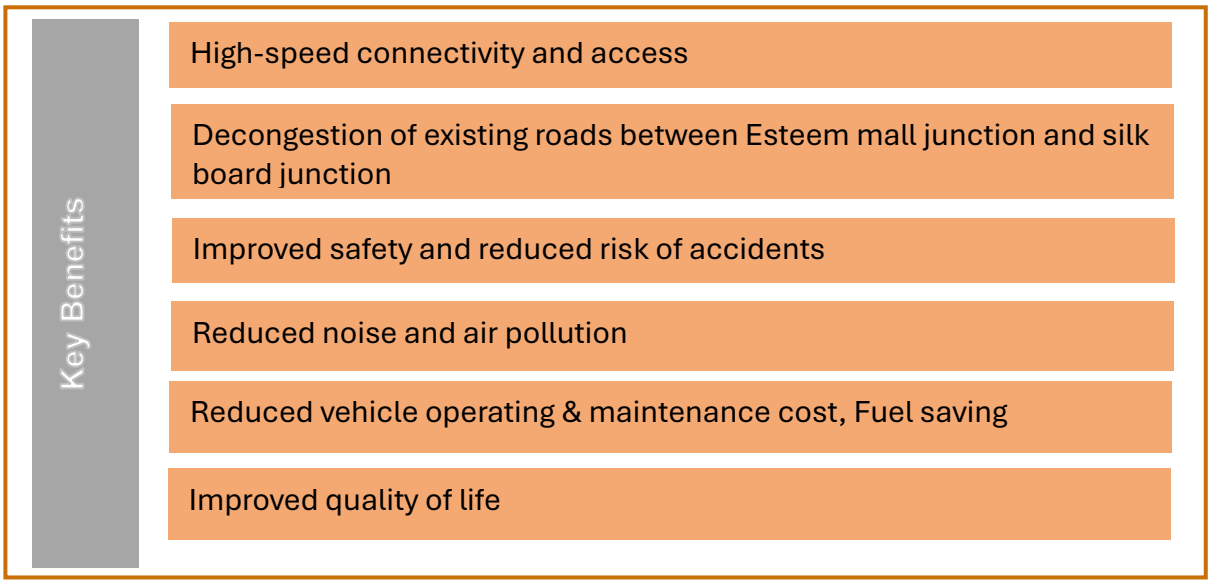


Figure 2: Project Key Benefit

1.5 Social And Economic Profile

1.5.1 Bengaluru Urban District

Bengaluru, officially known as Bengaluru, is the Capital of the Indian State of Karnataka. It has a population of over ten million, making it a megacity and the Third populous City and 5th most populous urban

agglomeration in India.

The Deputy Commissioner, being the head of the District Administration, is officer vested with powers under the Central and State Laws. The D.C. office comes in direct contact with the people and people's representatives at various levels. The office of the Deputy Commissioner apart from having many original works enumerated under different Acts and Rules has got the supervisory and coordinating roles at the district level. Apart from regulatory functions, the Deputy Commissioner guides and coordinates the developmental activities of the district.

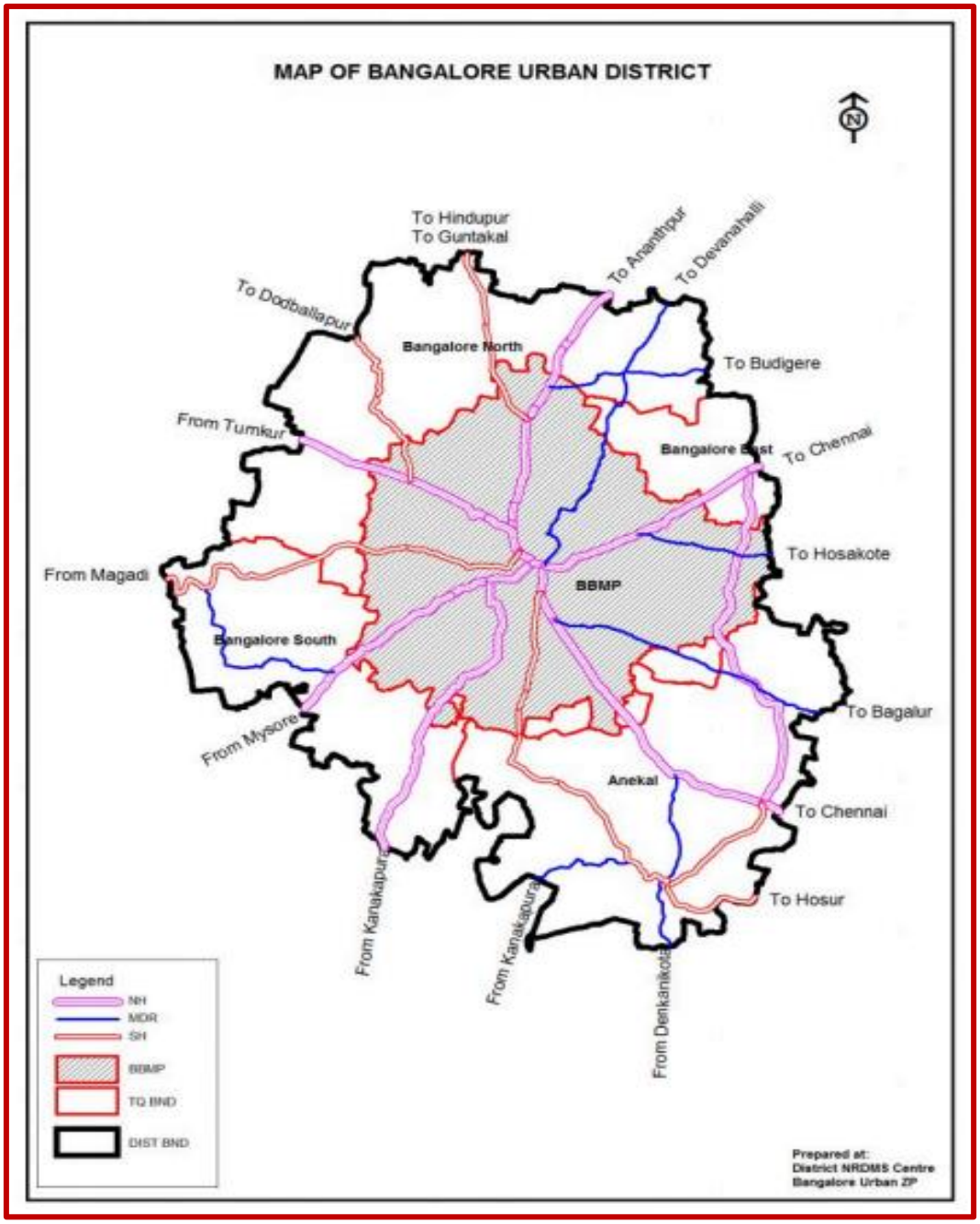


Figure 3: Bengaluru Districts Map

1.5.2 Geography

Bengaluru lies in the southeast of the South Indian state of Karnataka. It is in the heart of the Mysore Plateau (a region of the larger Precambrian Deccan Plateau) at an average elevation of 920 m (3,020 ft). It is positioned at 12.97°N 77.56°E and covers an area of 1741 km2 (673 mi2). Most of the city of Bengaluru

lies in the Bengaluru Urban district of Karnataka and the surrounding rural areas are a part of the Bengaluru Rural district. The region comprising the Bengaluru Urban and Rural districts is known as the Bengaluru (region). The Government of Karnataka has carved out the new district of Ramanagara from the old Bengaluru Rural district.

Bengaluru has a handful of freshwater lakes and water tanks, some of which are Madivala tank, Hebbal Lake, Ulsoor Lake and Sankey Tank. Groundwater occurs in silty to sandy layers of the alluvial sediments. The Peninsular Gneissic Complex (PGC) is the most dominant rock unit in the area and includes granites, gneisses and migmatites, while the soils of Bengaluru consist of red laterite and red, fine loamy to clayey soils.

1.5.3 Topography

Bengaluru has two unique Topography terrains—North Bengaluru taluk and the South Bengaluru taluk. The North Bengaluru taluk is a relatively higher-level plateau and lies between an average of 839 to 962 meters above sea level. The middle of the taluk has a prominent ridge running NNE-SSW. The highest point in the city, Doddabettahalli, (962m) is on this ridge. There are gentle slopes and valleys on either side of this ridge. The low-lying area is marked by a series of water tanks varying in size from a small pond to those of considerable extent, but all shallow.

1.5.4 Climate

Due to its elevation, Bengaluru enjoys a pleasant and equable climate throughout the year with occasional extreme weather events like heatwaves, coldwaves, floods and droughts. The highest temperature ever recorded in Bengaluru is 41.8°c in April 30, 2024 in Kengeri at Bengaluru. Winter temperatures rarely drop below 13 °C (52 °F) and summer temperatures seldom exceed 37 °C (97 °F).

The hottest summer day on average has a maximum temperature of about 37°c, and the coldest winter day has a temperature of about 13°c. Occasionally, heat waves can cause temperatures of up to 38-40°c. Occasional coldwaves will be leading to the temperatures as low as below 9-10°c. Bengaluru receives about 970 mm of rain annually, with the wettest months being August, September and October. The heaviest rainfall recorded in a 24-hour period was 18 cm recorded on 1988.

Most of the rainfall occurs during late afternoon, evening or night and rain before noon is infrequent. November 2015 (290.4 mm) was recorded as one of the wettest months in Bengaluru with heavy rains causing flooding in some areas.

1.5.5 Seismicity

Because it lies in the seismically stable region, Zone III (encompassing parts of Karnataka, Maharashtra, Kerala, Tamil Nadu and Andhra Pradesh), Bengaluru has been untouched by major seismic events. Only mild tremors have been recorded in the city. The largest earthquake that has ever hit the city was of magnitude 6.4 in April 1843.

1.5.6 Land use

According to data contained in the Bengaluru Mahanagara Palike Master Plan, 40.4% of the land in the city is used for residential purposes. Transport uses 24.3% of the land, while land used for industrial, and commercial purposes comprise 6.9% and 2.7% respectively. As the city of Bengaluru expands, the BMP expects the percentage of land used for industrial purposes to decrease, while it expects the percentages of land used for residential, commercial and public and semi-public purposes to increase.

1.5.7 Demographic Profile of the District

According to the 2011 census Bengaluru Urban district has a population of 9,621,551, roughly equal to the nation of Belarus. This gives it a ranking of third in India (out of a total of 640). The district has a population

density of 4,378 inhabitants per square kilometre (11,340/sq mi). Its population growth rate over the decade 2001-2011 was 46.68%. Bengaluru has a sex ratio of 908 females for every 1000 males, and a literacy rate of 88.48%. 90.94% of the population lives in urban areas. Scheduled Castes and Scheduled Tribes make up 12.46% and 1.98% of the population respectively.

Languages of Bengaluru Urban district (2011)

- Kannada (44.47%)
- Tamil (15.99%)
- Telugu (13.99%)
- Urdu (12.11%)
- Hindi (4.55%)
- Malayalam (2.94%)
- Marathi (1.92%)
- Others (4.82%)

Table 1: Demographic profile of Bengaluru urban Districts

Category	Absolute Figures
Area	2196 Sq.kms
Population- Total	9621551
Male	5022661
Female	4518890
Rural	871607
Urban	8749944
Decadal Population Growth	47.18%
Literacy-Total	87.67%
SC Population – Total	1198385
ST Population – Total	190239
Sex Ratio (females per 1000 males)	916
Child Sex Ratio (0 to 6 years)	944
Occupational pattern of Population Total Workers	3998286

1.5.8 Economy

Bengaluru is one of the fastest-growing metropolises in India. Bengaluru contributes 38% of India's total IT exports. Its economy is primarily service oriented and industrial, dominated by information technology, telecommunication, biotechnology, and manufacturing of electronics, machinery, automobiles, food, etc. Major industrial areas around Bengaluru are Adugodi, Bidadi, Bommanahalli, Bommasandra, Domlur, Hoodi, Whitefield, Doddaballapura, Hoskote, Bashettihalli, Yelahanka, Electronic City, Peenya, Krishnarajapuram, Bellandur, Narasapura, Rajajinagar, Mahadevapura etc. It is the fifth Indian city to host maximum numbers of Fortune Companies, after Mumbai, Delhi, Kolkata and Chennai.

The growth of IT has presented the city with unique challenges. Ideological clashes sometimes occur between the city's IT moguls, who demand an improvement in the city's infrastructure, and the state government, whose electorate is primarily from rural Karnataka. The encouragement of high-tech industry in Bengaluru, for example, has not favoured local employment development, but instead increased land values and forced out small enterprises. The state has also resisted the massive investments required to reverse the rapid decline in city transport, driving new and expanding businesses elsewhere in India. Bengaluru is a hub for Indian biotechnology-related industry and in 2005 was home to around 47% of the

265 biotechnology companies in India, including Biocon, India's largest biotechnology company, giving Bengaluru the nickname of the "Biotech Capital of India". Bengaluru is also the country's fourth largest fast-moving consumer goods (FMCG) market. Forbes considers Bengaluru one of "The Next Decade's Fastest-Growing Cities". The city is the third largest hub for high-net-worth individuals. There were a large number of high-net-worth individuals with a ₹4.5 crore investment surplus in 2007. In the Ease of Living Index 2020, it was ranked the most livable Indian city with a population of over a million.

1.5.9 Transport

Air

Bengaluru is served by Kempegowda International Airport, located at Devanahalli, about 40 km (25 mi) from the city centre. Formerly Bengaluru International Airport, the airport started operations from 24 May 2008 and is privately managed by a consortium led by the GVK Group. The city was earlier served by the HAL Airport at Vimanapura, a residential locality in the eastern part of the city. The airport is the third busiest in India after Delhi and Mumbai in terms of passenger and airplane traffic. Taxis and air-conditioned Volvo buses operated by BMTC connect the airport with the city.

Railways and Metro

As of 2022, a mass rapid transit system (MRTS) called the Namma Metro is being built in stages. Initially opened with the 7 km (4.3 mi) stretch from Baiyappanahalli to MG Road in 2011, metro lines totaling 42.30 km (26.28 mi) for the north–south and east–west lines were made operational in June 2017. Phase 2 of the metro covering 72.1 km (44.8 mi) is under construction and includes two new lines along with the extension of the existing north–south and east–west lines. There are also plans to extend the north–south line to the airport, covering a distance of 29.6 km (18.4 mi).

Bengaluru is a divisional headquarters in the South Western Railway zone of the Indian Railways. There are four major railway stations in the city: Krantiveera Sangolli Rayanna Railway Station; Bengaluru Cantonment railway station; Yeshwantapur Junction, Krishnarajapuram railway station and newly inaugurated Sir M. Visvesvaraya Terminus, with railway lines towards Jolarpettai in the east; Guntakal in the north; Kadapa (only operational until Kolar) in the northeast; Tumkur in the northwest; Hassan and Mangalore in the west; Mysore in the southwest; and Salem in the south. There is also a railway line from Baiyappanahalli to Vimanapura, no longer in use. Though Bengaluru has no commuter rail, there have been demands for a suburban rail service because of the large number of employees working in the IT corridor areas of Whitefield, Outer Ring Road and Electronic City. The Rail Wheel Factory is Asia's second-largest manufacturer of wheel and axle for railways and is headquartered in Yelahanka, Bengaluru.

Bus

Buses operated by Bengaluru Metropolitan Transport Corporation (BMTC) are a staple of city public transport. While commuters can buy tickets on boarding these buses, BMTC also provides an option of a bus pass to frequent users. BMTC runs air-conditioned luxury buses on major routes and operates shuttle services from various parts of the city to Kempegowda International Airport. The Karnataka State Road Transport Corporation operates 6,918 buses on 6,352 schedules, connecting Bengaluru with other parts of Karnataka and with neighbouring states. The main bus depots that KSRTC maintains are the Kempegowda Bus Station, locally known as "Majestic bus stand", where most of the buses going out of the city ply from. Some of the KSRTC buses to Tamil Nadu, Telangana and Andhra Pradesh ply from Shantinagar Bus Station, Satellite Bus Station at Mysore Road and Baiyappanahalli satellite bus station. BMTC and KSRTC were the first operators in India to introduce Volvo city buses and intra-city coaches in India.

Taxis

Three-wheeled, yellow and black or yellow and green auto-rickshaws, referred to as autos, are popular for

transport. They are metered and can accommodate up to three passengers. Taxis are usually available via phone calls or online services; they are metered and generally more expensive than auto-rickshaws.

Road

Bengaluru is well-connected with national highways with the rest of the country. The highways are National Highway 44 (NH-44), National Highway 48 (NH-48) (also Asian Highway 47 (AH-47)), National Highway 275 (NH-275), National Highway 75 (NH-75), National Highway 648 (NH-648) and National Highway 948 (NH-948), along with state highways and the city's roads total 11,000 km (6,835 mi).

Bengaluru currently has one expressway, the Bengaluru–Mysore Expressway, operational since March 2023, which is part of NH-275. In the coming years, the city will get more expressways, resulting in enhanced connectivity and commute with the rest of the country. They are as follows:

- Bengaluru–Chennai Expressway: Under construction since August 2019, to be completed by March 2024.
- Pune–Bengaluru Expressway: Proposed, to be completed by 2028.
- Nagpur–Hyderabad–Bengaluru Expressway: Proposed, expected to be completed by before 2030.

An average of 1,750 vehicles are registered daily in Bengaluru Regional Transport Offices (RTOs). The total number of vehicles, as of 2020, are around 8,500,000 vehicles.

1.5.10 Education

Bengaluru has a literacy rate of around 88%, according to the 2011 national census. Primary, middle school and secondary education in Bengaluru is offered by various schools which are affiliated to one of the government or government recognised private boards of education, such as the Secondary School Leaving Certificate (SSLC), Central Board of Secondary Education (CBSE), Council for the Indian School Certificate Examinations (CISCE), International Baccalaureate (IB), International General Certificate of Secondary Education (IGCSE) and National Institute of Open Schooling (NIOS). Schools in Bengaluru are either government run or are private (both aided and un-aided by the government). Bengaluru has a significant number of international schools due to large number of expats and people employed in the IT sector. After completing their secondary education, students either attend a pre-university course or continue an equivalent high school course in one of three streams – arts, commerce or science – in various combinations. Alternatively, students may enroll in diploma courses. Upon completing the required coursework, students enroll in general or professional degrees in universities through lateral entry.

The Bengaluru University, established in 1886, provides affiliation to over 500 colleges, with a total student enrolment exceeding 300,000. The university has two campuses within Bengaluru – Jnanabharathi and Central College. University Visvesvaraya College of Engineering was established in the year 1917, by Bharat Ratna Sir M. Visvesvaraya, At present, the UVCE is the only engineering college under the Bengaluru University. Bengaluru also has many private Engineering Colleges affiliated to Visvesvaraya Technological University.

Indian Institute of Science, which was established in 1909 in Bengaluru, National Centre for Biological Sciences, National Institute of Mental Health and Neuro-Sciences, Jawaharlal Nehru Centre for Advanced Scientific Research and the Raman Research Institute are the premier institutes for scientific research and study in India. Nationally renowned universities and institutes such as the, National Institute of Design, National Institute of Fashion Technology, National Law School of India University, the Indian Institute of Management, International Institute of Information Technology, Christ University, Brindavan College of Engineering, RV Educational Institutions, University of Agricultural Sciences, Bengaluru, the ICAR-National Institute of Animal Nutrition and Physiology, the Indian Statistical Institute are located in Bengaluru. Bengaluru also has some of the best medical colleges in the country, like St. John's Medical

College and Bengaluru Medical College and Research Institute. The M. P. Birla Institute of Fundamental Research has a branch located in Bengaluru. Mount Carmel College, a premier institution for women's education in India is located in Bengaluru. It is affiliated to Bengaluru University, as is Acharya Bengaluru Business School, established in 2008.

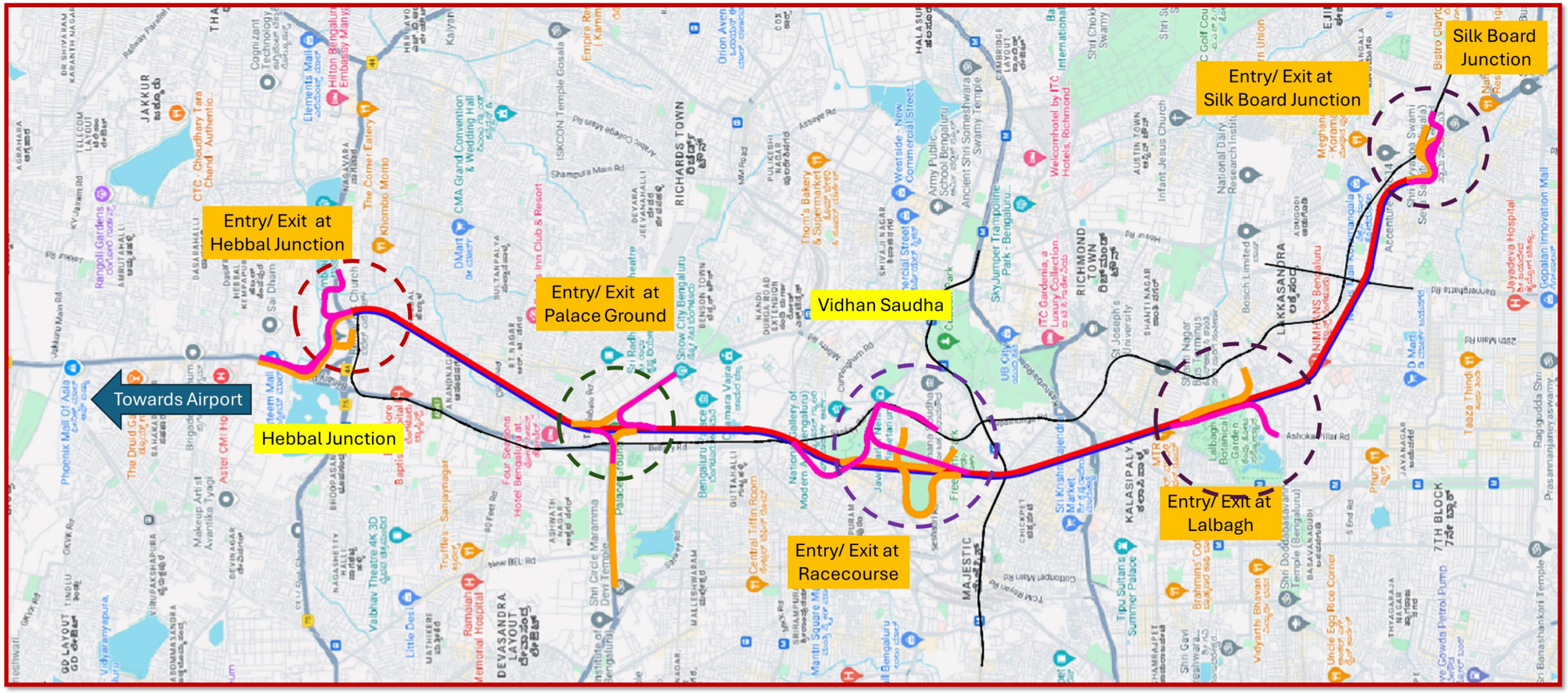


Figure 4: Project Alignment

1.6 Project Location and Alignment

The entire project is in Bengaluru city and connecting the northern part to the southern part of the city.

As per the feasibility report, the North – South Corridor starting from Hebbal Esteem Mall junction to Silk Board KSRP Junction is going to be developed as Underground Vehicular tunnel having 03 intermediate locations connected via ramps for entry & exit into the Main Tunnel. This alignment will connect the Hebbal and silk Board Junction and proposed 3 intermediate ramps at Mekri circle, Racecourse & Lalbagh directly. The travel time will be reduced from about 90 minutes to 20 minutes.

The details of alignment and its intermediate ramps have been provided in given table.

Table 2: Alignment Details of Main Tunnel

From Hebbal to Silk Board	From Silk Board to Hebbal
Length: 16.681 km	Length: 16.680 km
Lane Configuration: 3 Lane	Lane Configuration: 3 Lane
Start: Approach of Hebbal Flyover	Start: Approach of Hebbal Flyover
End: Hosur Road (Silk Board Junction)	End: Hosur Road (Silk Board Junction)

Table 3: Alignment Details of Intermediate ramps

Sr. No.	Location	Description	Length	Direction Of Traffic	Lane Configuration
Ramps at Start of Main Tunnel					
1	Hebbal Junction	Entry Ramp 1 into Main Tunnel	0.360 Kms	From Service Road Airport to Bangaluru City	2 Lane
2		Exit Ramp 08 from Main Tunnel	0.700 kms	To Service Road towards Sahakar Nagar, Yelahanka	2 Lane
3		Entry Ramp 2 into Main Tunnel	0.814 Kms	From KR Puram on Outer Ring Road	2 Lane
4		Exit Ramp 07 from Main Tunnel	0.400 Kms	Towards Yeswanthpur on Outer Ring Road	2 Lane
Intermediate Ramps					
1	Near Palace Ground/ Mekri Circle	Entry Ramp 03 into Main Tunnel	1.255 Kms	From Jayamahal Road	2 Lane
2		Exit Ramp 06 from Main Tunnel	1.910 Kms	Towards CV Raman Road	2 Lane
3		Entry Ramp 4 into Main Tunnel	1.320 Kms	Entry from CV Raman Road towards Hebbal	2 Lane
4		Exit Ramp 05 from Main Tunnel	0.963 Kms	Exit Towards Jayamahal Road	2 Lane
1	Near Racecourse / Vidhan Saudha	Entry Ramp 5 into Main Tunnel	1.387 Kms	From Palace Road Towards Hebbal	2 Lane
2		Entry Ramp 6 into Main Tunnel	1.906 Kms	From Palace Road Towards Silk Board	2 Lane

Sr. No.	Location	Description	Length	Direction Of Traffic	Lane Configuration
				Junction	
3		Exit Ramp 04 from Main Tunnel	1.376 Kms	On Seshadri Road (Towards KR Circle)	2 Lane
4		Exit Ramp 03 from Main Tunnel	1.864 Kms	On Race Couse Road (Towards Chalukya Circle	2 Lane
1	Near Lalbagh	Entry Ramp 7 into Main Tunnel	1.416 Kms	From Siddapura Road (Near Ashoka Pillar).	2 Lane
2		Exit Ramp 2 from Main Tunnel	1.073 Kms	On Siddapura Road Near Wilson Garden	2 Lane
Ramps at End of Main Tunnel					
1	Silk Board	Exit Ramp 1 from Main Tunnel	0.454 Kms	On Sarjapur Road / HSR layout (Ring Road)	2 Lane
2		Entry Ramp 8 into Main Tunnel	0.663 Kms	From Sarjapur Road / HSR layout (Ring Road)	2 Lane

1.5.1 The start Point of Project

The project Stretch Start from Hebbal near Esteem Mall and end near silk board junction, where existing road is a 6-lane divided carriageway road.

The starting point has two entry ramps into the tunnel and two exits. Each entry and exit have 2 lane configurations.

The Entry at the start location has been planned near esteem mall for connecting traffic from Airport flyover and another entry has been provided from service road for the traffic coming from Sahakarnagar & Yelahanka to the main tunnel for conflict free movement at junction another entry ramps have been proposed at the Ring Road. Similarly, two exits have been proposed, one towards the Ring road and another on service road.

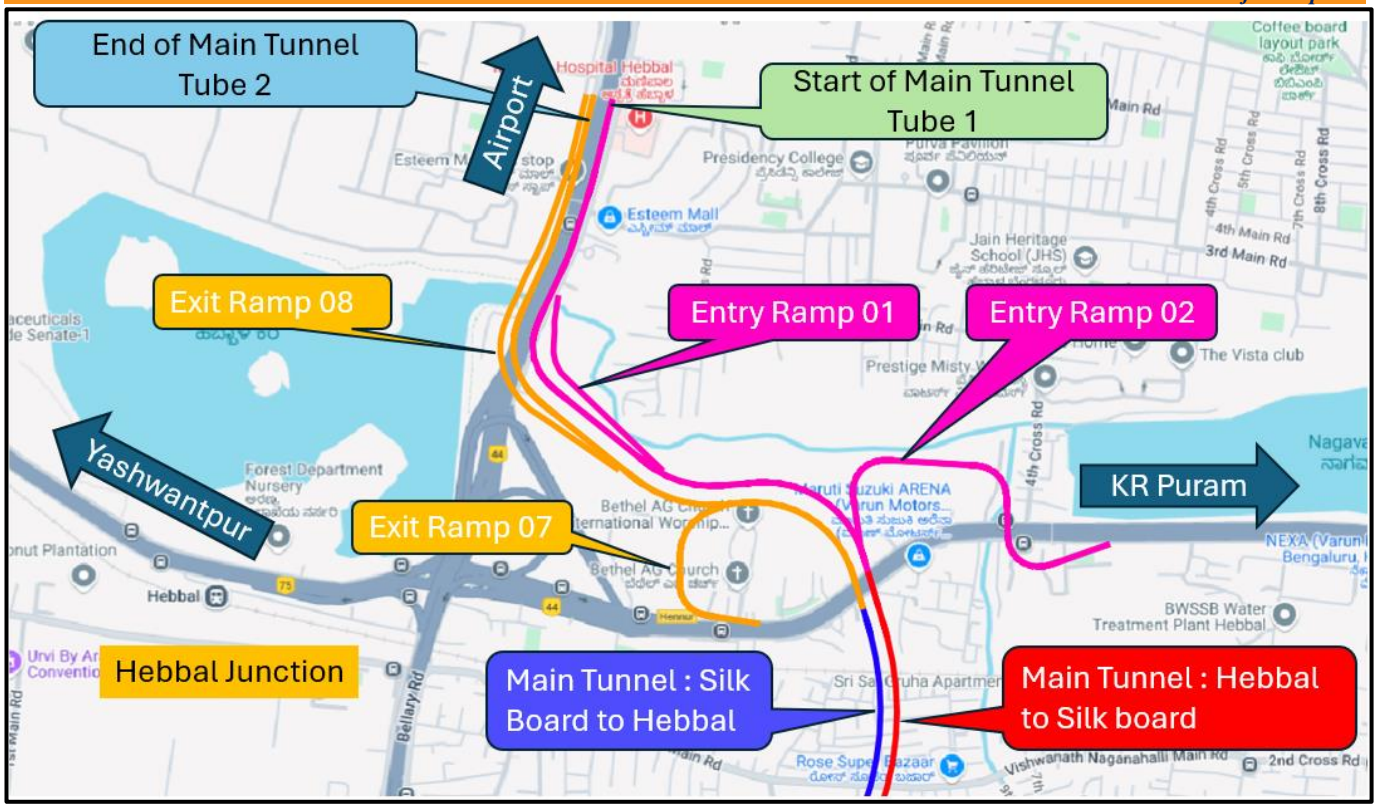


Figure 5: Entry and Exit at Hebbal Junction

Table 4: Entry Exit Details at Hebbal Junction

Sr. No.	Location	Description	Length	Direction Of Traffic	Lane Configuration
Main Tunnel					
1	Hebbal	Entry Ramp 1 into Main Tunnel	0.360 Kms	From Service Road Airport to Bangaluru City	2 Lane
2		Exit Ramp 08 from Main Tunnel	0.700 kms	To Service Road towards Sahakar Nagar, Yelahanka	2 Lane
3		Entry Ramp 2 into Main Tunnel	0.814 Kms	From KR Puram on Outer Ring Road	2 Lane
4		Exit Ramp 07 from Main Tunnel	0.400 Kms	Towards Yeswanthpur on Outer Ring Road	2 Lane

1.5.2 First Intermediate Ramps

The first intermediate location has been planned near Mehkri circle. Only two ramps has been provisioned, the entry ramp from Jayamahal main road for traffic going to silk board junction and exit ramps on C V Raman road.

Figure 6: Entry and Exit Ramps at Palace Ground

Table 5: Ramps Details at Palace Ground/Mekri Circle

Sr. No.	Location	Description	Length	Direction of Traffic	Lane Configuration
Intermediate Ramps					
1	Near Palace Ground/ Mekri Circle	Entry Ramp 03 into Main Tunnel	1.255 Kms	From Jayamahal Road	2 Lane
2		Exit Ramp 06 from Main Tunnel	1.910 Kms	Towards CV Raman Road	2 Lane
3		Entry Ramp 4 into Main Tunnel	1.320 Kms	Entry from CV Raman Road towards Hebbal	2 Lane
4		Exit Ramp 05 from Main Tunnel	0.963 Kms	Exit Towards Jayamahal Road	2 Lane

1.5.3 Second Intermediate Ramps

The Second intermediate ramps have been planned near racecourse/ Vidhan Soudha to connect the central part of Bengaluru. Entry and exit ramps have been provisioned in both tunnel tubes.

All the four ramps (2 entry and 2 exit ramps) have carriageway width of 2 lanes.

Two entry ramps from Palace Road, one towards Hebbal and one towards the Silk Board Junction. Two exit ramps, One exit on Seshadri Road (Towards KR Circle) and one exit on Race Course road (Toward Chalukya circle).

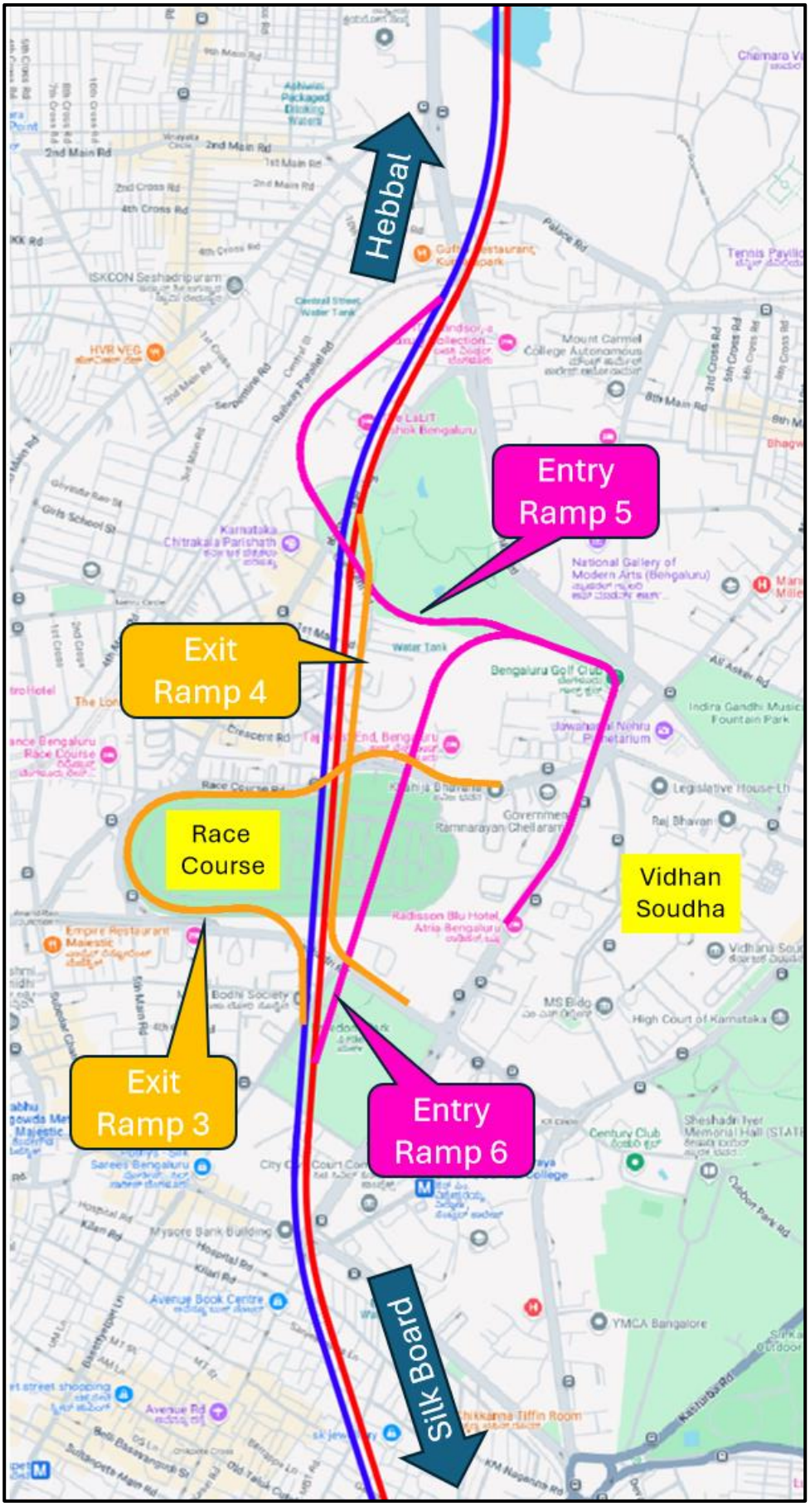


Figure 7: Entry and Exit Ramps at Race Course and Vidhan Soudha

Table 6: Ramps Details at Race Course/ Vidhan Saudha

Sr. No.	Location	Description	Length	Direction Of Traffic	Lane Configuration
Intermediate Ramps					
1	Near Race Course / Vidhan Saudha	Entry Ramp 5 into Main Tunnel	1.387 Kms	From Palace Road Towards Hebbal	2 Lane
2		Entry Ramp 6 into Main Tunnel	1.906 Kms	From Palace Road Towards Silk Board Junction	2 Lane
3		Exit Ramp 04 from Main Tunnel	1.376 Kms	On Seshadri Road (Towards KR Circle)	2 Lane
4		Exit Ramp 03 from Main Tunnel	1.864 Kms	On Race Couse Road (Towards Chalukya Circle	2 Lane

1.5.4 Third Intermediate Ramps

The 3rd intermediate location is planned near Lalbagh. Only two ramps have been provisioned, the entry ramp from Ashoka Pillar on Siddapura road for traffic going to Hebbal junction and exit ramps on Marigowda road towards Dairy circle at Wilson Garden.

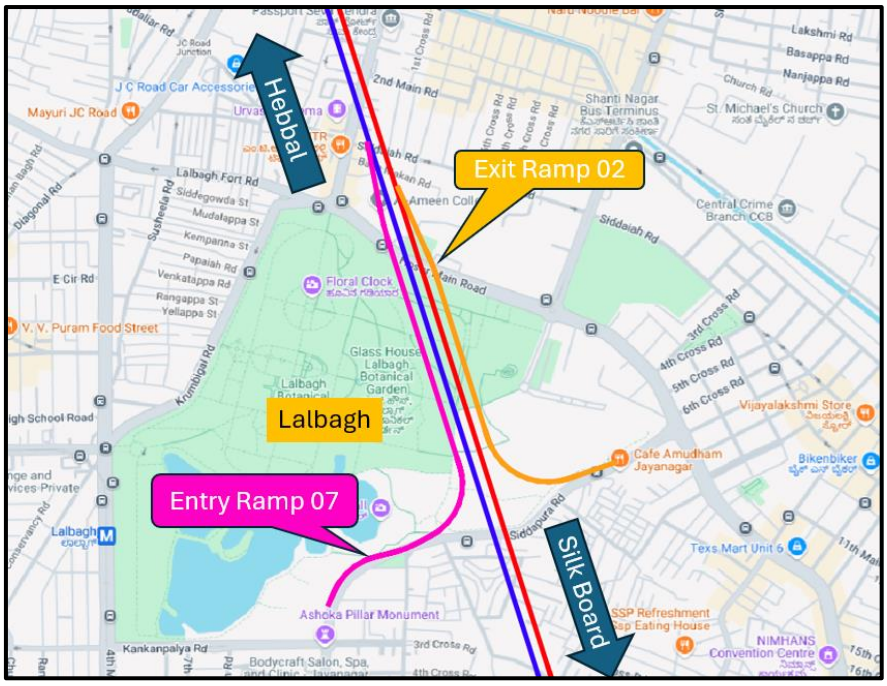


Figure 8: Entry and Exit Lalbagh Botanical Garden

Table 7: Ramps Details

Sr. No.	Location	Description	Length	Direction Of Traffic	Lane Configuration
Intermediate Ramps					
1	Near Lalbagh	Entry Ramp 7 into Main Tunnel	1.416 Kms	From Siddapura Road (Near Ashoka Pillar).	2 Lane
2		Exit Ramp 2 from Main Tunnel	1.073 Kms	On Siddapura Road Near Wilson Garden	2 Lane

- The entry ramp from Ashoka Pillar on Siddapura road for traffic going to Hebbal junction.
- Exit ramps on Siddapura road (marigowda road towards Dairy circle).

1.5.5 The End point of Project

The Tunnel ends before silk board junction on Hosur road. Both entry and exit ramps has been planned on Hosur Road for the traffic going to electronic city. However, additional, entry & exit ramp has been planned to connect the traffic going to Ring Road/ HSR layout area on Sarjapur road near St. John Hospital.

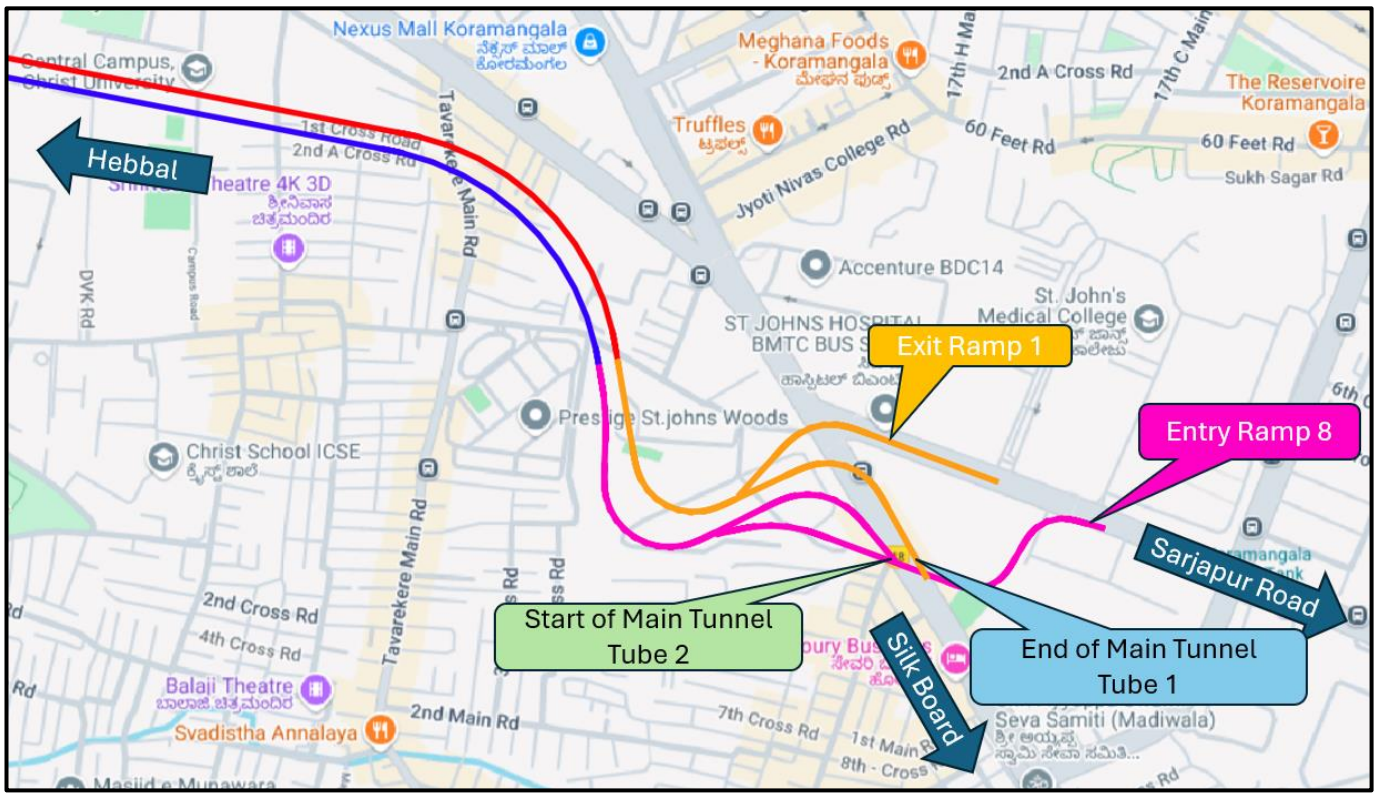


Figure 9: End Point of Project Alignment

Table 8: Entry and Exit Details

Sr. No.	Location	Description	Length	Direction Of Traffic	Lane Configuration
Main Tunnel					
1	Silk Board	Exit Ramp 1 from Main Tunnel	0.454 Kms	On Sarjapur Road / HSR layout (Ring Road)	2 Lane
2		Entry Ramp 8 into Main Tunnel	0.663 Kms	From Sarjapur Road / HSR layout (Ring Road)	2 Lane

1.5.6 Feasible Alignment

The alignment option has been discussed with stake holders such as BBMP, BMRCL, KRIDE and BDA. The proposal has been planned in such a way to minimise the infringement with the ongoing surrounding development project. The alignment proposed has been agreed by BBMP and it is the best feasible option for tunnel and its ramps.

1.5.7 Infringement with the proposed alignment:

The proposed tunnel alignment starting from Hebbal and ending at Silk Board junction including 3 intermediate ramps in between. The proposed development plan in having infringement with ongoing &

planned work of Metro and K-Ride. The detail is as under-

Table 9: Infringement Points with Proposed Tunnel

Proposed Tunnel Alignment Location/ CH	Infringement with	CH of metro/ Rail	Type of Infringement	Proposal in the instant Tunnel alignment	Remarks
KM 0.450 to 0.750	Metro Phase 2B (Elevated)	CH 11.480 to 11.600	Under construction Metro Pier is coming along alignment	Metro span to be increased	Discussion required with BMRCL
Km 1.425	Metro Phase 3 (elevated)	CH 10.500 to 10.600	Under construction Metro Pier is coming along alignment	Metro span to be increased	Discussion required with BMRCL
Km 1.425	Metro Phase 2B (elevated)	CH 10.500 to 10.600	Under construction Metro Pier is coming along alignment	Metro span to be increased	Discussion required with BMRCL
Km 1.600	K-Ride (C2 corridor, at grade)/ IR	10.200	Crossing alignment	Proposed Tunnel going Underground (with min. 1D cover)	Discussion required with KRIDE/ IR
Km 0.300 (Exit ramp 4 - CV Ramao Rd.)	Metro Phase 3A (UG)	CH 32.050	Crossing Proposed alignment	Proposed Tunnel going below proposed metro line (with 1D cover)	Discussion required with BMRCL
Km 7.000	K-Ride (C3 corridor, elevated)/ IR	CH 15.170 to 15.220	Crossing Proposed alignment	K-RIDE Span need to be re-checked if required	Discussion required with KRIDE/ IR
Km 7.000	Metro Phase 3A (UG)	CH 29.900 to 29.980	Crossing proposed alignment	Proposed Tunnel going below proposed metro line (with min. 1D cover)	Discussion required with BMRCL
Km 0.000 to km 0.750 (Entry ramp 1 – Palace Rd.)	Metro Phase 3A (UG)	CH 27.900 to 28.940	Parallel to proposed alignment	Proposed Tunnel ramps going parallel to metro line in Open cut and Cut & Cover; Integration is	Discussion required with BMRCL

Proposed Tunnel Alignment Location/ CH	Infringement with	CH of metro/ Rail	Type of Infringement	Proposal in the instant Tunnel alignment	Remarks
				required	
Km 8.550	Metro Phase 1 (UG)	CH 8.400 to 8.500	Crossing running metro line	Proposed Tunnel going below metro line (with min. 1D cover)	Discussion required with BMRCL
Km 14.550	Metro Phase 2 (UG)	CH 7.870 to 7.960	Crossing under construction metro line	Proposed Tunnel going below metro line (with minimum 1D cover)	Discussion required with BMRCL
Km 0.150 to 0.454 (exit 2 at silk board towards Sarjapur Rd., near St. john hospital)	Metro Phase 3A (UG)	CH 20.480 to 20.490	Crossing Proposed alignment	Proposed Tunnel ramps crossing proposed metro line in Cut & Cover; Integration is required	Discussion required with BMRCL
Km 0.550 to 0.663 (entry 4 at silk board towards Hebbal from Sarjapur Rd. near john hospital)	Metro Phase 3A (UG)	CH 20.040	Crossing Proposed alignment	Proposed Tunnel ramps crossing proposed metro line at grade; Integration is required	Discussion required with BMRCL

1.6 Engineering Surveys and Investigations

Based upon the objectives of the project. With careful planning and efficient use of resources different tasks have been done simultaneously. Based on the objectives and scope of the consultancy services, an appropriate methodology has been developed by the consultants to address the other requirements also, especially regarding various intermediate targets and completion period, manning schedule, and TOR.

A work plan has been prepared based on the methodology developed. A competent team of suitably qualified key professionals as per the requirements and other supporting staff has been selected to carry out the services fieldwork and office work.

1.6.1 Existing Features of Project

The project starts near Esteem Mall Hebbal Junction and Ends at Silk board Junction. The alignment passes through nodal points/ stretch of the Bengaluru city.

First stretch is Hebbal to Golf course whose existing roadway width is 6 lane divided carriageway, then further there is connectivity to Chalukya circle via 4 lane existing divided carriageway road. After that Calukya circle is connected to Lalbagh and finally Lalbagh to Silkboard junction all the stretches are 4 lane

divided carriageway.

The location of entry and exit ramps have been analyzed.

- At the Start End, the road is 6 lanes with divided carriageway. There is presence of Minor bridges near Esteem mall which channelizes the stream if Hebbal lake. The construction of metro (name of metro line and its links) is underway, which affects our project start point.
- At the End Point the road is 4 lanes with divided carriageway. The road have a under construction double decker flyover at Silk Board junction and metro is also under construction at the project end location.

The alignment passes through some of the prominent stretches of the Bengaluru city which caters the heavy traffic throughout the day.

1.6.2 Reconnaissance Survey

A preliminary survey has been conducted to gather general information about the project area. The purpose of the reconnaissance survey is to get a broad understanding of the terrain, conditions, Environmental and Social Considerations, Safety and Risk Assessment of the project area.

1.6.3 Road Inventory

Road inventory was carried out in the first week of August 2024 over the possible locations of the project alignment. The road conditions are found to be good, some of the roads have undergone strengthening of bitumen surface through the provision of White Topping. Metro is being constructed at the starting point of our project alignment. However, the project influence area the volume of traffic is quite high.

1.6.4 Existing Carriageway

The existing road infrastructure includes lane configurations of 4 lanes, and 6 lanes in various segments. Furthermore, it is observed that several metro routes intersect with these corridors. The road stretches and lane details are as follows:

Table 10: Existing Carriageway

Stretch	Lane Configuration
1. Hebbal to Golf course	6 lanes
2. Golf course to Chalukya	4 lanes
3. Chalukya to Lalbagh botanical garden	4 lanes
4. Lalbagh botanical garden to silk board	4 lanes

1.6.5 Alignment and Geometry

An current average travel speed is 15-20 km/hr in the project stretch because of traffic congestion.

1.6.6 Terrain and Land Use

Project area lies in plain terrain in entire length. The land-use pattern for the project area is densely populated builtup of Bengaluru City.

1.6.7 Traffic Survey at Site

For the evaluation of the traffic demand estimation on the proposed North – South corridor in Bengaluru and impact on the road network in study area, traffic model has been developed in PTV Visum 2024. Macro simulation analysis has been conducted to understand the overall travel patterns in the study area. PTV Visum 2024 helps to understand the existing traffic and travel patterns and bottlenecks in the transportation system. Further it is used for scenario testing according to the changes in demand and infrastructure. Comprehensive data collection has been done to understand the existing traffic and travel

pattern and for development of the base year model. Further updating the demand and network in the model the diversion to the corridor have been estimated.

The traffic survey has been planned along the proposed corridor, The location of traffic survey mainly for classified Volume count, O-D Survey and Turning movement survey has been studied and detailed analysis has been described in Chapter 6 of this report.

Figure 10: Traffic Surveys conducted at Project Location

1.6.8 Topography Survey:

The topography survey has been carried out using Drone LiDAR for the location which is in green zone however the yellow and red zone is still pending.

The Topography survey using DGPS (Differential Global Positioning System) has been conducted for all the entry, exit and intermediate ramps locations.

Figure 11: Topography Survey on Site

1.6.9 Geotechnical & Geophysical Investigation:

Secondary data from ongoing metro projects (Nearby Proposed tunnel alignment) has been considered for geological study. However, a confirmatory bore holes and geophysical survey (MASW-Multichannel Analysis of Surface Wave and SRT-Seismic Refraction Test), is being conducted to verify the reports collected for the design.

The details of the Secondary data is provided in GIR Volume submitted separately.

Figure 12: Geophysical Survey on Site

1.6.10 Traffic Surveys Analysis

Classified Vehicle Count, Origin and Destination and Turning Movement Count has been conducted at numerous locations. The locations have been selected to get the real traffic trends that directly and indirectly affect our project. The traffic surveys have been extended to a larger area outside of our project.

At the following locations Traffic Locations have been conducted and their detailed Analysis is presented in chapter 6 of Main report.

Table 11: Traffic Survey Locations (CVC and OD)

Sr. No.	Location	CVC	OD
1	NH-44 Bellary Road (Near-Sakar Nagar)	Done	Done
2	NH-75 Malur -Byranahalli Rd Outer Ring Road (Near-Nagavara park)	Done	Done
3	NH-75 Malur -Byranahalli Rd Outer Ring Road (Near-Devinagar BEL Circle)	Done	Done
4	AH-47 Malur Road (Near-Science Gallery)	Done	Done
5	Guttahalli Main Road (Near-Uniworth Plaza)	Done	Done
6	NR road (Near-Silver Jubilee Park)	Done	Done
7	Siddapura Road (Near-Maharaja Agrasena Bhavana)	Done	Done
8	Marigowda Road (Near-National Institute of Mental Health & Neuro Sciences)	Done	Done
9	NH-44 Bengaluru-Chennai Highway (Near-Madiwala footbridge)	Done	Done

The Turning Movement Count survey has been conducted at the following junctions in the project influence area.

Table 12: Traffic Survey Locations (Turning Moment Count)

Sr. No.	Turning Movement Count Locations
1	CN Rao underpass Junction
2	Banglore Cantt Junction
3	Basaveshwara circle
4	KR Circle
5	Cubbon Park UB City signal
6	Shoolay Circle
7	Lalbagh Chowk

Speed and Delay analysis has also been done for the project location. Traffic flow diagrams and traffic demand analysis have been done via PTV Vissum software and their findings are discussed in detail later in this report.

1.6.11 Current level of Service in the project Influence Area

The Level of service is defined as per the IRC: IRC:106-1990-Guidelines for Capacity of Urban Roads in Plain Areas.

Table 13: LOS as pre-IRC

LOS	Description
A	Represents a condition of free flow with average travel speeds usually about 90 per cent of the free-flow speed.
B	Represents a zone of stable flow, with the drivers still having reasonable freedom to select their desired speed and maneuver within the traffic stream
C	This also is a zone of stable flow but marks the beginning of the range of flow in which the operation of individual users becomes significantly affected by interactions with others in the traffic stream.
D	Represents the limit of stable flow, with conditions approaching close to unstable flow. Due to high density, the drivers are severely restricted in their freedom to select desired speed and maneuver within the traffic stream.
E	Represents operating conditions when traffic volumes are at or close to the capacity level. The speeds are reduced to a low, but relatively uniform value, average value being one-third the free flow speed.
F	Represents zone of forced or breakdown flow

As per the findings of traffic volume count the current Level of Service on the below mentioned stretches in the project influence area is mentioned below.

Table 14: LOS on the traffic cordon points on existing road

S. No.	Location Name	Directions	Level of Service (Base Year)
1	NH-44 Bellary Road (Near-Sakar Nagar)	Dir-I: Yelahanka to Hebbal	LOS F
		Dir I - Service Lane	LOS F
		Dir-II: Hebbal to Yelahanka	LOS F
		Dir II - Service Lane	LOS B
2	NH-75 Malur -Byranahalli Rd Outer Ring Road (Near-Nagavara park)	Dir-I: Bellary Road To Nagavara	LOS D
		Dir I - Service Lane	LOS E
		Dir-II :Nagavara To Bellary Road	LOS D
		Dir II - Service Lane	LOS C
3	NH-75 Malur -Byranahalli Rd Outer	Dir-I : Hebbal To	LOS E

S. No.	Location Name	Directions	Level of Service (Base Year)
	Ring Road (Near-Devinagar BEL Circle)	Yashwantpur	
		Dir-II : Yashwantpur To Hebbal	LOS C
4	AH-47 Malur Road (Near-Science Gallery)	Dir-I : Mekhri circle To Airport	LOS F
		Dir I - Service Lane	LOS E
		Dir-II : Airport To Mekhri circle	LOS F
		Dir II - Service Lane	LOS C
5	Guttahalli Main Road (Near-Uniworth Plaza)	Dir-I : Mahalakshmi Gudi Circle To Bengaluru Golf Club	LOS F
		Dir-II : Bengaluru Golf Club To Mahalakshmi Gudi Circle	LOS F
6	NR road (Near-Silver Jubilee Park)	Dir-I : Kempegowda Tower To Chamrajpet	LOS F
		Dir-II : Chamrajpet To Kempegowda Tower	LOS F
7	Siddapura Road (Near-Maharaja Agrasena Bhavana)	Dir-I : Ashoka Piller To Mallinge Hospital	LOS F
		Dir-II : Mallinge Hospital To Ashoka Piller	LOS C
8	Marigowda Road (Near-National Institute Of Mental Health & Neuro Sciences)	Dir-I : Dairy Circle To Wilson Garden	LOS F
		Dir-II :Wilson Garden To Dairy Circle	LOS F

1.6.12 Traffic Volume Counts at Cordon Points

Nine cordon points were identified for an understanding of the traffic characteristics in the study area. The analysis of the classified volume count survey at the cordons is given in the sub-sections below. The total inbound and outbound traffic flow at each of the cordons is presented in Table **and** daily traffic on each cordon point is shown in Figure direction wise.

Table 15: Traffic Volume Counts at Cordon Locations

Location		Direction	Vehicles	PCUs	Total Vehicles	Total PCUs
1	NH-44 Bellary Road (Near-Sakar Nagar)	Dir-I: Yelahanka To Hebbal	178815	175553	393137	385968
		Dir-II: Hebbal To Yelahanka	214322	210415		
2	NH-75 Malur - Byranahalli Rd Outer Ring Road (Near-Nagavara park)	Dir-I: Bellary Road To Nagavara	117553	113677	222323	212544
		Dir-II: Nagavara To Bellary Road	104770	98867		
3	NH-75 Malur - Byranahalli Rd Outer Ring Road (Near-Devinagar BEL Circle)	Dir-I: Hebbal To Yashwantpur	74262	68921	139793	130729
		Dir-II: Yashwantpur To Hebbal	65531	61809		
4	AH-47 Malur Road (Near-Science Gallery)	Dir-I: Malegaon To Nashik City	139418	131287	277295	263180
		Dir-II: Nashik City To Malegaon	137877	131893		
5	Guttahalli Main Road (Near-Uniworth	Dir-I: Malegaon To Nashik City	111699	105740	267771	256433

	Location	Direction	Vehicles	PCUs	Total Vehicles	Total PCUs
	Plaza)	Dir-II: Nashik City To Malegaon	156072	150694		
6	NR road (Near-Silver Jubilee Park)	Dir-I: Malegaon To Nashik City	121760	112552	252461	232259
		Dir-II: Nashik City To Malegaon	130701	119708		
7	Siddapura Road (Near-Maharaja Agrasena Bhavana)	Dir-I: Ashoka Piller To Mallinge Hospital	43860	38960	83509	73569
		Dir-II: Mallinge Hospital To Ashoka Piller	39649	34610		
8	Marigowda Road (Near-National Institute Of Mental Health & Neuro Sciences)	Dir-I: Dairy Circle To Wilson Garden	54855	54282	108421	107685
		Dir-II: Wilson Garden To Dairy Circle	53566	53402		
9	NH-44 Bengaluru-Chennai Highway (Near-Madiwala footbridge)	Dir-I: Adugodi To Electronic City	120551	103963	265528	227195
		Dir-II: Electronic City To Adugodi	144977	123232		

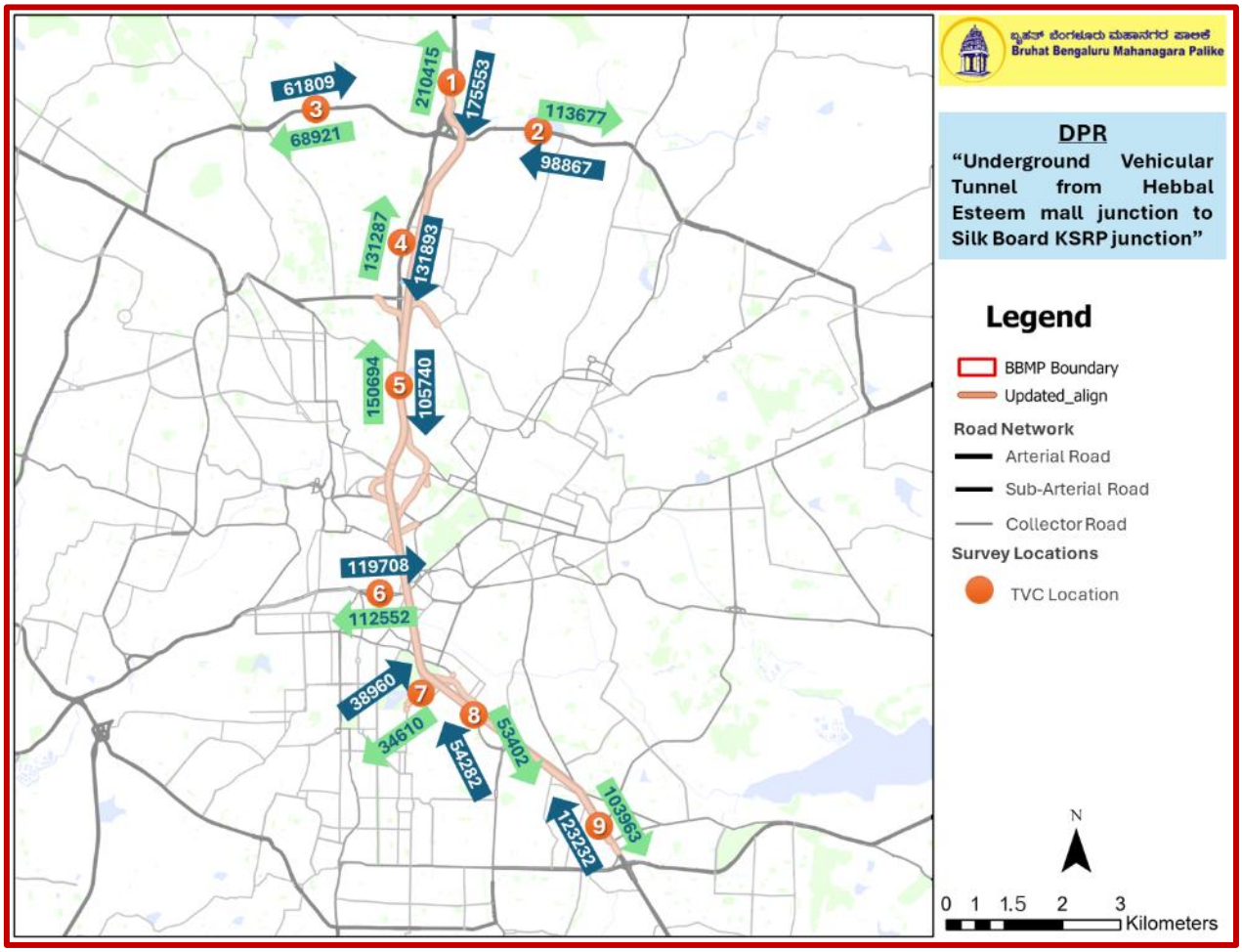


Figure 13: Map Showing Locations of Traffic Volume Count Surveys.

1.6.13 Traffic Modelling on our project alignment

The North-South Corridor is proposed in Bengaluru to decongest the vehicular traffic congestion within the city. The diversion estimation for the proposed North-South Corridor is done considering the Modal Share

prescribed in the Comprehensive Mobility Plan 2020 to understand the amount of traffic that will be diverted in the proposed facility.

The diversion estimation is done on state-of-the-art software PTV Visum 2024 to model real-life scenario for realistic traffic evaluation through the input of primary data as well as secondary data.

Table 16 below shows the total mode-wise estimated trips for horizon year 2031 and 2041 for all the three scenarios where Scenario 1 consist of largest share of cars and Scenario 3 consist of largest share of public transport due to which Scenario 1 has the highest number of car trips and Scenario 3 has the lowest number of car trips. Both scenario 1 and 3 are referred from CMP 2020. Scenario 2 is considered as the intermediate scenario having a reasonable modal share.

Table 16: Estimated Total trips during morning peak hour.

	Year 2031			Year 2041		
Mode	**S1**	**S2**	**S3**	**S1**	**S2**	**S3**
Auto Rickshaw	25111	23812	19859	29631	28098	23434
Two-Wheeler	153528	128708	100381	181163	151876	118449
Car	83005	72507	61168	97946	86211	72178

Further, all these three scenarios are evaluated considering toll and without toll conditions. In without toll condition, the Level of Service is compromised in year 2031 only for section 2 and 3 therefore it was not a viable option to be considered.

For with toll scenario, the average toll price considered for Car is Rs 16/km. Considering this, for horizon year 2031 and 2041 all the three scenarios were evaluated to understand the impact of the application of toll in the proposed North-South Corridor. However, the scenario 2 is considered as the reasonable scenario and it is considered for further evaluations.

The proposed corridor was divided into four sections based on the ramp locations. Table 17 shows section wise morning peak hour volume on the proposed corridor. It can be observed that all the sections of the corridor are having Level of Service B and C in horizon year 2031 and 2041. However, section 2 and 3 towards the Silkboard Junction has high volume in horizon year 2031.

Table 17: Assignment Results - Scenario 2 (Morning Peak Hour PCU) for 2031 and 2041 (with toll)

Section		**Year 2031 (With Toll)**		**Year 2041 (With Toll)**	
		PCU/Hr	**LOS**	**PCU/Hr**	**LOS**
Section 1	Towards Airport	902	LOS B	1276	LOS B
	Towards Bengaluru City	2645	LOS C	3770	LOS C
Section 2	Towards Airport	1834	LOS B	2333	LOS C
	Towards Bengaluru City	4030	LOS D	5161	LOS F
Section 3	Towards Airport	2653	LOS C	3742	LOS C
	Towards Bengaluru City	4705	LOS E	5559	LOS F
Section 4	Towards Airport	2005	LOS B	2951	LOS C
	Towards Bengaluru City	1551	LOS B	1811	LOS B

Considering the results obtained, a diversion of approximately 15% is estimated on the proposed North-South Corridor.

The detailed process of data collection, CMP-2020 incorporation in our project, Traffic analysis and traffic modelling through PTV Visum has been mentioned in detail in Traffic Chapter of Main Report.

1.7 Improvement Proposals

These improvement proposals are based on the findings of various engineering features carried out on the project roads such as Traffic Survey and Analysis, Inventory Data and Geotechnical & Geophysical Investigations.

The improvement proposals for proposed widening include the provisions for the following major items:

a) Main Tunnel (Twin tube uni-directional TBM tunnel, Cut & Cover, Open Cut)

b) Entry/ Exit ramps (NATM tunnel, Cut & Cover, Open Cut)

c) Tunnel Passage

d) Vertical Shaft

e) Traffic Control and Safety Measures

1.7.1 Design Standards

Geometric Design

Geometric design of a highway is the process whereby the layout of the road in specific terrain is designed to meet the needs of the road users keeping in view the road function, type and volume of traffic, potential traffic hazards and safety as well as convenience of the road users. The principal areas of control for fulfilment of this objective are- the horizontal alignment, vertical alignment and the road cross-section.

The Consultants have referred to the latest IRC publications and MORT&H circulars regarding design standards for National Highways in India. After careful review of all available data and requirements of the project road the proposed Design Standards for adoption on the project road have been recommended.

Design Speed

The project road passes through plain terrain. For geometric design of the highway, design speed is used as an index which links road function, traffic flow and terrain. An appropriate design speed should correspond to general topography and adjacent land use. The speed selected for design should also cater to travel needs and behaviour of the road users.

The design speed corresponding to the type of terrain as Per IRC 86-2018 is as under:

Table 18: Design Speed Standards

Class of Urban Road	Design Speed (km/h)	
	Ruling	Minimum
Arterial Road	60	50

Levels of Service (LOS)

The Level of Service (LOS) characterizes the operating conditions on the roadway in terms of traffic performance measures related to speed and travel time, freedom to manoeuvre, traffic interruptions, and comfort and convenience. The levels of service range from level-of-service A (least congested) to level-of-service F (most congested). The Highways Capacity Manual (HCM) provides the following levels of service definitions:

Table 19: Standards for Level of Service

Level of Service (LOS)	General Operating Conditions
A	Free flow
B	Reasonably free flow

Level of Service (LOS)	General Operating Conditions
C	Stable flow
D	Approaching unstable flow
E	Unstable flow
F	Forced or breakdown flow

Considering the importance of the highway, whereas Level of Service (LOS) 'B' is desirable and level of service up to LOS- 'C' may be acceptable.

1.7.2 Main Tunnel

A twin tube uni-directional tunnel has been proposed for connecting the northern part to the southern part of Bengaluru City. The project alignment starts from Hebbal Esteem Mall junction and terminates at Silk Board KSRP Junction.

Key Features: -

Table 20: Tube 1 – Hebbal to Silk Board

Total Length	16.690 Km
Length of Tunnel (TBM)	14.550 Km
Lane Configuration	3 Lanes
Diameter	Outer – 14.600m, Inner – 13.500m
Carriageway width	10.500m
Walkway	0.700m
Crash Barrier	0.500m
Cut & Cover Section	At Hebbal – 950m, At Silk Board – 600m
Open Cut Section	At Hebbal – 430m, At Silk Board -160m

Table 21: Tube 2 – Hebbal to Silk Board

Total Length	16.678 Km
Length of Tunnel (TBM)	14.530 Km
Lane Configuration	3 Lanes
Diameter	Outer – 14.600m, Inner – 13.500m
Carriageway width	10.500m
Walkway	0.700m
Crash Barrier	0.500m
Cut & Cover Section	At Hebbal – 970m, At Silk Board -640m
Open Cut Section	At Hebbal – 430m, At Silk Board -108m

1.7.2.1 For Bored Tunnels

Lining Type and Geometry

The finished inner diameter for the Underground Vehicular Tunnel is considered as 13.500m with a thickness of 550mm. Universal configuration of the segment is considered with 9+1 arrangement. The typical bored tunnel cross-section is shown in TCS-1 given later in the chapter along with their TCS Schedule.

Design Considerations

The segments shall be designed to ensure that the full design life of 100 years is achieved. The design method for the analysis of the bored tunnel linings shall be done considering the interaction between the lining and the ground, the deflection of the lining and the redistribution of the loading dependent upon the

relative flexibility of the lining, the variability and the compressibility of the ground, with this, the design shall take into account all additional loads, stresses and strains imposed by or on to adjacent Existing Building Structure (EBS).

The Loads acting on the lining include earth pressure, water pressure, dead load, reactions, surcharge & seismic forces. The lining shall also be checked to resist the various loads arising due to handling, stacking, temporary grout load pressure, TBM thrust, Load on Bolts & erector, gasket forces etc.,

The pre-cast concrete linings are designed in accordance with IS 456 However other International Codes may be used in addition to the Indian Standard as and when required.

The Analysis methods, Material and design calculation is mentioned in Design Report which is submitted as Volume II-B

1.7.2.2 For NATM Tunnel

As per the General arrangement Drawings prepared , there are two types of NATM sections available. i.e., Regular Cross Section and Regular Cross Section (VCP) which are use for the project. The NATM Tunnel is presented as TCS-5 and their Schedules which are mentioned later in chapter.

Design Considerations

The Tunnel tube is proposed to be constructed according to New Austrian Tunnelling Method (NATM) excavation in different weathering grade of rock mass. Ground excavations require the use of structural supports, to establish equilibrium and to limit the displacements around the excavation and at surface. The tunnel will be supported with primary support for temporary condition and a cast in-situ concrete as a permanent support. Primary support design has been done by considering site ground condition. The design has been performed for the combination of different load cases analyzed in STAAD. The Analysis methods, Material and design calculation is mentioned in Design Report which is submitted as Volume II-B

1.7.2.3 Cut and Cover Section

The Cross Sections of C&C Structures (C&C section of 2 lane and 3 lane) will be used as described Typical Cross Sections as TCS-6 (3 lane Section) and TCS-03 (2 Lane section) which are presented later in chapter. C&C Structures will have side walls, Bottom Slab and top slab with Reinforced Concrete Structure in which Bottom Slab of 1.0 m thick (2-lane) & 1.2m thick (3-lane) will casted over 0.2 m thick PCC and Side wall of 1.0 m thick (2-lane) & 1.2m thick (3-lane) and top slab with 1.0 m thick (2-lane) & 1.2m thick (3-lane).

The Analysis methods, Material and design calculation are mentioned in Design Report which is submitted as Volume II-B

1.7.2.4 Open Cut Section

The following Cross Sections of RAMP Structures (Ramp section of 2 lane and 3 lane) will be used as described in TCS-02 (3 Lane) and TCS-04 (2 Lane). RAMP Structures will have side walls and Bottom Slab with Reinforced Concrete Structure in which Bottom Slab of 1 m thick and Side wall of 1m with roofing C/W pipe truss and approved grade polycarbonate roofing sheets.

The Analysis methods, Material and design calculation are mentioned in Design Report which is submitted as Volume II-B.

1.7.3 Proposed Typical Cross Section

Typical cross section of the proposed section Main tunnel, Entry & Exit Ramps are as under:

Table 22: Proposed Typical Cross Section for Main Tunnel Tube 1 and Tube 2

Tube 1 : Hebbal to Silk Board (Left)						
SL No	Chainage		Length	TCS Type	TCS DETAILS	Lanes
	From	To				
1	0+000	0+430	430	open cut	TCS 2	3 Lane
2	0+430	1+380	950	cut and cover	TCS 6	3 Lane
3	1+380	15+930	14550	main TBM tunnel	TCS 1	3 Lane
4	15+930	16+530	600	cut and cover	TCS 6	3 Lane
5	16+530	16+690	160	open cut	TCS 2	3 Lane
Total Length			**16690**			

Tube 2 : Hebbal to Silk Board (Right)						
SL No	Chainage		Length	TCS Type	TCS DETAILS	Lanes
	From	To				
1	0+000	0+430	430	open cut	TCS 2	3 Lane
2	0+430	1+400	970	cut and cover	TCS 6	3 Lane
3	1+400	15+930	14530	main TBM tunnel	TCS 1	3 Lane
4	15+930	16+570	640	cut and cover	TCS 6	3 Lane
5	16+570	16+678	108	open cut	TCS 2	3 Lane
Total Length			**16678**			

Table 23: Entry/ Exit ramps at Hebbal Junction

Hebbal						
Entry Ramp 1 (Hebbal Service Road)						
SL No	Chainage		Length	TCS Type	TCS DETAILS	Lanes
	From	To				
1	0+000	0+170	170	TCS 4	Open Cut	2 Lane
2	0+170	0+360	190	TCS 3	Cut & Cover	2 Lane
Total Length			**360**			
Entry Ramp 2 (From ORR To Main Tunnel (km 1.300) Towards Silk Board/ Sarjapur road)						
SL No	Chainage		Length	TCS Type	TCS DETAILS	Lanes
	From	To				
1	0+000	0+600	600	Cut & Cover	TCS 3	2 Lane
2	0+600	814	214	Open Cut	TCS 4	2 Lane
Total Length			**814**			
Exit Ramp 8 (Hebbal Service Road)						
SL No	Chainage		Length	TCS Type	TCS DETAILS	Lanes
	From	To				
1	0+000	0+450	450	TCS 4	Open Cut	2 Lane
2	0+450	0+700	250	TCS 3	Cut & Cover	2 Lane
Total Length			**700**			
Exit Ramp 7 (From Main Tunnel (km 1.300) To ORR Towards ORR (Outer Ring Road))						
SL No	Chainage		Length	TCS Type	TCS DETAILS	Lanes
	From	To				
1	0+000	0+300	300	Cut & Cover	TCS 3	2 Lane
2	0+300	400	100	Open Cut	TCS 4	2 Lane
Total Length			**400**			

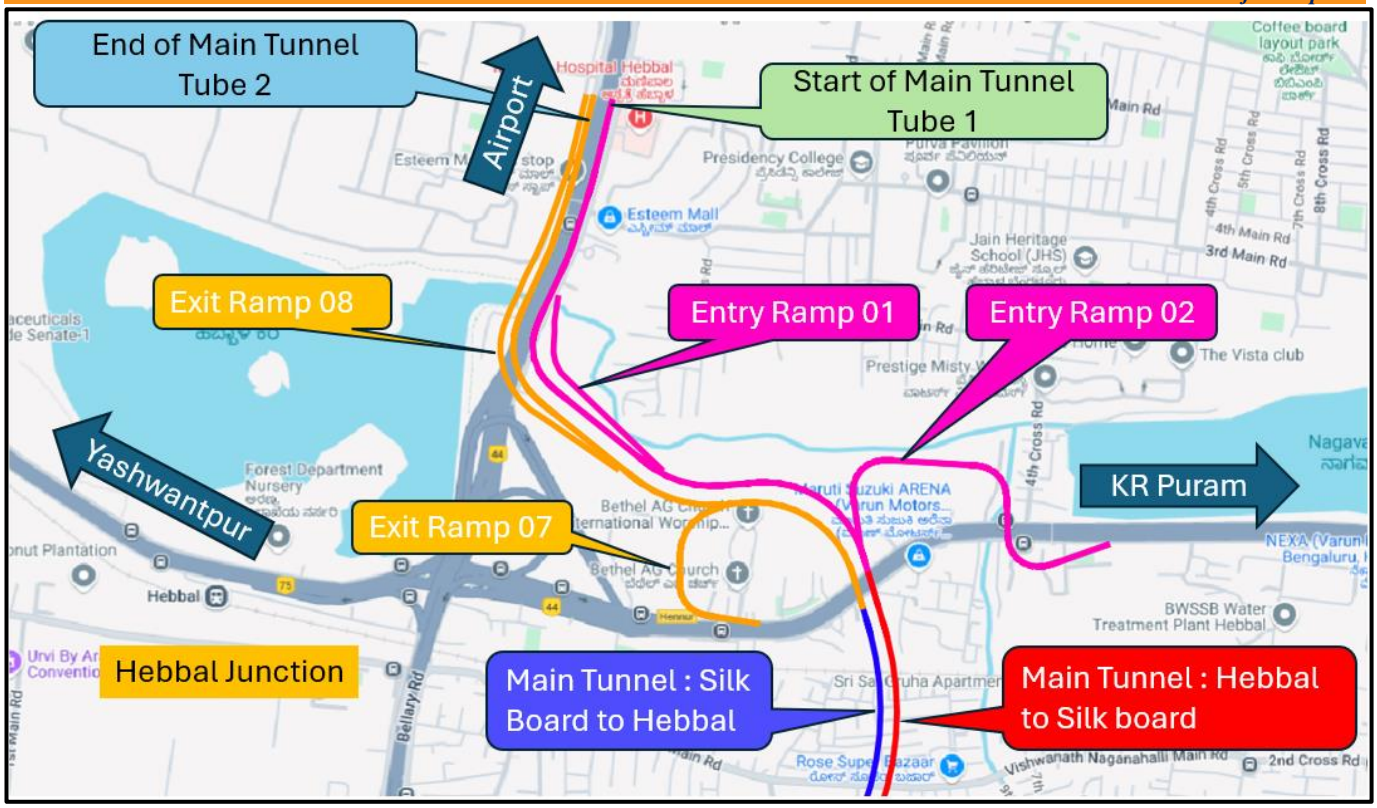


Figure 14: Entry and Exit Ramps at Hebbal Junction

Table 24: Entry/ Exit ramps at Palace Ground

Palace Ground						
Entry Ramp 03 (From Jaya Mahal Road)						
SL No	**Chainage**		**Length**	**TCS Type**	**TCS DETAILS**	**Lanes**
	From	**To**				
1	0+000	0+170	170	Open Cut	TCS 2	3 Lane
2	0+170	0+360	190	Cut & Cover	TCS 6	3 Lane
3	0+360	1+255	895	NATM Tunnel	TCS 5	2 Lane
Total Length			**1255**			
Entry Ramp 4 (From CV Raman Road To Main Tunnel (km 4.700) Towards Hebbal)						
SL No	**Chainage**		**Length**	**TCS Type**	**TCS DETAILS**	**Lanes**
	From	**To**				
1	0+000	1+320	1320	NATM Tunnel	TCS 5	2 Lane
Total Length			**1320**			
Exit Ramp 06 (Towards C V Raman Road)						
SL No	**Chainage**		**Length**	**TCS Type**	**TCS DETAILS**	**Lanes**
	From	**To**				
1	1+320	0+000	1320	NATM Tunnel	TCS 5	2 Lane
2	1+320	1+610	290	Cut & Cover	TCS 6	3 Lane
3	1+610	1+910	300	Open Cut	TCS 2	3 Lane
Total Length			**1910**			
Exit Ramp 5 (From Main Tunnel (km 4.450) To Jaymahal Road Towards Jaymahal Road)						
SL No	**Chainage**		**Length**	**TCS Type**	**TCS DETAILS**	**Lanes**
	From	**To**				
1	0+360	1+323	963	NATM Tunnel	TCS 5	2 Lane
Total Length			**963**			

Figure 15: Entry and Exit Ramps at Palace Ground

Table 25: Entry/ Exit ramps at Race Course:

Race Course						
Entry Ramp 5 (From Palace Road towards Hebbal)						
SL No	**Chainage**		**Length**	**TCS Type**	**TCS DETAILS**	**Lanes**
	From	**To**				
1	0+960	1+550	590	Cut & Cover	TCS 3	2 Lane
2	1+550	2347	797	NATM Tunnel	TCS 5	2 Lane
Total Length			**1387**			
Entry Ramp 6 (From Palace Road towards Silk Board)						
SL No	**Chainage**		**Length**	**TCS Type**	**TCS DETAILS**	**Lanes**
	From	**To**				
1	0+000	0+230	230	Open Cut	TCS 2	2 lane
2	0+230	0+960	730	Cut & Cover	TCS 6	3 Lane
3	0+960	1+100	140	Cut & Cover	TCS 3	2 Lane
4	1+100	1+906	806	NATM Tunnel	TCS 5	2 Lane
Total Length			**1906**			
Exit Ramp 4 (On Seshadri Road towards K R Circle from Hebbal)						
SL No	**Chainage**		**Length**	**TCS Type**	**TCS DETAILS**	**Lanes**
	From	**To**				
1	0+000	0+830	830	NATM Tunnel	TCS 5	2 Lane
2	0+830	1+060	230	Cut & Cover	TCS 3	2 Lane
3	1+060	1+376	316	Open Cut	TCS 4	2 Lane
Total Length			**1376**			
Exit Ramp 3 (On Race Course Road towards Chalukya Circle from Silk Board)						
SL No	**Chainage**		**Length**	**TCS Type**	**TCS DETAILS**	**Lanes**
	From	**To**				
1	0+000	0+880	880	NATM Tunnel	TCS 5	2 Lane
2	0+880	1+530	650	Cut & Cover	TCS 3	2 Lane
3	1+530	1+864	334	Open Cut	TCS 4	2 Lane
Total Length			**1864**			

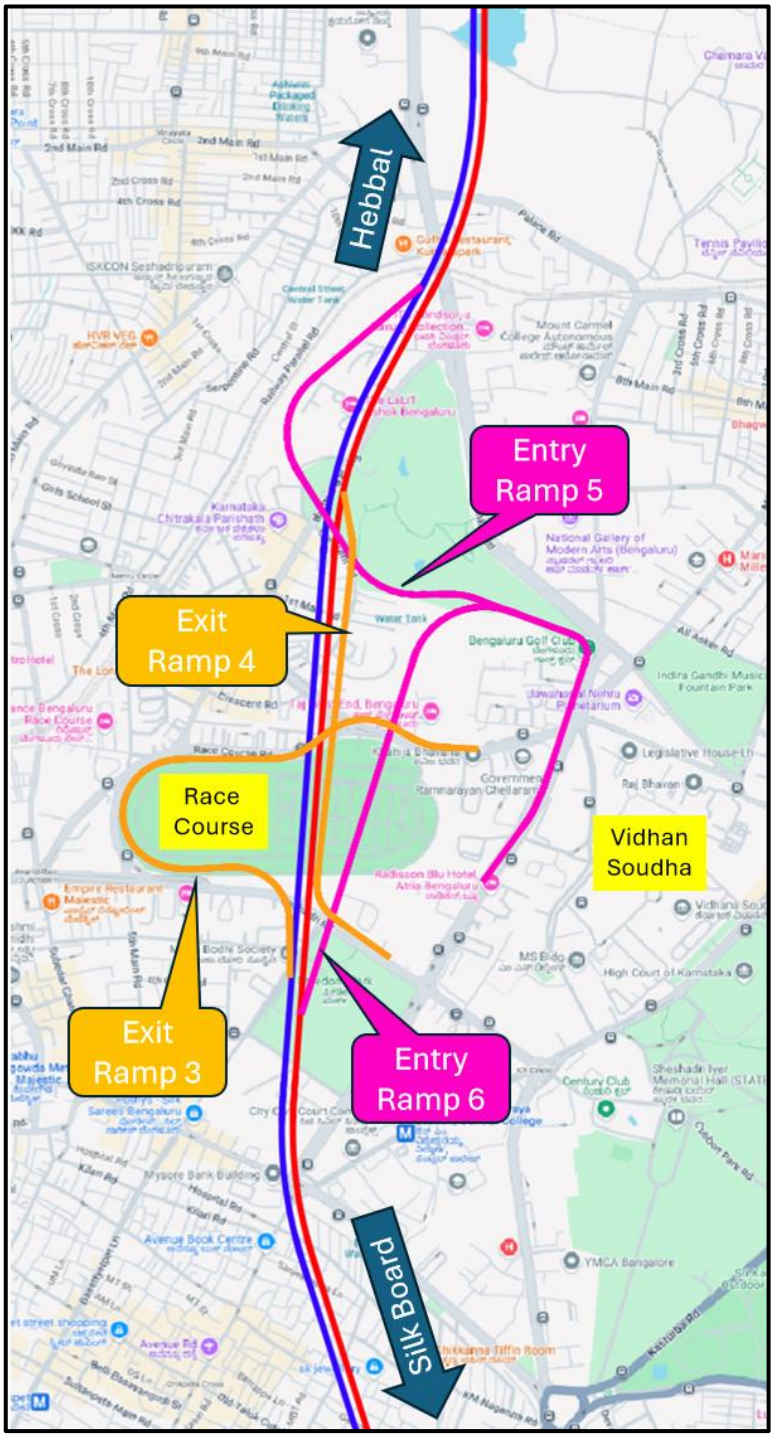


Figure 16: Entry and Exit Ramps at Racecourse

Table 26: Entry/ Exit ramps at Lal Bagh

Lal Bagh						
Entry Ramp 7 (From Siddapura Road near Ashok Pillar)						
SL No	**Chainage**		**Length**	**TCS Type**	**TCS DETAILS**	**Lanes**
	From	**To**				
1	0+000	0+150	150	Open Cut	TCS 4	2 Lane
2	0+150	0+470	320	Cut & Cover	TCS 3	2 Lane
3	0+470	1+416	946	NATM Tunnel	TCS 5	2 Lane
Total Length			**1416**			

Exit Ramp 2 (Towards Siddapura Road near Wilson Garden)						
SL No	Chainage		Length	TCS Type	TCS DETAILS	Lanes
	From	To				
1	0+000	0+870	870	NATM Tunnel	TCS 5	2 Lane
2	0+870	0+930	60	Cut & Cover	TCS 3	2 Lane
3	0+930	1+073	143	Open Cut	TCS 4	2 Lane
Total Length			1073			

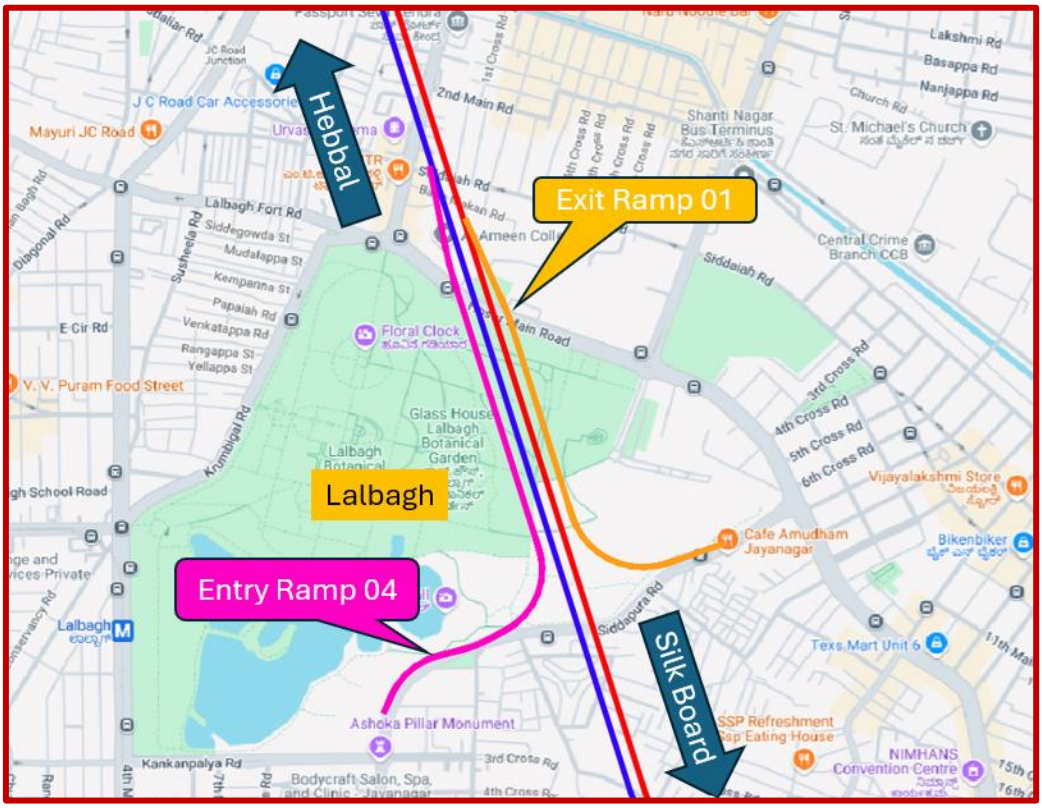


Figure 17: Entry and Exit ramp at Lalbagh

Table 27: Entry/ Exit ramps at Silk Board

Silk board						
Entry Ramp 8 (From Sarjapur Road)						
SL No	Chainage		Length	TCS Type	TCS DETAILS	Lanes
	From	To				
1	0+000	0+400	400	TCS 3	Cut & Cover	2 Lane
2	0+400	0+663	263	TCS 4	Open Cut	2 Lane
Total Length			663			
Exit Ramp 1 (Towards Sarjapur Road)						
SL No	Chainage		Length	TCS Type	TCS DETAILS	Lanes
	From	To				
1	0+000	0+240	240	TCS 3	Cut & Cover	2 Lane
2	0+240	0+454	214	TCS 4	Open Cut	2 Lane
Total Length			454			

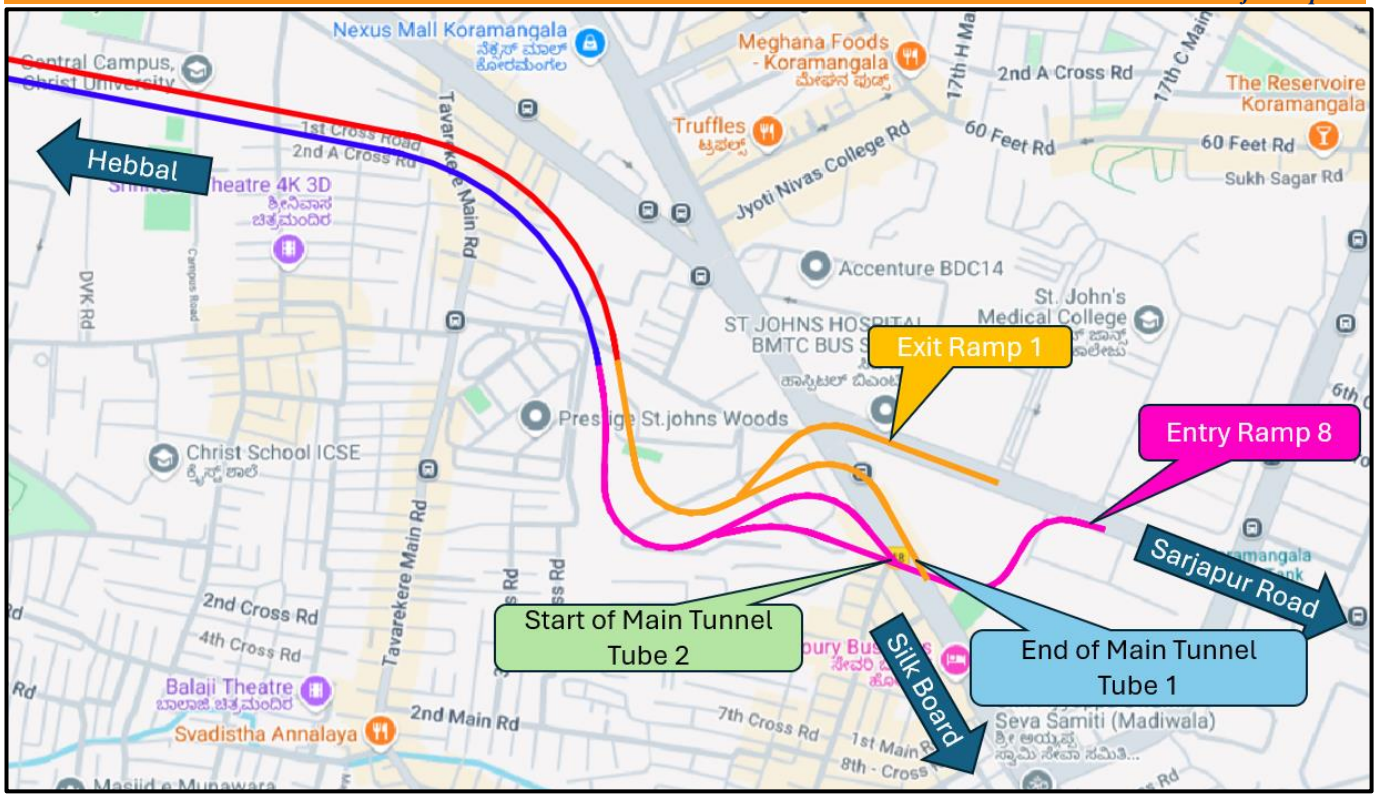


Figure 18: Entry and Exit ramp at Silk board

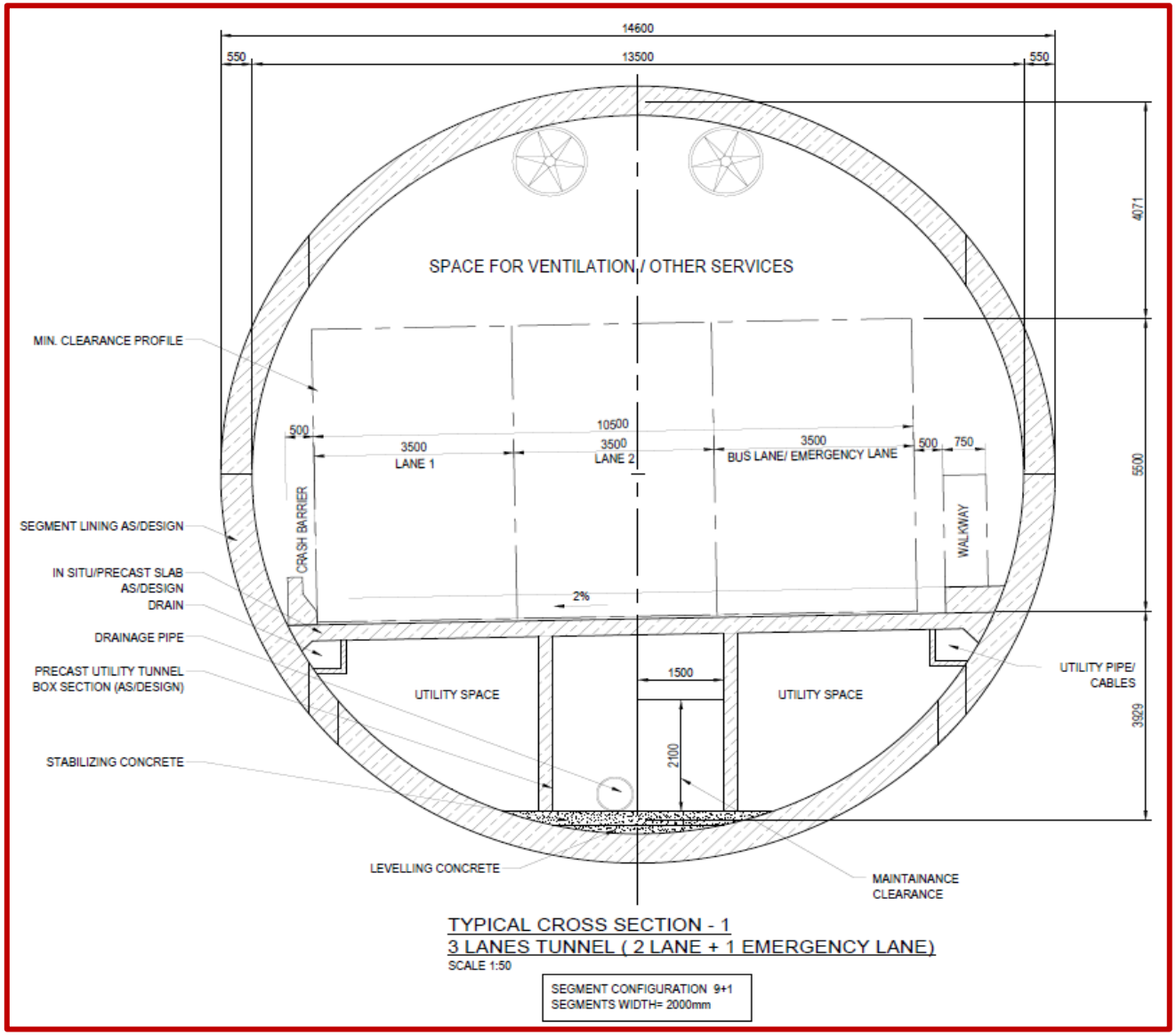


Figure 19: TCS-1, TBM Tunnel Cross-Section

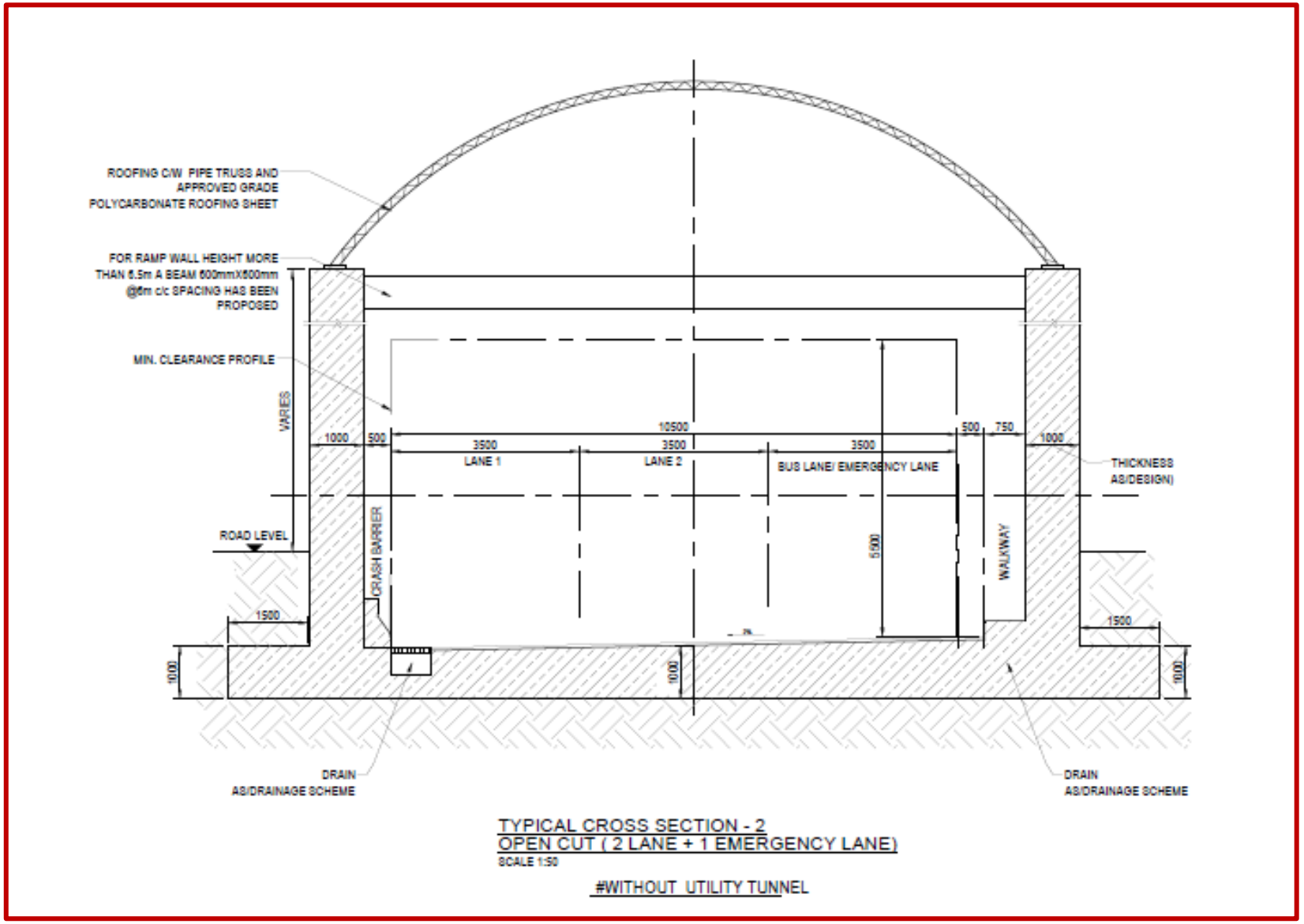


Figure 20: TCS-2, 3 lane Open Cut Section

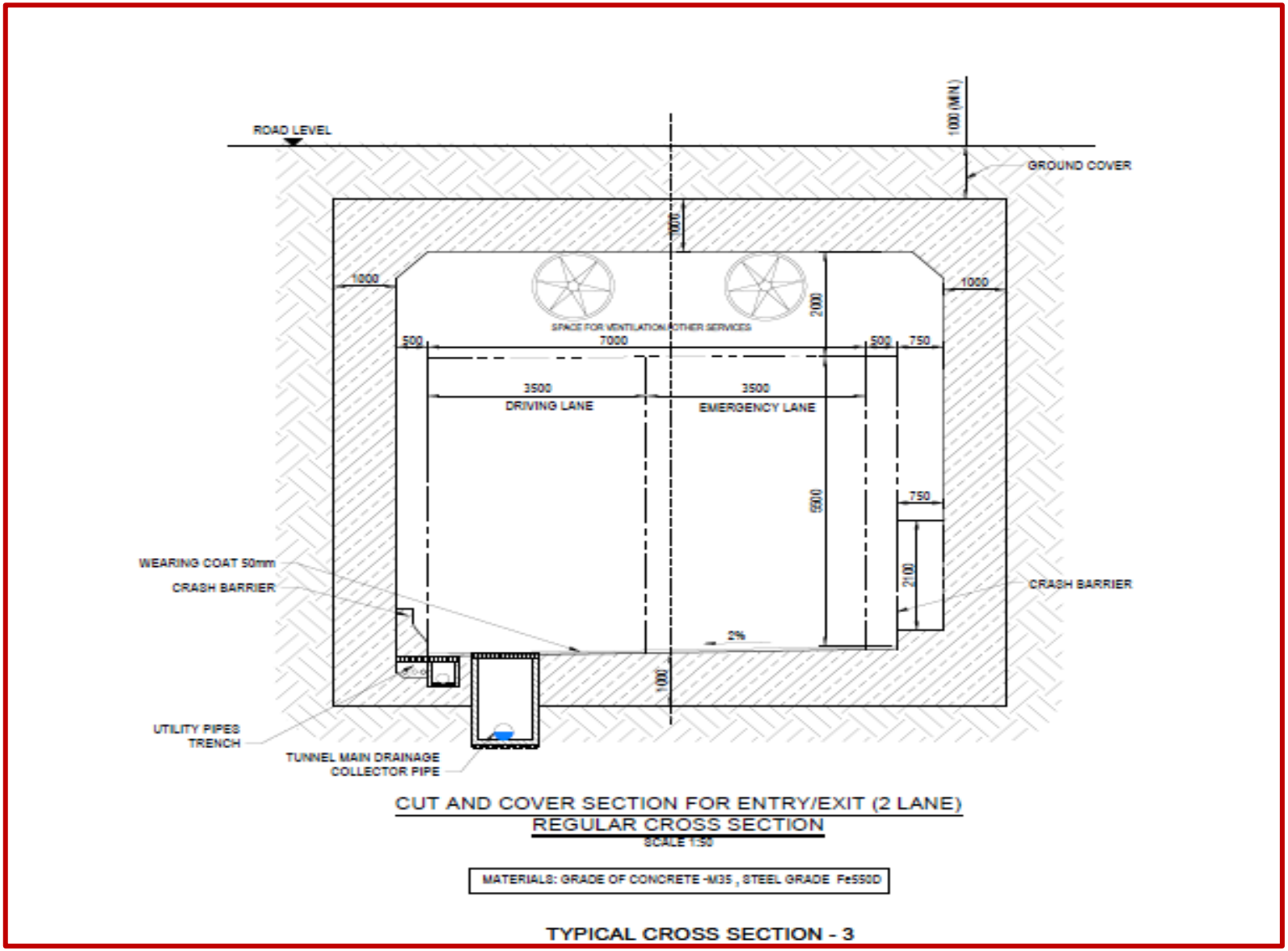


Figure 21: TCS-3, 2 lane Cut & Cover Section

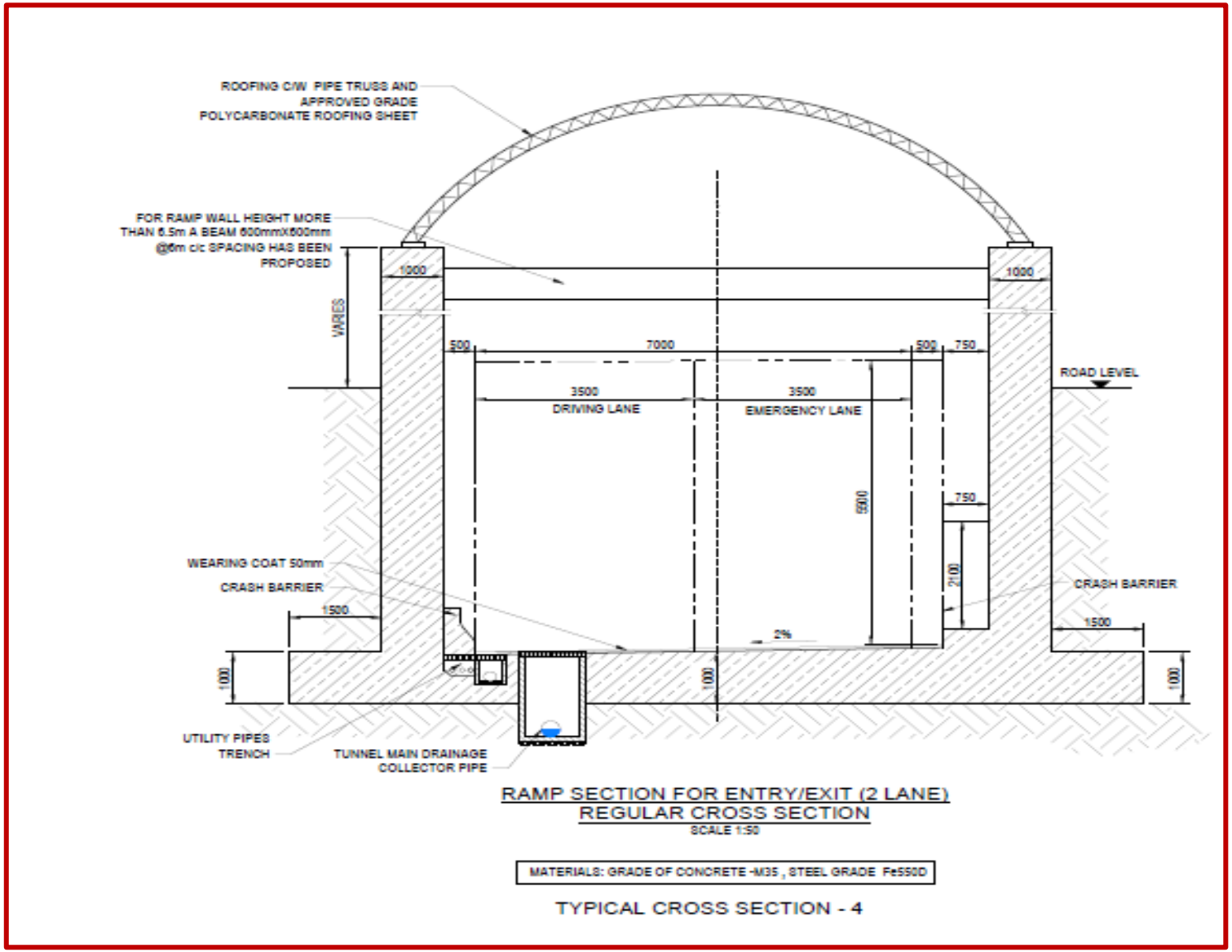


Figure 22: TCS-4, 2 lane Open Cut Section

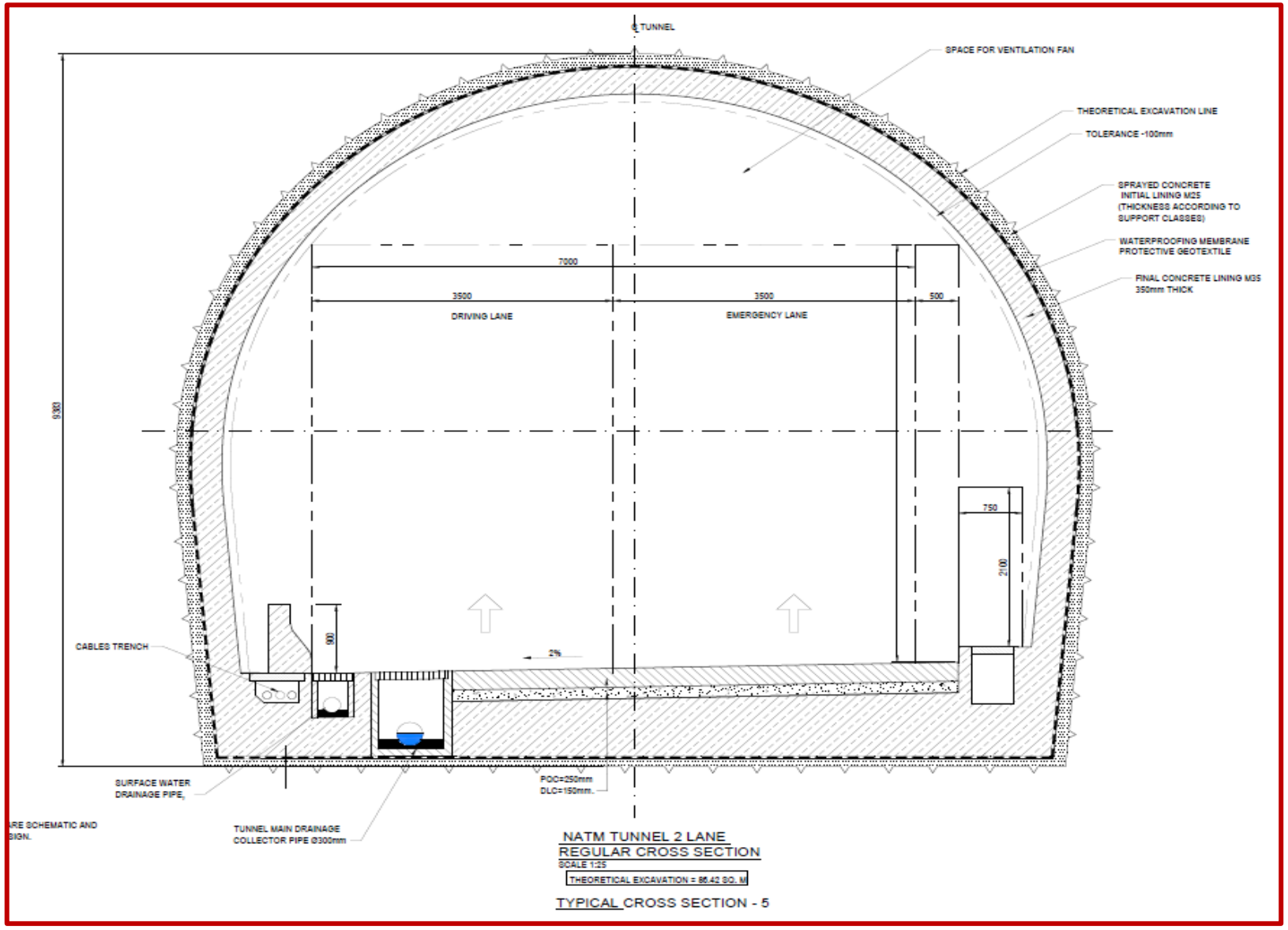


Figure 23: TCS-5, 2 lane NATM Tunnel Section

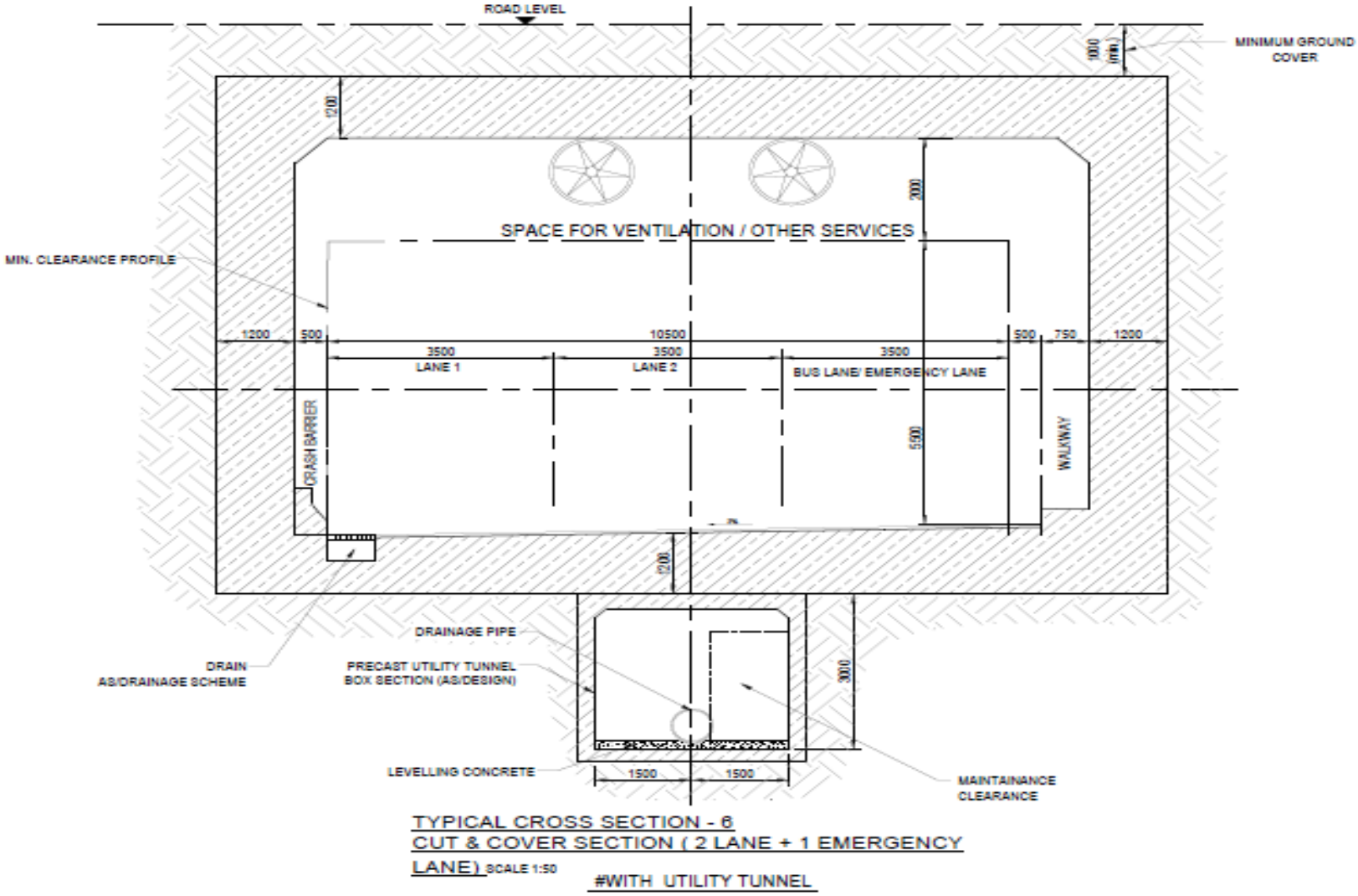


Figure 24: TCS-6, 3 lane Cut & Cover Section

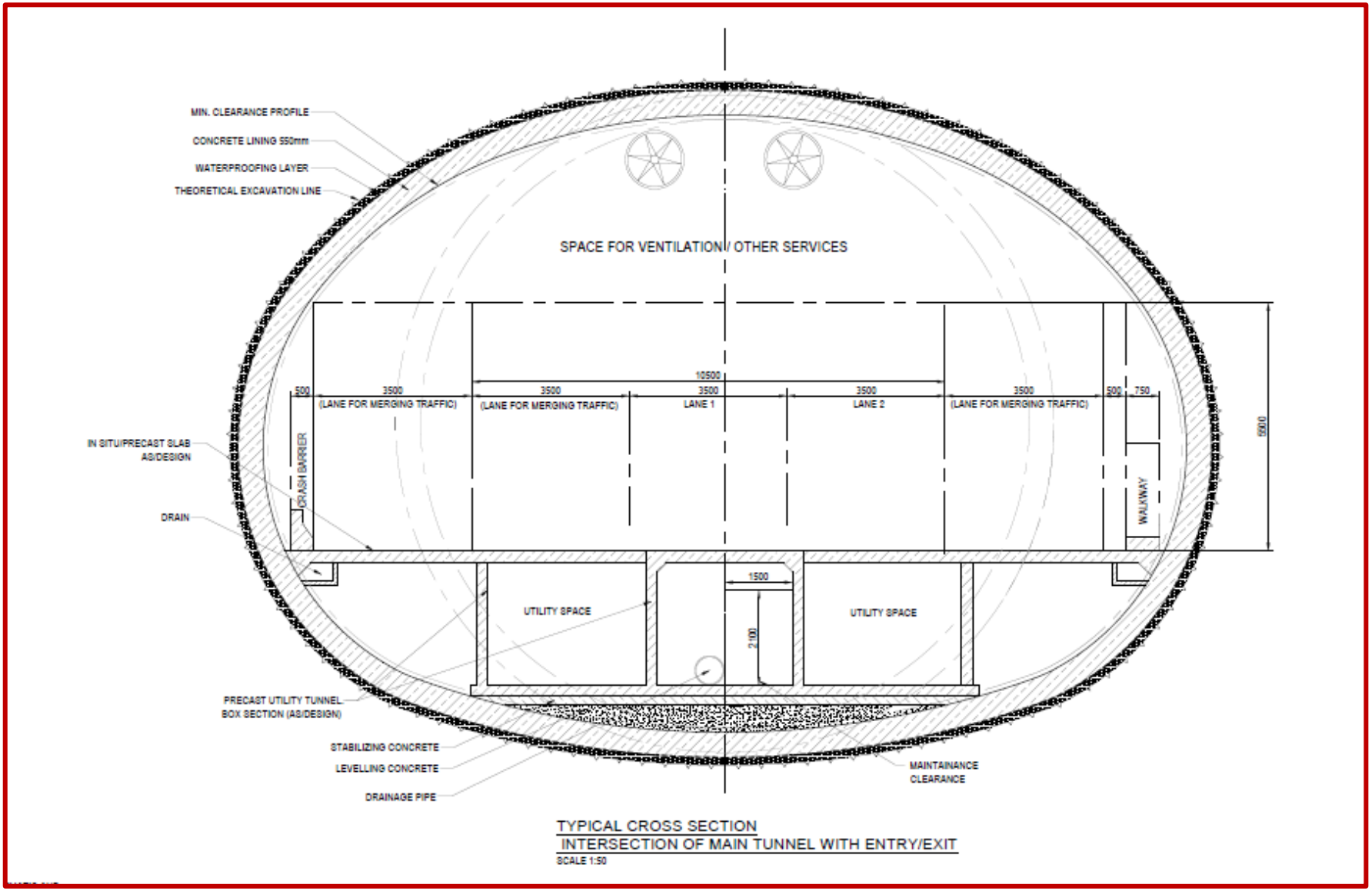


Figure 25: Typical Cross Section for merger section of Entry/ Exit Ramps & Main Tunnel

1.7.4 Tunnel spacing

The clear distance between the twin tubes shall be kept depending upon the type of strata and structural stability of the tunnel subject. However, the c/c spacing between the twin tubes shall not be less than two times the diameter of tunnel.

1.7.5 Cross Passage

The twin tube tunnels shall be connected by a cross passage at a spacing of 500 m to facilitate diversion of the traffic from one tube to other tube in the event of an incident/accident in one of the tubes. The cross passage shall have provision for one traffic lane, edge strip of 0.60 m, crash barriers and walkways on either side. In normal conditions the cross passage shall be barricaded.

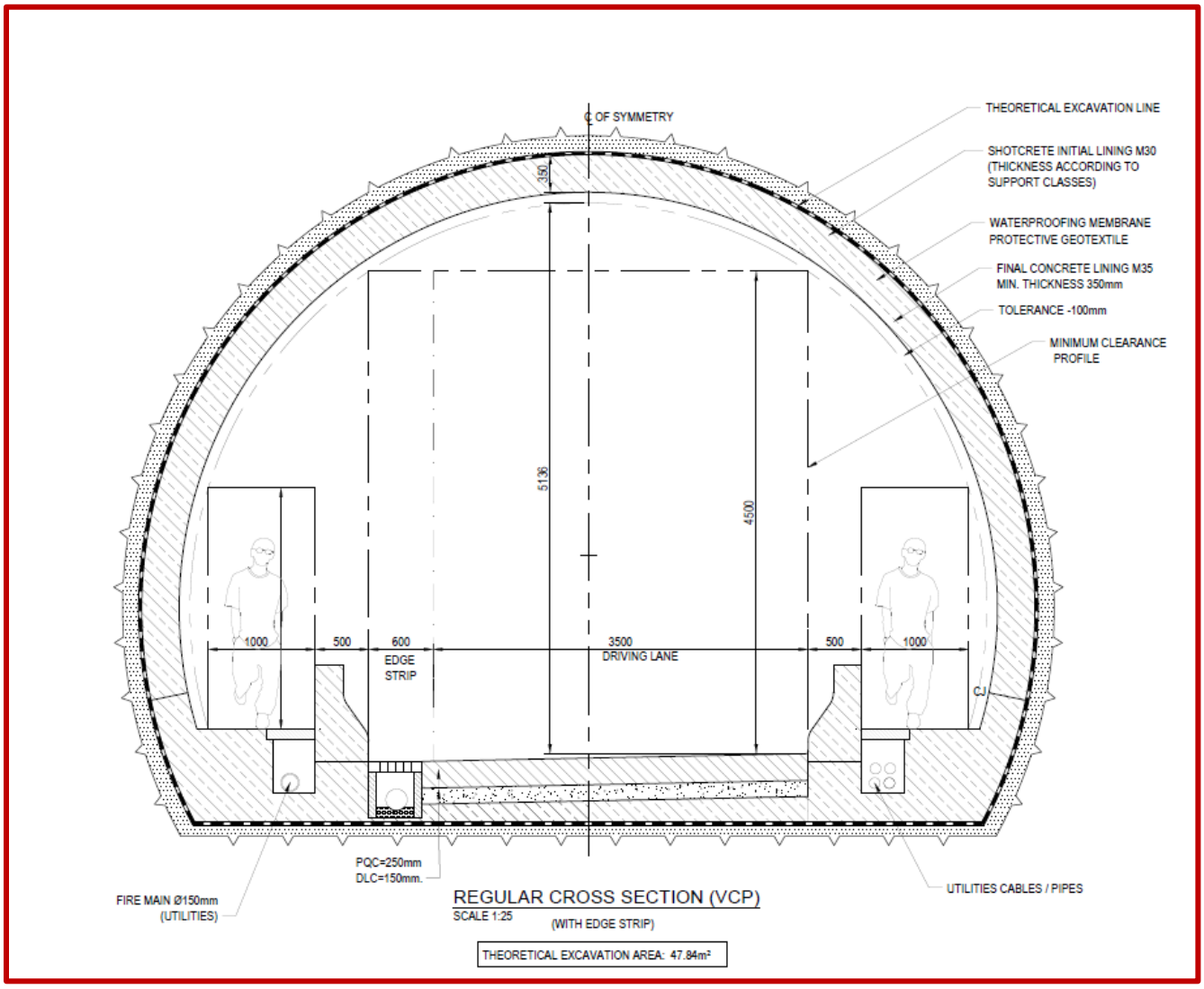


Figure 26: TCS for Tunnel Cross Passage

1.7.6 Vertical Shaft

A vertical shaft for a tunnel is a critical infrastructure component that connects the surface to underground passageways, serving multiple essential functions. Primarily, it provides access for workers and equipment,

enabling the efficient movement of personnel and materials to and from the tunnel. Additionally, these shafts play a vital role in ventilation, ensuring a continuous flow of fresh air to maintain safe working conditions below ground. The design of a vertical shaft typically considers factors such as depth, diameter, and structural integrity, often employing methods like drilling and blasting or cut-and-cover techniques for construction. Safety is paramount, with rigorous monitoring for ground stability and water ingress, as well as clear emergency egress routes for personnel. Overall, vertical shafts are indispensable in facilitating safe and efficient underground operations in tunneling projects.

Vertical Shafts has been provided at five locations i.e., Hebbal, Palace Ground, Race Course, Lalbagh and Silk Board. Dimensions of Vertical shafts are 100m x 50m.

1.7.7 Traffic Control and Safety Measures

Road Marking & Traffic Signs

Road markings will be made for centre and edge lines using reflective thermoplastic paints. Appropriate road markings will also be provided at junctions and crossings. Road signs are to placed according to IRC: 67-2012. The signs are to be placed on embankment so that extreme edge of sign would be 2.0 m away from the edge of the carriageway. The location of each sign is to be decided in accordance with the guidelines there in.

Illumination

Tunnel illumination/lighting shall be designed and provided as per MoRTH Guidelines for

Expressway, Chapter 13.5 for Tunnel Lighting.

Tunnel Furnishing

Provisions shall be made for installation of tunnel furnishing such as sign boards, firefighting arrangements, cable trays for telephone and power lines etc. in consultation with relevant local authorities.

Signages and Carriageway Markings

Variable messages signs inside the tunnel shall be provided for the information of traffic of lane blockage/closure due to incidents related to vehicles/non-vehicles, weather and human hazards etc. or maintenance operations as also to warn of possible hazard ahead due to any abnormal situation. Signage system shall be complemented by providing traffic lights above each lane at the entry portal end and inside. Signages indicating distance travelled, distance/ direction to an exit on evacuation route shall be provided inside the tunnel.

Tunnel carriageway markings consisting of a discontinuous line separating the traffic lanes and continuous line separating the lateral traffic lane from the paved shoulder and emergency lay-bye shall have good day/night visibility and conform to IRC:35. The markings shall be done by means of self-propelled machine which has a satisfactory cut-off capable of applying broken line automatically.

Ventilation

Tunnel ventilation systems should provide adequate in-tunnel air quality during normal and congested traffic operations and support the self-evacuation and rescue efforts during emergency incidents. Separately, the tunnel ventilation capacity requirements for emergency ventilation (typically for the control of smoke and hot gases during fire) must also be assessed and the system designed accordingly.

Detailed design of ventilation shall be carried out as per IRC:SP:91 keeping in view the length, shape, size, tunnel environs and complexion of the likely traffic for which tunnel has been designed. The details of design

of Tunnel Ventilation system has been given in Volume II-D.

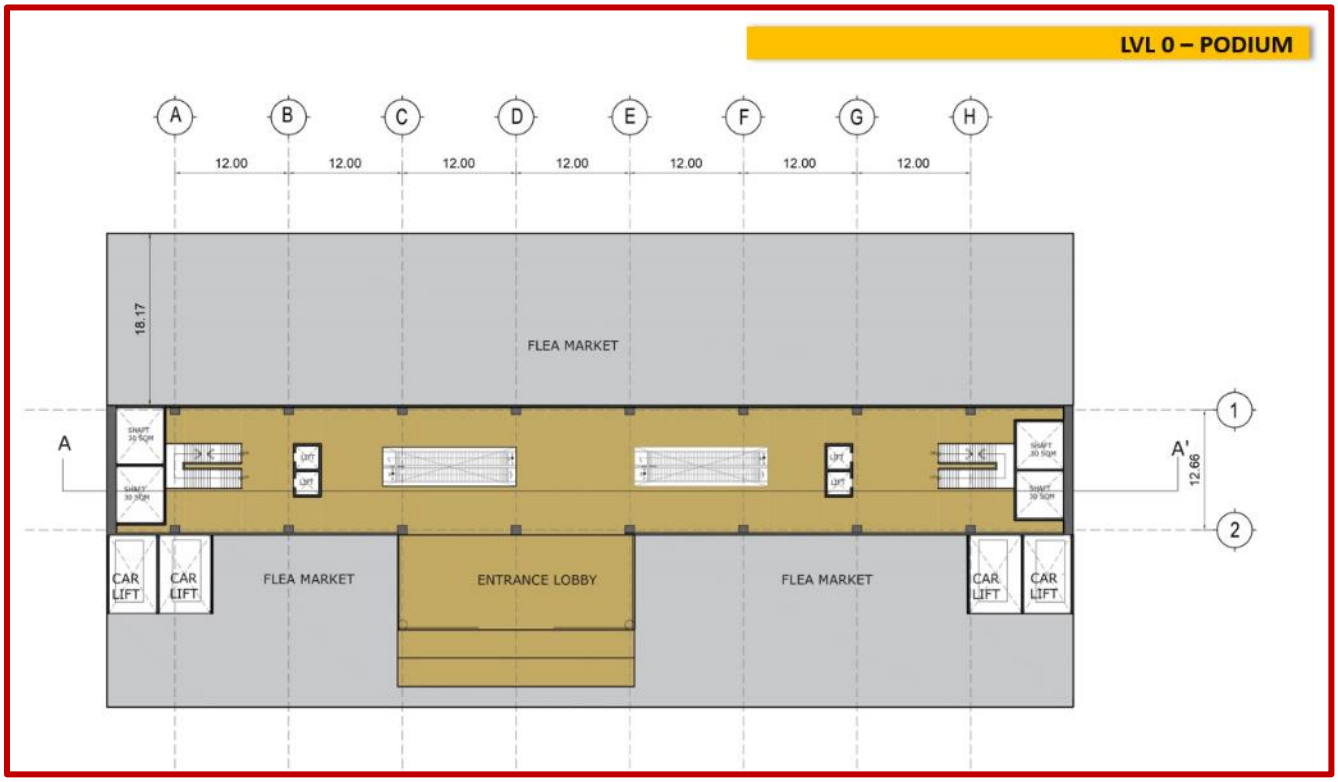
1.7.8 Inter Model Interchange Hubs

Intermodal interchange hubs for buses in tunnels are specialized facilities designed to facilitate the efficient transfer of passengers between different modes of transportation, particularly in urban settings where space is limited. The Hubs are designed to accommodate bus services alongside other transport modes, such as metros and public transport. Interchange hubs have well-planned layouts to ensure smooth passenger movement, minimizing congestion and wait times. Features may include escalators, elevators, and clear signage. Intermodal interchange hubs for buses in tunnels are essential for enhancing urban transit efficiency, safety, and sustainability, ultimately improving the passenger experience and contributing to a more effective transportation network.

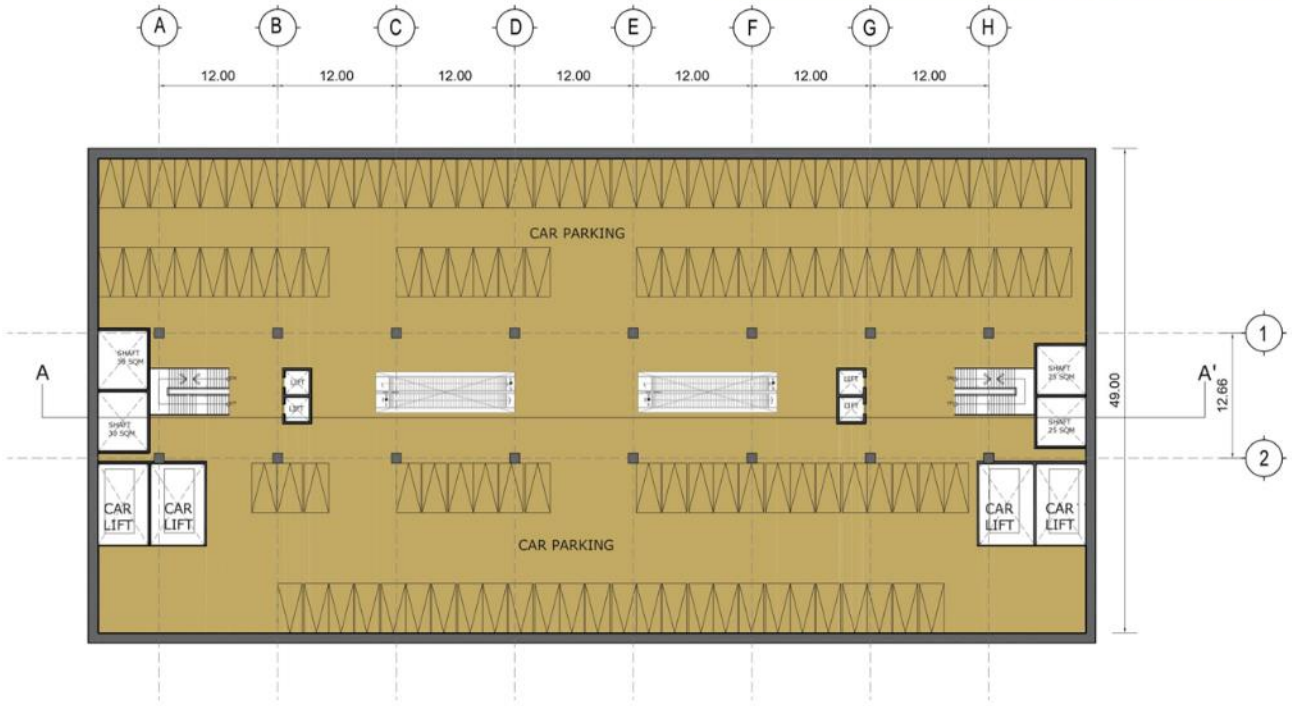
Following are the guiding principles for designing of intermodal interchange:

1. **Safety and Accessibility:** Ensure the station is safe and easily accessible for all passengers. This includes designing clear and simple navigation, providing adequate lighting and signage, and incorporating safety features such as emergency exits, fire alarms, and CCTV surveillance.
2. **Efficient Passenger Flow:** Design the station to facilitate efficient passenger flow and minimize congestion. This can be achieved by providing sufficient platform width, designing clear and intuitive routes for passengers, and incorporating features such as escalators, staircases, and elevators to facilitate easy movement between levels.
3. **Comfort and Amenities:** Create a comfortable and welcoming environment for passengers by incorporating amenities such as comfortable seating, clean and well-maintained facilities, and convenient services like Wi-Fi, charging stations, and retail outlets.
4. **Sustainability and Resilience:** Design the station with sustainability and resilience in mind. This includes incorporating energy-efficient systems, using durable and low-maintenance materials, and designing the station to withstand natural disasters and other potential disruptions.
5. **Aesthetic Appeal and Community Integration:** Create a visually appealing and unique design that reflects the local community and culture. This can be achieved by incorporating public art, using locally inspired materials and design elements, and designing the station to integrate seamlessly with the surrounding neighbourhood.

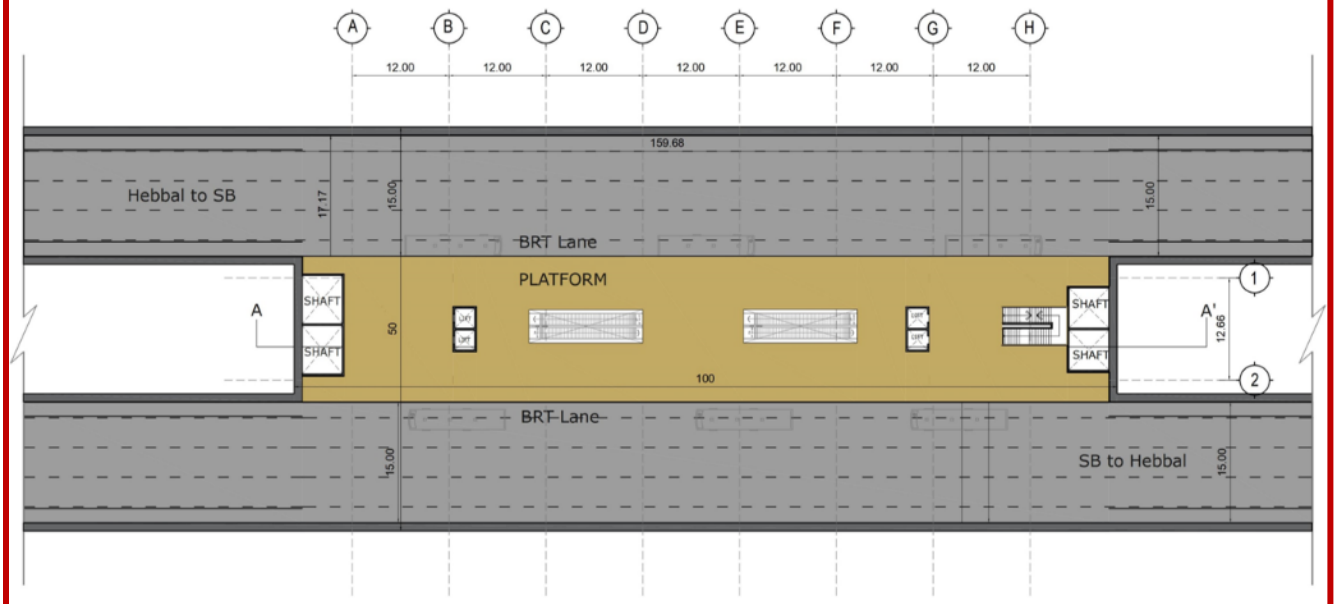
1.7.9 Conceptual layouts for Inter Model Interchange Hubs

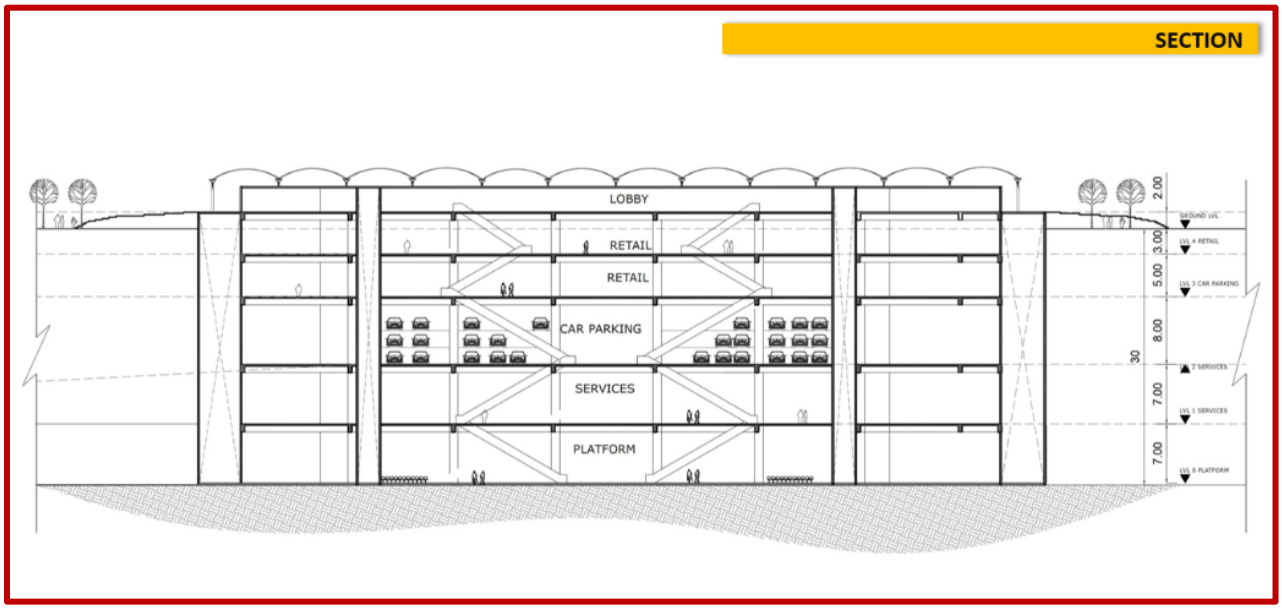


LVL 3 – CAR PARKING



LVL 5 – PLATFORM





1.7.10 Bi-articulated trolleybus

A trolley bus is an electric bus that operates by drawing power from overhead wires using two trolley poles, allowing it to move without the need for traditional fuel sources like diesel. This mode of transportation is characterized by its quiet operation and reduced emissions, making it an environmentally friendly option for urban transit.

A bi-articulated trolleybus is a type of articulated bus with two trailer sections instead of one. They are designed to transport large numbers of passengers

1.8 Design Proposal

Table 28: Geometric Design Criteria adopted (IRC 86-2018)

SL	Description	Details
1	Design Speed	60 KMPH (Arterial Road)
2	Lane Configuration on each tube (Mian Tunnel)	3 lane
3	Single lane width	3.5 m
4	Kerb Syness	0.5m
5	Lane Configuration of ramps (entry & exit)	2 lane
6	Radius of Horizontal Curve	400 m min.
7	Max. Super elevation	5%
8	Intermediate Sight Distance	240m
10	Minimum length of Vertical curve	60m
11	Cross fall camber	2.0%
12	Vertical clearances	5.5m
13	Vertical Gradient	
13A	Transition Ramp and Cut & Cover (adopted)	3-6%
13B	Tunnel	3% max.
14	Tunnel Dia Excavation Dia. Finished Dia.	 14.600m 13.500m
15	Cross Passage @ 500m interval Carriageway	29 Nos. 3.5m

SL	Description	Details
	Edge Strip	0.6m
	Crash Barrier	2 x 0.5m
	Walkway	2 x 1.0m

1.9 Safety Measures

For the safety during fire in tunnel safety measures via ventilation system has been proposed. The proposals for Road and Tunnel Markings, Smart traffic signs (VMS- Variable Message Sign Boards), Solar lights, CCTV Surveillance, Road Studs, Lights, Cat's Eye etc. as per IRC.

1.10 Preconstruction Activities

- Land Acquisition: The land acquisition will be required at tunnel approaches (Main Tunnel and intermediate ramps) in cut & cover section and open cut section Apart from it land acquisition will be required at TBM launching and retrieval location which shall be used as ventilation and inter modal terminal. The compensation to the landowner will be dealt with in accordance with the prevailing land acquisition act (State or central). The cost for Land acquisition and rehabilitation in cut & cover section has been considered in cost estimate
- Utility Shifting: The utilities shifting (Electrical, Tele communication and PHED) at the approach of the main tunnel and intermediate ramps will be required to be shifted. The cost for shifting utilities has been considered in cost estimate.
- Trees relocation: Trees coming under tunnel, intermediate ramps approaches (cut & cover and open cut section), Vertical Shaft locations will be required to be relocated. The cost of tree relocation and plantation has been considered in Cost Estimate. The requirement of tree plantation will be dealt with in accordance with MOEF guidelines.

1.11 Environmental Impact Assessment

The EIA notification S.O.1533 dated 14th September 2006 imposes certain restrictions and prohibitions on new projects or activities, or on the expansion or modernization of existing projects or activities based on their potential environmental impacts as indicated in the schedule to the notification, being undertaken in any part of India.

The notification has listed out the Projects or activities requiring prior environmental clearance under Category "A" and "B" based on the spatial extent of potential impacts, and the intensity of those impacts on human health and natural and manmade resources. Category "A" projects require prior environmental clearance from MoEF&CC (Ministry of Environment, Forests and Climate Change) on the recommendations of an Expert Appraisal Committee (EAC) and Category "B" projects require prior environmental clearance from State or Union territory Level Environment Impact Assessment Authority (SEIAA) on the recommendations of a State or Union Territory Level Expert Appraisal Committee (SEAC).

As per the notification, new National Highways and expansion of National Highways greater than 100 km, involving additional right of way or land acquisition greater than 40m on existing alignments and 60m on realignments or by-passes is categorized as "A."

All New State Highway projects: and State Highway expansion projects in hilly terrain (above 1,000 m AMSL) and or ecologically sensitive areas are categorized as "B." Any project specified in Category 'B' will be treated as Category A, if located in whole or in part within 5 km from the boundary of

- Protected Areas notified under the Wildlife (Protection) Act, 1972,
- Critically Polluted areas as notified by the Central Pollution Control Board from time to time,
- Eco-sensitive areas as notified under section 3 of the Environment (Protection) act, 1986, such as, Mahabaleshwar Panchgani, Matheran, Pachmarhi, Dahanu, Doon Valley, and (iv) inter-State boundaries and international boundaries

The proposed 18 km tunnel road between Central Silk Board junction to the Esteem Mall junction near the Hebbal flyover does not come under the purview of either category A of category B projects as per the notification of MoEFCC. Hence this does not call for any detailed EIA and public hearing from the regulatory point of view.

There is no regulatory requirement for carrying out environmental impact assessment for the said tunnel road project. However, evaluation comprising of socio-economic and environmental impacts will be carried out and suggested mitigation measures will be documented.

1.12 Construction Time and Phasing

The project is proposed to be completed in 61 months considering methodology of construction and the time required for procurement, transportation, mobilization and initial drive of Tunnel Boring Machines (TBM). It is presumed that six TBMs shall be driven in different sections simultaneously.

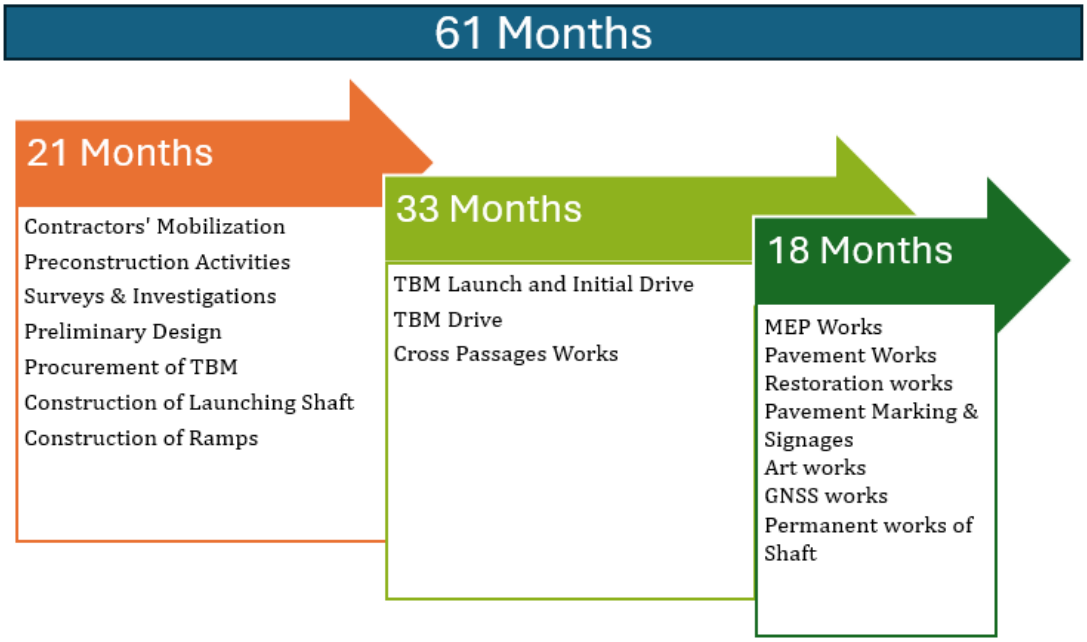


Figure 27: Phasing and Construction Time

1.13 Cost Estimate

1.13.1 General

Cost estimation is an important component of the study as it provides vital input & financial evaluation and insights for proper planning of project execution. Over and above construction costs, provision has been made for land acquisition social and environmental mitigation measures. Cost Estimates are done based on the

detailed engineering designs and detailed drawings presented in drawing volume.

1.13.2 Methodology

The cost of the tunnel, cut & cover and open cover sections has been worked out based on the cross-sections and the plan and other drawings for the project.

Tentative preliminary locations for TBM lowering shaft have been identified and suitably quantified for the cost estimation. The quantification of various items of work related to tunnels have been detailed out from the structural drawings.

Quantities of traffic signs, marking and other road appurtenances and various project facilities are worked out in the plan drawing and costing has been accordingly.

1.13.3 Unite Rates of Materials

The Rates of materials for different components of project is referred from the government issued data and prevailing market rates.

- SOR 2023-24 Karnataka for Zone 1
- Some rates have been taken from similar referral projects and market rates.
- Rate of special components such as TBM, Tunnel Ventilation and firefighting systems, Lighting and electrical components are taken from market.
- For the Control centre Building rates has been taken from Delhi Schedule of Rate 2023.
- MoRTH Standard Data book 2019.
- Electromechanical works in tunnel section has been takes as 8% of total tunnel cost.
- The Cost of High Capacity and high-speed buses with driving and trailing coaches (Neo Bus System) has been taken from other reference projects.
- GPS/GNSS Toll Rates have been taken from market.
- The cost of Tunnel Boring Machines has been based on inquiry from Herrenknecht AG. Six number TBM have been considered and 50% buy back cost has been considered at the end of the project.
- A lead of 45 Km has been considered for muck disposal and concrete/ precast concrete items.

1.13.4 Labour Rate

As per the Schedule of Rates, the labour wages as fixed by the State Government are to be taken for that area. Accordingly, the labour rate of Karnataka, Schedule of Rates-2023-24.

1.13.5 Plant and Machinery Rate

Plant and Machinery Rate has been considered from MoRT&H Standard Data Book 2019 for Analysis of Rates and have been escalated to 2024 on Wholesale price index basis. Where the rates of plant and machinery are not available in MoRT&H Standard Data Book and Karnataka Schedules of rate, market rates have been adopted.

1.13.6 Overhead, Contractor's Profit and Other components

The rates of materials, labour and Plant & Machinery derived as per above were used for analysis of items rate.

Overheads charges for Road Tunnel Works has been considered for this project as per MoRT&H Standard Data Book @ 25% for large projects having cost more than Rs. 1000 crores.

- Contractor profit @ 10% is adopted.
- GST @ 18% on Construction Cost.
- Contingencies @ 1 % on Construction cost.
- Supervision charges of 2% on Construction cost.

1.13.7 Summary of Cost Estimate

Table 29: Summary of Cost

S.No	Description	Length (km)	Rate	Total Amount in Rs.	Total Amount (Rs. in Crores)
BILL NO. 1	Site Clearance			78,89,328.33	0.79
BILL NO. 2	Earth Works			63,05,013.00	0.63
	Sub Total (Bill-1+Bill-2)			**1,41,94,341.33**	**1.42**
BILL NO. 3	**Tunnel Work**				
A	Main Tunnel				
a.	Tunnelling By TBM (Twin Tunnel)	14.54	415.70	60,44,26,70,696.60	6,044.27
b.	Cross Passages (27 No's)			28,88,85,247.22	28.89
c.	Cut And Cover Tunnel	4.08	238.96	9,74,95,68,000.00	974.96
d.	Open Cut (Ramps)	1.53	77.03	1,17,70,18,400.00	117.70
e.	Shafts (5 No's)			2,65,53,79,134.97	265.54
f.	Buildings (Control Center)			15,44,08,200.00	15.44
B	Intermediate Entry/Exit				
a.	Open Cut (Ramps)	3.67	72.77	2,67,35,69,800.00	267.36
b.	Cut And Cover Tunnel	4.26	219.46	9,34,89,96,000.00	934.90
c.	NATM Tunnel	8.61	87.02	7,48,98,11,400.00	748.98
C	**Sub Total Cost Of Tunnel Works(A+B)**			**93,98,03,06,878.80**	**9,398.03**
D	Electro- Mechanical Works @ 8% Of C			7,51,84,24,550.30	751.84
E	Tunnel Ventilation & Fire Fighting			4,84,73,00,000.00	484.73
G	**Pavement**			46,08,95,480.54	46.09
H	Inter Modal Logistic Building			6,08,81,90,000.00	608.82
BILL NO. 4	Traffic Signs, Markings, Crash Barrier Appurtenances			32,42,87,806.70	32.43
BILL NO. 5	**Road Restoration and Development**				
a.	Reclamation Of Existing Road in Approach Area & Ramps			68,00,75,000.00	68.01
b.	Street level Development near shaft Location (Road, Footpath, Lighting etc.)			30,00,00,000.00	30.00
c.	Junction Development			11,56,51,855.12	11.57

S.No	Description	Length (km)	Rate	Total Amount in Rs.	Total Amount (Rs. in Crores)
BILL NO. 6	Safety, Environmental Management Plan and Traffic Management During Construction @ 0.25% on **(C) Cost of Tunnel Works.**			23,49,50,767.20	23.50
BILL NO.7	High-Capacity & High-Speed Busses with Driving And Trailing Coaches (Neo-Bus System)				
a.	Traction & Power Supply (OHE)			50,00,00,000.00	50.00
b.	Telecommunication & Passenger Information System			10,00,00,000.00	10.00
c.	Fare Collection System			5,00,00,000.00	5.00
d.	Articulated Coach of Minimum 18 M Length			40,00,00,000.00	40.00
BILL NO. 8	Miscellaneous (Trees, Artwork in Tunnel, Construction Depot & Casting Yard, Tree Trans Plantation And Landscaping etc.)			65,08,23,320.00	65.08
BILL NO. 9	GPS/GNSS-Based Tolling	10.00	1.10	11,00,00,000.00	11.00
B) Estimated Construction Cost Without GST				**1,16,37,51,00,000.00**	**11,637.51**
GST @ 18% Payable on Construction Cost Only (On B)				20,94,75,18,000.00	2,094.75
C) Construction Cost Including GST				**1,37,32,26,18,000.00**	**13,732**
Contingencies @ 1% Of (B)				1,16,37,51,000.00	116.38
Construction Supervision Charges @ 2% Of (B)				2,32,75,02,000.00	232.75
D) Total Cost Including Centages				**1,40,81,38,71,000.00**	**14,081.39**
Land Acquisition, Resettlement, Rehabilitation Cost				8,00,00,00,000.00	800.00
Utility Shifting Cost				1,00,00,00,000.00	100.00
E) Total Project Cost (Sum of All the Above)				**1,49,81,38,71,000.00**	**14,981.39**

1.14 Financial Model

Financial viability has been carried out for concession period of 25-30 years excluding the construction period of five years for the present project corridor of length with two options with the following parameters with varying the subsidy up to 40%. The basic methodology followed for estimating the financial viability of the project is to calculate the FIRR (Financial Internal Rate of Return) on the investment for the project.

Based on the project cost, traffic study and toll rate analysis, operation and maintenance ,the financial viability analysis has been carried out as per the methodology outlined in financial chapter. The Returns on Investment and Returns on Equity for 30 years concession period with maximum subsidy up to 40% has been estimated and the summary of results for each scenario is given in Tables below.

The detailed analysis has been mentioned in Chapter xx of the main report along with its Annexures.

Table 30: Results in BOT Mode for 5+ 25 years of Concession period

Deciding factor	No Grant	With 20% Grant	With 30% Grant	With 40% Grant
Project IRR	10.81%	12.68%	13.86%	15.29%
Equity IRR	10.13%	13.28%	15.36%	17.92%
DSCR	1.37	1.68	1.90	2.2
NPV	-1213.55	588.90	1476.00	2347.96
Remark	Not Viable	Not Viable	Viable	Viable

Table 31: Results in BOT Mode for 5+ 30 years of Concession period.

Deciding factor	No Grant	With 20% Grant	With 30% Grant	With 40% Grant
Project IRR	11.61%	13.34%	14.45%	15.80%
Equity IRR	11.52%	14.32%	16.19%	18.55%
DSCR	1.37	1.68	1.90	2.20
NPV	-461.13	1340.83	2227.68	3099.41
Remark	Not Viable	Not Viable	Viable	Viable

1.15 Economic Benefits

The project will have direct and indirect benefits for the project influence areas and the commuters.

Economic benefits

- Saving in Vehicle operating cost, with reduction in wear and tear of vehicle components.
- Improved connectivity by providing congestion-free traffic over the project.
- Fuel savings due to reduced congestions.
- Increased employment opportunity for the local population during the construction and maintenance period.

Environment Benefits

- Reduced Emission of air pollutants and lower damage to environment due to pollution.
- Lower impact on environment by reducing greenhouse gas emissions increasing the health benefits for the city population.

Road Safety

- Reduced accidents and injuries due to good infrastructure with road safety provisions all along the corridor.
- Minimum effect on the need of land acquisition and Rehabilitation and relocation activities.

1.16 Conclusion and Recommendation

The project may be executed through BOT mode of construction as it is viable for 30 years concession period (5+25 years) with 30% of VGF

CHAPTER 2
SCOPE OF WORK

CHAPTER 2: SCOPE OF WORK

The project underlines the scope of work of the consultant and the deliverable planned at different stags of the project. A brief description of the Terms and reference (TOR) and deliverables are presented in the report. However, for the detailed Scope of work, TOR can be referred from the Contract Agreement.

2.1. Objective and Broad Scope of Work.

Detailed scope of work is presented below,

a. Traffic surveys and demand assessment

b. Engineering surveys and investigations

c. Location, layout and type of toll collection and toll plazas

d. Concept plan, detailed plan, virtual drive through, 3D Model with detachable segment to view a realistic Tunnel alignment etc.

e. Location and layout of approach ramps, loops ramps, interchanges and lay byes,

f. Vertical shafts, escape shafts etc.

g. Location and layout of bus bays and bus shelters at the interchange.

h. Social impact assessment.

i. Environment impact assessment.

j. Preliminary Typical designs of road, bridges, structures, etc.

k. Preparation of Land Plan Schedules.

l. Preparation of state-of-the-art Utility Relocation Plans.

m. Preparation of detailed BOQ and detailed Cost Estimates.

n. Preparation of RFP Document for main component work tender i.e., DPR.

o. Preparation of conceptual plans for road-side amenities and Land Acquisition drawings.

p. Physical facilities necessary for Advanced Traffic Management System (ATMS).

q. Survey of existing borewells, water bodies, building structures, pile foundations of major and multi storied structures along the alignment

r. Precautionary measures for construction of tunnel road.

s. Detailed design and drawings for fire safety and all other safety measures to be incorporated.

The above-mentioned work has been bifurcated in various stages of deliverables.

2.2. Stages of Deliverables

As per the TOR of the Contract Agreement following stages of deliverables are to be submitted.

Stage 1. Inception Report

On commencement of the Consultancy, the Inception Report. The Inception Report shall be submitted which will include (i) understanding the RFP and the Work Plan, (ii) Consultants team mobilization, (iii) survey and investigation plana and (iv) overall approach towards the assignment and deliverables

Stage 2. Draft Project Report

- Report on Available Data and Plans
- Report on Traffic Survey
- Development Proposal

Stage 3. Final Project Report

- Including the comments on draft report.

Stage 4. Draft Comprehensive Road Infrastructure Plan

- A Draft Project Report- Including Investigation report, Preliminary Designs, Set of General Arrangements of Drawings, Preliminary Costing
- Land Plan Schedules
- Utility Relocation Plans
- Report on Environment and Social Impact Assessment and
- Report on Indicative GAD's

Stage 5. Final Comprehensive Road Infrastructure Plan

- Final Report of above-mentioned reports.

2.3. Draft Detailed Project Report

This project report consists of deliverables of stage 2 and stage 4 as per the Terms of Reference of Contract Agreement.

Table 32: Description of data and reference locations

Description	Reference
Stage 2.	
Report on Available Data and Plans	Chapter 03
Report on Traffic Survey	Chapter 07
Development Proposal	Chapter 08
Stage 4.	
A Draft Project Report- Including Investigation report, Preliminary Designs, Set of General Arrangements of Drawings, Preliminary Costing	Chapter 08 and Volume V- Drawings
Land Plan Schedules	Under Progress
Utility Relocation Plans	Under Progress
Report on Environment and Social Impact Assessment and	Chapter 10
Report on Indicative GAD's	Chapter 8 , of Main Report, Volume-II B: Structural Design Report, Volume-II C: Electrical Design Report, Volume-II D: Ventilation Design Report and Volume V Drawings .

This stage is the draft project report stage. And the deliverables have been divided into volumes. The submission has the following volumes along with this Project Main Report.

- Volume-I: Main Report with Annexure
- Volume-II A: Geotech Design Report
- Volume-II B: Structural Design Report
- Volume-II C: Electrical Design Report
- Volume-II D: Ventilation Design Report
- Volume-III: Geotechnical Interpretive Report
- Volume-IV: Preliminary Cost
- Volume-V: Drawings

This Main Volume consists of 13 number of chapters which focuses on each aspect of project varying from investigations, design standards, cost and conclusion and recommendation. The chapters are as follows.

- Chapter 1: Executive Summary
- Chapter 2: Scope of Work
- Chapter 3: Social and Economic Profile
- Chapter 4: Available Data Plans
- Chapter 5: Alignment Study
- Chapter 6: Engineering Survey and Investigation
- Chapter 7: Traffic Study and Analysis
- Chapter 8: Improvement Proposals
- Chapter 9: Cost Estimation
- Chapter 10: Financial Analysis and Economic Benefits

CHAPTER 3
SOCIAL AND ECONOMIC PROFILE

CHAPTER 3: SOCIAL AND ECONOMIC PROFILE

3.1 Introduction

The project influence areas of the proposed project are located in the Bengaluru City of Bangalore Urban district in the state of Karnataka.

3.1.1 General

The description of socio-economic features of the state and districts through which the project road traverses comprise the demographic, social and economic aspect of the population, it includes the features of population distribution, density of population, workforce and share of workers in major economic categories, and the vulnerable groups.

The physical and socio-economic profile of the state and districts concerned are illustrated separately in the following sections.

3.2 Karnataka State

Karnataka is a state in the southwestern region of India. It was formed as Mysore State on 1st November 1956, with the passage of the States Reorganisation Act, and renamed Karnataka in 1973. The state is bordered by the Lakshadweep Sea to the west, Goa to the northwest, Maharashtra to the north, Telangana to the northeast, Andhra Pradesh to the east, Tamil Nadu to the southeast, and Kerala to the southwest. With 61,130,704 inhabitants at the 2011 census, Karnataka is the eighth-largest state by population, comprising 31 districts. With 15,257,000 residents, the state capital Bangalore is the largest city of Karnataka.

The economy of Karnataka is one of the most productive in comparison to other states in the country, with ₹20.5 trillion (US$260 billion) in gross domestic product and a per capita GDP of ₹305,000 (US$3,800). The state of Karnataka has one of the highest economic growth rates comparatively to other states in the country, with a GSDP (Gross State Domestic Product) growth of 9.5% in the 2021–22 fiscal year. After Bangalore Urban, Dakshina Kannada, Hubli-Dharwad, and Belagavi districts contribute the highest revenue to the state respectively. The capital of the state, Bangalore, is known as the Silicon Valley of India, for its immense contributions to the country's information technology sector. A total of 1,973 companies in the state were found to have been involved in the IT sector as of 2007.

Karnataka is the only southern state to have land borders with all of the other four southern Indian sister states. The state covers an area of 191,791 km2 (74,051 sq mi), or 5.83 per cent of the total geographical area of India. It is the sixth-largest Indian state by area. Kannada, one of the classical languages of India, is the most widely spoken and official language of the state. Other minority languages spoken include Urdu, Konkani, Marathi, Tulu, Tamil, Telugu, Malayalam, Kodava and Beary. Karnataka also contains some of the only villages in India where Sanskrit is primarily spoken.

3.2.1 Geography

The Indian State of Karnataka is located between 11°30' North and 18°30' North latitudes and between 74° East and 78°30' East longitude. It is situated on a tableland where the Western Ghats and Eastern Ghats converge into the complex, in the western part of the Deccan Peninsular region of India. The State is bounded by Maharashtra and Goa States in the north and northwest; by the Lakshadweep Sea in the west; by Kerala in the south-west and Tamil Nadu in the south and south-east, Andhra Pradesh in the south-east and east and Telangana in the north-east. Karnataka extends to about 850 km (530 mi) from north to south and about 450 km (280 mi) from east to west.

Karnataka is situated in the Deccan Plateau and is bordered by the Arabian Sea to the west, Goa to the northwest, Maharashtra to the north, Andhra Pradesh to the southeast and east, Telangana to the east, Tamil Nadu to the south and southeast, and Kerala to the southwest. It is situated at the angle where the Western Ghats and Eastern Ghats of South India converge into the Nilgiri hills. The highest point in Karnataka is the Mullayanagiri hill in Chikkamagaluru district which has an altitude of 1,929 metres (6,329 ft) above sea level.

Karnataka consists of four main types of geological formations – the Archean complex made up of Dharwad schists and granitic gneisses, the Proterozoic non-fossiliferous sedimentary formations of the Kaladgi and Bhima series, the Deccan trappean and intertrappean deposits and the tertiary and recent laterites and alluvial deposits. Laterite cappings that are found in many districts over the Deccan Traps were formed after the cessation of volcanic activity in the early tertiary period. Eleven groups of soil orders are found in Karnataka, viz. Entisols, Inceptisols, Mollisols, Spodosols, Alfisols, Ultisols, Oxisols, Aridisols, Vertisols, Andisols and Histosols. Depending on the agricultural capability of the soil, the soil types are divided into six types, viz. red, lateritic, black, alluvio-colluvial, forest and coastal soils.

About 38,284 km2 (14,782 sq mi) of Karnataka (i.e. 16% of the state's geographic area) is covered by forests. The forests are classified as reserved, protected, unclosed, village and private forests. The percentage of forested area is slightly less than the all-India average of about 23%, and significantly less than the 33% prescribed in the National Forest Policy.

3.2.2 Soil types

Eleven groups of soil orders are found in Karnataka. Entisols, Inceptisols, Mollisols, Spodosols, Alfisols, Ultisols, Oxisols, Aridisols, Vertisols, Andisols and Histosols. Depending on the agricultural capability of the soil, the soil types are divided into six types., Red, lateritic (lateritic soil is found in bidar and kolar district), black, alluvio-colluvial, forest and coastal soils. The common types of soil groups found in Karnataka are:

- Red soils: Red gravelly loam soil, Red loam soil, Red gravelly clay soil, Red clay soil
- Black soil: gravelly soil, loose, black soil, basalt deposits
- Lateritic soils: Lateritic gravelly soil, Lateritic soil
- Black soils: Deep black soil, Medium deep black soil, Shallow black soil
- Alluvio-Colluvial Soils: Non-saline, saline and sodic
- Forest soil: Brown forest soil
- Coastal soil:Coastal alluvial soil

3.2.3 Water Resources

With a surface water potential of about 102 kilometers (63 mi), Karnataka accounts for about six percent of the country's surface water resources. Around 60% of this is provided by the west flowing rivers while the remaining comes from the east flowing rivers. There are seven river basins in all formed by the Godavari, Kaveri, Krishna, the west-flowing rivers, Penna, Ponniyar, and Palar.

3.2.4 Rainfall

The southwest monsoon accounts for almost 80% of the rainfall that the state receives. The annual rainfall across the state ranges from low 50 cm (20 in) to copious 350 cm (140 in). The districts of Vijapura, Raichuru, Ballari, Yadagiri and Southern half of Kalaburagi experience the lowest rainfall ranging from 50 to 60 cm (24 in) while the west coastal region and Malenadu enjoy the highest rainfall.

3.2.5 Mineral resource

Karnataka is rich in mineral wealth which is distributed fairly evenly across the state. Karnataka's Geological Survey department started in 1880 is one of the oldest in the country. Rich deposits of asbestos, bauxite, chromite, dolomite, gold, iron ore, kaolin, limestone, magnesite, Manganese, ochre, quartz, and silica sand are found in the state. Karnataka is also a major producer of felsite, molding sand (63%), and fuchsite quartzite (57%) in the country.

Karnataka has two major centres of gold mining in the state Kolar and Raichur. These mines produce about 3000 kg of gold per annum which accounts for almost 84% of the country's production. Karnataka has very rich deposits of high-grade iron and manganese ores to the tune of 1,000 million tonnes. Most of the iron ores are concentrated around the Ballari-Hosapete region. Karnataka with a granite rock spread of over 4200 km² is also famous for its Ornamental Granites with different hues.

3.2.6 Climate

Karnataka experiences four seasons. The winter in January and February is followed by summer between March and May, the monsoon season between June and September and the post-monsoon season from October till December. Meteorologically, Karnataka is divided into three zones – coastal, north interior and south interior. Of these, the coastal zone receives the heaviest rainfall with an average rainfall of about 3,638.5 mm (143 in) per annum, far in excess of the state average of 1,139 mm (45 in). Amagaon in Khanapura taluka of Belgaum district received 10,068 mm (396 in) of rainfall in 2010. In 2014 Kokalli in Sirsi taluka of Uttara Kannada district received 8,746 mm (344 in) of rainfall. Agumbe in Thirthahalli taluka and Hulikal of Hosanagara taluka in Shimoga district were the rainiest cities in Karnataka, situated in one of the wettest regions in the world.

The state is projected to warm about 2.0 °C (4 °F) by 2030. The monsoon is set to provide less rainfall. Agriculture in Karnataka is mostly rainfed as opposed to irrigated, making it highly vulnerable to expected changes in the monsoon. The highest recorded temperature was 45.6 °C (114 °F) in Raichuru district. The lowest recorded temperature was 2.8 °C (37 °F) at Bidar district.

3.2.7 Flora and fauna

Karnataka is home to a variety of wildlife. It has a recorded forest area of 38,720 km2 (14,950 sq mi) which constitutes 12.3% of the total geographical area of the state. These forests support 25% of the elephant and 10% of the tiger population of India. Many regions of Karnataka are as yet unexplored, so new species of flora and fauna are found periodically. The Western Ghats, a biodiversity hotspot, includes the western region of Karnataka. The Bandipur and Nagarahole National Parks were included in the Nilgiri Biosphere Reserve in 1986, a UNESCO designation. The Indian roller and the Indian elephant are recognised as the state bird and animal while sandalwood and the lotus are recognised as the state tree and flower respectively. Karnataka has five national parks: Anshi, Bandipur, Bannerghatta, Kudremukh and Nagarhole. It also has 27 wildlife sanctuaries of which seven are bird sanctuaries.

Wild animals that are found in Karnataka include the elephant, the tiger, the leopard, the gaur, the sambar deer, the chital or spotted deer, the muntjac, the bonnet macaque, the slender loris, the common palm civet, the small Indian civet, the sloth bear, the dhole, the striped hyena, the Bengal fox and the golden jackal. Some of the birds found here are the great hornbill, the Malabar pied hornbill, the Ceylon frogmouth, herons, ducks, kites, eagles, falcons, quails, partridges, lapwings, sandpipers, pigeons, doves, parakeets, cuckoos, owls, nightjars, swifts, kingfishers, bee-eaters and munias. Some species of trees found in Karnataka are Calophyllum tomentosum, Calophyllum apetalum, Garcinia cambogia, Garcinia morella, Alstonia scholaris, Flacourtia

montana, Artocarpus hirsutus, Artocarpus lacucha, Cinnamomum zeylanicum, Grewia tiliifolia, Santalum album, Shorea talura, Emblica officinalis, Vitex altissima and Wrightia tinctoria. Wildlife in Karnataka is threatened by poaching, habitat destruction, human-wildlife conflict and pollution.

3.2.8 Forests

About 38724 km² (or 20% of Karnataka's geographic) are covered by forests. The forests are classified as reserved (28,611 km²) protected (3,932 km²), unclosed (5,748 km²), village (124 km²) and private (309 km²) forests. The percentage of forests area to Geographical area in the State is less than the all-India average of about 23%, and 33% prescribed in the National Forest Policy. The area under protected forests in the neighboring States is as follows: Andhra Pradesh 62,000 km² (9% of the total area of the country), Maharashtra 54,000 km² (8%), Tamil Nadu 22,000 km² (3%) and Kerala 11,000 km² (2%).

Karnataka is known for its valuable timbers from the evergreen forests in the Western Ghat region, notably Teak and Rosewood, the richly ornate panels of which adorn the beautiful chambers of the Two Houses of Karnataka Legislature.

3.2.9 Demographic Profile

Karnataka, with a total population of 61,100,000, is one of the major states in South India. Kannada is the official state language, while other linguistic minorities in the state include Kodava, Konkani, Tulu and Urdu. Karnataka is also at the forefront of population control measures, with the first two birth control clinics in history opening in 1930 in the Mandya district.

3.2.9.1 Population

At the time of the 2011 Census of India, the total population in Karnataka was 6.25 crores (an amount equating to 10 million), with 50.9% being males and 49.1% females. There was a decadal population increase of 17.3% between 1991 and 2001. As per the 2011 census, the population density is 319 per km², the sex ratio is 973 females to 1,000 males, and 38.67% of the people in Karnataka live in urban areas.

The literacy rate in Karnataka was 75.4% at the time of the 2001 census; the eight most-populous cities of the state, in-order from highest to lowest total population, were Bengaluru, Hubballi-Dharwad, Mysuru, Belagavi, Kalburgi, Mangaluru, Davanagere and Ballari. Bengaluru Urban and Belagavi are the most populous Districts, each of them having a population of more than three million. Gadaga, Chamarajanagara and Kodagu districts have a population of less than one million. Karnataka has one of the largest populations of Anglo-Indians in India. Seen below is a composite table of languages and religions of the state at the census of 2001.

Table 33: Languages and Religions of the State at the Census

Description	2011	2001
Approximate Population	6.11 Crores	5.29 Crore
Actual Population	61,095,297	52,850,562
Male	30,966,657	26,898,918
Female	30,128,640	25,951,644
Population Growth	15.60%	17.25%
Percentage of total Population	5.05%	5.14%
Sex Ratio	973	965
Child Sex Ratio	948	946
Density/km2	319	276
Area(Km 2)	191,791	191,791

Description	2011	2001
Total Child Population (0-6 Age)	7,161,033	7,182,100
Literacy	75.36 %	66.64 %
Male Literacy	82.47 %	76.10 %
Female Literacy	68.08 %	56.87 %

3.2.9.2 Religion

At the time of the 2011 Census of India, 84.0% of the population were Hindu, 13.00% Muslim, 1.80% Christian, 0.7% Jain, 0.2% Buddhist, <0.1% Sikhs, with the remaining percentage belonging to other religions. Karnataka is also the location of some tribes, such as the Nayaka, Soliga, and Yerava. The joint family system is prevalent in the rural areas of Karnataka; there are extreme cases, like the Narasinganavars, who reside in the Dharwad district, and are recognised as one of the largest undivided families in the world.

Table 34: Details of Religion

Description	Percentage
Hindu	84.00 %
Muslim	12.92 %
Christian	1.87 %
Jain	0.72 %

3.2.9.3 Caste and Communities

Just like other Ethnolinguistic groups in India, Kannada speaking people also form a number of distinct communities. The two single biggest communities numerically are the Lingayat and the Vokkaliga from North and South Karnataka respectively, while Scheduled Castes make up the largest cohesive group of communities. There are also numerous OBC (other backward communities) including the former pastoralist community of Kuruba, Scheduled Tribes like the Boya/Valmiki, scheduled castes like Banjara and Adi Karnataka. Kannada Brahmins are divided into several communities. Although historically Jainism in Karnataka had dominant presence, Kannada Jains today form a small minority. In Karnataka, 5 communities — Brahmin, Jain, Aryavaishya, Nagarthas and Modaliars — are outside the existing reservation matrix.

3.2.9.4 Languages

Government Census (2001) Kannada 68.5 %, Urdu 10.5 %, Telugu 6.2 %, Tamil 3.2 %, Tulu 2.1 %, Hindi 2.6%, Konkani 1.0 %, Beary 1.3 %, other 4.1 %.

3.2.10 Districts of Karnataka

Table 35: List of Karnataka Districts

District	Total area (sq km)	Total Population (2011)
Bidar	5448	17,03,300
Kalaburagi	10,951	25,66,326
Belagavi	13,415	47,79,661
Vijayapura	10,494	21,77,331
Yadagiri	5,273	11,74,271
Bagalkot	6,575	18,89,752
Raichur	8,440	19,28,812
Uttara Kannada	10,291	14,37,169
Dharwad	4,260	19,54,802

District	Total area (sq km)	Total Population (2011)
Gadag	4,656	10,64,570
Koppal	7,189	13,89,920
Ballari	4252	14,00,970
Vijayanagara	5644	13,53,628
Haveri	4,823	15,97,668
Shivamogga	8,477	17,52,753
Davanagere	5,924	19,45,497
Udupi	3,880	11,77,361
Chikkamagaluru	7,201	11,37,961
Chitradurga	8,440	16,59,456
Dakshina Kannada	4,560	20,89,649
Hassan	6,814	17,76,421
Tumakuru	10,597	26,78,980
Chikkaballapura	4,524	12,55,104
Kodagu	4,102	5,54,519
Mysuru	6,854	30,01,127
Mandya	4,961	18,05,769
Chamarajanagar	10,494	10,20,791
Ramanagara	6,827	10,82,636
Kolar	3,969	15,36,401
Bengaluru Rural	2,259	9,90,923
Bengaluru Urban	2,190	96,21,551

Figure 28: Districts of Karnataka

3.2.11 Economy

Karnataka had an estimated GSDP (Gross State Domestic Product) of about US$115.86 billion in the 2014–15 fiscal year. The state registered a GSDP growth rate of 7% for the year 2014–2015. Karnataka's contribution to India's GDP in the year 2014–15 was 7.54%. With GDP growth of 17.59% and per capita GDP growth of 16.04%, Karnataka is on the 6th position among all states and union territories. In an employment survey conducted for the year 2013–2014, the unemployment rate in Karnataka was 1.8% compared to the national rate of 4.9%. In 2011–2012, Karnataka had an estimated poverty ratio of 20.91% compared to the national ratio of 21.92%.

Nearly 56% of the workforce in Karnataka is engaged in agriculture and related activities. A total of 12.31 million hectares of land, or 64.6% of the state's total area, is cultivated. Much of the agricultural output is dependent on the southwest monsoon as only 26.5% of the sown area is irrigated.

Karnataka is the manufacturing hub for some of the largest public sector industries in India, including Hindustan Aeronautics Limited, National Aerospace Laboratories, Bharat Heavy Electricals Limited, Bharat Earth Movers Limited and HMT (formerly Hindustan Machine Tools), which are based in Bangalore. Many of India's premier science and technology research centres, such as Indian Space Research Organisation, Central Power Research Institute, Bharat Electronics Limited and the Central Food Technological Research Institute, are also headquartered in Karnataka. Mangalore Refinery and Petrochemicals Limited is an oil refinery, located in Mangalore.

The state has also begun to invest heavily in solar power centred on the Pavagada Solar Park. As of December 2017, the state has installed an estimated 2.2 gigawatts of block solar panelling and in January 2018 announced a tender to generate a further 1.2 gigawatts in the coming years: Karnataka Renewable Energy Development suggests that this will be based on 24 separate systems (or 'blocks') generating 50 megawatts each.

Since the 1980s, Karnataka has emerged as the pan-Indian leader in the field of IT (information technology). In 2007, there were nearly 2,000 firms operating in Karnataka. Many of them, including two of India's biggest software firms, Infosys and Wipro, are also headquartered in the state. Exports from these firms exceeded ₹500 billion (equivalent to ₹1.6 trillion or US$19 billion in 2023) in 2006–07, accounting for nearly 38% of all IT exports from India. The Nandi Hills area in the outskirts of Devanahalli is the site of the upcoming $22 billion, 50 km2 BIAL IT Investment Region, one of the largest infrastructure projects in the history of Karnataka. All this has earned the state capital, Bangalore, the sobriquet Silicon Valley of India.

Karnataka also leads the nation in biotechnology. It is home to India's largest biocluster, with 60% of the country's biotechnology firms being based here. The state has 18,000 hectares of land under flower cultivation, an upcoming industry which supplies flowers and ornamental plants worldwide.

Seven of India's banks, Canara Bank, Syndicate Bank, Corporation Bank, Vijaya Bank, Karnataka Bank, ING Vysya Bank and the State Bank of Mysore originated in this state. The coastal districts of Udupi and Dakshina Kannada have a branch for every 500 persons—the best distribution of banks in India. In March 2002, Karnataka had 4767 branches of different banks with each branch serving 11,000 persons, which is lower than the national average of 16,000.

A majority of the silk industry in India is headquartered in Karnataka, much of it in Doddaballapura in Bangalore Rural district and the state government intends to invest ₹700 million (equivalent to ₹1.4 billion or US$17 million in 2023) in a "Silk City" at Muddenahalli in Chikkaballapura district.

3.2.12 Transport

Karnataka, a state in South India has a well-developed transport system. Its capital city, Bengaluru is well-connected by air to domestic and international destinations and the Kempegowda International Airport (KIA) in the city is one of the busiest airports in India. It was also the headquarters of the airlines Air Deccan and Kingfisher Airlines. The road transport is also well developed in the state with many National and State highways providing means for fast transportation. The headquarters of the South-Western Railway division of Indian Railways is located at Hubballi and this division governs most of the railway network in the state. Konkan Railway which passes along the coastal region of the state is considered one of the toughest engineering projects being undertaken in India till date. Buses, cars and trains are the means of transport for moving across distant places in Karnataka. For transportation within the city or town limits; motorbikes, cars, autorickshaws and buses are used. With the advent of low-cost airlines, many people are choosing to travel via air as well.

3.2.12.1 Air transport

Kempegowda International Airport - Bengaluru is host to 9 domestic airlines and 19 international airlines and Lufthansa, British Airways, Air France, United Airlines, Qatar Airways, Singapore Airlines and Malaysia Airlines, connecting the city to almost 50 destinations across India and the world. With Bengaluru being the 'IT capital' of India, the air traffic to this city has increased manifold.

Mangaluru International Airport on the other hand connects 7 international destinations which includes Dubai, Bahrain, Qatar, Dammam, Kuwait, Abu Dhabi, Muscat and domestic destinations like Mumbai, Delhi, Bengaluru, Calicut, Chennai. Mangalore International Airport has recorded 28.1% annual growth in passenger traffic for the year 2015-2016 by carrying 1.67 million passengers, making it the fastest growing airport in the state.

Hubballi Airport is one of the major operational airports serving northern Karnataka. Currently Indigo Airlines have started its operation.

Mysuru Airport Many airlines disconnected the service from mysore as flights which plied to Kempegowda International airport did not go well. New routes of air service were introduced under the UDAAN scheme to Hyderabad and chennai everyday which received great response. Additional to that the state operates flights from bangalore to mysore during dasara festival. The airport landed in major controversies with the runway expansion. A decision was taken to build an underpass as it was blocked by rail route and a national highway connecting Kozhikode - a first kind in the country. Plans are to develop this major tourist destination's airport to an international service as there is competition now from the upcoming Kannur International Airport.

Belagavi Airport is the Oldest and north Karnataka busiest airport and the Major Airport in North Karnataka serving Belgaum city, Part of Goa and southernmost part of Maharashtra, Alliance Air(India) Indigo Star air To Bangalore, Air India started operation to Bangalore four days a week Mon, thu, fri, Sun including Pune. Spicejet operates daily flights to Mumbai, Bangalore, Hyderabad, Mangalore and Jabalpur. And also Star air operates daily flights to Bangalore and Ahmedabad.

Kalaburagi Airport serves direct flights to Bengaluru and has expansion plans to the other locations in near future.

There are airports at Ballari Airport and Bidar Airport that do not have any air service. In addition, there are private airstrips at Sedam Airport, Koppal Airport and Harihar Airport.

Shivamogga Airport is the newest operational airport with second longest runway after Bengaluru airport that serves direct flights to Bengaluru, Hyderabad, Goa, Tirupathi.

3.2.12.2 Rail transport

The total length of rail track in Karnataka is 3089 km For a long time after independence, the railway network in the state was under the Southern and Western railway zones which were headquartered at Chennai and Mumbai respectively. The South Western Zone, headquartered at Hubballi was created in 2003 thus fulfilling a long-standing demand of the state. Several parts of the state now come under this zone with the remaining being under Southern Railways. Coastal Karnataka is covered under the Konkan railway network, a project that is regarded as one of the feats of Indian engineering and included the construction of a bridge of length 2,023 metres (6,637 ft) across the river Sharavathi at Honnavar and a tunnel of length 2,960 metres (9,711 ft) at Karwar. Bengaluru, the capital city, is extensively connected with inter-state destinations while other important cities and towns in the state are not so well-connected.

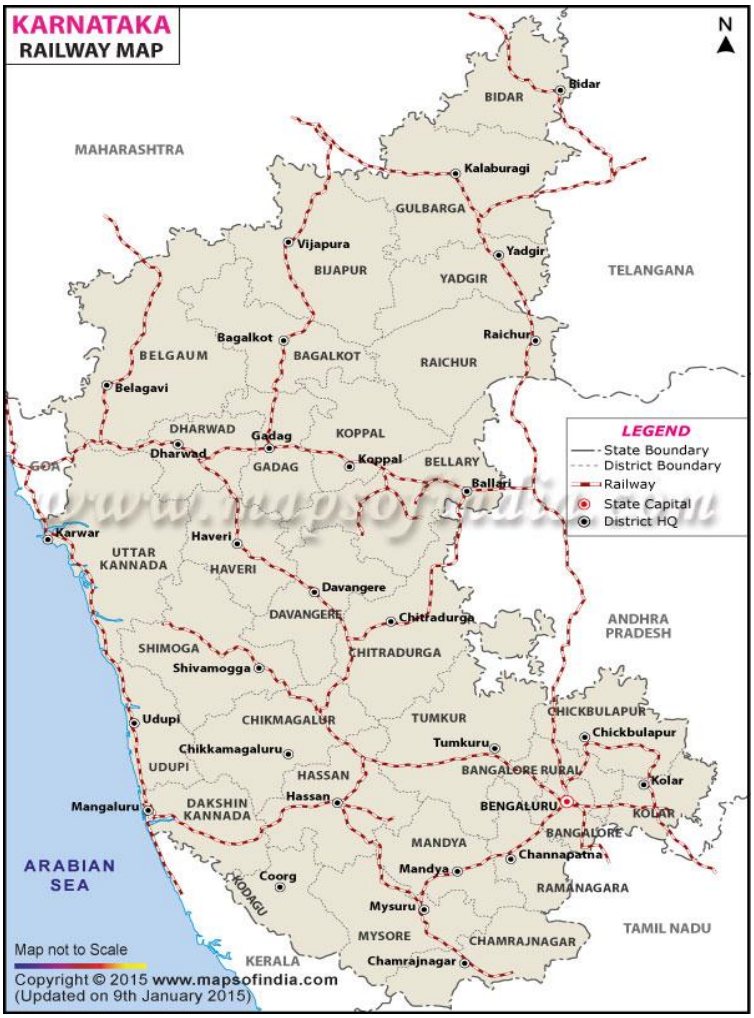


Figure 29:Karnataka Rail Network Map

3.2.12.3 Water transport

Karnataka has 1 major port; the New Mangaluru Port and 10 minor ports; Karwar, Belekeri, Tadri, Honnavara, Bhatkal, Kundapur, Hangarkatta, Malpe, Padubidri and Old Mangaluru. The construction of the New Mangaluru Port was started in 1962 and completed in 1974. It was incorporated as the 9th major port in India on 4 May 1974. This port handled 32.04 million tonnes of traffic in the fiscal year 2006–07 with 17.92 million tonnes of imports and 14.12 million tonnes of exports. This was actually a slowdown in traffic at this port

compared to the previous fiscal year mainly due to the reduction in iron ore exports from the Kudremukha Iron Ore Company limited. The port also handled 1015 vessels including 18 cruise vessels during the year 2006–07. The sector of Inland water transport within the rivers of Karnataka is not well-developed.

3.2.12.4 Road transport

Among the network of roads in Karnataka, 3973 km. of roads are National Highways. Karnataka also has state highways of length 9829 km.

The public bus transport in Karnataka is managed by the Karnataka State Road Transport Corporation. It was set up in 1961 with the objective of providing adequate, efficient, economic and properly coordinated road transport services. It operates 5100 schedules using 5400 vehicles covering 1.95 million kilometres and an average of 2.2 million passengers daily. About 25000 people are employed in Corporation For better management of public transport, Corporation was bifurcated into three Corporations viz., Bangalore Metropolitan Transport Corporation, Bengaluru on 15 August 1997, North-west Karnataka Road Transport Corporation, Hubballi on 1 November 1997 and North-East Karnataka Road Transport Corporation, Gulbarga on 1 October 2000. The reservation system is networked and computerised and tickets can be availed at designated kiosks in towns and cities. An online reservation system called AWATAR has also been devised by Corporation using which travellers can reserve tickets online.

Figure 30: Karnataka Road Map

3.3 Bangalore Urban District

Bangalore, officially known as Bengaluru, is the Capital of the Indian State of Karnataka. It has a population of over ten million, making it a megacity and the Third populous City and 5th most populous urban agglomeration in India. It is located in Southern India on the Deccan Pleteau . Its elevation is over 900 m (3,000 ft) above sea level, the highest of India's major cities.

Bengaluru Urban District has the distinction of being the Karnataka State Capital. State Legislature and High Court are in its jurisdiction. It is the nerve center of Karnataka State's Legislative, Judicial and Executive Administration. Bengaluru Urban District comprises five Taluks, namely

Bengaluru North, Bengaluru North (Addl.), Bengaluru South, Bengaluru East and Anekal

The district is the Principal Administrative unit below the state level. The Deputy Commissioner, being the head of the District Administration, is perhaps the only officer vested with powers under the largest number of both Central and State Laws. The D.C. office comes in direct contact with the people and people's representatives at various levels. The office of the Deputy Commissioner apart from having many original works enumerated under different Acts and Rules has got the supervisory and coordinating roles at the district level. Apart from regulatory functions, the Deputy Commissioner guides and coordinates the developmental activities of the district.

Bangalore is sometimes referred to as the "Silicon Valley of India" (or "IT capital of India") because of its role as the nation's leading information technology (IT) exporter. Indian technological organisations ISRO, Infosys, Wipro and HAL are headquartered in the city. A demographically diverse city, Bangalore is the second fastest-growing major metropolis in India. It is home to many educational and research institutions in India, such as Indian Institute of Science (IISc), Indian Institute of Management (Bangalore)(IIMB), National Institute of Fashion Technology, Bangalore, National Institute of Design, Bangalore (NID R&D Campus), National Law School of India University (NLSIU) and National Institute of Mental Health and Neurosciences (NIMHANS). Numerous state-owned aerospace and defence organisations, such as Bharat Electronics, Hindustan Aeronautics and National Aerospace Laboratories are located in the city. The city also houses the Kannada film industry.

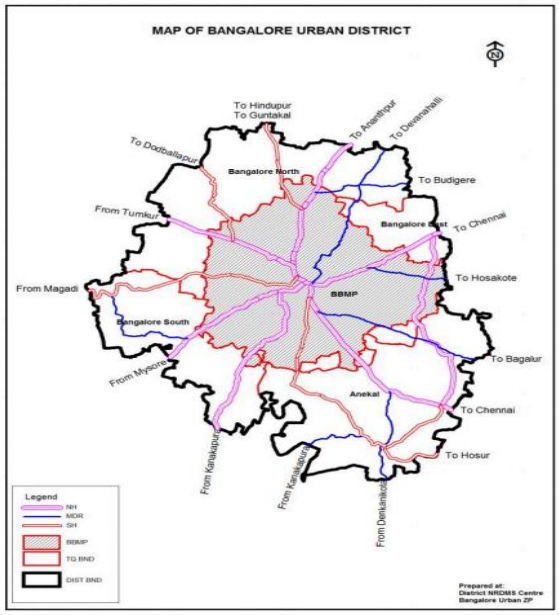


Figure 31: Bangalore Districts Map

3.3.1 Geography

Bangalore lies in the southeast of the South Indian state of Karnataka. It is in the heart of the Mysore Plateau (a region of the larger Precambrian Deccan Plateau) at an average elevation of 920 m (3,020 ft). It is positioned at 12.97°N 77.56°E and covers an area of 1741 km2 (673 mi2). The majority of the city of Bangalore lies in the Bangalore Urban district of Karnataka and the surrounding rural areas are a part of the Bangalore Rural district. The region comprising the Bangalore Urban and Rural districts is known as the Bangalore (region). The Government of Karnataka has carved out the new district of Ramanagara from the old Bangalore Rural district.

In the 16th century, Kempe Gowda I constructed many lakes to meet Bangalore's water requirements. The Kempambudhi Kere, since overrun by modern development, was prominent among those lakes. In the earlier half of 20th century, the Nandi Hills waterworks was commissioned by Sir Mirza Ismail (Diwan of Mysore, 1926–41 CE) to provide water supply to the city. Currently, the river Kaveri provides around 80% of the total water supply to the city with the remaining 20% being obtained from the Thippagondanahalli and Hesaraghatta reservoirs of the Arkavathi river. Bangalore receives 800 million liters (211 million US gallons) of water a day, more than any other Indian city. However, Bangalore sometimes does face water shortages, especially during the summer season — more so in the years of low rainfall. A random sampling study of the air quality index (AQI) of twenty stations within the city indicated scores that ranged from 76 to 314, suggesting heavy to severe air pollution around areas of traffic concentration.

Bangalore has a handful of freshwater lakes and water tanks, the largest of which are Madivala tank, Hebbal Lake, Ulsoor Lake and Sankey Tank. Groundwater occurs in silty to sandy layers of the alluvial sediments. The Peninsular Gneissic Complex (PGC) is the most dominant rock unit in the area and includes granites, gneisses and migmatites, while the soils of Bangalore consist of red laterite and red, fine loamy to clayey soils.

Vegetation in the city is primarily in the form of large deciduous canopy and minority coconut trees. Though Bangalore has been classified as a part of the seismic zone III, it has experienced quakes of magnitude as high as 6.4.

3.3.2 Topography

Bangalore has two unique Topography terrains—North Bangalore taluk and the South Bangalore taluk. The North Bangalore taluk is a relatively more level plateau and lies between an average of 839 to 962 meters above sea level. The middle of the taluk has a prominent ridge running NNE-SSW. The highest point in the city, Doddabettahalli, (962m) is on this ridge. There are gentle slopes and valleys on either side of this ridge. The low-lying area is marked by a series of water tanks varying in size from a small pond to those of considerable extent, but all fairly shallow.

The topography of Bangalore is undulating with a central ridge running NNE-SSW. The highest point is Doddabettahalli, which is 962 m (3,156 ft) and lies on this ridge. No major rivers run through the city, though the Arkavathi and (Dakshin Pinakini river) cross paths at the Nandi Hills, 60 km (37 mi.) to the north. River Vrishabhavathi, a minor tributary of the Arkavathi, arises within the city at Basavanagudi and flows through the city. The rivers Arkavathi and Vrishabhavathi together carry much of Bangalore's sewage. A sewerage system, constructed in 1922, covers 215 km2 (133 mi2) of the city and connects with five sewage treatment centers located in the periphery of Bangalore. Outflow from Bellandur lake and Varthur lake valleys go to Ponnaiyar river that flows towards Hosur.

The South Bangalore taluk has an uneven landscape with intermingling hills and valleys. The southern and western portions of the city consist of a topology of granite and gneissic masses. The eastern portion is a plane,

with rare minor undulations.

There are no major rivers flowing through the city. However, rivers Arkavathi and Kaveri merge within the proximity of Mekedatu, which lie 60 km south of Bangalore. River Vrishabhavati, a tributary of Arkavathi, flows for a small stretch in the Bangalore North taluk and carries a bulk of the city's sewerage. The age old South Pennar river, also known as Dakshina Pinakini, used to run through the eastern side of the city. Now it is being considered for renewal and rejuvenation by the government. The city has a handful of freshwater lakes and water tanks such as Madivala tank, Hebbal tank, Ulsoor lake and Sankey Tank. Groundwater occurs in silty to sandy layers of alluvial sediments and jointed quartzite.

The rock types prevalent in the district belong to the Saugar, Charnokite and Peninsular Gneissic Complex (PGC) groups. The PGC is the dominant group of rocks and covers two-thirds of the area and includes granites, gneisses and migmatites. The soils in Bangalore vary from red laterite to clayey soils.

3.3.3 Climate

Due to its elevation, Bangalore enjoys a pleasant and equable climate throughout the year with occasional extreme weather events like heatwaves, coldwaves, floods and droughts. The highest temperature ever recorded in Bengaluru is 41.8°c in April 30, 2024 in Kengeri at Bengaluru. Winter temperatures rarely drop below 13 °C (52 °F) and summer temperatures seldom exceed 37 °C (97 °F).

The hottest summer day on average has a maximum temperature of about 37°c , and the coldest winter day has a temperature of about 13°c. Occasionally, heat waves can cause temperatures of up to 38-40°c. Occasional coldwaves will be leading to the temperatures as low as below 9-10°c . Bangalore receives about 970 mm of rain annually, with the wettest months being August, September and October. The heaviest rainfall recorded in a 24-hour period was 18 cm recorded on 1988.

Most of the rainfall occurs during late afternoon, evening or night and rain before noon is infrequent. November 2015 (290.4 mm) was recorded as one of the wettest months in Bangalore with heavy rains causing severe flooding in some areas, and closure of a number of organisations for over a couple of days.

3.3.4 Seismicity

Because it lies in the seismically stable region, Zone III (encompassing parts of Karnataka, Maharashtra, Kerala, Tamil Nadu and Andhra Pradesh), Bangalore has been untouched by major seismic events. Only mild tremors have been recorded frequently in the city. The largest earthquake that has ever hit the city was of magnitude 6.4 in April 1843.

3.3.5 Land use

According to data contained in the Bangalore Mahanagara Palike Master Plan, 40.4% of the land in the city is used for residential purposes. Transport uses 24.3% of the land, while land used for industrial, and commercial purposes comprise 6.9% and 2.7% respectively. As the city of Bangalore expands, the BMP expects the percentage of land used for industrial purposes to decrease, while it expects the percentages of land used for residential, commercial and public and semi-public purposes to increase.

3.3.6 Demographic Profile of the District

According to the 2011 census Bangalore Urban district has a population of 9,621,551, roughly equal to the nation of Belarus. This gives it a ranking of third in India (out of a total of 640). The district has a population density of 4,378 inhabitants per square kilometre (11,340/sq mi). Its population growth rate over the decade 2001-2011 was 46.68%. Bangalore has a sex ratio of 908 females for every 1000 males, and a literacy rate of

88.48%. 90.94% of the population lives in urban areas. Scheduled Castes and Scheduled Tribes make up 12.46% and 1.98% of the population respectively.

Languages of Bangalore Urban district (2011)

- Kannada (44.47%)
- Tamil (15.99%)
- Telugu (13.99%)
- Urdu (12.11%)
- Hindi (4.55%)
- Malayalam (2.94%)
- Marathi (1.92%)
- Others (4.82%)

At the time of the 2011 census, 44.47% of the population spoke Kannada, 15.20% Tamil, 13.99% Telugu, 12.11% Urdu, 4.55% Hindi, 2.94% Malayalam and 1.92% Marathi as their first language.

Table 36: Demographic profile of Bangalore urban Districts

Category	Absolute Figures
Area	2196 Sq.kms
Population- Total	9621551
Male	5022661
Female	4518890
Rural	871607
Urban	8749944
Decadal Population Growth	47.18%
Literacy-Total	87.67%
SC Population – Total	1198385
ST Population – Total	190239
Sex Ratio (females per 1000 males)	916
Child Sex Ratio (0 to 6 years)	944
Occupational pattern of Population Total Workers	3998286

3.3.7 Economy

Bangalore is one of the fastest-growing metropolises in India. Bangalore contributes 38% of India's total IT exports. Its economy is primarily service oriented and industrial, dominated by information technology, telecommunication, biotechnology, and manufacturing of electronics, machinery, automobiles, food, etc. Major industrial areas around Bangalore are Adugodi, Bidadi, Bommanahalli, Bommasandra, Domlur, Hoodi, Whitefield, Doddaballapura, Hoskote, Bashettihalli, Yelahanka, Electronic City, Peenya, Krishnarajapuram, Bellandur, Narasapura, Rajajinagar, Mahadevapura etc. It is the fifth Indian city to host maximum numbers of Fortune Companies, after Mumbai, Delhi, Kolkata and Chennai.

The growth of IT has presented the city with unique challenges. Ideological clashes sometimes occur between the city's IT moguls, who demand an improvement in the city's infrastructure, and the state government, whose electorate is primarily from rural Karnataka. The encouragement of high-tech industry in Bangalore, for example, has not favoured local employment development, but instead increased land values and forced out

small enterprises. The state has also resisted the massive investments required to reverse the rapid decline in city transport, driving new and expanding businesses elsewhere in India. Bangalore is a hub for Indian biotechnology-related industry and in 2005 was home to around 47% of the 265 biotechnology companies in India, including Biocon, India's largest biotechnology company, giving Bangalore the nickname of the "Biotech Capital of India". Bangalore is also the country's fourth largest fast-moving consumer goods (FMCG) market. Forbes considers Bangalore one of "The Next Decade's Fastest-Growing Cities". The city is the third largest hub for high-net-worth individuals. There were a large number of high-net-worth individuals with a ₹4.5 crore investment surplus in 2007. In the Ease of Living Index 2020, it was ranked the most livable Indian city with a population of over a million.

The city is widely regarded as the "Silicon Valley of India", as the largest IT hub of the country. Infosys, Wipro, Mindtree, Mphasis, Flipkart, and Myntra are headquartered in Bangalore. IT companies located in the city contributed 33% of India's ₹1,442 billion (US$20 billion) IT exports in 2006–07. Bangalore's IT industry is divided into three main clusters: Software Technology Parks of India (STPI); International Tech Park, Bangalore (ITPB); and Electronic City. Most of the IT companies are located in Bommanahalli, Domlur, Whitefield, Electronic City, Krishnarajapuram, Bellandur, and Mahadevapura.

3.3.8 Economic sectors

The earliest startups that were launched in the city in the 1990s include Infosys, Wipro Technologies, and Mindtree being popular ones and smaller ones include Tejas Networks. Flipkart, having originated in Bangalore, acquired several other e-commerce companies in Bangalore like Myntra, and was eventually acquired by Walmart in 2018 for close to $20 Billion. Startup companies such as Swiggy, Ola Cabs, InMobi, Quikr, and RedBus are also based in the city.

Bangalore is a favorable destination for industrial development. United Breweries Group is headquartered in Bangalore. The city is an automobile production hub. Tata Hitachi Construction Machinery, Mahindra Electric, Bharat Earth Movers, Toyota Kirloskar Motor, Tesla India, and Ather Energy are headquartered in Bangalore within their operations. Robert Bosch GmbH, Mercedes-Benz, Volvo, General Motors, Royal Enfield, Honda Motorcycle and Scooter India, Scania AB, Larsen & Toubro have their plants and research & development (R&D) centers around Bangalore. ABB, General Electric, and Tyco International have their research and development centers in Bangalore. Aerospace industries are also popular around Bangalore, which made it as Aviation Monopoly capital of India. Airbus, Boeing, Tata Advanced Systems, Indian Space Research Organisation, and Liebherr Aerospace have their units in Bangalore. Bangalore has also emerged as an electronics and hardware manufacturing hub in India. It houses Dell, Nokia, Philips, and Wistron manufacturing and R&D units. Public sector undertakings (PSUs) such as Bharat Electronics Limited (BEL), Hindustan Aeronautics Limited (HAL), National Aerospace Laboratories (NAL), Bharat Earth Movers Limited (BEML), Central Manufacturing Technology Institute (CMTI), HMT (formerly Hindustan Machine Tools) and Rail Wheel Factory (RWF). SKF also has a plant in the city.

Information Technology

Bangalore is known for its IT industry, housing companies like Infosys, Mphasis, Wipro, Tata Consultancy Services, Nasdaq, Facebook, Google, and Microsoft etc. India's two largest IT companies – Infosys and Wipro to name a few have their headquarters here in Bangalore. Electronic City is a place in Bangalore, which houses IT companies in Bangalore along with Infosys headquarters. Whitefield is another major suburb housing many IT companies. It is called as "The Silicon Valley of India' and "IT Capital of India".

Aerospace and aviation

Bangalore is also called the aviation monopoly capital of India. It accounts for more than 65% of India's aerospace business. World Aerospace giants such as Boeing, Airbus, Goodrich Archived 6 June 2013 at the Wayback Machine, Dynamatics, Honeywell, GE Aviation, UTL, others have their Research & Development and Engineering centres in Bangalore.

Before Bangalore was called the Silicon Valley of India, the city made its name as headquarters to some of the largest public sector companies of India such as NGEF, BEML, BEL, BHEL etc. The Hindustan Aeronautics Limited (HAL) headquarters is in Bangalore, and is dedicated to research and development activities for indigenous fighter aircraft for the Indian Air Force. With over 9,500 employees, it is one of the largest public sector employers in Bangalore.

Today, HAL manufactures, under license, various fighter aircraft for the Indian Air Force (IAF) including Sukhoi 30 Flankers and Jaguars. HAL also develops indigenous products for the IAF such as HAL Tejas, Aeronautical Development Agency, HAL Dhruv and HAL HF-24 Marut. Aeronautical Development Agency is also headquartered in Bangalore.

The National Aerospace Laboratories (NAL) is also headquartered in Bangalore and is dedicated to the development of civil aviation technologies. Incorporated in 1960, NAL often works in conjunction with the HAL and has a staff strength of over 1,300 employees. NAL also investigates aircraft malfeasance.

A 1,000-acre (4.0 km2) special economic zone for the aerospace industry is being set up near the Kempegowda International Airport. Bangalore was also home to large domestic airlines – now defunct Simplifly Deccan and Kingfisher Airlines.

Biotechnology

Biotechnology is a rapidly expanding field in the city. Bangalore accounts for at least 97 of the approximately 240 biotechnology companies in India. Interest in Bangalore as a base for biotechnology companies stems from Karnataka's comprehensive biotechnology policy, described by the Karnataka Vision Group on Biotechnology. In 2003–2004, Karnataka attracted the maximum venture capital funding for biotechnology in the country – $8 million. Biocon, headquartered in Bangalore, is the nation's leading biotechnology company and ranks 16th in the world in revenues.

Institute of Bioinformatics and Applied Biotechnology (IBAB), initiated by Biotechnology vision group, ICICI and Biocon (located at ITPL) is trying to shape revolutionary scientists in the field.

Like the software industry which initially drew most of its workforce from the local public sector engineering industries, the biotechnology industry had access to talent from the National Center of Biological Sciences (NCBS) and the Indian Institute of Science (IISc).

Manufacturing

Other heavy industries in Bangalore include Bharat Electronics Limited, Bharat Heavy Electricals Limited (BHEL), Indian Telephone Industries (ITI), Bharat Earth Movers Limited (BEML), HMT (formerly Hindustan Machine Tools), Hindustan Motors (HM) and ABB Group.

Bangalore is also becoming a destination for the automotive industry. Volvo and many other auto suppliers have manufacturing plants in Bangalore.

Bangalore houses many small and medium scale industries in its Peenya industrial area that claimed to be one of the biggest in Asia 30-years ago; newly including Apple's India manufacturing plant – the only active plant

in the world outside of China.

Other sectors

The city has several types of entrepreneurial pursuits that have shaped it along the way from the early '90s. The city is known for several restaurateurs who innovated on fast service models commonly called Darshini restaurants that served hot breakfast and beverages. Orkla Foods, the Norwegian foods company bought MTR Foods, traditional ready-to-eat consumer goods brand in 2007 for approximately $60m. A recent $100m brand is ID foods, fast becoming popular in retail. Swiggy an on-demand food delivery Unicorn is popular along with Zomato, a restaurant review, listing and food delivery business, that initially started in Bangalore. FreshMenu is a near-unicorn cloud kitchen business that only delivers via mobile apps and other on-demand food apps. Cafe Coffee Day, a listed entity is a coffee store chain with stores in Prague, Bratislava, Riga and Warsaw. Chai Point is a chain of tea stores founded in Bangalore in 2010.

Several Venture Capital funded startups like housing.com, nestaway, nobroker, commonfloor.com (acquired by the Unicorn, Quikr) are disrupting the rental marketplace in India. Several listed real estate brands have their origins in the city like Prestige Group, Brigade Enterprises, Total Environment and Sobha Developers.

India's largest indigenous OEM, Hindustan Aeronautics Limited (HAL) had its headquarters in India. Several smaller tier 1 and tier 2 suppliers had their base in the city to serve the OEM need. The National Aerospace Laboratories (NAL) is also headquartered in Bangalore and is dedicated to the development of civil aviation technologies. Bangalore also housed now-defunct full-service airline brand Kingfisher Airlines, which acquired another airline startup, Air Deccan, a budget airline.

The Indian Space Research Organization (ISRO), one of the top national space agencies in the world is headquartered in the city. ISRO is recognized world over for its indigenous capabilities in launching low cost satellites using its own launch vehicles, the PSLV and the GSLVs. ISRO has a record of deploying 104 satellites in orbits successfully in a single launch, which is a world record. ISRO has also launched a Mars mission, Mars Orbital Mission Archived 5 February 2019 at the Wayback Machine, which was the lowest cost inter-planetary orbital mission. Startups have made attempts to launch lunar rovers and are analysing satellite images to uses in agriculture and climate.

Bangalore is the home of India's first electric car brand, Reva was acquired by a large domestic car company, Mahindra & Mahindra. Several startups in automotive services, marketplaces are situated in the city. On-demand taxi service, Ola Cabs, a Unicorn, originated in the city and acquired its early competition and peer, taxiforsure. Bounce is an on-demand motorbike startup that originated in the city. Car rental companies operating in the city includes Avis, Carzonrent, Hype Luxury Mobility, Mylescars, Revvcar and Zoomcar. Zoomcar is on demand inter city car transportation startup running out of the city. RedBus is an intercity bus aggregator that was bought by Naspers group.

BigBasket.com, Zopnow.com and Zopper.com, started in on-demand grocery and compete with Amazon's Prime Now platform. Offline, formal retail format grocers originating from the city include FoodWorld supermarkets that started in 1996 and several other local brands.

Urban Ladder is a leading omnichannel commerce furniture retailer founded by entrepreneurs from the city. Lifestyle, now part of Dubai-based Landmark group originated as a brand in Bangalore in 1999. Tanishq is a jewelry retail store brand and is owned by the Tata Group. Printo is a chain of stationery and printing services stores.

Several fintechs have their origins in the city. The revolutionary low-cost brokerage firm Zerodha, several cryptocurrency exchanges. Pine Labs is a recent unicorn that builds POS systems. Capillary Technologies is a loyalty, analytics provider built over POS systems. QwikCilver, a gifting and loyalty platform founded in Bangalore was acquired by Amazon.

The city is known for its craft breweries, popular ones being Toit, Arbor Brewing Company and others. Kingfisher is one of the world's largest beer brands that originated in Bangalore. Amrut is India's first Single Malt Whisky brand that is sold all over the world and was named as the number three whisky in the world in 2010. United Breweries Group has its headquarters in Bangalore. It produces Kingfisher (beer).

Biocon is one of India's largest pharmaceutical companies which also owns a majority stake in India's largest Clinical Research Outsourcing (CRO) company Syngene International that works with global pharmaceutical majors. Strides Arcolab manufactures pharma products for emerging markets and is a listed entity in the Indian Stock Markets. The Himalaya Drug company makes several pharma and beauty care products and is headquartered in Bangalore.

Wildcraft, a fast-growing outdoor adventure goods company was founded in the city. Zivame is an online commerce lingerie company fast growing into the number 1 brand in India.

Narayana Hrudayalaya, a listed business, is a popular hospital chain that was built by renowned Bangalore cardiac surgeon. Portea Medical and Practo are some of the fast-growing startups in the space. Cloud Nine is a chain of fast-growing maternity and childcare brands founded in the city in 2007.

DTDC is an asset light logistics company built by first generation entrepreneurs in the city.

Lucia is a Kannada movie that is renowned as India's first crowdsourced movie. The movie was extensively shot in Bangalore.

There are many sports facility aggregators where consumers can book indoor courts or swimming pool slots like Playo. Many entrepreneurs are setting up sports facilities due to higher interest in fitness. There is a fitness chain called CureFit, invested in by early entrepreneurs and restaurants attached like EatFit.

Many wine yards are springing up around the city due to interest among a globally aware community of people residing in the city. Bangalore is also India's largest export of roses, about 70% of all rose exports come from the city.

Samsung Electronics in 2018, opened Largest Mobile Experience Centre in the World at Bengaluru's Iconic Opera House. Samsung Opera House will be a must-do destination for the city's millennials looking for exciting tech-enabled experiences and entertainment. One will be able to enjoy VR experiences such as the 4D Sway Chair or the Whiplash Pulsar 4D chair that makes 360 degrees three-dimensional movements. One can slip into the role of a fighter pilot doing extreme aircraft stunts, or experience a space battle, or a roller coaster ride. The 33,000 sq ft standalone property, which during the British era hosted plays and Operas, has been restored over two years and its facade continues to don its magnificent original look and feel. On the inside, a modern experiential space has been developed with extensive use of modern technology.

Economic Zones in the City

There are several economic clusters, as in many cities in the world, in the city.

- Chickpete area is known for textile trades and early entrepreneurs in the city
- Shivajinagar area houses auto spares and services clusters

- Whitefield was a neighboring town to Bangalore, but over time has been assimilated into the city. Whitefield houses several Information Technology Parks and many global firms have their India headquarters located in the area.
- Koramangala and JP Nagar have traditionally been the area where tech startups take birth
- Electronics City houses all the major IT service providers of India

3.3.9 Transport

Air

Bangalore is served by Kempegowda International Airport, located at Devanahalli, about 40 km (25 mi) from the city centre. Formerly Bangalore International Airport, the airport started operations from 24 May 2008 and is privately managed by a consortium led by the GVK Group. The city was earlier served by the HAL Airport at Vimanapura, a residential locality in the eastern part of the city. The airport is the third busiest in India after Delhi and Mumbai in terms of passenger and airplane traffic. Taxis and air-conditioned Volvo buses operated by BMTC connect the airport with the city.

Railways and Metro

As of 2022, a rapid transit system called the Namma Metro is being built in stages. Initially opened with the 7 km (4.3 mi) stretch from Baiyappanahalli to MG Road in 2011, metro lines totaling 42.30 km (26.28 mi) for the north–south and east–west lines were made operational in June 2017. Phase 2 of the metro covering 72.1 km (44.8 mi) is under construction and includes two new lines along with the extension of the existing north–south and east–west lines. There are also plans to extend the north–south line to the airport, covering a distance of 29.6 km (18.4 mi).

Bangalore is a divisional headquarters in the South Western Railway zone of the Indian Railways. There are four major railway stations in the city: Krantiveera Sangolli Rayanna Railway Station; Bangalore Cantonment railway station; Yeshwantapur Junction, Krishnarajapuram railway station and newly inaugurated Sir M. Visvesvaraya Terminus, with railway lines towards Jolarpettai in the east; Guntakal in the north; Kadapa (only operational until Kolar) in the northeast; Tumkur in the northwest; Hassan and Mangalore in the west; Mysore in the southwest; and Salem in the south. There is also a railway line from Baiyappanahalli to Vimanapura, no longer in use. Though Bangalore has no commuter rail as of 2022, there have been demands for a suburban rail service because of the large number of employees working in the IT corridor areas of Whitefield, Outer Ring Road and Electronic City. The Rail Wheel Factory is Asia's second-largest manufacturer of wheel and axle for railways and is headquartered in Yelahanka, Bangalore.

Bus

Buses operated by Bangalore Metropolitan Transport Corporation (BMTC) are a staple of city public transport. While commuters can buy tickets on boarding these buses, BMTC also provides an option of a bus pass to frequent users. BMTC runs air-conditioned luxury buses on major routes and operates shuttle services from various parts of the city to Kempegowda International Airport. The Karnataka State Road Transport Corporation operates 6,918 buses on 6,352 schedules, connecting Bangalore with other parts of Karnataka and with neighbouring states. The main bus depots that KSRTC maintains are the Kempegowda Bus Station, locally known as "Majestic bus stand", where most of the buses going out of the city ply from. Some of the KSRTC buses to Tamil Nadu, Telangana and Andhra Pradesh ply from Shantinagar Bus Station, Satellite Bus Station at Mysore Road and Baiyappanahalli satellite bus station. BMTC and KSRTC were the first operators in India to introduce Volvo city buses and intra-city coaches in India. Three-wheeled, yellow and black or yellow and

green auto-rickshaws, referred to as autos, are popular for transport. They are metered and can accommodate up to three passengers. Taxis are usually available via phone calls or online services; they are metered and generally more expensive than auto-rickshaws.

Road

Bangalore is well-connected with national highways with the rest of the country. The highways are National Highway 44 (NH-44), National Highway 48 (NH-48) (also Asian Highway 47 (AH-47)), National Highway 275 (NH-275), National Highway 75 (NH-75), National Highway 648 (NH-648) and National Highway 948 (NH-948), along with state highways. An average of 1,750 vehicles are registered daily in Bangalore Regional Transport Offices (RTOs). The total number of vehicles, as of 2020, are around 8,500,000 vehicles, and the city's roads total 11,000 km (6,835 mi).

Bangalore currently has one expressway, the Bangalore–Mysore Expressway, operational since March 2023, which is part of NH-275. In the coming years, the city will get more expressways, resulting in enhanced connectivity and commute with the rest of the country. They are as follows:

- Bangalore–Chennai Expressway: Under construction since August 2019, to be completed by March 2024.
- Pune–Bangalore Expressway: Proposed, to be completed by 2028.
- Nagpur–Hyderabad–Bengaluru Expressway: Proposed, expected to be completed by before 2030.

Education

Bangalore has a literacy rate of around 88%, according to the 2011 national census. Primary, middle school and secondary education in Bangalore is offered by various schools which are affiliated to one of the government or government recognised private boards of education, such as the Secondary School Leaving Certificate (SSLC), Central Board of Secondary Education (CBSE), Council for the Indian School Certificate Examinations (CISCE), International Baccalaureate (IB), International General Certificate of Secondary Education (IGCSE) and National Institute of Open Schooling (NIOS). Schools in Bangalore are either government run or are private (both aided and un-aided by the government). Bangalore has a significant number of international schools due to large number of expats and people employed in the IT sector. After completing their secondary education, students either attend a pre-university course or continue an equivalent high school course in one of three streams – arts, commerce or science – in various combinations. Alternatively, students may enroll in diploma courses. Upon completing the required coursework, students enroll in general or professional degrees in universities through lateral entry.

The Bangalore University, established in 1886, provides affiliation to over 500 colleges, with a total student enrolment exceeding 300,000. The university has two campuses within Bangalore – Jnanabharathi and Central College. University Visvesvaraya College of Engineering was established in the year 1917, by Bharat Ratna Sir M. Visvesvaraya, At present, the UVCE is the only engineering college under the Bangalore University. Bangalore also has many private Engineering Colleges affiliated to Visvesvaraya Technological University.

Indian Institute of Science, which was established in 1909 in Bangalore, National Centre for Biological Sciences, National Institute of Mental Health and Neuro-Sciences, Jawaharlal Nehru Centre for Advanced Scientific Research and the Raman Research Institute are the premier institutes for scientific research and study in India. Nationally renowned universities and institutes such as the, National Institute of Design, National Institute of Fashion Technology, National Law School of India University, the Indian Institute of Management, International Institute of Information Technology, Christ University, Brindavan College of Engineering, RV Educational Institutions, University of Agricultural Sciences, Bangalore, the ICAR-National Institute of

Animal Nutrition and Physiology, the Indian Statistical Institute are located in Bangalore. Bangalore also has some of the best medical colleges in the country, like St. John's Medical College and Bangalore Medical College and Research Institute. The M. P. Birla Institute of Fundamental Research has a branch located in Bangalore. Mount Carmel College, a premier institution for women's education in India is located in Bangalore. It is affiliated to Bangalore University, as is Acharya Bangalore Business School, established in 2008.

CHAPTER 4
AVAILABLE DATA PLANS

CHAPTER 4: AVAILABLE DATA PLANS

Bangalore city has undergone rapid development in the last decade and to meet the demand of growing population and stay ahead in order to provide populus with state of the art connectivity. The development proposals have been planned and some are under execution stage.

The authority has aimed to mitigate the congestion of the city and in order to find conclusion steps have been taken to find both short-term and long-term traffic mitigation plans. Few of the past studies have been analyzed to plan the North South Vehicular Tunnel connecting Hebbal to Silkboard Junction. Some major construction projects are under execution, and some are in pipelines in near coming future.

The past traffic studies, under construction projects and planned projects are mentioned below.

4.1 Comprehensive Mobility Plan-2020 prepared by Infrastructure Development Corporation (Karnataka) Limited

This is the detailed report which gives us detailed account of the traffic, possible scenarios of developments by integration of Public Transport, Multimodal connectivity and other scenarios.

- Strategy 1: Expand reach and augment capacity of public transport system.
- Strategy 2: Improve operational efficiency of public transport systems.
- Strategy 3: Promote multimodal operations
- Strategy 4: Promote Transit Oriented Development.
- Strategy 5: Improve efficiency of road infrastructure.
- Strategy 6: Augment capacity of road infrastructure.
- Strategy 7: Make commuters bear full cost of externalities of mobility modes.
- Strategy 8: Influence mobility choice through regulatory, fiscal and pricing.
- Strategy 9: Promoting use of electric and cleaner fuel vehicles.
- Strategy 10: Establish mechanism for planning, capacity building and accountability.

The CMP has been incorporated in our project traffic analysis for future forecasting and assuming the intermodal split of traffic.

4.2 Feasibility Study Report (North South Corridor) prepared by Altinok Consulting Engineering Inc. in JV with Lion Group.

A comprehensive road Infrastructure plan has been prepared in this report which propose the 190 Kms of the congested sections of Bangaluru City. Out of which North- South Corridor proposed to be taken up as Underground Vehicular Tunnel was one of the critical sections.

The report focuses on how the proposal of tunnel is better for the construction of the project over the elevated proposal or widening of the existing road. The benefits of tunnel such as uninterrupted flow, lower land acquisition, minimal disruption to existing traffic and lower environmental impact.

The feasibility gives us information about the current Level of Serviceability (LOS) in Peak Hour, which varies in LOS of E and LOS F.

The Feasibility paved the way for the further preparation of Detailed Project Report for Underground Vehicular Tunnel connecting Hebbal junction to Silk board junction while also connecting ramps at Palace Ground,

Racecourse/Vidhan Soudha and Lalbagh Botanical Garden.

Currently there are three road projects that are sanctioned in Bengaluru, which are Satellite Town Ring Road, Intermediate Ring Road and Peripheral Ring Road as shown in Figure.

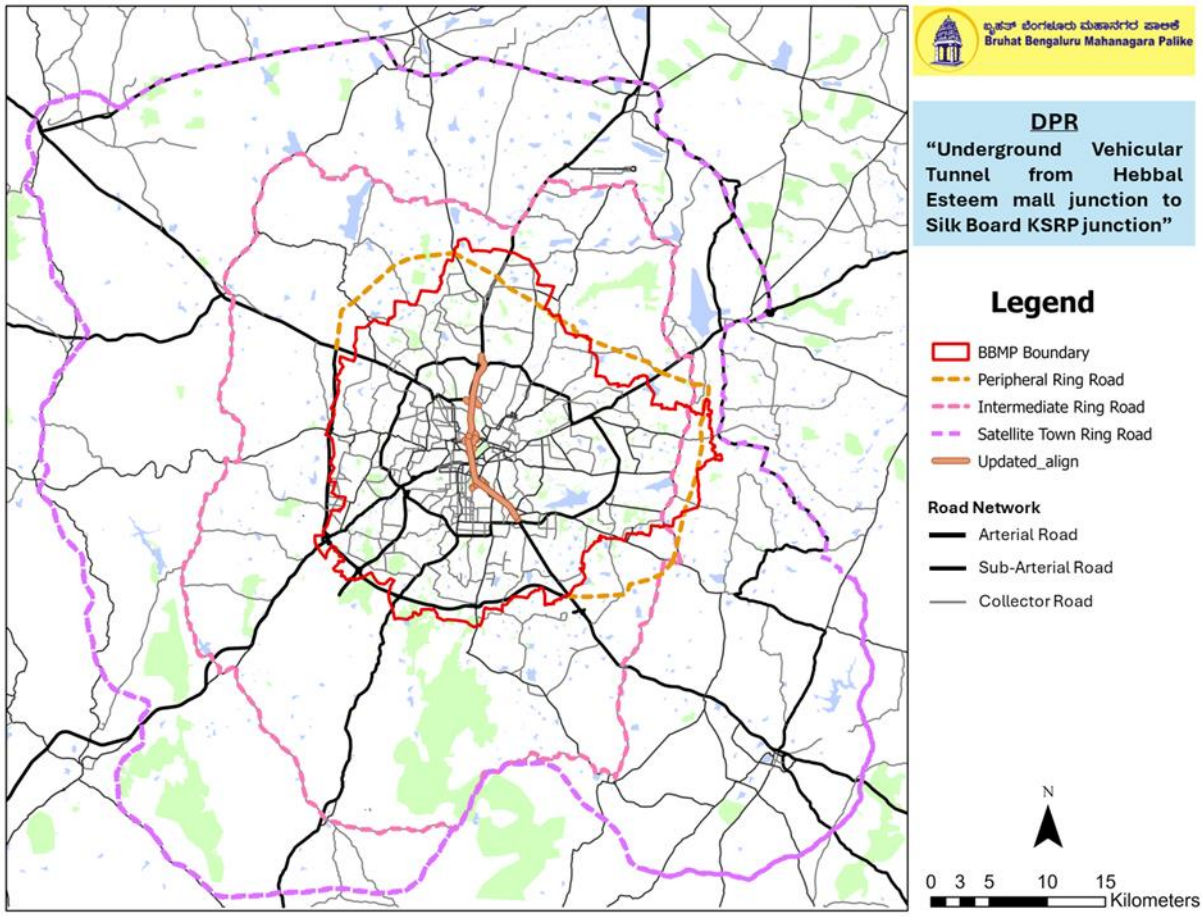


Figure 32: Three Road Projects that are Sanctioned in Bengaluru

4.3 Satellite Town Ring Road:

In order to ensure safe, smooth, efficient, and high-speed transport corridor to Bangalore city, it is impetus that the infrastructure of city and adjoining towns anticipated the development. National Highways NH 648 (NH 207), NH 48 (NH 4), NH 275, NH 948, NH 209 & NH 75 (Hassan Road), and majority of State Highways SH 3, SH 85, & SH 35 pass through Bangalore city comprising heavy commercial traffic movement. Most of this traffic are not intend to pass through Bangalore city. This traffic further aggravate the scenario in the city roads and resulting huge traffic jams. The satellite town ring road will prevents the inclusion of non-intended traffic into city traffic , traffic would be mitigated through the Satellite Town Ring road project.

4.4 Peripheral Ring Road:

The proposed "Peripheral Ring Road" is 65 km long and connects 10 major Highways namely Tumkur Road(NH-4), Hesaraghatta Road(SH-39), Doddaballapura Road(SH-09), Bellary Road (NH-7), Hennur-Baglur Road (SH-104), OMR (NH-4), Whitefield road, Channasandra Main Road, Hoskote-Anekal Road(SH-35), Sarjapur Road and Hosur Road(NH-7). Overall, it intersects 4 National Highways and 6 state Highways. The proposed PRR length from start point on Tumkur road upto end point on Hosur road is 64.201 Km. Since,

the alignment is getting integrated with NICE road on Tumkur road (~ 368m) and Hosur road (~ 546m), the total length of the project road is considered to be 65.115 Km.

4.5 Inner Ring Road:

Inner Peripheral Ring Road, which is a newly identified ring in between ORR and PRR. The alignment is a combination of existing and new roads. It connects suburbs such as Yelahanka, Jakkur, RK Hegde Nagar, Horamavu, Kithaganur, Sonnenahalli, Kadugodi, Varthur, ChikkaBegur, Hulimavu, Kengeri, Ullal, Nagasandra and Chikbanavara.

4.6 Metro

Transport Demand Forecast Study and Identification of Phase III Corridors of Bengaluru Metro was undertaken by Bengaluru Metro Rail Corporation Limited (BMRCL) to extend the metro system in Phase-III for the areas not covered by Phase-I & II and interconnect the metro system network as shown in Table. All metro routes of Phase-I are operational, some routes of Phase-II are operational, and the rest are ongoing projects and all routes in Phase-III are the upcoming projects as given in the metro DPRs.

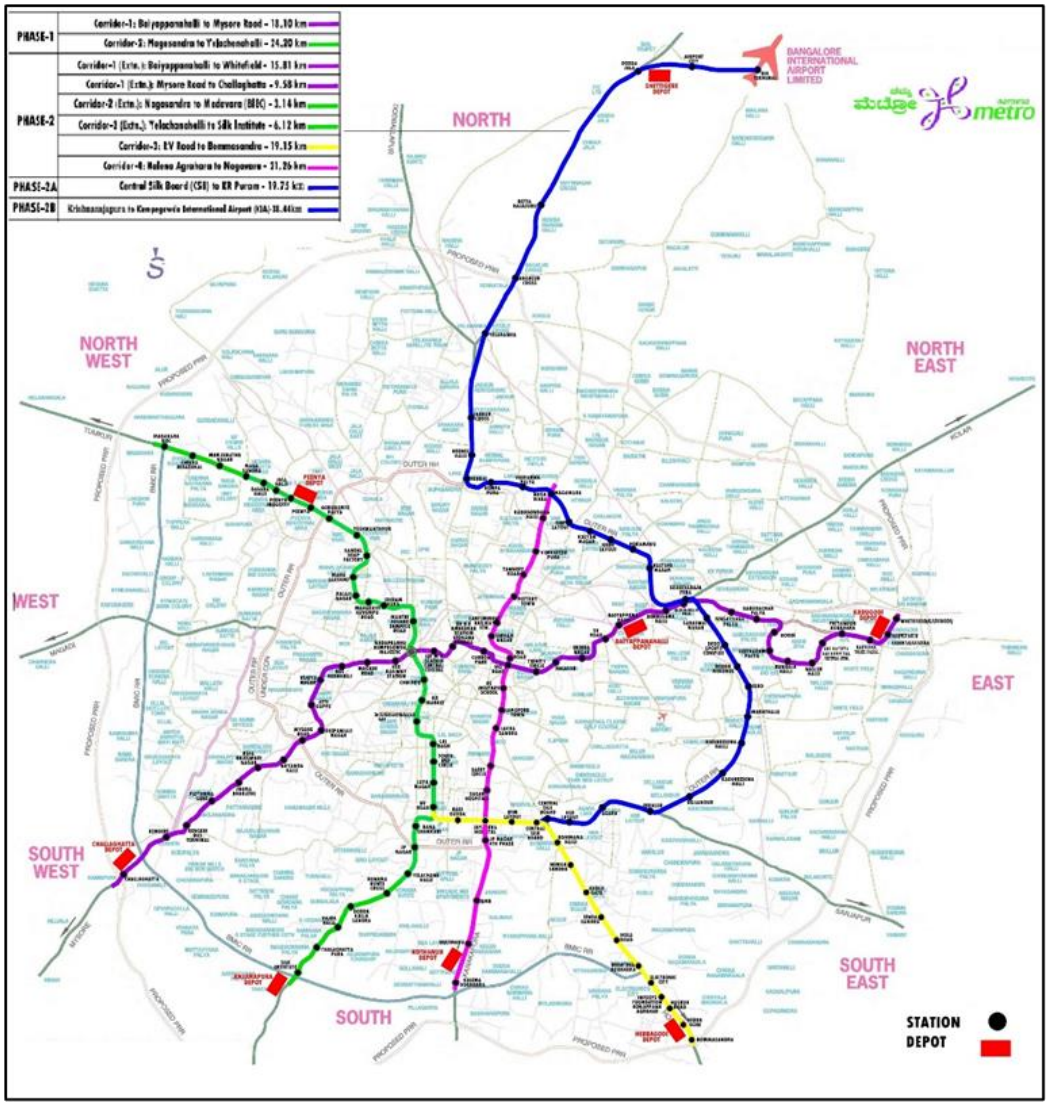


Figure 33: Metro Connectivity

CHAPTER 5
ALIGNMENT STUDY

CHAPTER 5: ALIGNMENT STUDY

The alignment developed were analysed for the merits and demerits on basis of a matrix developed with robust criteria, which shall involve and consider all aspects pertaining to Ease of Construction, Land Acquisition, Environment, and Social Impact, traffic movement, nodal point and direct connection between two nodes.

5.1 Design Consideration

The horizontal and the vertical alignments of the roads will have a significant impact on the design of the tunnel which will need to account for aspects such as stoppage distances, lines of sight in narrow curves, speed limits, number of lanes, gradients, etc. In addition, the design must consider all applicable Codes and Standards. In this case, the options were based on the design criteria of having 6 total lanes, three in each direction.

Table 37: Geometric Design Criteria adopted (IRC 86-2018)

SL	Description	Details
1	Design Speed	60 KMPH (Arterial Road)
2	Lane Configuration on each tube (Mian Tunnel)	3 lane
3	Single lane width	3.5 m
4	Kerb Syness	0.5m
5	Lane Configuration of ramps (entry & exit)	2 lane
6	Radius of Horizontal Curve	400 m min.
7	Max. Super elevation	5%
8	ISD	240m
10	Minimum length of Vertical curve	60m
11	Cross fall camber	2.0%
12	Vertical clearances	5.5m
13	Vertical Gradient	
13A	Transition Ramp and Cut & Cover (adopted)	3-6%
13B	Tunnel	3% max.

The entire project is in Bengaluru city and connecting the northern part to the southern part of the city.

As per the feasibility report, the North – South Corridor starting from Hebbal Esteem Mall junction to Silk Board KSRP Junction is going to develop as Underground Vehicular tunnel with tune tube configuration having 03 intermediate ramps for entry & exit.

The alignment plan of the proposed tunnel is given below-

The alignment of the project has been finalized after the detailed traffic study, ongoing and planned construction and development proposals and the need to provide connectivity to central Bangalore. An extensive exercise of discussion with various stakeholders of the city has been conducted, trends were analyzed whose brief description is mentioned below.

The alignment have following proposal

- Entry Point at Hebbal: with 2 entry and 2 exits
- 3 Intermediate locatins to provide connectivity in the city. The locations are ,
  - Near Palace Ground
  - Near Race Course/Vidhan Saudha
  - Near Lalbagh Botanical garden.

- Exit point at Silk Board Junction with 2 entries and 2 exits.

5.2 The start Point of Project

The project Stretch Start from Hebbal near Esteem Mall and end near silk board junction, where existing road is a 6-lane divided carriageway road.

The starting point has two entry ramps into the tunnel and two exits. Each entry and exit have 2 lane configurations.

The Entry at the start location has been planned near esteem mall for connecting traffic from Airport flyover and another entry has been provided from service road for the traffic coming from Sahakarnagar & Yelahanka to the main tunnel for conflict free movement at junction another entry ramps have been proposed at the Ring Road. Similarly, two exits have been proposed, one towards the Ring road and another on service road.

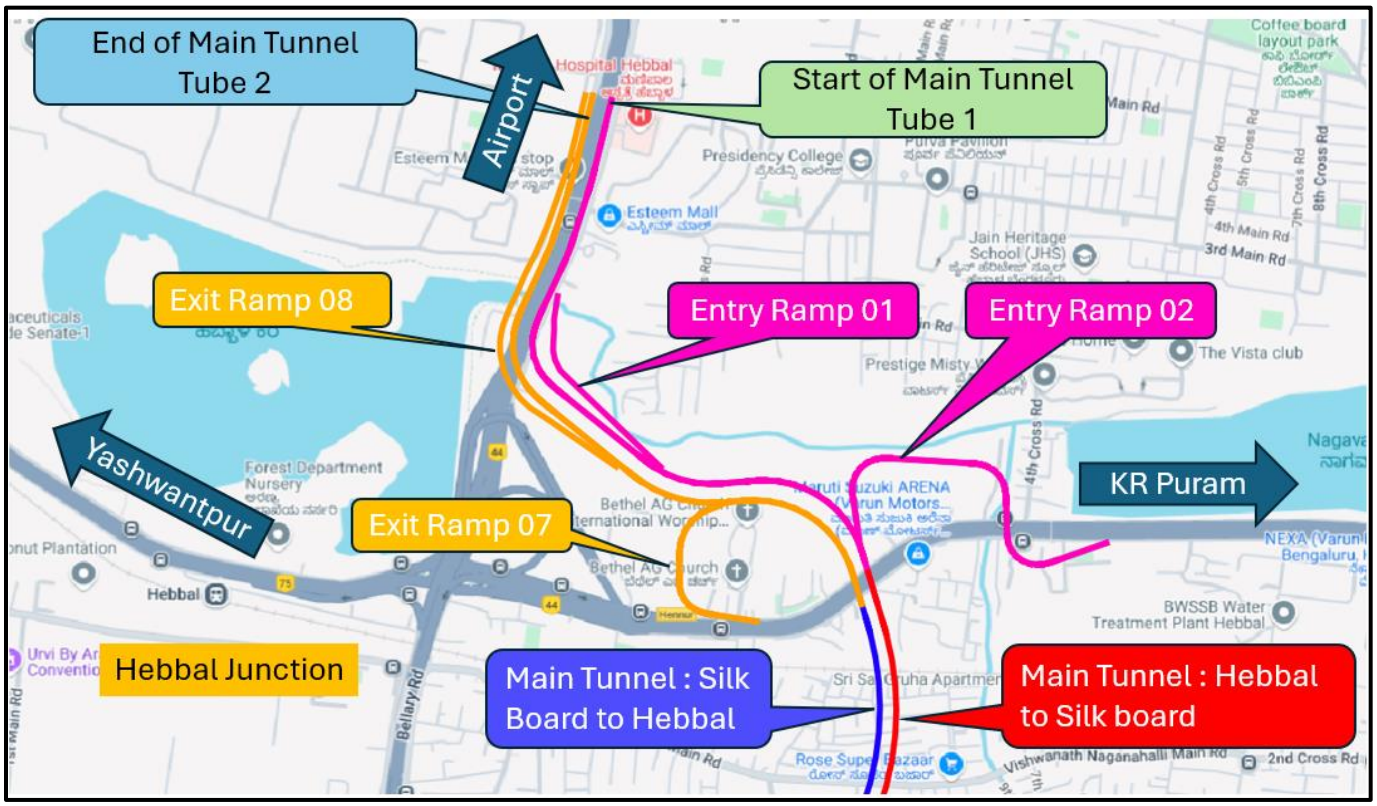


Figure 34: Entry and Exit at Hebbal Junction

Table 38: Entry Exit Details at Hebbal Junction

Sr. No.	Location	Description	Length	Direction Of Traffic	Lane Configuration
Main Tunnel					
1	Hebbal	Entry Ramp 1 into Main Tunnel	0.360 Kms	From Service Road Airport to Bangaluru City	2 Lane
2		Exit Ramp 08 from Main Tunnel	0.700 kms	To Service Road towards Sahakar Nagar, Yelahanka	2 Lane
3		Entry Ramp 2 into Main Tunnel	0.814 Kms	From KR Puram on Outer Ring Road	2 Lane

Sr. No.	Location	Description	Length	Direction Of Traffic	Lane Configuration
4		Exit Ramp 07 from Main Tunnel	0.400 Kms	Towards Yeswanthpur on Outer Ring Road	2 Lane

5.3 First Intermediate Ramps

The first intermediate location has been planned near Mehkri circle. Only two ramps has been provisioned, the entry ramp from Jayamahal main road for traffic going to silk board junction and exit ramps on C V Raman road.

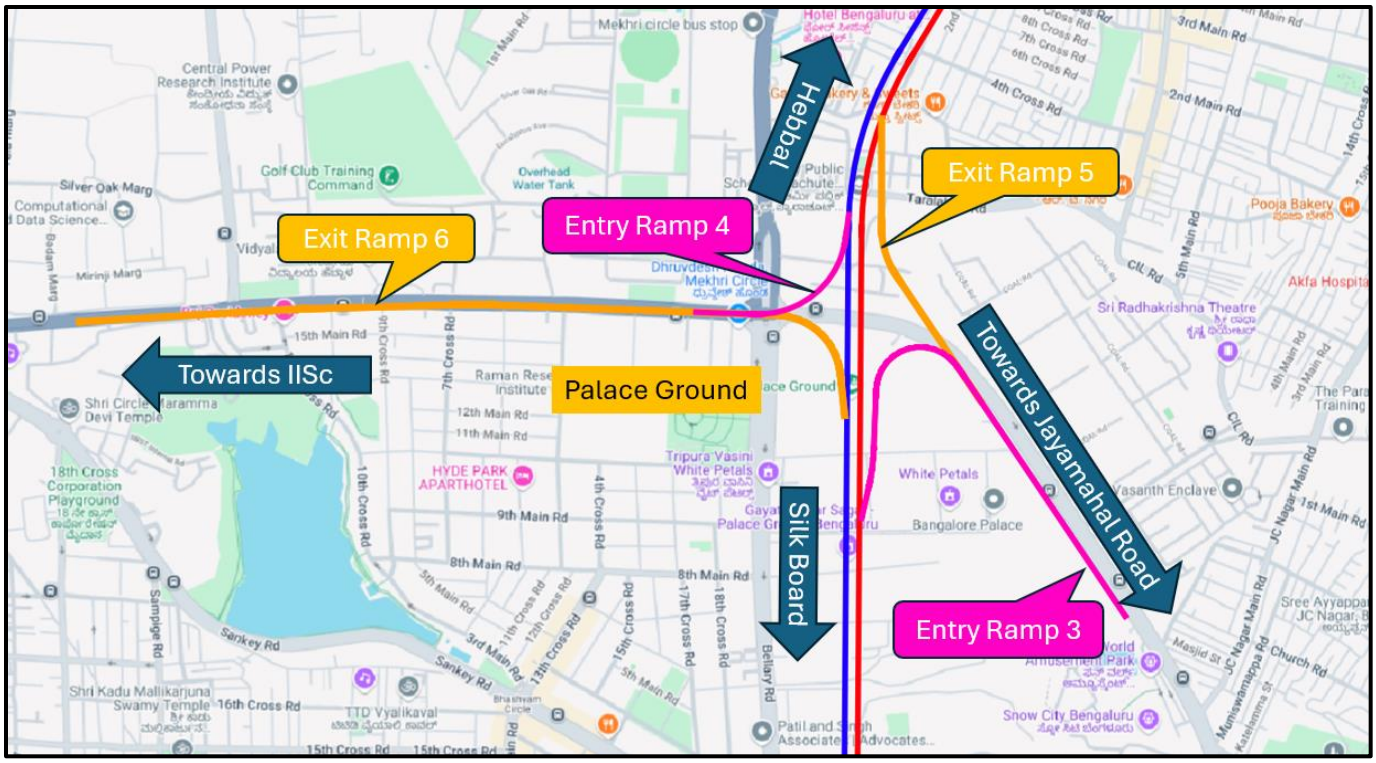


Figure 35: Entry and Exit Ramps at Palace Ground

Table 39: Ramps Details at Palace Ground/Mekri Circle

Sr. No.	Location	Description	Length	Direction of Traffic	Lane Configuration
Intermediate Ramps					
1	Near Palace Ground/ Mekri Circle	Entry Ramp 03 into Main Tunnel	1.255 Kms	From Jayamahal Road	2 Lane
2		Exit Ramp 06 from Main Tunnel	1.910 Kms	Towards CV Raman Road	2 Lane
3		Entry Ramp 4 into Main Tunnel	1.320 Kms	Entry from CV Raman Road towards Hebbal	2 Lane
4		Exit Ramp 05 from Main Tunnel	0.963 Kms	Exit Towards Jayamahal Road	2 Lane

5.4 Second Intermediate Ramps

The Second intermediate ramps have been planned near racecourse/ Vidhan Soudha to connect the central part of Bengaluru. Entry and exit ramps have been provisioned in both tunnel tubes.

All the four ramps (2 entry and 2 exit ramps) have carriageway width of 2 lanes.

Two entry ramps from Palace Road, one towards Hebbal and one towards the Silk Board Junction. Two exit ramps, One exit on Seshadri Road (Towards KR Circle) and one exit on Race Course road (Toward Chalukya circle).

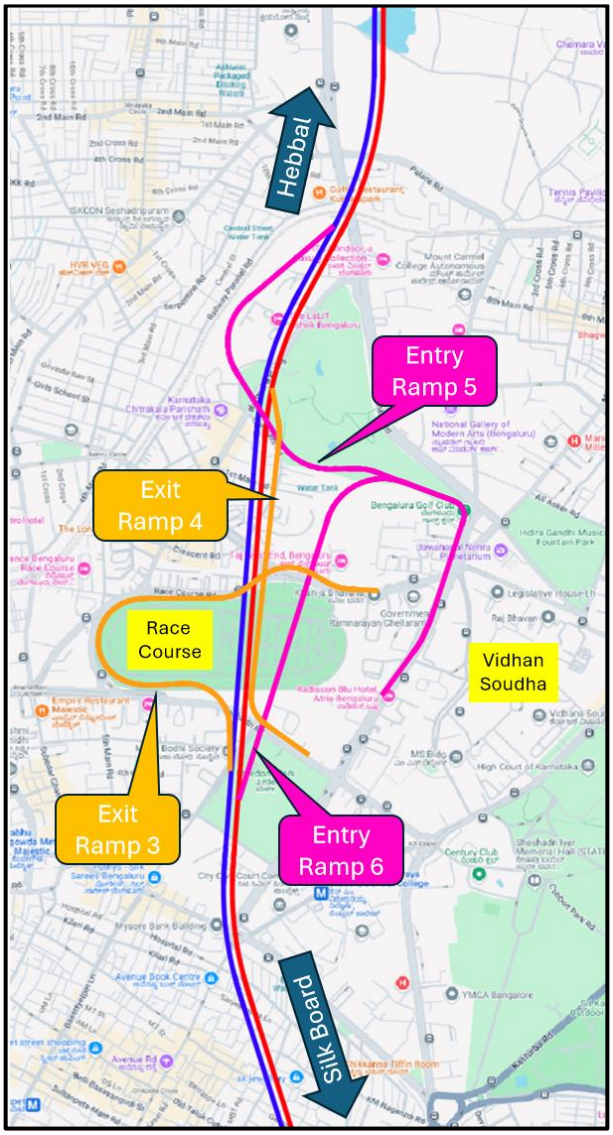


Figure 36: Entry and Exit Ramps at Race Course and Vidhan Soudha

Table 40: Ramps Details at Race Course/ Vidhan Saudha

Sr. No.	Location	Description	Length	Direction Of Traffic	Lane Configuration
Intermediate Ramps					
1	Near Race Course /	Entry Ramp 5 into	1.387	From Palace Road	2 Lane

Sr. No.	Location	Description	Length	Direction Of Traffic	Lane Configuration
	Vidhan Saudha	Main Tunnel	Kms	Towards Hebbal	
2		Entry Ramp 6 into Main Tunnel	1.906 Kms	From Palace Road Towards Silk Board Junction	2 Lane
3		Exit Ramp 04 from Main Tunnel	1.376 Kms	On Seshadri Road (Towards KR Circle)	2 Lane
4		Exit Ramp 03 from Main Tunnel	1.864 Kms	On Race Couse Road (Towards Chalukya Circle	2 Lane

5.5 Third Intermediate Ramps

The 3rd intermediate location is planned near Lalbagh. Only two ramps have been provisioned, the entry ramp from Ashoka Pillar on Siddapura road for traffic going to Hebbal junction and exit ramps on Marigowda road towards Dairy circle at Wilson Garden.

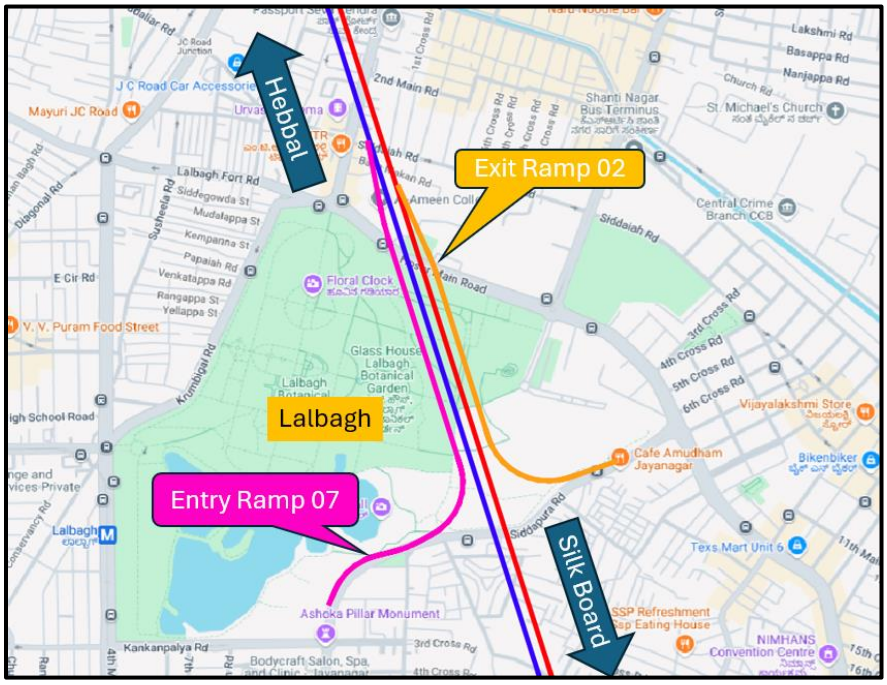


Figure 37: Entry and Exit Lalbagh Botanical Garden

Table 41: Ramps Details

Sr. No.	Location	Description	Length	Direction Of Traffic	Lane Configuration
Intermediate Ramps					
1	Near Lalbagh	Entry Ramp 7 into Main Tunnel	1.416 Kms	From Siddapura Road (Near Ashoka Pillar).	2 Lane
2		Exit Ramp 2 from Main Tunnel	1.073 Kms	On Siddapura Road Near Wilson Garden	2 Lane

- The entry ramp from Ashoka Pillar on Siddapura road for traffic going to Hebbal junction.
- Exit ramps on Siddapura road (marigowda road towards Dairy circle).

5.6 The End point of Project

The Tunnel ends before silk board junction on Hosur road. Both entry and exit ramps has been planned on Hosur Road for the traffic going to electronic city. However, additional, entry & exit ramp has been planned to connect the traffic going to Ring Road/ HSR layout area on Sarjapur road near St. John Hospital.

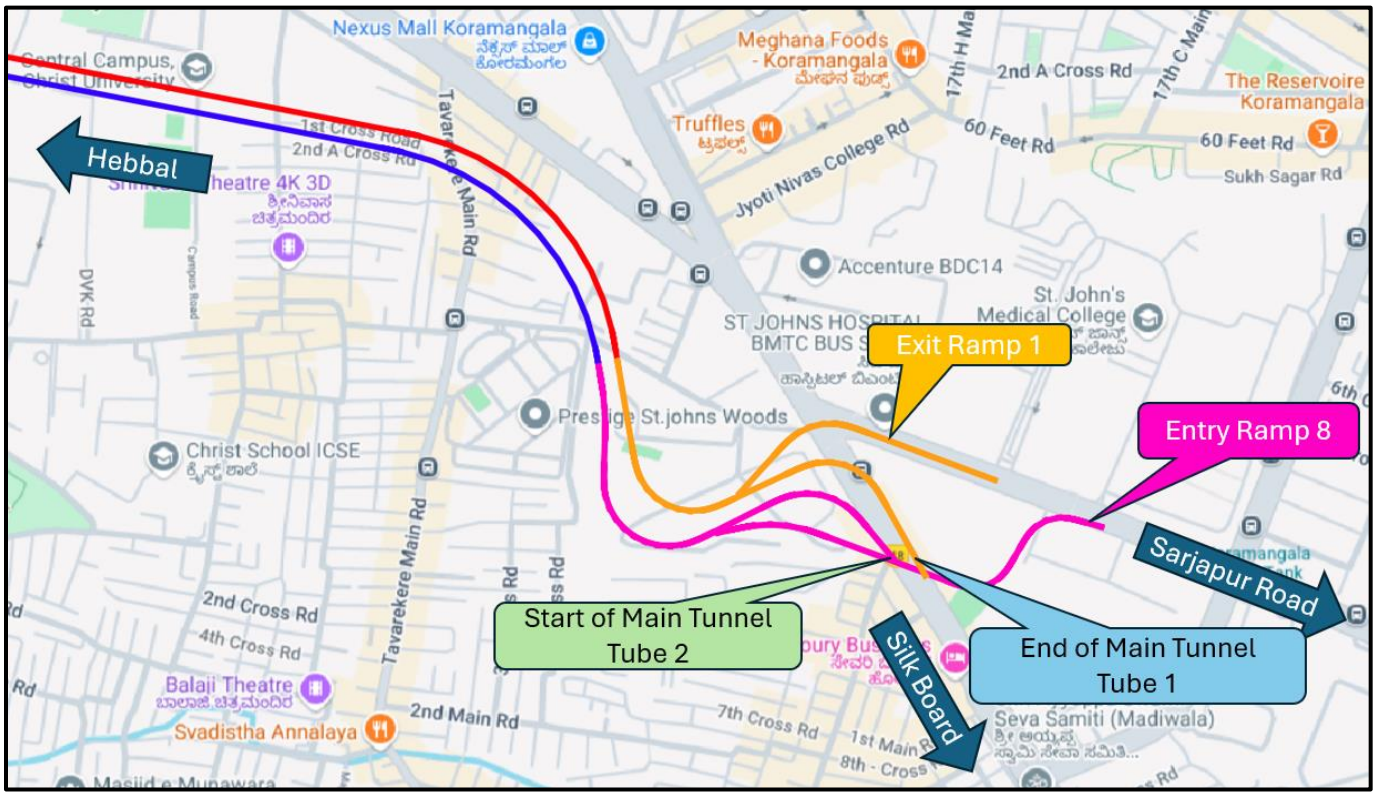


Figure 38: End Point of Project Alignment

Table 42: Entry and Exit Details

Sr. No.	Location	Description	Length	Direction Of Traffic	Lane Configuration
Main Tunnel					
1	Silk Board	Exit Ramp 1 from Main Tunnel	0.454 Kms	On Sarjapur Road / HSR layout (Ring Road)	2 Lane
2		Entry Ramp 8 into Main Tunnel	0.663 Kms	From Sarjapur Road / HSR layout (Ring Road)	2 Lane

5.7 Feasible Alignment

The alignment option has been discussed along with stake holders such as BBMP, BMRCL, KRIDE and BDA. The proposal has been planned in such a way to minimise the infringement with the surrounding under development project. The alignment proposed has been agreed by BBMP and it is the best feasible option for tunnel and its ramps.

5.8 Infringement with the proposed alignment:

The proposed tunnel alignment starting from Hebbal and ending at Silk Board junction including 3 intermediate ramps in between. The proposed development plan in having infringement with ongoing & planned work of Metro and K-Ride. The detail is as under-

Table 43: Infringement Points with Proposed Tunnel

Proposed Tunnel Alignment Location/ CH	Infringement with	CH of metro/ Rail	Type of Infringement	Proposal in the instant Tunnel alignment	Remarks
KM 0.450 to 0.750	Metro Phase 2B (Elevated)	CH 11.480 to 11.600	Under construction Metro Pier is coming along alignment	Metro span to be increased	Discussion required with BMRCL
Km 1.425	Metro Phase 3 (elevated)	CH 10.500 to 10.600	Under construction Metro Pier is coming along alignment	Metro span to be increased	Discussion required with BMRCL
Km 1.425	Metro Phase 2B (elevated)	CH 10.500 to 10.600	Under construction Metro Pier is coming along alignment	Metro span to be increased	Discussion required with BMRCL
Km 1.600	K-Ride (C2 corridor, at grade)/ IR	10.200	Crossing alignment	Proposed Tunnel going Underground (with min. 1D cover)	Discussion required with KRIDE/ IR
Km 0.300 (Exit ramp 4 - CV Ramao Rd.)	Metro Phase 3A (UG)	CH 32.050	Crossing Proposed alignment	Proposed Tunnel going below proposed metro line (with 1D cover)	Discussion required with BMRCL
Km 7.000	K-Ride (C3 corridor, elevated)/ IR	CH 15.170 to 15.220	Crossing Proposed alignment	K-RIDE Span need to be re-checked if required	Discussion required with KRIDE/ IR
Km 7.000	Metro Phase 3A (UG)	CH 29.900 to 29.980	Crossing proposed alignment	Proposed Tunnel going below proposed metro line (with min. 1D cover)	Discussion required with BMRCL
Km 0.000 to km 0.750 (Entry ramp 1 – Palace Rd.)	Metro Phase 3A (UG)	CH 27.900 to 28.940	Parallel to proposed alignment	Proposed Tunnel ramps going parallel to metro line in Open cut and Cut & Cover;	Discussion required with BMRCL

Proposed Tunnel Alignment Location/ CH	Infringement with	CH of metro/ Rail	Type of Infringement	Proposal in the instant Tunnel alignment	Remarks
				Integration is required	
Km 8.550	Metro Phase 1 (UG)	CH 8.400 to 8.500	Crossing running metro line	Proposed Tunnel going below metro line (with min. 1D cover)	Discussion required with BMRCL
Km 14.550	Metro Phase 2 (UG)	CH 7.870 to 7.960	Crossing under construction metro line	Proposed Tunnel going below metro line (with minimum 1D cover)	Discussion required with BMRCL
Km 0.150 to 0.454 (exit 2 at silk board towards Sarjapur Rd., near St. john hospital)	Metro Phase 3A (UG)	CH 20.480 to 20.490	Crossing Proposed alignment	Proposed Tunnel ramps crossing proposed metro line in Cut & Cover; Integration is required	Discussion required with BMRCL
Km 0.550 to 0.663 (entry 4 at silk board towards Hebbal from Sarjapur Rd. near john hospital)	Metro Phase 3A (UG)	CH 20.040	Crossing Proposed alignment	Proposed Tunnel ramps crossing proposed metro line at grade; Integration is required	Discussion required with BMRCL

CHAPTER 6
ENGINEERING SURVEY AND INVESTIGATION

CHAPTER 6: ENGINEERING SURVEYS AND INVESTIGATION

6.1 General

Bruhat Bengaluru Mahanagara Palike (BBMP) intends to Construct a Underground Vehicular Tunnel for the North – South Corridor starting from Hebbal Esteem Mall junction to Silk Board KSRP Junction.

In pursuance of the above, Rodic Consultants Pvt Ltd., New Delhi has been appointed as consultants for, "Consultancy Services for Preparation of DPR for the work of Construction of Underground Vehicular Tunnel from Hebbal Esteem Mall junction to Silk Board KSRP junction". The project influence areas of the proposed project lie in the district of Bengaluru Urban in the state of Karnataka.

6.2 Engineering Surveys and Investigations

Based upon the objectives of the project. With careful planning and efficient use of resources different tasks have been done simultaneously. Based on the objectives and scope of the consultancy services, an appropriate methodology has been developed by the consultants to address the other requirements also, especially regarding various intermediate targets and completion period, manning schedule, and TOR.

A work plan has been prepared based on the methodology developed. A competent team of suitably qualified key professionals as per the requirements and other supporting staff has been selected to carry out the services fieldwork and office work.

6.3 Existing Features of Project

The project starts near Esteem Mall Hebbal Junction and Ends at Silk board Junction. The alignment passes through nodal points/ stretch of the Bengaluru city.

First stretch is Hebbal to Golf course whose existing roadway width is 6 lane divided carriageway, then further there is connectivity to Chalukya circle via 4 lane existing divided carriageway road. After that Calukya circle is connected to Lalbagh and finally Lalbagh to Silkboard junction all the stretches are 4 lane divided carriageway.

The location of entry and exit ramps have been analyzed.

- At the Start End, the road is 6 lanes with divided carriageway. There is presence of Minor bridges near Esteem mall which channelizes the stream if Hebbal lake. The construction of metro (name of metro line and its links) is underway, which affects our project start point.
- At the End Point the road is 4 lanes with divided carriageway. The road have a under construction double decker flyover at Silk Board junction and metro is also under construction at the project end location.

The alignment passes through some of the prominent stretches of the Bengaluru city which caters the heavy traffic throughout the day.

6.4 Reconnaissance Survey

A preliminary survey has been conducted to gather general information about the project area. The purpose of the reconnaissance survey is to get a broad understanding of the terrain, conditions, Environmental and Social Considerations, Safety and Risk Assessment of the project area.

6.5 Road Inventory

Road inventory was carried out in the first week of August 2024 over the possible locations of the project alignment. The road conditions are found to be good, some of the roads have undergone strengthening of

bitumen surface through the provision of White Topping. Metro is being constructed at the starting point of our project alignment. However, the project influence area the volume of traffic is quite high.

6.6 Existing Carriageway

The existing road infrastructure includes lane configurations of 4 lanes, and 6 lanes in various segments. Furthermore, it is observed that several metro routes intersect with these corridors. The road stretches and lane details are as follows:

Table 44: Existing Carriageway

Stretch	Lane Configuration
1. Hebbal to Golf course	6 lanes
2. Golf course to Chalukya	4 lanes
3. Chalukya to Lalbagh botanical garden	4 lanes
4. Lalbagh botanical garden to silk board	4 lanes

6.7 Alignment and Geometry

An current average travel speed is 15-20 km/hr in the project stretch because of traffic congestion.

6.8 Terrain and Land Use

Project area lies in plain terrain in entire length. The land-use pattern for the project area is densely populated builtup of Bengaluru City.

6.9 Traffic Survey

For the evaluation of the traffic demand estimation on the proposed North – South corridor in Bengaluru and impact on the road network in study area, traffic model will be developed in PTV Visum 2024. Macro simulation analysis will be conducted to understand the overall travel patterns in the study area. PTV Visum 2024 helps to understand the existing traffic and travel patterns and bottlenecks in the transportation system. Further it is used for scenario testing according to the changes in demand and infrastructure. Comprehensive data collection will be done to understand the existing traffic and travel pattern and for development of the base year model. Further updating the demand and network in the model the diversion to the corridor will be estimated.

The traffic survey has been planned along the proposed corridor, The location of traffic survey mainly for classified Volume count, O-D Survey and Turning movement survey has been studied and detailed analysis has been described in Chapter 6 of this report.

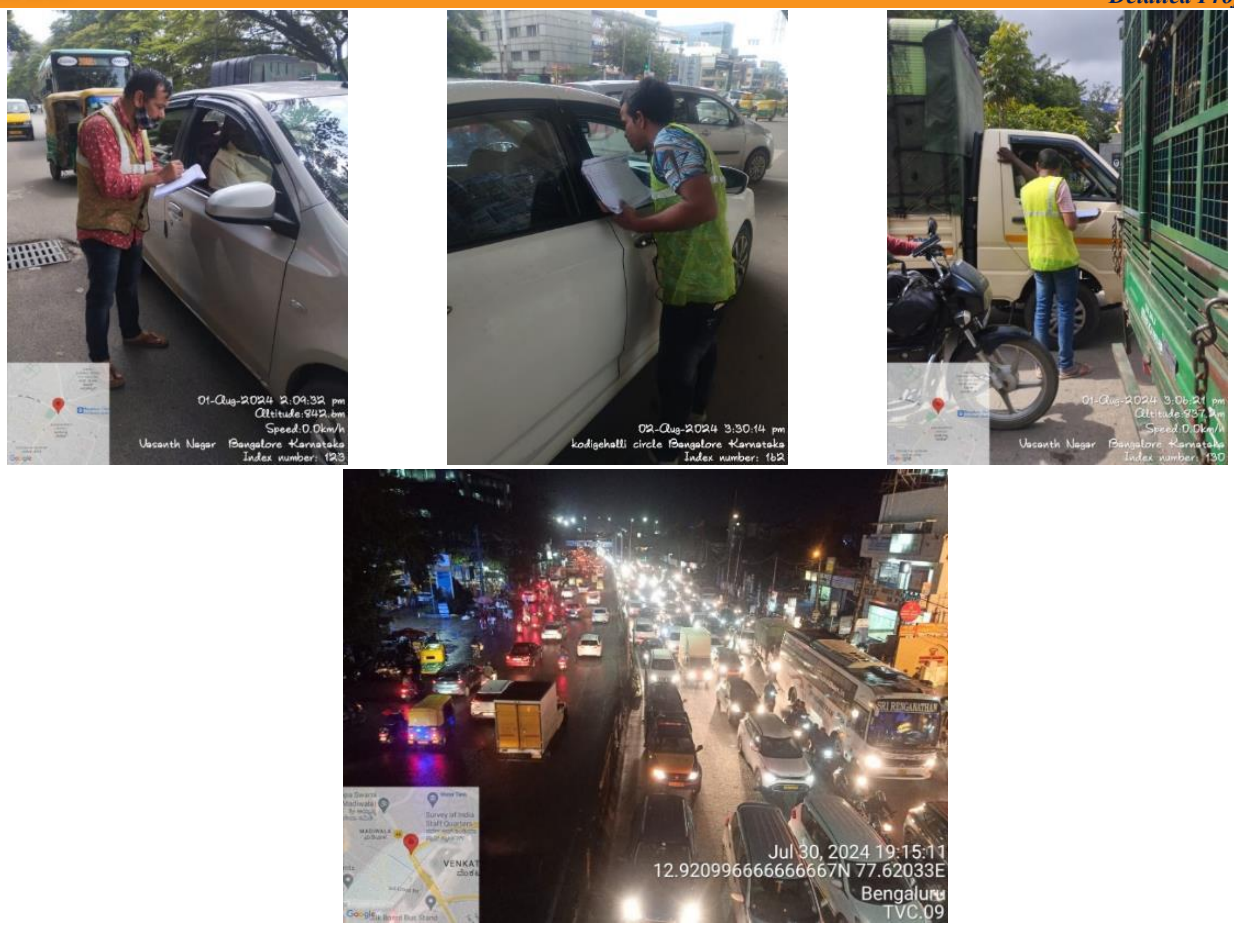


Figure 39: Traffic Surveys conducted at Project Location

6.10 Topography Survey:

The topography survey has been carried out using Drone LiDAR for the location which is in green zone however the yellow and red zone is still pending. The Topography survey using DGPS (Differential Global Positioning System) has been conducted for all the entry, exit and intermediate ramps locations.

Figure 40: Topography Survey on Site

6.11 Geotechnical & Geophysical Investigation:

Secondary data from ongoing metro projects (Nearby Proposed tunnel alignment) has been considered for

geological study. However, a confirmatory bore holes and geophysical survey (MASW-Multichannel Analysis of Surface Wave and SRT-Seismic Refraction Test), is being conducted to verify the reports collected for the design.

The details of the Secondary data is provided in GIR Volume submitted separately.

Figure 41: Geophysical Survey on Site

CHAPTER 7
TRAFFIC STUDY AND ANALYSIS

CHAPTER 7: TRAFFIC STUDY AND ANALYSIS

7.1 Project Background

The Government of Karnataka (GoK) has launched an ambitious program to elevate Bengaluru to a world-class city status, with a focus on enhancing urban infrastructure. Among the various infrastructure projects underway, a Comprehensive Road Infrastructure Plan has emerged as a critical initiative. This plan includes the potential development of elevated corridors and tunnels aimed at improving traffic movement and alleviating congestion within the city. The responsibility for implementing this significant project has been assigned to the Bruhat Bengaluru Mahanagara Palike (BBMP). To facilitate the project, BBMP engaged ALTINOK to conduct a feasibility study, which has now been completed. Further for preparation of DPR BBMP engaged Rodic Consultants, where the detail design will be carried out along with traffic estimation and forecasting on the corridor by developing model in VISUM.

7.2 Need of the Study

Bengaluru's population has grown dramatically in the last decade, and the city now ranks among the top metropolitan areas in the country, both in terms of population and in terms of economic activity. The city has undergone a rapid transformation into one of the most storied economic centers of the world and attracted millions of job-seeking migrants. Increasing traffic volumes and its associated adverse impacts on congestion and air quality is a key problem in Bengaluru and elsewhere in India and this situation is likely to deteriorate further. The proposed North-South corridor is planned to reduce the congestion levels on roads and reduce the travel time of people. To predict the traffic volume that will divert to the proposed corridor, it is required to carry out traffic demand estimation.

7.3 Approach & Methodology

7.3.1 Approach

For the evaluation of the traffic demand estimation on the proposed North – South corridor in Bengaluru and impact on the road network in study area, traffic model will be developed in PTV Visum 2024. Macro simulation analysis will be conducted to understand the overall travel patterns in the study area. PTV Visum 2024 helps to understand the existing traffic and travel patterns and bottlenecks in the transportation system. Further it is used for scenario testing according to the changes in demand and infrastructure. Comprehensive data collection will be done to understand the existing traffic and travel pattern and for development of the base year model. Further updating the demand and network in the model the diversion to the corridor will be estimated.

7.3.2 About the Software

For the development of the simulation models State of the art simulation software's of PTV Visum 2024 and PTV Vissim will be used. The macro and micro software packages are selected as they can integrated seamlessly with each other to allow for comprehensive strategic and operational analysis.

PTV Visum 2024 is a comprehensive, flexible software system for strategic traffic and transport planning. Around the globe, the system is used for metropolitan, regional and state-wide infrastructure planning. PTV Visum 2024 is one of the world's leading software for traffic analyses, forecasts and GIS-based data management. It consistently models all road users and their interactions and has become a recognized standard in the field of transport planning. Transportation experts use PTV Visum 2024 to model transport networks and travel demand, to analyse expected traffic flows, to plan public transport services and to develop advanced transport strategies and solutions.

7.3.3 Methodology

The overall methodology includes various steps starting from data collection and analysis, deriving inputs from secondary data, base year model preparation and validation in PTV Visum 2024, Updating demand and network and estimation of diversion on the proposed corridor. Figure 42 provides the complete methodology for the travel demand estimation.

The process is divided into seven distinct stages, each with specific objectives and tasks. Stage 1 focuses on data collection, encompassing both primary and secondary sources. Primary data is gathered through classified traffic volume surveys, classified turning movement surveys, origin-destination surveys, and speed and delay studies. Secondary data is sourced from previous studies such as the Comprehensive Mobility Plan 2020, feasibility reports, sustainable mobility reports, and Metro DPRs. This data is utilized to extract valuable information like zone boundaries, link shape files, demand matrices, and other relevant planning data.

In Stage 2, the collected data undergoes analysis to derive inferences and identify potential transport and infrastructure proposals and projections. Stage 3 involves developing a base-year macro simulation model using PTV Visum 2024 software, incorporating both primary and secondary survey data. Model calibration and validation using primary count data occur in Stage 4. Stage 5 focuses on deriving projections for traffic, mode share, and modal shift based on past studies. Stage 6 updates the model's demand and network considering future proposals, while Stage 7 estimates diversion for the corridor using the PTV Visum 2024 model. This comprehensive approach ensures a thorough understanding of the existing traffic conditions and facilitates informed decision-making for future transportation planning and development.

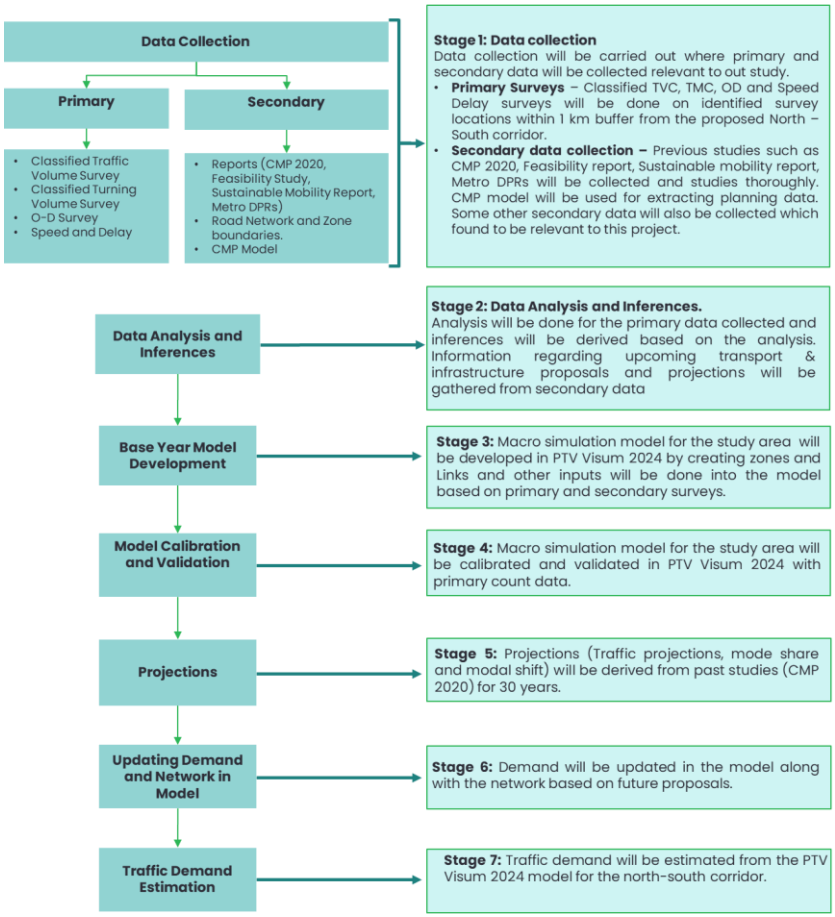


Figure 42: Overall Methodology

7.3.4 Stage 1 - Data Collection

This stage focuses on data collection, encompassing both primary and secondary sources. Primary data is gathered through classified traffic volume surveys, classified turning movement surveys, origin-destination surveys, and speed and delay studies. Secondary data is sourced from previous studies such as the Comprehensive Mobility Plan 2020, feasibility reports, sustainable mobility reports, and Metro DPRs. This data is utilized to extract valuable information like zone boundaries, link shape files, demand matrices, and other relevant planning data.

Primary Data collection

To comprehensively understand the traffic and travel dynamics within the study area, a series of surveys will be conducted. These surveys will include:

- **Classified Traffic Volume Count at Mid-blocks:** This survey will involve recording the volume of vehicles passing through designated mid-block sections along the corridor. By categorizing vehicles based on type (e.g., cars, trucks) and direction (e.g., northbound, southbound), patterns of traffic flow can be analyzed.
- **Classified Turning Movement Count at Intersections:** At key intersections within the study area, turning movement counts will be conducted. This involves observing and categorizing vehicles based on their turning movements (e.g., left turn, right turn, through movement). This data will provide insights into the distribution of traffic movements at critical junctions.
- **Origin and Destination Survey**: This survey aims to identify the starting points (origins) and destinations of vehicles traveling along the corridor. By understanding where vehicles begin and end their journeys, planners can assess travel patterns and needs, which is crucial for future transportation planning and infrastructure development.
- **Speed-Delay Surveys**: Speed and delay measurements will be recorded at various points along the corridor. This survey will capture data on vehicle speeds and any delays encountered due to congestion, traffic signals, or other factors. Analyzing speed and delay data helps in evaluating the efficiency of the roadway network and identifying potential areas for improvement.

These surveys are essential for gathering accurate and detailed information about traffic flow, travel patterns, and operational characteristics within the study area. The data collected will form the basis for informed decision-making in transportation planning and management, aiming to enhance overall traffic efficiency and commuter experience along the corridor.

Secondary Data collection

Various reports and secondary data including comprehensive mobility plan, Bengaluru 2020, feasibility report (North – South corridor), sustainable mobility report, metro DPRs, Metro routes, bus routes, vehicular registration data, CMP Model, road network, zone boundaries and other relevant data will be collected in this stage.

7.3.5 Stage 2 - Data Analysis and Inferences

In this stage analysis will be done for the primary data collected and inferences will be derived based on the analysis such as the peak hour traffic and PCU counts and travel pattern for each mode. Information regarding upcoming proposals of transport and infrastructure projects, proposed mode share and modal shift, metro DPRs, feasibility report and sustainable mobility report. Data from CMP model will be extracted to get planning data.

7.3.6 Stage 3 - Base year model development

The development of the base year model in PTV Visum 2024 involves a structured process aimed at accurately representing the current transportation network and travel patterns within the study area. The immediate study area is considered approximately 1-2 km buffer from the proposed North-South Corridor which consist of internal zones for the model. Base year model will consist of the existing road network (Links and Nodes) which is imported from OSM Maps and the carriageway widths are validated from reconnaissance survey, further the data is imported into the model regarding inventory information, traffic analysis zones, OD matrices from primary survey and base year PCU counts based on the primary survey. The methodology for model development is given below in Figure 43.

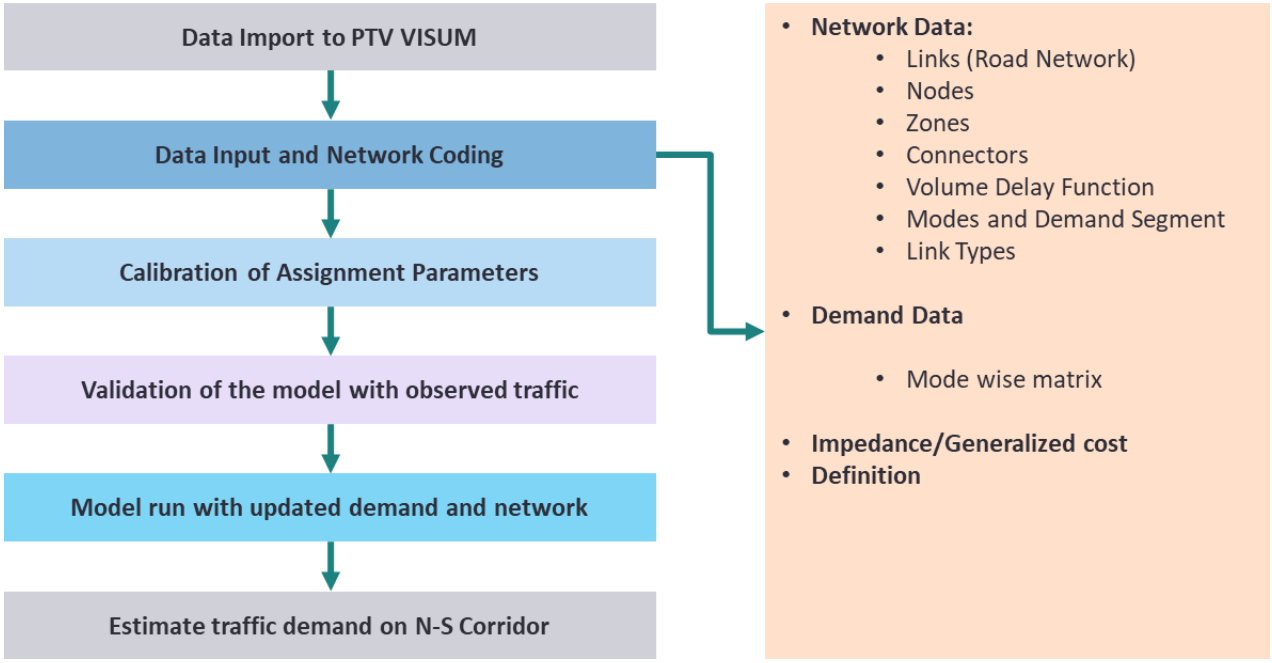


Figure 43: Model Development

7.3.7 Stage 4 - Model calibration and validation

In this stage the vehicle data count from the primary survey and the model outputs from PTV Visum 2024 will be compared for accuracy. Based on statistical measures such as GEH the model counts will be validated. In case of deviation from the standards, the OD matrices for each will be updated based on the matric correction procedure T-Flow fuzzy procedure. T-Flow-Fuzzy is meant to adjust a demand matrix, so that its assignment results for a supply match the real supply observed. In relation to our current assignment, it could be used for following purposes:

- A matrix generated from the transport network model is to be calibrated, therefore counted volume data are to be used.
- A matrix generated from incomplete or not reliable data is to be improved by more comprehensive/reliable volume data counted simultaneously.

For the update, the specified count values will be compared with the volumes, which result from a pre-calculated assignment of the previous demand matrix. Differences between count values and volumes are balanced by adjustment of the demand matrix for the assigned demand segment. The volumes from the selected network object are then taken from the assignment result of this demand result, and the count values also only

refer to this demand segment. The Fuzzy procedure is shown in Figure 44.

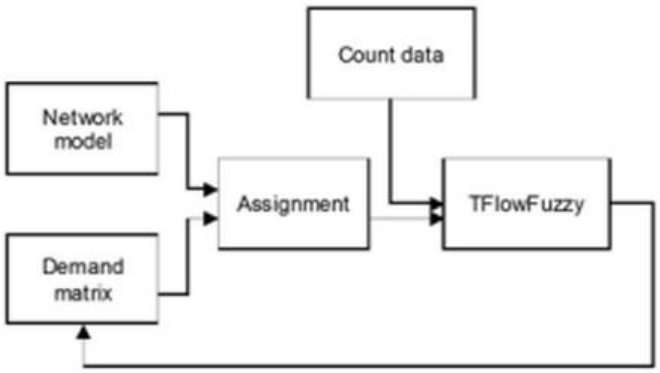


Figure 44: Fuzzy Procedure

7.3.8 Stage 5 - Projections

In this stage the projections will be derived from secondary data. The future traffic growth, and modal shift will be referred from the CMP 2020 report for the study horizon period of 25 years. Other information such as Vehicular Registration data, and proposals regarding the road upgradation, new road construction, proposed metro routes and other infrastructure projects will be referred to estimate the projection factors for each mode.

7.3.9 Stage 6 - Updating demand and network in model

In this stage the model will be updated with the projected demand and the road network will also be updated based on the proposals from the reports regarding upgradation and new construction. The proposed North – South corridor will be added to the model at this stage.

7.3.10 Stage 7 – Traffic Demand Estimation

In this stage traffic assignment will be done in the calibrated model to estimate the traffic demand on the proposed North – South corridor. The model will provide the traffic to be expected on the corridor and its impact on the road network in the study area.

7.4 Report Structure

The report structure is as follows:

- Introduction
- Study Area
- City Urban Transport Characteristics and Secondary Data information
- Primary Data Collection and Analysis
- Base Year Travel Demand Model
- Horizon year Model

7.5 Study area

For estimation of traffic on the proposed North-South corridor, the study area considers the entire BBMP area + BDA Area. Primary study area is taken as a buffer of approximately 2 km from the corridor as shown in Figure 45. The zones within the study area (Approximately 2-3 km) are considered as primary internal zones, Zones with the remaining BBMP and BDA area are considered as secondary zones. Beyond the primary zones the access to the corridor will be via the major road network only.

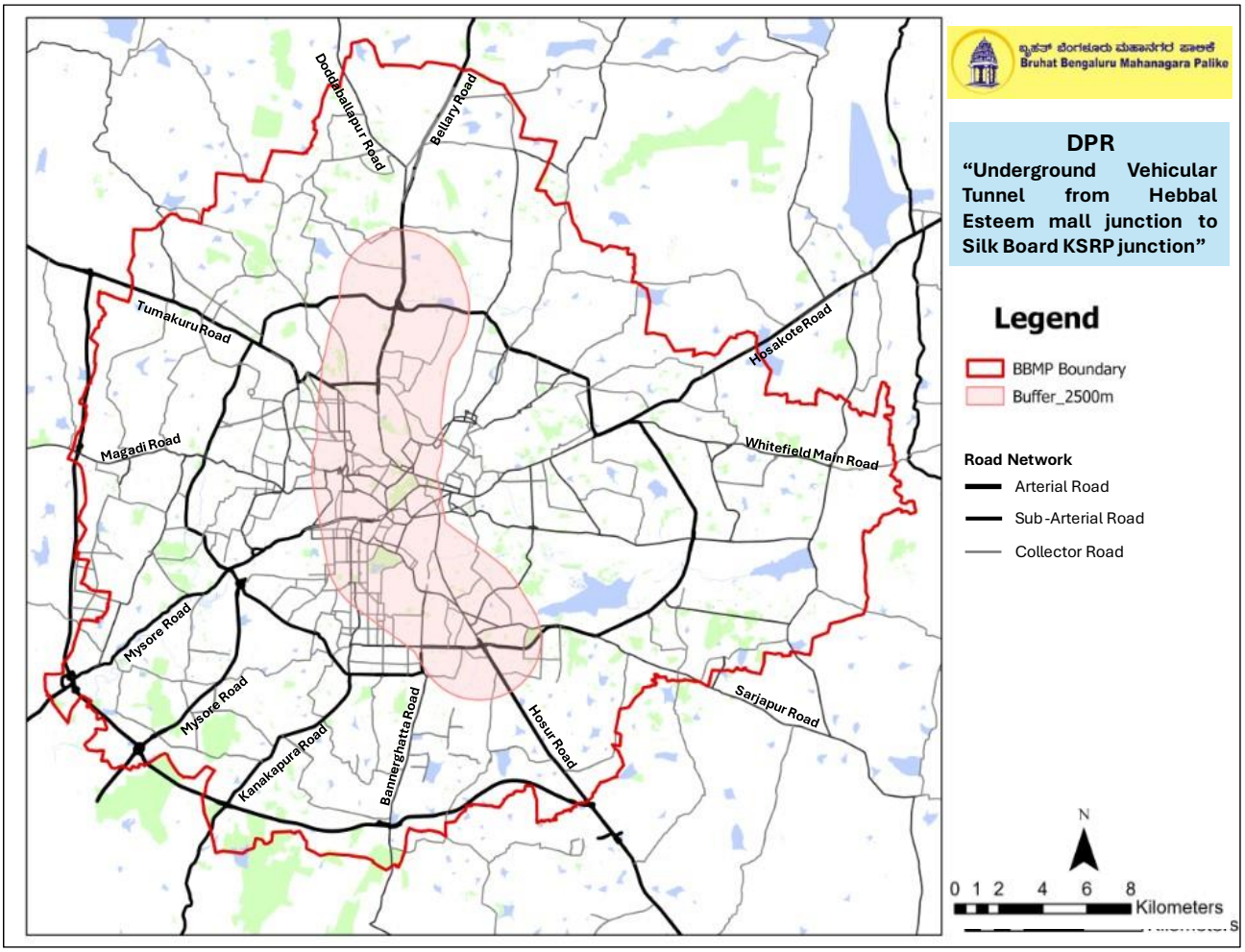


Figure 45: Study Area

7.6 Zoning

Traffic Analysis Zones (TAZs) are geographically defined areas that are used to model traffic flow and demand within a transportation network. These zones typically represent neighborhoods, commercial districts, industrial areas, or other distinct land-use zones. By dividing a study area into TAZs, transportation planners can analyze traffic patterns, forecast future demand, and evaluate the effectiveness of various transportation improvement projects. The size and shape of TAZs can vary depending on the specific study objectives and the characteristics of the study area.

In CMP 2020 ward boundaries were taken as TAZs. As this study is related to the estimation of traffic on proposed North-South Corridor, therefore the wards along the proposed corridor are sub-divided into smaller zones up to an influence area of approximately 2 km (Zone 1 to 74) and these zones are considered as internal

zones for this study. The Wards outside the influence area are clubbed into larger zones (Zone 201 to 307) and these are the immediate external zones. The area outside the BBMP is divided into 4 Zones i.e. Zone no. 501, 502, 503 and 504 based on direction (North, West, South and East respectively). Figure 46 shown the TAZs of study area.

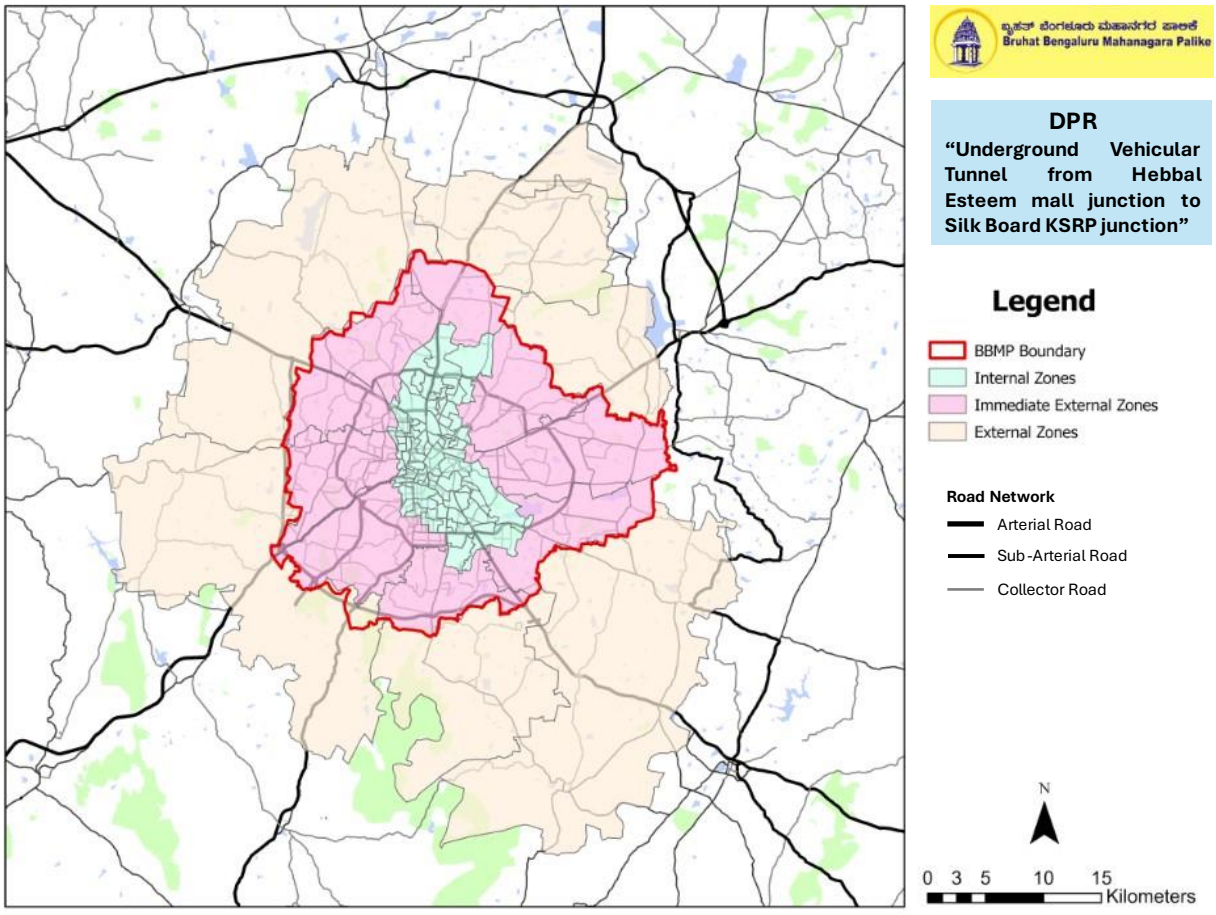


Figure 46: Zoning of Study Area

7.7 Road Network

Bengaluru's road network is a testament to the city's rapid growth and development, boasting a vast expanse of arterial roads, sub-arterial roads, and Collector roads as shown in Figure 47.

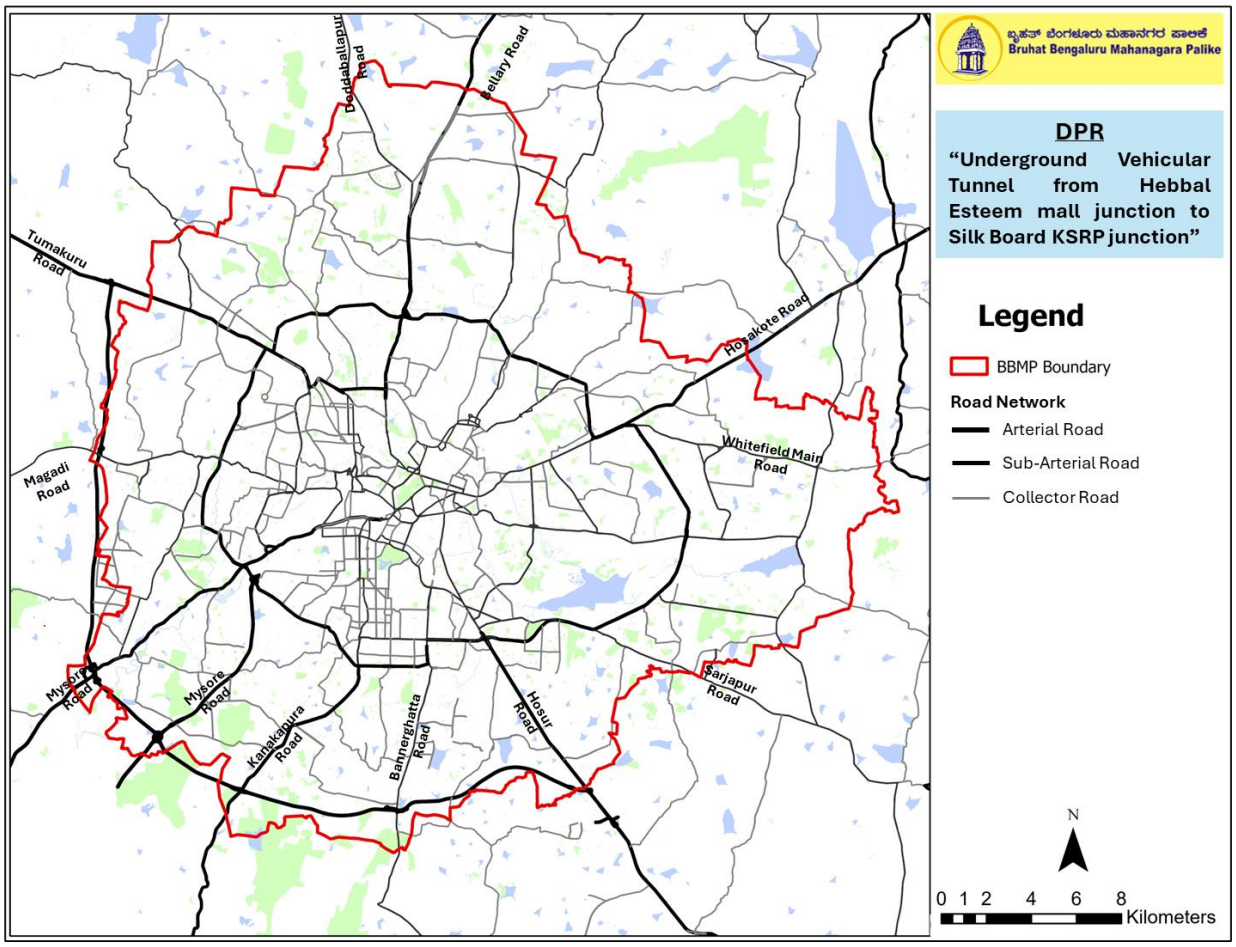


Figure 47: Bengaluru Road Network

For this study the road network in the primary zones network is considered for developing the transport demand model as shown in Figure 47.

7.8 City Urban Transport Scenario and Secondary Data Information

7.8.1 City Profile

Bengaluru, the capital of Karnataka, is a bustling metropolis renowned as India's "Silicon Valley," largely due to its influential technology sector. With a population of over 12 million, it ranks among the most populous cities in India. Despite its economic vitality, Bengaluru faces significant challenges related to traffic and transportation. The city's rapid urbanization has led to severe traffic congestion, exacerbated by an influx of vehicles and inadequate road infrastructure. Although Bengaluru boasts an expanding metro system and a well-developed road network, these developments have struggled to keep pace with the growing demand. Addressing these traffic and infrastructure issues remains crucial for maintaining the city's economic and livability standards.

7.8.2 Population

Population of Bengaluru Metropolitan Area has been growing since independence as shown in Figure 48. The BMA area, which had a population of about 17 Lakh in 1971, reached 85 lakhs in 2011. Bengaluru was one of the fastest-growing Indian metropolises for the decade 1991–2011. It has an average density of about 148

people / hectare. In CMP 2020 the estimated population is 122.98 Lakh for 2018.

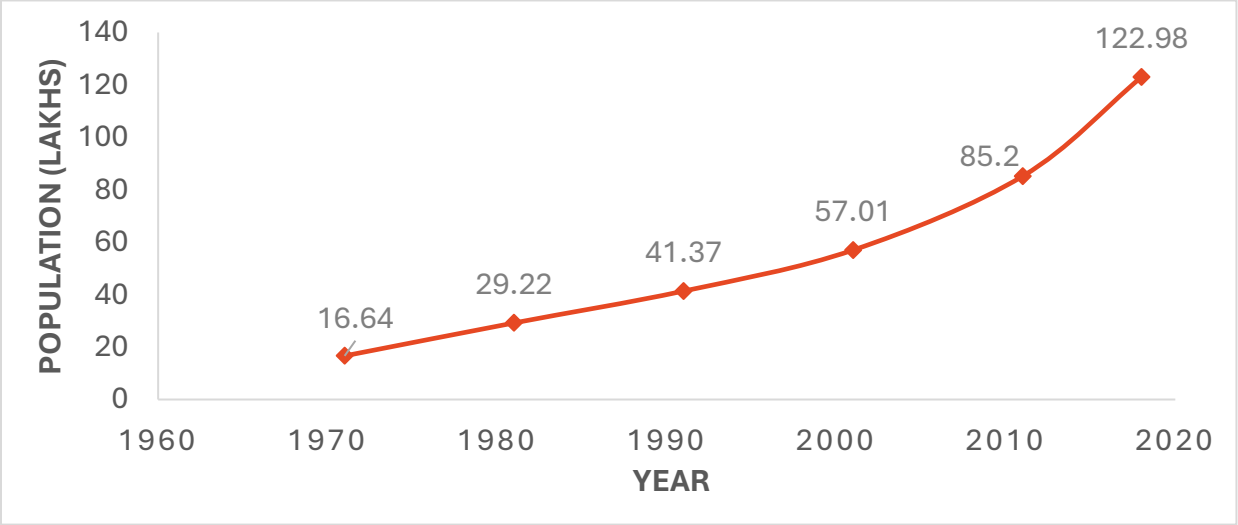


Figure 48: Growth of Population in BMA

Source: Census; CMP 2020

7.8.3 Road Network

Bengaluru is endowed with a ring radial pattern of road network in the core area of the city. Bengaluru's road network, spanning 14,000 km of the road network consists of ring roads, major roads (arterial roads, sub-arterial roads and other mobility corridors) and residential streets. However, there is no clear hierarchy of roads, and this situation has resulted in low speeds, increased conflicts of traffic, etc. Though there is a large network of roads in the city, the major arterial road network comprised less than 20% of the total road network in the city. The major roads in the study area are shown in Figure 49**.**

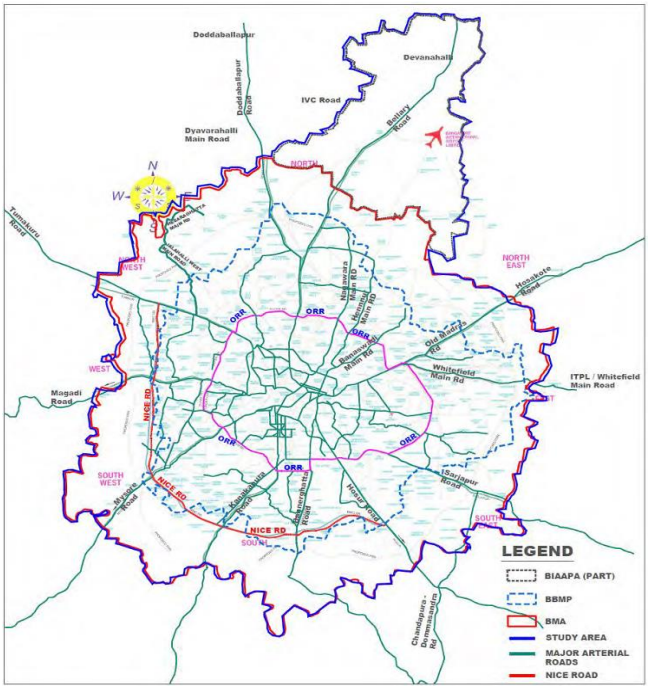


Figure 49: Road Network of Bengaluru City

7.8.4 Overview of Public Transport

7.8.4.1 Bus

The bus system operated by BMTC has been the primary public transport system in Bengaluru City. BMTC has established 45 depots for providing services in the city. BMTC is operating 6143 schedules (as of Aug 2018) every day. The Physical performance of BMTC is presented in Table 45.

Table 45: Bus Performance in Bengaluru

Parameter	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19
Depots	39	39	40	40	43	44	45
Fleet Operated	6139	6473	6244	6216	6219	6143	6143
Vehicles Held	6431	6775	6522	6401	6161	6677	6634
Effective Km. Per day (Lakh)	12.71	13.14	12.9	12.21	11.52	11.42	11.38
Total Service km (Lakh km)	4638.38	4795.9	4708.6	4469.8	4205.2	4164.5	-
Veh. Utilization (Km)	221.1	218.2	214.5	208.5	206.5	203.8	202
Passengers carried per day (Lakh)	48.46	50.25	51.3	50.74	45.34	44.37	-
Passenger load factor (%)	68.5	67.2	75.8	74.2	68.8	66.8	-

Source: BMTC Bengaluru

7.8.4.2 Metro

Two corridors of Metro Rail are in operation in Bengaluru. One is the East-West corridor, and the other is the North-South corridor. The East-West Corridor starts at Baiyappanahalli (R1) and ends at Mysore Road (R2). The North-South Corridor starts at Nagasandra (R3) and ends at Puttenahalli (R4). The total length of the Metro Rail network under operation is 42.30 Km. Table 46 presents the operational metro in Bengaluru.

Table 46: Metro Corridors along with Stretches and their Status

S. No.	Corridor	Length (km)	Status
Phase 1			
1	Baiyappanahalli to Mysore Road (East - West Corridor- Purple Line) (R1 & R2)	18.1	Operational
2	Nagasandra to Yelachenahalli (North- South Corridor- Green Line) (R3 & R4)	24.2	Operational

Source: BMRC

7.8.4.3 Sub-Urban Rail

Bengaluru city has a good rail network of about 62 km within the city. There are a few diesels operated passenger trains that connect to Bengaluru City with Tumkur, Mysore and Kuppam (Andhra Pradesh). The trains run in the morning and return in the evening catering to commuters from suburban areas, satellite towns and neighboring cities. They are well patronized and in the recent past the patronage has shown a good growth rate. But their frequency and availability are not adequate to make this as primary / preferred mode of transportation. The utilization of existing railway network in the city for running robust sub-urban rail services connecting the peripheral areas and settlements around Bengaluru is being explored and a detailed study has been made by Indian Railways to introduce a commuter rail service including identifying the improvement requirement to the railway network.

7.8.4.4 Vehicle Growth in the City

Bengaluru City has a total registered vehicular count of approximately 1 crore vehicles in 2023, vehicle has grown at an average growth rate of 8% over the past 10 years. The vehicle registration trend is shown in below.

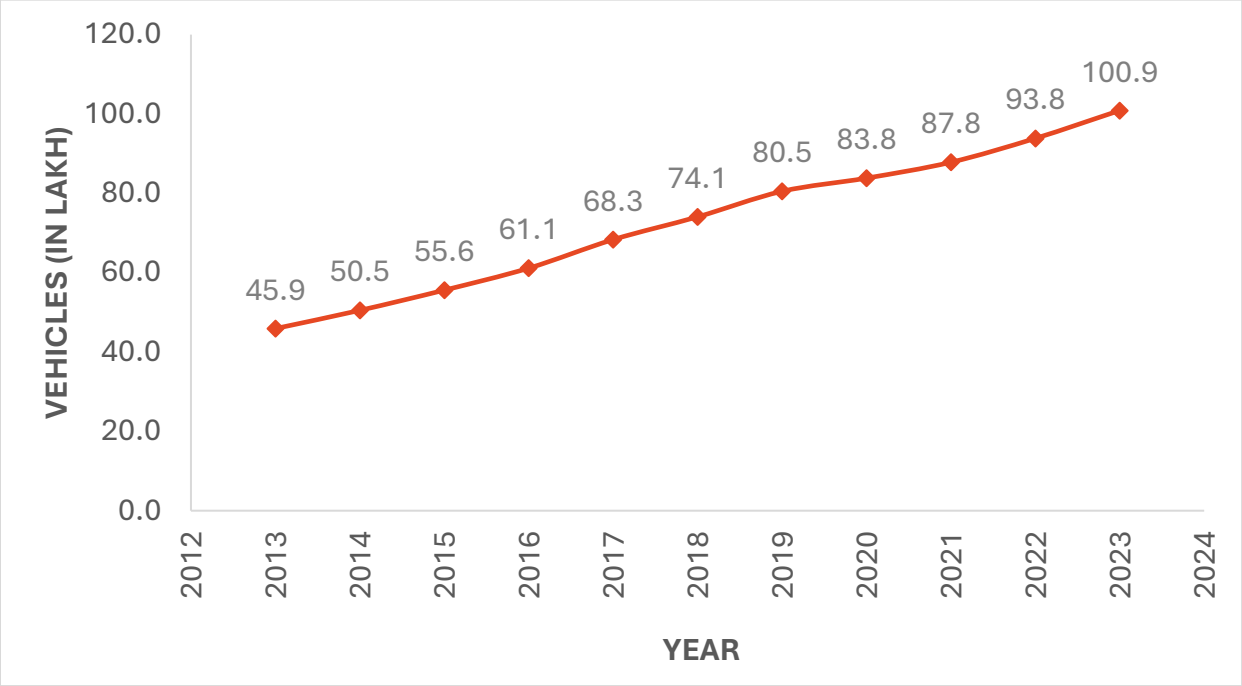


Figure 50: Vehicular growth in Bengaluru

(Source: Annual report – Karnataka Transport Department)

7.8.5 Transport and Infrastructure Proposals

7.8.5.1 Road

Currently there are three road projects that are sanctioned in Bengaluru, which are Satellite Town Ring Road, Intermediate Ring Road and Peripheral Ring Road as shown in Figure 51.

a) **Satellite Town Ring Road:** To ensure safe, smooth, efficient, and high-speed transport corridor to Bangalore city, it is impetus that the infrastructure of city and adjoining towns anticipated the development. National Highways NH 648 (NH 207), NH 48 (NH 4), NH 275, NH 948, NH 209 & NH 75 (Hassan road), and majority of State Highways SH 3, SH 85, & SH 35 pass through Bangalore city comprising heavy commercial traffic movement. Most of this traffic are not intend to pass through the Bangalore city. This traffic further aggravate the scenario in the city roads and resulting huge traffic jams.

b) **Peripheral Ring Road:** The proposed "Peripheral Ring Road" is 65 km long and connects 10 major Highways namely Tumkur Road(NH-4), Hesaraghatta Road(SH-39), Doddaballapura Road(SH-09), Bellary Road (NH-7), Hennur- Baglur Road (SH-104), OMR (NH-4), Whitefield road, Channasandra Main Road, Hoskote-Anekal Road(SH-35), Sarjapur Road and Hosur Road(NH-7). Overall, it intersects 4 National Highways and 6 state Highways. The proposed PRR length from start point on Tumkur road upto end point on Hosur road is 64.201 Km. Since, the alignment is getting integrated with NICE road on Tumkur road (~ 368m) and Hosur road (~ 546m), the total length of the project road is considered to be 65.115 Km.

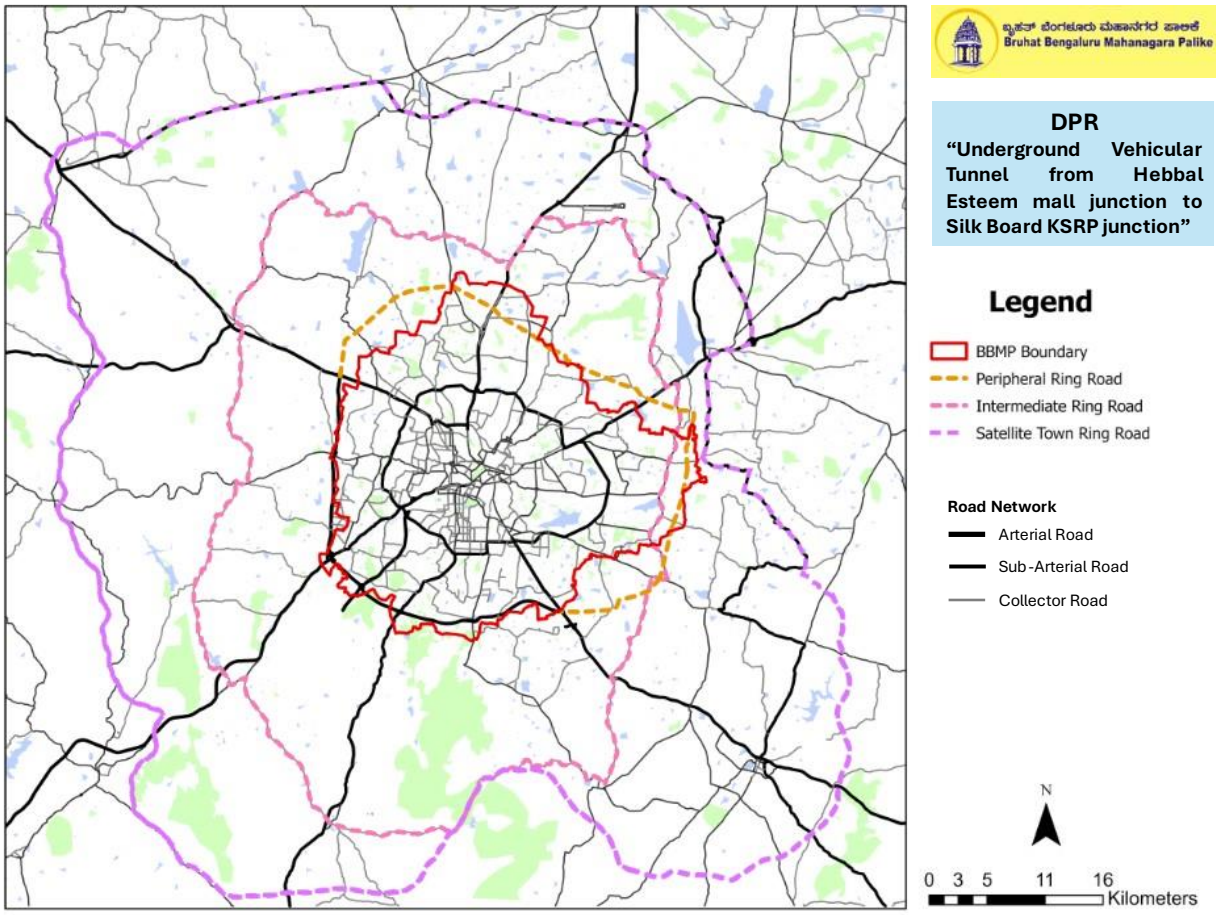


Figure 51: Proposed Roads in Bengaluru

Source: Feasibility reports and DPR

7.8.5.2 Metro

Transport Demand Forecast Study and Identification of Phase III Corridors of Bengaluru Metro was undertaken by Bengaluru Metro Rail Corporation Limited (BMRCL) to extend the metro system in Phase-III for the areas not covered by Phase-I & II and interconnect the metro system network as shown in Figure 52. All metro routes of Phase-I are operational, some routes of Phase-II are operational, and the rest are ongoing projects and all routes in Phase-III are the upcoming projects as given in the metro DPRs. The details of Phase-I, Phase-II and Phase-III are shown in Table 47, 48 & 49.

Table 47: Metro Operational Projects

S. No	Phase	Detail	Length in KM			No of Stations		
			UG	Elevated	Total	UG	Elevated	Total
1	Phase 1	Mysore Road To Kempegowda Metro Station, Majestic, Kempe Gowda Metro Station Majestic to Baiyappanahalli, Nagasandra To Yeshwantpur, Yeshwantpur To Kempegowda Metro Station Majestic, Kempegowda Metro Station Majestic To Yelachenahalli	8.79	33.51	42.3	9	34	43
2	Phase	Baiyappanahalli to Krishnaraja Pura, Kengeri to	-	31.51	31.51	-	27	27

S. No	Phase	Detail	Length in KM			No of Stations		
			UG	Elevated	Total	UG	Elevated	Total
	2	Challaghatta, Krishnarajapura To Whitefield, Yelachenahalli To Silk Institute, Kengeri To Mysore Road						

Source: Metro DPR

Table 48: Merto Ongoing Projects

S. No	Phase	Detail	Length in KM			No of Stations		
			UG	Elevated	Total	UG	Elevated	Total
1	Phase 2	Nagasandra to Madavara (BIEC),Bommasandra to Beratena Agrahara, Beratena Agrahara To Bommanahalli, Bommanahalli To R.V. Road,Kalena Agrahara To Tavarekere, Tavarekere to Rashtriya Military School, Rashtriya Military School To Shivajinagar, Shivajinagar Station to Tannery Road, Tannery Road To Nagawara	13.88	29.66	43.54	12	25	37
2	Phase 2A	Central Silk Board To Kadubeesanahalli, Kodibeesanahalli To K.R. Puram	-	19.75	19.75	-	13	13
3	Phase 2B	Kasturi Nagar To Kempapura, Hebbal To Bagalur Cross, Bettahalasuru To KIA Terminal	-	38.44	38.44	-	17	17

Source: Metro DPR

Table 49: Metro Upcomming Projects

S. No	Phase	Section		Length in KM			No of Stations		
		From	To	UG	Elevated	Total	UG	Elevated	Total
1	Phase-3	1. Hebbal	1. J.P. Nagar 4th Phase	-	31	43		40	40
		2. Hosahalli	2. Kadabagere		12				
2	Phase-3A	1. Sarjapur	1. Hebbal	17	19	36	14	15	29

Source: Metro DPR

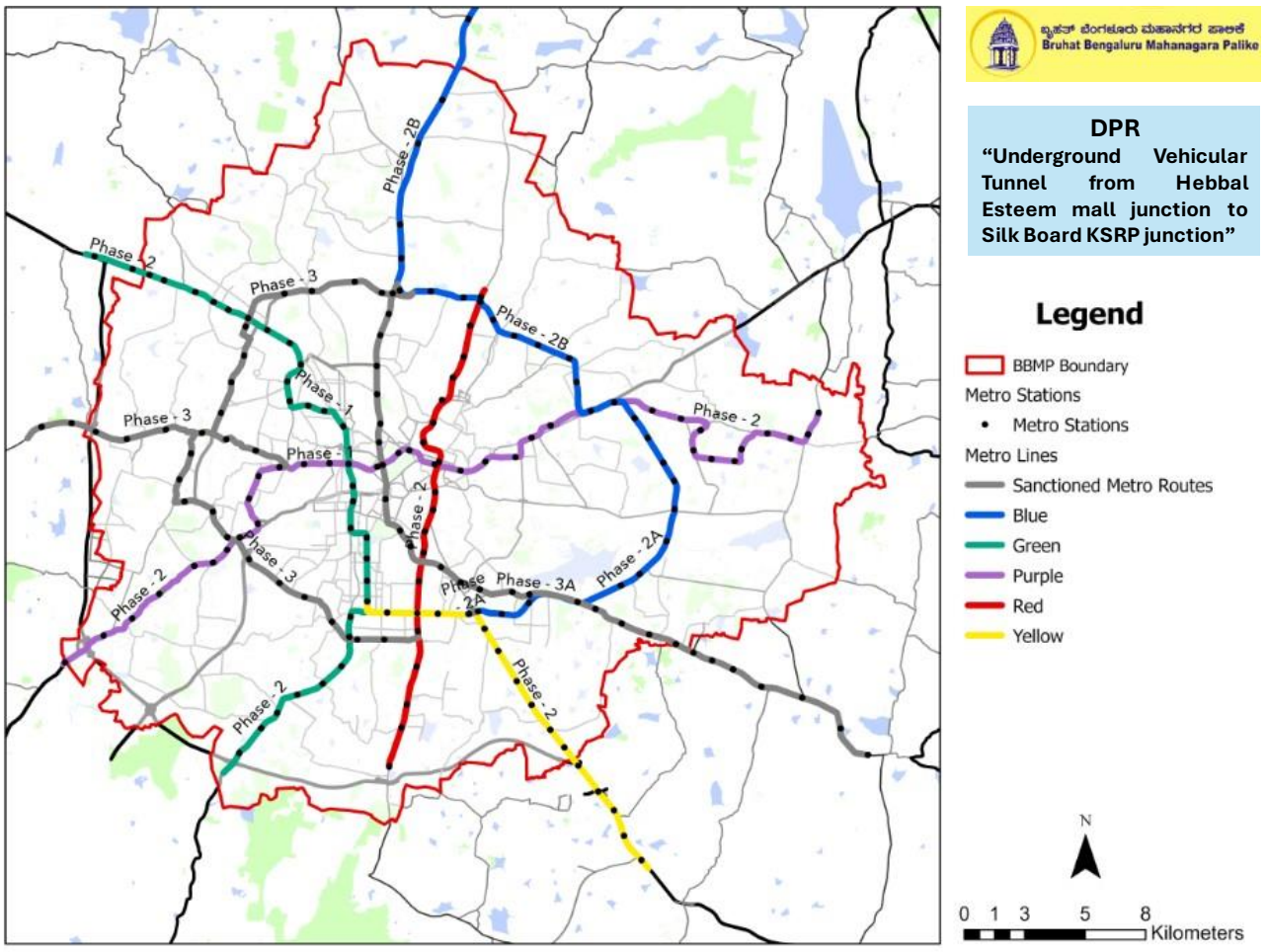


Figure 52: Bengaluru metro network

Source: BMRC

7.8.6 Travel Characteristics

This section discussed the trip characteristics based on the CMP 2020 report. These trip characteristics will be used the validate the outputs from this study.

7.8.7 Mode Share Motorized trips

The modal split of motorized trips referred from CMP 2020 is shown in Table 50**.**

Table 50: Mode Share (Motorized Trips)

S. No.	Mode	No. of trips	Trips
1	Car/Taxi	264649	21.0%
2	2-Wheeler	296468	23.5%
3	Auto Rikshaw	96655	7.7%
4	Public Transport	601861	47.8%
Total		**1259633**	**100%**

Source: CMP 2020

7.8.8 Mode wise Distribution of Average Trip Length

Average trip length as per CMP 2020 by mode of travel is presented in Table 51. Average trip length for walk is 1.0 Km, for 2-wheeler 8.0 km, for car and taxi is 12.8 km and 13.1 km respectively and for Bus it is about 10.7 km.

Table 51: Mode Wise Average Trip Length

S. No.	Mode	Average Trip Length (Km)
1	Car	12.8
2	Taxi	13.1
3	Shared Taxi	15.4
4	2- Wheelers	8
5	Auto	3.7
6	Bus	10.7
7	Minibus	10.7
8	School Bus	5.1
9	Chartered Bus	15.1
10	Cycle	2.6
11	Walk	1

Source: CMP 2020

7.9 Travel Demand Assessment

The travel demand assessment was carried out in the CMP 2020 with the focus to develop a long-term transportation strategy for Bengaluru with the help of an urban transport planning model. The outputs from the CMP will be used for trips forecasting for the current study. This section summarizes the main outputs.

7.9.1 Population Forecasting

The population in CMP 2020 has been forecasted up to year 2051 shown below in Table 52. The population of BMA Area and Extended Area has been forecasted separately.

Table 52: Forecasted population in CMP Study Area

Area	2015	2031	2041	2051
BMA	1,12,27,977	2,03,13,499	2,57,09,017	3,16,36,758
Extended Area	2,55,449	5,50,000	8,95,892	16,04,406
Total	**1,14,83,426**	**2,08,63,499**	**2,66,04,909**	**3,32,41,165**

Source: CMP 2020

7.9.2 Scenarios

For horizon year mode share and average trip lengths, CMP 2020 will be referred where the projections have been done in various scenarios. The scenarios are given below:

a) Scenario 1: Business as Usual scenario

The mode share and average trip length calculated in the Scenario 1 are shown in Table 53.

Table 53: Comparison of Travel Characteristics between Base Year and Horizon Year

Modes	Peak Hour Trips	Base Year (2015)	BAU (2031)	
		Mode Share	Peak Hour Trips	Mode Share
Car + Taxi	264649	21%	689673	30%
Two-Wheeler	296468	24%	666685	29%
Auto Rickshaw	96655	8%	114946	5%
Public Transport	601861	48%	827608	36%
Total	**1259633**		**2298912**	

Source: CMP 2020

b) Scenario 2: Public Transport Augmentation and Efficiency Improvement, and Multimodal Transport.

The mode share calculated in the Scenario 2 are shown in Table 54.

Table 54: Forecast Mode Share – Scenario 2

Modes	**BAU (2031)**		**Scenario 2**	
	Peak Hour Trips	**Mode Share**	**Peak Hour Trips**	**Mode Share**
Car + Taxi	689673	30%	572638	25%
Two-Wheeler	666685	29%	304780	13%
Auto Rickshaw	114946	5%	71406	3%
Public Transport	827608	36%	1350088	59%
Total	**2298912**		**2298912**	

Source: CMP 2020

c) Scenario 3 – Public Transport Augmentation Plus Enhances capacity and Efficiency of Road Infrastructure.

The mode share calculated in the Scenario 1 are shown in Table 55.

Table 55: Forecast Mode Share – Scenario 3

Modes	**BAU (2031)**		**Scenario 3**	
	Peak Hour Trips	**Mode Share**	**Peak Hour Trips**	**Mode Share**
Car + Taxi	689673	30%	532581	23%
Two-Wheeler	666685	29%	261240	11%
Auto Rickshaw	114946	5%	67922	3%
Public Transport	827608	36%	1437168	68%
Total	**2298912**		**2298912**	

Source: CMP 2020

d) Scenario 4 – Comprehensive Mobility Strategy: Transit Oriented Development, Factoring-in full cost of externalities, Regulations on private vehicles, besides Public Transport Augmentation Plus Enhances Capacity and efficiency of Road Infrastructure, and cleaner technology Vehicles.

The mode share calculated in the Scenario 4 are shown in Table 56.

Table 56: Forecast Mode Share – Scenario 4

Modes	**BAU (2031)**		**Scenario 3**	
	Peak Hour Trips	Mode Share	Peak Hour Trips	Mode Share
Car + Taxi	689673	30%	394472	17%

Modes	BAU (2031)		Scenario 3	
	Peak Hour Trips	Mode Share	Peak Hour Trips	Mode Share
Two-Wheeler	666685	29%	181126	8%
Auto Rickshaw	114946	5%	42669	2%
Public Transport	827608	36%	1680644	73%
Total	**2298912**		**2298912**	

Source: CMP 2020

7.10 Primary Data Collection and analysis

In any transport planning exercise, data collection is the cornerstone and the very foundation on which rests the superstructure. The data, so collected, is used to analyze the existing transport and traffic situation in the study area and to develop an urban transport demand model for the study area. This activity is undertaken to understand traffic and travel characteristics and highlight city-specific problems. The first and foremost step to initiate in the development of a transport demand model is the collection of relevant data to understand travel patterns and the factors that influence them. These travel patterns shall be the guiding principles in determining the traffic on the north-south corridor. The following surveys were carried out as shown in Table 57 to meet the above objectives.

Table 57: Survey Details

S. No.	Particulars of Survey	Unit	Quantity	Survey Date
1	Classified Traffic Volume Count	Location	9	Aug-2024
2	Turning Moment Count at Intersections	Location	7	Aug-2024
3	Passenger Origin-Destination Survey	Locations	11	Aug-2024
4	Speed and delay survey	KM	25	Aug-2024

Figure 53 provides the map showing the survey locations.

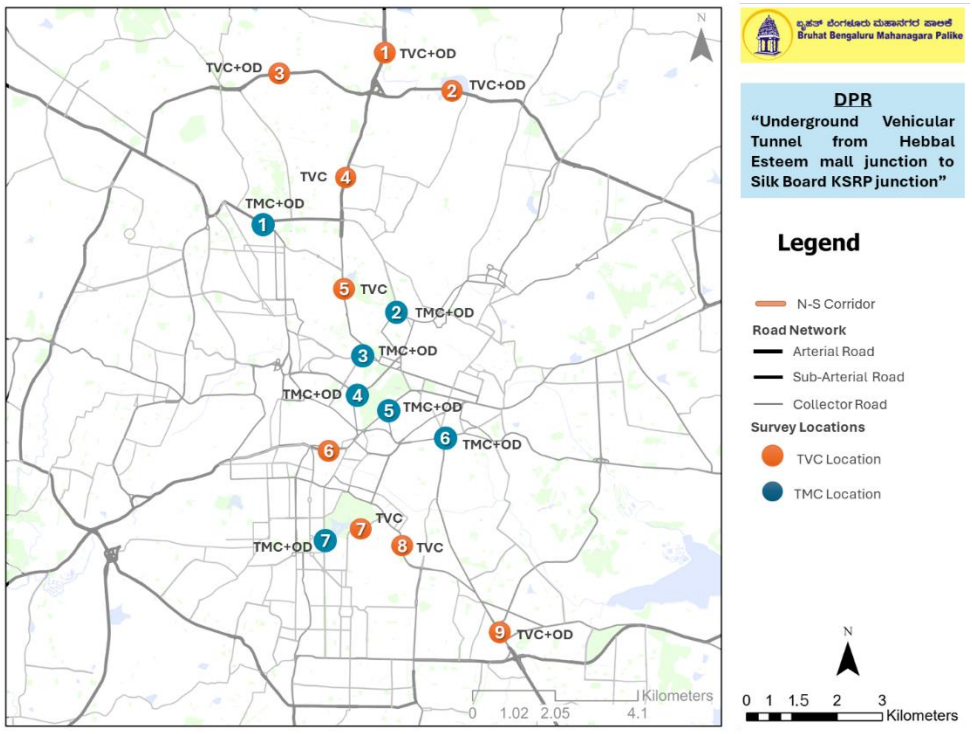


Figure 53: Survey Locations

7.11 Traffic Conditions

Objective of Survey: Surveys were conducted at critical identified locations along the proposed NS Corridor.

Scope of Survey: Counting of vehicles, classified by the type of vehicle, at selected locations, covering all turning movements, midblock & screen line.

Conduct: Videographic traffic counts were carried out at all the locations listed. At each identified station, both directional counts were done by vehicle type, i.e., fast-moving passenger vehicles, goods vehicles and slow-moving non-motorized vehicles. The vehicles counted were converted to Passenger Car Units (PCU) by adopting equivalent PCUs. The PCUs corresponding to urban roads as per IRC: 106-1990 is used and the values adopted are given in Table 58 below.

Table 58: PCU Values for Different Categories of Vehicles

Vehicle Type	PCU Values	
	Urban	
	UP TO 5%	> 5%
Bus	2.2	3.7
Car/Jeep/Van/Taxi	1	1
Two-Wheeler	0.5	0.75
E-Rickshaw	1.2	2
Auto-Rickshaw	1.2	2
Truck	2.2	3.7
MAV	4	5
LCV	1.4	2
Cycle	0.4	0.5
Tractor	4	5
Cart	2	3
Cycle Rickshaw	1.5	2

Source: IRC:106-1990

7.11.1 Traffic Volume Counts at Cordon Points

Nine cordon points were identified for an understanding of the traffic characteristics in the study area. The analysis of the classified volume count survey at the cordons is given in the sub-sections below. The total inbound and outbound traffic flow at each of the cordons is presented in Table 59 and daily traffic on each cordon point is shown in Figure 54 direction wise.

Table 59: Daily Traffic Volume Counts at Cordon Locations

Location		Direction	Daily Vehicles per Direction	Daily PCUs per Direction	Total Daily Vehicles	Total Daily PCUs
1	NH-44 Bellary Road (Near-Sakar Nagar)	Dir-I : Yelahanka To Hebbal	144592	138970	288243	276854
		Dir-II : Hebbal To Yelahanka	143651	137884		
2	NH-75 Malur -Byranahalli Rd Outer Ring Road (Near-Nagavara park)	Dir-I : Bellary Road To Nagavara	117553	113677	222323	212544
		Dir-II :Nagavara To Bellary Road	104770	98867		

Location		Direction	Daily Vehicles per Direction	Daily PCUs per Direction	Total Daily Vehicles	Total Daily PCUs
3	NH-75 Malur -Byranahalli Rd Outer Ring Road (Near-Devinagar BEL Circle)	Dir-I : Hebbal To Yashwantpur	74262	74124	139793	140205
		Dir-II : Yashwantpur To Hebbal	65531	66081		
4	AH-47 Malur Road (Near-Science Gallery)	Dir-I : Mekhri circle To Airport	128808	122070	246077	232456
		Dir-II : Airport To Mekhri circle	117269	110386		
5	Guttahalli Main Road (Near-Uniworth Plaza)	Dir-I : Mahalakshmi Gudi Circle To Bengaluru Golf Club	103247	97762	203804	195093
		Dir-II : Bengaluru Golf Club To Mahalakshmi Gudi Circle	100557	97332		
6	NR road (Near-Silver Jubilee Park)	Dir-I : Kempegowda Tower To Chamrajpet	82397	83027	180589	177180
		Dir-II : Chamrajpet To Kempegowda Tower	98192	94154		
7	Siddapura Road (Near-Maharaja Agrasena Bhavana)	Dir-I : Ashoka Piller To Mallinge Hospital	31705	28716	65075	58422
		Dir-II : Mallinge Hospital To Ashoka Piller	33370	29706		
8	Marigowda Road (Near-National Institute Of Mental Health & Neuro Sciences)	Dir-I : Dairy Circle To Wilson Garden	54855	54282	108421	107685
		Dir-II :Wilson Garden To Dairy Circle	53566	53402		
9	NH-44 Bengaluru-Chennai Highway (Near-Madiwala footbridge)	Dir-I : Adugodi To Electronic City	117725	109335	232494	216724
		Dir-II : Electronic City To Adugodi	114769	107389		

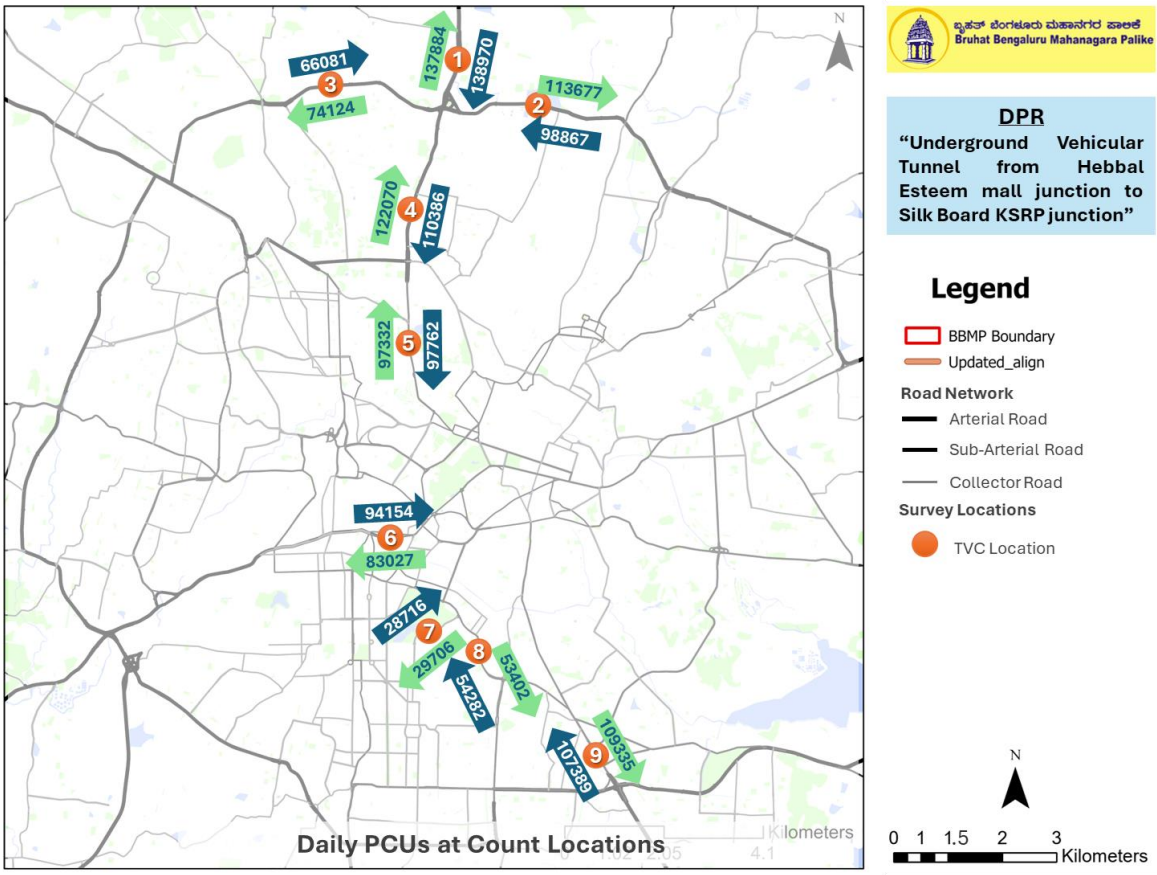


Figure 54: Map Showing Daily Traffic Volume at Count Locations.

Figure 55 presents the overall vehicle composition of the traffic. The highest share is of private vehicles, at 80%, of which two-wheelers constitute 42% and four-wheelers 38%. This is followed by IPT vehicles, which contribute to about 9% of the total traffic.

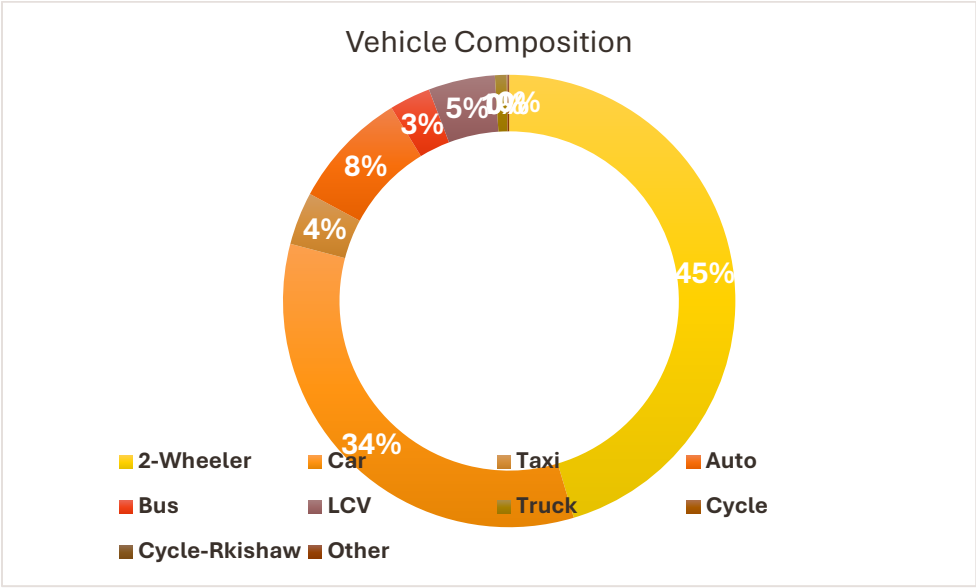


Figure 55: Overall traffic composition

The temporal variation of the traffic flow at each cordon is given in Figure 56. Based on primary data for all the cordons, the morning peak period can be considered from 09:00 to 12:00 hours and the evening peak period can be considered from 17:00 to 20:00 hours.

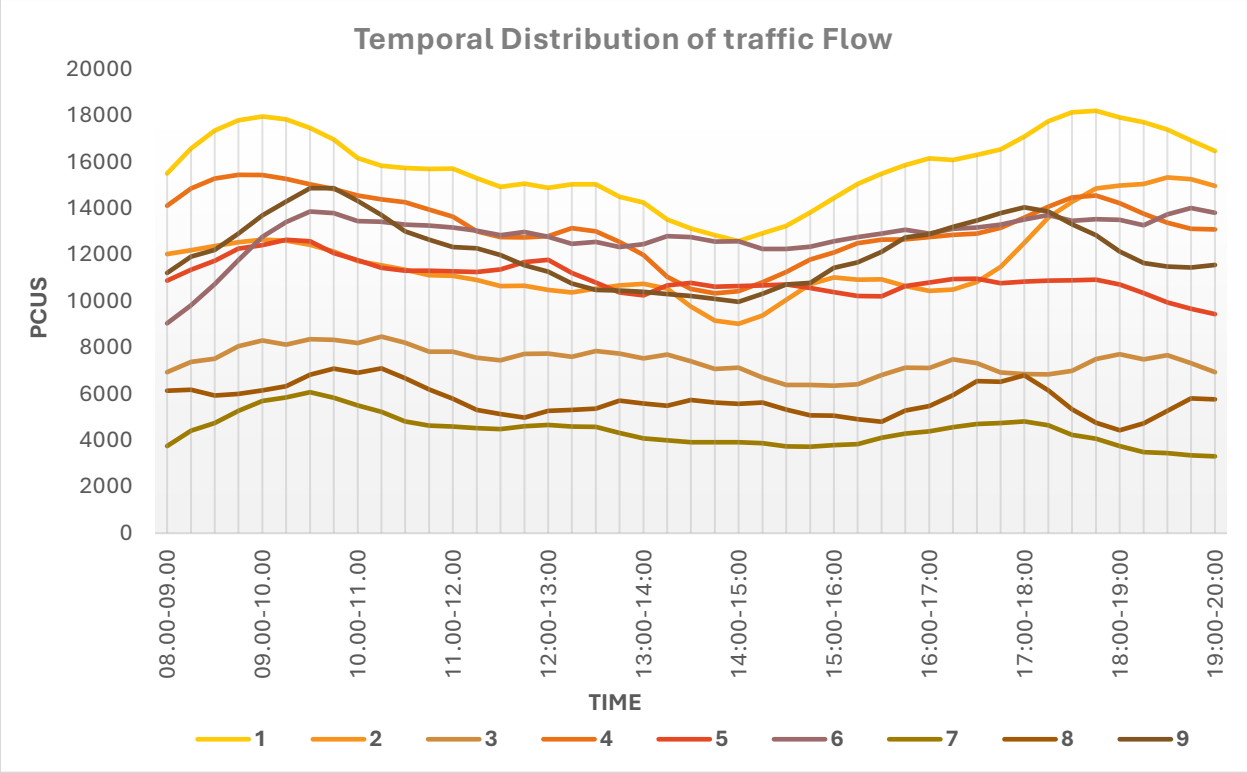


Figure 56: Temporal Distribution of traffic at cordon points

The peak volume and peak period at each cordon location are given in Table 60 & 61 . The volume in the peak hour varies in the range of 7-8% of the total volume.

Table 60: Morning Peak hour Volume at Surveyed Locations

Location		Direction	Both Direction Vehicles	Peak Vehicles	Segregated Peak Vehicles	Both Direction PCUs	Peak PCUs	Segregated Peak PCUs	Peak Hour %	Level of Service	Peak Time
1	NH-44 Bellary Road (Near-Sakar Nagar)	Dir-I : Yelahanka To Hebbal (Towards Bengaluru)	19755	9794	6335	17967	8962	5718	6%	**LOS F**	09.00-10.00
		Dir I - Service Lane (Towards Bengaluru)			3459			3244		**LOS E**	
		Dir-II : Hebbal To Yelahanka (Towards Airport)		9961	9634		9005	8627		**LOS F**	
2	NH-75 Malur - Byranahalli Rd Outer Ring Road (Near-Nagavara park)	Dir-I : Bellary Road To Nagavara	13865	7728	4945	12441	7011	3797	6%	**LOS C**	09.30-10.30
		Dir I - Service Lane			2785			2321		**LOS E**	
		Dir-II :Nagavara To Bellary Road		6137	4440		5430	3377		**LOS C**	
		Dir II - Service Lane			1697			1242		**LOS C**	
3	NH-75 Malur - Byranahalli Rd Outer Ring Road (Near-Devinagar BEL Circle)	Dir-I : Hebbal To Yashwantpur	10563	5567	5567	9663	5171	5171	7%	**LOS F**	10.15-11.15
		Dir-II : Yashwantpur To Hebbal		4996	4996		4493	4493		**LOS E**	
4	AH-47 Malur Road (Near-Science Gallery)	Dir-I : Mekhri circle To Airport	17156	8914	5568	15443	7988	4996	7%	**LOS E**	09.00-10.00
		Dir I - Service Lane			3346			2991		**LOS F**	
		Dir-II : Airport To Mekhri circle		8242	5743		7455	5362		**LOS F**	
		Dir II - Service Lane			2499			2093		**LOS D**	
5	Guttahalli Main	Dir-I :	13777	8129	8129	12651	7318	7318	6.5%	**LOS F**	09.15-10.15

Location		Direction	Both Direction Vehicles	Peak Vehicles	Segregated Peak Vehicles	Both Direction PCUs	Peak PCUs	Segregated Peak PCUs	Peak Hour %	Level of Service	Peak Time
	Road (Near-Uniworth Plaza)	Mahalakshmi Gudi Circle To Bengaluru Golf Club									
		Dir-II : Bengaluru Golf Club To Mahalakshmi Gudi Circle		5648	5648		5333	5333		**LOS F**	
6	NR road (Near-Silver Jubilee Park)	Dir-I : Kempegowda Tower To Chamrajpet	12753	4814	4814	11773	4534	4534	6.64%	**LOS D**	09.30-10.30
		Dir-II : Chamrajpet To Kempegowda Tower		7938	7938		7240	7240		**LOS F**	
7	Siddapura Road (Near-Maharaja Agrasena Bhavana)	Dir-I : Ashoka Piller To Mallinge Hospital	5897	3750	3750	5133	3307	3307	9%	**LOS F**	09.30-10.30
		Dir-II : Mallinge Hospital To Ashoka Piller		2147	2147		1826	1826		**LOS C**	
8	Marigowda Road (Near-National Institute Of Mental Health & Neuro Sciences)	Dir-I : Dairy Circle To Wilson Garden	7510	3845	3845	7105	3702	3702	7%	**LOS F**	10.15-11.15
		Dir-II :Wilson Garden To Dairy Circle		3665	3665		3404	3404		**LOS F**	
9	NH-44 Bengaluru-Chennai Highway (Near-Madiwala footbridge)	Dir-I : Adugodi To Electronic City	16872	7056	7056	14875	6186	6186	7%	**LOS F**	09.30-10.30
		Dir-II : Electronic City To Adugodi		9816	9816		8690	8690		**LOS F**	

Table 61: Evening Peak hour Volume at Surveyed Locations

Location		Direction	Both Direction Vehicles	Peak Vehicles	Segregated Peak Vehicles	Both Direction PCUs	Peak PCUs	Segregated Peak PCUs	Peak Hour %	Peak Time	LOS
1	NH-44 Bellary Road (Near-Sakar Nagar)	Dir-I : Yelahanka To Hebbal (Towards Bengaluru)	19609	10256	5507	18214	9483	5201	7%	17:45-18:45	**LOS F**
		Dir I - Service Lane (Towards Bengaluru)			4749			4282			**LOS F**
		Dir-II : Hebbal To Yelahanka (Towards Airport)		9353	8746		8731	8100			**LOS F**
		Dir II - Service Lane (Towards Airport)			607			632			**LOS B**
2	NH-75 Malur - Byranahalli Rd Outer Ring Road (Near-Nagavara park)	Dir-I : Bellary Road To Nagavara	17381	9904	6337	15341	8673	5549	7%	18:30-19:30	**LOS F**
		Dir I - Service Lane			3569			3125			**LOS F**
		Dir-II :Nagavara To Bellary Road		7477	5409		6668	4824			**LOS E**
		Dir II - Service Lane			2068			1844			**LOS C**
3	NH-75 Malur - Byranahalli Rd Outer Ring Road (Near-Devinagar BEL Circle)	Dir-I : Hebbal To Yashwantpur	9271	5140	5140	8673	4839	4839	6%	18:00-19:00	**LOS E**
		Dir-II : Yashwantpur To Hebbal		4131	4131		3833	3833			**LOS C**
4	AH-47 Malur Road (Near-Science Gallery)	Dir-I : Mekhri circle To Airport	15816	8358	5404	14555	7715	4998	6%	17:45-18:45	**LOS E**
		Dir I - Service Lane			2954			2717			**LOS F**
		Dir-II : Airport To Mekhri circle		7458	6240		6840	5769			**LOS F**
		Dir II - Service Lane			1218			1072			**LOS B**
5	Guttahalli Main Road (Near-Uniworth Plaza)	Dir-I : Mahalakshmi Gudi Circle To Bengaluru Golf	11487	5341	5341	10964	5083	5083	6%	16:15-17:15	**LOS E**

Location		Direction	Both Direction Vehicles	Peak Vehicles	Segregated Peak Vehicles	Both Direction PCUs	Peak PCUs	Segregated Peak PCUs	Peak Hour %	Peak Time	LOS
		Club									
		Dir-II : Bengaluru Golf Club To Mahalakshmi Gudi Circle		6146	6146		5882	5882			**LOS F**
6	NR road (Near-Silver Jubilee Park)	Dir-I : Kempegowda Tower To Chamrajpet	11519	6087	6087	11022	5897	5897	6%	18:45-19:45	**LOS F**
		Dir-II : Chamrajpet To Kempegowda Tower		5432	5432		5125	5125			**LOS E**
7	Siddapura Road (Near-Maharaja Agrasena Bhavana)	Dir-I : Ashoka Piller To Mallinge Hospital	4844	1971	1971	4336	1823	1823	7%	17:00-18:00	**LOS C**
		Dir-II : Mallinge Hospital To Ashoka Piller		2873	2873		2514	2514			**LOS E**
8	Marigowda Road (Near-National Institute Of Mental Health & Neuro Sciences)	Dir-I : Dairy Circle To Wilson Garden	6994	3469	3469	6806	3358	3358	6%	17:00-18:00	**LOS F**
		Dir-II :Wilson Garden To Dairy Circle		3525	3525		3448	3448			**LOS F**
9	NH-44 Bengaluru-Chennai Highway (Near-Madiwala footbridge)	Dir-I : Adugodi To Electronic City	15427	9198	9198	14048	8267	8267	6%	17:00-18:00	**LOS F**
		Dir-II : Electronic City To Adugodi		6229	6229		5781	5781			**LOS F**

The cordon-wise traffic composition during the peak hour for the cordons is given in Figure 57. Private modes (cars and two-wheelers) occupy the major share, at 83.4%, followed by Auto which is 9%.

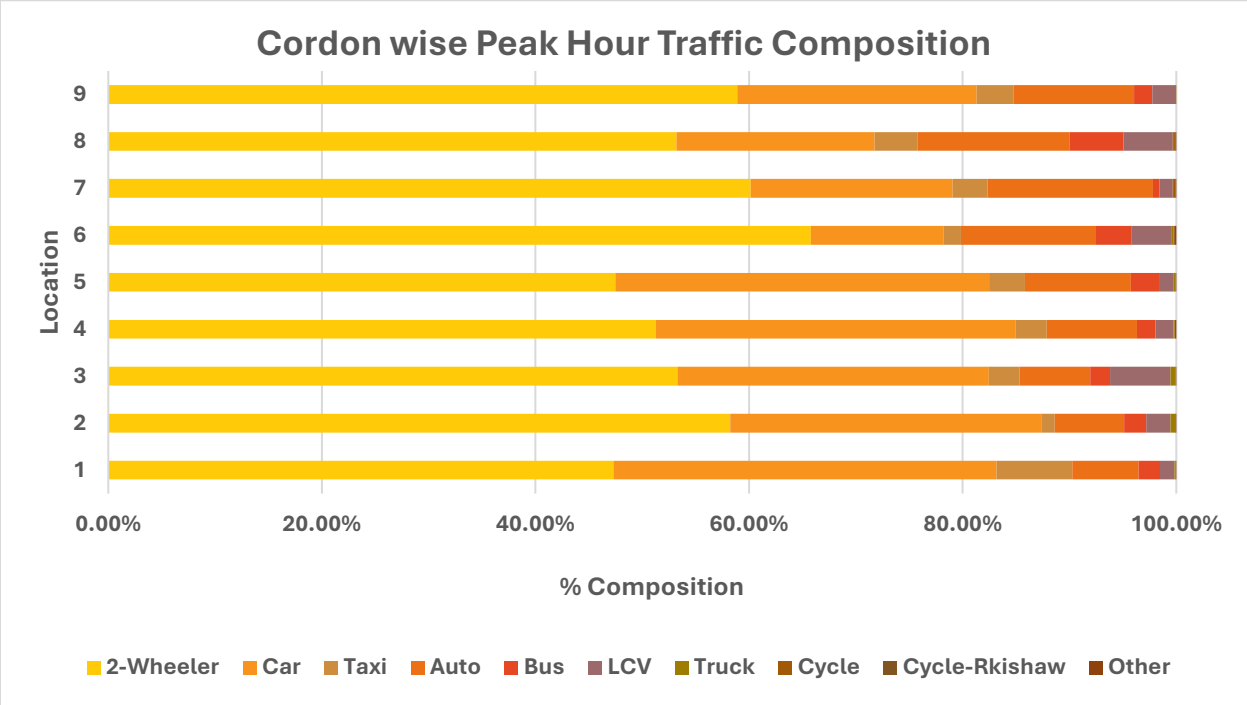


Figure 57: Cordon wise Peak hour Traffic Composition

7.11.2 Turning Movement Counts at Intersections

A total of 7 critical intersections were identified where the volume of vehicles in all turning directions were noted. The analysis of the turning movement volume count survey at the intersections is given in sub-sections below. Amongst the identified locations above, it was observed that, on an average, the total traffic is more than 1,50,000 vehicles per day, with the highest per day vehicular volume observed at Basaveshwara circle, where 2,38,685 vehicles had accumulated, followed by Shoolay circle, Bangalore Cantt Jn, Cn Rao Underpass Jn with 1,87,462, 1,70,379, 1,72,303 vehicles, respectively. The lowest per day traffic volume was observed at Lalbagh Chowk with 1,19,980 vehicles in one day**.** Table 62 shows the total volumes recorded at the intersections and Figure 58 shows the Temporal distribution of traffic at the Intersections.

Table 62: Traffic Volume at Intersections

Location	Name of Junction	Daily Vehicles	Daily PCU	Morning			Evening			Direction of maximum Flow
				Peak Hour	Peak Hour Vehicles	Peak Hour PCUs	Peak Hour	Peak Hour Vehicles	Peak Hour PCUs	
1	CN Rao underpass Junction	172303	158783	10.45-11.45	13658	12244	18:45-19:45	12599	11237	Mekhri circle
2	Banglore Cantt Junction	170379	155088	09.30-10.30	12797	11267	18:45-19:45	12589	11161	Vasant Nagar
3	Basaveshwara circle	238685	218271	09.00-10.00	15026	13347	18:00-19:00	16817	15053	Vasanth Nagar
4	KR Circle	163363	148977	10.15-11.15	13119	11432	16:00-17:00	10901	9686	Anand Rao Junction
5	Cubbon Park UB City signal	155057	142475	09.30-10.30	9681	8351	19:15-20:15	10617	9453	Kempegowda Tower
6	Shoolay Circle	187462	175475	09.30-10.30	12574	11160	18:45-19:45	11619	10335	Malitry Area
7	Lalbagh Chowk	119980	108159	10.45-11.45	7451	6581	16:30-17:30	7925	7034	South End Circle

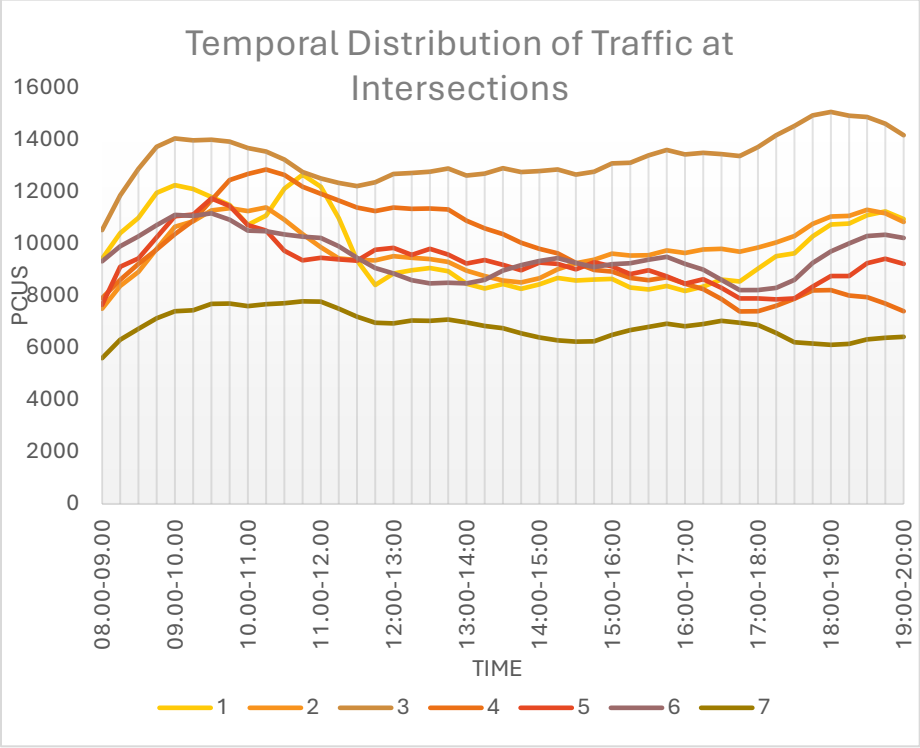


Figure 58: Temporal Distribution of traffic at Intersections

Figure 59 shows the turning moment count survey locations spatially with the daily volume at each intersection. An average traffic of 1,58,000 PCU are observed on the intersections with the highest traffic at Basaveshwara circle consisting of 2,18,271 PCUs.

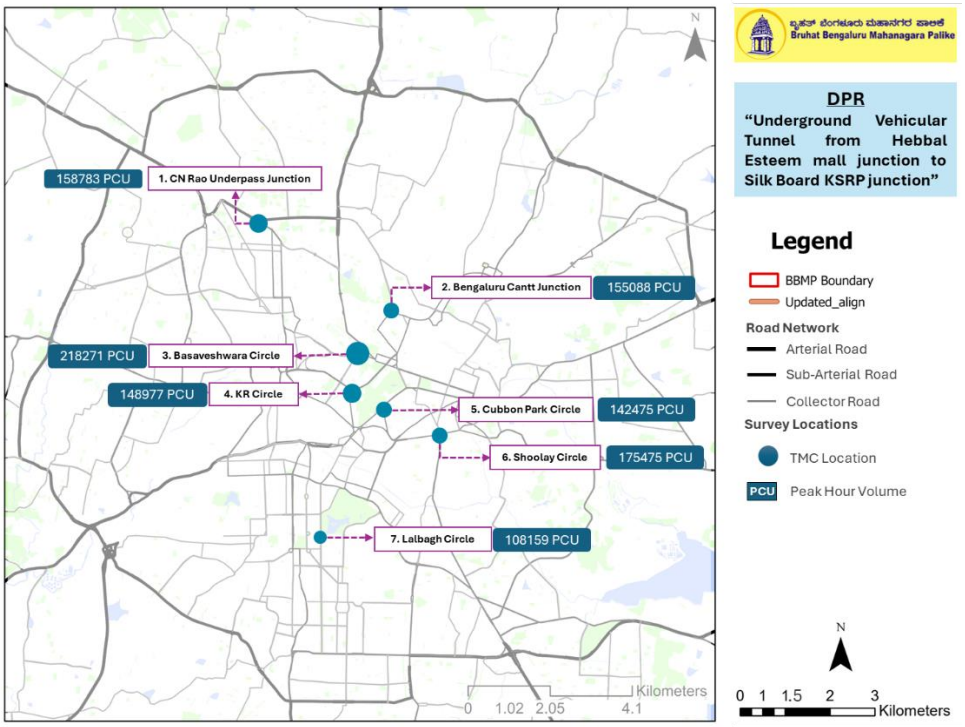


Figure 59: Map Showing Total Daily Traffic at Junctions in PCU

7.11.3 Speed and Delay

Speed and Delay study is done along the road connecting from Hebbal to Silk Board Junction (Upto Ring Road). As Shown in Figure 60 the route is congested at most of the locations, especially near the core area

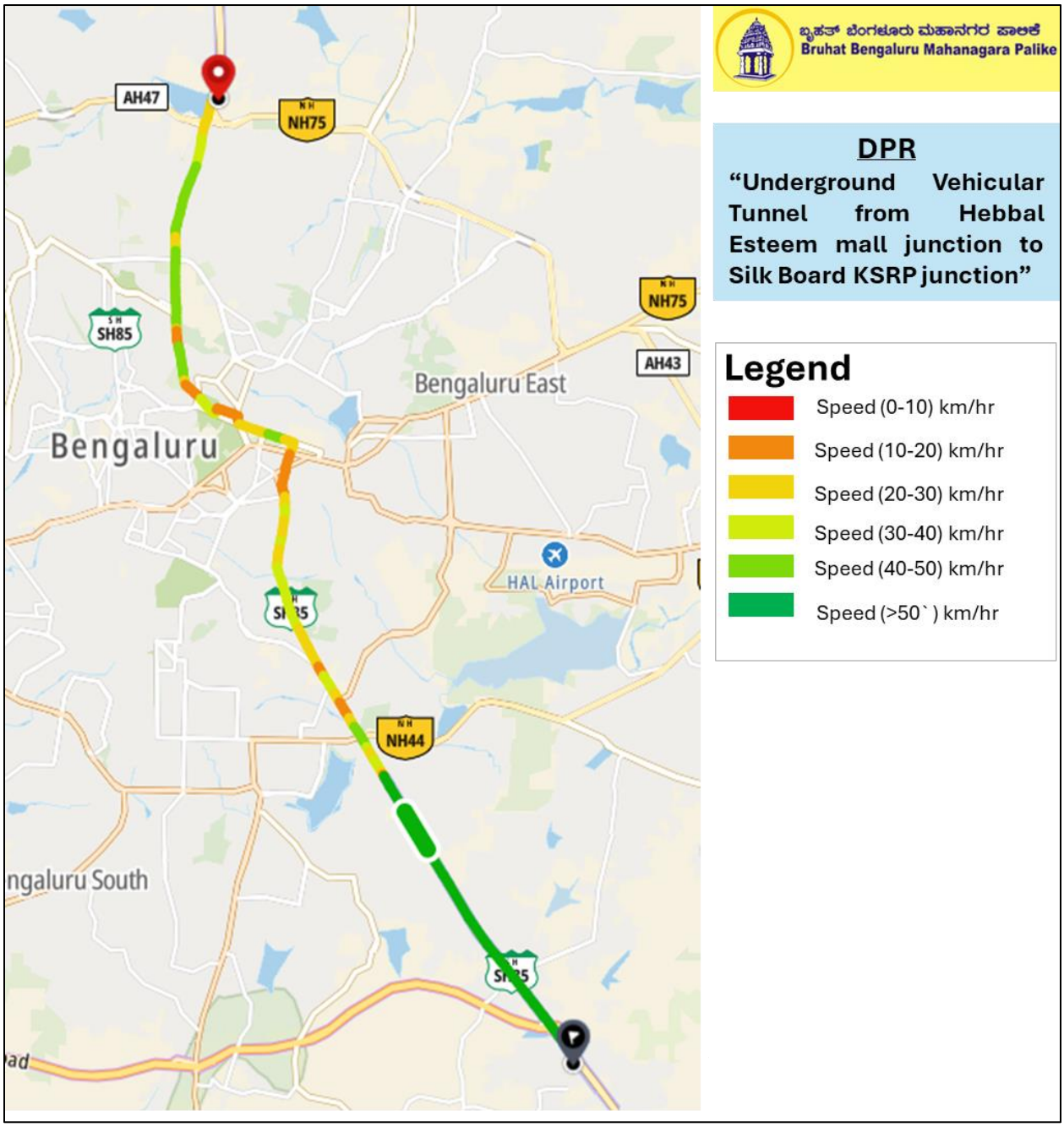


Figure 60: Speed and Delay

7.12 Travel Behavior

7.12.1 Origin-Destination Survey at Cordon Points

Roadside interviews were carried out on a sample basis to understand the characteristics of the ongoing trips. They captured details like purpose, modes, origin-destination, etc.

OBJECTIVE	• To derive the passenger and freight travel pattern by road • These surveys will be aimed at analysing the movement between the study area and external zones.
METHOD	• Interviews will be carried out on a sample basis by stopping the vehicles
OUTPUT	• Information's like origin and destination of trip, occupancy, trip purpose and in the case of goods vehicles their type and tonnage.

7.12.2 Average Trip lengths

Based on analysis of OD data the average trip lengths (ATL) for each mode is calculated as shown in Table 63. For internal-to-internal movement the ATL of car is 8 km followed by two-wheeler having 7.6 km ATL and 6.6 km for Auto.

Table 63: Averagse Trip Lengths (km)

	I-I	I-E	E-E	E-I
2-Wheeler	7.6	15.8	19	14.7
CAR	8.0	16.2	24.5	18.4
AUTO	6.6	13.5	16.2	12.7
LCV	7.1	18.3	24	20
HCV	5.8	13.6	14.1	18

7.12.3 Frequency Distribution

Trip Length Frequency Distribution for car for Internal to Internal, Internal to External, External to External and External to Internal is shown below.

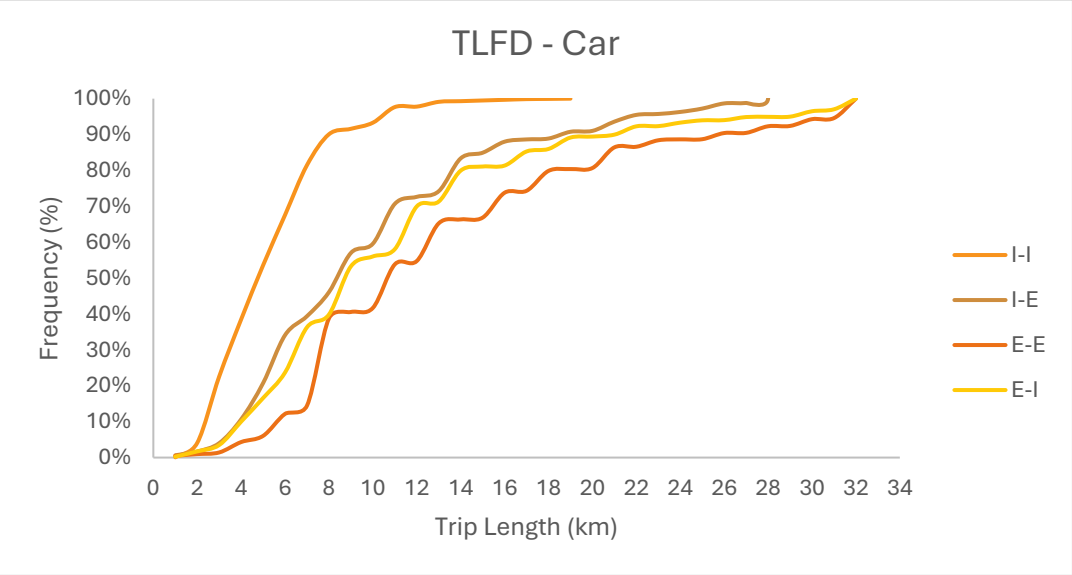


Figure 61: Trip Length Frequency Distribution Curve for Car

7.12.4 Trip Purpose

The purpose wise distribution of trips is shown in Figure 62. The work trips has highest share of 69% followed by Business trips 16% out of the total trips.

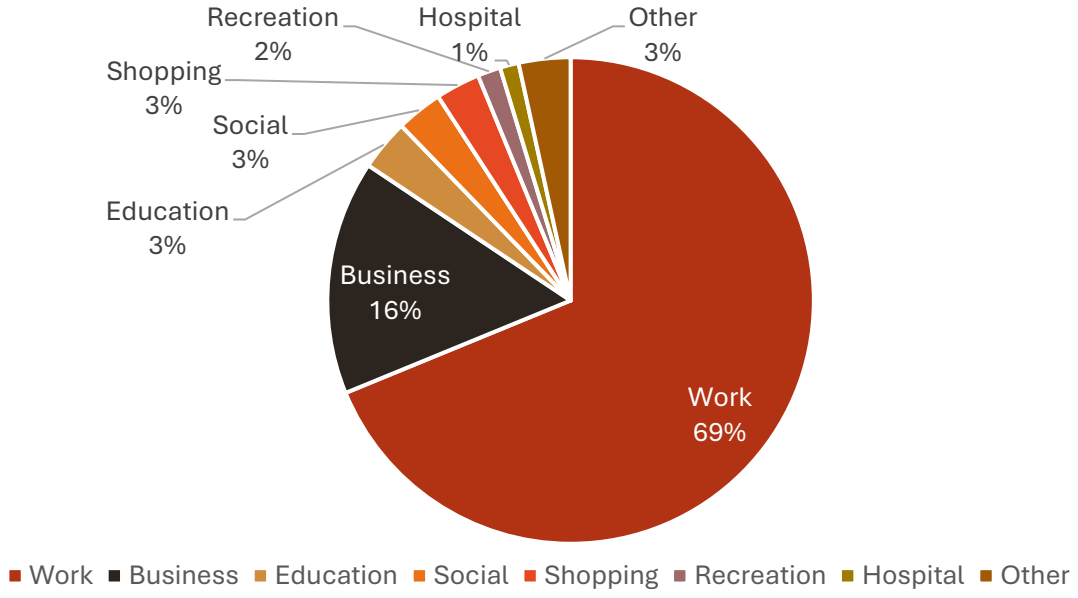


Figure 62: Purpose wise Distribution of Trips during peak hour

7.13 Base Year Travel Demand Model

7.13.1 Introduction

The base year model is developed for the year 2024 to understand and validate the travel patterns. A validated base year model acts as a check of the network credibility and is used to further evaluate future scenarios. For the present assignment base model, PTV VISUM 2024 is used. The model is developed for private transport models only. The bus PCU's on the road network are taken as preload based on the count data.

PTV Visum 2024 is a comprehensive, flexible software system for strategic traffic and transport planning. Around the globe, the software is used for metropolitan, regional and state-wide infrastructure planning. PTV Visum is the world's leading software for traffic analyses, forecasts and GIS-based data management. It consistently models all road users and their interactions and has become a recognized standard in the field of transport planning. Transportation experts use PTV Visum to model transport networks and travel demand, to analyze expected traffic flows in the future, to plan public transport services and to develop advanced transport strategies and solutions.

7.13.2 Methodology for Base year model development

The base year model is developed for the critical peak hour i.e., 09:30 am to 10:30 am. The base year model is developed to establish calibrated matrices for different modes and the model is validated using the traffic count data at various locations. The data input for the base year is based on the primary survey data, additional secondary data for upcoming public transport and road infrastructure project reports as discussed in further sections.

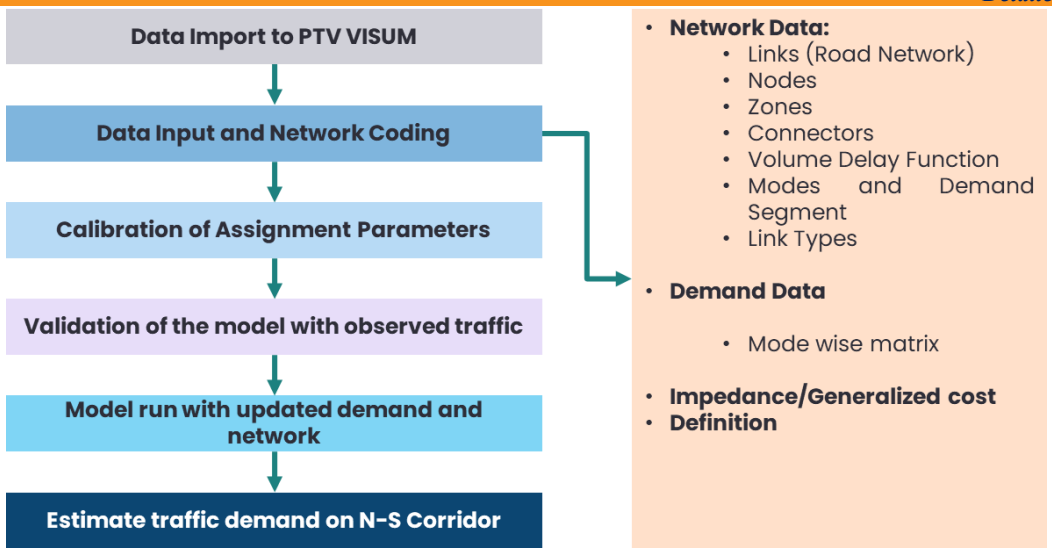


Figure 63: Methodology for base year development

Figure 63 provides the overall methodology for model development. The base year modelling involved data input to PTV Visum in the form of Traffic Volume Counts Data, Origin-Destination Matrices for each mode, etc. Network coding through formation of links, nodes, zones and connectors and input of Volume Delay Function. The parameters are modified to represent the travel pattern as observed. After which, the assignment procedure was executed.

Next step is calibration and validation of the model with observed traffic through volume counts data collected through primary survey data collection. The models must be checked to assure that they adequately perform the functions for which they are intended. This is usually done by (process called validation) assigning the developed matrices on the network and checking the assigned flows across the screen line/cordon against the observed count.

7.14 Network Development

7.14.1 Road (Links/Nodes)

The transport network in the study area includes road network. Figure 64 below show the base year road network in the study area. All the characteristics of the road links are collected by network inventory. Link characteristics collected include length, carriageway type (divided/ undivided), type of operation (one-way/ two-way), number of lanes, average speed etc.

The road network has been imported from Open Street Maps and is validated with Bengaluru's Open Data and Network Inventory Primary Survey. (https://www.openstreetmap.org)

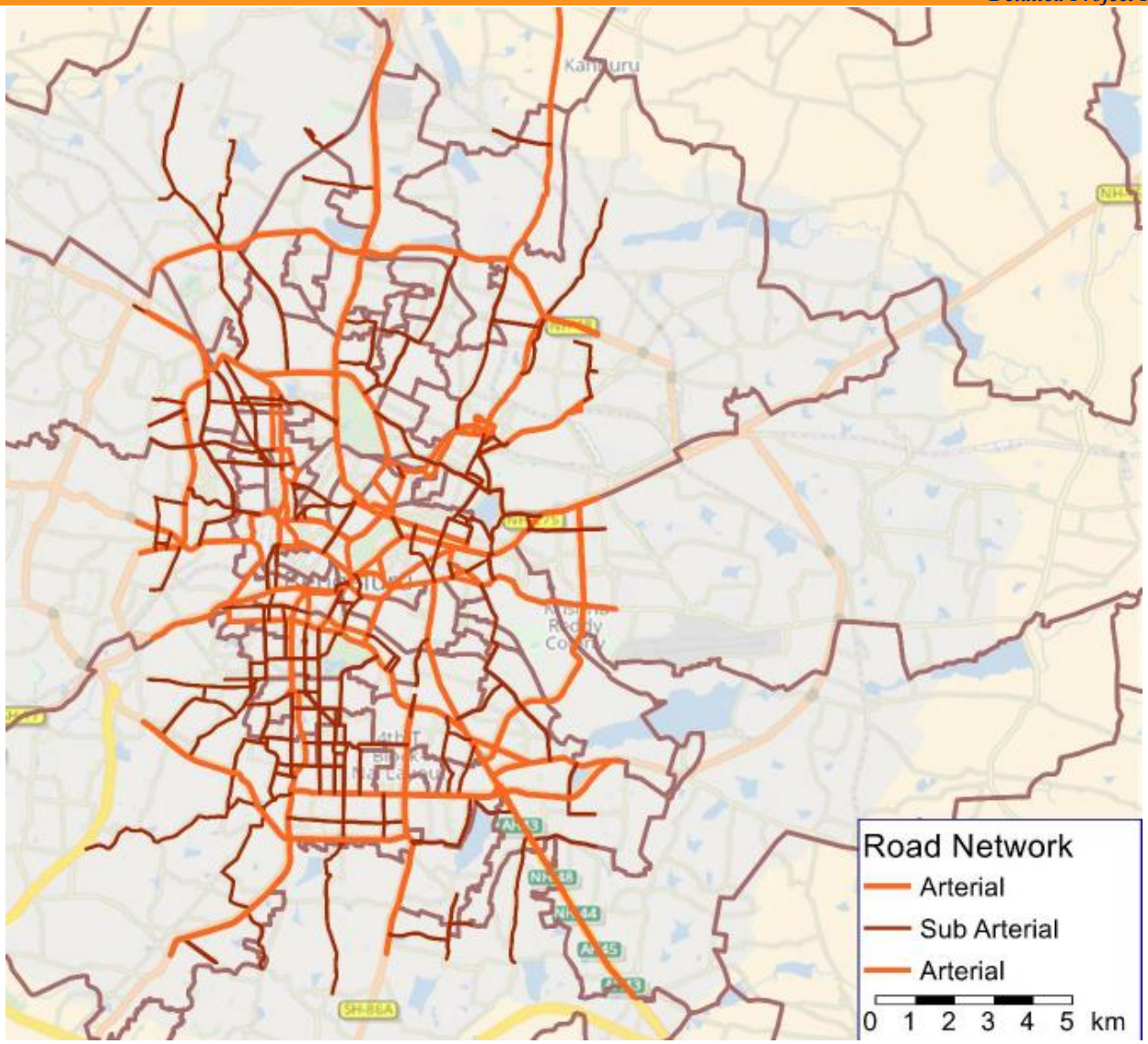


Figure 64: Road network developed in PTV Visum

7.14.2 Link Types

The traffic related properties of links are described via Link Types and following are the important parameters of a link type:

- List of permitted transport systems on a link
- Capacity
- Permitted free flow
- Number of lanes

Volume Delay functions or capacity restrain functions define correlation between current volume of traffic and roadway capacity of a link. The result of the V-D function is the travel times in the loaded network for the Private vehicles. Thus, a V-D function defines the travel time of traversing a link in loaded state. The values for the different calibrated volume delay functions were estimated based on the capacity values for IRC 106

and Indo HCM. Conical functions were preferred over others because of their better representation with behavior as compared on the ground.

7.15 Base Year Travel Demand Analysis

The base year travel demand was estimated by importing the origin-destination matrices and executing the mode-wise matrix correction procedure through T-flow fuzzy method. T-flow fuzzy method also considers the volume count data of survey locations Figure 65.

The assignment procedure was executed iteratively after the matrix correction procedure. The assignment results are obtained in the form of bars where the large width bars represent more traffic on the links. (Figure 65)

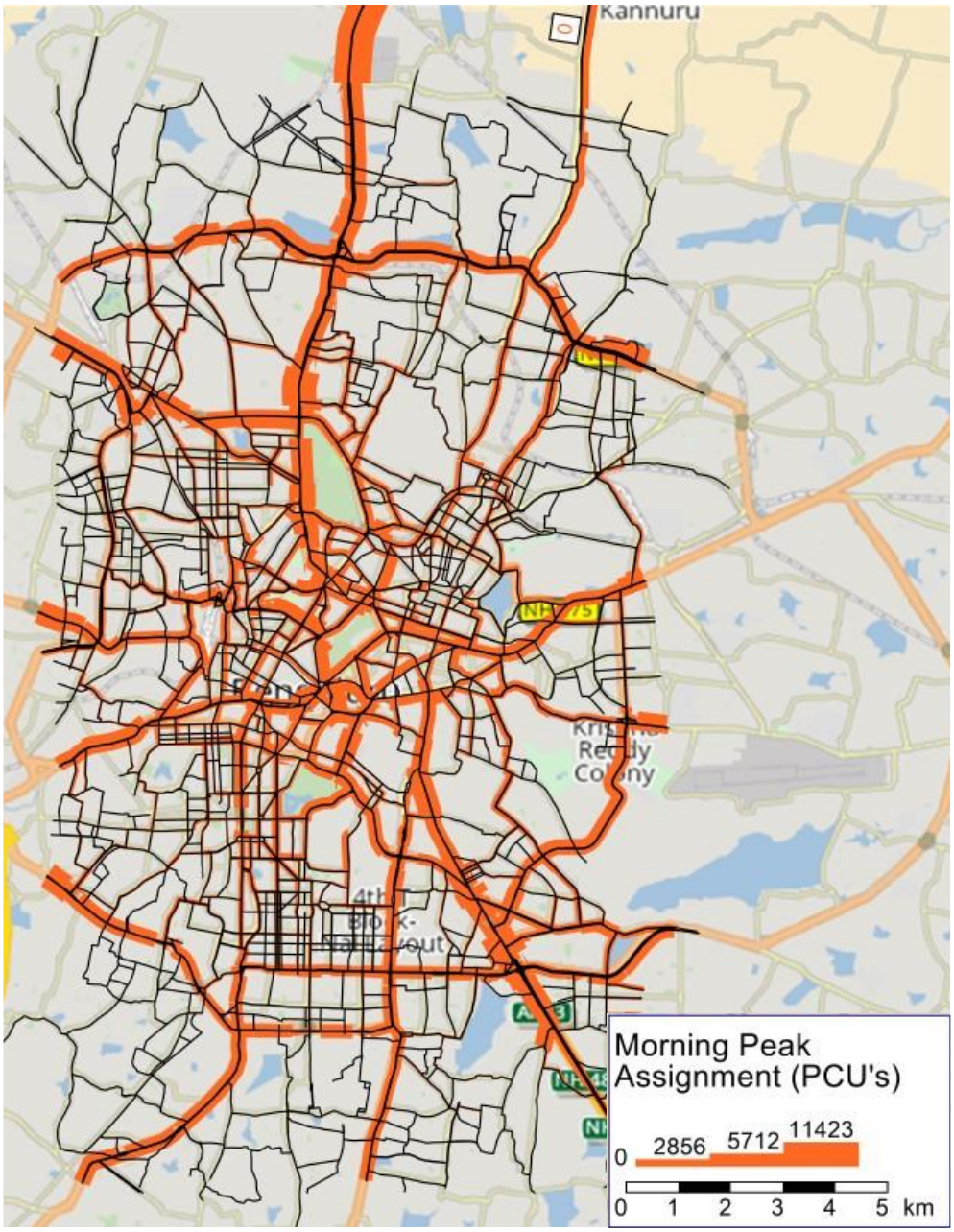


Figure 65: Traffic assignment, Bengaluru (Base Year)

Figure 66, 67 & 68 demonstrate the count locations used to validate the assignment results with survey data.

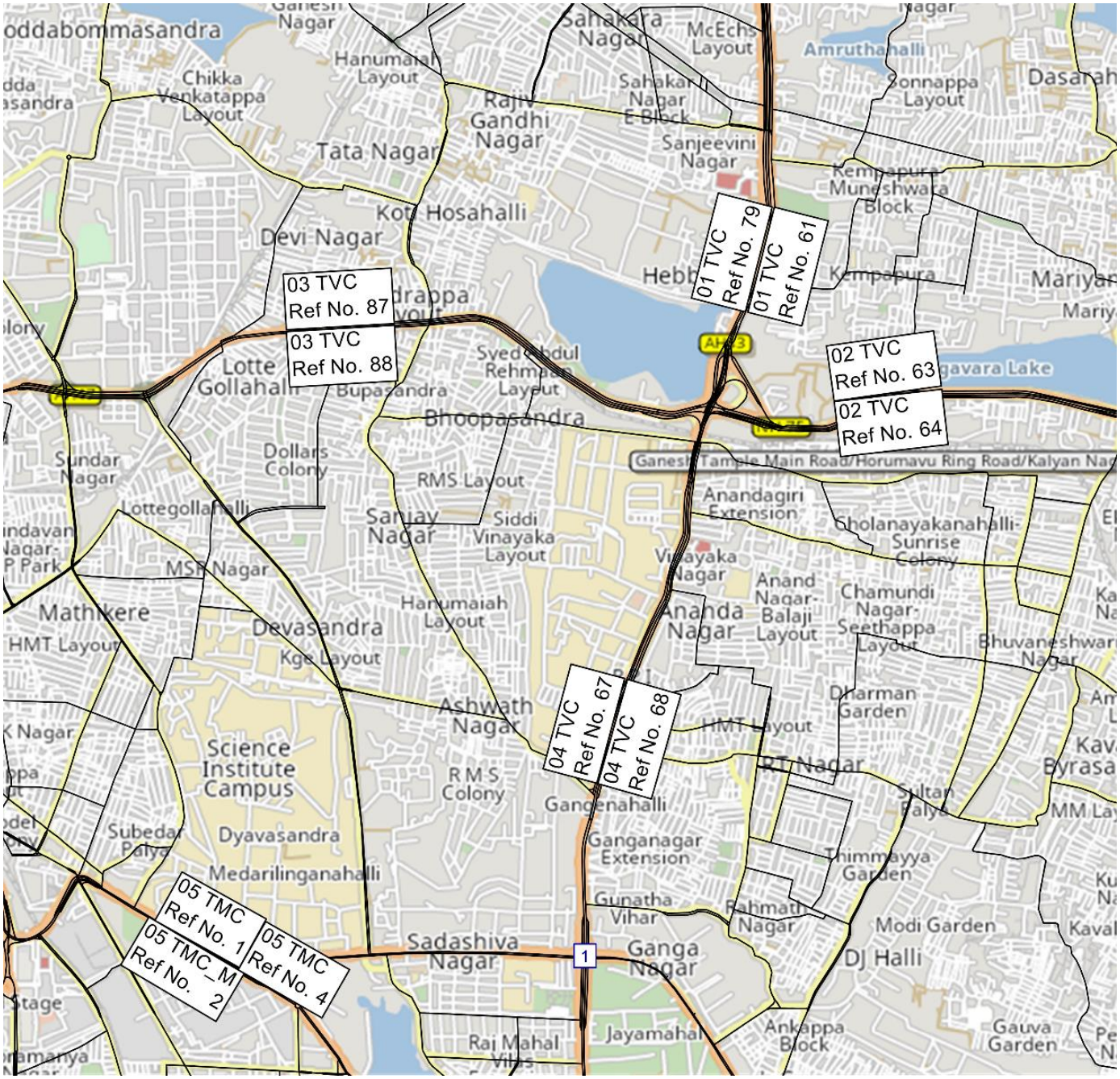


Figure 66: Count Locations for validation of base year assignment (a)

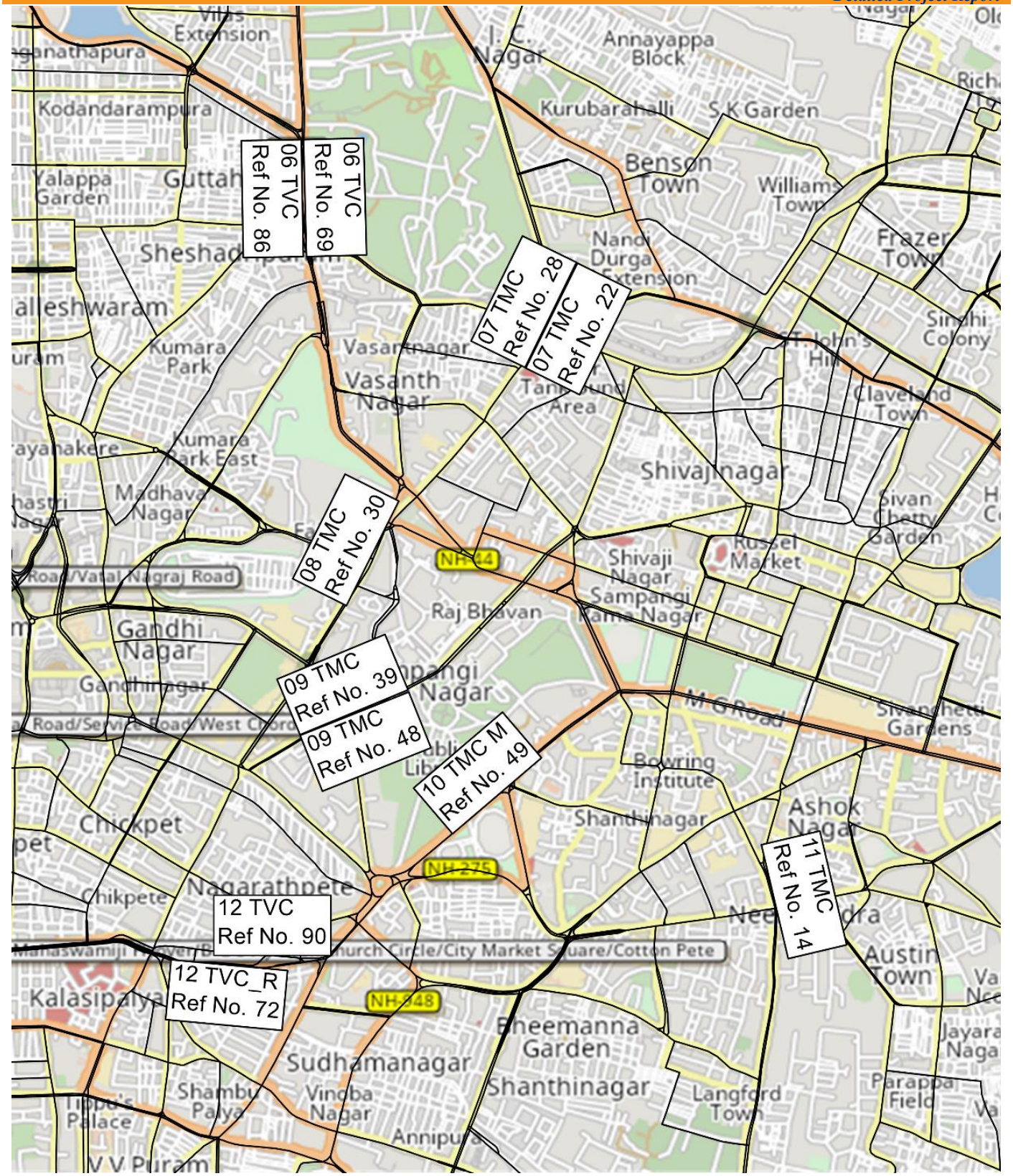


Figure 67: Count Locations for validation of base year assignment (b)

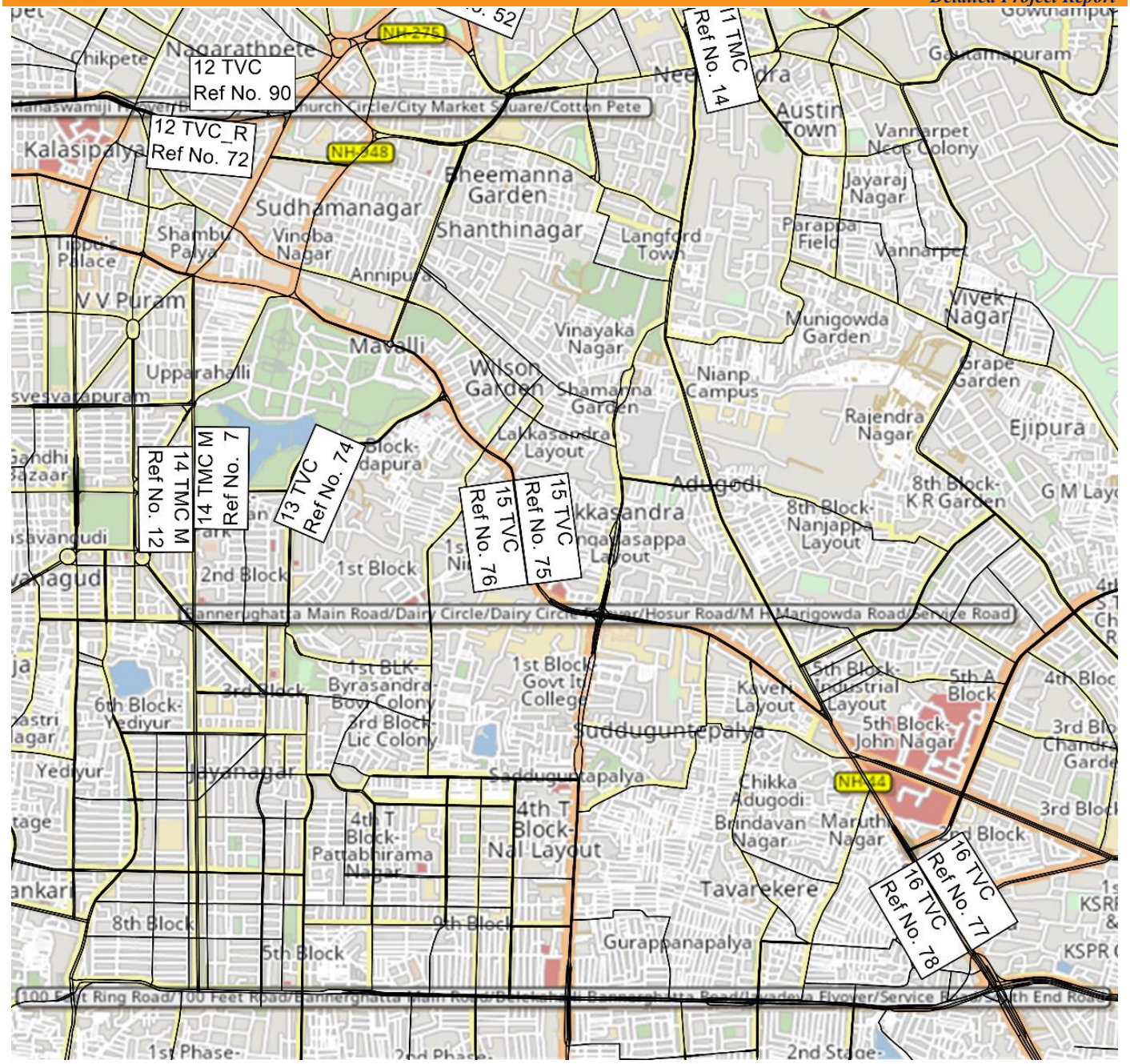


Figure 68: Count Locations for validation of base year assignment (c)

The assignment results are validated through GEH value which suggests that 90% of the assignment results should have GEH value of less than 10. This is considered as a validation measure to validate the model's accuracy. The GEH Values of the model results are shown in Table 64.

Table 64: Model Results

Name	Car Observed Volume	Car Modelled Volume	GEH_CAR	TW Observed Volume	TW Modelled Volume	GEH_TW	Auto Peak Hour Observed Volume	Auto Peak Hour Modelled Volume	GEH_AUTO
01 TVC	3638	3805	3	2850	2625	4	320	320	0
01 TVC	3194	3314	2	2580	2348	5	295	229	4
01 TVC	1348	1209	4	1571	1787	5	245	253	1
02 TVC	1812	1671	3	2643	2552	2	492	392	5
02 TVC	1839	1558	7	2397	2268	3	311	327	1
02 TVC	799	806	0	1606	1684	2	0	129	16
02 TVC	130	291	11	1212	1281	2	101	105	0
03 TVC	1455	1334	3	3040	2889	3	324	314	1
03 TVC	1883	1883	0	2949	3235	5	396	382	1
04 TVC	2366	2059	7	2573	2263	6	295	385	5
04 TVC	2748	2826	1	2349	2253	2	427	415	1
06 TVC	2736	3107	7	4141	4346	3	526	621	4
06 TVC	1991	2133	3	2393	2459	1	751	740	0
12 TVC	1538	1509	1	2324	2458	3	1001	930	2
12 TVC	538	653	5	2550	1829	15	751	800	2
13 TVC	405	380	1	2600	2921	6	473	420	3
13 TVC	340	312	2	1434	1259	5	402	332	4
15 TVC	753	776	1	2005	1978	1	308	329	1
15 TVC	1097	885	7	2189	1677	12	584	489	4
16 TVC	1563	1531	1	4412	4564	2	956	751	7
16 TVC	2714	2834	2	5525	5823	4	926	1150	7

Table 65: Synthetics Validation of Base Year Network – Peak Hour

GEH Range	Car	Two-Wheeler	Auto-Rickshaw
<10	95%	90%	96%
>10	5%	10%	5%

7.16 Base Year Outputs

The outputs from the model are in the form of Trip Length Frequency Distribution to calculate mode-wise Average Trip Lengths along with Total number of Trips generated and attracted in the modeled peak hour.

7.16.1 Trip Length Frequency Distribution

Trip Length Frequency Distribution provides insights into travel patterns, to understand the average distances traveled by commuters and identify areas with high concentrations of short or long trips. Through analyzing Trip Length Frequency Distribution, Average Trip Lengths mode-wise are obtained to understand travel patterns within the study area.

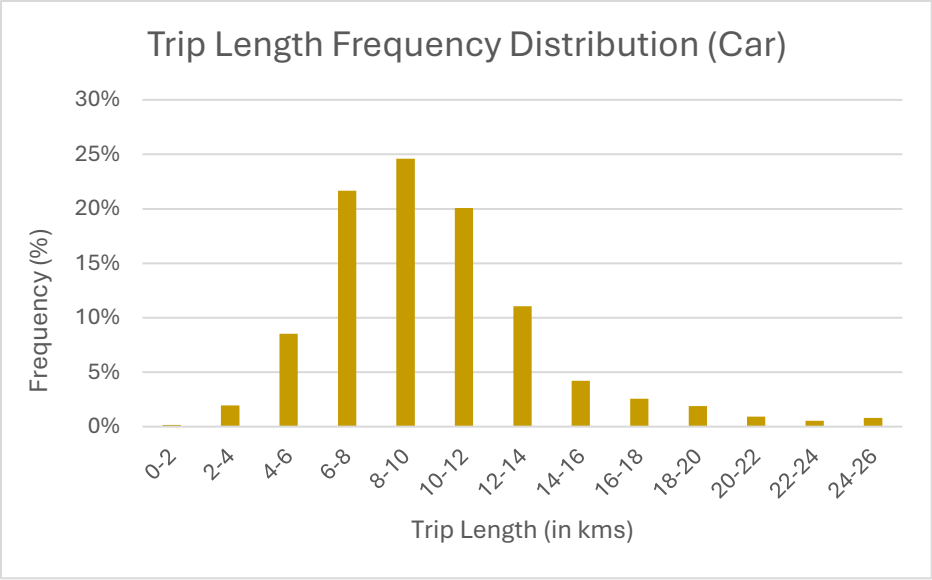


Figure 69: TLFD for Car Trips

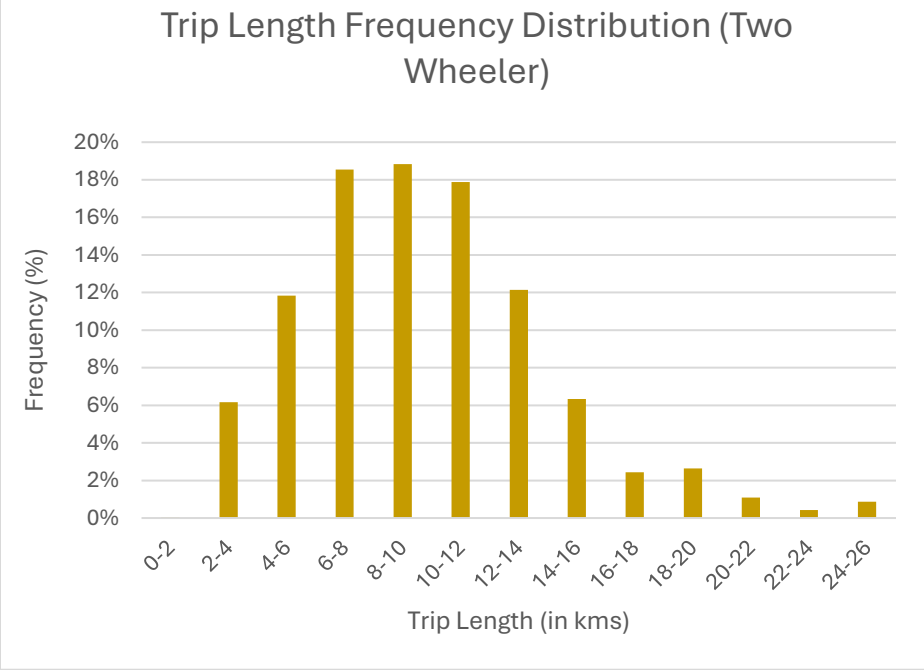


Figure 70: TLFD for Two-Wheeler Trips

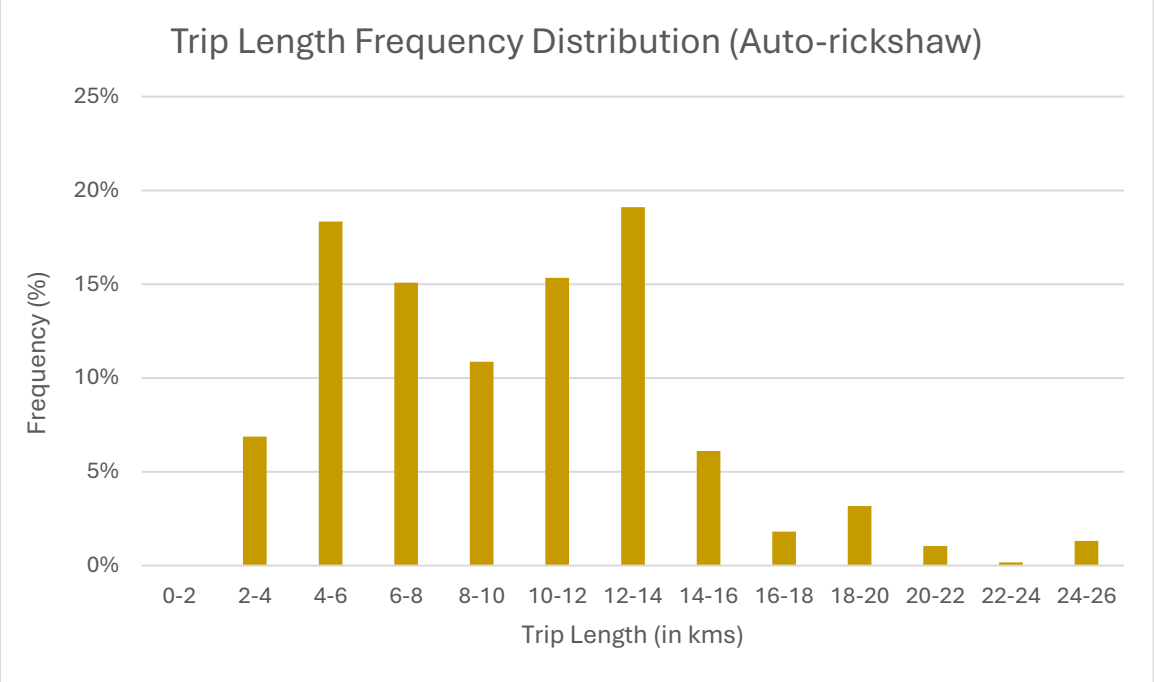


Figure 71: TLFD for Autorickshaw Trips

7.16.2 Estimated Trips

Table 66 shows the total no. of estimated trips produced by each mode for the study area. The maximum no. of trips produced is observed for Two-wheeler i.e., 1,20,288 trips followed by Car i.e., 59,322 and 25,603 by Autorickshaw among passenger vehicle in the modeled peak hour. A total of 3,854 trips are produced by freight vehicles in the modeled peak hour.

Table 66: Total no. of Trips (Mode-wise)

Mode	No. of Trips
Car	59,322
Two-Wheeler	1,20,288
Autorickshaw	25,603
Light Commercial Vehicle	3,640
Heavy Commercial Vehicle	214

7.17 Summary

After running multiple iteration of base year assignment, the base year model has been calibrated and the model is fit for the calculation of future travel demand of horizon year.

7.18 Horizon Year Model

7.18.1 Planning Period

The demand to be calculated for the future is to be estimated for 10 years, 15 years, 20 years and 25 years from the base year i.e., 2024. For future growth estimation, three scenarios are developed to estimate the number of trips diverted on the North-South corridor for Horizon Year. The model runs are done for the years of 2031 and 2041, and other results are extracted from the result of these 2 years.

7.18.2 Planning Parameters

Population data is referred from CMP 2020 and the zone wise population distribution has been carried out for base year and zonal distribution of population has been done for horizon year considering similar distribution.

The horizon year population is given bellow in Table 67.

Table 67: BBMP Population Projections

Year	Population
2021	1,28,62,825
2024	1,32,62,233
2031	1,68,56,904
2041	1,98,67,161

Source: CMP 2020

7.18.3 Scenario Building

The scenario building is done considering the scenarios formulated in Comprehensive Mobility Plan, 2020 for Bengaluru to guide the development of the city in line with the Comprehensive Mobility Plan 2020. In the Comprehensive Mobility Plan 2020, BAU scenario is considered to have the highest number of Cars, and the Scenario 4 is considered to have the highest share of Public Transport as compared to other scenarios.

For the study, 3 scenarios are considered Scenario 1 with highest modal share of Car, Scenario 3 with lowest modal share of Car and an intermediate scenario between Scenario 1 and Scenario 3 i.e., Scenario 2 having a moderate modal share of Car and higher modal share of Public Transport compared to Scenario 1.

In scenario 1, the high share of cars leads to could not align with the transport proposal as the city is focused on improving public transport. Also the scenario 3 is very must optimistic where the public transport share increases to 73 %. Therefore to scenario 2 is considered to be the reasonable scenario where realistic modal share is considered. All the further analysis are done based on

7.18.3.1 Scenario 1 (S1)

This scenario considers the mode share estimates as per the BAU scenario of CMP.

7.18.3.2 Scenario 2 (S2)

This is considered as an intermediate scenario. The projections are based on the intermediate growth rates estimated for each Zones for scenario 1 and scenario 3.

7.18.3.3 Scenario 3 (S3)

This scenario considers all future developments and redevelopments guided by Transit Oriented Development facilitating compact development coupled with efficient public transport corridors reducing the demand for large trip lengths. The use of private vehicles is discouraged significantly and leveraging road infrastructure for

public transport. This scenario focuses on expanding public transport systems and multi-modal integration.

The modal share for all scenarios is shown below in Table 68 which is referred from CMP 2020.

The scenario 1 and 3 are directly taken from CMP 2020 where S1 shows a high share of cars whereas S3 shows a low share of cars and high share of public transport. Scenario 2 is considered as an intermediate scenario whose modal share falls in between these two scenarios 1 and 3.

Table 68: Forecasted Modal Share for 2031

Mode	Year 2015	Year 2031	
	Base Year	BAU - S1	S3
Car + Taxi	21%	30%	17%
Two-Wheeler	24%	29%	8%
Auto Rickshaw	8%	5%	2%
Public Transport	48%	36%	73%

Source: CMP 2020

The horizon year of CMP 2020 was 2031 therefore to forecast vehicular trips for 2041 the population projections given in the CMP are used. The total trips are assumed to be growing in align with population growth as per the trip generation estimates in the CMP.

7.19 Projections

7.19.1 Key Assumptions

- It is assumed that the city growth pattern will align with the vision of CMP 2020.
- Mode share has been referred from CMP 2020 for different scenarios of horizon year.
- For projection of trips for external zones, DPRs of sanctioned projects (Satellite Town Ring Road and Peripheral Ring Road) are referred and growth rates are derived from these documents.

7.19.2 Demand Projections

7.19.2.1 Zones within BBMP Area

To project the trips for horizon year, the percentage of base year production and attraction totals of each zone has been calculated from the zone-wise population for each mode to get the mode-wise proportion of population in each zone. Further, the modal shift (derived from CMP 2020) has been added to this mode-wise population proportion to get the horizon year proportion of population for each mode and horizon year trips have been calculated by multiplying the horizon year population with this proportion. With this process, for the trip generation process, the production and attraction trip totals mode-wise for each scenario has been obtained. Table 69 below provides the estimated for passenger modes

Table 69: Estimated Total trips during morning peak hour.

	Year 2031			Year 2041		
Model	**S1**	**S2**	**S3**	**S1**	**S2**	**S3**
Auto Rickshaw	25111	23812	19859	29631	28098	23434
Two-Wheeler	153528	128708	100381	181163	151876	118449
Car	83005	72507	61168	97946	86211	72178

7.19.2.2 Zones outside the BBMP Area

The population data was available for BBMP area. To forecast the trips in the zones which fall outside the BBMP area, growth rates are referred from Peripheral Ring Road project which shows average annual growth rate of 7 %. The trips in the external zones (outside BBMP area are assumed to grow annually at a growth rate of 7%.

7.19.2.3 Freight Vehicles

For projecting trips for freight vehicles, the DPR documents for satellite town ring road and peripheral ring road were referred. Also, the SGDP and vehicle registration data were referred to derive growth rates for freight vehicles. Up to 2031 growth rate of 7% was taken and after 2031 growth rate of 5 % was considered for these vehicles.

7.19.3 Estimating Horizon year OD Matrices

Based on the estimated trip ends as discussed above, for the trip distribution procedure, to obtain the inter-zonal trip interchanges for each scenario of horizon year, fratar method of trip distribution was used.

The Fratar method, a widely used technique in urban planning and transportation engineering, is designed to model and distribute trips across various zones in a region. This iterative procedure starts with an initial set of trip distributions. It then adjusts these distributions to align with observed trip generation and attraction data for each zone. The process involves iteratively updating the trip matrix until the calculated trip ends match the known totals for each zone, ensuring a balanced distribution. This method is valued for its ability to reconcile initial estimates with actual data, providing a more accurate reflection of travel patterns and improving the reliability of transportation planning and infrastructure development.

$$T_{i-j} = t_{i-j} \, x \, \frac{P_i}{p_i} \, x \, \frac{A_i}{a_i} \, x \, \frac{\sum^{k} t_{i-k}}{\sum^{k} \left[A_k / a_k \right] x \, t_{i-k}}$$

Ti-j = Future Trips from Zone I to Zone j

ti-j = Present Trips from Zone I to Zone j

Pi = Future trips produced at Zone i

pi = Present trips produced at Zone i

Aj = Future trips attracted at Zone j

aj = Present trips attracted at Zone j

k = Total Number of Zones

The horizon year matrices for each scenario were obtained after applying this procedure.

7.20 Model Results

In this section the projected traffic on the corridor is discussed. Initially for horizon year, the model assignment was carried out considering all vehicles for the proposed North-South Corridor which resulted in a V/C ratio of 0.7 and more for all sections.

Considering this, only Cars were considered as the mode for the North-South Corridor. This is also in line with

the allowed vehicles in similar facilities around the country. The assignment procedure was executed for the year 2031 and 2041 to keep in line with the modal share assumed in Comprehensive Mobility Plan 2020. The traffic assignment was then interpolated for the years 2034, 2039, 2044 and 2049.

For each scenario and horizon year, the model assignment was done for 2 sub scenarios with and without tolls for using the corridor. The average toll price considered for Car is Rs 16/km. Considering this, for 2031 and 2041 all the three scenarios were calculated with toll and without toll to understand the impact of the application of toll in the proposed North South Corridor.

In sub-scenario with toll, scenario 1 having high share of cars leads to poor LOS on the proposed NS corridor. Also, scenario 3 is very optimistic where the public transport share increases to 73 % leading to very less traffic on the proposed NS corridor. Therefore, scenario 2 with toll is the reasonable scenario where realistic modal share is considered.

For facilitating ease of analysis, the corridor is subdivided into 4 sections, Section1 starting from Hebbal and Section 4 ending at Silk Board Junction. Further, the entry and exit ramps are coded alphabetically to identify the entry and exit volumes at ramps (Figure 72).

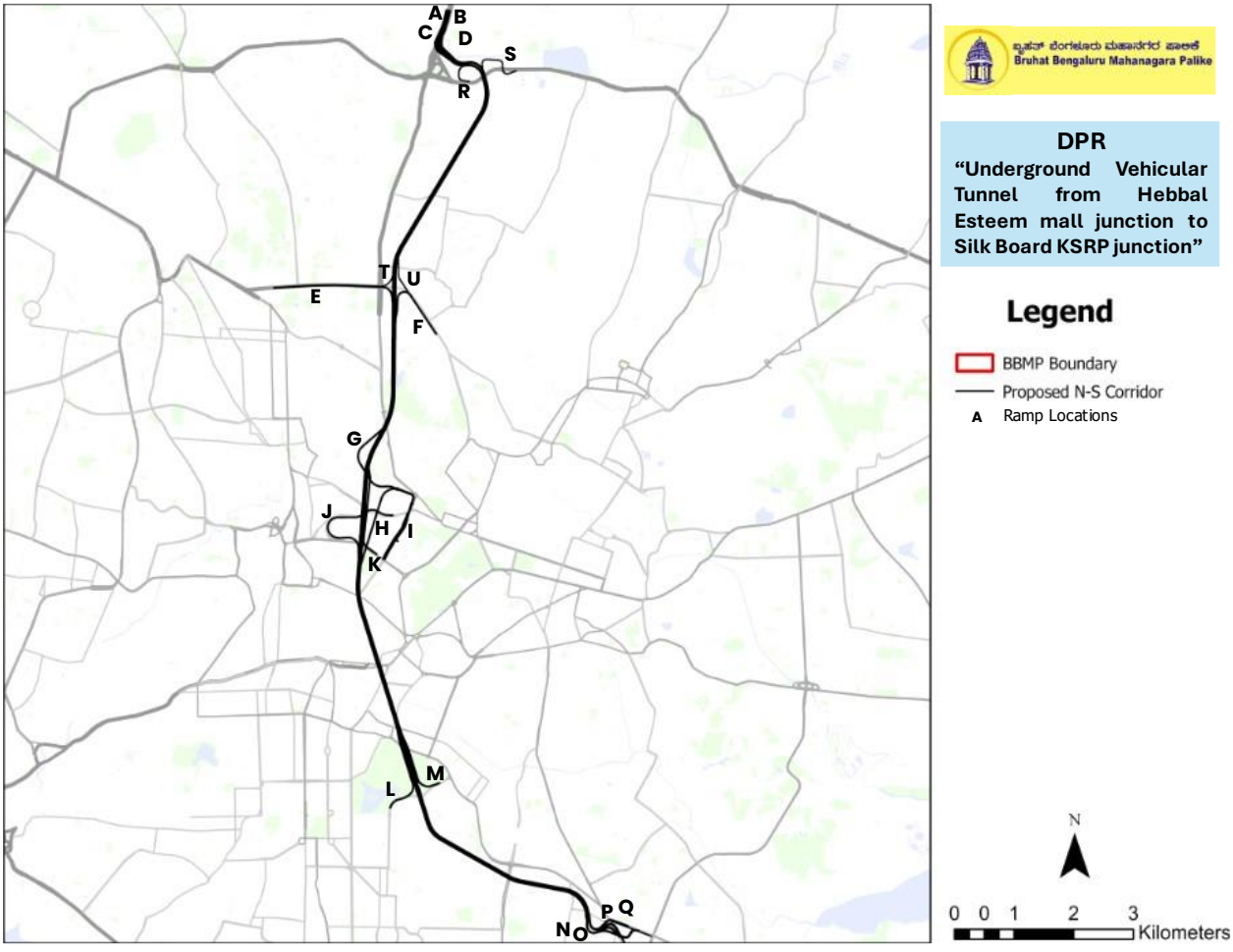


Figure 72: North-South Corridor: Entry/Exit Ramps Coding

7.20.1 Horizon Year Model Outputs – Without Tolls

The assignment results are shown in the Table 70. The highest volume in all the three scenarios for 2031 and

2041 is observed in the case of Section 2, particularly the traffic movement towards Silk Board Junction for the morning peak hour. The section traffic is considered as average if there are more than 1 links in a section.

Table 70: Assignment Results (Morning Peak Hour PCU) for 2031 and 2041 (without toll)

Average Traffic on each Section		Morning Peak Hour (PCU)					
		S1	S2	S3	S1	S2	S3
		Year 2031 (Without Toll)			Year 2041 (Without Toll)		
Section 1	**Towards Airport**	1416	1139	1157	1915	1665	1318
	Towards Bengaluru City	1535	1343	1190	1850	1621	1356
	Ramp A (Main Exit)	991	797	810	1341	1165	923
	Ramp B (Main Entry)	537	470	416	647	567	475
	Ramp C (Service Exit)	425	342	347	575	499	395
	Ramp D (Service Entry)	998	873	773	1202	1054	881
	Ramp E	1009	787	568	1253	1057	845
	Ramp F	3450	3065	2767	3847	3543	3271
Section 2	**Towards Airport**	2045	1696	1477	2566	2244	1814
	Towards Bengaluru City	6840	6151	5448	7712	7041	6287
	Ramp G	759	459	497	1206	955	698
	Ramp H	3711	3486	2982	4031	3755	3321
	Ramp I	4470	3946	3480	5238	4709	4018
	Ramp J	2464	1998	1176	3046	2693	1972
	Ramp K	2829	2507	2179	3113	2895	2522
Section 3	**Towards Airport**	4129	3464	2405	5009	4460	3437
	Towards Bengaluru City	5866	5388	4760	6614	6023	5426
	Ramp L	1315	1134	912	1527	1436	1184
	Ramp M	3920	3656	3383	4234	4018	3810
Section 4	**Towards Airport**	2814	2330	1493	3481	3024	2252
	Towards Bengaluru City	1946	1732	1377	2381	2005	1615
	Ramp N	2814	2330	1493	3481	3024	2252
	Ramp O	2587	2368	1931	3124	2627	2240
	Ramp P	1305	1096	823	1637	1383	991

As shown in Table 70, for year 2031 in all three scenarios the LOS is compromised on section 2 and section 3 in both direction of traffic flow.

7.20.2 Horizon Year Model Outputs with Tolls

In sub-scenario with toll, scenario 1 having high share of cars leads to poor LOS on the proposed NS corridor. Also, scenario 3 is very optimistic where the public transport share increases to 73 % leading to very less traffic on the proposed NS corridor. Therefore, scenario 2 with toll is the reasonable scenario which is considered for evaluation purpose.

After the application of tolls in the model, the assignment procedures were executed again to observe the impact of tolls on the proposed North South Corridor.

Table 71: Assignment Results - Scenario 2 (Morning Peak Hour PCU) for 2031 and 2041 (with toll)

Assignment Results		Morning Peak Hour (PCU) Year 2031 (With Toll)	Morning Peak Hour (PCU) Year 2041 (With Toll)
Section 1	**Towards Airport**	902	1276
	Towards Bengaluru City	2645	3770
Section 2	**Towards Airport**	1834	2333

Assignment Results		Morning Peak Hour (PCU) Year 2031 (With Toll)	Year 2041 (With Toll)
	Towards Bengaluru City	4030	5161
Section 3	**Towards Airport**	2653	3742
	Towards Bengaluru City	4705	5559
Section 4	**Towards Airport**	2005	2951
	Towards Bengaluru City	1551	1811

After considering tolls for horizon year model, the traffic is significantly reduced as can be observed in Table 72.

The average cross-sectional traffic for each section for the morning peak hour with tolls is presented in Table 72. The maximum cross-sectional volumes are observed for Section 3 followed by Section 2.

Table 72: Average Cross section traffic on Each Section (Peak Hour) – With Toll

Section	Average Cross section traffic on Each Section (Peak hour) (PCU) – S2 Toll Scenario		
	2031	**2041**	**2049**
Section 1	3547	5046	6245
Section 2	5864	7524	8852
Section 3	7358	9431	11089
Section 4	3556	4929	6027

The average cross-sectional daily traffic for each section with tolls is presented in Table 73. The maximum cross-sectional volumes are observed for Section 3 followed by Section 2.

Table 73: Average Cross section traffic on Each Section (Daily Traffic) – With Toll

Section	Average Cross section traffic on Each Section (Daily) (PCU) - Toll Scenarios		
	2031	**2041**	**2049**
Section 1	31334	44576	55170
Section 2	51802	66466	78198
Section 3	65000	83313	97963
Section 4	31413	43542	53246

For detailed insights on the usage of the proposed North-South Corridor, vehicles using the corridor are estimated through model assignment for the scenarios with toll for 2031, 2041 and 2049 (Table 74). This table illustrates the diversion of Car trips to the proposed North-South Corridor, a total of 17%, 18% and 19% trips are diverted in the years 2031, 2041 and 2049 respectively considering tolls.

Table 74: Vehicles using the corridor during peak hour in Scenario 2

Vehicles using the corridor during peak hour			
	2031 (Toll)	**2041 (Toll)**	**2049 (Toll)**
Total Car Trips using Corridor	12364	15938	18797

In the following Table 75, the level of service can be observed for each Section. Level of Service D is observed in the case of Section 3 with traffic movement towards Bengaluru (Silk Board Junction).

Table 75: Level of Service for Scenario 2 – Morning Peak (2027-28)

	S2 2027-28 with toll	**Car** (Peak Hour Volume)	**Level of Service**
Section 1	Towards Airport	806	**LOS B**
	Towards Bengaluru City	2362	**LOS C**

	S2 2027-28 with toll	Car (Peak Hour Volume)	Level of Service
Section 2	Towards Airport	1638	**LOS B**
	Towards Bengaluru City	3599	**LOS C**
Section 3	Towards Airport	2369	**LOS C**
	Towards Bengaluru City	4202	**LOS D**
Section 4	Towards Airport	1791	**LOS B**
	Towards Bengaluru City	1385	**LOS B**

7.20.3 Summary

As per the model assignment results, since the volume in without toll scenarios is getting saturated leading to a poor level of service of the corridor. The recommended scenarios for maintaining a good level of service in the future are Scenario 2 with toll.

Figure 73 below shows the snapshot for road network where volume is expected to reduce due to the proposed corridor and ease the flow on these routes.

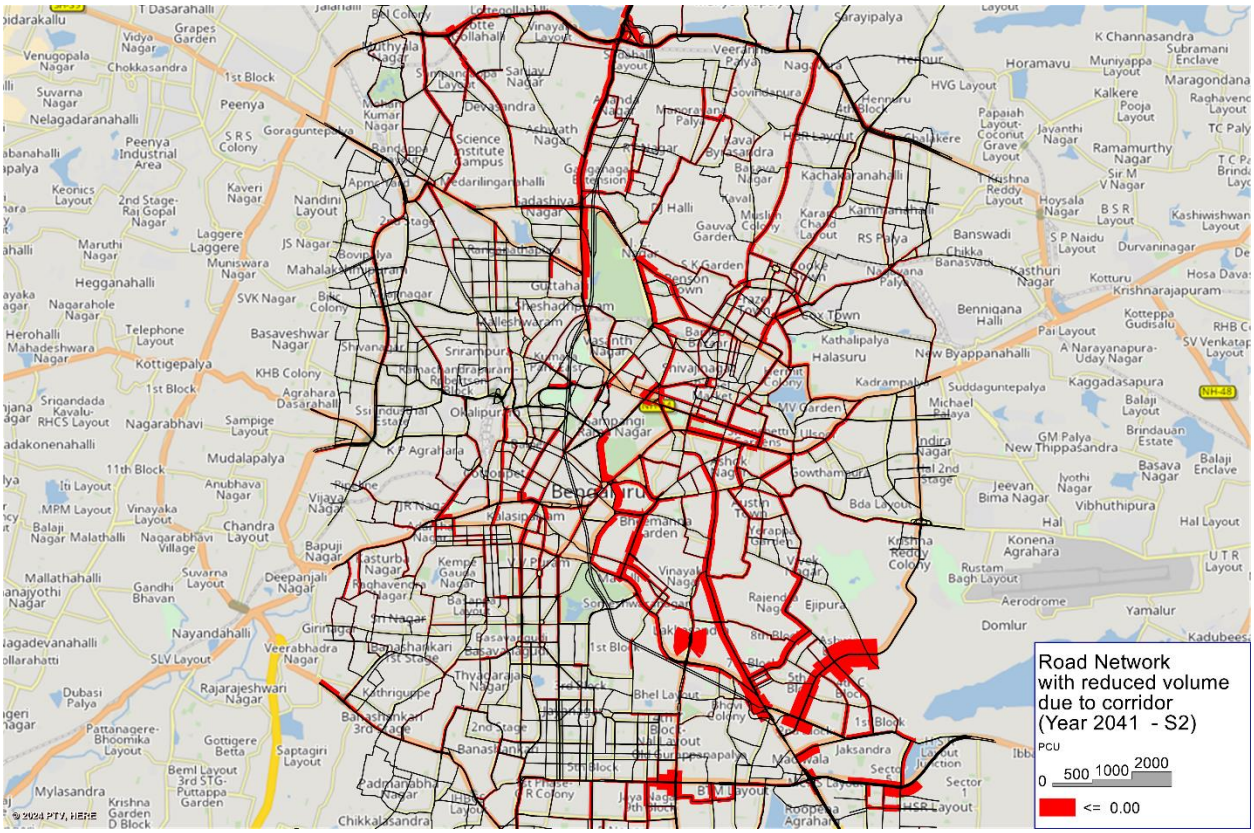


Figure 73: Road network with reduced volume after corridor

Further, the critical junctions have been identified that are getting significantly impacted from the proposed North-South Corridor (Figure 74).

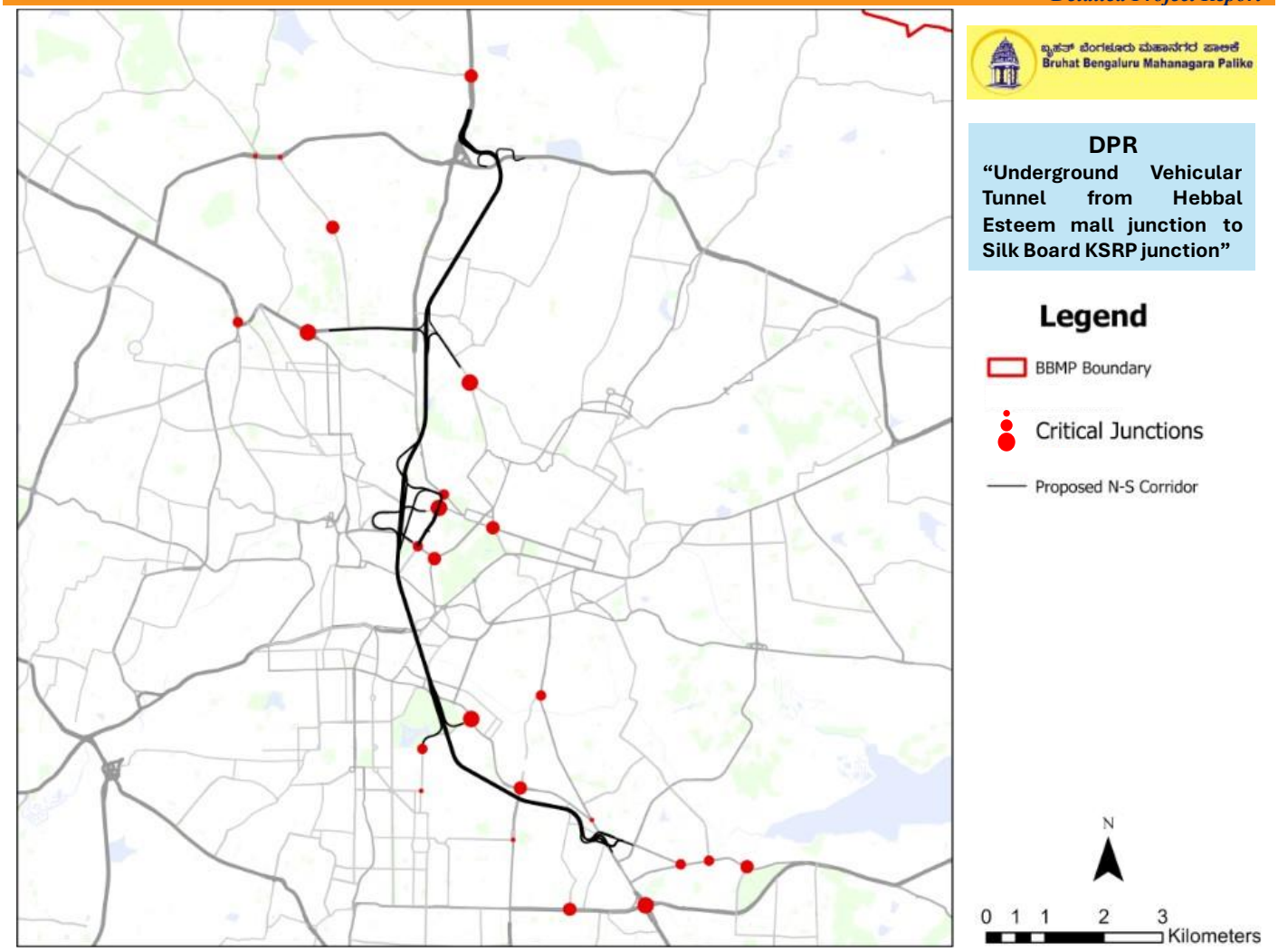


Figure 74: Critical Junctions impact by N-S Corridor

7.21 TMC Diagrams of Surveyed Locations during peak hour

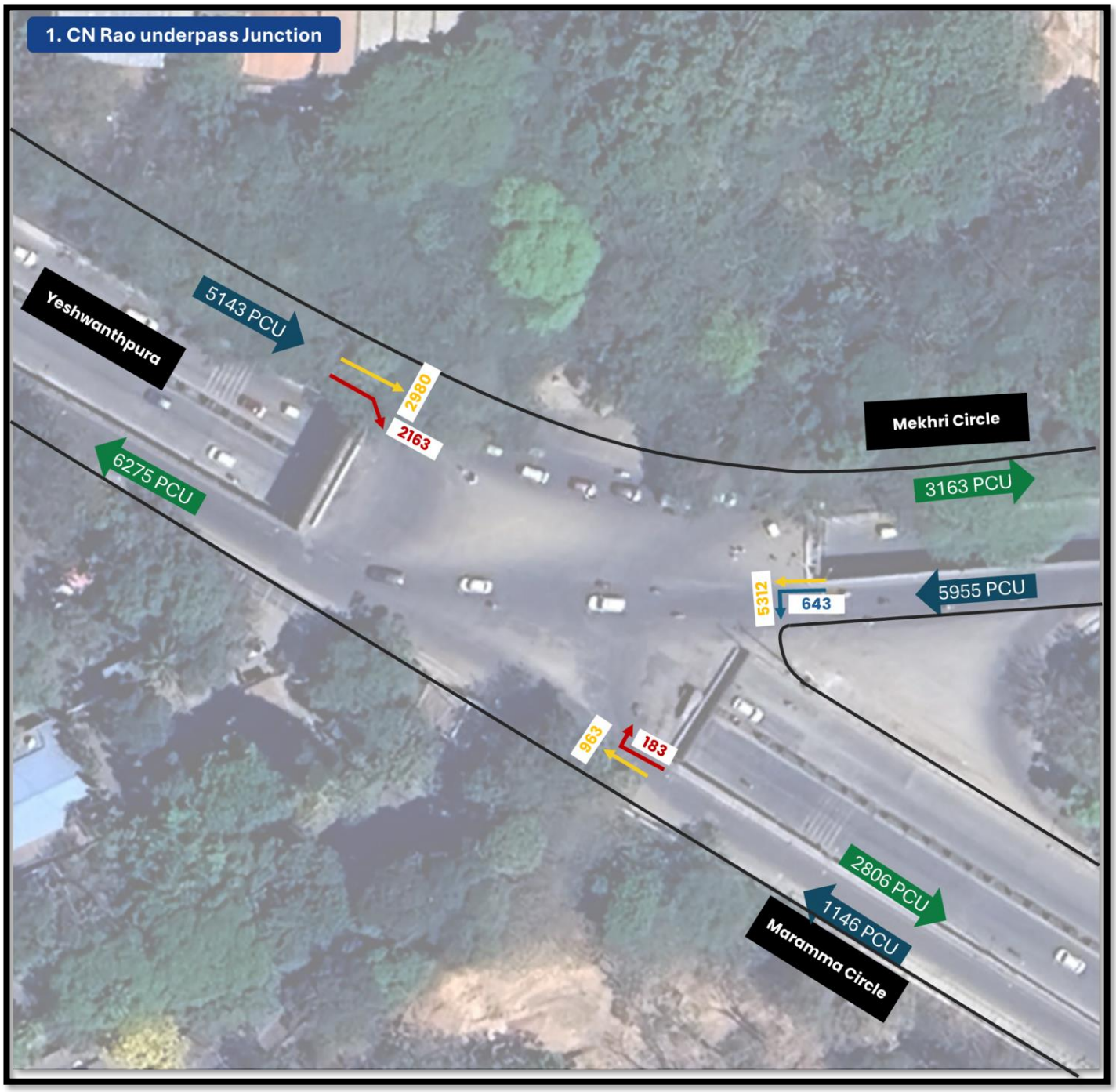


Figure 75: TMC at CN Rao Underpass Junction

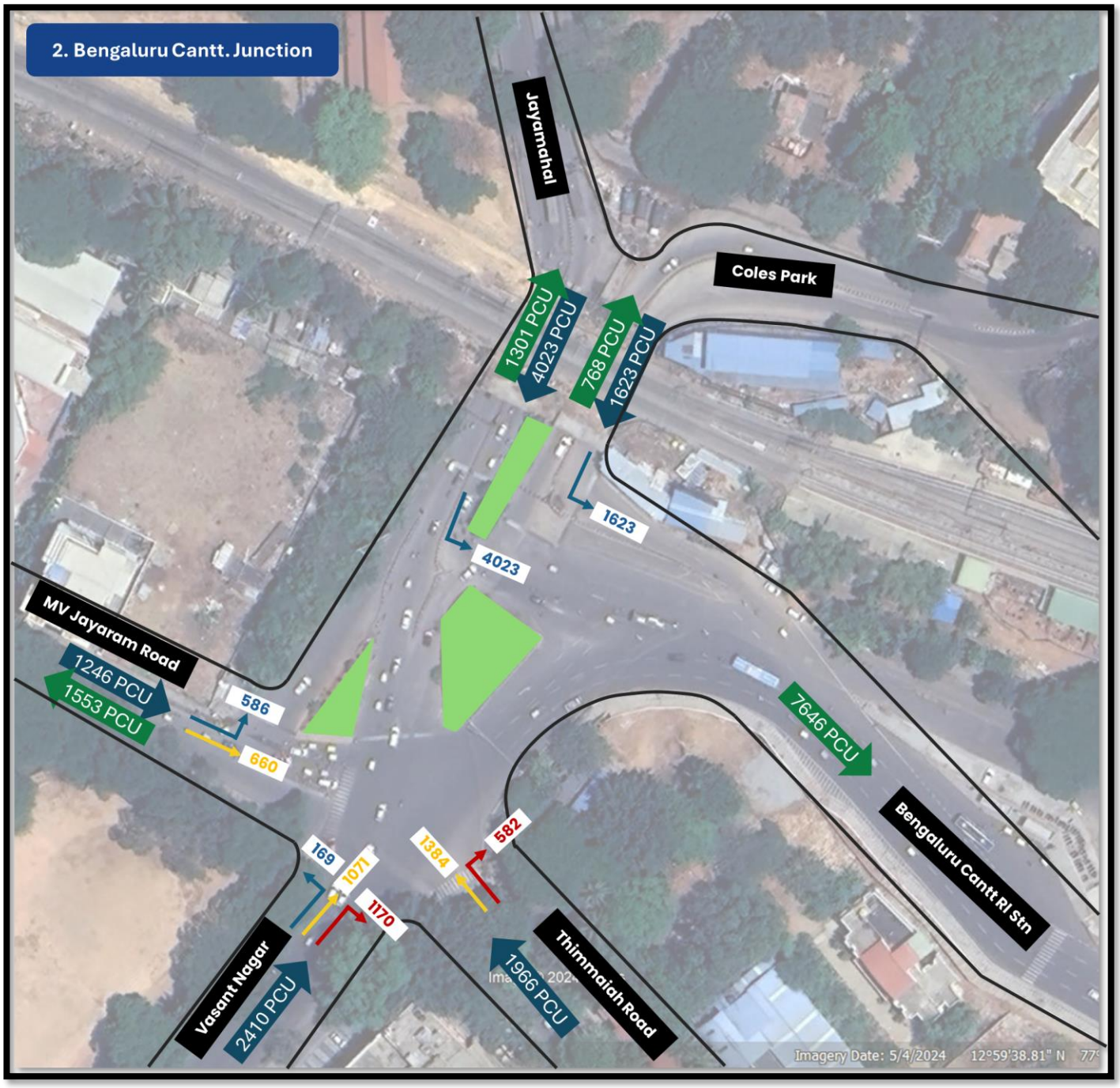


Figure 76: TMC at Bengaluru Cantt Junction

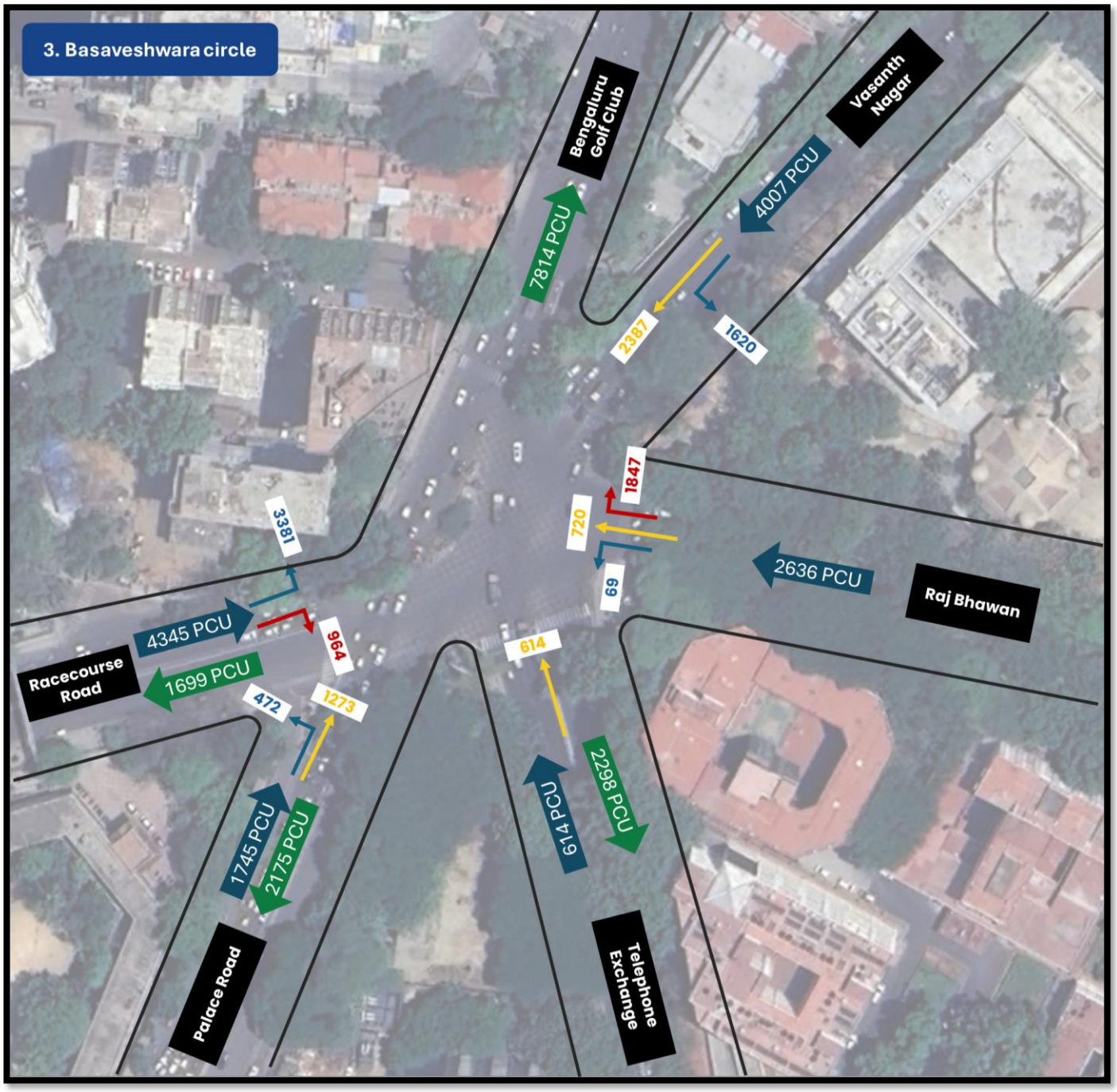


Figure 77: TMC at Basaveshwara Circle

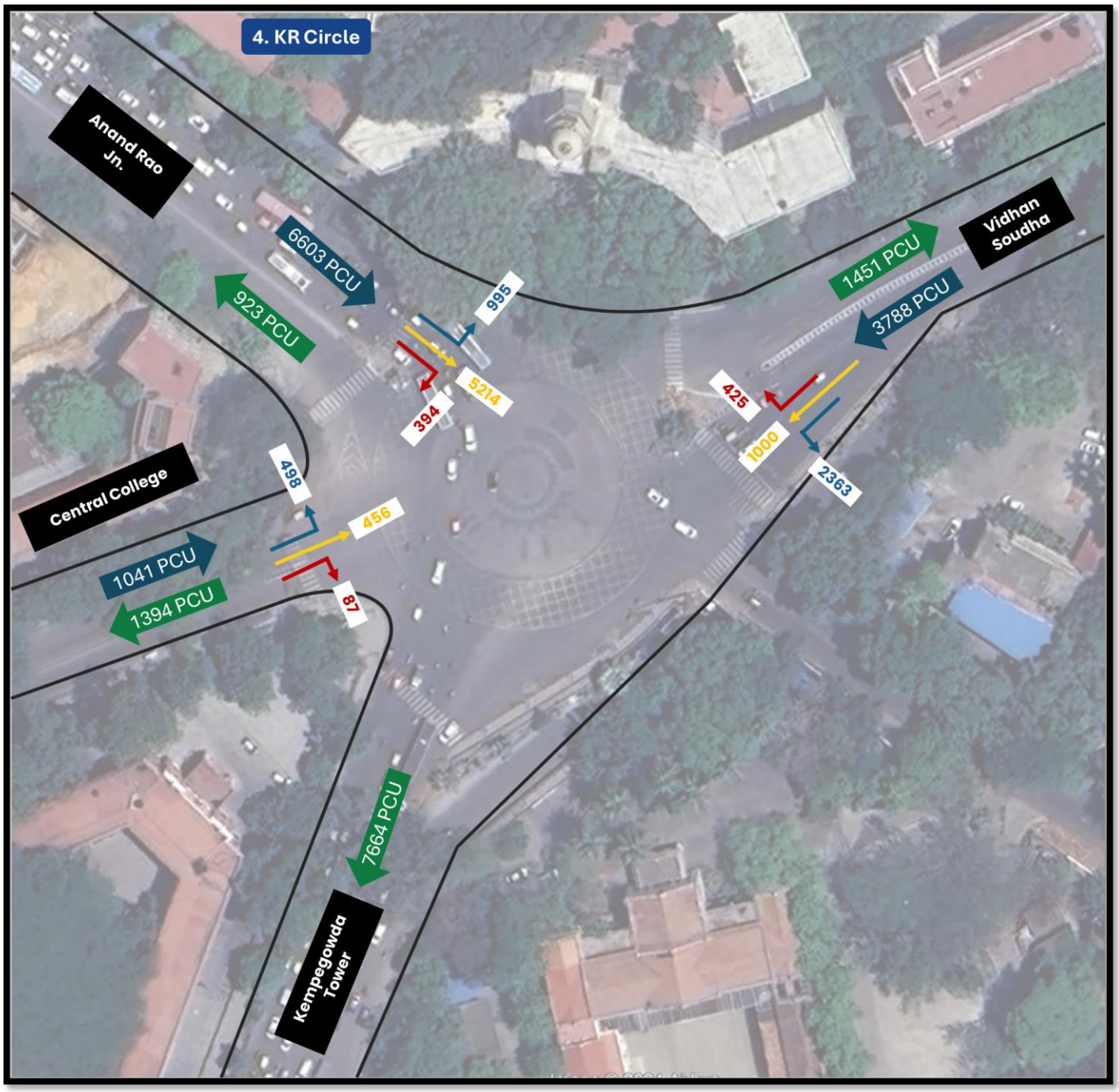


Figure 78: TMC at KR Circle

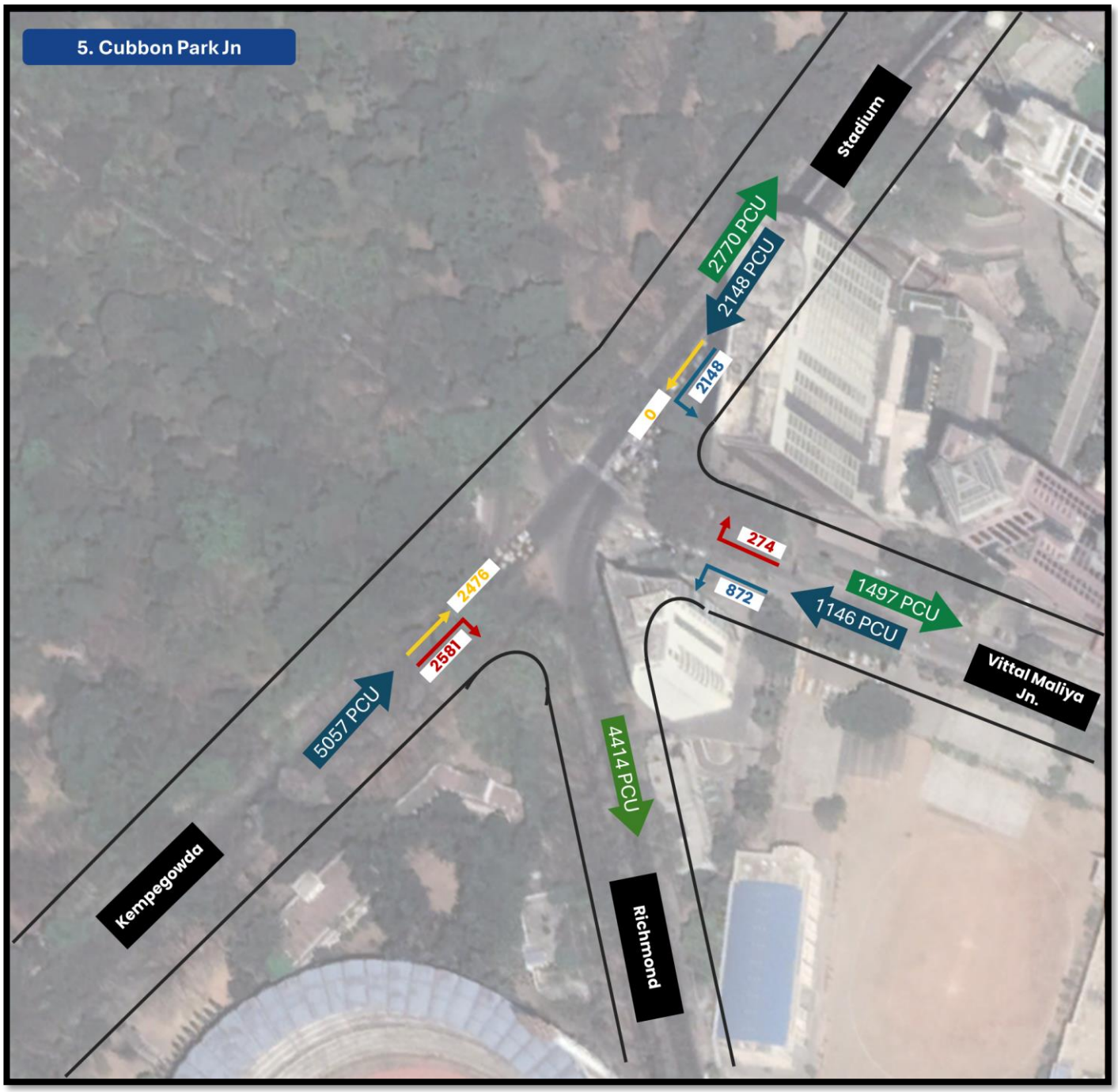


Figure 79: TMC at Cubbon Park Junction

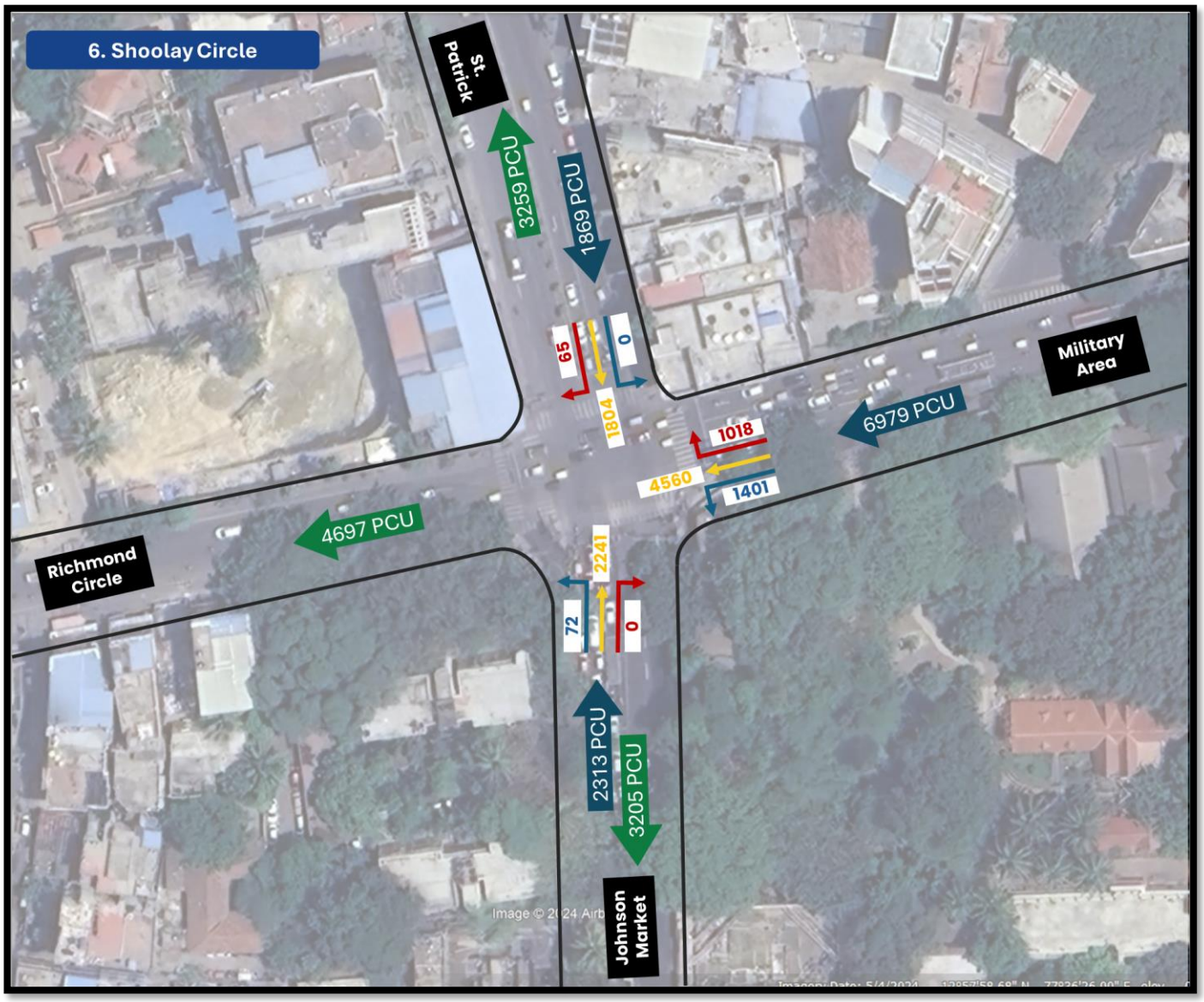


Figure 80: TMC at Shoolay Circle

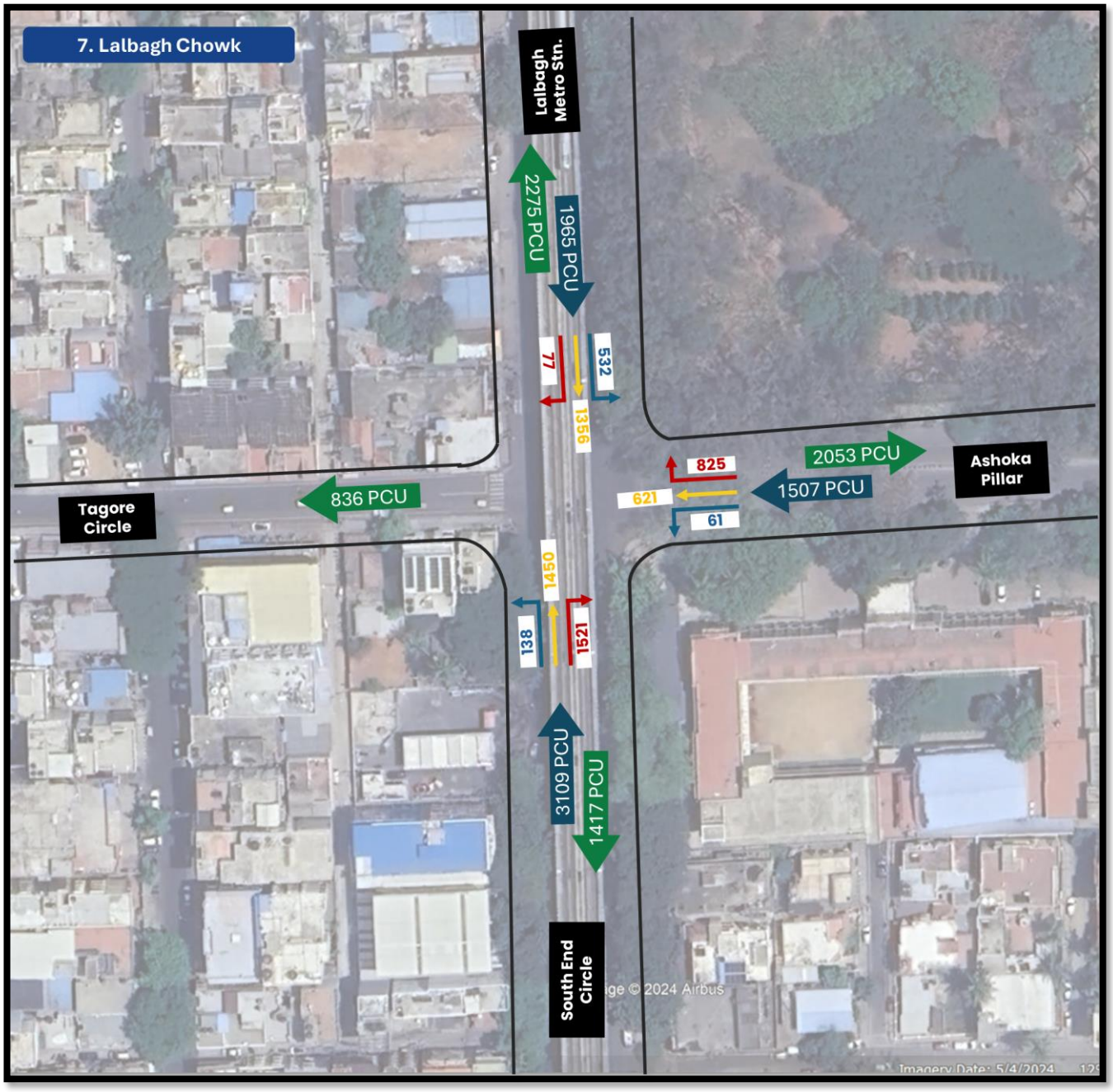


Figure 81: TMC at Lalbagh Chowk

CHAPTER 8
IMPROVEMENT PROPOSALS

CHAPTER 8: IMPROVEMENT PROPOSALS

8.1 General

This chapter describes the various improvement proposals and their necessities to upgrade the existing carriageway facility of project road into two/four lane with paved shoulder in accordance with the Indian standard configuration and design standards proposed for the project road. These improvement proposals are based on the findings of various engineering features carried out on the project roads such as Traffic Survey and Analysis, Inventory Data and Geotechnical & Geophysical Investigations.

The improvement proposals for proposed widening include the provisions for the following major items:

f) Main Tunnel (Twin tube uni-directional TBM tunnel, Cut & Cover, Open Cut)

g) Entry/ Exit ramps (NATM tunnel, Cut & Cover, Open Cut)

h) Tunnel Passage

i) Vertical Shaft

j) Traffic Control and Safety Measures

8.2 Design Standards

8.2.1 Geometric Design

8.2.1.1 General

Geometric design of a highway is the process whereby the layout of the road in specific terrain is designed to meet the needs of the road users keeping in view the road function, type and volume of traffic, potential traffic hazards and safety as well as convenience of the road users. The principal areas of control for fulfilment of this objective are- the horizontal alignment, vertical alignment and the road cross-section.

The Consultants have referred to the latest IRC publications and MORT&H circulars regarding design standards for National Highways in India. After careful review of all available data and requirements of the project road the proposed Design Standards for adoption on the project road have been recommended.

8.2.1.2 Design Speed

The project road passes through plain terrain. For geometric design of the highway, design speed is used as an index which links road function, traffic flow and terrain. An appropriate design speed should correspond to general topography and adjacent land use. The speed selected for design should also cater to travel needs and behaviour of the road users.

The design speed corresponding to the type of terrain as Per IRC 86-2018 is as under:

Table 76: Design Speed Standards

Class of Urban Road	Design Speed (km/h)	
	Ruling	Minimum
Arterial Road	60	50

8.2.1.3 Levels of Service (LOS)

The Level of Service (LOS) characterizes the operating conditions on the roadway in terms of traffic performance measures related to speed and travel time, freedom to manoeuvre, traffic interruptions, and comfort and convenience. The levels of service range from level-of-service A (least congested) to level-of-service F (most congested). The Highways Capacity Manual (HCM) provides the following levels of service definitions:

Table 77: Standards for Level of Service

Level of Service (LOS)	General Operating Conditions
A	Free flow
B	Reasonably free flow
C	Stable flow
D	Approaching unstable flow
E	Unstable flow
F	Forced or breakdown flow

Considering the importance of the highway, whereas Level of Service (LOS) 'B' is desirable and level of service up to LOS- 'C' may be acceptable.

8.3 Main Tunnel

A twin tube uni-directional tunnel has been proposed for connecting the northern part to the southern part of Bengaluru City. The project alignment starts from Hebbal Esteem Mall junction and terminates at Silk Board KSRP Junction.

Key Features: -

Table 78: Tube 1 – Hebbal to Silk Board

Total Length	16.690 Km
Length of Tunnel (TBM)	14.550 Km
Lane Configuration	3 Lanes
Diameter	Outer – 14.600m Inner – 13.500m
Carriageway width	10.500m
Walkway	0.700m
Crash Barrier	0.500m
Cut & Cover Section	At Hebbal – 950m At Silk Board – 600m
Open Cut Section	At Hebbal – 430m At Silk Board -160m

Table 79: Tube 2 – Hebbal to Silk Board

Total Length	16.678 Km
Length of Tunnel (TBM)	14.530 Km
Lane Configuration	3 Lanes
Diameter	Outer – 14.600m Inner – 13.500m
Carriageway width	10.500m
Walkway	0.700m
Crash Barrier	0.500m
Cut & Cover Section	At Hebbal – 970m At Silk Board -640m
Open Cut Section	At Hebbal – 430m At Silk Board -108m

For Bored Tunnels

Lining Type and Geometry

The finished inner diameter for the Underground Vehicular Tunnel is considered as 13.500m with a thickness of 550mm. Universal configuration of the segment is considered with 9+1 arrangement. The typical bored tunnel cross-section is shown in TCS-1 given later in the chapter along with their TCS Schedule.

Design Considerations

The segments shall be designed to ensure that the full design life of 100 years is achieved. The design method for the analysis of the bored tunnel linings shall be done considering the interaction between the lining and the ground, the deflection of the lining and the redistribution of the loading dependent upon the relative flexibility of the lining, the variability and the compressibility of the ground, with this, the design shall take into account all additional loads, stresses and strains imposed by or on to adjacent Existing Building Structure (EBS).

The Loads acting on the lining include earth pressure, water pressure, dead load, reactions, surcharge & seismic forces. The lining shall also be checked to resist the various loads arising due to handling, stacking, temporary grout load pressure, TBM thrust, Load on Bolts & erector, gasket forces etc.,

The pre-cast concrete linings are designed in accordance with IS 456 However other International Codes may be used in addition to the Indian Standard as and when required.

The Analysis methods, Material and design calculation is mentioned in Design Report which is submitted as Volume II-B

For NATM Tunnel

As per the General arrangement Drawings prepared , there are two types of NATM sections available. i.e., Regular Cross Section and Regular Cross Section (VCP) which are use for the project. The NATM Tunnel is presented as TCS-5 and their Schedules which are mentioned later in chapter.

Design Considerations

The Tunnel tube is proposed to be constructed according to New Austrian Tunnelling Method (NATM) excavation in different weathering grade of rock mass. Ground excavations require the use of structural supports, to establish equilibrium and to limit the displacements around the excavation and at surface. The tunnel will be supported with primary support for temporary condition and a cast in-situ concrete as a permanent support. Primary support design has been done by considering site ground condition. The design has been performed for the combination of different load cases analyzed in STAAD. The Analysis methods, Material and design calculation is mentioned in Design Report which is submitted as Volume II-B

Cut and Cover Section

The Cross Sections of C&C Structures (C&C section of 2 lane and 3 lane) will be used as described Typical Cross Sections as TCS-6 (3 lane Section) and TCS-03 (2 Lane section) which are presented later in chapter. C&C Structures will have side walls, Bottom Slab and top slab with Reinforced Concrete Structure in which Bottom Slab of 1.0 m thick (2-lane) & 1.2m thick (3-lane) will casted over 0.2 m thick PCC and Side wall of 1.0 m thick (2-lane) & 1.2m thick (3-lane) and top slab with 1.0 m thick (2-lane) & 1.2m thick (3-lane).

The Analysis methods, Material and design calculation are mentioned in Design Report which is submitted as Volume II-B

Open Cut Section

The following Cross Sections of RAMP Structures (Ramp section of 2 lane and 3 lane) will be used as described in TCS-02 (3 Lane) and TCS-04 (2 Lane) . RAMP Structures will have side walls and Bottom Slab with Reinforced Concrete Structure in which Bottom Slab of 1 m thick will be casted over 0.2 m thick PCC and Side wall of 1m with roofing C/W pipe truss and approved grade polycarbonate roofing sheets. For Ramp wall height more than 6.5m, a beam 0.6m X 0.6m Beam at 6m spacing has been proposed.

The Analysis methods, Material and design calculation is mentioned in Design Report which is submitted as Volume II-B.

8.4 Proposed Typical Cross Section

Typical cross section of the proposed section Main tunnel, Entry & Exit Ramps are as under:

Table 80: Proposed Typical Cross Section for Main Tunnel Tube 1 and Tube 2

Tube 1 : Hebbal to Silk Board (Left)						
SL No	Chainage		Length	TCS Type	TCS DETAILS	Lanes
	From	To				
1	0+000	0+430	430	open cut	TCS 2	3 Lane
2	0+430	1+380	950	cut and cover	TCS 6	3 Lane
3	1+380	15+930	14550	main TBM tunnel	TCS 1	3 Lane
4	15+930	16+530	600	cut and cover	TCS 6	3 Lane
5	16+530	16+690	160	open cut	TCS 2	3 Lane
Total Length			16690			

Tube 2 : Hebbal to Silk Board (Right)						
SL No	Chainage		Length	TCS Type	TCS DETAILS	Lanes
	From	To				
1	0+000	0+430	430	open cut	TCS 2	3 Lane
2	0+430	1+400	970	cut and cover	TCS 6	3 Lane
3	1+400	15+930	14530	main TBM tunnel	TCS 1	3 Lane
4	15+930	16+570	640	cut and cover	TCS 6	3 Lane
5	16+570	16+678	108	open cut	TCS 2	3 Lane
Total Length			16678			

Table 81: Entry/ Exit ramps at Hebbal Junction

Hebbal						
Entry Ramp 1 (Hebbal Service Road)						
SL No	Chainage		Length	TCS Type	TCS DETAILS	Lanes
	From	To				
1	0+000	0+170	170	TCS 4	Open Cut	2 Lane
2	0+170	0+360	190	TCS 3	Cut & Cover	2 Lane
Total Length			360			
Entry Ramp 2 (From ORR To Main Tunnel (km 1.300) Towards Silk Board/ Sarjapur road)						
SL No	Chainage		Length	TCS Type	TCS DETAILS	Lanes
	From	To				
1	0+000	0+600	600	Cut & Cover	TCS 3	2 Lane
2	0+600	814	214	Open Cut	TCS 4	2 Lane
Total Length			814			
Exit Ramp 8 (Hebbal Service Road)						
SL No	Chainage		Length	TCS Type	TCS DETAILS	Lanes
	From	To				
1	0+000	0+450	450	TCS 4	Open Cut	2 Lane
2	0+450	0+700	250	TCS 3	Cut & Cover	2 Lane
Total Length			700			
Exit Ramp 7 (From Main Tunnel (km 1.300) To ORR Towards ORR (Outer Ring Road))						
SL No	Chainage		Length	TCS Type	TCS DETAILS	Lanes
	From	To				
1	0+000	0+300	300	Cut & Cover	TCS 3	2 Lane
2	0+300	400	100	Open Cut	TCS 4	2 Lane
Total Length			400			

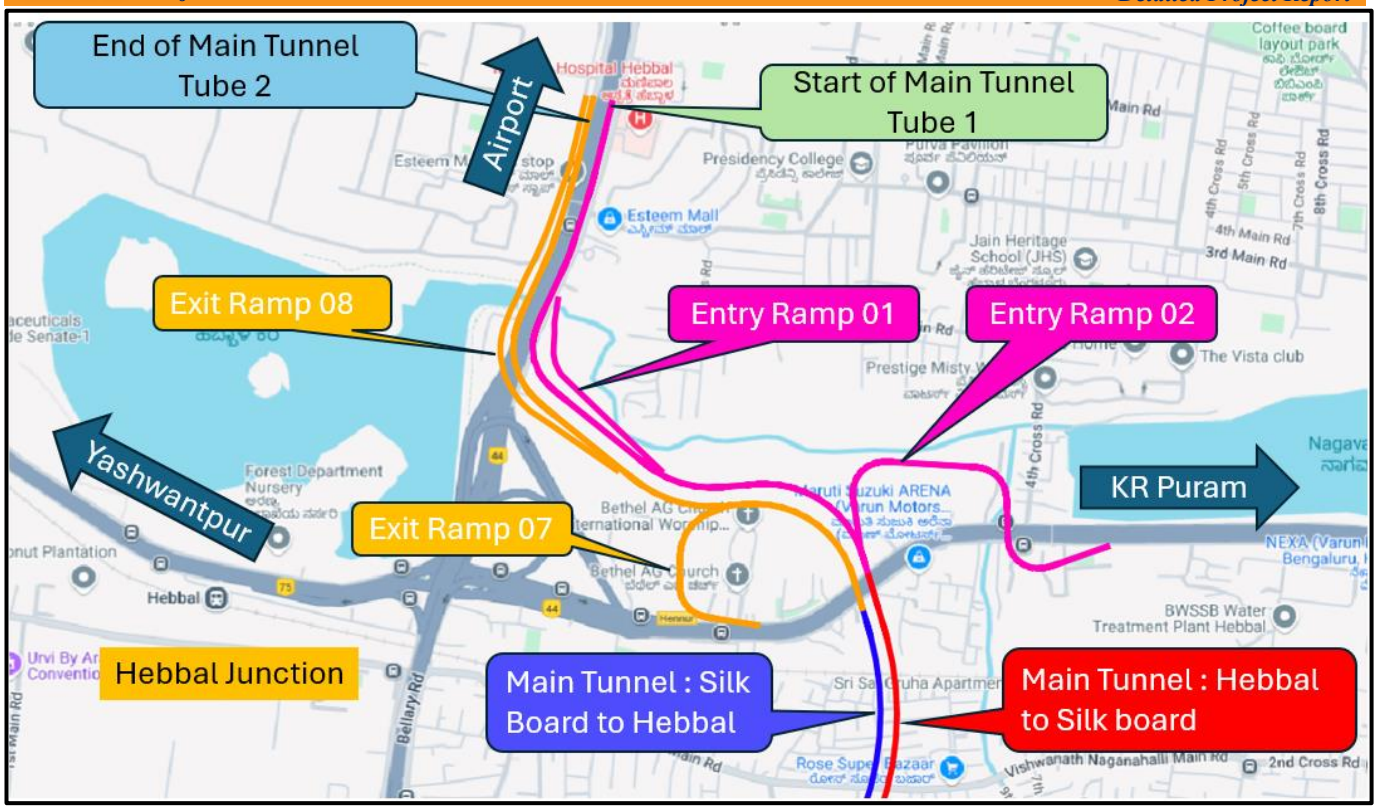


Figure 82: Entry and Exit Ramps at Hebbal Junction

Table 82: Entry/ Exit ramps at Palace Ground

Palace Ground						
Entry Ramp 03 (From Jaya Mahal Road)						
SL No	**Chainage**		**Length**	**TCS Type**	**TCS DETAILS**	**Lanes**
	From	**To**				
1	0+000	0+170	170	Open Cut	TCS 2	3 Lane
2	0+170	0+360	190	Cut & Cover	TCS 6	3 Lane
3	0+360	1+255	895	NATM Tunnel	TCS 5	2 Lane
Total Length			**1255**			
Entry Ramp 4 (From CV Raman Road To Main Tunnel (km 4.700) Towards Hebbal)						
SL No	**Chainage**		**Length**	**TCS Type**	**TCS DETAILS**	**Lanes**
	From	**To**				
1	0+000	1+320	1320	NATM Tunnel	TCS 5	2 Lane
Total Length			**1320**			
Exit Ramp 06 (Towards C V Raman Road)						
SL No	**Chainage**		**Length**	**TCS Type**	**TCS DETAILS**	**Lanes**
	From	**To**				
1	1+320	0+000	1320	NATM Tunnel	TCS 5	2 Lane
2	1+320	1+610	290	Cut & Cover	TCS 6	3 Lane
3	1+610	1+910	300	Open Cut	TCS 2	3 Lane
Total Length			**1910**			
Exit Ramp 5 (From Main Tunnel (km 4.450) To Jaymahal Road Towards Jaymahal Road)						
SL No	**Chainage**		**Length**	**TCS Type**	**TCS DETAILS**	**Lanes**
	From	**To**				
1	0+360	1+323	963	NATM Tunnel	TCS 5	2 Lane
Total Length			**963**			

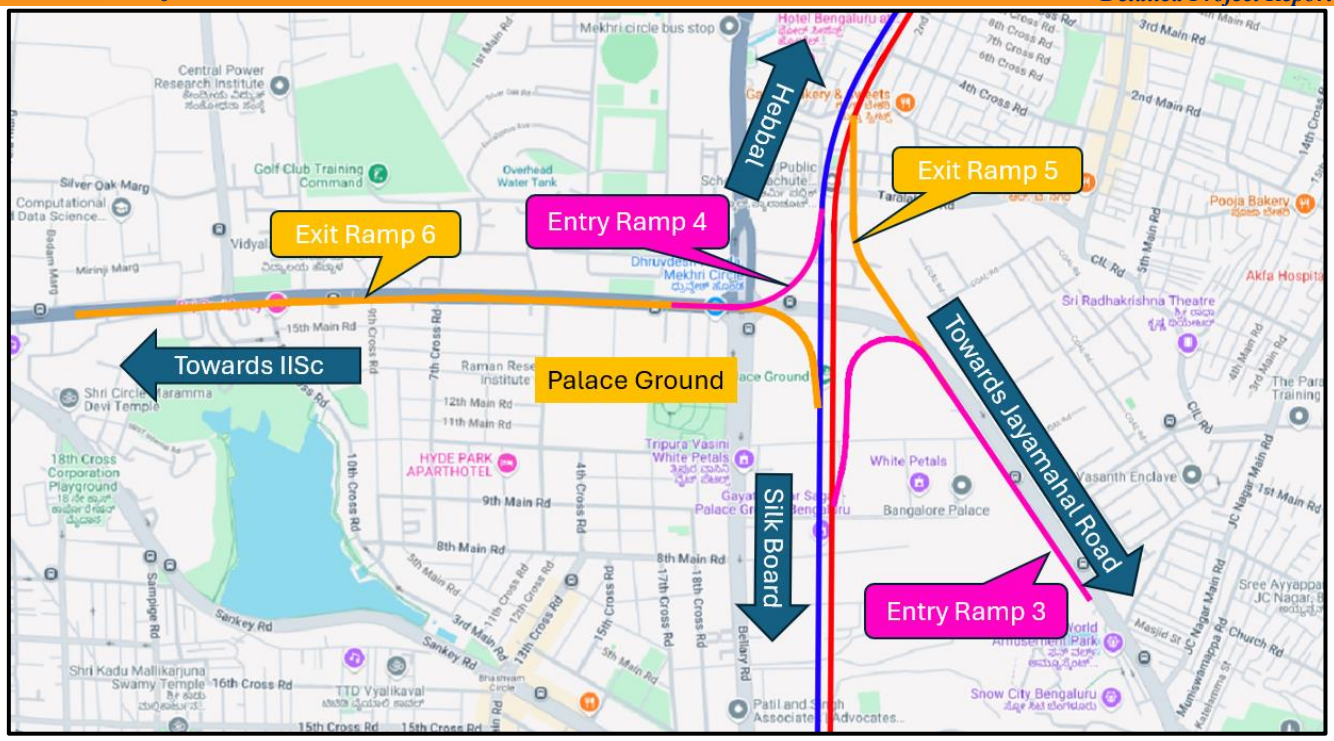


Figure 83: Entry and Exit Ramps at Palace Ground

Table 83: Entry/ Exit ramps at Race Course:

Race Course						
Entry Ramp 5 (From Palace Road towards Hebbal)						
SL No	**Chainage**		**Length**	**TCS Type**	**TCS DETAILS**	**Lanes**
	From	**To**				
1	0+960	1+550	590	Cut & Cover	TCS 3	2 Lane
2	1+550	2347	797	NATM Tunnel	TCS 5	2 Lane
Total Length			**1387**			
Entry Ramp 6 (From Palace Road towards Silk Board)						
SL No	**Chainage**		**Length**	**TCS Type**	**TCS DETAILS**	**Lanes**
	From	**To**				
1	0+000	0+230	230	Open Cut	TCS 2	2 lane
2	0+230	0+960	730	Cut & Cover	TCS 6	3 Lane
3	0+960	1+100	140	Cut & Cover	TCS 3	2 Lane
4	1+100	1+906	806	NATM Tunnel	TCS 5	2 Lane
Total Length			**1906**			
Exit Ramp 4 (On Seshadri Road towards K R Circle from Hebbal)						
SL No	**Chainage**		**Length**	**TCS Type**	**TCS DETAILS**	**Lanes**
	From	**To**				
1	0+000	0+830	830	NATM Tunnel	TCS 5	2 Lane
2	0+830	1+060	230	Cut & Cover	TCS 3	2 Lane
3	1+060	1+376	316	Open Cut	TCS 4	2 Lane
Total Length			**1376**			
Exit Ramp 3 (On Race Course Road towards Chalukya Circle from Silk Board)						
SL No	**Chainage**		**Length**	**TCS Type**	**TCS DETAILS**	**Lanes**
	From	**To**				
1	0+000	0+880	880	NATM Tunnel	TCS 5	2 Lane
2	0+880	1+530	650	Cut & Cover	TCS 3	2 Lane
3	1+530	1+864	334	Open Cut	TCS 4	2 Lane
Total Length			**1864**			

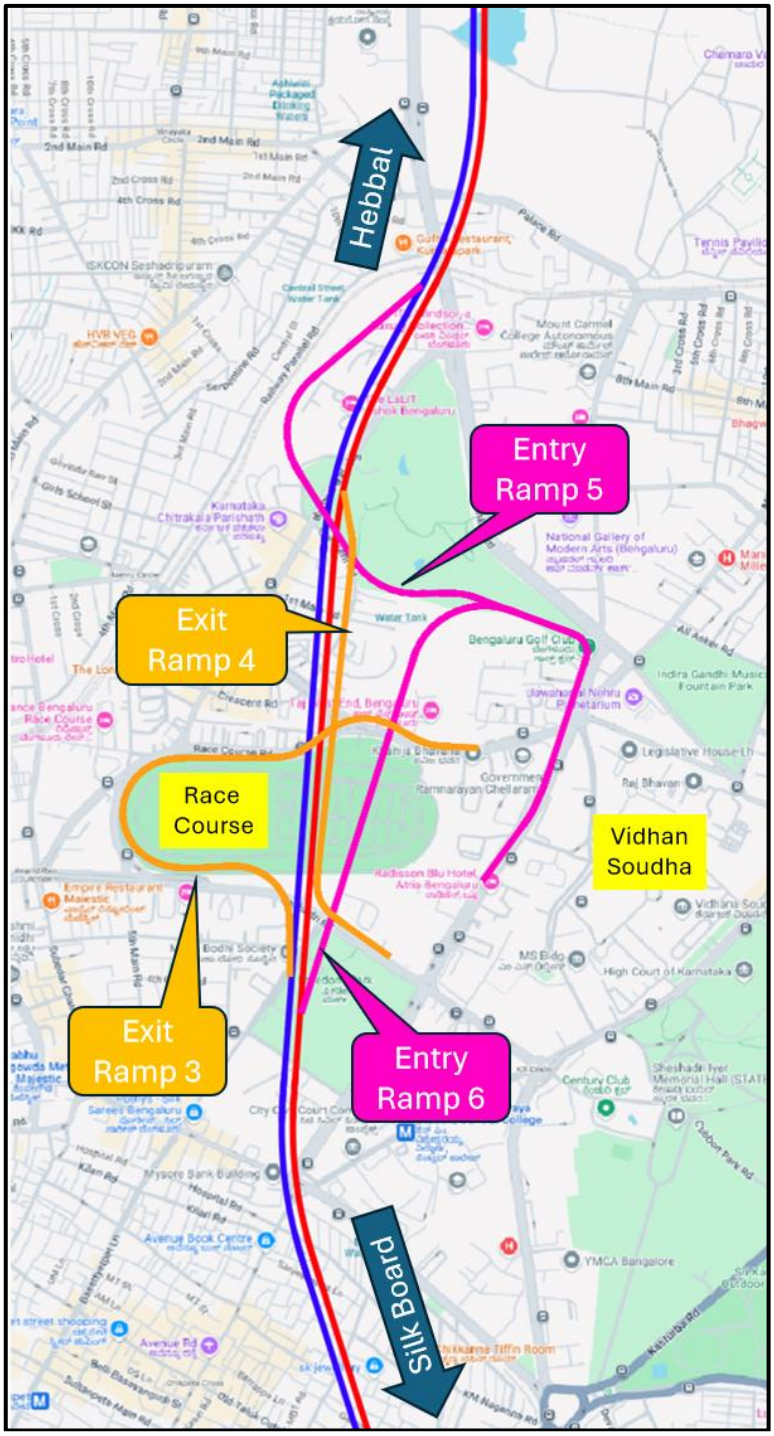


Figure 84: Entry and Exit Ramps at Racecourse

Table 84: Entry/ Exit ramps at Lal Bagh

Lal Bagh						
Entry Ramp 7 (From Siddapura Road near Ashok Pillar)						
SL No	Chainage		Length	TCS Type	TCS DETAILS	Lanes
	From	To				
1	0+000	0+150	150	Open Cut	TCS 4	2 Lane
2	0+150	0+470	320	Cut & Cover	TCS 3	2 Lane
3	0+470	1+416	946	NATM Tunnel	TCS 5	2 Lane
Total Length			1416			

Exit Ramp 2 (Towards Siddapura Road near Wilson Garden)						
SL No	**Chainage**		**Length**	**TCS Type**	**TCS DETAILS**	**Lanes**
	From	**To**				
1	0+000	0+870	870	NATM Tunnel	TCS 5	2 Lane
2	0+870	0+930	60	Cut & Cover	TCS 3	2 Lane
3	0+930	1+073	143	Open Cut	TCS 4	2 Lane
Total Length			**1073**			

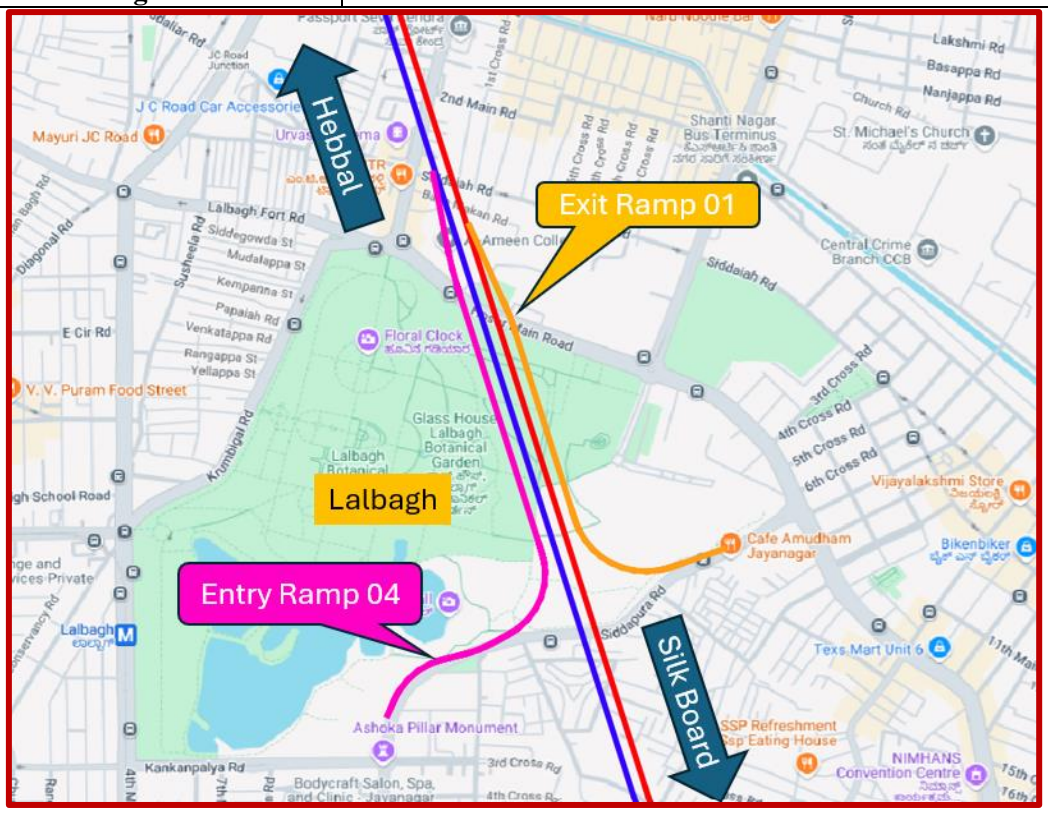


Figure 85: Entry and Exit ramp at Lalbagh

Table 85: Entry/ Exit ramps at Silk Board

Silk board						
Entry Ramp 8 (From Sarjapur Road)						
SL No	**Chainage**		**Length**	**TCS Type**	**TCS DETAILS**	**Lanes**
	From	**To**				
1	0+000	0+400	400	TCS 3	Cut & Cover	2 Lane
2	0+400	0+663	263	TCS 4	Open Cut	2 Lane
Total Length			**663**			
Exit Ramp 1 (Towards Sarjapur Road)						
SL No	**Chainage**		**Length**	**TCS Type**	**TCS DETAILS**	**Lanes**
	From	**To**				
1	0+000	0+240	240	TCS 3	Cut & Cover	2 Lane
2	0+240	0+454	214	TCS 4	Open Cut	2 Lane
Total Length			**454**			

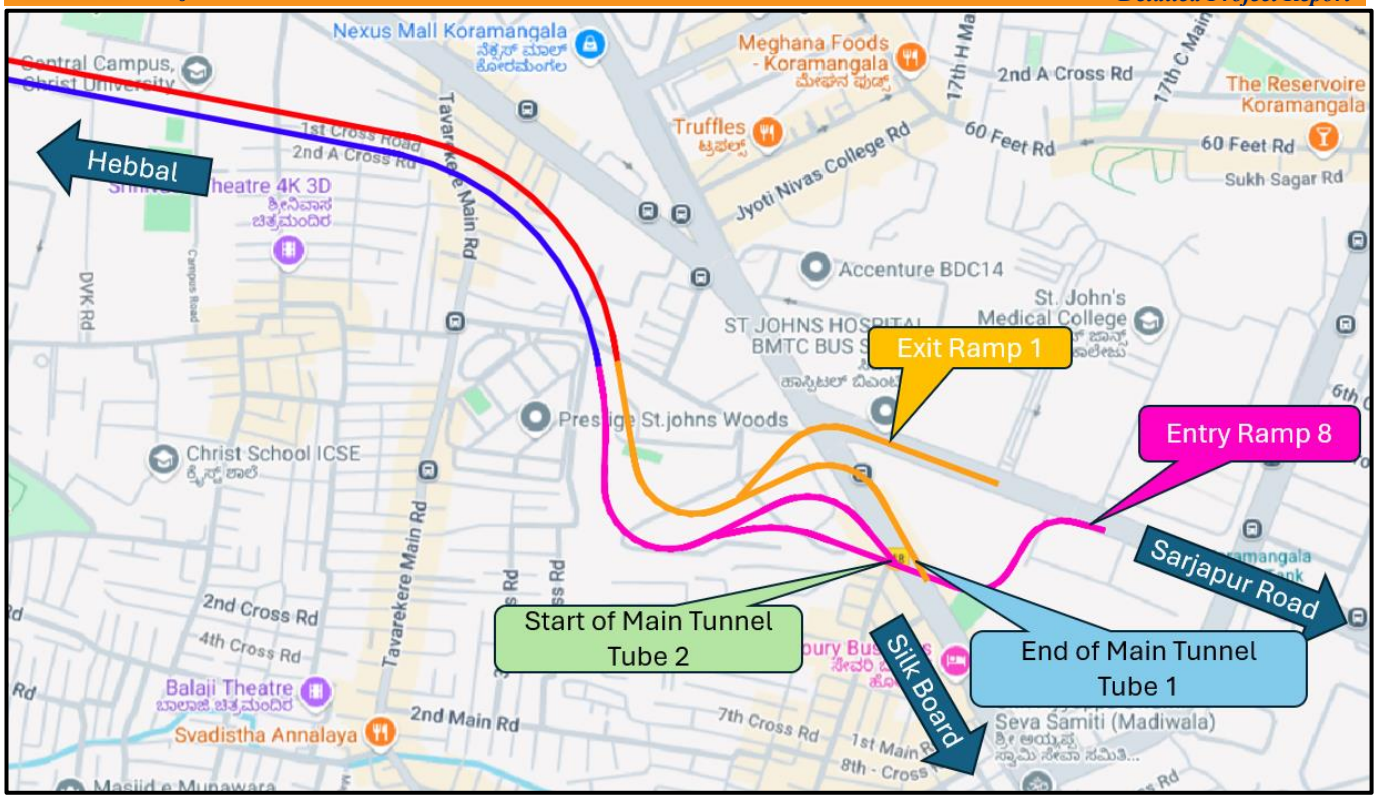


Figure 86: Entry and Exit ramp at Silk board

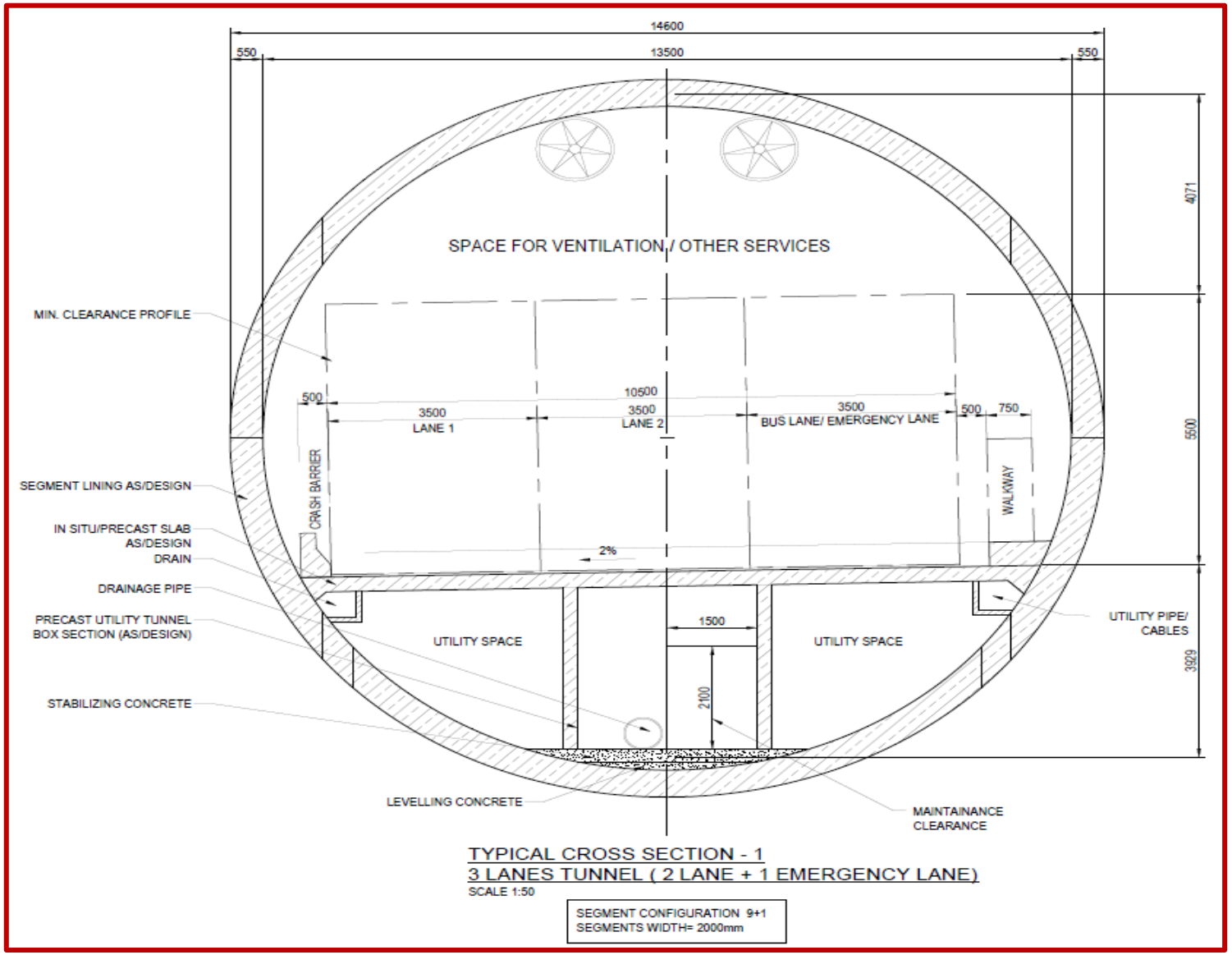


Figure 87: TCS-1, TBM Tunnel Cross-Section

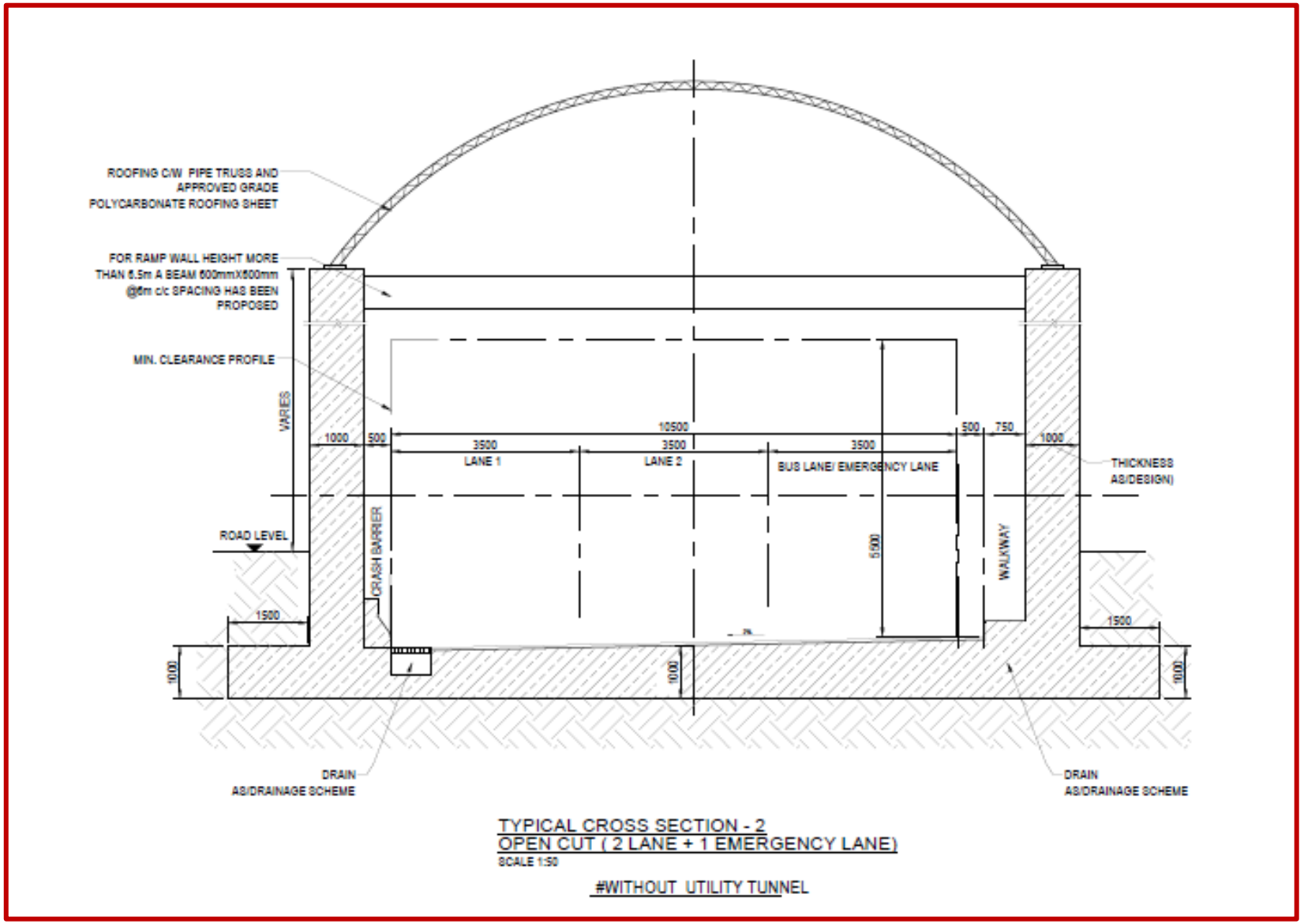


Figure 88: TCS-2, 3 lane Open Cut Section

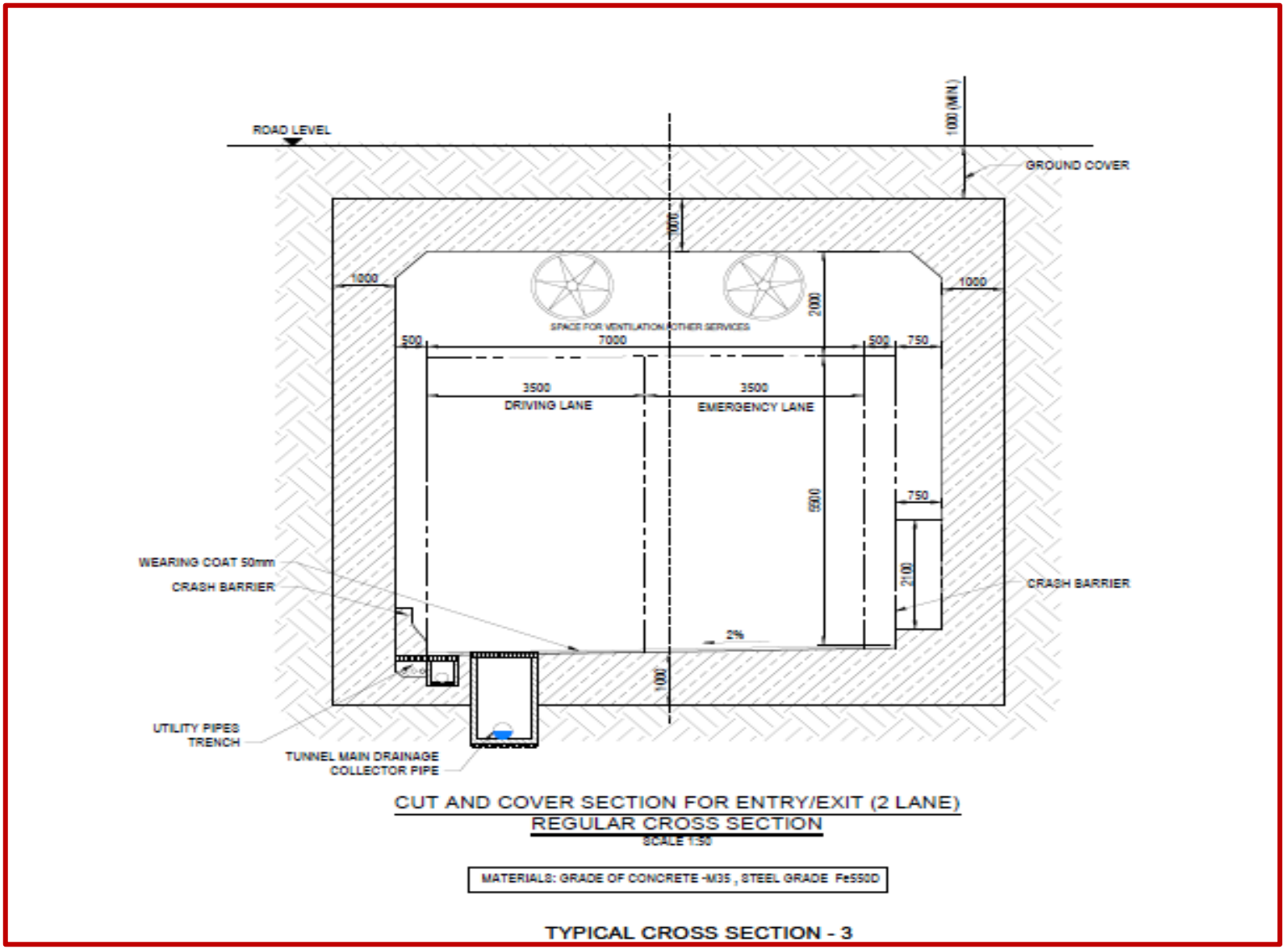


Figure 89: TCS-3, 2 lane Cut & Cover Section

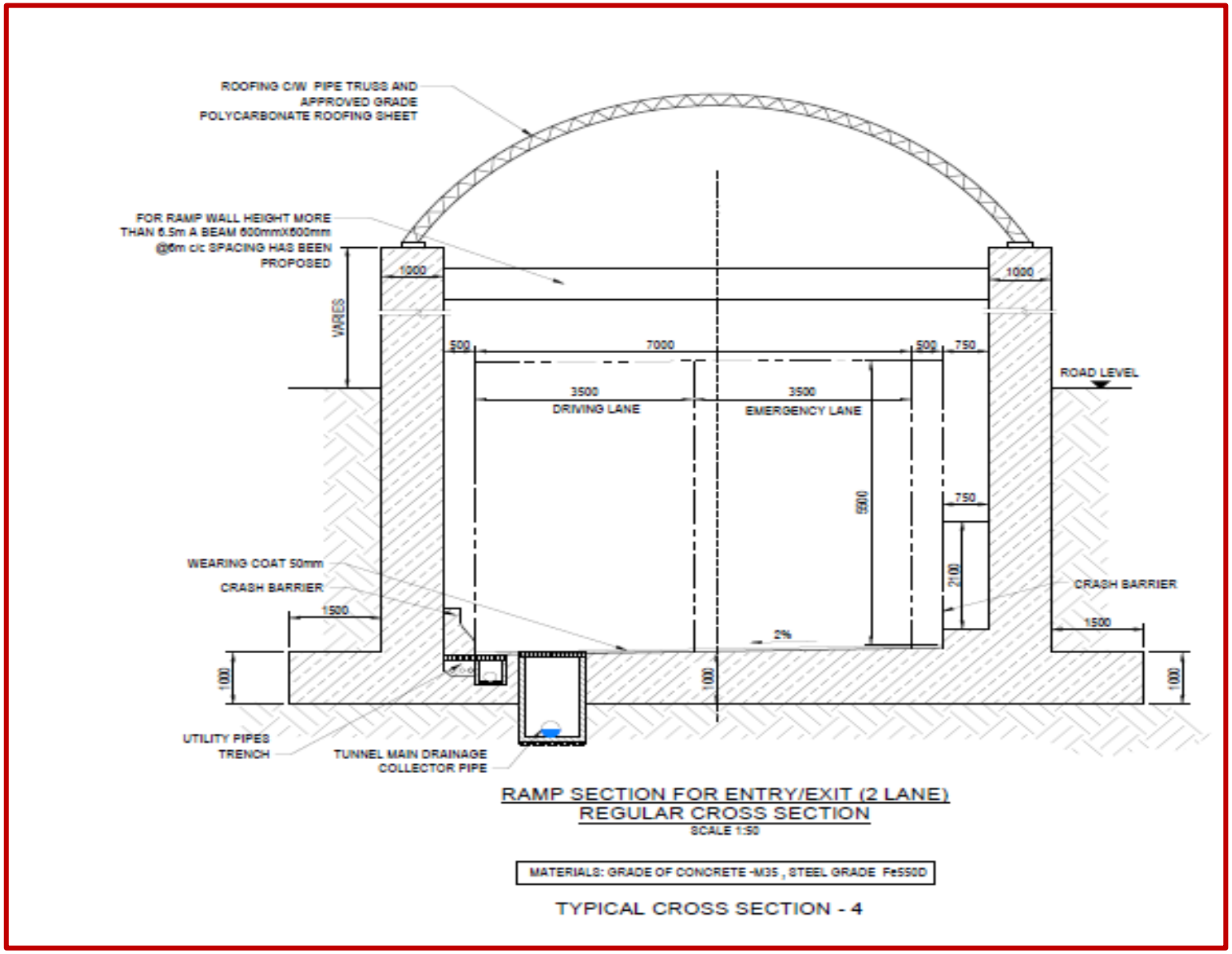


Figure 90: TCS-4, 2 lane Open Cut Section

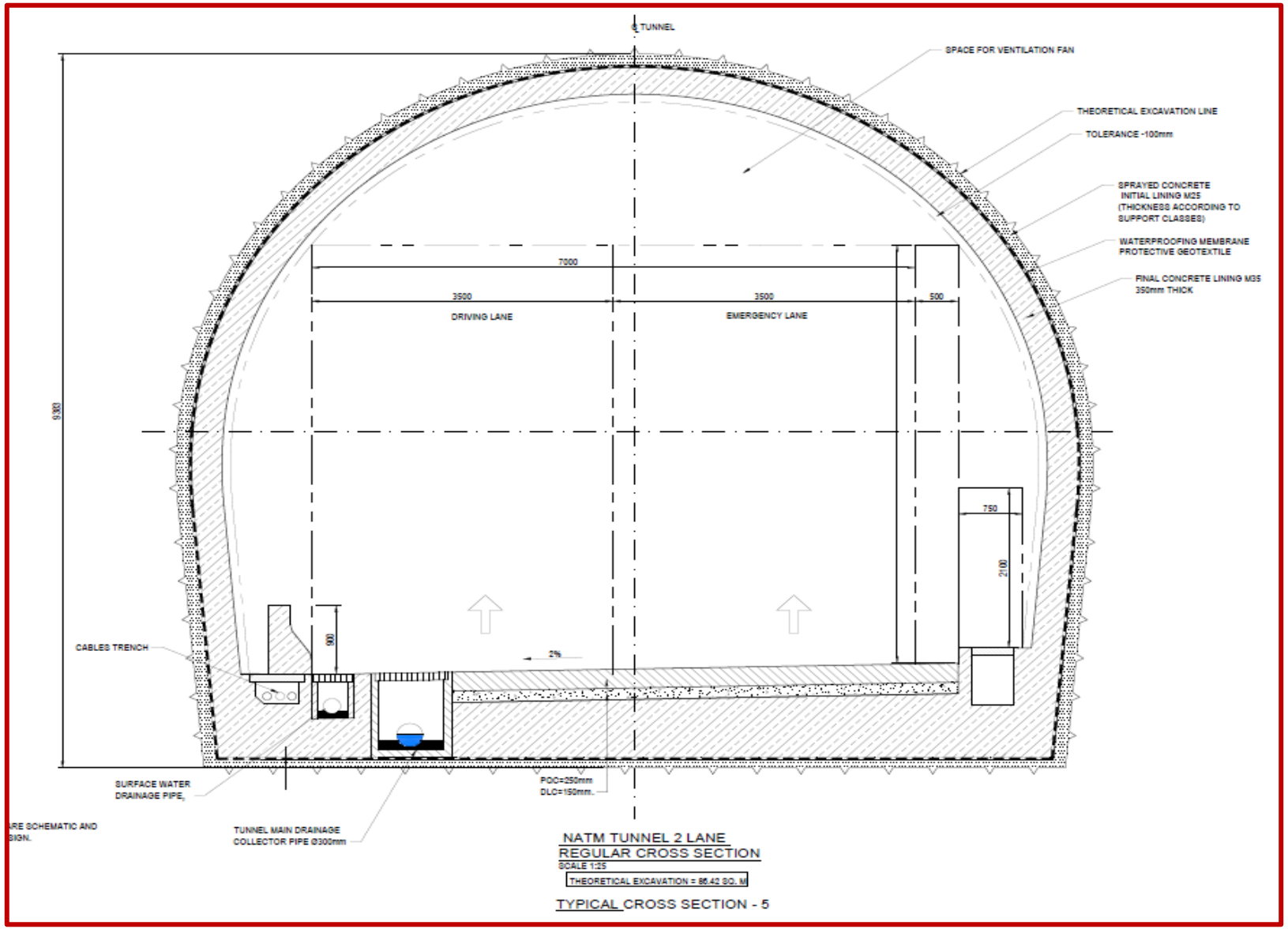


Figure 91: TCS-5, 2 lane NATM Tunnel Section

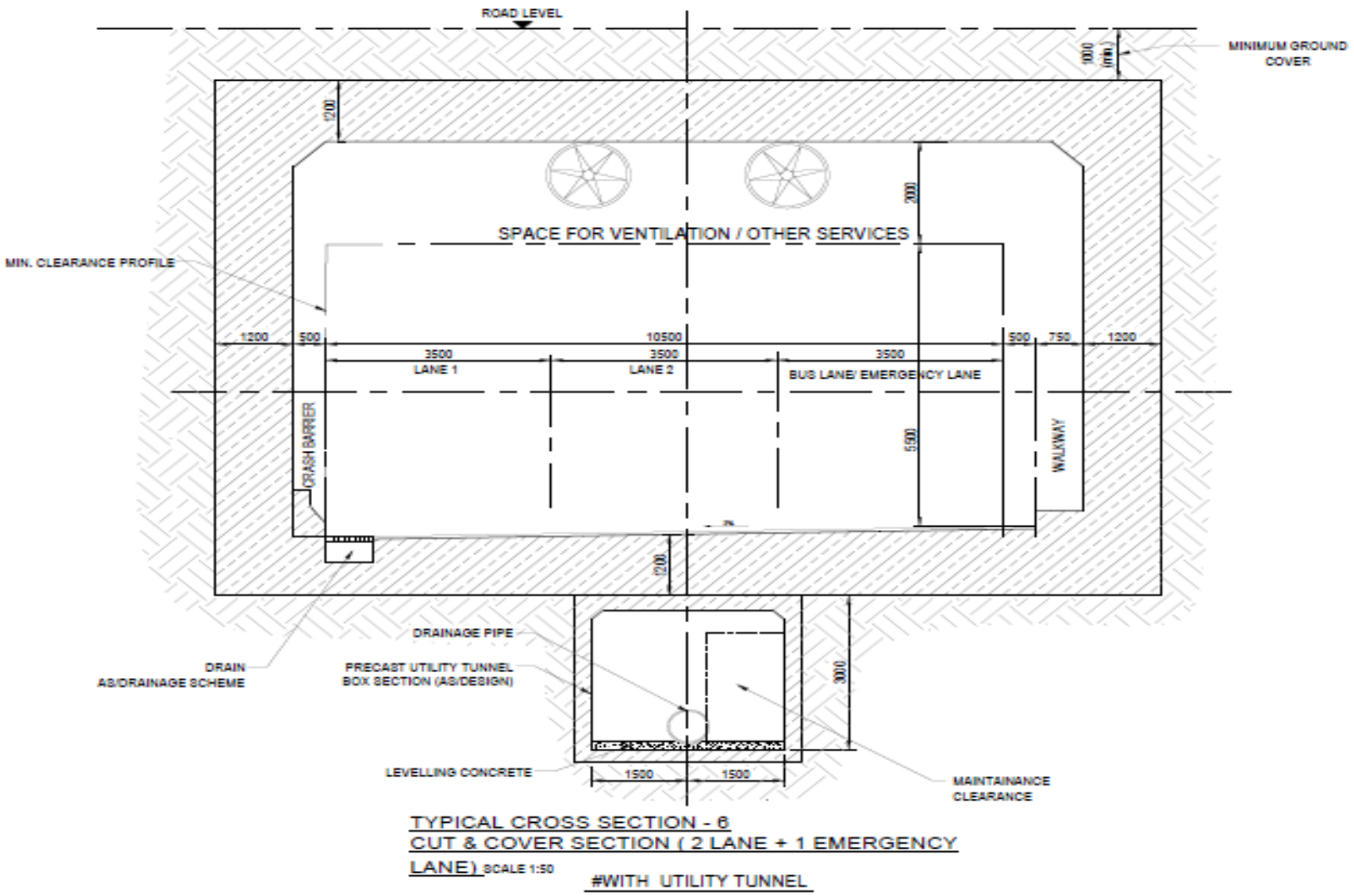


Figure 92: TCS-6, 3 lane Cut & Cover Section

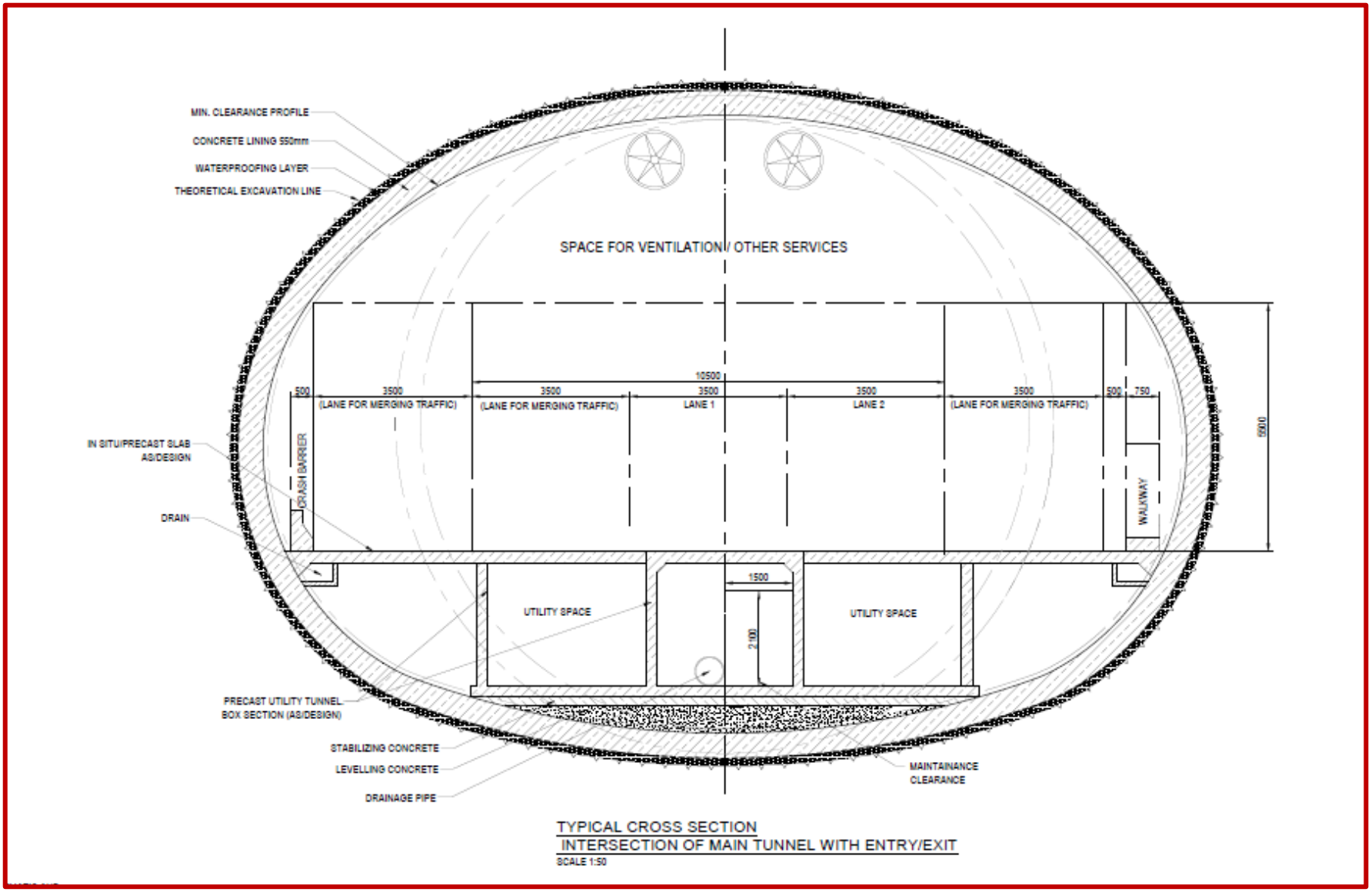


Figure 93: Typical Cross Section for merger section of Entry/ Exit Ramps & Main Tunnel

8.5 Tunnel spacing

The clear distance between the twin tubes shall be kept depending upon the type of strata and structural stability of the tunnel subject. Adopted tunnel spacing is two times of diameter size.

8.6 Tunnel Passage

The twin tube tunnels shall be connected by a cross passage to facilitate diversion of the traffic from one tube to other tube in the event of an incident/accident in one of the tubes at a spacing of 500 m. The cross passage shall have provision for one traffic lane, edge strip of 0.60 m, crash barriers and walkways on either side. In normal conditions the cross passage shall be barricaded.

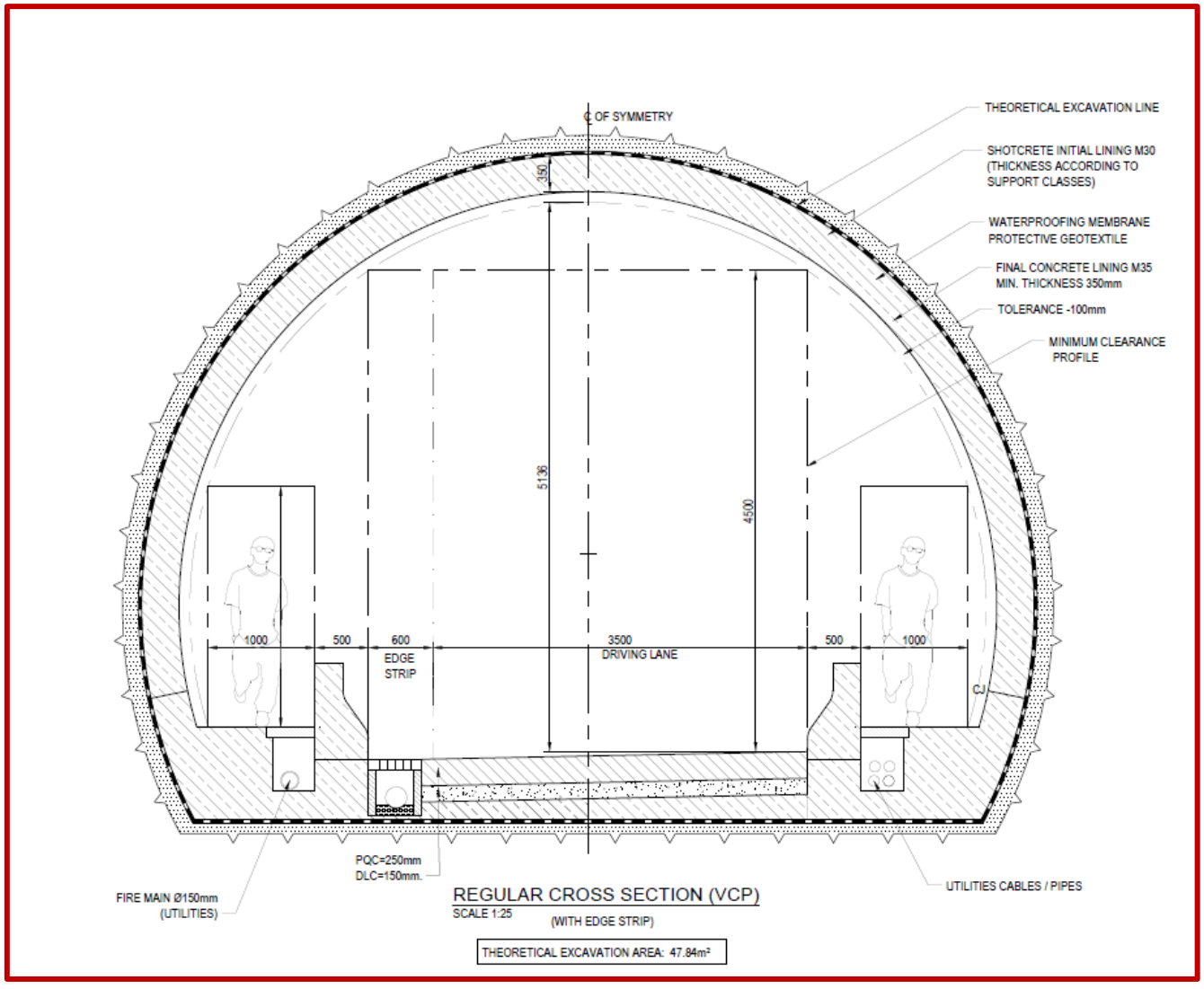


Figure 94: TCS for Tunnel Cross Passage

8.7 Vertical Shaft

A vertical shaft for a tunnel is a critical infrastructure component that connects the surface to underground passageways, serving multiple essential functions. Primarily, it provides access for workers and equipment, enabling the efficient movement of personnel and materials to and from the tunnel. Additionally, these shafts play a vital role in ventilation, ensuring a continuous flow of fresh air to maintain safe working conditions below ground. The design of a vertical shaft typically considers factors such as depth, diameter, and structural integrity, often employing methods like drilling and blasting or cut-and-cover techniques for construction. Safety is paramount, with rigorous monitoring for ground stability and water ingress, as well

as clear emergency egress routes for personnel. Overall, vertical shafts are indispensable in facilitating safe and efficient underground operations in tunneling projects.

Vertical Shafts has been provided at five locations i.e., Hebbal, Palace Ground, Race Course, Lalbagh and Silk Board. Dimensions of Vertical shafts are 100m x 50m.

8.8 Traffic Control and Safety Measures

Road Marking & Traffic Signs

Road markings will be made for centre and edge lines using reflective thermoplastic paints. Appropriate road markings will also be provided at junctions and crossings. Road signs are to placed according to IRC: 67-2012. The signs are to be placed on embankment so that extreme edge of sign would be 2.0 m away from the edge of the carriageway. The location of each sign is to be decided in accordance with the guidelines there in.

Illumination

Tunnel illumination/lighting shall be designed and provided as per MoRTH Guidelines for

Expressway, Chapter 13.5 for Tunnel Lighting.

Tunnel Furnishing

Provisions shall be made for installation of tunnel furnishing such as sign boards, firefighting arrangements, cable trays for telephone and power lines etc. in consultation with relevant local authorities.

Signages and Carriageway Markings

Variable messages signs inside the tunnel shall be provided for the information of traffic of lane blockage/closure due to incidents related to vehicles/non-vehicles, weather and human hazards etc. or maintenance operations as also to warn of possible hazard ahead due to any abnormal situation. Signage system shall be complemented by providing traffic lights above each lane at the entry portal end and inside. Signages indicating distance travelled, distance/ direction to an exit on evacuation route shall be provided inside the tunnel.

Tunnel carriageway markings consisting of a discontinuous line separating the traffic lanes and continuous line separating the lateral traffic lane from the paved shoulder and emergency lay-bye shall have good day/night visibility and conform to IRC:35. The markings shall be done by means of self-propelled machine which has a satisfactory cut-off capable of applying broken line automatically.

Ventilation

Tunnel ventilation systems should provide adequate in-tunnel air quality during normal and congested traffic operations and support the self-evacuation and rescue efforts during emergency incidents. Separately, the tunnel ventilation capacity requirements for emergency ventilation (typically for the control of smoke and hot gases during fire) must also be assessed and the system designed accordingly.

Detailed design of ventilation shall be carried out as per IRC:SP:91 keeping in view the length, shape, size, tunnel environs and complexion of the likely traffic for which tunnel has been designed. The details of design of Tunnel Ventilation system has been given in Volume II-D.

8.9 Inter Model Interchange Hubs

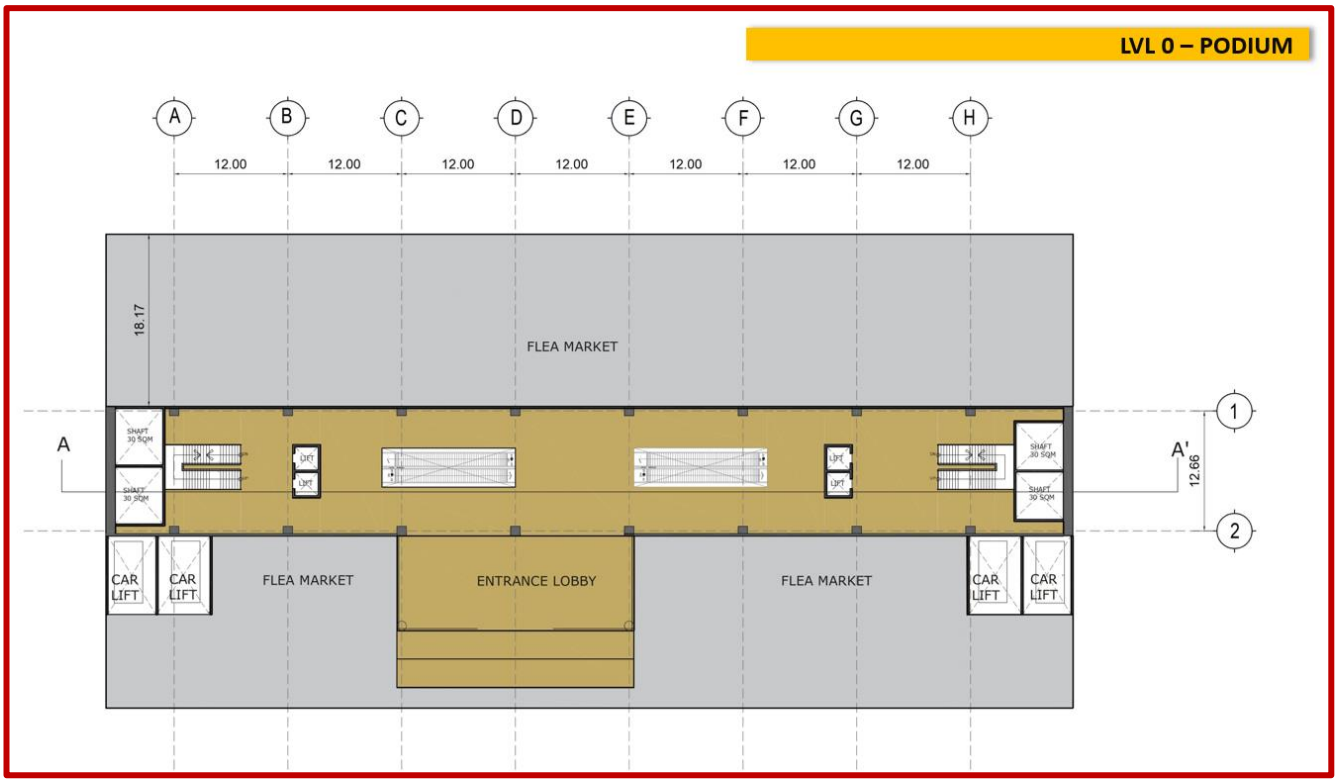
Intermodal interchange hubs for buses in tunnels are specialized facilities designed to facilitate the efficient transfer of passengers between different modes of transportation, particularly in urban settings where space is limited. The Hubs are designed to accommodate bus services alongside other transport modes, such as metros and public transport. Interchange hubs have well-planned layouts to ensure smooth passenger

movement, minimizing congestion and wait times. Features may include escalators, elevators, and clear signage. Intermodal interchange hubs for buses in tunnels are essential for enhancing urban transit efficiency, safety, and sustainability, ultimately improving the passenger experience and contributing to a more effective transportation network.

Following are the guiding principles for designing of intermodal interchange:

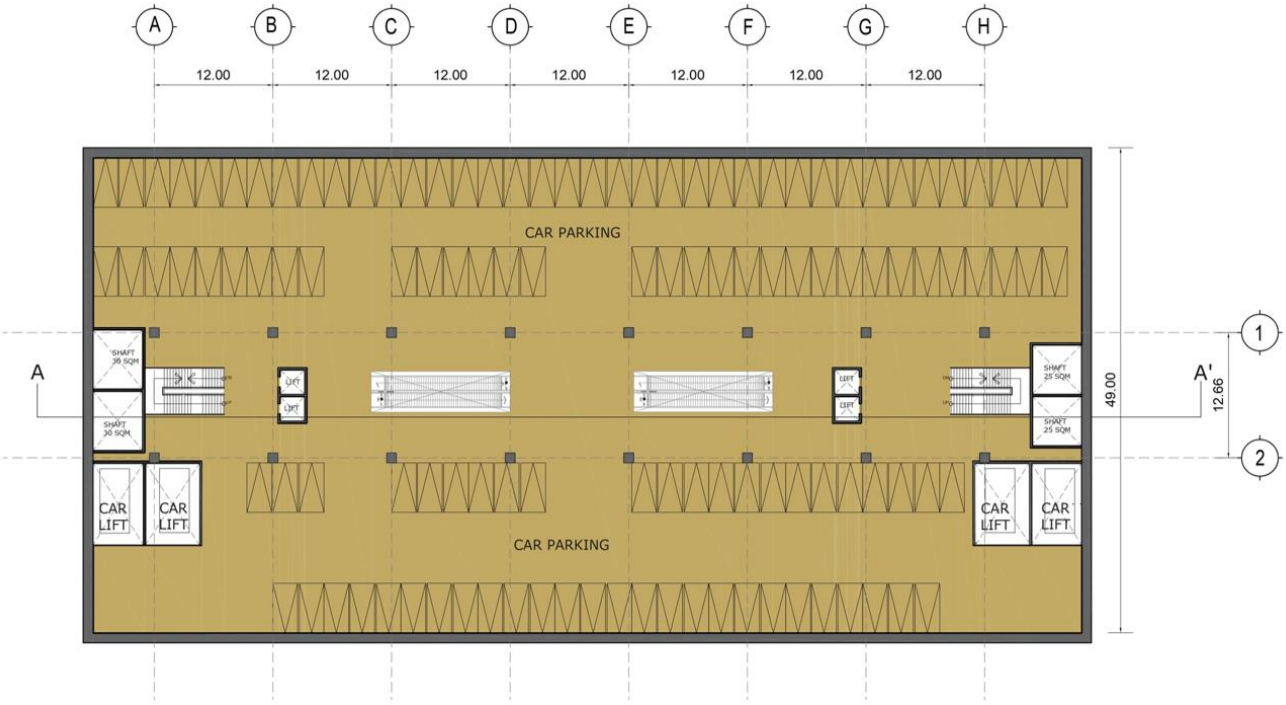
1. **Safety and Accessibility:** Ensure the station is safe and easily accessible for all passengers. This includes designing clear and simple navigation, providing adequate lighting and signage, and incorporating safety features such as emergency exits, fire alarms, and CCTV surveillance.
2. **Efficient Passenger Flow:** Design the station to facilitate efficient passenger flow and minimize congestion. This can be achieved by providing sufficient platform width, designing clear and intuitive routes for passengers, and incorporating features such as escalators, staircases, and elevators to facilitate easy movement between levels.
3. **Comfort and Amenities:** Create a comfortable and welcoming environment for passengers by incorporating amenities such as comfortable seating, clean and well-maintained facilities, and convenient services like Wi-Fi, charging stations, and retail outlets.
4. **Sustainability and Resilience:** Design the station with sustainability and resilience in mind. This includes incorporating energy-efficient systems, using durable and low-maintenance materials, and designing the station to withstand natural disasters and other potential disruptions.
5. **Aesthetic Appeal and Community Integration:** Create a visually appealing and unique design that reflects the local community and culture. This can be achieved by incorporating public art, using locally inspired materials and design elements, and designing the station to integrate seamlessly with the surrounding neighbourhood.

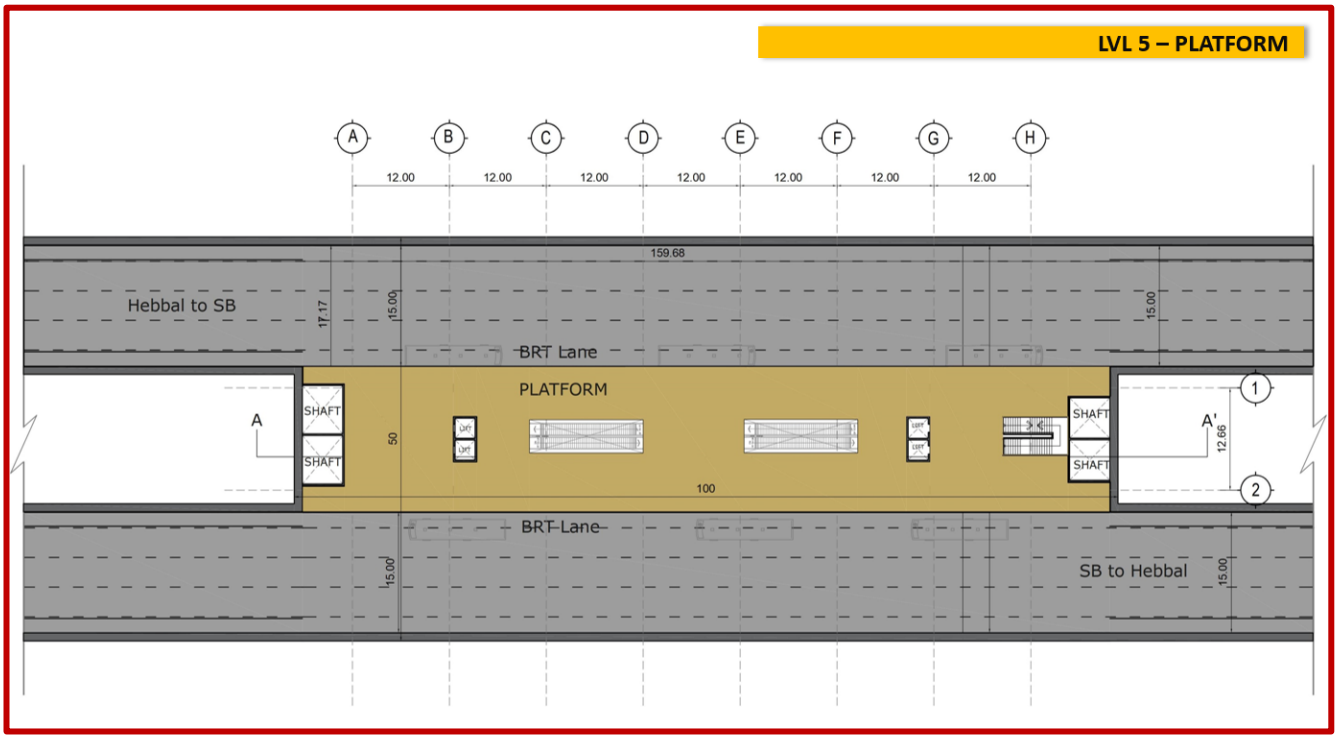
Conceptual layouts for Inter Model Interchange Hubs

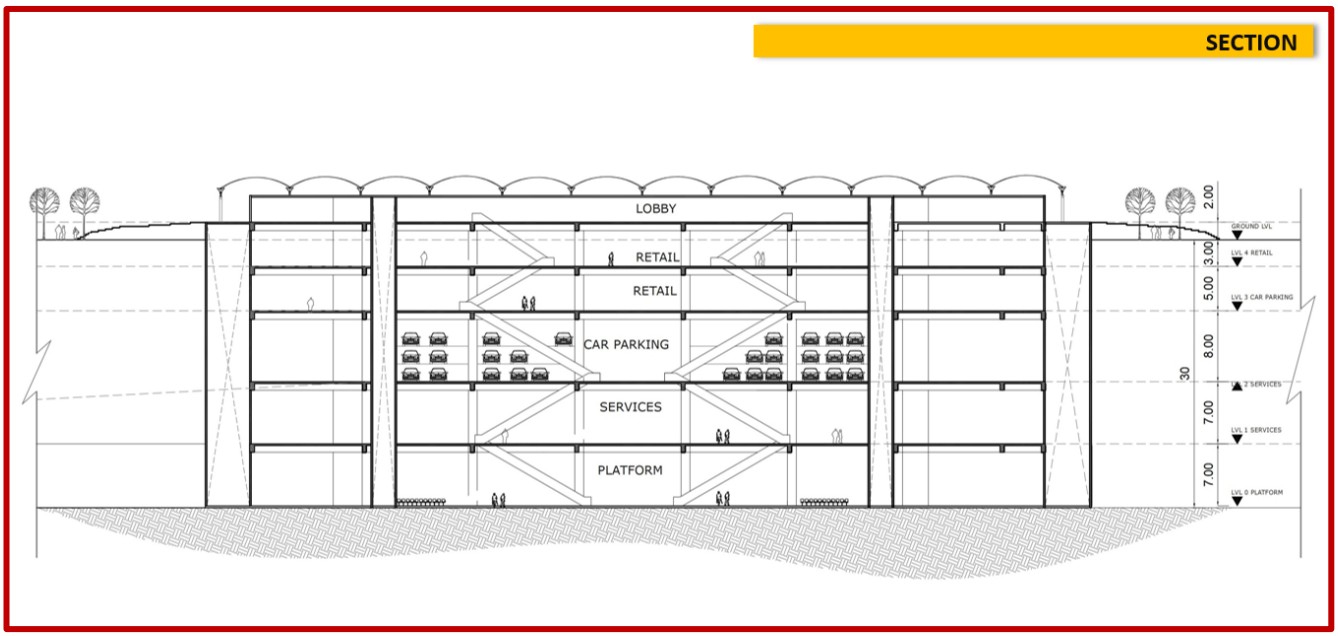


LVL 1&2 – RETAIL

LVL 3 – CAR PARKING







Bi-articulated trolleybus

A trolley bus is an electric bus that operates by drawing power from overhead wires using two trolley poles, allowing it to move without the need for traditional fuel sources like diesel. This mode of transportation is characterized by its quiet operation and reduced emissions, making it an environmentally friendly option for urban transit.

A bi-articulated trolleybus is a type of articulated bus with two trailer sections instead of one. They are designed to transport large numbers of passengers

CHAPTER 9
COST ESTIMATION

CHAPTER 9: COST ESTIMATION

9.1 General

Cost estimation is an important component of the study as it provides vital input & financial evaluation and insights for proper planning of project execution. Over and above construction costs, provision has been made for land acquisition social and environmental mitigation measures. Cost Estimates are done based on the detailed engineering designs and detailed drawings presented in drawing volume.

9.2 Methodology

The cost of the tunnel, cut & cover and open cover sections has been worked out based on the cross-sections and the plan and other drawings for the project.

Tentative preliminary locations for TBM lowering shaft have been identified and suitably quantified for the cost estimation. The quantification of various items of work related to tunnels have been detailed out from the structural drawings.

Quantities of traffic signs, marking and other road appurtenances and various project facilities are worked out in the plan drawing and costing has been accordingly.

9.3 Unite Rates of Materials

The Rates of materials for different components of project is referred from the government issued data and prevailing market rates.

- SOR 2023-24 Karnataka for Zone 1
- Some rates have been taken from similar referral projects and market rates.
- Rate of special components such as TBM, Tunnel Ventilation and firefighting systems, Lighting and electrical components are taken from market.
- For the Control centre Building rates has been taken from Delhi Schedule of Rate 2023.
- MoRTH Standard Data book 2019.
- Electromechanical works in tunnel section has been takes as 8% of total tunnel cost.
- The Cost of High Capacity and high-speed buses with driving and trailing coaches (Neo Bus System) has been taken from other reference projects.
- GPS/GNSS Toll Rates have been taken from market.
- The cost of Tunnel Boring Machines has been based on inquiry from Herrenknecht AG. Six number TBM have been considered and 50% buy back cost has been considered at the end of the project.
- A lead of 45 Km has been considered for muck disposal and concrete/ precast concrete items.

9.4 Labour Rate

As per the Schedule of Rates, the labour wages as fixed by the State Government are to be taken for that area. Accordingly, the labour rate of Karnataka, Schedule of Rates-2023-24.

9.5 Plant and Machinery Rate

Plant and Machinery Rate has been considered from MoRT&H Standard Data Book 2019 for Analysis of Rates and have been escalated to 2024 on Wholesale price index basis. Where the rates of plant and machinery are not available in MoRT&H Standard Data Book and Karnataka Schedules of rate, market rates have been adopted.

9.6 Overhead, Contractor's Profit and Other components

The rates of materials, labour and Plant & Machinery derived as per above were used for analysis of items rate. Overheads charges for Road Tunnel Works has been considered for this project as per MoRT&H Standard Data Book @ 25% for large projects having cost more than Rs. 1000 crores.

- Contractor profit @ 10% is adopted.
- GST @ 18% on Construction Cost.
- Contingencies @ 1 % on Construction cost.
- Supervision charges of 2% on Construction cost.

9.7 Summary of Cost Estimate

The project cost summary is mentioned below.

S.No	Description	Length (km)	Rate	Total Amount in Rs.	Total Amount (Rs. in Crores)
BILL NO. 1	Site Clearance			78,89,328.33	0.79
BILL NO. 2	Earth Works			63,05,013.00	0.63
	Sub Total (Bill-1+Bill-2)			**1,41,94,341.33**	**1.42**
BILL NO. 3	**Tunnel Work**				
A	Main Tunnel				
a.	Tunnelling By TBM (Twin Tunnel)	14.54	415.70	60,44,26,70,696.60	6,044.27
b.	Cross Passages (27 No's)			28,88,85,247.22	28.89
c.	Cut And Cover Tunnel	4.08	238.96	9,74,95,68,000.00	974.96
d.	Open Cut (Ramps)	1.53	77.03	1,17,70,18,400.00	117.70
e.	Shafts (5 No's)			2,65,53,79,134.97	265.54
f.	Buildings (Control Center)			15,44,08,200.00	15.44
B	Intermediate Entry/Exit				
a.	Open Cut (Ramps)	3.67	72.77	2,67,35,69,800.00	267.36
b.	Cut And Cover Tunnel	4.26	219.46	9,34,89,96,000.00	934.90
c.	NATM Tunnel	8.61	87.02	7,48,98,11,400.00	748.98
C	**Sub Total Cost Of Tunnel Works(A+B)**			**93,98,03,06,878.80**	**9,398.03**
D	Electro- Mechanical Works @ 8% Of C			7,51,84,24,550.30	751.84
E	Tunnel Ventilation & Fire Fighting			4,84,73,00,000.00	484.73
G	**Pavement**			46,08,95,480.54	46.09
H	Inter Modal Logistic Building			6,08,81,90,000.00	608.82
BILL NO. 4	Traffic Signs, Markings, Crash Barrier Appurtenances			32,42,87,806.70	32.43
BILL NO. 5	**Road Restoration and Development**				
a.	Reclamation Of Existing Road in Approach Area & Ramps			68,00,75,000.00	68.01
b.	Street level Development near shaft Location (Road, Footpath, Lighting etc.)			30,00,00,000.00	30.00
c.	Junction Development			11,56,51,855.12	11.57
BILL NO. 6	Safety, Environmental Management Plan and Traffic Management During Construction @ 0.25% on **(C) Cost of Tunnel Works.**			23,49,50,767.20	23.50

S.No	Description	Length (km)	Rate	Total Amount in Rs.	Total Amount (Rs. in Crores)
BILL NO.7	High-Capacity & High-Speed Busses with Driving And Trailing Coaches (Neo-Bus System)				
a.	Traction & Power Supply (OHE)			50,00,00,000.00	50.00
b.	Telecommunication & Passenger Information System			10,00,00,000.00	10.00
c.	Fare Collection System			5,00,00,000.00	5.00
d.	Articulated Coach of Minimum 18 M Length			40,00,00,000.00	40.00
BILL NO. 8	Miscellaneous (Trees, Artwork in Tunnel, Construction Depot & Casting Yard, Tree Trans Plantation And Landscaping etc.)			65,08,23,320.00	65.08
BILL NO. 9	GPS/GNSS-Based Tolling	10.00	1.10	11,00,00,000.00	11.00
B) Estimated Construction Cost Without GST				**1,16,37,51,00,000.00**	**11,637.51**
GST @ 18% Payable on Construction Cost Only (On B)				20,94,75,18,000.00	2,094.75
C) Construction Cost Including GST				**1,37,32,26,18,000.00**	**13,732**
Contingencies @ 1% Of (B)				1,16,37,51,000.00	116.38
Construction Supervision Charges @ 2% Of (B)				2,32,75,02,000.00	232.75
D) Total Cost Including Centages				**1,40,81,38,71,000.00**	**14,081.39**
Land Acquisition, Resettlement, Rehabilitation Cost				8,00,00,00,000.00	800.00
Utility Shifting Cost				1,00,00,00,000.00	100.00
E) Total Project Cost (Sum of All the Above)				**1,49,81,38,71,000.00**	**14,981.39**

CHAPTER 10
FINANCIAL ANALYSIS AND ECONOMIC BENEFITS

CHAPTER 10: FINANCIAL ANALYSIS AND ECONOMIC BENEFITS

10.1 Financial Analysis

The Project Road has been studied for the financial viability to assess whether the project is attractive enough for private sector participation under the BOT model or not. The analysis ascertains the extent to which the investment by the BOT concessionaire can be recovered through toll revenue and the gap, if any, be funded through government subsidy or alternative revenue sources. This covers aspects like government grant, financing through debt and equity, loan repayment, debt servicing, taxation, depreciation, etc. The viability is evaluated in terms of the Project IRR (Financial Internal Rate of Return (FIRR) on total investment) and the Equity IRR (FIRR on equity investment), using discounted cash flow analysis. Both costs and revenues have been indexed to take account of inflation.

Target IRRs

To assess whether the project is commercially viable, the returns to investors, in terms of the pre-tax Project FIRR, post-tax Project FIRR and the Equity FIRR, were compared with the target IRRs. The returns expected by investors are a function of the value of equity issues on the Indian stock markets, interest rates on commercial loans, the risk profile of the investment and alternative investment opportunities.

10.2 Overview of implementation modes

Historically, investments in the infrastructure space, particularly in the highways/expressways etc., were being made by the Government mainly because of the large volume of resources required, long gestation period, and associated externalities. The galloping resource requirements, concern for managerial efficiency and consumer responsiveness have led in recent times to an active involvement of private sector investments.

Under PPP mechanism for road infrastructure, Government earlier offered two models viz. Build - Operate - Transfer (Toll) and Build - Operate - Transfer (Annuity). Most of the projects were awarded on these two models. In recent times, the Government has come up with a new model Hybrid Annuity Mode (HAM) and several projects are being awarded on HAM model.

PPP means an arrangement between a government or statutory entity or government owned entity on one side and a private sector entity on the other, for the provision of public assets and/or related services for public benefit, through investments being made by and/or management undertaken by the private sector entity for a specified time period. There is a substantial risk sharing with the private sector and the private sector receives performance linked payments that conform (or are benchmarked) to specified, pre-determined and measurable performance standards.

A PPP brings the public and private sectors together as partners in a contractual agreement, for a pre-defined period matched to the life of the infrastructure assets used to provide the services. The private partners (investors, contractors and operators) provide specified infrastructure services and, in return, the public sector either pays for those services or grants the private partner the right to generate revenue from the project.

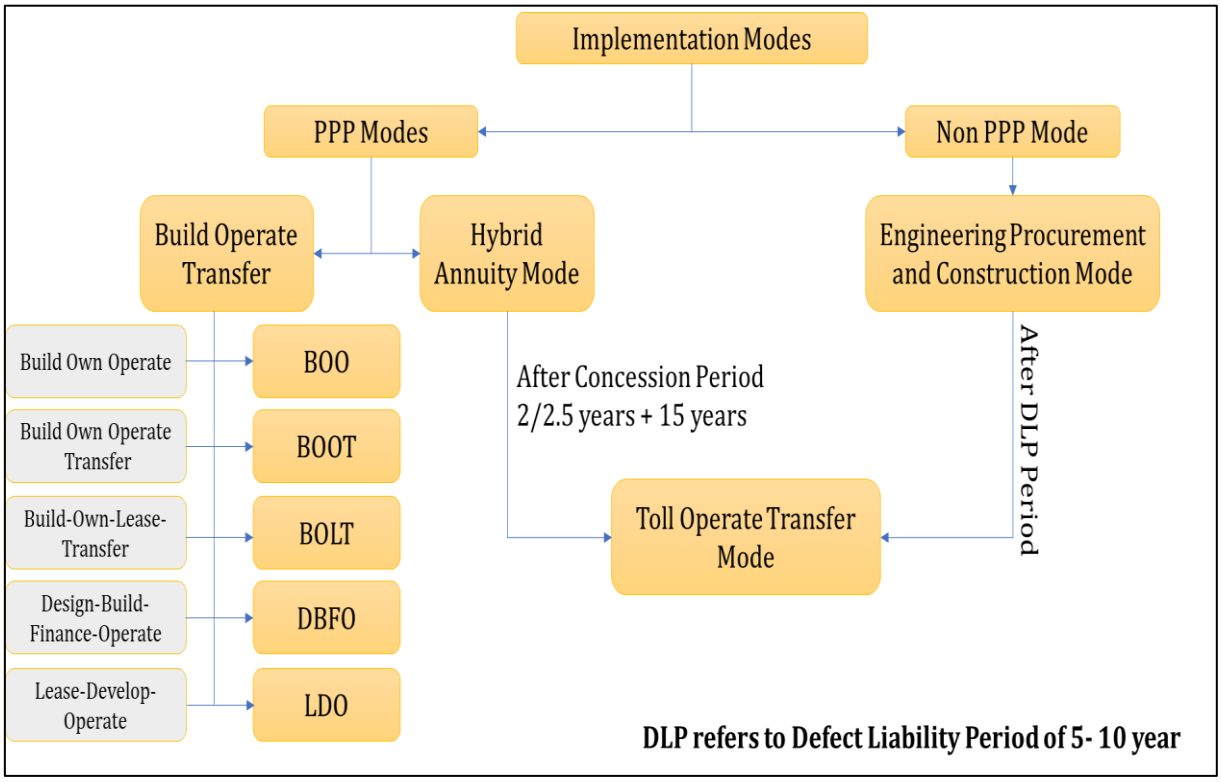


Figure 95: Implementation modes overview

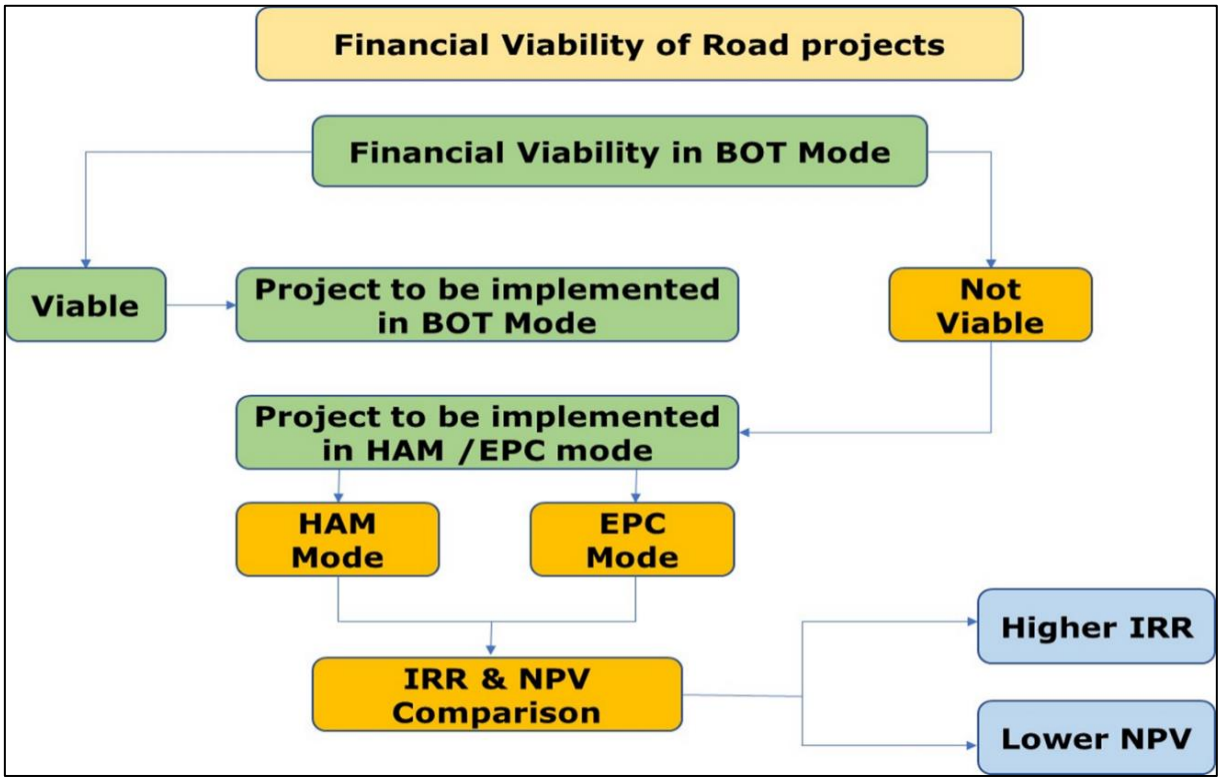


Figure 96: Flow chart of financial viability

Type of Risk → / Type of Model ↓	Financing Risk	Revenue Risk or Toll collection Risk	O & M Risk
BOT Model	By Private	By Private	By Private
Annuity Model	By Private	By Govt.	By Private
BOT-VGF Model	By Govt. & Private	By Private.	By Private
EPC Model	By Govt.	By Govt.	By Govt.
HAM Model	By Govt. & Private	By Govt.	By Private

Figure 97: Comparative Analysis of Implementation Modes

Engineering Procurement & Construction Mode

- Under the EPC model, government pays private players to lay roads. The private player has no role in the road's ownership, toll collection or maintenance (it is taken care of by the government).
- The concept of Defect Liability Period in adopted for this type of projects for about 5-10 years of Operational & Maintenance.
- In this mode, there is no criteria for selection of bids, the return ratio for particular period should be greater when compared with other modes.

Hybrid Annuity Mode

- HAM's a hybrid – a mix of the EPC (engineering, procurement and construction) and BOT (build, operate, transfer)- Annuity models. HAM combines EPC (40 percent) and BOT-Annuity (60 percent).
- On behalf of the government, NHAI releases fixed grant of 40 per cent of the total bid cost. The balance 60 per cent is arranged by the developer.
- HAM arose out of a need to have a better financial mechanism for road development.
- HAM is a good trade-off, spreading the risk between developers and the Government.
- The concept of price Indexation is applicable during construction and O & M period instead of escalation.
- Price Indexation contributes to 70% of WPI component and 30% of CPI Component.
- In this mode, the Equity IRR needs to be 15% and the bid amounts are to be quoted to 15% EIRR.
- The 60% of amount is paid back in the form of Annuities for 15 Years for every half year period.
- The grant during construction period shall be disbursed in 10 instalments (each of 4%).

Build Operate Transfer

- Under the BOT model though, private players have an active role - they build, operate and maintain

the road for a specified number of years before transferring the asset back to the government. Under BOT, the private player arranged all the finances for the project, while collecting toll revenue or annuity fee from the Government.

- The BOT model ran into roadblocks with private players not quite forthcoming to invest. The private player had to fully arrange for its finances be it through equity contribution or debt.
- In this mode, the Equity IRR needs to be 15% from the net cash flows.

10.3 Project section

The project section is 18.2 km underground vehicular tunnel for the north-south corridor in the city of Bengaluru, starting from Hebbal Esteem Mall Junction to the Silk Board KSRP Junction. The project includes four stretches with various entry and exit points. The details of stretches are as follows:

Table 86: Project section details

S. No.	Particulars	Length in Kms
1	Esteem Mall-Hebbal-Mekhri Circle-Palace Grounds	5.7
2	Palace Grounds-Golf Course-Race Course-Palace Road	2.8
3	Race Course/Chalukya Circle-Lalbagh	4.1
4	Lalbagh-Silk Board KSRP Junction	5.6
Total Length		**18.2**

The main purpose of the proposed North south tunnel corridor is to decongest city roads, NH 44 and to provide seamless transportation facilities for the traffic towards various locations in the city of Bengaluru. The tunnel road shall reduce the travel time from 1 hour to 20 -25 minutes. The tunnel road will be built 30m below and will run below the upcoming metro corridor in the area and Hebbal Flyover.

10.4 Capital Costs and Its Phasing

The capital cost of the Project relates to initial construction cost and land acquisition cost. Land acquisition costs have been excluded from the financial analysis, as the government has to provide land free of encumbrances to the concessionaire.

10.4.1 Base Project Cost

The total cost of the project is the cost at the time of commissioning and includes aggregate of base project cost, escalation cost, financing cost and interest during construction (IDC), Design, PMC. The Total Project Cost (TPC) is presented below Table.

Table 87: Total Project Cost Details

S. No.	Particulars	Cost in Cr.
1	Total Tunnel Length in Km. (6 lane Kms)	16.687
2	Total Approach Length in Km. (2 lane Kms)	17.24
3	Total Civil Cost in Crore	11637.21
4	Other costs (IDC, Escalation, Contingencies)	4073.13
Total Project Cost in Crore		15710.64

10.4.2 Escalation Cost

The base costs have been escalated at a rate of 5 percent per annum to account for inflation and obtain the actual costs in the year of expenditure. This is in line with the long-term inflation rate generally considered for financial analysis.

10.4.3 Financing Cost on Debt

Financing cost, comprising processing fee, sponsor's contingency, etc., has been considered as per NHAI

guidelines. 2% of debt amount is considered if the civil cost in up to Rs. 500 crores, 1.5% of debt amount is accounted if the civil cost is in the range of Rs. 500 crores and Rs. 1000 crores and 1% of debt amount is taken if the civil cost is more than Rs. 1000 crores.

10.4.4 Interest during Construction (IDC)

The interest during construction, which is the cost of funding incurred on the debt portion of the project, has been calculated as per SBI MCLR rate and additional 2% has been considered for the analysis which is in tune with the prevailing market interest rates for infrastructure projects.

10.4.5 Landed Project Cost (TPC)

The total cost of the project is the cost at the time of commissioning and includes aggregate of base project cost, escalation cost, financing cost and interest during construction (IDC), Design, PMC. The TPC at the end of the construction period has been estimated and presented in above table.

10.4.6 Tax rate

Tax Rate: The tax rate adopted for this study is 25.2% (22% tax + 10% surcharge + 4% education tax) assuming that the contractor shall opt for section 15BAA.

Minimum Alternate Tax (MAT): Minimum Alternate Tax (MAT) of 0% (0% base rate +10% surcharge and 4% Education cess) has been taken into account for the total concession period, assuming that the contractor shall opt for 15BAA section.

10.5 Approach to Financial Evaluation on BOT Basis

The viability of the project depends on the working cash flows available to service the debt and equity. This working cash flow is basically dependent upon the following: -

- Project Cost
- Traffic & Traffic Growth
- Toll Structure
- Operation and Maintenance expenses
- Interest on Debt
- Tax

10.6 Assumption for Financial Analysis

The assumptions for financial analysis are enclosed in Annexures.

10.7 Traffic details

The tollable and commercial vehicular details at each count station is provided in below table. The node-to-node traffic is assessed from OD Matrix, a traffic growth rate of 5% is adopted for all tollable vehicles for financial analysis.

Based on the diversion analysis, the tollable diverted analysis from existing road to tunnel road is presented in below table.

Table 88: Tollable Vehicle details for the year 2027-28 (Silk Board to Hebbal)

From Silk Board to Hebbal				Year 27-28
S. No.	From	To	Travel Length (km)	Estimated ADT
1	Silk Board (km 16.693)-Hosur	Hebbal (Main & Service Rd.)	16.68	2927

From Silk Board to Hebbal				Year 27-28
S. No.	**From**	**To**	**Travel Length (km)**	**Estimated ADT**
		ORR (towards KR Puram) (km 1.100)	16.03	3597
		CV Raman Road (Mekhri Circle) (km 5.150)	13.441	3661
		Race Course Road (9.000)	9.544	8631
2	Sarjapur/ HSR layout (Ring Road) (km 16.386)	Hebbal (Main & Service Rd.)	16.924	1554
		ORR (towards KR Puram) (km 1.100)	16.274	1002
		CV Raman Road (Mekhri Circle)	13.685	2288
		Race Course Road (9.000)	9.788	4394
3	Jayanagar (From Ashoka Pillar) (km 11.600)	Hebbal (Main & Service Rd.)	13.017	2280
		ORR (towards KR Puram) (km 1.100)	12.367	2966
		CV Raman Road (Mekhri Circle)	9.778	4252
		Race Course Road (9.000)	5.881	20283
4	Race Course (km 7.05) from Palace Rd.	Hebbal (Main & Service Rd.)	9.518	4189
		ORR (towards KR Puram) (km 1.100)	8.868	5893
		CV Raman Road (Mekhri Circle)	6.279	11652
5	CV Raman Road (km 4.700)	Hebbal (Main & Service Rd.)	6.601	10477
		ORR (towards KR Puram) (km 1.100)	5.951	8276

Table 89: Tollable Vehicle details for the year 2027-28 (Hebbal to Silk Board)

From Hebbal to Silk Board			Year 27-28
From	**To**	**Travel Length (km)**	**Estimated ADT**
Hebbal (km 0.000) (Main & Service Road)	Silk Board Junction on Hosur Road	16.693	2927
	Sarjapur/ HSR layout (Ring Road)	16.386	1554
	Hosur Main Road (Wilson Garden)	12.798	2280
	Seshadri Road (Towards KR Circle)	9.051	4189
	Palace Ground (Mekhri Circle)	5.773	10477
ORR (km 1.300) from KR Puram	Silk Board Junction on Hosur Road	16.204	3597
	Sarjapur/ HSR layout (Ring Road)	15.897	1002
	Hosur Main Road (Wilson Garden)	12.309	2966
	Seshadri Road (Towards KR Circle)	8.562	5893
	Palace Ground (Mekhri Circle)	5.284	8276
Mekhri Circle (5.400)	Silk Board Junction	12.548	3661
	Sarjapur/ HSR layout (Ring Road)	12.241	2288
	Hosur Main Road (Wilson Garden)	8.653	4252
	Seshadri Road (Towards KR Circle)	4.906	11652
Race Course (km 9.100) from palace rd.	Silk Board Junction	9.893	8631
	Sarjapur/ HSR layout (Ring Road)	9.586	4394
	Hosur Main Road (Wilson Garden)	5.998	20283

10.8 Tollable road/ structure Length Details

The tollable road/structure length as per initial designs are as follows for both options.

Table 90: Tollable road/structure length details in kms

Entry/ Exit points	Hebbal	ORR (from KR Puram)	CV Raman Road (Mekhri Circle)	Race Course	Silk Board Junction	Sarjapur/ HSR layout	Hosur Main Road (Wilson Garden)	Seshadri Road (Towards KR Circle)
Hebbal (km 0.000)	-				16.693	16.386	12.798	9.051
ORR (Km 1.30 from KR Puram)		-			16.204	15.89	12.309	8.562
Mekhri Circle (5.400)			-		12.548	12.241	8.653	4.906
Race Course (km 9.100) from palace rd.				-	9.893	9.586	5.998	-
Silk Board (km 16.693)	16.68	16.03	13.44	9.54	-			
Sarjapur/ HSR layout (Ring Road) (km 16.386)	16.92	16.27	13.69	9.79		-		
Jayanagar (From Ashoka Pillar) (km 11.600)	13.02	12.37	9.78	5.88			-	
Race Course (km 7.05) from Palace Rd.	9.52	8.87	6.28	-				-

10.9 Toll Rates

Toll rates are estimated based on the Gazette's published by MoRT&H. The base toll rates are considered from the Toll gazette G.S.R 838 (E) dated 05th December 2008 and G.S.R 15 (E) dated 12th January 2011. These base toll rates are applicable for a section of National Highway of four lane or more lanes. As per rule 5, sub rule (1) of gazette G.S.R 838 (E), the base rates are increased by 3% each year without compounding with effect from 1st April 2008.

As per Sub-rule (2) of gazette G.S.R 838 (E), the applicable base rates are revised with the effect from 1st April each year to reflect the increase in wholesale price index between the week ending on or subsequent to January 1st, the wholesale price index for the month of December of the immediately preceding year. The base toll rates are given in Table 91. For satellite based tolling system, the charges would be collected for the distance travelled in Kms.

Table 91: Toll Capping Rates

Type of vehicles	Base Rate of Fee per km in Rs (Year 2007 – 2008)
Car/Jeep/Van	0.65
LCV/Mini Bus	1.05
Bus/Truck	2.20
3 Axle trucks	2.40
MAV (4 Axle and above) Heavy Construction machinery	3.45

Type of vehicles	Base Rate of Fee per km in Rs (Year 2007 – 2008)
(HCM), Earth Moving Equipment (EME)	
Oversized Vehicles (7 or more axles)	4.2

10.10 Toll Fee

Toll revenue is the product of the forecasted traffic expected to use the project road and the appropriate toll fee for the vehicle category. Toll indexing has been carried out as per the toll policy and rounded off to nearest rupee.

- Revenue from Single Trips: Number of vehicles making single trips X Toll Fee X 365 days
- Revenue from Return Trips: Number of vehicles making Return Trips X Toll Fee X 150% X 365 days
- Revenue from Monthly Traffic Trips: Number of vehicles making Single Trip X Toll Fee X 2/3*50* 12 months.

A local user shall, on an application made to the other officials in charge, be issued a pass on payment of fee as per recent NHAI toll circular per calendar month authorizing it to cross the toll plaza specified in such pass for use of a section of the National Highway, for non-commercial purposes; provided that such use of National Highways shall not extend beyond another toll plaza on the National Highway; provided further that no such pass shall be issued of a service road or alternative route is available; provided also that no pass shall be required to fee collected from a vehicle that uses part of the highway and does not cross a toll plaza.

Based on the above discussions the toll revenue has been computed for the toll plaza proposed. Further the above toll rate will be adjusted by 3% per annum without compounding for the subsequent years. It is further adjusted on the basis of Wholesale Price Index as per the following formula:

- Applicable Rate of fee= Base Rate + Base Rate X {(WPI A-WPI B)/ WPI B}X 0.4
- Where WPI A = Wholesale price index for the month of December of the immediately preceding year and
- WPI B = Whole sale price index of the week ending on 6th January 2007 i.e. 208.7

The toll rates for the subsequent years were calculated on the basis of 5% annual increase in WPI with 40% restriction. The base year for the toll revenue is considered as FY 2030-31.

NHAI toll capping rates have been escalated with an inflation WPI rate of 5% every year. Toll rates in the 1st year of operation i.e., 2030-31 for the section including road length, structure length and bypass length is presented in the below tables.

Table 92: Toll rate in Rs. for entry & exits for single trip for the year 2030-31

Hebbal to Silk Board Direction				Single way in INR
S. No.	From	To	Length In Kms	Car
1	Hebbal (km 0.000)	Silk Board Junction	16.693	330
2	Hebbal (km 0.000)	Sarjapur/ HSR layout (Ring Road)	16.386	320
3	Hebbal (km 0.000)	Hosur Main Road (Wilson Garden)	12.798	250
4	Hebbal (km 0.000)	Seshadri Road (Towards KR Circle)	9.051	180
5	Hebbal (km 0.000)	Palace Road (Mekhri Circle)	5.773	115

Hebbal to Silk Board Direction				Single way in INR
S. No.	**From**	**To**	**Length In Kms**	**Car**
6	ORR (Km 1.30 from KR Puram)	Silk Board Junction	16.204	320
7	ORR (Km 1.30 from KR Puram)	Sarjapur/ HSR layout (Ring Road)	15.89	310
8	ORR (Km 1.30 from KR Puram)	Hosur Main Road (Wilson Garden)	12.309	240
9	ORR (Km 1.30 from KR Puram)	Seshadri Road (Towards KR Circle)	8.562	170
10	ORR (Km 1.30 from KR Puram)	Palace Road (Mekhri Circle)	5.284	105
11	Mekhri Circle (5.400)	Silk Board Junction	12.548	245
12	Mekhri Circle (5.400)	Sarjapur/ HSR layout (Ring Road)	12.241	240
13	Mekhri Circle (5.400)	Hosur Main Road (Wilson Garden)	8.653	170
14	Mekhri Circle (5.400)	Seshadri Road (Towards KR Circle)	4.906	95
15	Race Course (km 9.100) from palace rd.	Silk Board Junction	9.893	195
16	Race Course (km 9.100) from palace rd.	Sarjapur/ HSR layout (Ring Road)	9.586	190
17	Race Course (km 9.100) from palace rd.	Hosur Main Road (Wilson Garden)	5.998	120
From Silk Board to Hebbal				
1	Silk Board (km 16.693)	Hebbal	16.68	325
2	Silk Board (km 16.693)	ORR (Km 1.30 from KR Puram)	16.03	315
3	Silk Board (km 16.693)	CV Raman Road (Mekhri Circle)	13.441	265
4	Silk Board (km 16.693)	Race Course	9.544	185
5	Sarjapur/ HSR layout (Ring Road) (km 16.386)	Hebbal	16.924	330
6	Sarjapur/ HSR layout (Ring Road) (km 16.386)	ORR (Km 1.30 from KR Puram)	16.274	320
7	Sarjapur/ HSR layout (Ring Road) (km 16.386)	CV Raman Road (Mekhri Circle)	13.685	270
8	Sarjapur/ HSR layout (Ring Road) (km 16.386)	Race Course	9.788	190
9	Jayanagar (From Ashoka Pillar) (km 11.600)	Hebbal	13.017	255
10	Jayanagar (From Ashoka Pillar) (km 11.600)	ORR (Km 1.30 from KR Puram)	12.367	245
11	Jayanagar (From Ashoka Pillar) (km 11.600)	CV Raman Road (Mekhri Circle)	9.778	190
12	Jayanagar (From Ashoka Pillar) (km 11.600)	Race Course	5.881	115
13	Race Course (km 7.05) from Palace Rd.	Hebbal	9.518	185
14	Race Course (km 7.05) from Palace Rd.	ORR (Km 1.30 from KR Puram)	8.868	175
15	Race Course (km 7.05) from Palace Rd.	CV Raman Road (Mekhri Circle)	6.279	125
16	CV Raman Road	Hebbal	6.601	130

Hebbal to Silk Board Direction				Single way in INR
S. No.	**From**	**To**	**Length In Kms**	**Car**
17	CV Raman Road	ORR (Km 1.30 from KR Puram)	5.951	115

Table 93: Traffic for the year 2027 - 28

Hebbal to Silk Board Direction				Traffic in No's
S. No.	**From**	**To**	**Length In Kms**	**Car**
1	Hebbal (km 0.000)	Silk Board Junction	16.693	2927
2	Hebbal (km 0.000)	Sarjapur/ HSR layout (Ring Road)	16.386	1554
3	Hebbal (km 0.000)	Hosur Main Road (Wilson Garden)	12.798	2280
4	Hebbal (km 0.000)	Seshadri Road (Towards KR Circle)	9.051	4189
5	Hebbal (km 0.000)	Palace Road (Mekhri Circle)	5.773	10477
6	ORR (Km 1.30 from KR Puram)	Silk Board Junction	16.204	3597
7	ORR (Km 1.30 from KR Puram)	Sarjapur/ HSR layout (Ring Road)	15.89	1002
8	ORR (Km 1.30 from KR Puram)	Hosur Main Road (Wilson Garden)	12.309	2966
9	ORR (Km 1.30 from KR Puram)	Seshadri Road (Towards KR Circle)	8.562	5893
10	ORR (Km 1.30 from KR Puram)	Palace Road (Mekhri Circle)	5.284	8276
11	Mekhri Circle (5.400)	Silk Board Junction	12.548	3661
12	Mekhri Circle (5.400)	Sarjapur/ HSR layout (Ring Road)	12.241	2288
13	Mekhri Circle (5.400)	Hosur Main Road (Wilson Garden)	8.653	4252
14	Mekhri Circle (5.400)	Seshadri Road (Towards KR Circle)	4.906	11652
15	Race Course (km 9.100) from palace rd.	Silk Board Junction	9.893	8631
16	Race Course (km 9.100) from palace rd.	Sarjapur/ HSR layout (Ring Road)	9.586	4394
17	Race Course (km 9.100) from palace rd.	Hosur Main Road (Wilson Garden)	5.998	20283
From Silk Board to Hebbal				
1	Silk Board (km 16.693)	Hebbal	16.68	2927
2	Silk Board (km 16.693)	ORR (Km 1.30 from KR Puram)	16.03	3597
3	Silk Board (km 16.693)	CV Raman Road (Mekhri Circle)	13.441	3661
4	Silk Board (km 16.693)	Race Course	9.544	8631
5	Sarjapur/ HSR layout (Ring Road) (km 16.386)	Hebbal	16.924	1554
6	Sarjapur/ HSR layout (Ring Road) (km 16.386)	ORR (Km 1.30 from KR Puram)	16.274	1002
7	Sarjapur/ HSR layout (Ring Road) (km 16.386)	CV Raman Road (Mekhri Circle)	13.685	2288

Hebbal to Silk Board Direction				Traffic in No's
S. No.	**From**	**To**	**Length In Kms**	**Car**
8	Sarjapur/ HSR layout (Ring Road) (km 16.386)	Race Course	9.788	4394
9	Jayanagar (From Ashoka Pillar) (km 11.600)	Hebbal	13.017	2280
10	Jayanagar (From Ashoka Pillar) (km 11.600)	ORR (Km 1.30 from KR Puram)	12.367	2966
11	Jayanagar (From Ashoka Pillar) (km 11.600)	CV Raman Road (Mekhri Circle)	9.778	4252
12	Jayanagar (From Ashoka Pillar) (km 11.600)	Race Course	5.881	20283
13	Race Course (km 7.05) from Palace Rd.	Hebbal	9.518	4189
14	Race Course (km 7.05) from Palace Rd.	ORR (Km 1.30 from KR Puram)	8.868	5893
15	Race Course (km 7.05) from Palace Rd.	CV Raman Road (Mekhri Circle)	6.279	11652
16	CV Raman Road	Hebbal	6.601	10477
17	CV Raman Road	ORR (Km 1.30 from KR Puram)	5.951	8276

10.11 Proposed Sources of Finance

In general, the developer shall crystallize the sources of finance by optimizing his equity returns keeping in view the project cash flows, terms, and conditions of various financing options available. Further the market standing and financial strength of the Developer would largely determine the terms and conditions of finance offered to the Developer by various lending agencies. For the purpose of the study, following sources of finance have been taken:

- Equity: To be provided by the Developer
- Subsidy / Grant for viability of funding, to be provided by the client.
- Debt: To be arranged by the Developer / Concessionaire

10.12 Resource Mobilization Schedule

The Project construction period has been considered as 5 years (1825 days) and development period of 8 months due to its complex nature, huge capital involved. Based on the implementation period, the project cost for each section as well as total project road as a single section.

10.13 Operations & Maintenance Cost

Routine maintenance comprises primarily of maintenance of the pavement, collection of litter, traffic management (policing), accident repairs and all ancillary works including beautification. Routine Maintenance and periodic Maintenance cost is considered as MoRT&H circular No. RW/NH-37011/02/2010/PPP (Vol.II) dated 16th November 2011 in BOT Mode.

Table 94: Routine and Periodic Maintenance cost

S. No.	Pavement Type	Routine Maintenance cost every year	Periodic Maintenance cost for every 6th year
1	Flexible	3.5 lacs per km/year	35 lacs/km
2	Rigid	4.0 lacs per km/year	-

The above said maintenance costs are escalated with 5% for 2024 prices. The operation and maintenance cost for the toll plaza includes pay roll cost of the crew, communication & security services, cost of spare parts, power consumption, computer systems etc. The annual expensed of toll plaza for O&M is considered is @ Rs. 3.75 crore/year as per 2011 circular and inflation of 5% per year has been considered.

10.14 Minimum Return Criteria

Keeping in view the present market condition, the minimum return criteria for the BOT project is considered as follows: -

- Project FIRR – Post Tax : Minimum of 13%
- Return on Equity (Equity IRR) : Minimum of 15%
- Debt Service Coverage Ratio (DSCR) : Minimum 1.0
- Net Present Value (NPV) @ 12% : Should be positive

10.15 Financial Viability

Financial viability has been carried out for concession period of 25-30 years excluding the construction period of five years for the present project corridor of length with two options with the following parameters with varying the subsidy 40%. The basic methodology followed for estimating the financial viability of the project is to calculate the FIRR (Financial Internal Rate of Return) on the investment for the project.

The following assumptions are taken into consideration for the financial analysis: -

- Debt – Equity ratio: - 70:30
- Escalation – 5%.
- Moratorium: six months

10.16 Results and Analysis

Based on the traffic study and toll rate analysis, the financial viability analysis has been carried out as per the methodology outlined in earlier sections. The objective of the viability analysis is to ascertain the existence of sustainable project returns, which shall successfully meet the expectations of its financial investors. The Returns on Investment and Returns on Equity for 30 years concession period with maximum subsidy up to 40% has been estimated and the summary of results for each scenario is given in Table 95 & 96.

Table 95: Results in BOT Mode for 5+ 25 years of Concession period

Deciding factor	No Grant	With 20% Grant	With 30% Grant	With 40% Grant
Project IRR	10.81%	12.68%	13.86%	15.29%
Equity IRR	10.13%	13.28%	15.36%	17.92%
DSCR	1.37	1.68	1.90	2.2
NPV	-1213.55	588.90	1476.00	2347.96
Remark	Not Viable	Not Viable	Viable	Viable

Table 96: Results in BOT Mode for 5+ 30 years of Concession period

Deciding factor	No Grant	With 20% Grant	With 30% Grant	With 40% Grant
Project IRR	11.61%	13.34%	14.45%	15.80%
Equity IRR	11.52%	14.32%	16.19%	18.55%
DSCR	1.37	1.68	1.90	2.20
NPV	-461.13	1340.83	2227.68	3099.41
Remark	Not Viable	Not Viable	Viable	Viable

10.17 Economic Benefits

The project will have direct and indirect benefits for the project influence areas and the commuters.

Economic benefits

- Saving in Vehicle operating cost, with reduction in wear and tear of vehicle components.
- Improved connectivity by providing congestion-free traffic over the project.
- Fuel savings due to reduced congestions.
- Increased employment opportunity for the local population during the construction and maintenance period.

Environment Benefits

- Reduced Emission of air pollutants and lower damage to environment due to pollution.
- Lower impact on environment by reducing greenhouse gas emissions increasing the health benefits for the city population.

Road Safety

- Reduced accidents and injuries due to good infrastructure with road safety provisions all along the corridor.
- Minimum effect on the need of land acquisition and Rehabilitation and relocation activities.

ANNEXURE - BOT - TUNNEL - NO GRANT

Project Name: Bengaluru Tunnel Project from Hebbal to Silk board			
General Assumptions			
Bid Date	**10-Feb-25**	Construction start date	**10-Oct-25**
Construction Period in days	1825	No. years of construction	5.0
Construction End date	9-Oct-30	No. of years before COD	6
COD	10-Oct-30	Type of Pavement	Rigid
First FY year in Construction	31-Mar-25	WPI- Dec 2023	150.4
First FY in O & M period	31-Mar-31	WPI on Dec before COD	619.48
No. of days in first O & M year	173	Debt Repayment start date	30-Apr-31
Debt Repayment in years	13	Debt Repayment End date	30-Apr-44
% of days in first COD	47.4%	% of days in last O & M year	52.6%
WPI growth considered (yearly)	5.0%	**Maintenance Expenses (in crores)**	
Grant during construction	0.0%	Other office Expenses for 1st O & MYear	10.45
To be Arranged By contractor/Concessionaire	100%	Insurance	26.18
Equity	30%	Electricity & patrolling expenses for 1st O & M Year	0.87
Debt	70%	**Flexible Pavement in Lakhs**	
Interest on Debt	11.10%	Routine Maintenance (Every year) for 1st Year	0.000
No. of Lanes	6	Periodic Maintenance (Every 6 th year)	0.000
Fully Access Controlled Expressway	No	**Rigid Pavement In Lakhs**	
Financing Cost on debt %	1.0%	Routine Maintenance (Every year) for 1st Year	357.11
Road Length			
Flexible Pavement - MCW Road		**Rigid Pavement - MCW Road**	
Length of 2 lane section	0.00	Length of 2 lane section	0.00
Length of 4 lane section	0	Length of 4 lane section	0
Length of 6 lane section	0	Length of 6 lane section	16.687
Total 4 lane Equivalent Length	**0.00**	**Total 4 lane Equivalent Length**	**25.03**
Flexible Pavement - SR Road		**Rigid Pavement - SR Road**	
Length of 2 lane section	0	Length of 2 lane section	17.24
Length of 4 lane section	0	Length of 4 lane section	0
Length of 6 lane section	0	Length of 6 lane section	0
Total 4 lane Equivalent Length	**0.00**	**Total 4 lane Equivalent Length**	**8.62**
		Det Repayment Years (from Start of Construction)	13

Costing Details (in Crores)	
Length of Corridor	16.687
Total Civil Cost	11637.51
Other costs	4073.13
Total Project cost	15710.64

Tax Assumptions			
Corporate Tax Rate			
Section 15BAA opted	Yes		
Case I		**Case II**	
If income exceeds Rs. 1 cr. but not exceeding 400 Cr.		**If income exceeds Rs. 400 cr.**	
Base rate	22%	Base rate	22%
Surcharge	10%	Surcharge	10%
Cess	4%	Cess	4%
Total Applicable Tax	**25.2%**	**Total Applicable Tax**	**25.2%**
MAT Tax Rate			
Case I		**Case II**	
Base rate	0.0%	Base rate	0.0%
Surcharge	10%	Surcharge	10%
Cess	4%	Cess	4%
Total Applicable Tax	**0.0%**	**Total Applicable Tax**	**0.0%**

Project Name: Bengaluru Tunnel Project from Hebbal to Silk board

Cash Flow Statement (In crores)-5 Years of Construction period - 25 years O& M Period															
	VGF	0.00%			PBDIT		Section 15 BAA Opted			Yes	No. of O & M Years		25	D/E Ratio		2.33
S. No.	Year	% of days	Revenue	Expenses	Net Income	Depreciation	PBIT	Interest on Debt	Profit Before Tax (PBT)	TAX	Profit After Tax (PAT)	Net operating Income after Tax	Repayment	DSCR	Net Cash flow	NPV
-5	31-Mar-26				-1480.67		-1480.67		-1480.67			-1480.67			-444.20	-1480.67
-4	31-Mar-27				-3142.13		-3142.13		-3142.13			-3142.13			-942.64	-3142.13
-3	31-Mar-28				-3150.74		-3150.74		-3150.74			-3150.74			-945.22	-3150.74
-2	31-Mar-29				-3142.13		-3142.13		-3142.13			-3142.13			-942.64	-3142.13
-1	31-Mar-30				-3142.13		-3142.13		-3142.13			-3142.13			-942.64	-3142.13
0	31-Mar-31	47.4%	617.18	19.47	-1055.13	297.86	-1352.99	0.00	-1352.99	0.00	-1352.99	-1055.13	0.00		-495.85	-1055.13
1	31-Mar-32	100.0%	1460.46	43.13	1417.33	628.43	788.90	855.17	-66.27	0.00	-66.27	1417.33	604.26	0.97	-42.10	1417.33
2	31-Mar-33	100.0%	1573.54	45.28	1528.25	628.43	899.83	1609.74	-709.91	0.00	-709.91	1528.25	1208.51	0.54	-1289.99	1528.25
3	31-Mar-34	100.0%	1695.87	47.55	1648.32	628.43	1019.90	1475.59	-455.70	0.00	-455.70	1648.32	1208.51	0.61	-1035.78	1648.32
4	31-Mar-35	100.0%	1829.08	49.93	1779.15	628.43	1150.73	1341.45	-190.72	0.00	-190.72	1779.15	1208.51	0.70	-770.80	1779.15
5	31-Mar-36	100.0%	1971.79	52.42	1919.37	628.43	1290.94	1207.30	83.64	0.00	83.64	1919.37	1208.51	0.79	-496.45	1919.37
6	31-Mar-37	100.0%	2123.50	55.04	2068.46	628.43	1440.03	1073.16	366.88	26.92	339.96	2041.54	1208.51	0.89	-240.13	2041.54
7	31-Mar-38	100.0%	2286.23	57.80	2228.44	628.43	1600.01	939.01	661.00	123.30	537.70	2105.14	1208.51	0.98	-42.39	2105.14
8	31-Mar-39	100.0%	2458.90	60.69	2398.21	628.43	1769.79	804.87	964.92	219.91	745.01	2178.30	1208.51	1.08	164.92	2178.30
9	31-Mar-40	100.0%	2647.51	63.72	2583.79	628.43	1955.36	670.72	1284.64	318.49	966.15	2265.30	1208.51	1.21	386.06	2265.30
10	31-Mar-41	100.0%	2848.22	66.91	2781.32	628.43	2152.89	536.58	1616.31	418.26	1198.05	2363.05	1208.51	1.35	617.96	2363.05
11	31-Mar-42	100.0%	3065.55	70.25	2995.30	628.43	2366.87	402.43	1964.44	520.55	1443.89	2474.75	1208.51	1.54	863.80	2474.75
12	31-Mar-43	100.0%	3298.56	73.76	3224.80	628.43	2596.37	268.29	2328.08	625.27	1702.81	2599.52	1208.51	1.76	1122.72	2599.52
13	31-Mar-44	100.0%	3547.76	77.45	3470.31	628.43	2841.88	134.14	2707.74	732.71	1975.03	2737.60	1208.51	2.04	1394.95	2737.60
14	31-Mar-45	100.0%	3821.42	81.32	3740.10	628.43	3111.67	16.77	3094.90	840.84	2254.06	2899.25	604.26	4.67	2278.23	2899.25
15	31-Mar-46	100.0%	4114.94	85.39	4029.55	628.43	3401.12	0.00	3401.12	927.54	2473.58	3102.01	0.00		3102.01	3102.01
16	31-Mar-47	100.0%	4423.29	89.66	4333.63	628.43	3705.20	0.00	3705.20	1012.73	2692.47	3320.90			3320.90	3320.90
17	31-Mar-48	100.0%	4749.82	94.14	4655.68	628.43	4027.26	0.00	4027.26	1101.58	2925.68	3554.10			3554.10	3554.10
18	31-Mar-49	100.0%	5119.06	98.85	5020.20	628.43	4391.78	0.00	4391.78	1200.34	3191.44	3819.87			3819.87	3819.87
19	31-Mar-50	100.0%	5501.15	103.79	5397.36	628.43	4768.93	0.00	4768.93	1301.58	3467.36	4095.78			4095.78	4095.78
20	31-Mar-51	100.0%	5920.07	108.98	5811.08	628.43	5182.66	0.00	5182.66	1411.39	3771.27	4399.70			4399.70	4399.70
21	31-Mar-52	100.0%	6361.29	114.43	6246.86	628.43	5618.43	0.00	5618.43	1526.18	4092.26	4720.68			4720.68	4720.68
22	31-Mar-53	100.0%	6846.31	120.15	6726.15	628.43	6097.73	0.00	6097.73	1651.41	4446.32	5074.75			5074.75	5074.75
23	31-Mar-54	100.0%	7359.70	126.16	7233.54	628.43	6605.11	0.00	6605.11	1783.25	4821.86	5450.29			5450.29	5450.29
24	31-Mar-55	100.0%	7909.40	132.47	7776.93	628.43	7148.50	0.00	7148.50	1923.74	5224.76	5853.19			5853.19	5853.19
25	31-Mar-56	52.6%	4470.03	73.17	4396.86	330.57	4066.29	0.00	4066.29	1090.71	2975.58	3306.15			3306.15	3306.15
		Total	98020.61	2011.93	Pre- Tax IRR							Post Tax IRR		DSCR	Equity IRR	NPV
					11.97%							10.81%		1.37	10.13%	-1213.55

Project Name: Bengaluru Tunnel Project from Hebbal to Silk board

Cash Flow Statement (In crores)-5 Years of Construction period - 30 years O& M Period																
	VGF	0.00%			PBDIT		Section 15 BAA Opted			Yes	No. of O & M Years		30	D/E Ratio		2.33
S. No.	Year	% of days	Revenue	Expenses	Net Income	Depreciation	PBIT	Interest on Debt	Profit Before Tax (PBT)	TAX	Profit After Tax (PAT)	Net operating Income after Tax	Repayment	DSCR	Net Cash flow	NPV
-5	31-Mar-26				-1480.67		-1480.67		-1480.67			-1480.67			-444.20	-1480.67
-4	31-Mar-27				-3142.13		-3142.13		-3142.13			-3142.13			-942.64	-3142.13
-3	31-Mar-28				-3150.74		-3150.74		-3150.74			-3150.74			-945.22	-3150.74
-2	31-Mar-29				-3142.13		-3142.13		-3142.13			-3142.13			-942.64	-3142.13
-1	31-Mar-30				-3142.13		-3142.13		-3142.13			-3142.13			-942.64	-3142.13
0	31-Mar-31	47.4%	617.18	19.47	-1055.13	248.21	-1303.34	0.00	-1303.34	0.00	-1303.34	-1055.13	0.00		-495.85	-1055.13
1	31-Mar-32	100.0%	1460.46	43.13	1417.33	523.69	893.64	855.17	38.47	0.00	38.47	1417.33	604.26	0.97	-42.10	1417.33
2	31-Mar-33	100.0%	1573.54	45.28	1528.25	523.69	1004.57	1609.74	-605.17	0.00	-605.17	1528.25	1208.51	0.54	-1289.99	1528.25
3	31-Mar-34	100.0%	1695.87	47.55	1648.32	523.69	1124.63	1475.59	-350.96	0.00	-350.96	1648.32	1208.51	0.61	-1035.78	1648.32
4	31-Mar-35	100.0%	1829.08	49.93	1779.15	523.69	1255.46	1341.45	-85.98	0.00	-85.98	1779.15	1208.51	0.70	-770.80	1779.15
5	31-Mar-36	100.0%	1971.79	52.42	1919.37	523.69	1395.68	1207.30	188.38	0.00	188.38	1919.37	1208.51	0.79	-496.45	1919.37
6	31-Mar-37	100.0%	2123.50	55.04	2068.46	523.69	1544.77	1073.16	471.61	26.92	444.70	2041.54	1208.51	0.89	-240.13	2041.54
7	31-Mar-38	100.0%	2286.23	57.80	2228.44	523.69	1704.75	939.01	765.74	123.30	642.44	2105.14	1208.51	0.98	-42.39	2105.14
8	31-Mar-39	100.0%	2458.90	60.69	2398.21	523.69	1874.53	804.87	1069.66	219.91	849.74	2178.30	1208.51	1.08	164.92	2178.30
9	31-Mar-40	100.0%	2647.51	63.72	2583.79	523.69	2060.10	670.72	1389.38	318.49	1070.89	2265.30	1208.51	1.21	386.06	2265.30
10	31-Mar-41	100.0%	2848.22	66.91	2781.32	523.69	2257.63	536.58	1721.05	418.26	1302.79	2363.05	1208.51	1.35	617.96	2363.05
11	31-Mar-42	100.0%	3065.55	70.25	2995.30	523.69	2471.61	402.43	2069.17	520.55	1548.62	2474.75	1208.51	1.54	863.80	2474.75
12	31-Mar-43	100.0%	3298.56	73.76	3224.80	523.69	2701.11	268.29	2432.82	625.27	1807.54	2599.52	1208.51	1.76	1122.72	2599.52
13	31-Mar-44	100.0%	3547.76	77.45	3470.31	523.69	2946.62	134.14	2812.48	732.71	2079.77	2737.60	1208.51	2.04	1394.95	2737.60
14	31-Mar-45	100.0%	3821.42	81.32	3740.10	523.69	3216.41	16.77	3199.64	840.84	2358.80	2899.25	604.26	4.67	2278.23	2899.25
15	31-Mar-46	100.0%	4114.94	85.39	4029.55	523.69	3505.86	0.00	3505.86	927.54	2578.32	3102.01	0.00		3102.01	3102.01
16	31-Mar-47	100.0%	4423.29	89.66	4333.63	523.69	3809.94	0.00	3809.94	1012.73	2797.21	3320.90			3320.90	3320.90
17	31-Mar-48	100.0%	4749.82	94.14	4655.68	523.69	4131.99	0.00	4131.99	1101.58	3030.41	3554.10			3554.10	3554.10
18	31-Mar-49	100.0%	5119.06	98.85	5020.20	523.69	4496.52	0.00	4496.52	1200.34	3296.18	3819.87			3819.87	3819.87
19	31-Mar-50	100.0%	5501.15	103.79	5397.36	523.69	4873.67	0.00	4873.67	1301.58	3572.09	4095.78			4095.78	4095.78
20	31-Mar-51	100.0%	5920.07	108.98	5811.08	523.69	5287.40	0.00	5287.40	1411.39	3876.01	4399.70			4399.70	4399.70
21	31-Mar-52	100.0%	6361.29	114.43	6246.86	523.69	5723.17	0.00	5723.17	1526.18	4196.99	4720.68			4720.68	4720.68
22	31-Mar-53	100.0%	6846.31	120.15	6726.15	523.69	6202.47	0.00	6202.47	1651.41	4551.06	5074.75			5074.75	5074.75
23	31-Mar-54	100.0%	7359.70	126.16	7233.54	523.69	6709.85	0.00	6709.85	1783.25	4926.60	5450.29			5450.29	5450.29
24	31-Mar-55	100.0%	7909.40	132.47	7776.93	523.69	7253.24	0.00	7253.24	1923.74	5329.50	5853.19			5853.19	5853.19
25	31-Mar-56	100.0%	8497.71	139.09	8358.61	523.69	7834.92	0.00	7834.92	2073.49	5761.43	6285.12			6285.12	6285.12
26	31-Mar-57	100.0%	9139.75	146.05	8993.70	523.69	8470.01	0.00	8470.01	2236.35	6233.66	6757.35			6757.35	6757.35
27	31-Mar-58	100.0%	9813.79	153.35	9660.44	523.69	9136.76	0.00	9136.76	2406.88	6729.88	7253.57			7253.57	7253.57
28	31-Mar-59	100.0%	10539.42	161.02	10378.40	523.69	9854.71	0.00	9854.71	2590.02	7264.69	7788.38			7788.38	7788.38
29	31-Mar-60	100.0%	11235.44	169.07	11066.37	523.69	10542.68	0.00	10542.68	2765.37	7777.31	8301.00			8301.00	8301.00
30	31-Mar-61	52.6%	6352.98	93.38	6259.60	275.47	5984.13	0.00	5984.13	1566.04	4418.09	4693.57			4693.57	4693.57
		Total	149129.67	2800.72	Pre- Tax IRR							Post Tax IRR		DSCR	Equity IRR	NPV
					12.74%							11.61%		1.37	11.52%	-461.13

ANNEXURE - BOT - TUNNEL - 20% GRANT

Project Name: Bengaluru Tunnel Project from Hebbal to Silk board			
General Assumptions			
Bid Date	**10-Feb-25**	Construction start date	**10-Oct-25**
Construction Period in days	1825	No. years of construction	5.0
Construction End date	9-Oct-30	No. of years before COD	6
COD	10-Oct-30	Type of Pavement	Rigid
First FY year in Construction	31-Mar-25	WPI- Dec 2023	150.4
First FY in O & M period	31-Mar-31	WPI on Dec before COD	619.48
No. of days in first O & M year	173	Debt Repayment start date	30-Apr-31
Debt Repayment in years	13	Debt Repayment End date	30-Apr-44
% of days in first COD	47.4%	% of days in last O & M year	52.6%
WPI growth considered (yearly)	5.0%	**Maintenance Expenses (in crores)**	
Grant during construction	20.0%	Other office Expenses for 1st O & MYear	10.45
To be Arranged By contractor/Concessionaire	80%	Insurance	26.18
Equity	30%	Electricity & patrolling expenses for 1st O & M Year	0.87
Debt	70%	**Flexible Pavement in Lakhs**	
Interest on Debt	11.10%	Routine Maintenance (Every year) for 1st Year	0.000
No. of Lanes	6	Periodic Maintenance (Every 6 th year)	0.000
Fully Access Controlled Expressway	No	**Rigid Pavement In Lakhs**	
Financing Cost on debt %	1.0%	Routine Maintenance (Every year) for 1st Year	357.11
Road Length			
Flexible Pavement - MCW Road		**Rigid Pavement - MCW Road**	
Length of 2 lane section	0.00	Length of 2 lane section	0.00
Length of 4 lane section	0	Length of 4 lane section	0
Length of 6 lane section	0	Length of 6 lane section	16.687
Total 4 lane Equivalent Length	**0.00**	**Total 4 lane Equivalent Length**	**25.03**
Flexible Pavement - SR Road		**Rigid Pavement - SR Road**	
Length of 2 lane section	0	Length of 2 lane section	17.24
Length of 4 lane section	0	Length of 4 lane section	0
Length of 6 lane section	0	Length of 6 lane section	0
Total 4 lane Equivalent Length	**0.00**	**Total 4 lane Equivalent Length**	**8.62**
		Det Repayment Years (from Start of Construction)	13

Costing Details (in Crores)	
Length of Corridor	16.687
Total Civil Cost	11637.51
Other costs	4073.13
Total Project cost	15710.64

Tax Assumptions			
Corporate Tax Rate			
Section 15BAA opted	Yes		
Case I		**Case II**	
If income exceeds Rs. 1 cr. but not exceeding 400 Cr.		**If income exceeds Rs. 400 cr.**	
Base rate	22%	Base rate	22%
Surcharge	10%	Surcharge	10%
Cess	4%	Cess	4%
Total Applicable Tax	**25.2%**	**Total Applicable Tax**	**25.2%**
MAT Tax Rate			
Case I		**Case II**	
Base rate	0.0%	Base rate	0.0%
Surcharge	10%	Surcharge	10%
Cess	4%	Cess	4%
Total Applicable Tax	**0.0%**	**Total Applicable Tax**	**0.0%**

Project Name: Bengaluru Tunnel Project from Hebbal to Silk board

Cash Flow Statement (In crores)-5 Years of Construction period - 25 years O& M Period

	VGF	20.00%			PBDIT		Section 15 BAA Opted			Yes	No. of O & M Years		25	D/E Ratio		2.33
S. No.	Year	% of days	Revenue	Expenses	Net Income	Depreciation	PBIT	Interest on Debt	Profit Before Tax (PBT)	TAX	Profit After Tax (PAT)	Net operating Income after Tax	Repayment	DSCR	Net Cash flow	NPV
-5	31-Mar-26				-1184.54		-1184.54		-1184.54			-1184.54			-355.36	-1184.54
-4	31-Mar-27				-2513.70		-2513.70		-2513.70			-2513.70			-754.11	-2513.70
-3	31-Mar-28				-2520.59		-2520.59		-2520.59			-2520.59			-756.18	-2520.59
-2	31-Mar-29				-2513.70		-2513.70		-2513.70			-2513.70			-754.11	-2513.70
-1	31-Mar-30				-2513.70		-2513.70		-2513.70			-2513.70			-754.11	-2513.70
0	31-Mar-31	47.4%	617.18	19.47	-724.56	238.29	-962.85	0.00	-962.85	0.00	-962.85	-724.56	0.00		-396.68	-724.56
1	31-Mar-32	100.0%	1460.46	43.13	1417.33	502.74	914.59	684.14	230.45	0.00	230.45	1417.33	483.40	1.21	249.79	1417.33
2	31-Mar-33	100.0%	1573.54	45.28	1528.25	502.74	1025.51	1287.79	-262.28	0.00	-262.28	1528.25	966.81	0.68	-726.34	1528.25
3	31-Mar-34	100.0%	1695.87	47.55	1648.32	502.74	1145.58	1180.47	-34.89	0.00	-34.89	1648.32	966.81	0.77	-498.96	1648.32
4	31-Mar-35	100.0%	1829.08	49.93	1779.15	502.74	1276.41	1073.16	203.25	0.00	203.25	1779.15	966.81	0.87	-260.81	1779.15
5	31-Mar-36	100.0%	1971.79	52.42	1919.37	502.74	1416.62	965.84	450.78	41.24	409.54	1878.12	966.81	0.97	-54.53	1878.12
6	31-Mar-37	100.0%	2123.50	55.04	2068.46	502.74	1565.72	858.53	707.19	125.65	581.54	1942.81	966.81	1.06	117.47	1942.81
7	31-Mar-38	100.0%	2286.23	57.80	2228.44	502.74	1725.70	751.21	974.49	210.81	763.68	2017.63	966.81	1.17	299.61	2017.63
8	31-Mar-39	100.0%	2458.90	60.69	2398.21	502.74	1895.47	643.89	1251.58	296.65	954.93	2101.57	966.81	1.30	490.86	2101.57
9	31-Mar-40	100.0%	2647.51	63.72	2583.79	502.74	2081.05	536.58	1544.47	384.85	1159.62	2198.94	966.81	1.46	695.55	2198.94
10	31-Mar-41	100.0%	2848.22	66.91	2781.32	502.74	2278.58	429.26	1849.31	474.61	1374.70	2306.70	966.81	1.65	910.63	2306.70
11	31-Mar-42	100.0%	3065.55	70.25	2995.30	502.74	2492.56	321.95	2170.61	567.21	1603.40	2428.09	966.81	1.88	1139.33	2428.09
12	31-Mar-43	100.0%	3298.56	73.76	3224.80	502.74	2722.05	214.63	2507.42	662.54	1844.88	2562.25	966.81	2.17	1380.81	2562.25
13	31-Mar-44	100.0%	3547.76	77.45	3470.31	502.74	2967.57	107.32	2860.25	760.85	2099.40	2709.46	966.81	2.52	1635.34	2709.46
14	31-Mar-45	100.0%	3821.42	81.32	3740.10	502.74	3237.36	13.41	3223.94	860.94	2363.01	2879.16	483.40	5.80	2382.34	2879.16
15	31-Mar-46	100.0%	4114.94	85.39	4029.55	502.74	3526.81	0.00	3526.81	944.86	2581.95	3084.69	0.00		3084.69	3084.69
16	31-Mar-47	100.0%	4423.29	89.66	4333.63	502.74	3830.89	0.00	3830.89	1028.32	2802.57	3305.31			3305.31	3305.31
17	31-Mar-48	100.0%	4749.82	94.14	4655.68	502.74	4152.94	0.00	4152.94	1115.61	3037.33	3540.07			3540.07	3540.07
18	31-Mar-49	100.0%	5119.06	98.85	5020.20	502.74	4517.46	0.00	4517.46	1212.97	3304.50	3807.24			3807.24	3807.24
19	31-Mar-50	100.0%	5501.15	103.79	5397.36	502.74	4894.62	0.00	4894.62	1312.94	3581.67	4084.41			4084.41	4084.41
20	31-Mar-51	100.0%	5920.07	108.98	5811.08	502.74	5308.34	0.00	5308.34	1421.62	3886.73	4389.47			4389.47	4389.47
21	31-Mar-52	100.0%	6361.29	114.43	6246.86	502.74	5744.12	0.00	5744.12	1535.38	4208.73	4711.47			4711.47	4711.47
22	31-Mar-53	100.0%	6846.31	120.15	6726.15	502.74	6223.41	0.00	6223.41	1659.69	4563.72	5066.46			5066.46	5066.46
23	31-Mar-54	100.0%	7359.70	126.16	7233.54	502.74	6730.80	0.00	6730.80	1790.71	4940.09	5442.83			5442.83	5442.83
24	31-Mar-55	100.0%	7909.40	132.47	7776.93	502.74	7274.19	0.00	7274.19	1930.45	5343.74	5846.48			5846.48	5846.48
25	31-Mar-56	52.6%	4470.03	73.17	4396.86	264.46	4132.40	0.00	4132.40	1093.89	3038.51	3302.97			3302.97	3302.97
		Total	98020.61	2011.93	Pre- Tax IRR							Post Tax IRR		DSCR	Equity IRR	NPV
					13.93%							12.68%		1.68	13.28%	588.90

Project Name: Bengaluru Tunnel Project from Hebbal to Silk board

Cash Flow Statement (In crores)-5 Years of Construction period - 30 years O& M Period																
	VGF	20.00%			PBDIT		Section 15 BAA Opted			Yes	No. of O & M Years		30	D/E Ratio		2.33
S. No.	Year	% of days	Revenue	Expenses	Net Income	Depreciation	PBIT	Interest on Debt	Profit Before Tax (PBT)	TAX	Profit After Tax (PAT)	Net operating Income after Tax	Repayment	DSCR	Net Cash flow	NPV
-5	31-Mar-26				-1184.54		-1184.54		-1184.54			-1184.54			-355.36	-1184.54
-4	31-Mar-27				-2513.70		-2513.70		-2513.70			-2513.70			-754.11	-2513.70
-3	31-Mar-28				-2520.59		-2520.59		-2520.59			-2520.59			-756.18	-2520.59
-2	31-Mar-29				-2513.70		-2513.70		-2513.70			-2513.70			-754.11	-2513.70
-1	31-Mar-30				-2513.70		-2513.70		-2513.70			-2513.70			-754.11	-2513.70
0	31-Mar-31	47.4%	617.18	19.47	-724.56	198.57	-923.13	0.00	-923.13	0.00	-923.13	-724.56	0.00		-396.68	-724.56
1	31-Mar-32	100.0%	1460.46	43.13	1417.33	418.95	998.38	684.14	314.24	0.00	314.24	1417.33	483.40	1.21	249.79	1417.33
2	31-Mar-33	100.0%	1573.54	45.28	1528.25	418.95	1109.30	1287.79	-178.49	0.00	-178.49	1528.25	966.81	0.68	-726.34	1528.25
3	31-Mar-34	100.0%	1695.87	47.55	1648.32	418.95	1229.37	1180.47	48.90	0.00	48.90	1648.32	966.81	0.77	-498.96	1648.32
4	31-Mar-35	100.0%	1829.08	49.93	1779.15	418.95	1360.20	1073.16	287.04	0.00	287.04	1779.15	966.81	0.87	-260.81	1779.15
5	31-Mar-36	100.0%	1971.79	52.42	1919.37	418.95	1500.41	965.84	534.57	41.24	493.33	1878.12	966.81	0.97	-54.53	1878.12
6	31-Mar-37	100.0%	2123.50	55.04	2068.46	418.95	1649.51	858.53	790.98	125.65	665.33	1942.81	966.81	1.06	117.47	1942.81
7	31-Mar-38	100.0%	2286.23	57.80	2228.44	418.95	1809.49	751.21	1058.28	210.81	847.47	2017.63	966.81	1.17	299.61	2017.63
8	31-Mar-39	100.0%	2458.90	60.69	2398.21	418.95	1979.26	643.89	1335.37	296.65	1038.72	2101.57	966.81	1.30	490.86	2101.57
9	31-Mar-40	100.0%	2647.51	63.72	2583.79	418.95	2164.84	536.58	1628.26	384.85	1243.41	2198.94	966.81	1.46	695.55	2198.94
10	31-Mar-41	100.0%	2848.22	66.91	2781.32	418.95	2362.37	429.26	1933.10	474.61	1458.49	2306.70	966.81	1.65	910.63	2306.70
11	31-Mar-42	100.0%	3065.55	70.25	2995.30	418.95	2576.35	321.95	2254.40	567.21	1687.19	2428.09	966.81	1.88	1139.33	2428.09
12	31-Mar-43	100.0%	3298.56	73.76	3224.80	418.95	2805.84	214.63	2591.21	662.54	1928.67	2562.25	966.81	2.17	1380.81	2562.25
13	31-Mar-44	100.0%	3547.76	77.45	3470.31	418.95	3051.36	107.32	2944.04	760.85	2183.20	2709.46	966.81	2.52	1635.34	2709.46
14	31-Mar-45	100.0%	3821.42	81.32	3740.10	418.95	3321.15	13.41	3307.73	860.94	2446.80	2879.16	483.40	5.80	2382.34	2879.16
15	31-Mar-46	100.0%	4114.94	85.39	4029.55	418.95	3610.60	0.00	3610.60	944.86	2665.74	3084.69	0.00		3084.69	3084.69
16	31-Mar-47	100.0%	4423.29	89.66	4333.63	418.95	3914.68	0.00	3914.68	1028.32	2886.36	3305.31			3305.31	3305.31
17	31-Mar-48	100.0%	4749.82	94.14	4655.68	418.95	4236.73	0.00	4236.73	1115.61	3121.12	3540.07			3540.07	3540.07
18	31-Mar-49	100.0%	5119.06	98.85	5020.20	418.95	4601.25	0.00	4601.25	1212.97	3388.29	3807.24			3807.24	3807.24
19	31-Mar-50	100.0%	5501.15	103.79	5397.36	418.95	4978.41	0.00	4978.41	1312.94	3665.46	4084.41			4084.41	4084.41
20	31-Mar-51	100.0%	5920.07	108.98	5811.08	418.95	5392.13	0.00	5392.13	1421.62	3970.52	4389.47			4389.47	4389.47
21	31-Mar-52	100.0%	6361.29	114.43	6246.86	418.95	5827.91	0.00	5827.91	1535.38	4292.52	4711.47			4711.47	4711.47
22	31-Mar-53	100.0%	6846.31	120.15	6726.15	418.95	6307.20	0.00	6307.20	1659.69	4647.51	5066.46			5066.46	5066.46
23	31-Mar-54	100.0%	7359.70	126.16	7233.54	418.95	6814.59	0.00	6814.59	1790.71	5023.88	5442.83			5442.83	5442.83
24	31-Mar-55	100.0%	7909.40	132.47	7776.93	418.95	7357.98	0.00	7357.98	1930.45	5427.53	5846.48			5846.48	5846.48
25	31-Mar-56	100.0%	8497.71	139.09	8358.61	418.95	7939.66	0.00	7939.66	2079.53	5860.13	6279.08			6279.08	6279.08
26	31-Mar-57	100.0%	9139.75	146.05	8993.70	418.95	8574.75	0.00	8574.75	2241.79	6332.96	6751.91			6751.91	6751.91
27	31-Mar-58	100.0%	9813.79	153.35	9660.44	418.95	9241.49	0.00	9241.49	2411.77	6829.72	7248.67			7248.67	7248.67
28	31-Mar-59	100.0%	10539.42	161.02	10378.40	418.95	9959.45	0.00	9959.45	2594.42	7365.03	7783.98			7783.98	7783.98
29	31-Mar-60	100.0%	11235.44	169.07	11066.37	418.95	10647.42	0.00	10647.42	2769.33	7878.09	8297.04			8297.04	8297.04
30	31-Mar-61	52.6%	6352.98	93.38	6259.60	220.38	6039.22	0.00	6039.22	1567.91	4471.31	4691.69			4691.69	4691.69
		Total	149129.67	2800.72	Pre- Tax IRR							Post Tax IRR		DSCR	Equity IRR	NPV
					14.57%							13.34%		1.68	14.32%	1340.83

ANNEXURE - BOT -TUNNEL -30% GRANT

Project Name: Bengaluru Tunnel Project from Hebbal to Silk board			
General Assumptions			
Bid Date	**10-Feb-25**	Construction start date	**10-Oct-25**
Construction Period in days	1825	No. years of construction	5.0
Construction End date	9-Oct-30	No. of years before COD	6
COD	10-Oct-30	Type of Pavement	Rigid
First FY year in Construction	31-Mar-25	WPI- Dec 2023	150.4
First FY in O & M period	31-Mar-31	WPI on Dec before COD	619.48
No. of days in first O & M year	173	Debt Repayment start date	30-Apr-31
Debt Repayment in years	13	Debt Repayment End date	30-Apr-44
% of days in first COD	47.4%	% of days in last O & M year	52.6%
WPI growth considered (yearly)	5.0%	**Maintenance Expenses (in crores)**	
Grant during construction	30.0%	Other office Expenses for 1st O & MYear	10.45
To be Arranged By contractor/Concessionaire	70%	Insurance	26.18
Equity	30%	Electricity & patrolling expenses for 1st O & M Year	0.87
Debt	70%	**Flexible Pavement in Lakhs**	
Interest on Debt	11.10%	Routine Maintenance (Every year) for 1st Year	0.000
No. of Lanes	6	Periodic Maintenance (Every 6 th year)	0.000
Fully Access Controlled Expressway	No	**Rigid Pavement In Lakhs**	
Financing Cost on debt %	1.0%	Routine Maintenance (Every year) for 1st Year	357.11
Road Length			
Flexible Pavement - MCW Road		**Rigid Pavement - MCW Road**	
Length of 2 lane section	0.00	Length of 2 lane section	0.00
Length of 4 lane section	0	Length of 4 lane section	0
Length of 6 lane section	0	Length of 6 lane section	16.687
Total 4 lane Equivalent Length	**0.00**	**Total 4 lane Equivalent Length**	**25.03**
Flexible Pavement - SR Road		**Rigid Pavement - SR Road**	
Length of 2 lane section	0	Length of 2 lane section	17.24
Length of 4 lane section	0	Length of 4 lane section	0
Length of 6 lane section	0	Length of 6 lane section	0
Total 4 lane Equivalent Length	**0.00**	**Total 4 lane Equivalent Length**	**8.62**
		Det Repayment Years (from Start of Construction)	13

Costing Details (in Crores)	
Length of Corridor	16.687
Total Civil Cost	11637.51
Other costs	4073.13
Total Project cost	15710.64

Tax Assumptions			
Corporate Tax Rate			
Section 15BAA opted	Yes		
Case I		**Case II**	
If income exceeds Rs. 1 cr. but not exceeding 400 Cr.		**If income exceeds Rs. 400 cr.**	
Base rate	22%	Base rate	22%
Surcharge	10%	Surcharge	10%
Cess	4%	Cess	4%
Total Applicable Tax	**25.2%**	**Total Applicable Tax**	**25.2%**
MAT Tax Rate			
Case I		**Case II**	
Base rate	0.0%	Base rate	0.0%
Surcharge	10%	Surcharge	10%
Cess	4%	Cess	4%
Total Applicable Tax	**0.0%**	**Total Applicable Tax**	**0.0%**

Project Name: Bengaluru Tunnel Project from Hebbal to Silk board

Cash Flow Statement (In crores)-5 Years of Construction period - 25 years O& M Period

	VGF	30.00%			PBDIT		Section 15 BAA Opted			Yes	No. of O & M Years		25	D/E Ratio		2.33
S. No.	Year	% of days	Revenue	Expenses	Net Income	Depreciation	PBIT	Interest on Debt	Profit Before Tax (PBT)	TAX	Profit After Tax (PAT)	Net operating Income after Tax	Repayment	DSCR	Net Cash flow	NPV
-5	31-Mar-26				-1036.47		-1036.47		-1036.47			-1036.47			-310.94	-1036.47
-4	31-Mar-27				-2199.49		-2199.49		-2199.49			-2199.49			-659.85	-2199.49
-3	31-Mar-28				-2205.52		-2205.52		-2205.52			-2205.52			-661.65	-2205.52
-2	31-Mar-29				-2199.49		-2199.49		-2199.49			-2199.49			-659.85	-2199.49
-1	31-Mar-30				-2199.49		-2199.49		-2199.49			-2199.49			-659.85	-2199.49
0	31-Mar-31	47.4%	617.18	19.47	-559.28	208.50	-767.78	0.00	-767.78	0.00	-767.78	-559.28	0.00		-347.10	-559.28
1	31-Mar-32	100.0%	1460.46	43.13	1417.33	439.90	977.43	598.62	378.81	0.00	378.81	1417.33	422.98	1.39	395.73	1417.33
2	31-Mar-33	100.0%	1573.54	45.28	1528.25	439.90	1088.36	1126.82	-38.46	0.00	-38.46	1528.25	845.96	0.77	-444.52	1528.25
3	31-Mar-34	100.0%	1695.87	47.55	1648.32	439.90	1208.42	1032.91	175.51	0.00	175.51	1648.32	845.96	0.88	-230.55	1648.32
4	31-Mar-35	100.0%	1829.08	49.93	1779.15	439.90	1339.25	939.01	400.24	18.23	382.01	1760.92	845.96	0.99	-24.05	1760.92
5	31-Mar-36	100.0%	1971.79	52.42	1919.37	439.90	1479.47	845.11	634.36	96.47	537.88	1822.89	845.96	1.08	131.82	1822.89
6	31-Mar-37	100.0%	2123.50	55.04	2068.46	439.90	1628.56	751.21	877.35	175.02	702.33	1893.44	845.96	1.19	296.27	1893.44
7	31-Mar-38	100.0%	2286.23	57.80	2228.44	439.90	1788.54	657.31	1131.23	254.57	876.66	1973.87	845.96	1.31	470.60	1973.87
8	31-Mar-39	100.0%	2458.90	60.69	2398.21	439.90	1958.32	563.41	1394.91	335.01	1059.89	2063.20	845.96	1.46	653.83	2063.20
9	31-Mar-40	100.0%	2647.51	63.72	2583.79	439.90	2143.89	469.51	1674.38	418.03	1256.35	2165.76	845.96	1.65	850.29	2165.76
10	31-Mar-41	100.0%	2848.22	66.91	2781.32	439.90	2341.42	375.61	1965.81	502.79	1463.03	2278.53	845.96	1.87	1056.97	2278.53
11	31-Mar-42	100.0%	3065.55	70.25	2995.30	439.90	2555.40	281.70	2273.69	590.54	1683.15	2404.75	845.96	2.13	1277.09	2404.75
12	31-Mar-43	100.0%	3298.56	73.76	3224.80	439.90	2784.90	187.80	2597.09	681.18	1915.92	2543.62	845.96	2.46	1509.86	2543.62
13	31-Mar-44	100.0%	3547.76	77.45	3470.31	439.90	3030.41	93.90	2936.51	774.92	2161.59	2695.39	845.96	2.87	1755.53	2695.39
14	31-Mar-45	100.0%	3821.42	81.32	3740.10	439.90	3300.20	11.74	3288.46	870.98	2417.48	2869.11	422.98	6.60	2434.40	2869.11
15	31-Mar-46	100.0%	4114.94	85.39	4029.55	439.90	3589.65	0.00	3589.65	953.52	2636.13	3076.02	0.00		3076.02	3076.02
16	31-Mar-47	100.0%	4423.29	89.66	4333.63	439.90	3893.73	0.00	3893.73	1036.12	2857.61	3297.51			3297.51	3297.51
17	31-Mar-48	100.0%	4749.82	94.14	4655.68	439.90	4215.78	0.00	4215.78	1122.63	3093.15	3533.05			3533.05	3533.05
18	31-Mar-49	100.0%	5119.06	98.85	5020.20	439.90	4580.31	0.00	4580.31	1219.28	3361.02	3800.92			3800.92	3800.92
19	31-Mar-50	100.0%	5501.15	103.79	5397.36	439.90	4957.46	0.00	4957.46	1318.62	3638.83	4078.73			4078.73	4078.73
20	31-Mar-51	100.0%	5920.07	108.98	5811.08	439.90	5371.19	0.00	5371.19	1426.73	3944.46	4384.35			4384.35	4384.35
21	31-Mar-52	100.0%	6361.29	114.43	6246.86	439.90	5806.96	0.00	5806.96	1539.99	4266.97	4706.87			4706.87	4706.87
22	31-Mar-53	100.0%	6846.31	120.15	6726.15	439.90	6286.26	0.00	6286.26	1663.84	4622.42	5062.32			5062.32	5062.32
23	31-Mar-54	100.0%	7359.70	126.16	7233.54	439.90	6793.64	0.00	6793.64	1794.44	4999.20	5439.10			5439.10	5439.10
24	31-Mar-55	100.0%	7909.40	132.47	7776.93	439.90	7337.03	0.00	7337.03	1933.81	5403.22	5843.12			5843.12	5843.12
25	31-Mar-56	52.6%	4470.03	73.17	4396.86	231.40	4165.46	0.00	4165.46	1095.48	3069.98	3301.38			3301.38	3301.38
		Total	98020.61	2011.93	Pre- Tax IRR							Post Tax IRR		DSCR	Equity IRR	NPV
					15.18%							13.86%		1.90	15.36%	1476.00

Project Name: Bengaluru Tunnel Project from Hebbal to Silk board

Cash Flow Statement (In crores)-5 Years of Construction period - 30 years O& M Period																
	VGF	30.00%			PBDIT		Section 15 BAA Opted			Yes	No. of O & M Years		30	D/E Ratio		2.33
S. No.	Year	% of days	Revenue	Expenses	Net Income	Depreciation	PBIT	Interest on Debt	Profit Before Tax (PBT)	TAX	Profit After Tax (PAT)	Net operating Income after Tax	Repayment	DSCR	Net Cash flow	NPV
-5	31-Mar-26				-1036.47		-1036.47		-1036.47			-1036.47			-310.94	-1036.47
-4	31-Mar-27				-2199.49		-2199.49		-2199.49			-2199.49			-659.85	-2199.49
-3	31-Mar-28				-2205.52		-2205.52		-2205.52			-2205.52			-661.65	-2205.52
-2	31-Mar-29				-2199.49		-2199.49		-2199.49			-2199.49			-659.85	-2199.49
-1	31-Mar-30				-2199.49		-2199.49		-2199.49			-2199.49			-659.85	-2199.49
0	31-Mar-31	47.4%	617.18	19.47	-559.28	173.75	-733.03	0.00	-733.03	0.00	-733.03	-559.28	0.00		-347.10	-559.28
1	31-Mar-32	100.0%	1460.46	43.13	1417.33	366.58	1050.75	598.62	452.13	0.00	452.13	1417.33	422.98	1.39	395.73	1417.33
2	31-Mar-33	100.0%	1573.54	45.28	1528.25	366.58	1161.67	1126.82	34.86	0.00	34.86	1528.25	845.96	0.77	-444.52	1528.25
3	31-Mar-34	100.0%	1695.87	47.55	1648.32	366.58	1281.74	1032.91	248.82	0.00	248.82	1648.32	845.96	0.88	-230.55	1648.32
4	31-Mar-35	100.0%	1829.08	49.93	1779.15	366.58	1412.57	939.01	473.56	18.23	455.33	1760.92	845.96	0.99	-24.05	1760.92
5	31-Mar-36	100.0%	1971.79	52.42	1919.37	366.58	1552.78	845.11	707.67	96.47	611.20	1822.89	845.96	1.08	131.82	1822.89
6	31-Mar-37	100.0%	2123.50	55.04	2068.46	366.58	1701.88	751.21	950.67	175.02	775.65	1893.44	845.96	1.19	296.27	1893.44
7	31-Mar-38	100.0%	2286.23	57.80	2228.44	366.58	1861.85	657.31	1204.55	254.57	949.98	1973.87	845.96	1.31	470.60	1973.87
8	31-Mar-39	100.0%	2458.90	60.69	2398.21	366.58	2031.63	563.41	1468.22	335.01	1133.21	2063.20	845.96	1.46	653.83	2063.20
9	31-Mar-40	100.0%	2647.51	63.72	2583.79	366.58	2217.21	469.51	1747.70	418.03	1329.67	2165.76	845.96	1.65	850.29	2165.76
10	31-Mar-41	100.0%	2848.22	66.91	2781.32	366.58	2414.74	375.61	2039.13	502.79	1536.34	2278.53	845.96	1.87	1056.97	2278.53
11	31-Mar-42	100.0%	3065.55	70.25	2995.30	366.58	2628.71	281.70	2347.01	590.54	1756.47	2404.75	845.96	2.13	1277.09	2404.75
12	31-Mar-43	100.0%	3298.56	73.76	3224.80	366.58	2858.21	187.80	2670.41	681.18	1989.23	2543.62	845.96	2.46	1509.86	2543.62
13	31-Mar-44	100.0%	3547.76	77.45	3470.31	366.58	3103.73	93.90	3009.83	774.92	2234.91	2695.39	845.96	2.87	1755.53	2695.39
14	31-Mar-45	100.0%	3821.42	81.32	3740.10	366.58	3373.51	11.74	3361.78	870.98	2490.79	2869.11	422.98	6.60	2434.40	2869.11
15	31-Mar-46	100.0%	4114.94	85.39	4029.55	366.58	3662.96	0.00	3662.96	953.52	2709.44	3076.02	0.00		3076.02	3076.02
16	31-Mar-47	100.0%	4423.29	89.66	4333.63	366.58	3967.05	0.00	3967.05	1036.12	2930.93	3297.51			3297.51	3297.51
17	31-Mar-48	100.0%	4749.82	94.14	4655.68	366.58	4289.10	0.00	4289.10	1122.63	3166.47	3533.05			3533.05	3533.05
18	31-Mar-49	100.0%	5119.06	98.85	5020.20	366.58	4653.62	0.00	4653.62	1219.28	3434.34	3800.92			3800.92	3800.92
19	31-Mar-50	100.0%	5501.15	103.79	5397.36	366.58	5030.78	0.00	5030.78	1318.62	3712.15	4078.73			4078.73	4078.73
20	31-Mar-51	100.0%	5920.07	108.98	5811.08	366.58	5444.50	0.00	5444.50	1426.73	4017.77	4384.35			4384.35	4384.35
21	31-Mar-52	100.0%	6361.29	114.43	6246.86	366.58	5880.28	0.00	5880.28	1539.99	4340.29	4706.87			4706.87	4706.87
22	31-Mar-53	100.0%	6846.31	120.15	6726.15	366.58	6359.57	0.00	6359.57	1663.84	4695.73	5062.32			5062.32	5062.32
23	31-Mar-54	100.0%	7359.70	126.16	7233.54	366.58	6866.95	0.00	6866.95	1794.44	5072.52	5439.10			5439.10	5439.10
24	31-Mar-55	100.0%	7909.40	132.47	7776.93	366.58	7410.35	0.00	7410.35	1933.81	5476.54	5843.12			5843.12	5843.12
25	31-Mar-56	100.0%	8497.71	139.09	8358.61	366.58	7992.03	0.00	7992.03	2082.55	5909.48	6276.06			6276.06	6276.06
26	31-Mar-57	100.0%	9139.75	146.05	8993.70	366.58	8627.12	0.00	8627.12	2244.51	6382.61	6749.19			6749.19	6749.19
27	31-Mar-58	100.0%	9813.79	153.35	9660.44	366.58	9293.86	0.00	9293.86	2414.22	6879.65	7246.23			7246.23	7246.23
28	31-Mar-59	100.0%	10539.42	161.02	10378.40	366.58	10011.82	0.00	10011.82	2596.62	7415.19	7781.77			7781.77	7781.77
29	31-Mar-60	100.0%	11235.44	169.07	11066.37	366.58	10699.79	0.00	10699.79	2771.31	7928.48	8295.06			8295.06	8295.06
30	31-Mar-61	52.6%	6352.98	93.38	6259.60	192.83	6066.77	0.00	6066.77	1568.85	4497.92	4690.75			4690.75	4690.75
		Total	149129.67	2800.72	Pre- Tax IRR							Post Tax IRR		DSCR	Equity IRR	NPV
					15.74%							14.45%		1.90	16.19%	2227.68

ANNEXURE - BOT -TUNNEL -40% GRANT

Project Name: Bengaluru Tunnel Project from Hebbal to Silk board			
General Assumptions			
Bid Date	**10-Feb-25**	Construction start date	**10-Oct-25**
Construction Period in days	1825	No. years of construction	5.0
Construction End date	9-Oct-30	No. of years before COD	6
COD	10-Oct-30	Type of Pavement	Rigid
First FY year in Construction	31-Mar-25	WPI- Dec 2023	150.4
First FY in O & M period	31-Mar-31	WPI on Dec before COD	619.48
No. of days in first O & M year	173	Debt Repayment start date	30-Apr-31
Debt Repayment in years	13	Debt Repayment End date	30-Apr-44
% of days in first COD	47.4%	% of days in last O & M year	52.6%
WPI growth considered (yearly)	5.0%	**Maintenance Expenses (in crores)**	
Grant during construction	40.0%	Other office Expenses for 1st O & MYear	10.45
To be Arranged By contractor/Concessionaire	60%	Insurance	26.18
Equity	30%	Electricity & patrolling expenses for 1st O & M Year	0.87
Debt	70%	**Flexible Pavement in Lakhs**	
Interest on Debt	11.10%	Routine Maintenance (Every year) for 1st Year	0.000
No. of Lanes	6	Periodic Maintenance (Every 6 th year)	0.000
Fully Access Controlled Expressway	No	**Rigid Pavement In Lakhs**	
Financing Cost on debt %	1.0%	Routine Maintenance (Every year) for 1st Year	357.11
Road Length			
Flexible Pavement - MCW Road		**Rigid Pavement - MCW Road**	
Length of 2 lane section	0.00	Length of 2 lane section	0.00
Length of 4 lane section	0	Length of 4 lane section	0
Length of 6 lane section	0	Length of 6 lane section	16.687
Total 4 lane Equivalent Length	**0.00**	**Total 4 lane Equivalent Length**	**25.03**
Flexible Pavement - SR Road		**Rigid Pavement - SR Road**	
Length of 2 lane section	0	Length of 2 lane section	17.24
Length of 4 lane section	0	Length of 4 lane section	0
Length of 6 lane section	0	Length of 6 lane section	0
Total 4 lane Equivalent Length	**0.00**	**Total 4 lane Equivalent Length**	**8.62**
		Det Repayment Years (from Start of Construction)	13

Costing Details (in Crores)	
Length of Corridor	16.687
Total Civil Cost	11637.51
Other costs	4073.13
Total Project cost	15710.64

Tax Assumptions			
Corporate Tax Rate			
Section 15BAA opted	Yes		
Case I		**Case II**	
If income exceeds Rs. 1 cr. but not exceeding 400 Cr.		**If income exceeds Rs. 400 cr.**	
Base rate	22%	Base rate	22%
Surcharge	10%	Surcharge	10%
Cess	4%	Cess	4%
Total Applicable Tax	**25.2%**	**Total Applicable Tax**	**25.2%**
MAT Tax Rate			
Case I		**Case II**	
Base rate	0.0%	Base rate	0.0%
Surcharge	10%	Surcharge	10%
Cess	4%	Cess	4%
Total Applicable Tax	**0.0%**	**Total Applicable Tax**	**0.0%**

Project Name: Bengaluru Tunnel Project from Hebbal to Silk board

Cash Flow Statement (In crores)-5 Years of Construction period - 25 years O& M Period															
	VGF	40.00%			PBDIT		Section 15 BAA Opted			Yes	No. of O & M Years		25	D/E Ratio		2.33
S. No.	Year	% of days	Revenue	Expenses	Net Income	Depreciation	PBIT	Interest on Debt	Profit Before Tax (PBT)	TAX	Profit After Tax (PAT)	Net operating Income after Tax	Repayment	DSCR	Net Cash flow	NPV
-5	31-Mar-26				-888.40		-888.40		-888.40			-888.40			-266.52	-888.40
-4	31-Mar-27				-1885.28		-1885.28		-1885.28			-1885.28			-565.58	-1885.28
-3	31-Mar-28				-1890.44		-1890.44		-1890.44			-1890.44			-567.13	-1890.44
-2	31-Mar-29				-1885.28		-1885.28		-1885.28			-1885.28			-565.58	-1885.28
-1	31-Mar-30				-1885.28		-1885.28		-1885.28			-1885.28			-565.58	-1885.28
0	31-Mar-31	47.4%	617.18	19.47	-393.99	178.71	-572.70	0.00	-572.70	0.00	-572.70	-393.99	0.00		-297.51	-393.99
1	31-Mar-32	100.0%	1460.46	43.13	1417.33	377.06	1040.27	513.10	527.17	0.39	526.78	1416.93	362.55	1.62	541.28	1416.93
2	31-Mar-33	100.0%	1573.54	45.28	1528.25	377.06	1151.20	965.84	185.36	0.00	185.36	1528.25	725.11	0.90	-162.69	1528.25
3	31-Mar-34	100.0%	1695.87	47.55	1648.32	377.06	1271.27	885.35	385.91	8.01	377.90	1640.31	725.11	1.02	29.85	1640.31
4	31-Mar-35	100.0%	1829.08	49.93	1779.15	377.06	1402.10	804.87	597.23	79.59	517.64	1699.56	725.11	1.11	169.59	1699.56
5	31-Mar-36	100.0%	1971.79	52.42	1919.37	377.06	1542.31	724.38	817.93	151.70	666.23	1767.67	725.11	1.22	318.18	1767.67
6	31-Mar-37	100.0%	2123.50	55.04	2068.46	377.06	1691.40	643.89	1047.51	224.39	823.12	1844.07	725.11	1.35	475.07	1844.07
7	31-Mar-38	100.0%	2286.23	57.80	2228.44	377.06	1851.38	563.41	1287.97	298.32	989.65	1930.12	725.11	1.50	641.60	1930.12
8	31-Mar-39	100.0%	2458.90	60.69	2398.21	377.06	2021.16	482.92	1538.24	373.38	1164.86	2024.83	725.11	1.68	816.81	2024.83
9	31-Mar-40	100.0%	2647.51	63.72	2583.79	377.06	2206.73	402.43	1804.30	451.21	1353.09	2132.58	725.11	1.89	1005.04	2132.58
10	31-Mar-41	100.0%	2848.22	66.91	2781.32	377.06	2404.26	321.95	2082.31	530.96	1551.35	2250.36	725.11	2.15	1203.30	2250.36
11	31-Mar-42	100.0%	3065.55	70.25	2995.30	377.06	2618.24	241.46	2376.78	613.87	1762.91	2381.42	725.11	2.46	1414.86	2381.42
12	31-Mar-43	100.0%	3298.56	73.76	3224.80	377.06	2847.74	160.97	2686.77	699.81	1986.96	2524.98	725.11	2.85	1638.90	2524.98
13	31-Mar-44	100.0%	3547.76	77.45	3470.31	377.06	3093.25	80.49	3012.77	788.99	2223.78	2681.32	725.11	3.33	1875.73	2681.32
14	31-Mar-45	100.0%	3821.42	81.32	3740.10	377.06	3363.04	10.06	3352.98	881.03	2471.95	2859.07	362.55	7.67	2486.45	2859.07
15	31-Mar-46	100.0%	4114.94	85.39	4029.55	377.06	3652.49	0.00	3652.49	962.18	2690.31	3067.36	0.00		3067.36	3067.36
16	31-Mar-47	100.0%	4423.29	89.66	4333.63	377.06	3956.57	0.00	3956.57	1043.91	2912.66	3289.72			3289.72	3289.72
17	31-Mar-48	100.0%	4749.82	94.14	4655.68	377.06	4278.63	0.00	4278.63	1129.64	3148.98	3526.04			3526.04	3526.04
18	31-Mar-49	100.0%	5119.06	98.85	5020.20	377.06	4643.15	0.00	4643.15	1225.60	3417.55	3794.61			3794.61	3794.61
19	31-Mar-50	100.0%	5501.15	103.79	5397.36	377.06	5020.30	0.00	5020.30	1324.31	3695.99	4073.05			4073.05	4073.05
20	31-Mar-51	100.0%	5920.07	108.98	5811.08	377.06	5434.03	0.00	5434.03	1431.84	4002.18	4379.24			4379.24	4379.24
21	31-Mar-52	100.0%	6361.29	114.43	6246.86	377.06	5869.80	0.00	5869.80	1544.59	4325.21	4702.27			4702.27	4702.27
22	31-Mar-53	100.0%	6846.31	120.15	6726.15	377.06	6349.10	0.00	6349.10	1667.98	4681.12	5058.17			5058.17	5058.17
23	31-Mar-54	100.0%	7359.70	126.16	7233.54	377.06	6856.48	0.00	6856.48	1798.16	5058.32	5435.37			5435.37	5435.37
24	31-Mar-55	100.0%	7909.40	132.47	7776.93	377.06	7399.87	0.00	7399.87	1937.16	5462.71	5839.77			5839.77	5839.77
25	31-Mar-56	52.6%	4470.03	73.17	4396.86	198.34	4198.52	0.00	4198.52	1097.07	3101.45	3299.79			3299.79	3299.79
		Total	98020.61	2011.93	Pre- Tax IRR							Post Tax IRR		DSCR	Equity IRR	NPV
					16.71%							15.29%		2.20	17.92%	2347.96

Project Name: Bengaluru Tunnel Project from Hebbal to Silk board

Cash Flow Statement (In crores)-5 Years of Construction period - 30 years O& M Period																
	VGF	40.00%			PBDIT		Section 15 BAA Opted			Yes	No. of O & M Years		30	D/E Ratio		2.33
S. No.	Year	% of days	Revenue	Expenses	Net Income	Depreciation	PBIT	Interest on Debt	Profit Before Tax (PBT)	TAX	Profit After Tax (PAT)	Net operating Income after Tax	Repayment	DSCR	Net Cash flow	NPV
-5	31-Mar-26				-888.40		-888.40		-888.40			-888.40			-266.52	-888.40
-4	31-Mar-27				-1885.28		-1885.28		-1885.28			-1885.28			-565.58	-1885.28
-3	31-Mar-28				-1890.44		-1890.44		-1890.44			-1890.44			-567.13	-1890.44
-2	31-Mar-29				-1885.28		-1885.28		-1885.28			-1885.28			-565.58	-1885.28
-1	31-Mar-30				-1885.28		-1885.28		-1885.28			-1885.28			-565.58	-1885.28
0	31-Mar-31	47.4%	617.18	19.47	-393.99	148.93	-542.92	0.00	-542.92	0.00	-542.92	-393.99	0.00		-297.51	-393.99
1	31-Mar-32	100.0%	1460.46	43.13	1417.33	314.21	1103.12	513.10	590.01	0.39	589.62	1416.93	362.55	1.62	541.28	1416.93
2	31-Mar-33	100.0%	1573.54	45.28	1528.25	314.21	1214.04	965.84	248.20	0.00	248.20	1528.25	725.11	0.90	-162.69	1528.25
3	31-Mar-34	100.0%	1695.87	47.55	1648.32	314.21	1334.11	885.35	448.75	8.01	440.75	1640.31	725.11	1.02	29.85	1640.31
4	31-Mar-35	100.0%	1829.08	49.93	1779.15	314.21	1464.94	804.87	660.07	79.59	580.48	1699.56	725.11	1.11	169.59	1699.56
5	31-Mar-36	100.0%	1971.79	52.42	1919.37	314.21	1605.15	724.38	880.77	151.70	729.07	1767.67	725.11	1.22	318.18	1767.67
6	31-Mar-37	100.0%	2123.50	55.04	2068.46	314.21	1754.25	643.89	1110.35	224.39	885.97	1844.07	725.11	1.35	475.07	1844.07
7	31-Mar-38	100.0%	2286.23	57.80	2228.44	314.21	1914.22	563.41	1350.82	298.32	1052.49	1930.12	725.11	1.50	641.60	1930.12
8	31-Mar-39	100.0%	2458.90	60.69	2398.21	314.21	2084.00	482.92	1601.08	373.38	1227.70	2024.83	725.11	1.68	816.81	2024.83
9	31-Mar-40	100.0%	2647.51	63.72	2583.79	314.21	2269.58	402.43	1867.14	451.21	1415.93	2132.58	725.11	1.89	1005.04	2132.58
10	31-Mar-41	100.0%	2848.22	66.91	2781.32	314.21	2467.10	321.95	2145.16	530.96	1614.20	2250.36	725.11	2.15	1203.30	2250.36
11	31-Mar-42	100.0%	3065.55	70.25	2995.30	314.21	2681.08	241.46	2439.62	613.87	1825.75	2381.42	725.11	2.46	1414.86	2381.42
12	31-Mar-43	100.0%	3298.56	73.76	3224.80	314.21	2910.58	160.97	2749.61	699.81	2049.80	2524.98	725.11	2.85	1638.90	2524.98
13	31-Mar-44	100.0%	3547.76	77.45	3470.31	314.21	3156.10	80.49	3075.61	788.99	2286.62	2681.32	725.11	3.33	1875.73	2681.32
14	31-Mar-45	100.0%	3821.42	81.32	3740.10	314.21	3425.88	10.06	3415.82	881.03	2534.79	2859.07	362.55	7.67	2486.45	2859.07
15	31-Mar-46	100.0%	4114.94	85.39	4029.55	314.21	3715.33	0.00	3715.33	962.18	2753.15	3067.36	0.00		3067.36	3067.36
16	31-Mar-47	100.0%	4423.29	89.66	4333.63	314.21	4019.42	0.00	4019.42	1043.91	2975.50	3289.72			3289.72	3289.72
17	31-Mar-48	100.0%	4749.82	94.14	4655.68	314.21	4341.47	0.00	4341.47	1129.64	3211.82	3526.04			3526.04	3526.04
18	31-Mar-49	100.0%	5119.06	98.85	5020.20	314.21	4705.99	0.00	4705.99	1225.60	3480.39	3794.61			3794.61	3794.61
19	31-Mar-50	100.0%	5501.15	103.79	5397.36	314.21	5083.14	0.00	5083.14	1324.31	3758.84	4073.05			4073.05	4073.05
20	31-Mar-51	100.0%	5920.07	108.98	5811.08	314.21	5496.87	0.00	5496.87	1431.84	4065.03	4379.24			4379.24	4379.24
21	31-Mar-52	100.0%	6361.29	114.43	6246.86	314.21	5932.64	0.00	5932.64	1544.59	4388.06	4702.27			4702.27	4702.27
22	31-Mar-53	100.0%	6846.31	120.15	6726.15	314.21	6411.94	0.00	6411.94	1667.98	4743.96	5058.17			5058.17	5058.17
23	31-Mar-54	100.0%	7359.70	126.16	7233.54	314.21	6919.32	0.00	6919.32	1798.16	5121.16	5435.37			5435.37	5435.37
24	31-Mar-55	100.0%	7909.40	132.47	7776.93	314.21	7462.72	0.00	7462.72	1937.16	5525.55	5839.77			5839.77	5839.77
25	31-Mar-56	100.0%	8497.71	139.09	8358.61	314.21	8044.40	0.00	8044.40	2085.57	5958.83	6273.04			6273.04	6273.04
26	31-Mar-57	100.0%	9139.75	146.05	8993.70	314.21	8679.49	0.00	8679.49	2247.23	6432.26	6746.48			6746.48	6746.48
27	31-Mar-58	100.0%	9813.79	153.35	9660.44	314.21	9346.23	0.00	9346.23	2416.66	6929.57	7243.78			7243.78	7243.78
28	31-Mar-59	100.0%	10539.42	161.02	10378.40	314.21	10064.18	0.00	10064.18	2598.82	7465.36	7779.57			7779.57	7779.57
29	31-Mar-60	100.0%	11235.44	169.07	11066.37	314.21	10752.16	0.00	10752.16	2773.29	7978.86	8293.08			8293.08	8293.08
30	31-Mar-61	52.6%	6352.98	93.38	6259.60	165.28	6094.32	0.00	6094.32	1569.79	4524.53	4689.81			4689.81	4689.81
		Total	149129.67	2800.72	Pre- Tax IRR							Post Tax IRR		DSCR	Equity IRR	NPV
					17.18%							15.80%		2.20	18.55%	3099.41

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