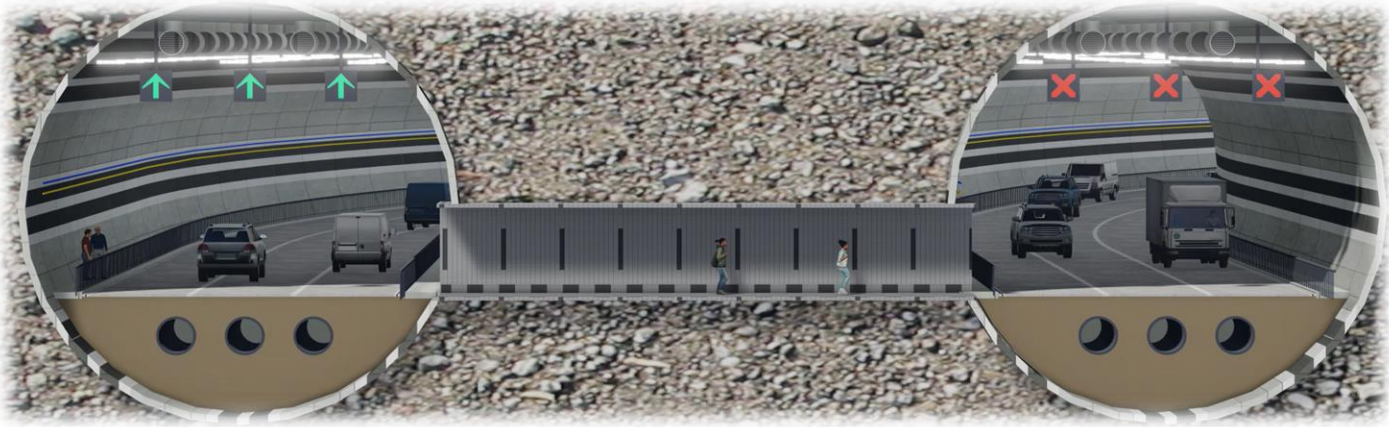
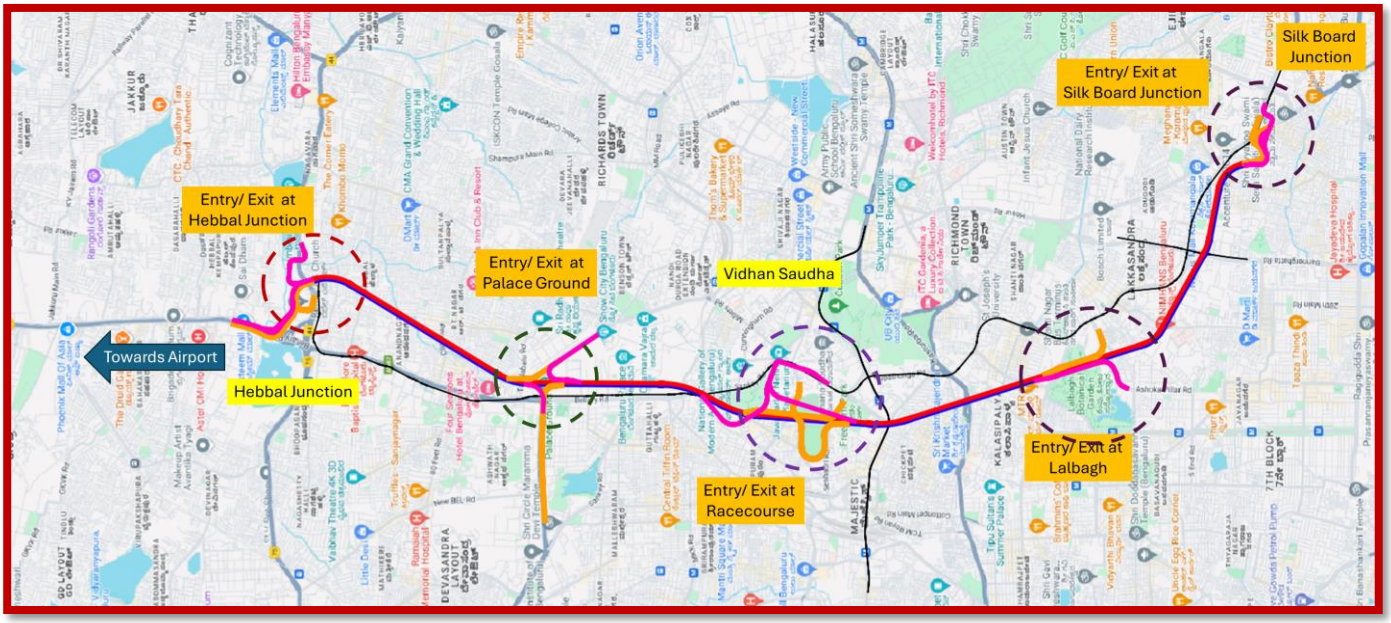
GOVERNMENT OF KARNATAKA



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

EXECUTIVE SUMMARY

September 2024

Rodic
ENGINEERING. PASSION

RODIC CONSULTANTS PVT. LTD

BRUHAT BENGALURU MAHANAGARA PALIKE

DOCUMENT SUMMARY SHEET

Doc. No.	DGN-1640-HO-DPR-2024/0018	**Rodic Consultants Private Limited**
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Date	24th September 2024	
Page no.	61	
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	***Executive Summary***	

Name and Designation				
Owner	**Rodic Consultants Pvt. Ltd.**			
Prepared By	***Name & Designation***	***Remarks***	***Name & Designation***	***Remarks***
	Mr. Ravi Ranjan	Ok		
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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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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.

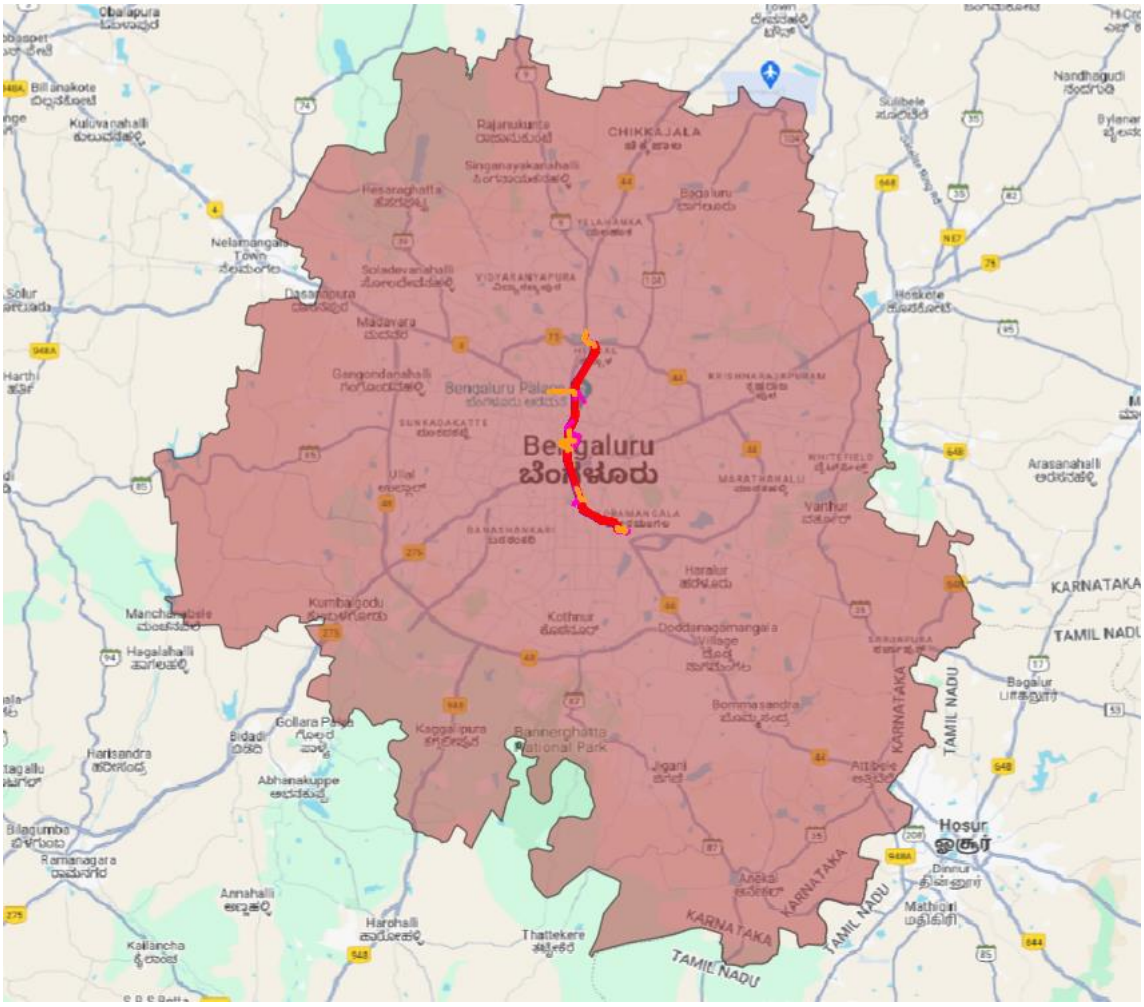


Figure 1: Project Location in Bangaluru Administrative Boundary

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.

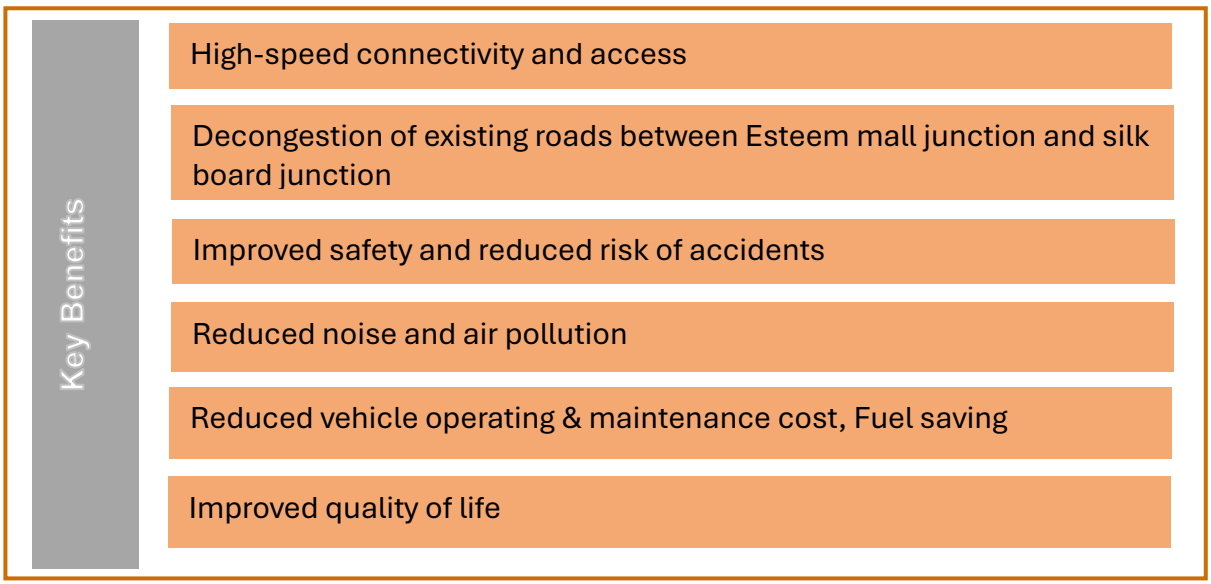


Figure 2: Project Key Benefit

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.

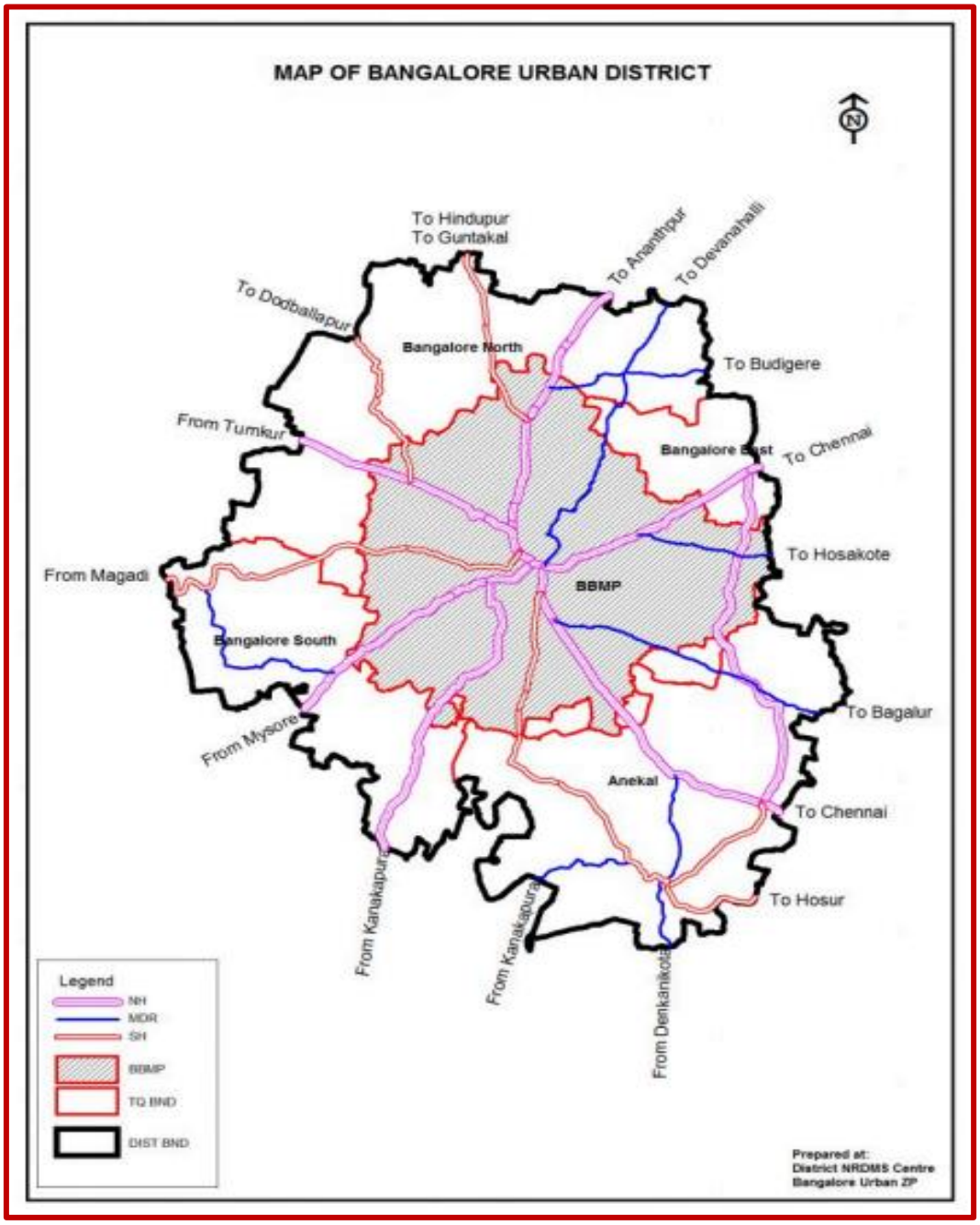


Figure 3: Bengaluru Districts Map

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.

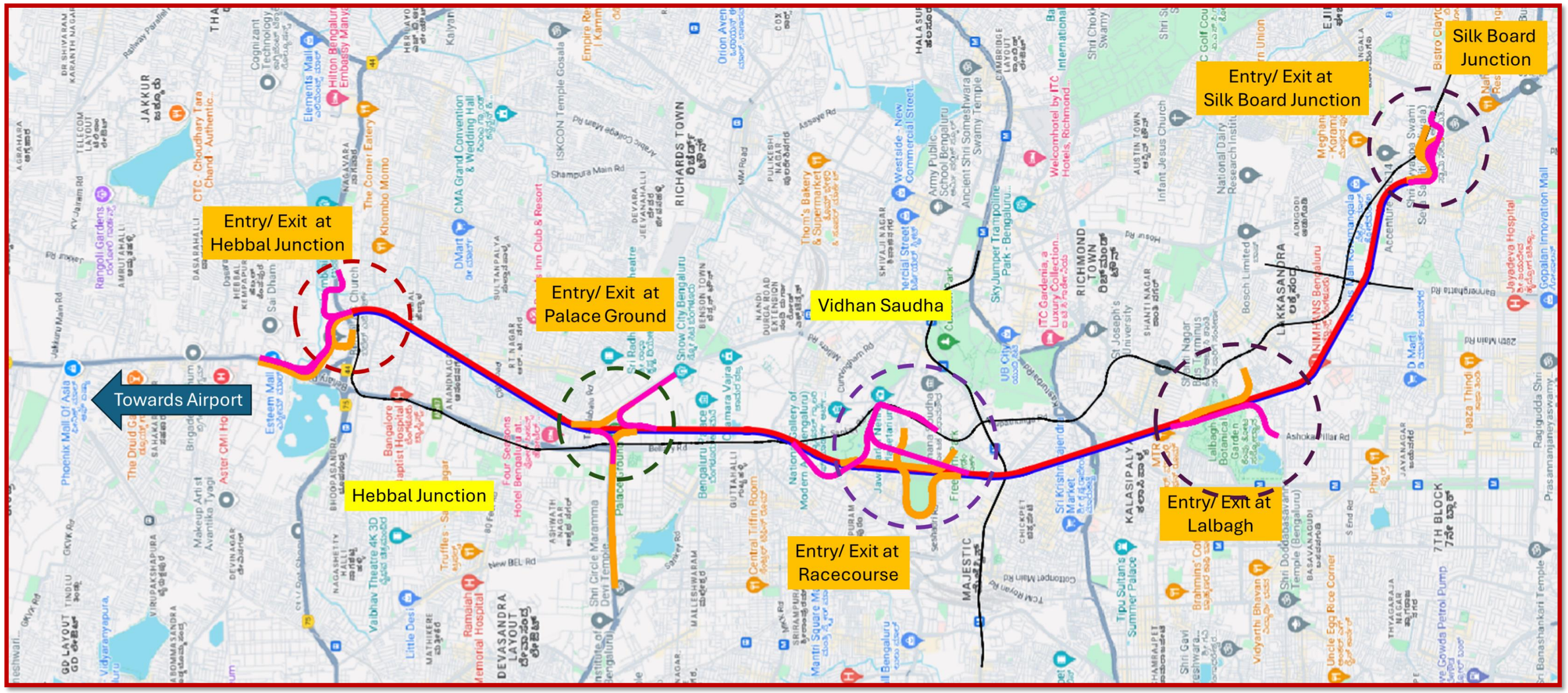


Figure 4: Project Alignment

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	1.906 Kms	From Palace Road	2 Lane

Sr. No.	Location	Description	Length	Direction Of Traffic	Lane Configuration
		Main Tunnel		Towards Silk Board 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.

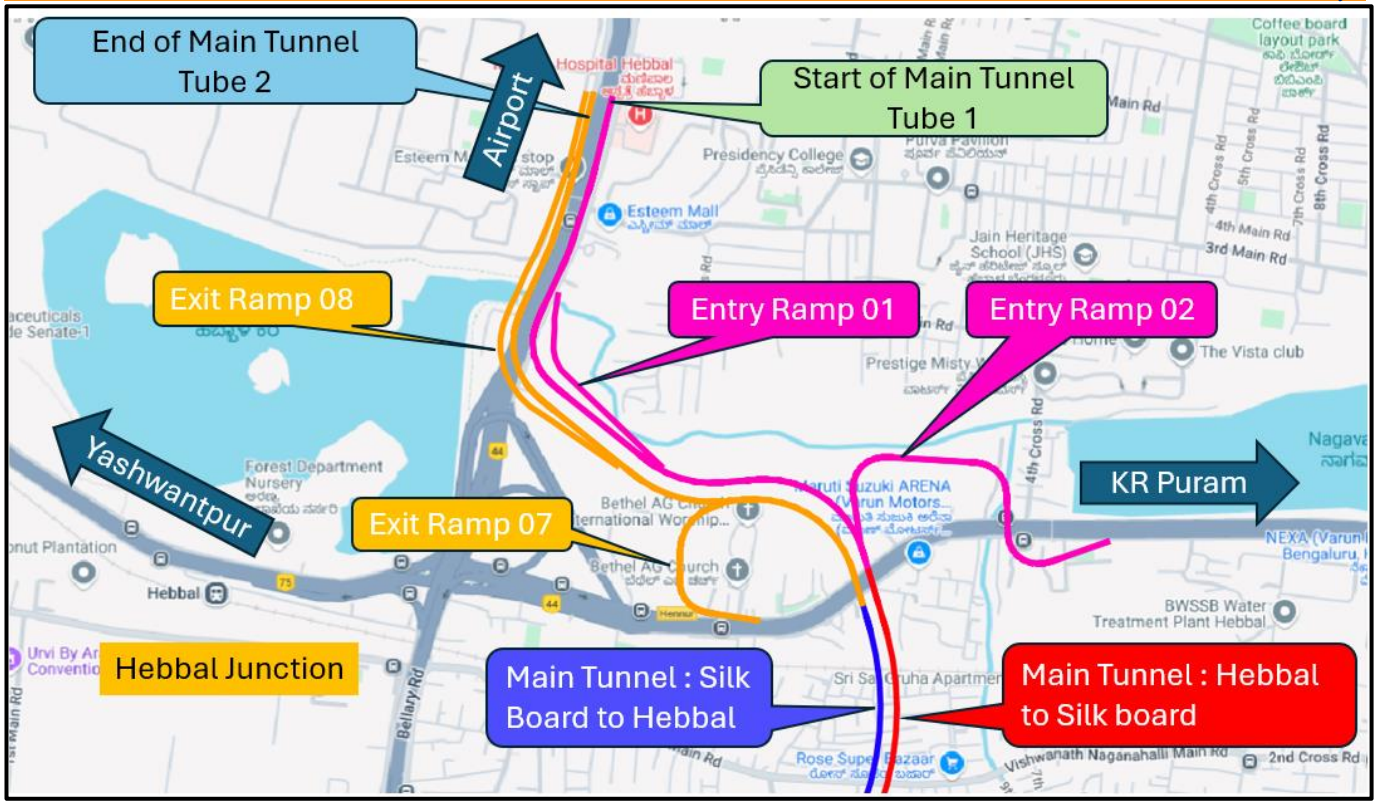


Figure 5: Entry and Exit at Hebbal Junction

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.

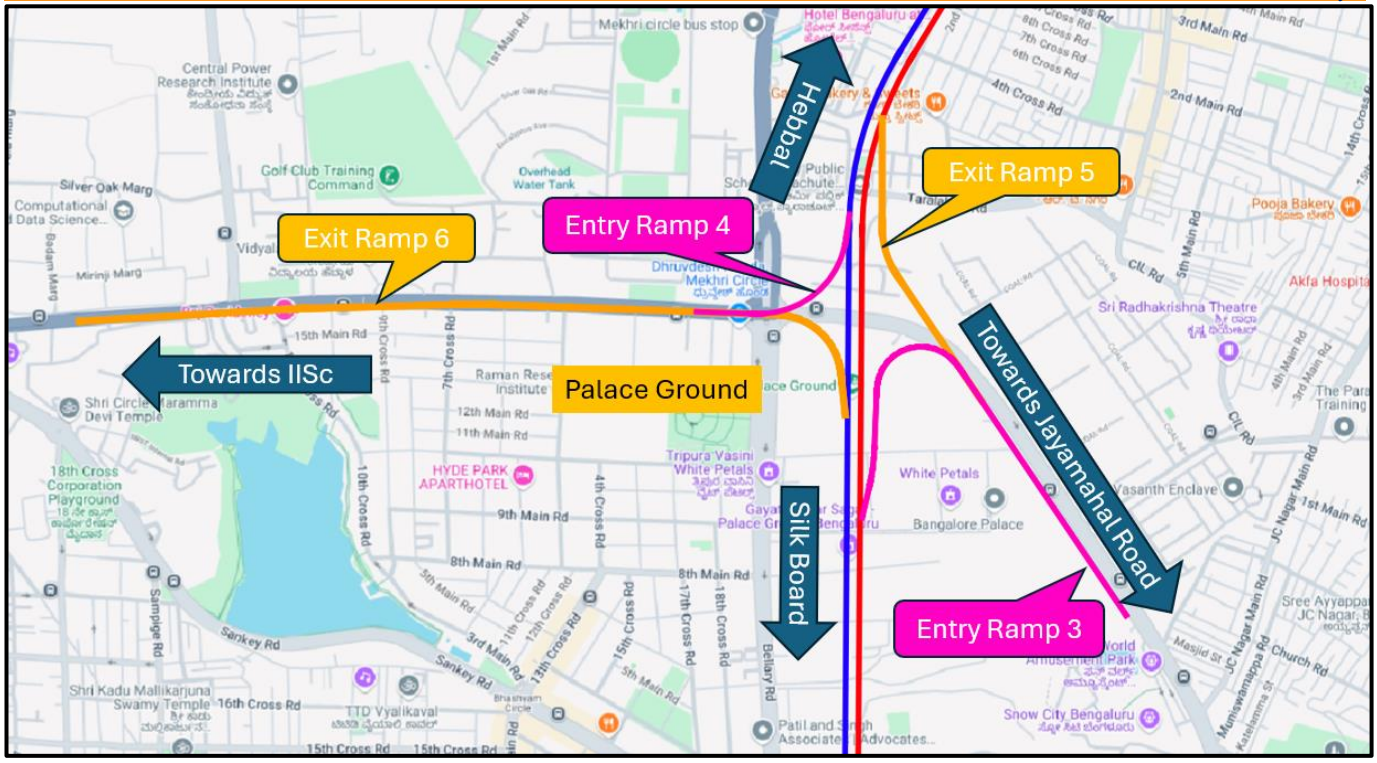


Figure 6: Entry and Exit Ramps at Palace Ground

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).

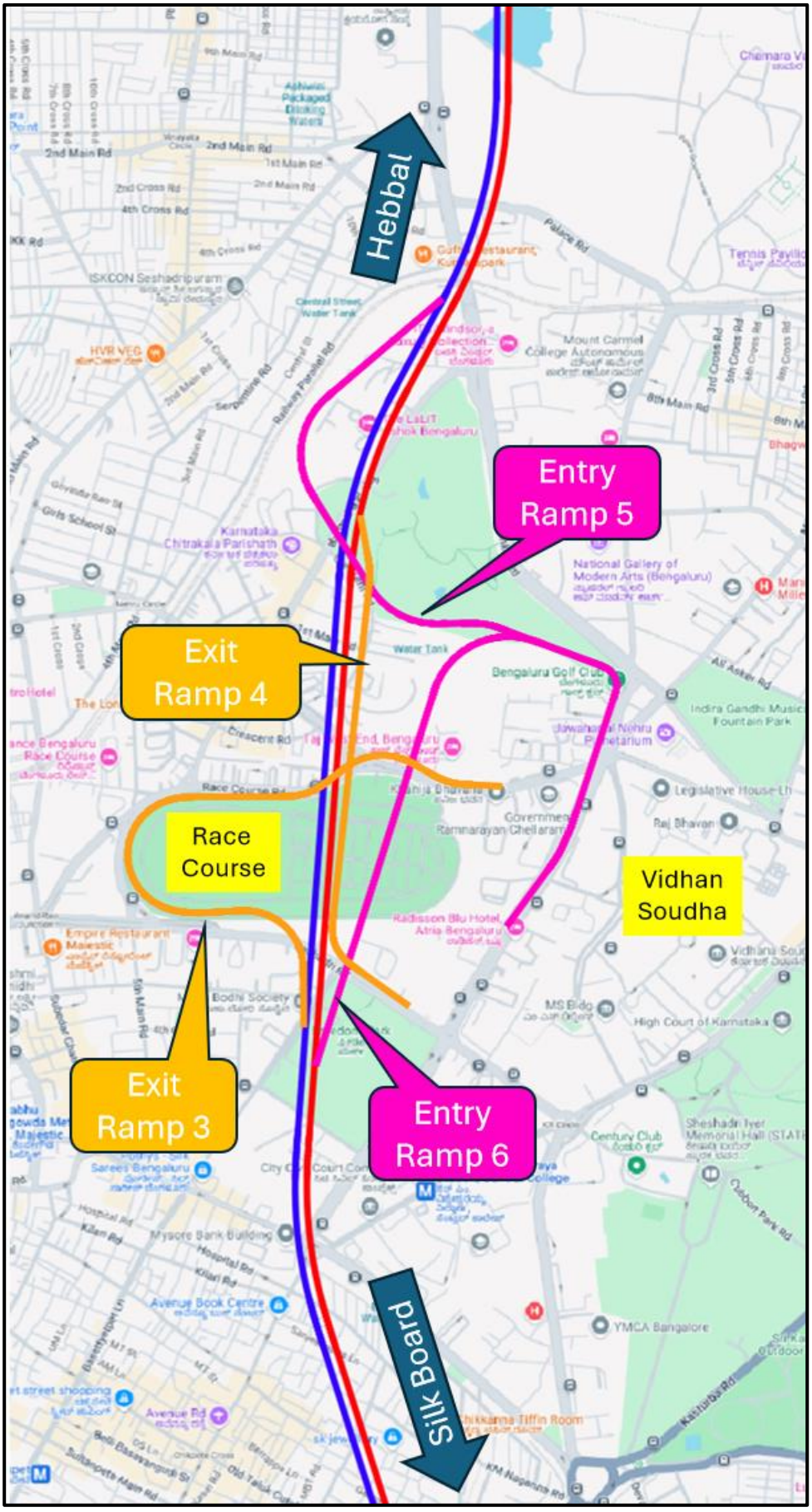


Figure 7: Entry and Exit Ramps at Race Course and Vidhan Soudha

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.

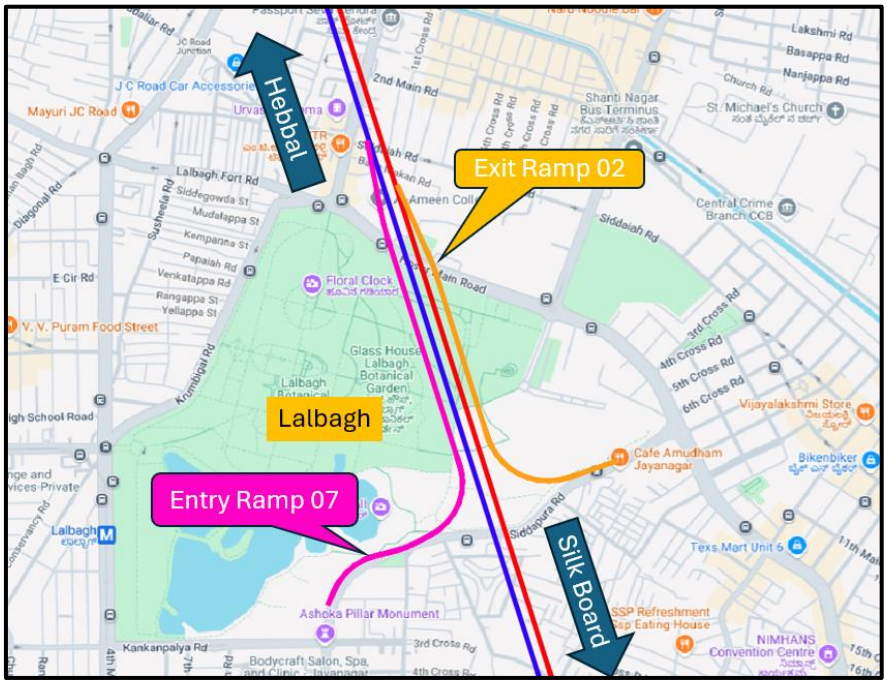


Figure 8: Entry and Exit Lalbagh Botanical Garden

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.

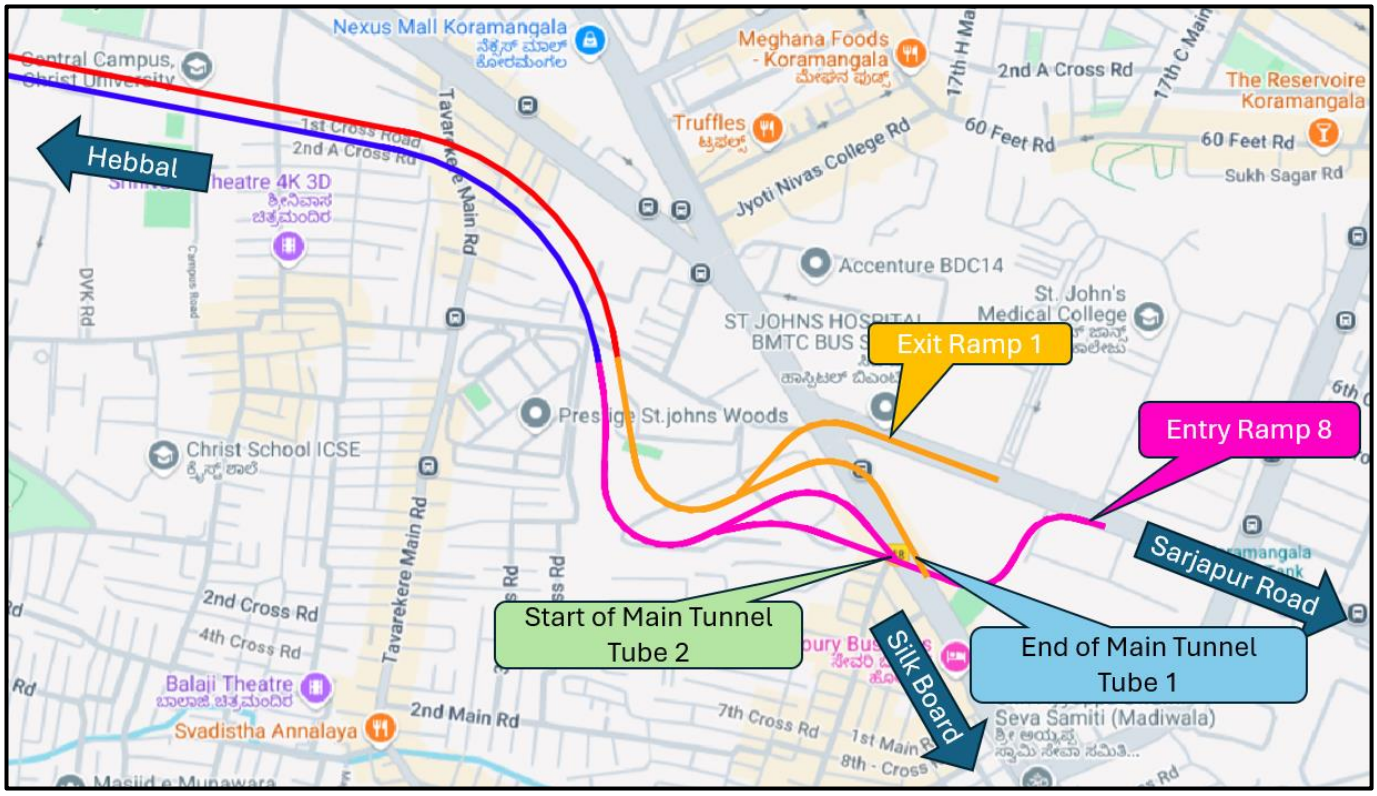


Figure 9: End Point of Project Alignment

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	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
				cover)	
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 required	Discussion required with BMRCL
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 Ring Road (Near-Devinagar BEL Circle)	Dir-I : Hebbal To Yashwantpur	LOS E
		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 Plaza)	Dir-I: Malegaon To Nashik City	111699	105740	267771	256433
		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		

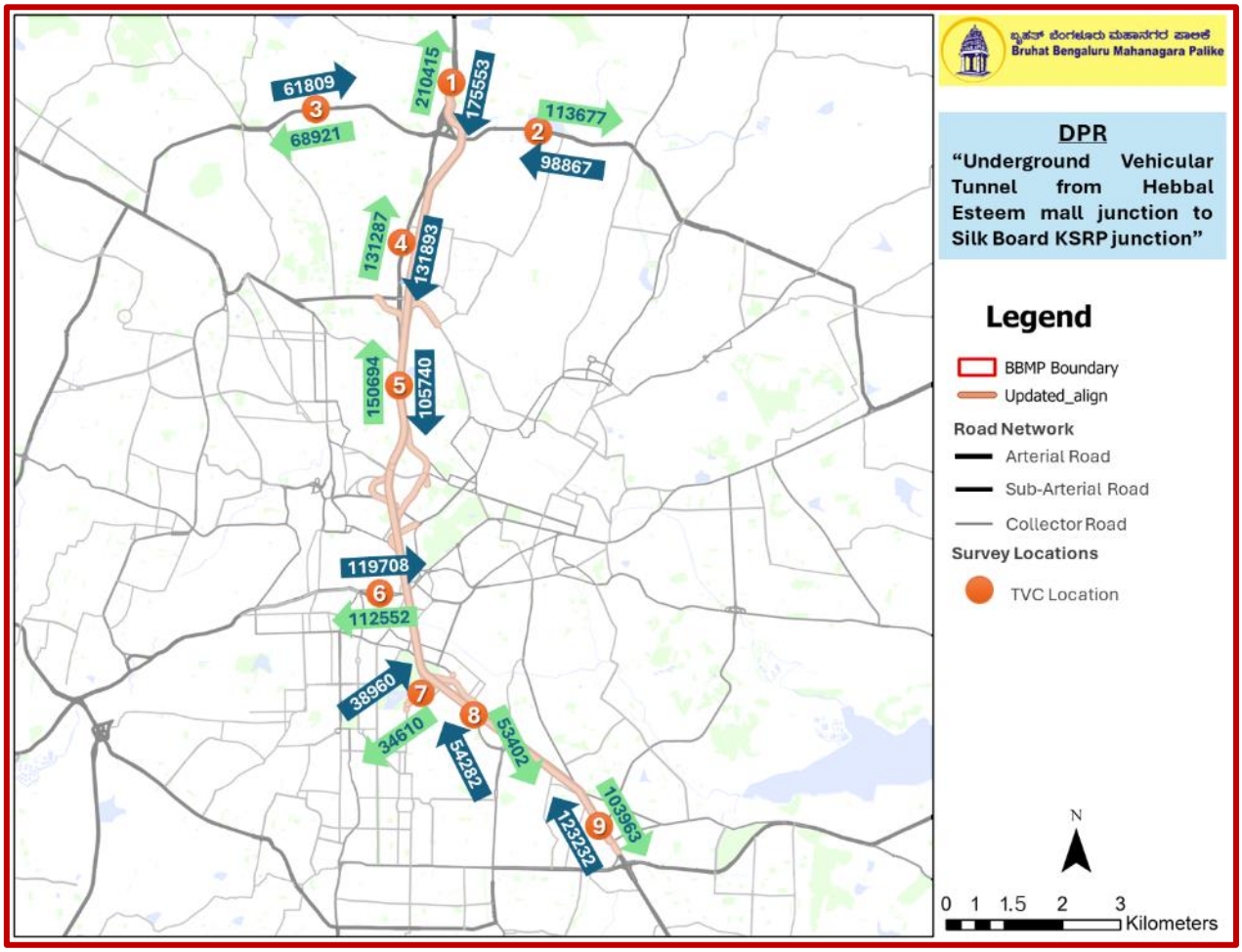


Figure 13: Map Showing Locations of Traffic Volume Count Surveys.

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
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**			

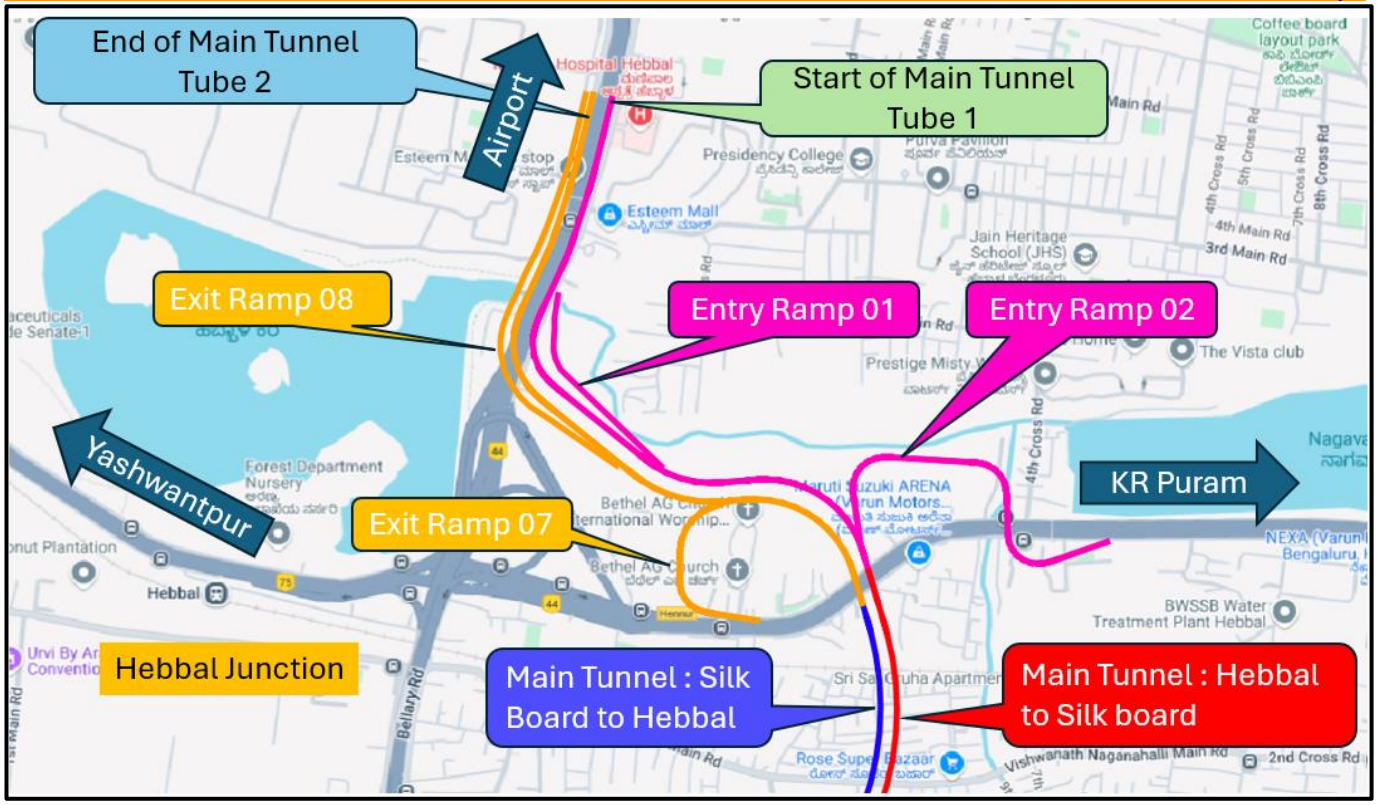


Figure 14: Entry and Exit Ramps at Hebbal Junction

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**			

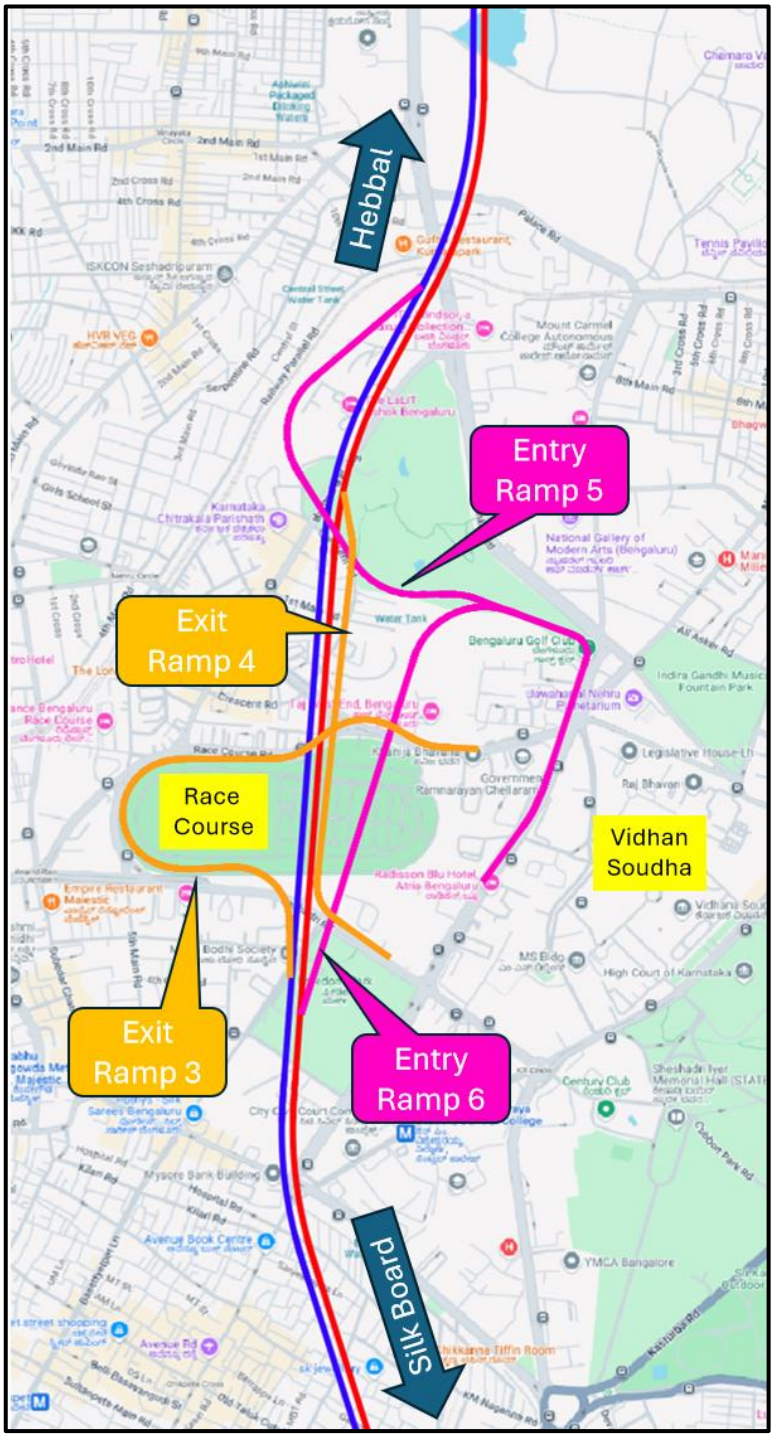


Figure 16: Entry and Exit Ramps at Racecourse

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			

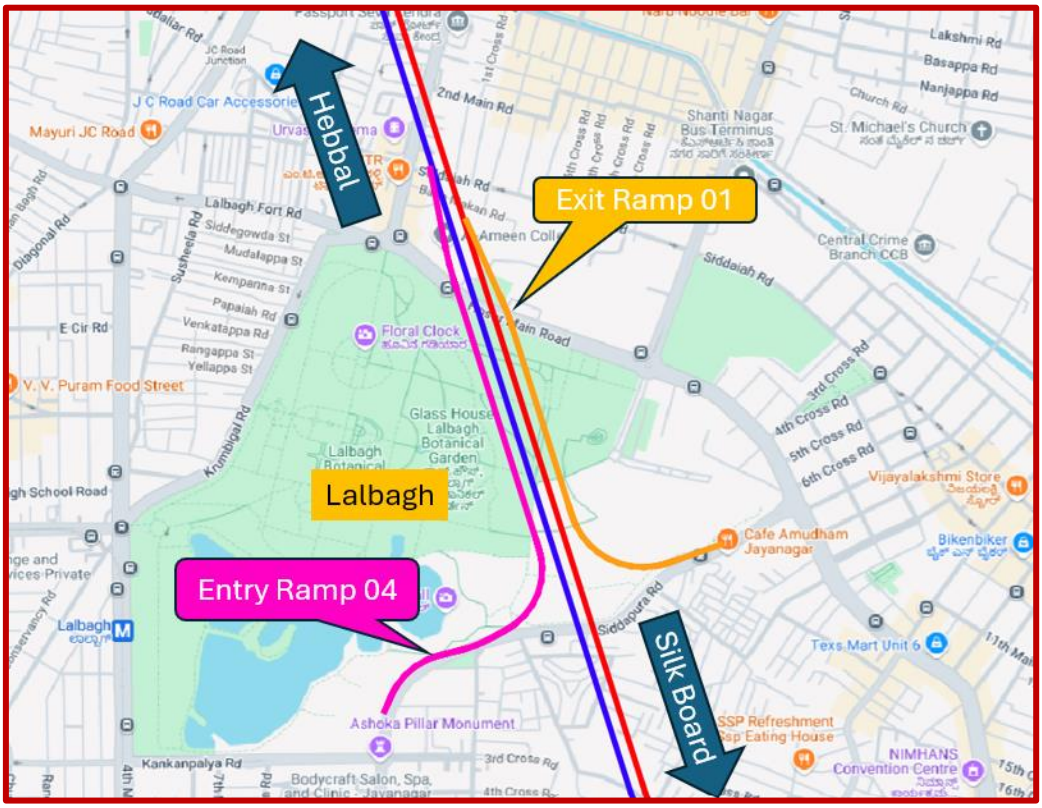


Figure 17: Entry and Exit ramp at Lalbagh

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			

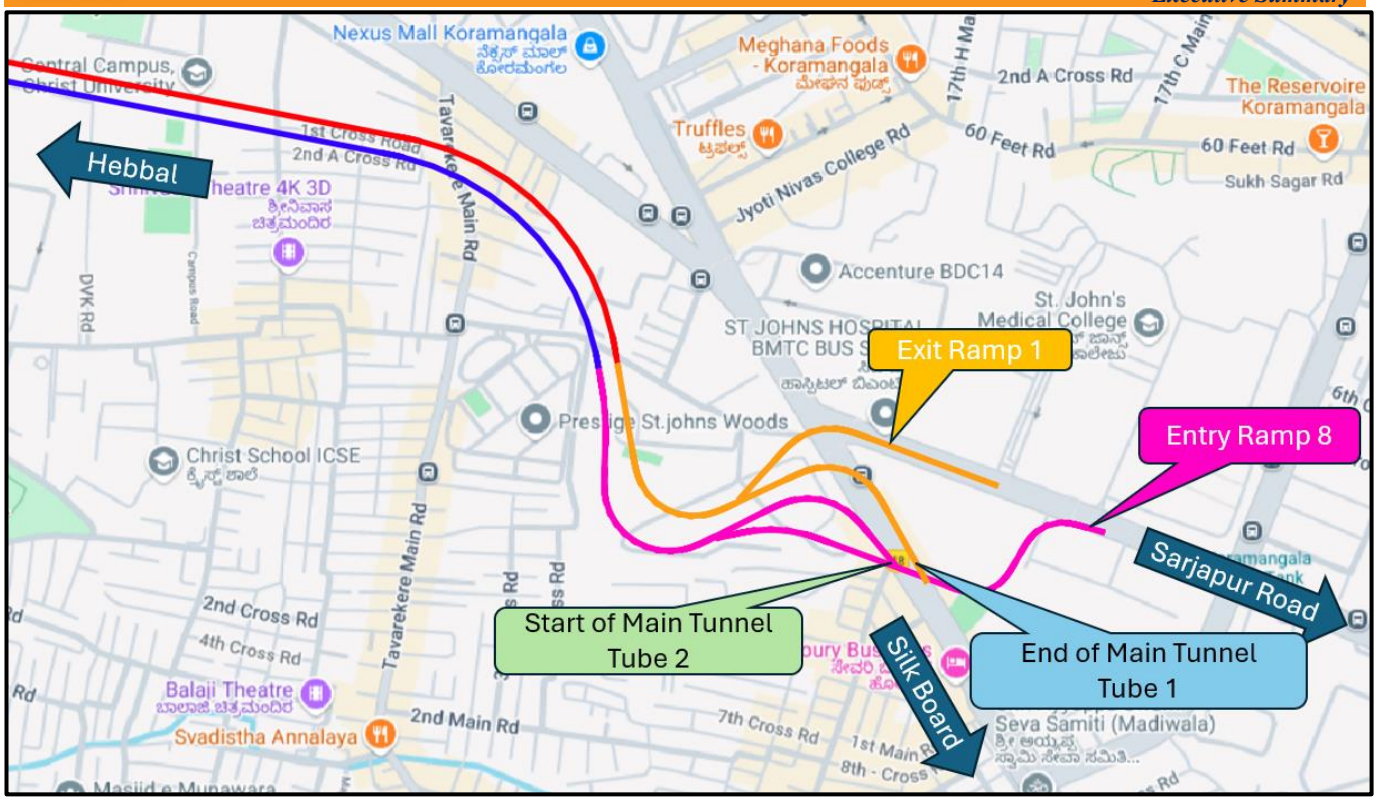


Figure 18: Entry and Exit ramp at Silk board

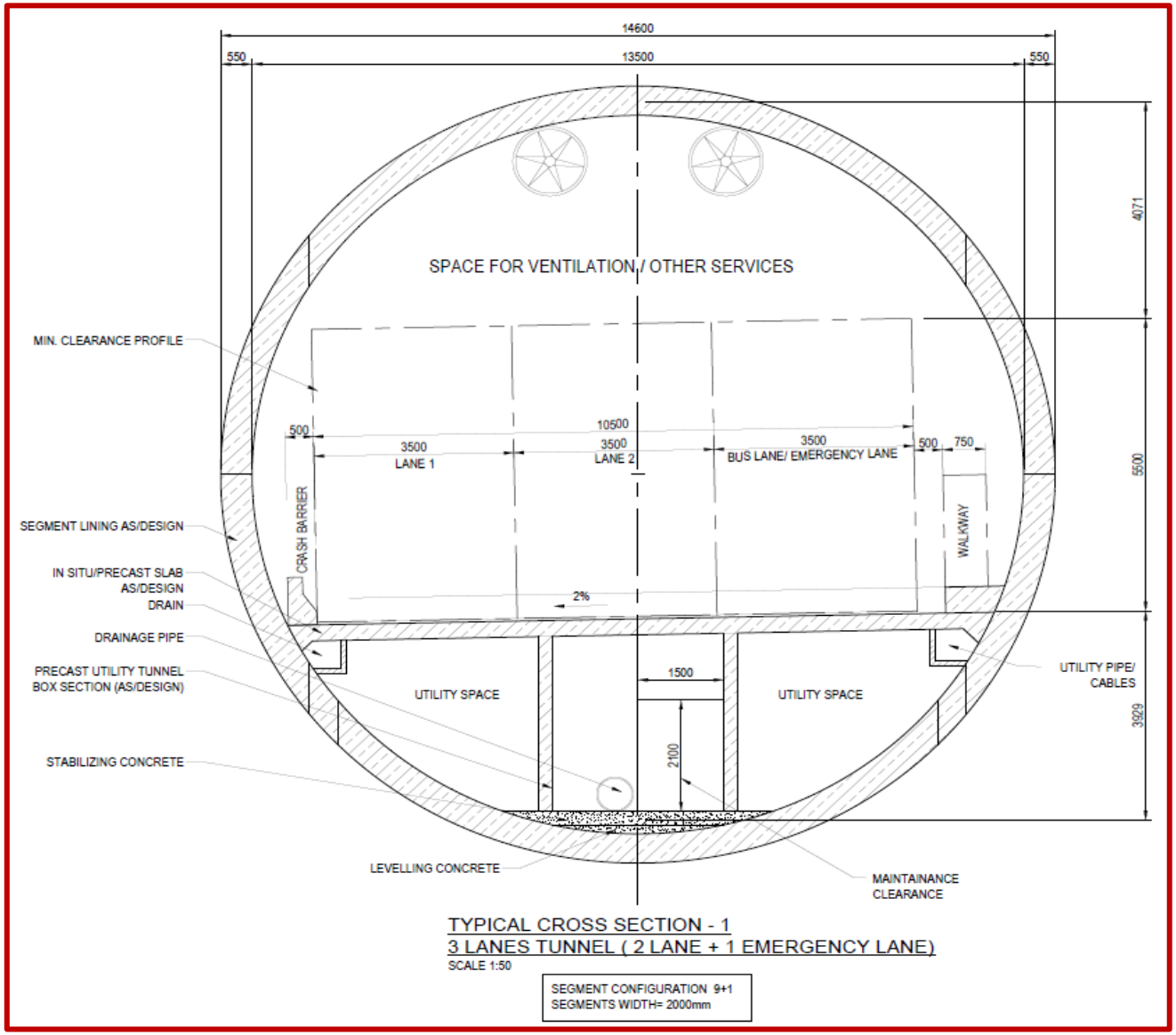


Figure 19: TCS-1, TBM Tunnel Cross-Section

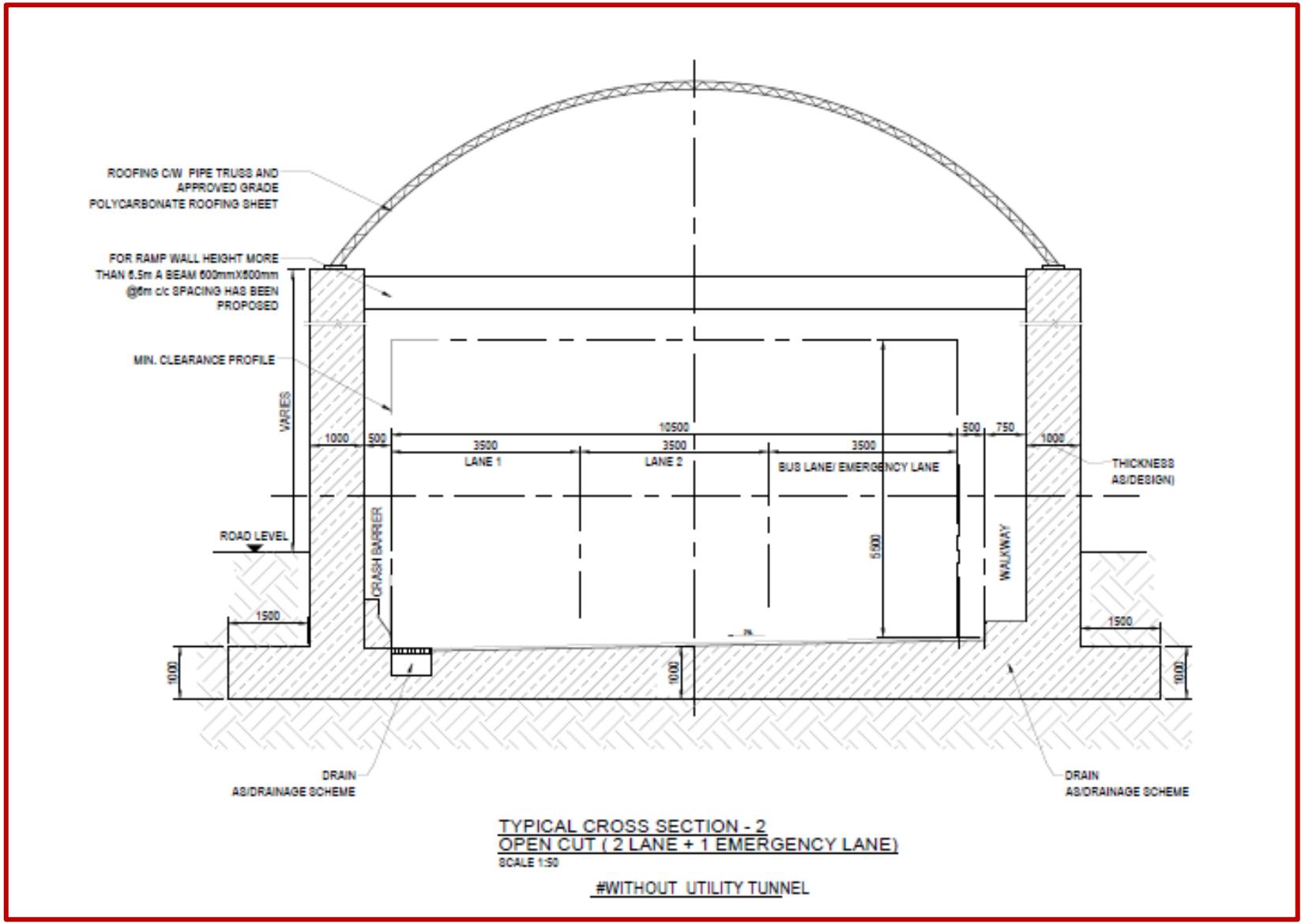


Figure 20: TCS-2, 3 lane Open Cut Section

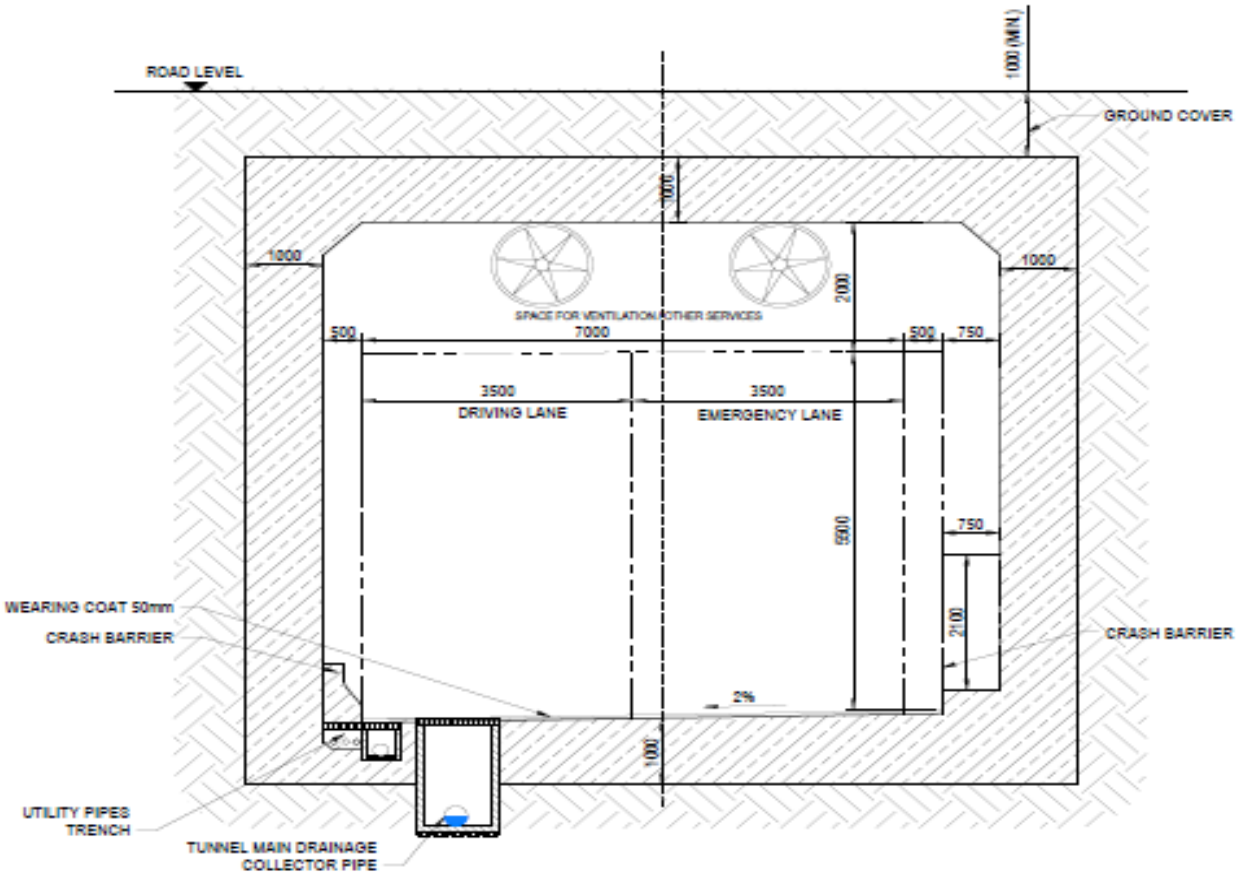


Figure 21: TCS-3, 2 lane Cut & Cover Section

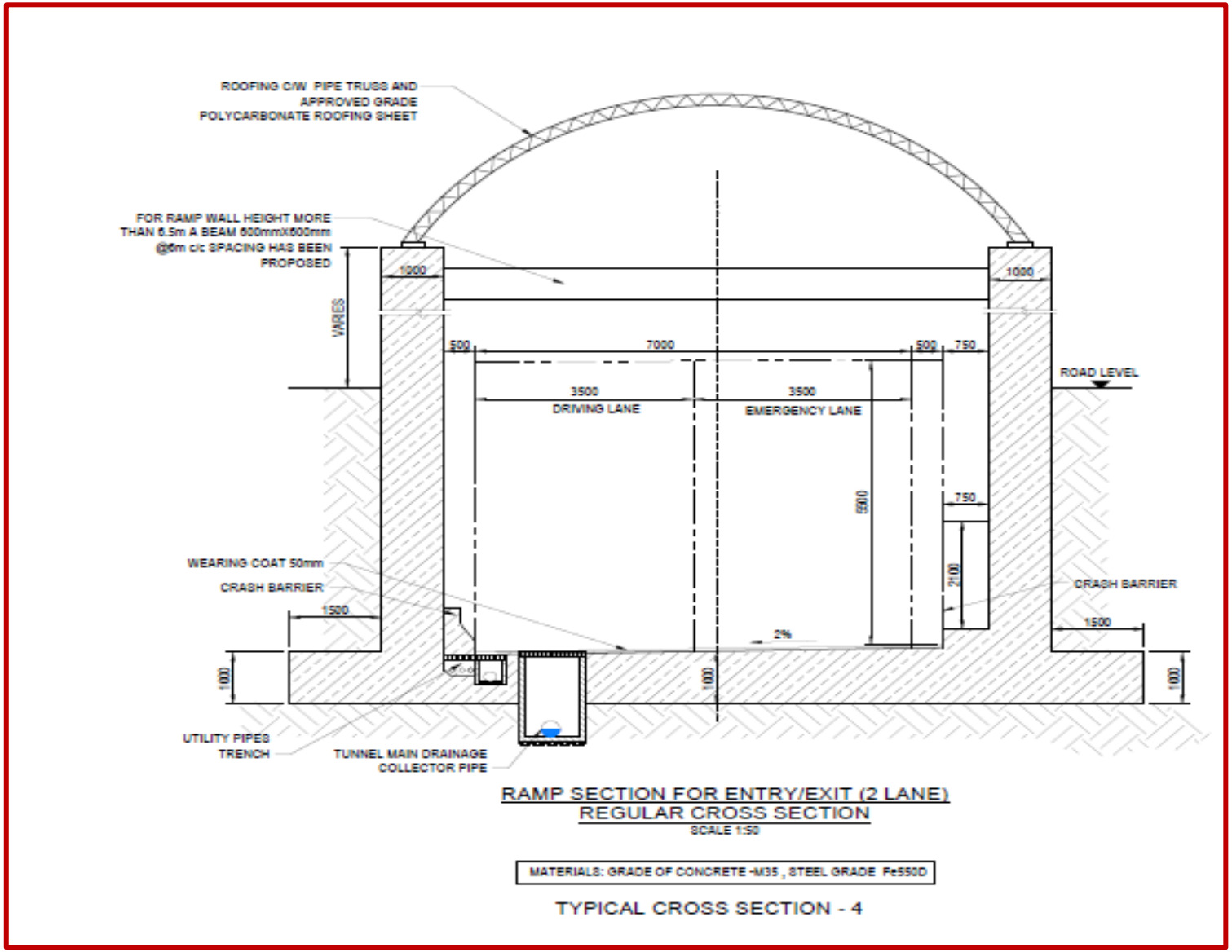


Figure 22: TCS-4, 2 lane Open Cut Section

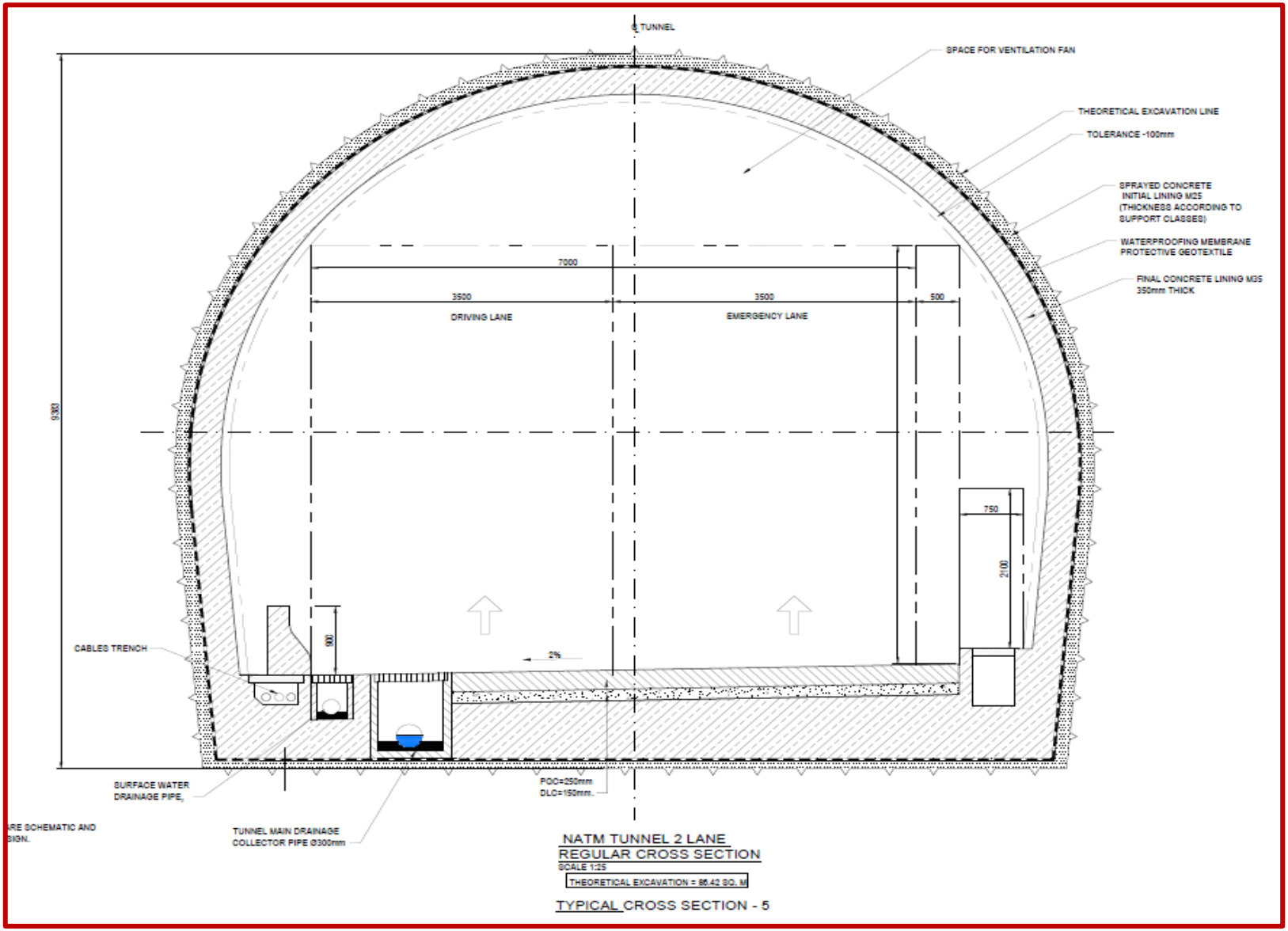


Figure 23: TCS-5, 2 lane NATM Tunnel Section

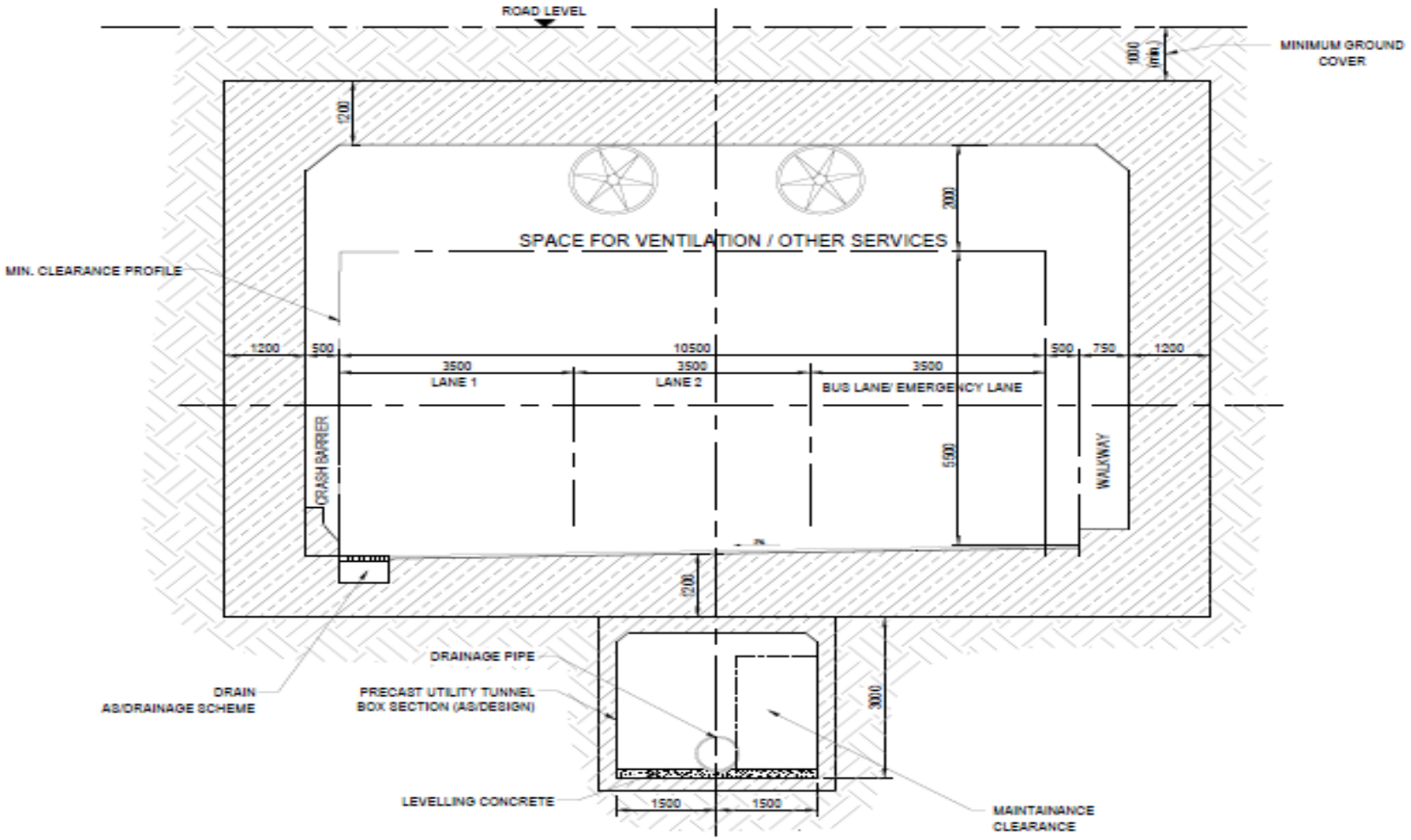


Figure 24: TCS-6, 3 lane Cut & Cover Section

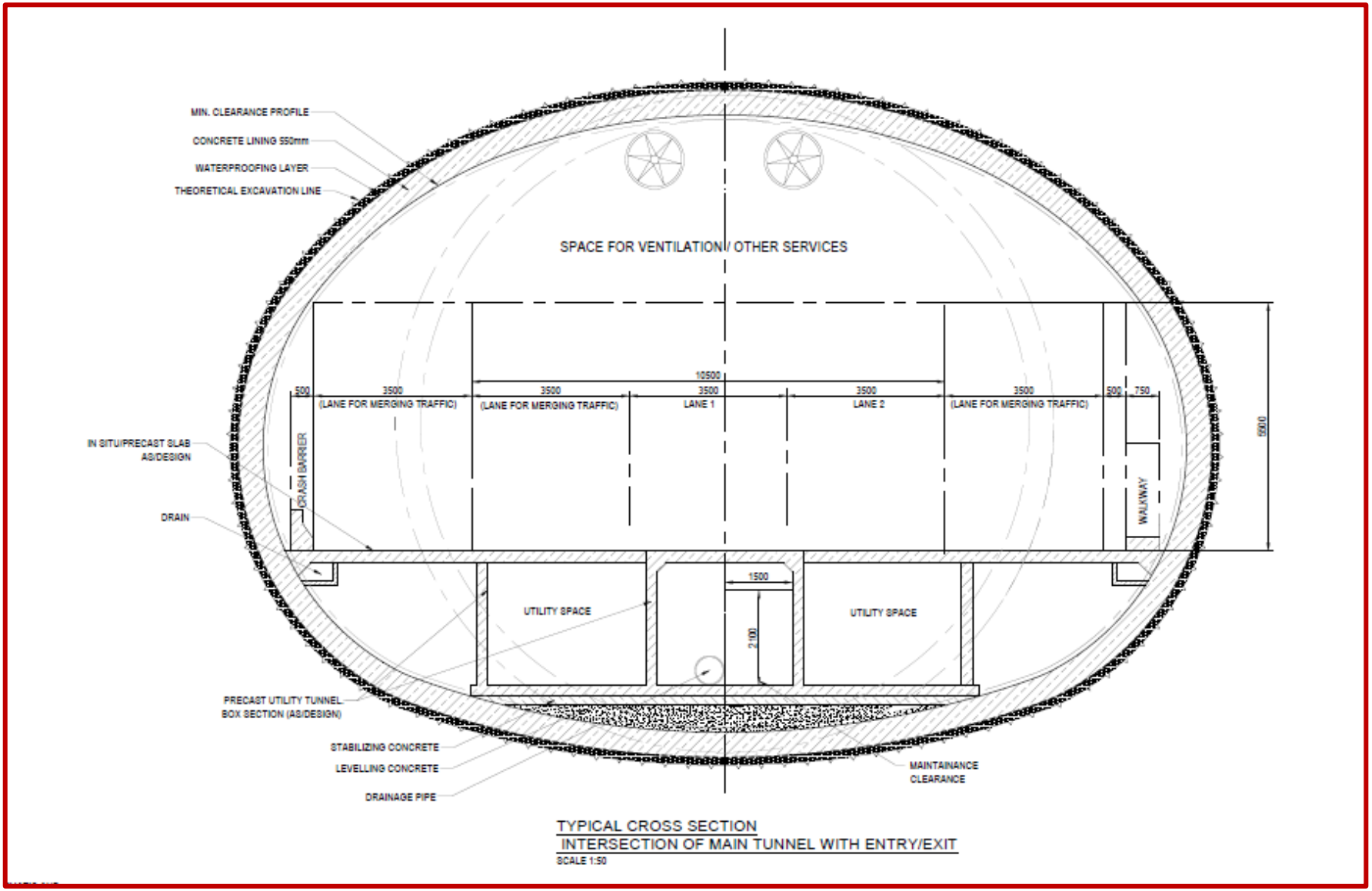


Figure 25: Typical Cross Section for merger section of Entry/ Exit Ramps & Main Tunnel

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.

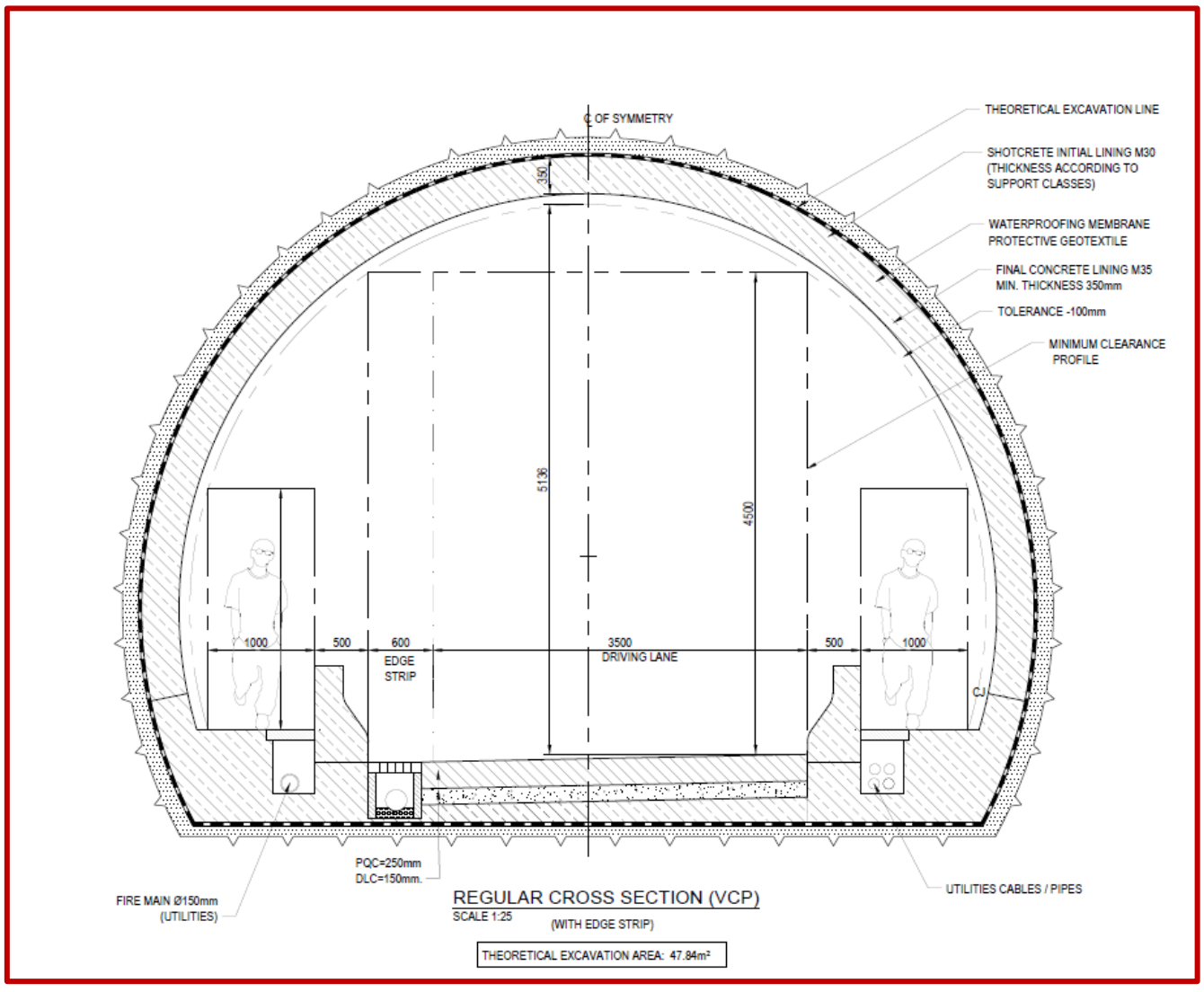


Figure 26: TCS for Tunnel Cross Passage

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.

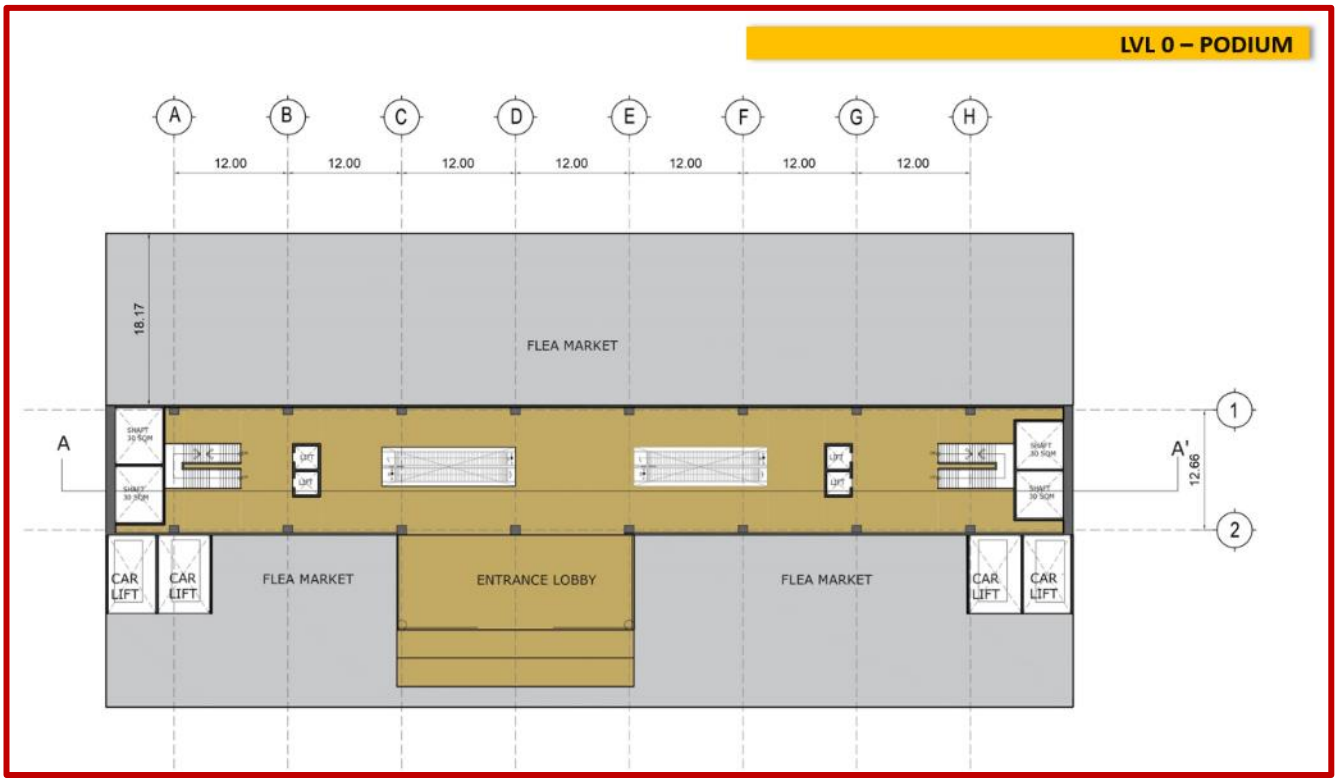
1.7.8 Inter Model Interchange Hubs

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.

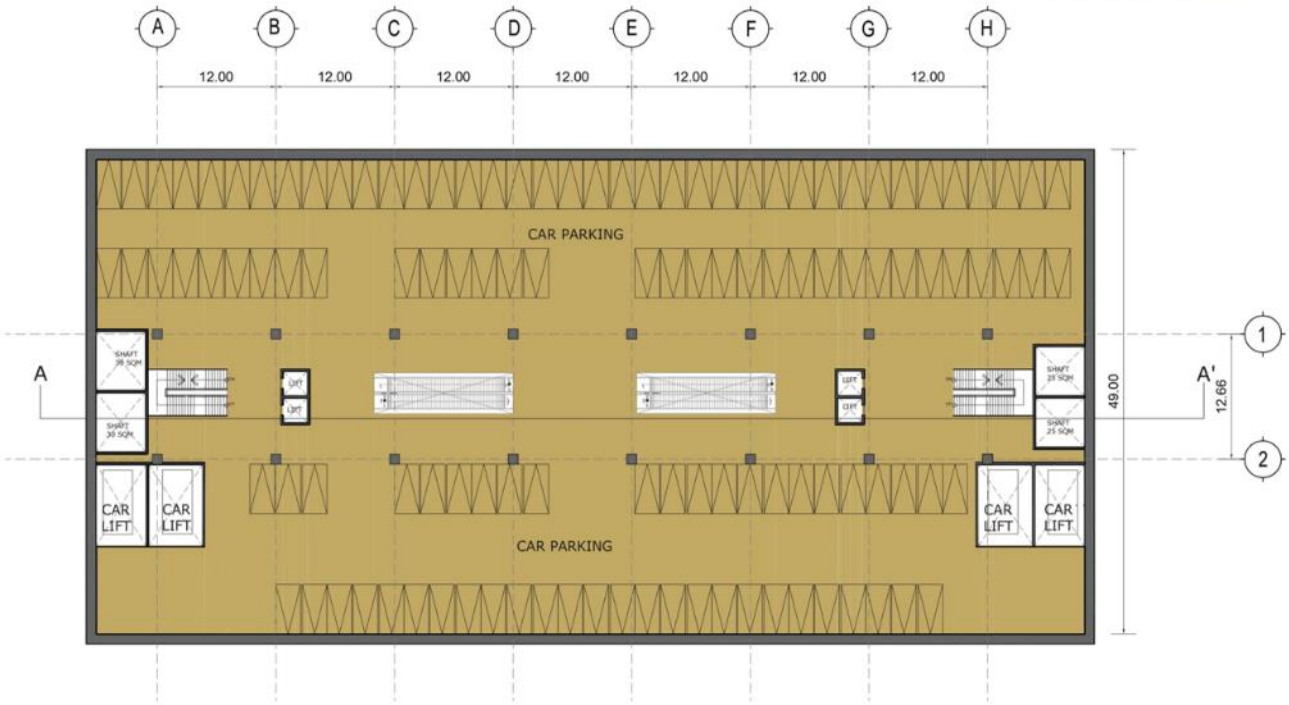
Following are the guiding principles for designing of intermodal interchange:

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.

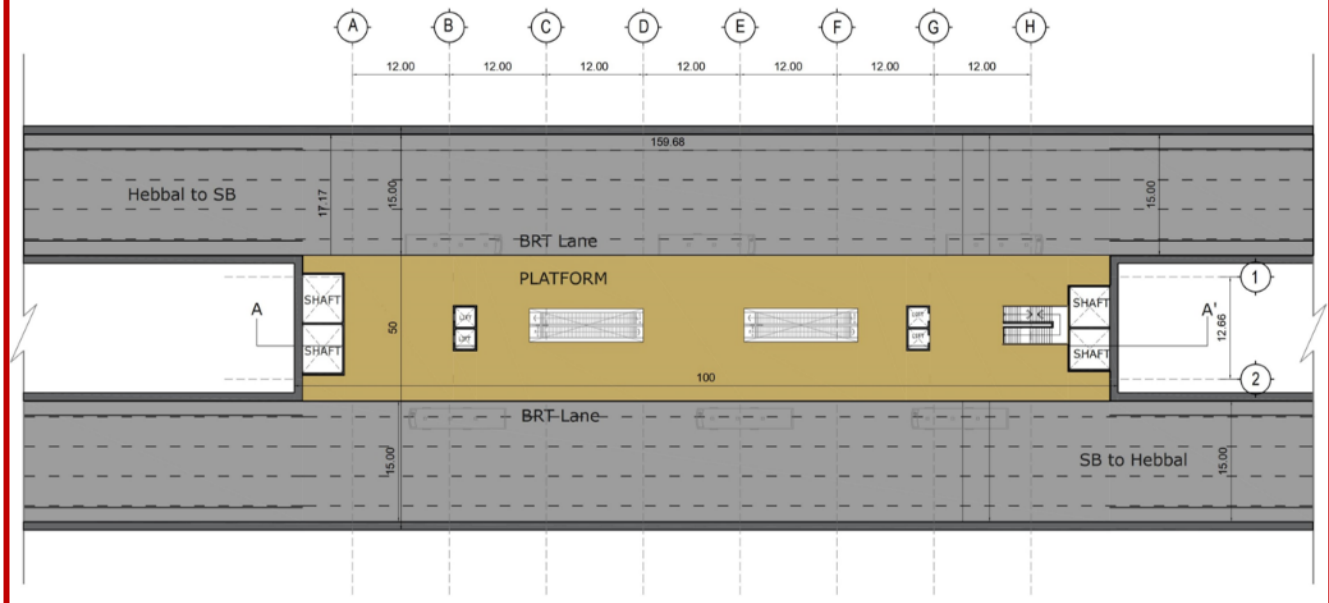
1.7.9 Conceptual layouts for Inter Model Interchange Hubs

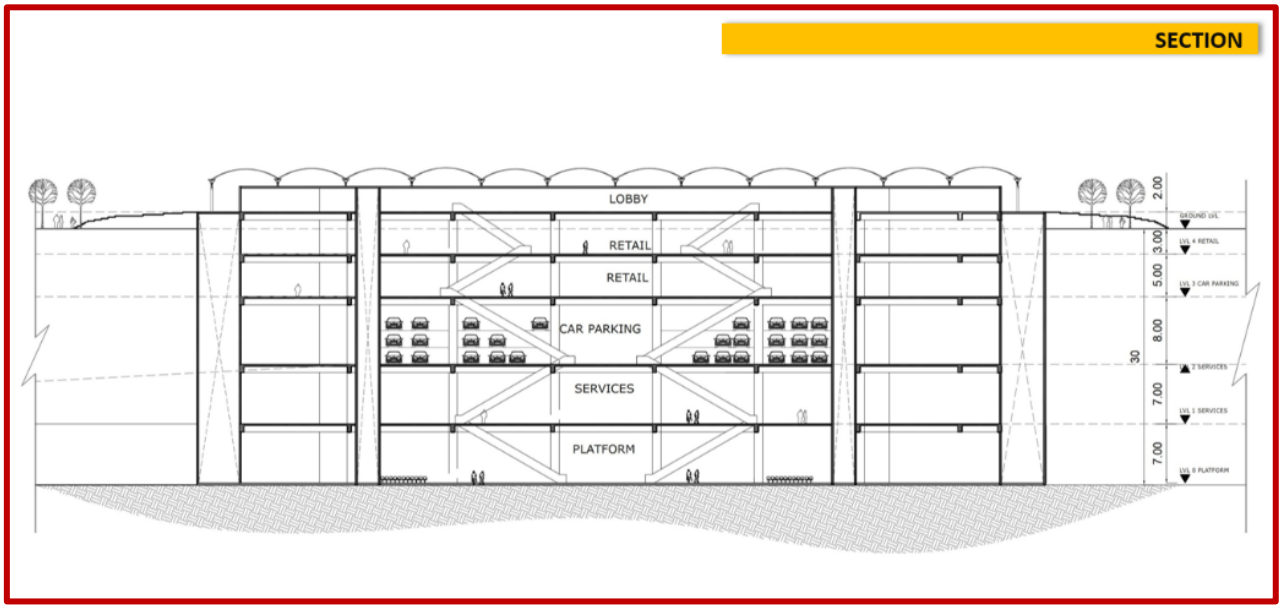


LVL 3 – CAR PARKING



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 Edge Strip Crash Barrier Walkway	29 Nos. 3.5m 0.6m 2 x 0.5m 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.

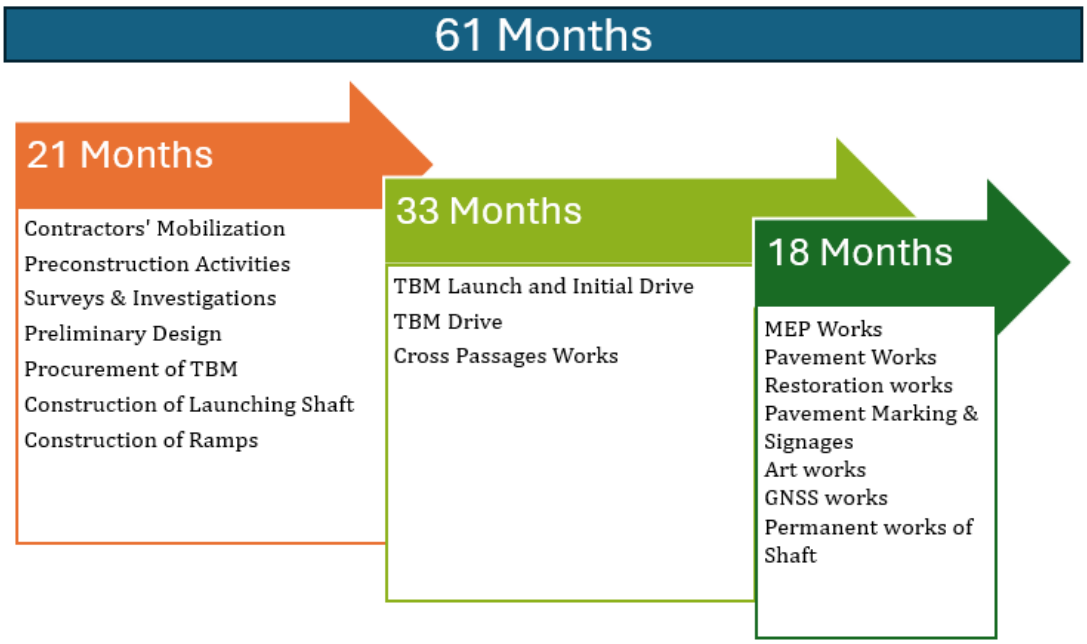


Figure 27: Phasing and Construction Time

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
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

S.No	Description	Length (km)	Rate	Total Amount in Rs.	Total Amount (Rs. in Crores)
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.

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