CHAPTER – 6

FUTURE DEMAND ANALYSIS AND SYSTEM SELECTION

6.1 FUTURE GROWTH SCENARIO

6.1.1 Revised Master Plan-2015 for the BMA has been published. This document gives the likely growth to take place in various areas of the BMA. The population of the BMA is expected to grow from 61 lakh in 2001 (70 lakh in 2006) to 88 lakh in 2015 and 122 lakh in 2025. The plan also gives locations of various land uses such as residential, commercial, industrial, IT uses etc. This has already been explained in Chapter 1.

6.1.2 The proposed growth of population and economy is expected to generate high travel demand. As per travel demand modeling exercise, daily travel demand is expected to grow from 57.2 lakh person trips in year 2006 to 127 lakh in year 2025. Thus while population is expected to become 1.74 times in 19 years, the travel demand is likely to become 2.25 times. Similarly inter-city travel demand from/ to Bangalore and through traffic are also expected to more than double of present levels. Transport network will also need to be augmented to cater to the expected travel demand. The present chapter examines some transport scenarios to meet the travel demand and recommends the best scenario.

6.2 DO MINIMUM SCENARIO

6.2.1 The conventional approach is to assume a 'Do nothing' scenario in respect of transport facility development and asses what the problems would be with the expected growth of population and trip generation towards horizon year. But this is not considered realistic since some committed and sanctioned schemes of road-widening, provision of grade-separators etc would nevertheless be carried out as is being done at present. Otherwise dynamism of growth will be lost. The scenario that will be available by the horizon year therefore would be a 'Do minimum' situation with some of the committed schemes of road capacity augmentation implemented. The base year network was updated by including identified committed road and public transport schemes to form the forecast Do minimum network which includes

a. Base year network with proposed road capacity augmentation.
b. Changes to bus frequencies to keep up with increase in demand generally

6.2.2 Having achieved satisfactory validation of base year transport model, forecast year model for 2025 was set up with changes in population and other changed scale economic factors and also minimum network changes for peak and off peak. In each case, iterative procedure goes through a series of network skims, trip distribution / modal split runs to produce synthetic trip matrices, subsequent

assignments (followed by skims for next iteration). It was found that to achieve convergence, eight iterations were required.

6.2.3 The Do-minimum assignment was carried out to identify the bottlenecks, over capacity links etc. With this it is possible to identify the major constraints in the network. Once the constraints are identified it is easy to formulate schemes to overcome the problems. New infrastructure, traffic management plans, and policy controls can be worked out with the help of identified schemes. The calibrated deterrence functions for various modes and various purposes have been adopted. Forecast test of each scheme will be assessed against the Do-Minimum assignment.

6.2.4 For the Do Minimum Scenario, the expected modal split for the year 2025 is given in **Table 6.1**. This table shows that the modal split in favour of public/mass transport will fall to about 29% by 2025 against base year modal split of 47%. Share of trips by personalized motor vehicles such as car and two wheelers is expected to increase from 40% to 60%. This is expected to increase the traffic volumes on the most of the road network beyond its capacity. The desireline diagram for private vehicles for 2025 is shown in **Figure 6.1**. Peak hour traffic assignment on the road network is shown in **Figure 6.2**. These figures indicate heavy radial movements to the core of the city and also circumferential movements. Heavy traffic is likely to be experienced on all radial roads, Outer Ring Road and various roads in core area. V/C ratio will be more than 0.8 on most of the roads. Travel speeds will fall to 6-7 kmph. Environmental pollution from motor vehicles will assume critical dimensions.

Table 6.1 Expected Modal Split – Do Minimum Scenario (Scenario –I)

Modes	Modal Split			
	Base Year Scenario – 2006		Scenario –1 (Do Minimum) – 2025	
	Daily Trips (lakhs)	%age	Daily Trips (lakhs)	%age
Car	4.2	7.5	15.5	12.2
2W	18.4	32.8	60.4	47.5
IPT	7.3	12.9	14.9	11.7
BUS	26.3	46.8	36.3	28.6
Total	**56.2**	**100.0**	**127.2**	**100.0**

6.3 SCENARIO 2

6.3.1 Considering the evaluation of the above scenario, the most important issue to reduce road traffic will be to increase the share of trips by public/mass transport. This will mean providing high capacity mass transport system on many corridors. Revised Master Plan-2015 has proposed the following public transport system and major roads.

Figure 6.1 Desireline Diagram for Private Vehicles for 2025 (Do Minimum)

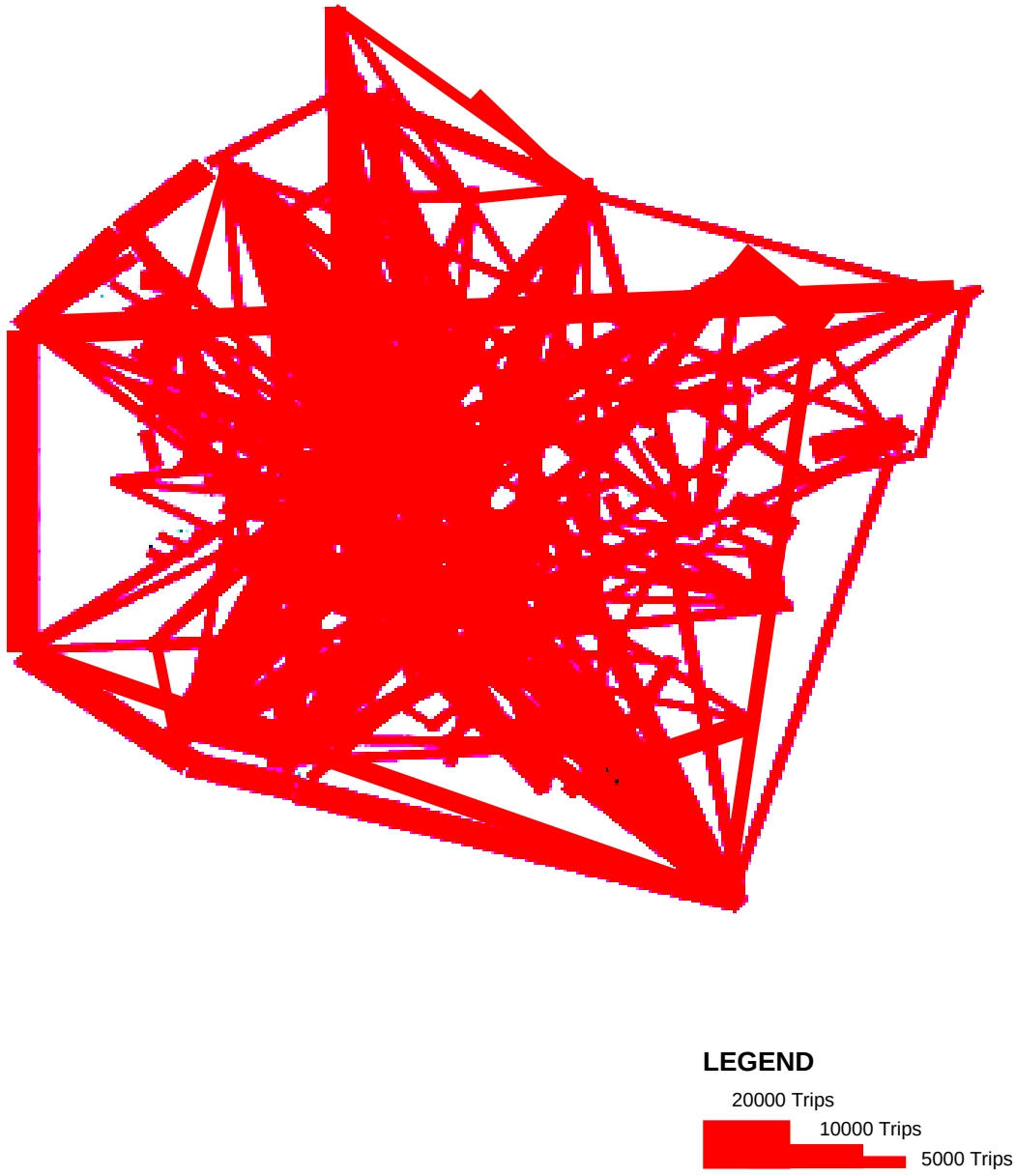


Figure 6.2 Peak Hour Traffic Assignment on Road Network (Do minimum)

i. Metro System (36.8 km) (Mysore Road-Baiyyappanahalli and Peenya-RV Terminal corridors)
ii. Monorail system (47km) (from Kanakapura Road to Bellary Road along ORR, Kathriguppe to National College, Bannerghatta-Adugodi along Bannerghatta and ORR to Toll Gate junction along Magadi Road)
iii. BRT (30km) (on ORR)
iv. Commuter Rail Service in Bangalore (Kangeri-Whitefield, Bangalore City Satation-Baiyyappanahalli via Lottagolahalli (60 km)
v. Elevated Core Ring Road (30 km)
vi. Peripheral Ring Road (114 km)
vii. New Airport Expressway (26 km)

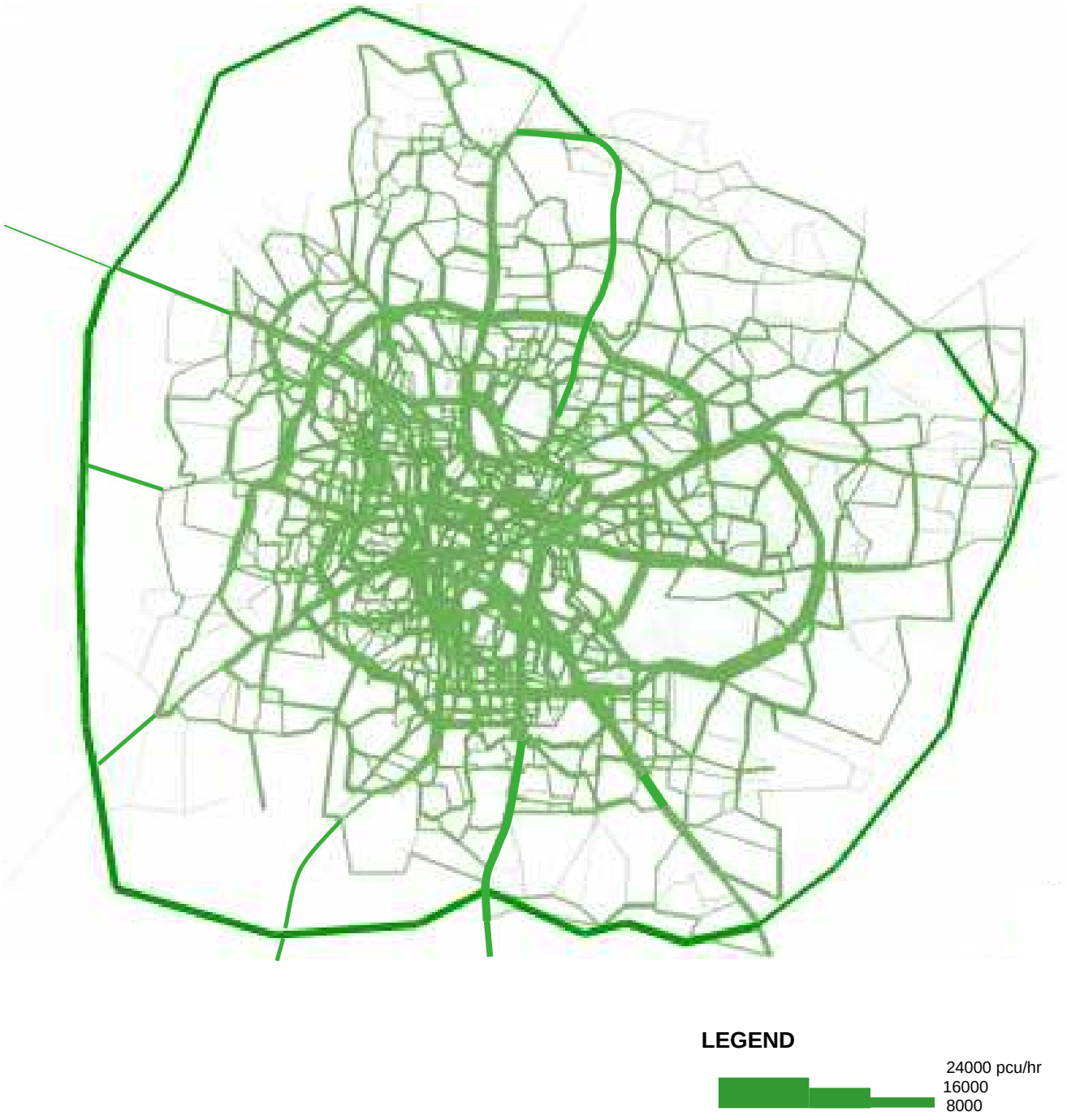
6.3.2 Considering above, another network Scenario (termed as Scenario 2) was developed, travel demand modeling and forecasting carried out and results evaluated. For this Scenario, the expected modal split for the year 2025 is given in **Table 6.2**. This table shows that the modal split in favour of public/mass transport will increase marginally to about 50% by 2025 against base year modal split of 47%. Share of trips by personalized motor vehicles such as car and two wheelers is expected to increase from 40% to 44%, although in absolute numbers their demand will increase from 23 lakh (2006) to 55 lakh (2025) daily trips. This is also expected to increase the traffic volumes on the many of the road network beyond its capacity, although, the traffic levels will be much less as compared to Do Minimum Scenario. This can be seen in traffic assignment figures. Peak hour peak direction trips (phpdt) on mass transport network for this scenario is shown in **Figure 6.3**. Peak hour traffic assignment on the road network for 2025 for this scenario is shown in **Figure 6.4**. These figures indicate significant traffic on mass transport network and reduced traffic on many roads. However, many roads such as Hosur Road, Kanakapura Road, Airport Road, Mysore Road, ORR, many roads in core area and outer areas will continue to be overloaded. Thus share of public/mass transport in total demand will still need to be increased substantially.

Table 6.2 Expected Modal Split –Scenario 2

Modes	Modal Split			
	Base Year Scenario (2006)		Scenario 2 (2025)	
	Daily Trips (lakhs)	% age	Daily Trips (lakhs)	% age
Car	4.2	7.5	9.7	7.6
2W	18.4	32.8	45.6	35.9
IPT	7.3	12.9	8.9	7.0
Public/Mass Transport	26.3	46.8	50.0	49.5
Total	**56.2**	**100.0**	**127.2**	**100.0**

Figure 6.3 Peak Hour Peak Direction Trips (PHPDT) on Mass Transport Network (Scenario 2)

Figure 6.4 Peak Hour Traffic Assignment on the Road Network for 2025 (Scenario 2)



6.4 SCENARIO 3

6.4.1 Considering that many of the road corridors will still be overloaded in Scenario 2, the public/mass transport network and road network has been extended on the following corridors and the alternative termed as Scenario 3.

1. Mass transport network and Major Road Network as in Scenario 2
2. Additional Mass Transport Corridors
   i. Baiyyappanahalli to Benaiganahalli
   ii. R.V. Terminal to PRR along Kanakapura Road
   iii. Yelahanka Road to PRR via Nagavara, Electronic City
   iv. Indiranagar to Whitefield along Airport Road
   v. Devenahalli Airport to MG Road via Bellary Road (New Airport)
   vi. Kanakapura Road to Bannerghatta Road along ORR
   vii. PRR to ORR along Magadi Road
   viii. Benaiganahalli (ORR) to PRR along old Madras Road
   ix. From ORR to Hosur Rd along Hitech Corridor Jn.
   x. Hosur Rd-PRR Junction to Tumkur Rd along PRR (western part)
   xi. Tumkur Road-PRR Jn. to Hosur Rd along PRR via Tirumanahalli, Old Madras Road, Whitefield (eastern part of PRR)
   xii. Along Core Ring Road
   xiii. Vidyaranyapura to Nagavarapalya Via Hebbal, Jayamahal Road, Queens Road, M.G. Road, Ulsoor, Indranagar, CV Raman Nagar
   xiv. Kengeri Sattelite Town to J.P. Nagar along Uttarahalli Road, Kodipur
   xv. Banshankari III stage to Banshankari VI stage Ext. along Ittamadu Road, Turahalli, Thalaghattapura.
   xvi. Domlur Ext. to Kormangala along inner ring road
   xvii. PRR (Mulur) to Maruti Nagar (up to Hitech corridor) along Sarjapur Road
   xviii. Peenya to PRR along Tumkur Road
   xix. Old Madras Road near Indranagar to ORR near Banaswadi along Baiyyappanahali Road -Banaswadi Road
   xx. Commuter Rail Corridors
      - Lottegollahalli to Yelahanka
      - Banaswadi -Hosur
      - Kangeri- Ramnagaram
      - Yeshwantpur to Tumkur

6.4.2 Expected modal split for Scenario 3 for 2025 is shown in **Table 6.3**. It is seen that share of person trips for public/mass transport is expected to increase to 73%. This share in favour of public/mass transport is desirable for the city of size of population more than one crore as recommended by the Committee for the Report on 'Alternative Systems of Urban Transport' set up by the Government of India.

Table 6.3 Expected Modal Split –Scenario 3

Modes	Modal Split			
	Base Year Scenario (2006)		Scenario 3 (2025)	
	Daily Trips (lakhs)	%age	Daily Trips (lakhs)	%age
Car	4.2	7.5	7.0	5.5
2W	18.4	32.8	20.6	16.2
IPT	7.3	12.9	6.7	5.3
Public/Mass Transport	26.3	46.8	92.9	73.0
Total	**56.2**	**100.0**	**127.2**	**100.0**

6.4.3 The desireline diagram for private vehicles for 2025 is shown in **Figure 6.5**. The traffic desire by these vehicles will be significantly reduced. Peak hour peak direction trips (phpdt) on mass transport network for this scenario are shown in **Figure 6.6**. Peak hour traffic assignment on the road network for 2025 for this scenario is shown in **Figure 6.7**. These figures indicate significant traffic on mass transport network and further reduced traffic on roads as compared to Scenario 2.

6.5 RECOMMENDED SCENARIO

6.5.1 The above evaluation of alternative scenarios shows that the public/mass transport system has to be extensive with high capacity mass transport systems on major corridors in order to achieve a modal split of more than 70% in favour of public/mass transport. Scenario 3 will not only enable the commuters to travel from one part to another of the city with good level of service, convenience and comfort but also help in the shift to public transport. This is also desirable as available ROW s of roads in Bangalore are not adequate. Provision of a city-wide extensive public/mass transport is the only way to solve mobility problem of Bangalore. Thus Scenario 3 public/mass transport network should be aimed at in order to cater to travel demand of 2025 and beyond.

6.5.2 The balance demand can generally be met by augmentation of road system in the form of new roads, road widening, provision of grade separators, pedestrian facilities, traffic management measures etc. The proposals for these are detailed in Chapter 7.

6.6 SYSTEM SELECTION

6.6.1 Criteria for Choice of Mode

Choice of mode will depend mainly on demand level on a corridor, available road right-of-way (ROW) and the capacity of the mode. Other considerations are the land-use along the corridor, the location of building lines, and the potential for

Figure 6.5 Desireline Diagram for Private Vehicles for 2025 (Scenario 3)

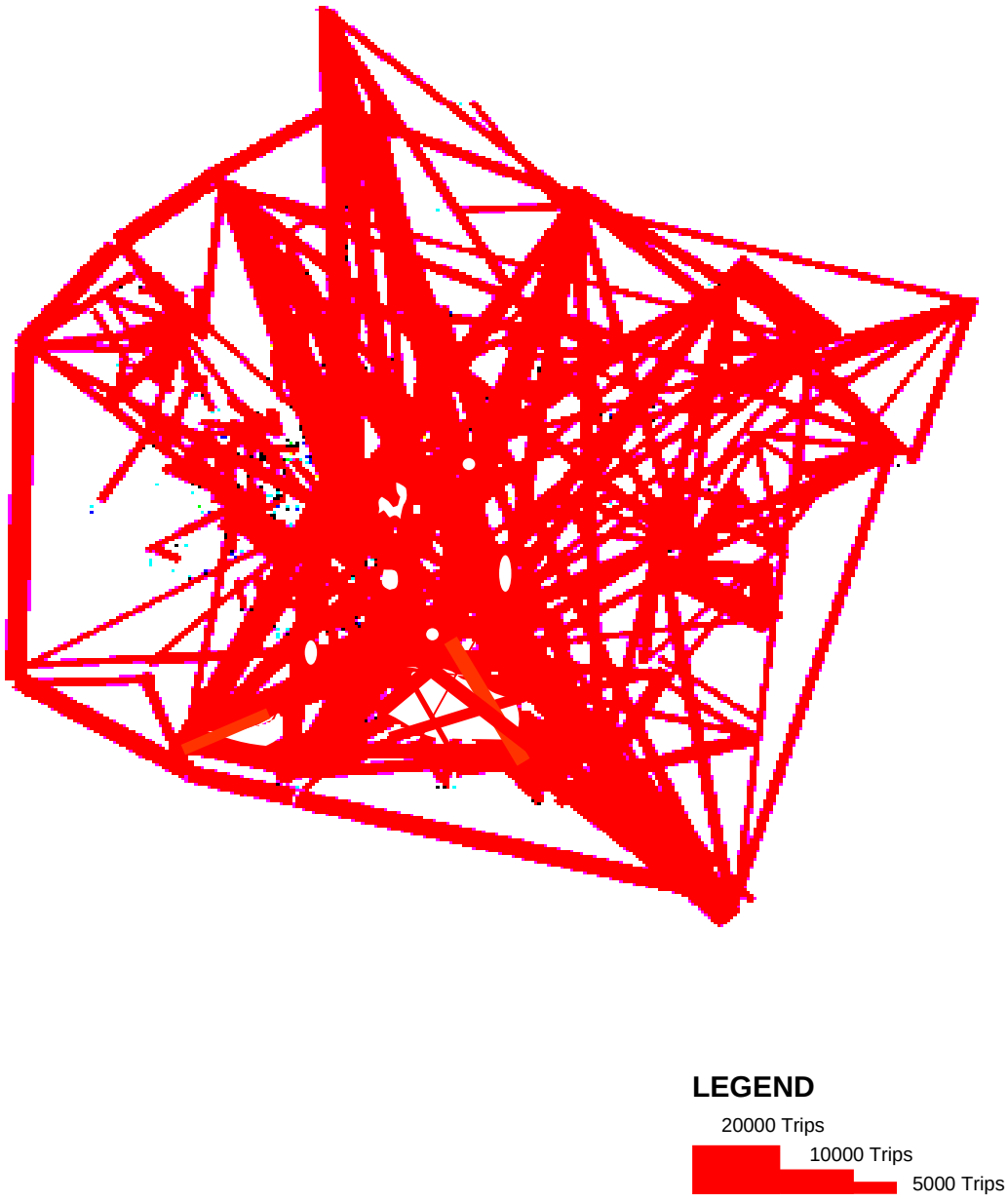
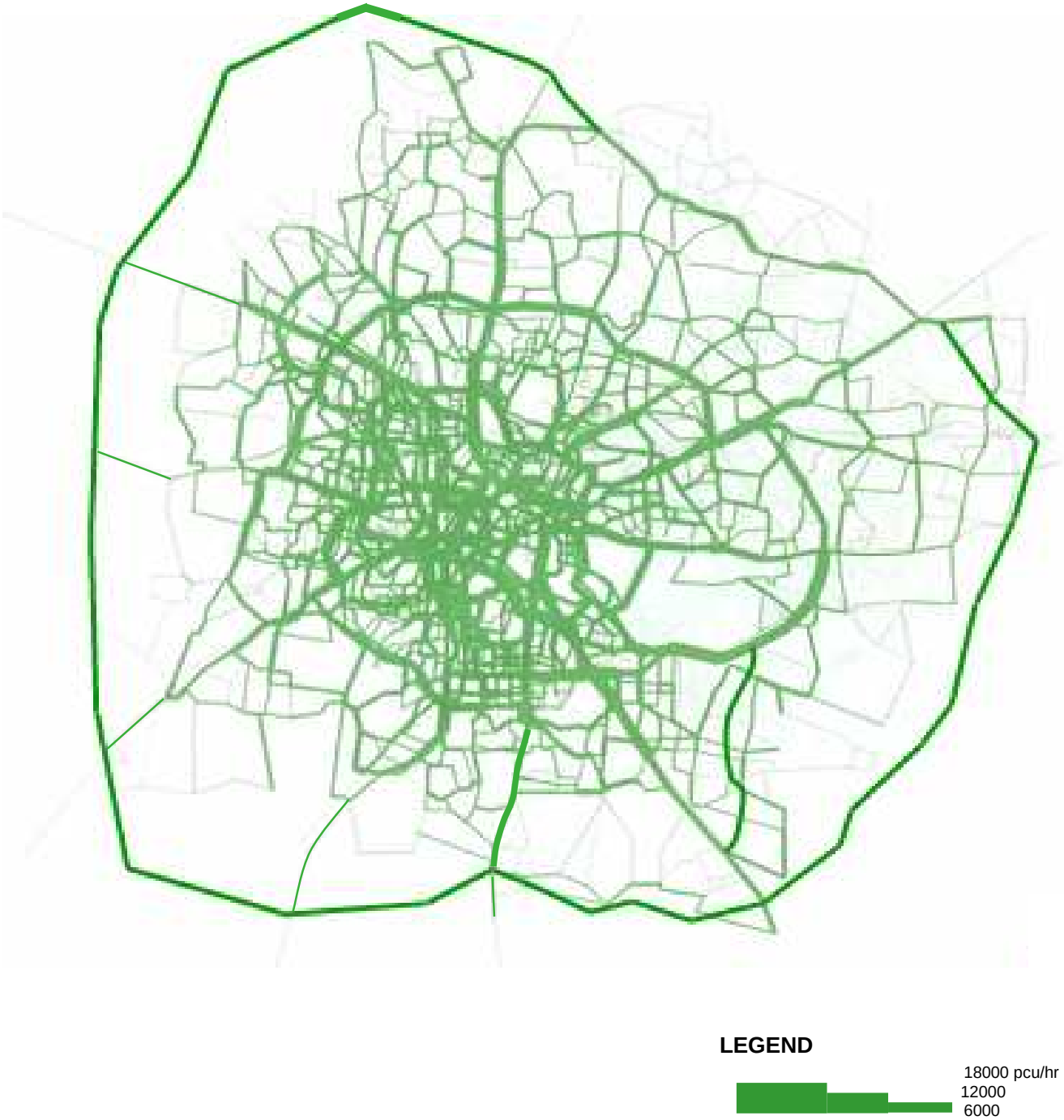


Figure 6.6 Peak Hour Peak Direction Trips (PHPDT) on Mass Transport Network (Scenario 3)

Figure 6.7 Peak Hour Traffic Assignment on Road Network for 2025 (Scenario 3)



increasing the ROW. Cost of the same mode of transport can vary at different locations depending on engineering constraints. It is therefore important that the final choice of mode is based on techno-economic considerations.

6.6.2 In choosing a mode for a corridor, first priority should be given to at-grade services and BRT. It offers convenience to commuters particularly the short distance users. Commuters do not have to walk up and down to use the services. The construction cost is low. It offers the best financial sustainability. If road ROW is inadequate and it cannot be widened, and/or the route is congested, an elevated mode needs to be proposed.

6.6.3 Capacity of Various Modes

The comparative capacity of the main transport modes used in developing cities is reported in a TRRL-UK study (1995) and World Bank study (2000). As per these studies, it appears that the capacity of various modes may be taken as follows;

BRT (HCBS) at-grade	10000 to 20000 phpdt
LRT at-grade	2000 to 20000 phpdt
Metro/ Suburban Rail	30000 to 80000 phpdt

There is no mention of the Monorail in this study, but based on information available, it appears that the mode has been used up to a demand level of 10000 phpdt and designed and used in one case up to 20000 phpdt. Thus, it appears that BRT, Monorail and LRT, can be used when the demand on a corridor is not expected to exceed 20000 phpdt. Beyond the demand level of about 20000 phpdt, a metro appears to be the only choice.

The World Bank report further states that the bus way output depend greatly on road network configuration, junction spacing and stop spacing. It typically has been demonstrated to be high at about 10,000 phpdt at 20 km/h on arterial corridors and 15-17 km/h on urban corridors for a one-lane each way bus-way. If provision for bus overtaking at stops is provided, passenger throughputs of 20,000 phpdt have been demonstrated.

6.6.4 Proposed Capacity of Various Modes for Bangalore

Based on studies by World Bank and others, the following capacity norms for various modes are proposed to be adopted for Bangalore.

Table 6.4 Proposed Capacity of Various Modes for Bangalore

Modes	Capacity (phpdt)
Metro rail	> 30000
Elevated LRT	upto 30000
Elevated Monorail	upto 20000
At grade LRT	upto 15000
At grade HCBS	upto 20000 (with overtaking facility)

6.6.5 Right of Way Requirement

All medium capacity modes normally lie within the road right of way and hence require a share in the road space. At-grade modes however require more space than elevated modes. For at-grade BRT, the desirable right of way requirement is 35 m to meet the requirements of the IRC code, but with an absolute minimum of 28 m. The latter allows for two- lane sub-standard carriageways each way and a combined cycle track and footpath. Additional 7 m space is required at stations/stops. This includes the requirement for overtaking facility as well. It may be possible to reduce the requirement further when the demand level is low such as at the periphery of the city. The above does not include service roads. It is highly unlikely that the desired ROW will be available for full length of the corridor. Elevating the corridor at tight locations could be one option.

If minimum ROW of 28m (desirably 35m) is not available, elevated modes become necessary. For elevated Monorail or LRT, desirable ROW is 30 m to meet the requirements of the IRC code, and an absolute minimum of 20 m because at ground level space is required only for a column and its protective measures. At stations, additional space will be required on the roadside.

Typical cross-sections of road with BRT, elevated LRT and Monorail are shown in **Figures 6.8 and 6.9** respectively.

6.7 SUGGESTED MASS TRANSPORT SYSTEMS FOR BANGALORE

On the basis of expected traffic demand in 2025 on the proposed mass transport corridors of Scenario 3 as explained above, available Right of Way on the corridors, capacity of various mass transport modes and already available mass transport system along a corridor, the mass transport systems on various corridors have been suggested. These are given in **Table 6.5**.

Table 6.5 - Public Transport System Selection

S. No.	CORRIDOR	Expected Maximum Traffic (PHPDT)	Available ROW (m)	System Recommended
1	Mysore Road to Baiyyappanahalli	75,000		Metro
2	Peenya to R V Road	75,000		Metro
3	Baiyyappanahalli to Benniganahalli	25,000	25	Metro
4	R.V. Terminal to PRR	25,000	25	Metro
5	Yelahanka Road to junction of Hi-tech corridor and Hosur Road via Nagavara, Electronic City	45,000	30	Metro
6	Indiranagar to Whitefield Road	35,000	25	Metro
7	Devenahalli Airport to MG Road via	20,000	24	Metro

S. No.	CORRIDOR	Expected Maximum Traffic (PHPDT)	Available ROW (m)	System Recommended
	Bellary Road (New Airport)		(within city)	
8	Hebbal to Bannerghatta Road along Western portion of ORR	20,000	20	Monorail / LRT
9	PRR to Toll Gate along Magadi Road	12,000	22	Monorail / LRT
10	Kattriguppe Road / Ring Road Junction to National College	14,000	18	Monorail / LRT
11	Hosur Road to PRR along Bannerghatta Road	18,000	22	Monorail / LRT
12	Hebbal to Bannerghatta Road along Eastern portion of ORR	15000	40	BRT
13	Benniganahalli (ORR) to PRR along Old Madras Road	10,000	30	BRT
14	From ORR to Hosur Road along Hi-tech Corridor	12,000	60	BRT
15	Hosur Road to Tumkur Road along PRR (western part)	8,000	100	BRT
16	Tumkur Road to Hosur Road along eastern side of PRR	6,000	100	BRT
17	Along Core Ring Road	12,000	25	BRT
18	Vidyaranayapura to Nagavarapalya	12,000	25	BRT
19	Kengeri Satellite Town to J.P. Nagar along Uttarahalli Road, Kodipura	12,000	30	BRT
20	Banashanakari III stage to Banshankari VI Stage Extension along Ittamadu Road, Turahalli, Thalaghattapura	9,000	35	BRT
21	Domlur Extension to Koramangala along inner Ring Road	10,000	25	BRT
22	PRR to Maruti Nagar (upto Hi-tech Corridor) along Sarjapur Road	15,000	25	BRT
23	Peenya to PRR along Tumkur Road	12,000	30	BRT
24	Old Madras Road near Indranagar to ORR near Banaswadi along Baiyyappanahalli Road – Banaswadi Road	10,000	22	BRT
25	Commuter Rail Corridors (10 corridors)	10,000	-	Commuter Rail System

Figures 6.8 Typical Cross-Sections of Road with BRT System – Mid Section (Minimum ROW – 28 m)

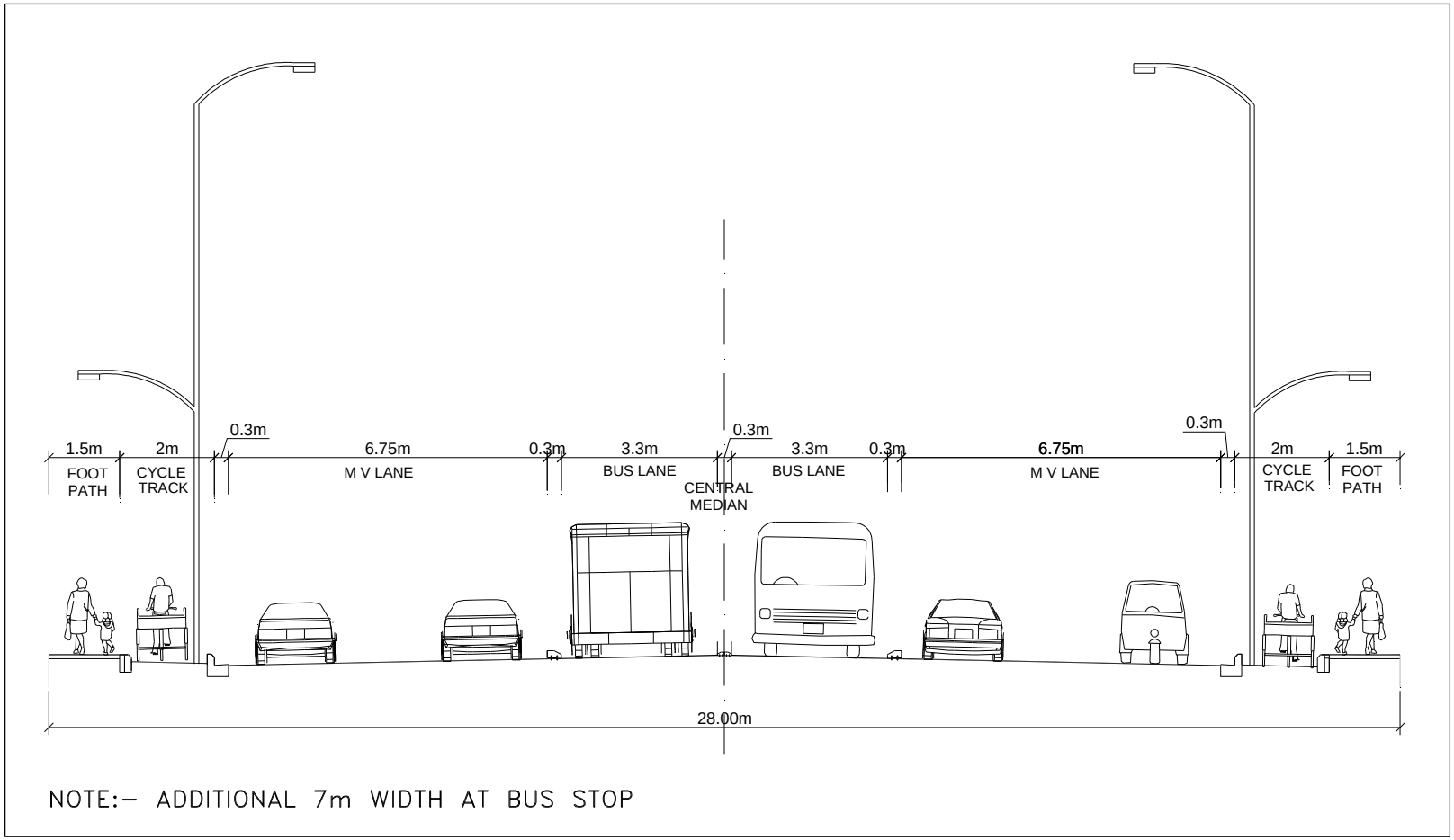
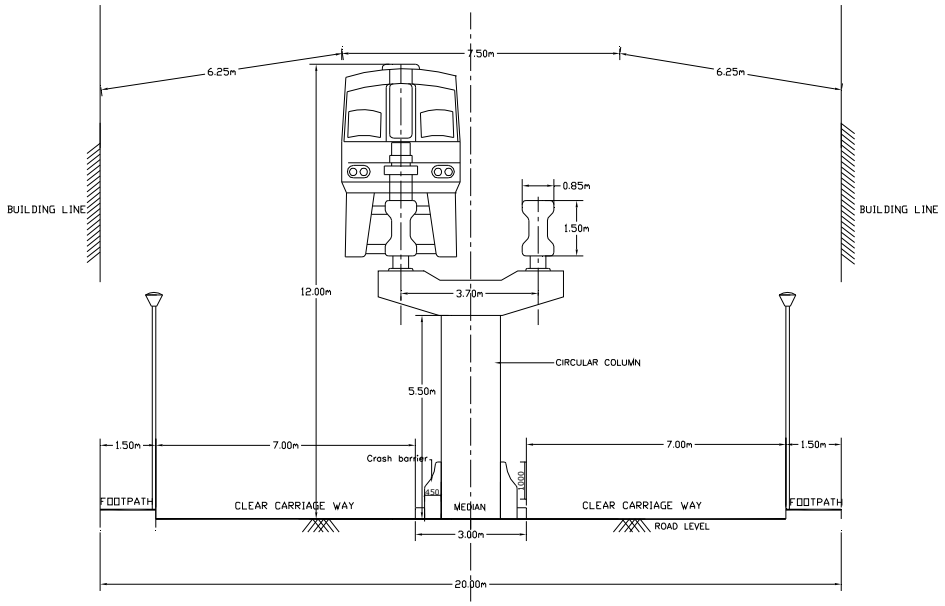
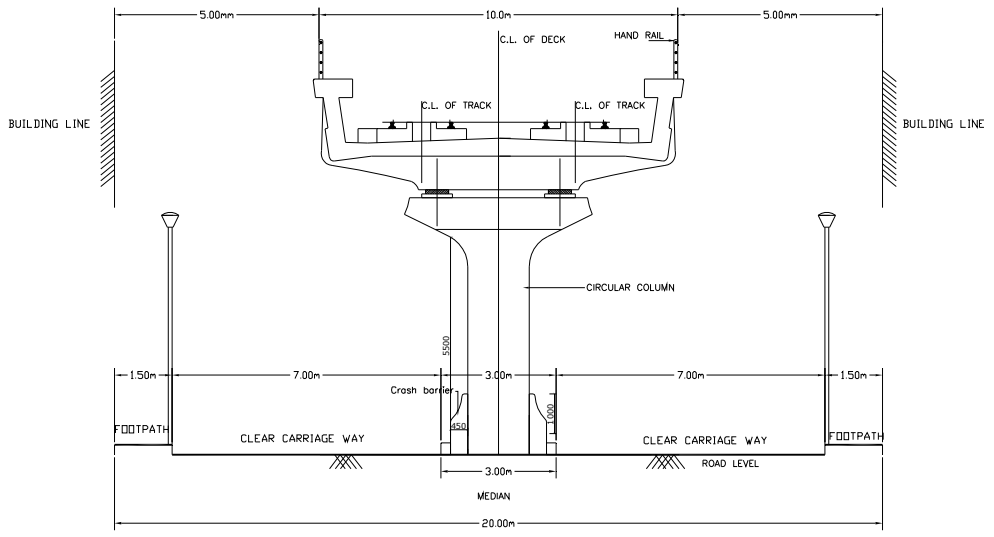


Figure 6.9 Typical Cross-Sections of Road with Elevated LRT and Monorail



NOTE:- ADDITIONAL 8m WIDTH AT STATION

TYPICAL CROSS SECTION OF ROAD WITH MONORAIL - MID SECTION (MINIMUM ROW - 20m)



NOTE:- ADDITIONAL 8m WIDTH AT STATION

TYPICAL CROSS SECTION OF ROAD WITH LRT - MID SECTION (MINIMUM ROW - 20m)