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OFFICE OF ORIGIN

BANGALORE

OWNER / CLIENT

BANGALORE DEVELOPMENT AUTHORITY

CONTRACTOR

PROJECT **PROVIDING CONSULTANCY SERVICES FOR CONSTRUCTION OF SIX LANE ELEVATED ROAD FROM BASAVESHWARA CIRCLE TO HEBBAL FLYOVER VIA LE-MERIDIAN HOTEL AND MEKHRI CIRCLE IN BANGALORE**

DPR FOR CONSTRUCTION OF SIX LANE ELEVATED ROAD FROM BASAVESHWARA CIRCLE TO HEBBAL FLYOVER

TITLE

DETAILED PROJECT REPORT

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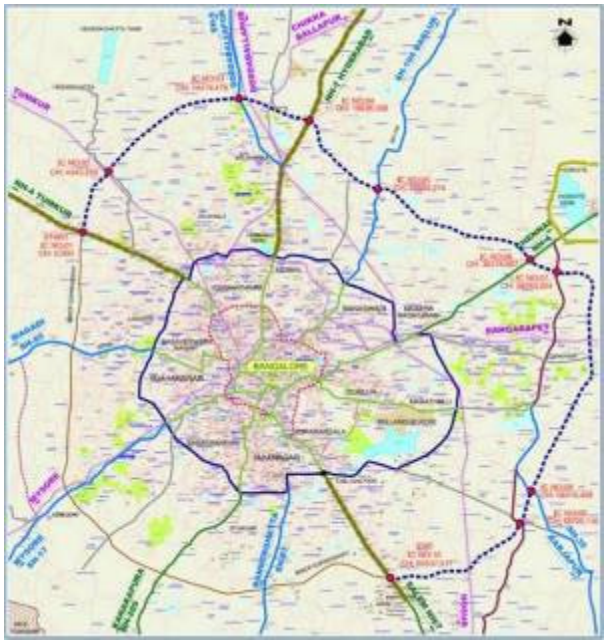
EXECUTIVE SUMMARY

0.1. Background

Bangalore is the fifth largest city in India with an en estimated population of around 95 Lakhs spread over 821 Sq Km. The present day vehicle population is ~52 Lakh. The city has seen an increase of over 10.2% in last 10 years while the population is has increased by ~ 3.25% during the same period.

Bangalore has a radial road network with 6 primary roads (National Highways) and 5 secondary roads (State Highways) converging / diverging from existing Outer Ring Road. The outer most road for Bangalore city at present is 65 Km long Outer Ring Road (ORR) constructed by Bangalore Development Authority. ORR was constructed as bypass to city taking away commercial vehicles and long distance personalised vehicles. Due to rapid ribbon development along ORR and beyond ORR lead to increase traffic on ORR and its interconnected roads. This has lead to traffic congestion at all major intersections and at midblock sections. Shift in International Airport from HAL to Devanahalli has changed the travel pattern in the city. At present, agencies like BDA and BBMP are implementing grade separators along ORR and at important junctions in the city. But this has not relieved traffic congestion between junctions.



In addition, agencies like Bangalore Development Authority (BDA) and Bhrhat Bengaluru Mahanagara Palike (BBMP) have taken up various road improvement measures to improve traffic movement on few road networks in Bangalore and make them signal free corridor for through traffic. In this regard, grade separators are constructed and few of them have been proposed at major junctions along these corridors, especially of Outer Ring Road and dense city roads.

The project corridor (road section between Basaveshwara Circle to Hebbal totalling ~ 6.7 Km) is one of the busiest roads in Bangalore city which is taking traffic from southern, part of south-east and south-west extensions of Bangalore and CBD area towards northern part of Bangalore and beyond. With the shift in Bangalore Airport from HAL to Devanahlli (Kempegowda International Airport (KIAL)), there has been manifold increase in passenger car and bus traffic which is predominant on the project road. Considering the increase in

traffic, NHAI has built 6 lane elevated road beyond Hebbal flyover leading to Airport. The surface level road has been upgraded to 6 lane main carriageway with 2 lane service road both sides. Presently the traffic from these 16 lanes is converging to 4 lane flyover at existing Hebbal flyover which is a bottleneck. In addition, NHAI has also augmented existing 2 lane flyover bound towards Airport with an additional lane to increase the capacity. With this, there is considerable reduction in traffic congestion, which at the same time reduces travel time between Hebbal flyover and Airport.

The road section between Hebbal and Basaveshwara Circle (via Mekhri circle) is already congested with traffic queue pile up for longer durations during peak hour. Traffic from Airport will suddenly get converge at Hebbal flyover (2 lane) and towards the city. The existing land use pattern is such that horizontal widening of existing road is practically not possible.

Thus, construction of proposed elevated road to make the project corridor signal free and access controlled is essential for the following reasons,

- *To reduce signal time and delay*
- *To increase travel speed*
- *To cater for unhindered movement of traffic from NH-7*
- *To cater for airport bound traffic*
- *To cater for future project traffic*

0.2. Scope of Work

Bangalore Development Authority (Client) has appointed M/s STUP Consultants Pvt. Ltd to carry out Detailed Project Report. The consultant has carried out various activities as part of the assignment which is covered in the DPR:

- *Field surveys and investigations – reconnaissance, topography, traffic studies and geotechnical investigations.*
- *Concept plan - concept plan alternatives were developed for the project corridor, discussed and presented to BDA and best suited alternative was selected for implementation. The concept plan includes elevated road, widening of existing Hebbal flyover on RHS and proposal for an underpass at Hebbal junction.*
- *Alignment planning and design – existing road centre is followed for proposed elevated road as far as possible to avoid / minimise land acquisition.*
- *Vertical profile design as per IRC standards*
- *Junction layout and design – remodelling of existing major intersections*

- *Road miscellaneous items – road side drainage, road signs, lane markings, kerb stones, crash barrier and other traffic safety appurtenances*
- *Design and drawings for plan and profile*
- *Drawings for pavement typical cross sections*
- *Bill of Quantities, rate analysis and Cost estimate as per PWD SR.*
- *Presentation to BDA, Traffic Police Department and Technical Advisory Committee*

0.3. Salient Features of Proposal

Key Plan of the proposed elevated road corridor is given in Figure 8-3. The salient features of the proposal are as follows:

- *Construction of Elevated road*
  - *Main Flyover between Rajbhavan and Hebbal - 6687.000 m*
  - *Up ramp towards Maharani College - 1157.000 m*
  - *Down ramp towards Maharani College - 1295.000 m*
  - *Up ramp towards Vidhana Soudha - 479.000m*
  - *Down ramp towards Vidhana Soudha - 403.000 m*
  - *Down ramp towards Race Course - 293.000 m*
  - *Down ramp at Mekhri Circle - 660.000 m*
  - *Down ramp at Vasanthanagar - 280.000 m*
  - *Down ramp at Sanjay Nagar - 371.000 m*
- *Construction of Underpass*
  - *Along Rajbhavan towards Race Course - 870.000 m*
  - *Along Millers Road towards Race Course - 285.000 m*
  - *Along Cunningham Road towards Airport - 235.000 m*
- *Cross Section Configuration of Grade Separator*
  - *Main Flyover - 6 lane of 24.20 m*
  - *Ramps - 2 lane of 8.50 m*
  - *Underpass along Rajbhavan and Millers road - 2 lane of 8.50 m*
  - *Underpass along Race Course road - 3 lane of 10.00 m*
  - *Cunningham Road Underpass - single lane of 4.00 m*
- *Cross Section Configuration of Surface Level Road*
  - *Main Road - 9.00 m*
  - *Service Road - 7.50 m*
  - *Other Roads - 5.50 m (min)*
  - *Central Median - 4.50 m*

- *Separator Median - 1.00 m*
- *Footpath cum Drain - 1.50 m (min)*

- *Cross Slope - 2.5 %*
- *Vertical Clearance*
  - *Flyover - 5.50 m (min)*
  - *Underpass - 4.50 m (min)*
- *Design Speed*
  - *Main Flyover - 50 kmph*
  - *Underpass and Ramps - 30 kmph*

0.4. Land Acquisition

Additional land acquisition area required for construction of comprehensive proposal is about 19115 sqm (Govt. land 13979 sqm & Pvt. Land = 5136 sqm).

0.5. Improvement

On completion of elevated road from between Basaveshwara Circle and Hebbal,

- *Reduces travel time for through traffic between city and KIAL*
- *Reduces traffic congestion at surface level*
- *Reduces signal timing and delay at all major junctions*

0.6. Project Cost and Benefit

The estimated cost for construction of proposed elevated road excluding land acquisition cost works out to Rs. ***1350*** *Crores based on 2014-15 PWD Schedule of Rates, Bangalore Circle.*

The consultant has carried out economic evaluation of the project and finds that the Economic Internal Rate of Return (EIRR) for project road is ***17.07%*** *with Benefit to Cost ratio of* ***1.90****.*

<u>This document is prepared based on suggestions and directions given by BDA at the time of submitting this DPR.</u>

1.0 INTRODUCTION

1.1 Background

Bangalore, officially known as "Bangalore" is the 3rd most populous city in India and 18th most populous city in the world. Bangalore was the fastest-growing Indian metropolis after New Delhi between 1991 and 2001, with a growth rate of 38% during the decade. Bangalore which is also referred as the “Silicon Valley” of India has evolved as a global competitive city in the recent years in IT field. Bangalore is known for its pleasant climate throughout the year. It is the highest metro city in India. The city is amongst the top ten preferred entrepreneurial locations in the world. The majority of the city of Bangalore lies in the Bangalore Urban district and the surrounding rural areas are a part of Bangalore Rural district, together covers an area of about 741 sq.kms. The population has increased from 5.1 million in 2001 to 8.4 million in 2011 with about 65% growth in a decade. Over 60% of the Bangalore population comes from natural growth, while the migrant population constitutes about 25%.

Rising traffic congestion is one of the key issues in the City. In the recent past there has been an appreciable increase in the volume of personalized and public modes of vehicles plying on city roads. The number of registered vehicles in Bangalore has increased rapidly from 400,000 (1987) to 3.9 million (2011). The number of 2-wheelers in particular constitutes to nearly 74 % of the total vehicles. The vehicular growth rate in Bangalore city between 1980 and 2001 is about 11%. In view of above, there has been a huge increase in volume of vehicles on the city roads. The lack of need based public transport system with mass rapid transport system like metro train still under construction stage amplified traffic congestion problem. Hence, there is an urgent necessity to decongest the over congested intersections.

1.2 Need for Improvement

Project road is one of the important road of the city connecting Central Business District and National Highway No 7 leading to Hyderabad. Due to the shift in Bangalore Airport from HAL to Devanahalli, there has been tremendous increase in traffic on this section of road. The proportion of Passenger cars, Light commercial vehicles and Public Transport bus service has increased manifold to provide faster connectivity to Kempegowda International Airport (KIAL). Presence of airport at Devanahalli has lead to development of residential, commercial and educational institutions due to which volume of other motor vehicles like T/w and auto have also increased upto Yelahankha.

In order to provide adequate roadway capacity in this stretch for present traffic and increased traffic at future, National Highway Authority of India (NHAI) has constructed 6 lane elevated road after Hebbal flyover towards KIAL with provision of 6 lane surface level road and 4 lane slip road (2 on either side). On completion, traffic from KIAL towards city will suddenly converge to 4 lanes at Hebbal flyover (existing Hebbal flyover is 4 lanes, bi-directional). On crossing Hebbal flyover, local traffic, especially T/w and auto will get added to the through traffic and has to use existing 6 lane road. Surface level widening of existing road to increase the capacity of road section practically difficult due to land acquisition issues. Hence, the other option for increase in capacity is to review provision of grade separator for through traffic (between Highgrounds junction and Hebbal). This will reduce traffic congestion at surface level and signal time at junctions.

Bangalore Development Authority (henceforth referred to as “Client”) is desirous of taking up implementation of elevated road between Le-Meridian Hotel to Hebbal flyover for segregating through traffic between Le-Meridian hotel and Hebbal from surface level traffic. BDA has planned to complete concept plan and preliminary traffic study before taking up Detailed Project Report for the project. They have appointed STUP Consultants Pvt Ltd (henceforth referred to as “Consultant”) to carry out traffic study and prepare preliminary traffic survey report for the project vide Agreement dated 27/11/2013 and issued work order vide letter No. BDA/EE/Infra-Dvn-3/WO/T-10/2013 dated 27/11/2013.

1.3 Coverage of Present Report

The present report covers the following under various chapters.

- CHAPTER 2.0 : OBJECTIVE AND SCOPE OF WORK
- CHAPTER 3.0 : PROJECT COSTING
- CHAPTER 4.0 : FIELD SURVEY AND INVESTIGATION
- CHAPTER 5.0 : TRAFFIC ANALYSIS
- CHAPTER 6.0 : GEOTECHNICAL INVESTIGATIONS
- CHAPTER 7.0 : PLANNING AND DESIGN CRITERIA
- CHAPTER 8.0 : ALIGNMENT OPTIONS
- CHAPTER 9.0 : IMPLEMENTATION PLAN
- CHAPTER 10.0 : TRAFFIC DIVERSION AND MANAGEMENT
- CHAPTER 11.0 : ECONOMIC ANALYSIS
- CHAPTER 12.0 : PROJECT INSTITUTIONAL FRAMEWORK
- CHAPTER 13.0 : LEAGAL ASSESSMENT
- CHAPTER 14.0 : RISK ASSESSMENT
- CHAPTER 15.0 : OTHER COMPONENTS DURING CONSTRUCTION PHASE
- CHAPTER 16.0 : CONCLUSION AND WAY FORWARD

2.0 OBJECTIVE AND SCOPE OF WORK

2.1 Objective

The primary objectives of the study are listed below:

- Topographic surveys on existing road for alignment planning and design.
- Traffic studies for assessment of lane requirement.
- Geotechnical investigations to study existing ground strata beneath the ground
- Feasibility of Elevated Road along the project stretch,
- Suitability of Up and Down ramps at major intersections along the project corridor,
- Improvement of at-grade junctions,
- Integration with Existing grade separator facility,
- The traffic management measure with an aim to relieve traffic congestion at surface level to reasonable extent along the corridor,
- Preparation of Detailed Project Report,
- Preparation of Bidding Documents and assistance in awarding of the contract.

2.2 Scope of Work

The scope of work of the project defined in TOR is envisaged to be carried out in two phases as follows:

Phase I

- Topographical Survey capturing the following details
    - Road land available and existing building lines
    - Existing surface utilities lines
    - Road side features – c/w, shoulder / footpath / median with spot levelsJunctions and interchanges
- Traffic studies
    - Classified traffic volume counts
    - Limited Origin and destination surveys
    - Speed and delay studies

- Junction delay studies
- Pedestrian volume count

- Geotechnical investigations to generally establish sub soil strata
  - Borehole investigations - Mechanical and Auger Bore
  - Laboratory test for collected soil sample

Phase II

- Preparation of concept plan for proposed elevated road with options.
- Preparation of alignment plan and profile drawings for finalized concept plan option.
- Preparation of Preliminary Traffic Survey Report
- Preparation of Detailed Project Report
- Preparation of BOQ and Cost Estimate
- Preparation of Tender Document, assist BDA in evaluating bids

2.3 Work Methodology

The activities that are involved for the present assignment are highlighted in the following section. The stage wise outputs in the process along with the inputs required for the same is presented in the form of a flow chart and elaborated in following sections. The assignment is split into following phases:

- Project conceptualization with pre-feasibility study report
- Preparation of feasibility report
- Financial analysis and financial structuring
- Preparation of Detailed Project Report(DPR)
- Preparation of tender documents and assistance in bid-processes

Figure 2-1 shows the proposed methodology chart for carrying out various tasks of the project. The exact sequence is likely to vary during the course of the study, however a general guideline is proposed in the form of flow chart. The various activities envisaged as per TOR are defined stage wise and BDA may decide to take up any stages in-between during the course of the assignment.

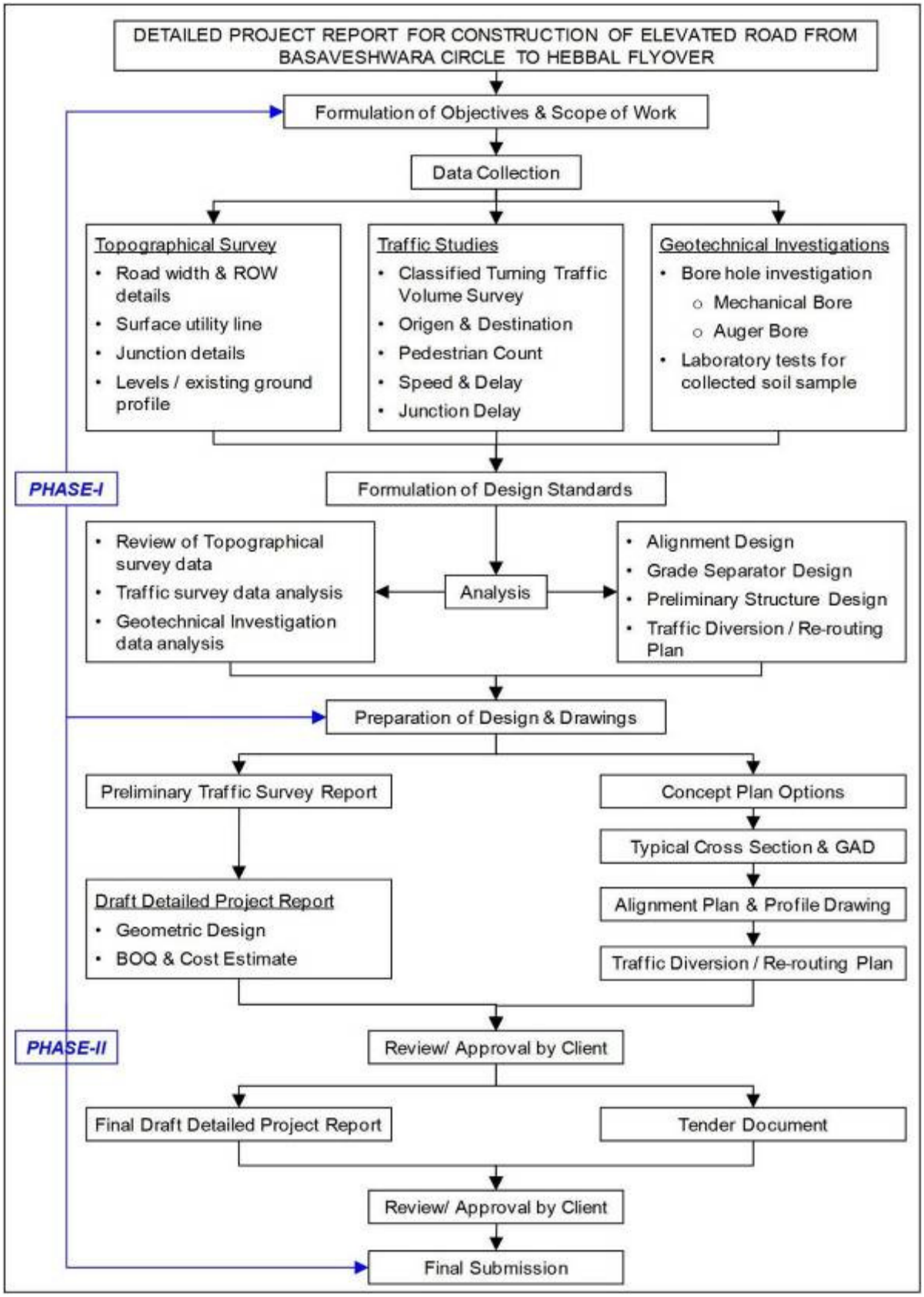


Figure 2-1 Work Methodology Chart

2.4 Design Philosophy

The Technical proposal given in this report consists of designs, drawings and all technical details based on surveys and investigations stated in Section 2.2 above.

The design standards adopted in the present design are in accordance with the codal provisions of India as stipulated by the Indian Roads Congress (IRC), Indian Standards Specification (IS) and the Ministry of Road Transport & Highways. Deviations have been reviewed from projects of similar nature and considered in planning / design parameters only if required under unavoidable circumstances considering the dense urban conditions from the present codal provisions. These modifications in the design are adopted based on projects under similar situations at urban locations as “Good Engineering Practice” and after discussing with client.

The designs and drawings presented as a part of this report are based on Study, Investigations and Designs followed up with consultation with BDA at various stages considering interfaces with on-going works. The consultants opine that the details provided in the present report will form the basis for detailed engineering designs and drawings prior to construction of the facility.

2.5 Deliverables

Following drawings & documents are proposed to be submitted as part of this Report:

- Road Drawings
    - Plan & Profile drawing for Main Flyover, all underpasses, up & down ramps
    - Road marking and signage drawings
    - Junction improvement drawings
    - Road drain plan & profile drawing
    - Traffic diversion plan & Road miscellaneous drawings
- Structural General Arrangement Drawings
    - Foundation, Sub-structure & Superstructure drawings
    - Standard span, Obligatory span & Portal span details
    - Retaining wall of Underpass & RE panelling for flyover ramp details, etc
- Electrical layout plan
- BOQ, Cost estimates and Rate analysis for all items of the proposal

3.0 PROJECT COSTING

Detailed cost estimate are prepared for the project based on KPWD Schedule of Rate 2014-15. Data rates are prepared for structural steel works for which rates are not available in SoR. Quantities of different work items have been worked out considering the typical cross sections, proposed improvement, road alignment and widening proposals as recommended and submitted to BDA. The project costs are estimated for all related and associated works required to complete elevated road on steel flyover. The summary of the costs of the proposed elevated road is given in Table 3-1. The detailed cost estimate for proposed elevated road, assumptions made and basis for arriving at quantities is submitted to BDA with report No **CN-160 Rev R(7)** vide letter no 14/11480/E/KGK/641 dated 15/10/2015.

Table 3-1 Summary of Cost Estimates

Sl No	Description	Amount (Crores)
A	**Construction costs**	
1	Steel flyover both (Main flyover & Ramps)	1106.86
2	Approaches to steel flyover with RE panel	20.90
3	Grade separators (3 underpasses)	20.88
4	Road widening works including drainage & signages	103.11
5	Contiguous piles at Hebbal ramps for traffic diversion	1.33
6	Illumination works	17.63
B	**Preliminary costs**	
1	Topo survey	0.13
2	Geo technical investigations	0.64
3	Utilities diversions / shifting - re-routing works	
(i)	for BWSSB - Water lines	6.90
(ii)	for BWSSB - UGD lines	0.39
(iii)	for shifting / re-routing electrical utilities	13.18
(iv)	for infrastructure deposit for BESCOM / KPTCL	8.68
4	Improvement & Maintenance of Road under Traffic Management	18.23
5	Railway Dept overheads & supervision charges only - @ 6.25%	0.75
5	Span load testing as per IRC-51 by NABL accredited agencies	0.56
6	Miscellaneous and unforeseen works	
7	Contingency and rounding off (including rental charges for 6 acres of land for site office, batching plant, reinforcement storage and bar bending, etc)	2.20
C	**Engineering & Construction supervision costs**	
1	Design Engineering charges	5.16
2	PMC charges	13.22
3	Miscellaneous, animation, unforeseen works & rounding off	9.24
	Project Cost	**1350.00**
Note : *Excluding Land Acquisition Cost*		

4.0 FIELD SURVEY AND INVESTIGATION

4.1 Introduction

The consultant has carried out various field studies and investigations which are used in designs and analysis for preparation of Detailed Project Report. Various surveys and investigations carried out for the study include:

- Reconnaissance
- Topography Survey
- Traffic Survey
    - Classified Turning Traffic Volume Count
    - Origin & Destination Survey
    - Speed & Delay Survey
    - Junction Delay Survey
    - Pedestrian Volume Survey
- Geotechnical Investigations

4.2 Site Appreciation and Reconnaissance

The Consultant visited the site to acquaint themselves and to study existing features and other site related aspects, which are necessary in review and planning the feasibility of providing elevated road facility along the project stretch.

The project corridor is located along Palace Road between Rajbhavan and Hebbal flyover. The length of project stretch on existing road is about 6.80 kms. The project road is divided into two homogenous segments for convenience, i.e., (i) Rajbhavan to Mekhri Circle and (ii) Mekhri circle to Hebbal flyover approach. The main road traffic (Airport – City bound) is presently signal free between Mekhri circle to Hebbal while the road section between Rajbhavan to Mekhri circle comprises of both straight moving and turning traffic on main road.

There are six major junctions in the project stretch as follows:

- Basaveshwara Circle (including Highgrounds & Millers Road junction)
- Kumarakrupa Road Junction (near Windsor Mannor bridge)
- Vasanthanagar Road junction
- Cauvery Theatre Junction

- Mekhri circle & RT Nagar (Taralabalu) Road
- Sanjaynagar Road Junction
- Anandanagar Road Junction

BBMP has constructed precast box type underpass for cross traffic at Cunningham cross road, Vasanthanagar cross road, Cauvery Theatre junction, Sanjaynagar road junction and Anandanagar road junction, which facilitates unhindered movement of main road traffic.

In addition, the project stretch has:

- Railway Over Bridge (ROB) (Bangalore – Chennai line) at Windsor Mannor.
- Existing underpass at Mekhri circle junction

Key Plan showing the project road section is given in Figure 4-1.

Figure 4-1 Key Plan Showing the Project Road

4.3 Reconnaissance Survey

The observations made during the reconnaissance survey in and around the project corridor is summarised below and photographs highlighting some of the existing features is shown below. The observations made during the reconnaissance survey include road user movements, roadside developments, road widening proposals, bus stop locations, drain, street lighting pattern, general road geometry and constraints.

4.3.1 Basaveshwara Circle

- It is a six arm intersection. One arm leads to Rajbhavan; one arm leads to Dr.B.R.Ambedkar Veedhi, one arm to Palace Road, one arm to Race Course, High Grounds Junction and one arm to Millers Road.
- There is a bi-directional traffic movement at surface along Dr.B.R.Ambedkar Veedhi Road, Palace Road and Race Course Road. The other three roads are one-way.

Plate 4-1 Traffic accumulated on Millers Road at Chalukya Circle

Plate 4-2 Traffic accumulated on Rajbhavan Road at Chalukya Circle

4.3.2 High Grounds Junction

- It is a four arm junction
- One arm leads to Chowdaiah Road, one arm leads to Palace Road (Basaveshwara Circle), one arm leads to Sanky Road and one arm leads to Palace Cross Road (Vasanth Nagar)
- There is a bi-directional traffic flow along Sanky Road. The other three roads are one-way.
- A small elliptical/ oval shaped rotary is present at the junction along with channelising island between Chowdaiah Road and Palace Road.
- Pedestrian Skywalk is present for Chowdaiah Road and Palace Road.
- The merging movement is causing traffic congestion at the entrance of Chowdaiah Road.
- The vertical clearance is more than 5.00mt for pedestrian skywalk at Chowdaiah Road and Palace Road.

Plate 4-3 Pedestrian Skywalk at High Grounds Junction

Plate 4-4 Conflict due to weaving of traffic at High Grounds Junction

4.3.3 Kumarakrupa Road Junction

- It is a four arm intersection. One arm leads to High Grounds Junction, one arm leads to Kumarakrupa Road (Kumara Park East), one arm leads to Sanky Road and the other one is a cross road
- Bi-directional traffic flows on all four roads
- Manual signal will be operating at this junction during peak hours
- A small oval shaped rotary is present at the junction along with channelising island for Sanky Road.
- Windsor Manner Bridge and an RUB is located close to the junction
- The ramp starts/ ends exactly at the junction
- The vertical clearance for main road at Windsor Manner Bridge is very much less than 5.00mt.

Plate 4-5 Windsor Manner Bridge Ramp Starting at Kumarakrupa Road Junction

Plate 4-6 RUB Near Kumarakrupa Road Junction

4.3.4 Palace Road Junction

- It is a four arm intersection.
- Sanky Road is the main road at this intersection with one cross road leading towards Palace Road and the other road leading towards V.S.Raju Road
- All the four arms are catering for bi-directional traffic movement
- The main road is grade separated by Precast Box at this junction
- The cross roads run at-grade under the Precast Box

Plate 4-7 View of At-grade Road below Grade Separator at Palace Road Junction

Plate 4-8 View of Service Road at Palace Road Junction

4.3.5 Cauvery Theatre Junction

- It is a three arm Y-type intersection. One arm leads to Palace Road Junction, one arm leads to Sanky Tank and the other arm leads to Mekhri Circle
- All the three arms cater for bi-directional traffic movement
- Precast Box type under pass exists towards Sanky Road at the junction.
- The traffic from Sanky tank side comes through the underpass to the junction.
- The through traffic coming from Palace Road takes left turn at the junction to Sanky road, U-turn over the underpass and again takes left turn at the junction to go towards Mekhri Circle.
- This highly complicated movement is causing delay and traffic jam at the junction

Plate 4-9 View of Sanky Road Up-ramp at Cauvery Theatre Junction

Plate 4-10 View of Underpass at Cauvery Theatre Junction

4.3.6 Mekhri Circle

- It is a four arm intersection. All four roads are major roads with bi-directional flow
- 6 lane underpass exists in the direction Bellary Road with 7.50m wide service roads available in all the directions for surface level traffic
- Channalising islands exists which helps smooth traffic flow
- Presently junction is operated with pre timed signals.
- Good drainage system exists at the junction.
- Junction is illuminated with High Mask Lighting
- Air Force Quarters is located on the left side of corridor and Palace ground on the right side.

Plate 4-11 Existing underpass at Mekhri Circle along NH-7

Plate 4-12 Turning traffic left on service road towards Jayamahal

4.3.7 Sanjaynagar Road Junction

- Three arm signalised intersection
- Bellary Road is the main road and D.Rajagopal Road is the cross road which leads towards Raj Mahal Vilas
- Bi-directional traffic operates both on main road and cross road
- Grade separator exists close to the junction and the up-ramp starts exactly at the junction
- 6 lane road exists over the grade separator
- The service roads are wide enough to accommodate the traffic

Plate 4-13 View of at-grade service road

Plate 4-14 View of vehicular underpass at Sanjaynagar Road Junction

4.3.8 CBI Junction

- It is a three arm T-type intersection. Bellary Road is the main road and CBI Road is the cross road which leads towards R.T.Nagar
- Bi-directional traffic operates both on main road and cross road
- Grade separator exists for main road at the junction
- 6 lane road exists over the grade separator
- The service roads are wide enough to accommodate the traffic
- Through traffic of main road moves over the grade separator, where as the cross and turning traffic moves at-grade
- Government Veterinary College is located close to the junction

Plate 4-15 At-grade Road at CBI Junction

Plate 4-16 View of vehicular underpass at CBI Junction

4.3.9 Hebbal Junction

- It is a four arm junction intersecting two major roads. One is Bellary Road and the other one is Outer Ring Road
- All four arms carry bi-directional traffic
- Bellary road comprise of four lane divided carriageway with service road both side at the junction
- Outer Ring Road comprise of six lane divided carriageway with service road both side at the junction
- The junction is grade separated with partial clover leaf type grade separator
- Through traffic of Bellary Road moves over the grade separator, where as the through traffic of Outer Ring Road travels at grade
- Down ramp exists for right and left turning traffic coming from the city through Bellary Road towards Outer Ring road.
- Up ramp exists for traffic entering the city from Outer Ring Road through Bellary Road from either directions
- Free left turning is provided for traffic coming from Bellary Road (Airport side) to Outer Ring Road (Nagavara side), and Outer Ring Road (BEL side) to Bellary Road (Airport side)
- Hebbal Lake is located to left side of Bellary road at the junction
- The grade separator passes over railway track
- Hebbal railway station is located close to the junction

Plate 4-17 Flyover at Hebbal Junction (End of the Project Road)

Plate 4-18 View of at-grade road at Hebbal Junction

Plate 4-19 Ramp and at-grade roads at Hebbal Junction

Plate 4-20 Aerial view of ORR towards kolar at Hebbal Junction

4.4 Existing Traffic Flow Pattern

The existing traffic movement pattern on the project road is shown in Figure 4-2 and details as follows:

- Basaveshwara circle is 6 arm junction out of which 3 roads are cater for one way traffic movement.
- Mekhri Circle is a 4 arm junction for turning movements with underpass for through traffic along the project road.
- Hebbal Junction is with 4 lane flyover along Bangalore – Hebbal and 3 arm junction at surface along ORR.
- Other major intersections at Cunningham road cross, Kumarakrupa road junction, Vasanthanagar, Cauvery theatre junction, CBI junction has precast box for cross road traffic movement.

The proposed improvement on the project road from Basaveshwara Circle (Chalukya circle) to Hebbal provides for bi-directional traffic flow throughout. The existing scenario is such that even though the existing roadway is provided with divided carriageway and underpass at few major junctions, the traffic flow along with project corridor at few sections gets completely chocked during peak duration in the morning and in the evening.

- Kumarakrupa Road Junction: Uncontrolled traffic movement around mini roundabout has resulted in traffic congestion in all 3 arms of the junction. Traffic queue is seen for a length of 100m in all 3 arms.
- Cauvery theatre junction: The through traffic moving towards airport has to make “hair pin bend turn” (take left turn to Sankey road then takes u-turn over the underpass and again taking left turn) to come back to the main road. The road width and turning radius over the underpass appears not be in accordance with IRC provisions. Because of the sharp and acute turn, buses and other heavy vehicles find it difficult to manoeuvre u-turn at this junction. During peak hours, queuing of vehicles is seen for a length of 150m – 200m on Bangalore side.
- Mekhri Circle - Even though main traffic (Airport bound) gets segregated through existing underpass, traffic congestion is observed on Hebbal side approach of this junction due to following reasons:
    - Close proximity to Taralabalu road (free left turning towards Mekhri circle).
    - Presence of auto stand, BMTC bus stop and unregulated parking of cabs
    - Narrow approach road on LHS towards Jayamahal junction

- Narrow road width beyond Mekhri circle towards Yeshwanthapur

The result of traffic congestion at Mekhri circle leads to traffic blockade upto Baptiste hospital during peak duration in morning and evening.

Pedestrian crossing zones are present at 5 locations; most of them are in proximity with the existing bus stops. The location of existing pedestrian crossings along the project road is shown in Figure 4-3.

- Highgrounds Police Station (infront of Sophia school)
- Vasanthanagar junction near BDA,
- Sanjaynagar Junction,
- CBI Junction,
- Anandnagar Junction in-front of University of Agricultural Science, and
- In-front of Hebbal Police Station.

Figure 4-2 Existing Traffic Flow Pattern

Figure 4-3 Existing Pedestrian Crossing Locations

4.5 Existing Signal Timing

Presently, Basaveshwara Circle, Millers Road Junction and Mekhri Circle are the signalised intersection existing along the project road. At Mekhri Circle junction through traffic between Hebbal - Highground is signal free which is using existing underpass at the junction. But traffic movement flow is very slow at approach to Mekhri circle underpass. Signals are present for at-grade traffic movement along cross roads. The existing signal timings are measured during site inspection with different signal phases at these three junctions are given in Figure 4-4 through Figure 4-6. The average total signal time is 197 seconds at Basaveshwara Circle, 111 seconds at Millers Road Junction and 227 seconds at Mekhri Circle respectively.

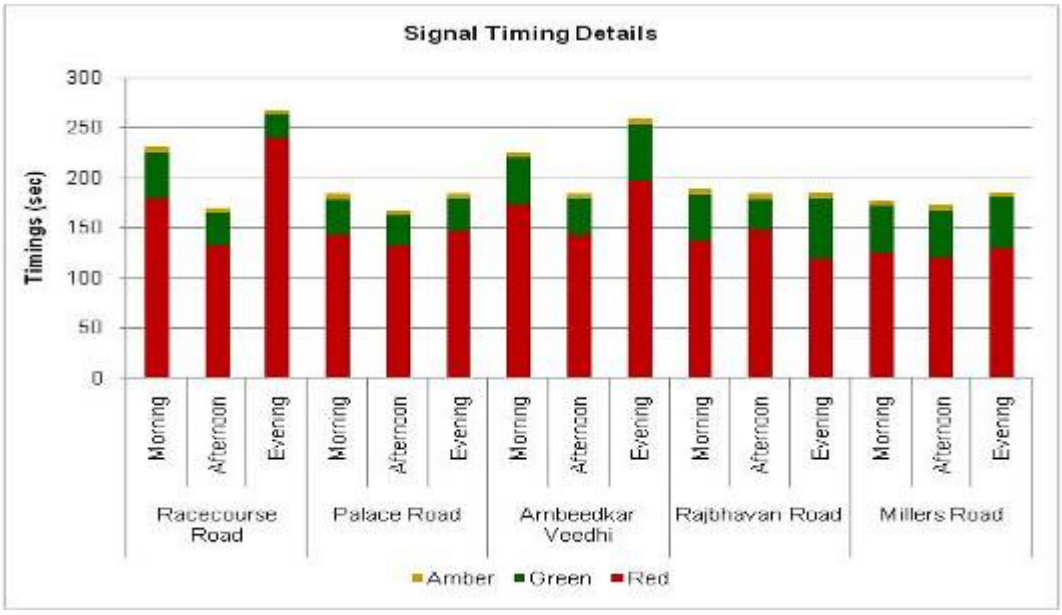


Figure 4-4 Signal Phase diagram of Basaveshwara Circle Junction

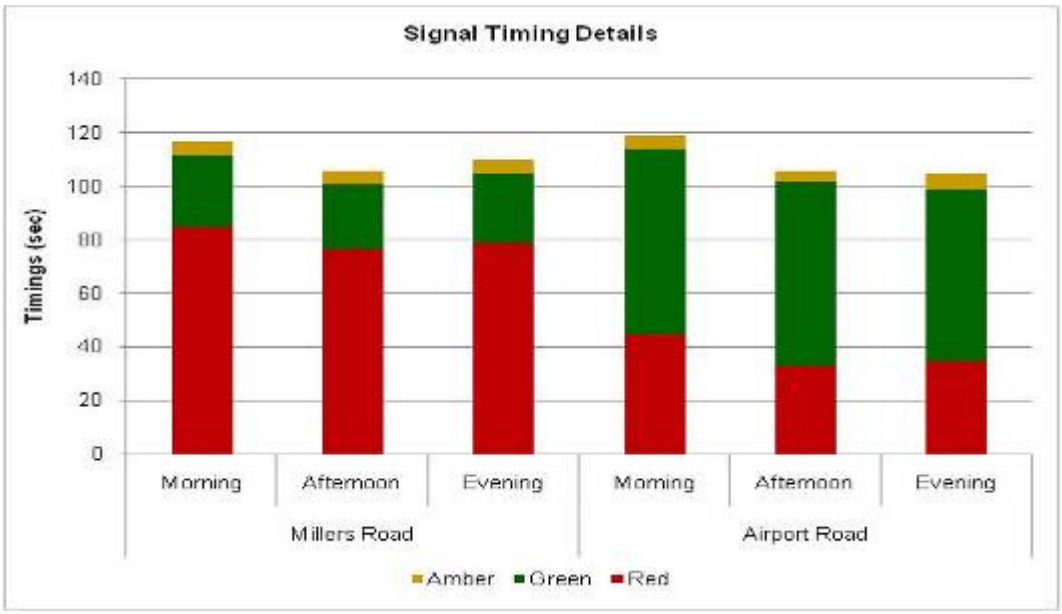


Figure 4-5 Signal Phase diagram of Millers Road Junction

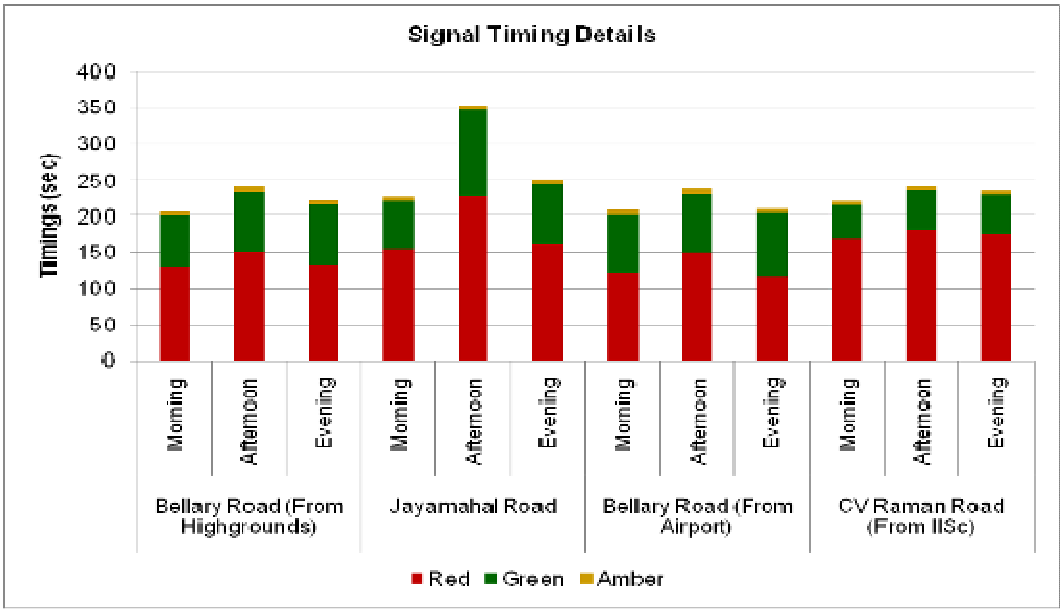


Figure 4-6 Signal Phase diagram of Mekhri Circle Junction

4.6 Topographical Survey

Topographical survey was conducted to capture the site features with total station for capturing vertical data. GTS benchmark was transferred to the site by carrying out fly levelling and the benchmarks were established at site. Entire levelling was carried out using GTS benchmark.

The following features were collected during survey:

- Existing pavement surface, its variation in width along with all other pertinent road details – centreline of carriageway, pavement edge, side drains, signs, km posts etc.
- Location of traffic islands, median, police chowkis, within limits of ROW.
- All religious places – temples, mosques, churches, graveyards etc., including location, building lines and clear dimensions of compound walls and extensions.
- Location of roadside drains, clearly identifying the type (open/close), width of drain, including the beginning and end of drains. All water features within ROW i.e. ponds, lakes, streams, canals.
- Identification of all culverts and other structures along the alignment
- Trees (position, species and girth measured 1.2m from ground level).
- Building fronts and outlines (to be classified by construction type i.e. RCC/tiled house/thatched house etc with number of stories).

- Any over crossing or under crossing of the road by road or rail.
- Electric transformers, mast, tower, etc.
- All telephone lines, OFC lines, Private OFC lines, Water Pipes including manholes above and below the ground belonging to layouts/ colonies and other bodies, electricity lines etc.

The width of the survey corridor was increased to collect data on arms of existing road junctions.. where the adjoining road, additional land was be surveyed for a distance of 100 m with cross sections at 25m c/c. Existing Building outlines were also recorded.

Levels along alignment were taken at every 25m intervals and at all intermediate breaks along the centre line of the existing alignment. Spot levels were recorded at critical points such as horizontal curve start, center and end points and vertical curve start, center and end points. The levels were recorded systematically in the open area.

Cross sections, covering drain to drain on either side of service road or compound-to-compound or building line which ever was more, were taken at intervals of 25 m in general with levels at 5 m c/c. Cross sections were taken at the centerline of all culverts and at all critical points, mentioned earlier.

4.7 Traffic Survey

4.7.1 Classified Turning Traffic Volume Count

Road design requires information on traffic that will be using the facility. Data regarding the traffic movement at different intersection in-between the corridor would help in planning the grade separators and junction improvements. To know the existing traffic flow pattern at various junctions along the project stretch, a typical 24-hour classified turning traffic volume count survey was conducted on a working day at all major intersections along the project road, which are listed below:

- Basaveshwara Circle
- High Grounds Junction
- Millers Road Junction
- Kumarakrupa Road junction
- Cauvery theatre Junction
- Mekhri Circle

- Sanjaynagar Road Junction
- R.T.Nagar Road Junction
- Hebbal Junction

The survey is done by manual count method. Traffic enumeration was made using tally marks at every 15 minute interval compiled for an hour. The survey was conducted to capture various vehicle classes categorized under Fast Moving Traffic and Slow Moving Traffic. The traffic data was analyzed later for hourly/daily fluctuations in traffic. From the volume count surveys, traffic composition, average daily traffic and peak hour traffic analysis is carried out for preliminary traffic study stage.

4.7.2 Origin & Destination survey

In order to ascertain the proportion of traffic likely to utilize the proposed road corridor, it is essential to conduct origin and destination (O&D) survey. Details regarding origin, destination, time taken, preferred route, journey purpose etc was collected, during the duration of stop signal at major crossings. The data derived from surveys was analyzed to bring out the preferred travel route, which aids in designing the proposed elevated corridor facility. The data will also be used in deciding the locations of intermittent ramp facilities along with site constraints.

4.7.3 Speed & Delay Survey

Speed and delay survey provides information on the average running speed and average journey speed along the corridor and delays occurring at junctions and intermittent locations. This in turn helps in identification of specific traffic congestion spots to plan improvement schemes. Since traffic plying along project corridor comprises of both through traffic (i.e., Airport, Bellary Road (NH-07) and Outer Ring Road bound) and local traffic which has origin and destination in and around Mekhri circle, speed and delay survey is carried out considering project area as a whole. The project area is divided into 2 major sections, one from Highgrounds police station junction to Mekhri circle and second, from Mekhri circle to Hebbal Junction. “Moving car observer” method is adopted to carry out speed and delay survey. Three runs were made along each stretch. Time taken to travel from one control point to next control point is noted down. Whenever queuing was encountered, time of delay was noted down as this is deducted to arrive at running speed.

4.7.4 Junction Delay Survey

The junction delay is an important parameter to be considered in the design of signalised intersection. The delay measurement is one of the attribute to be considered in estimation of vehicle operating cost. The reduction in delay at junction after the improvement is a measure of reduction in vehicle operating cost due to improved facility to the road user.

The delay measurement for each leg of the intersection was carried out. For this, road section at approach to junction is marked at every 50m interval. During the red phase of the traffic signal cycle, classified vehicle counts are taken for every 50m length and corresponding time taken for vehicles to occupy 50m length is noted. Like-wise, classified vehicle count and corresponding time taken for subsequent segments are noted until red phase is completed. Schematic representation of survey is given in Figure 4-7. The survey is repeated with many numbers of trials for all the arms of the junction till consistent results / data are obtained.

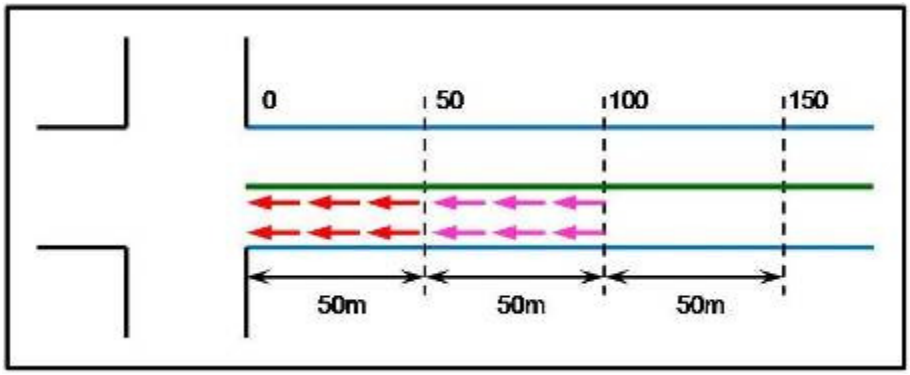


Figure 4-7 Typical Representation of Junction Delay Measurement

4.7.5 Pedestrian Volume Count

Pedestrian counts are carried out at suitable sections to decide on the provision of appropriate crossing facility, such as foot over bridge / pedestrian underpass and to check the adequacy of the width of the footpath provided. The study is carried out for duration of 16 hours on a characteristic working day, by adopting manual count method.

4.8 Geotechnical Investigations

Geotechnical investigation carried out includes drilling boreholes (mechanical and auger boring) at identified locations to determine the profile of natural ground strata below the project road. During the investigation, soil samples were collected and laboratory test was performed to evaluate both the index and engineering properties of the soil.

In addition to the above information about existing ground water table was collected.

5.0 TRAFFIC ANALYSIS

Traffic data collected as part of field investigations are analyzed and presented in following sections.

5.1 Classified Turning Traffic Volume Count

5.1.1 Traffic Flow Characteristics

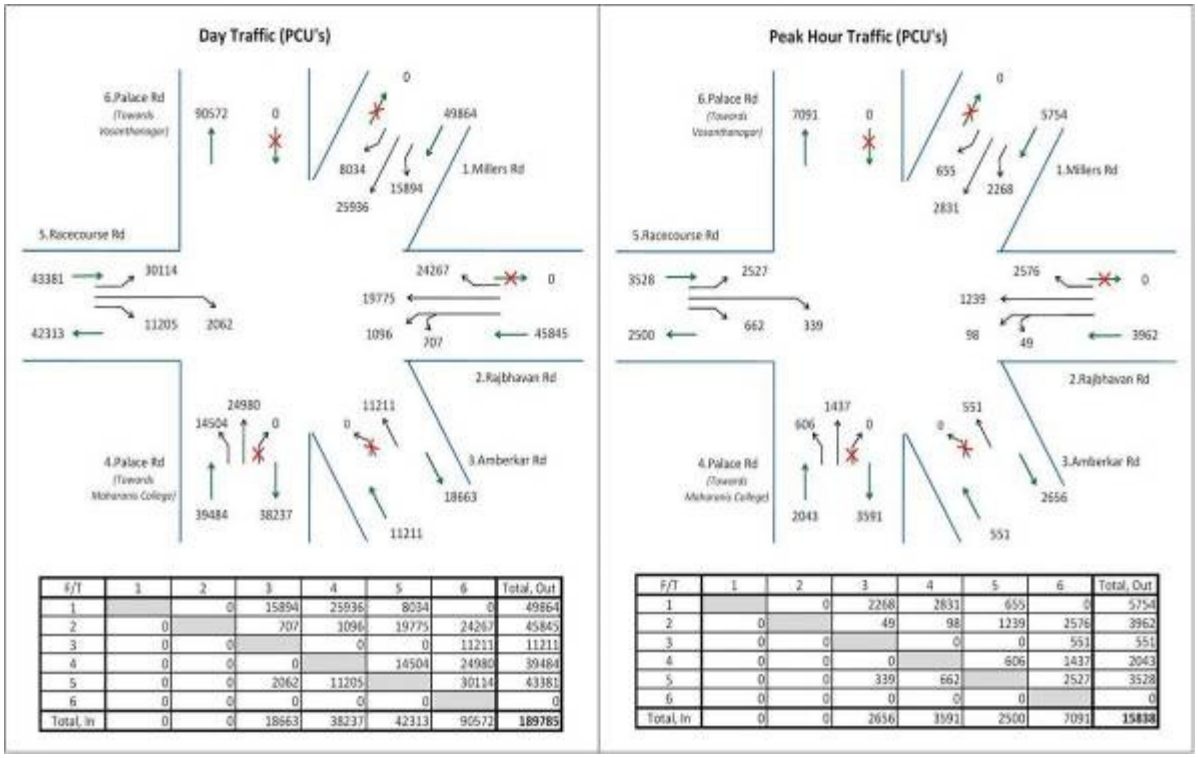
The data collected in terms of number of vehicles was first standardized by using applicable Passenger Car Units (PCU) for the respective vehicle type. The vehicle classification system and the respective PCU adopted as per IRC: 106-1990 for analysis is presented in Table 5-1.

Table 5-1 Vehicle Classification System Adopted with PCU Values

Sl No	Vehicle Type	Equivalent PCU Factors	
		% Composition of vehicle type in traffic stream	
		5%	10% and above
Fast Moving Vehicles			
1	Two Wheelers	0.50	0.75
2	Passenger car/Taxi/Jeep	1.00	1.00
3	Auto-rickshaw	1.20	2.00
4	Light Commercial Vehicle	1.40	2.00
5	Truck or Bus	2.20	3.70
6	Agricultural Tractor Trailer	4.00	5.00
Slow Moving Vehicles			
7	Cycle	0.40	0.50
8	Cycle rickshaw	1.50	2.00
9	Animal drawn vehicle	1.50	2.00
10	Hand cart	2.00	3.00

5.1.2 Summary of Traffic Flow

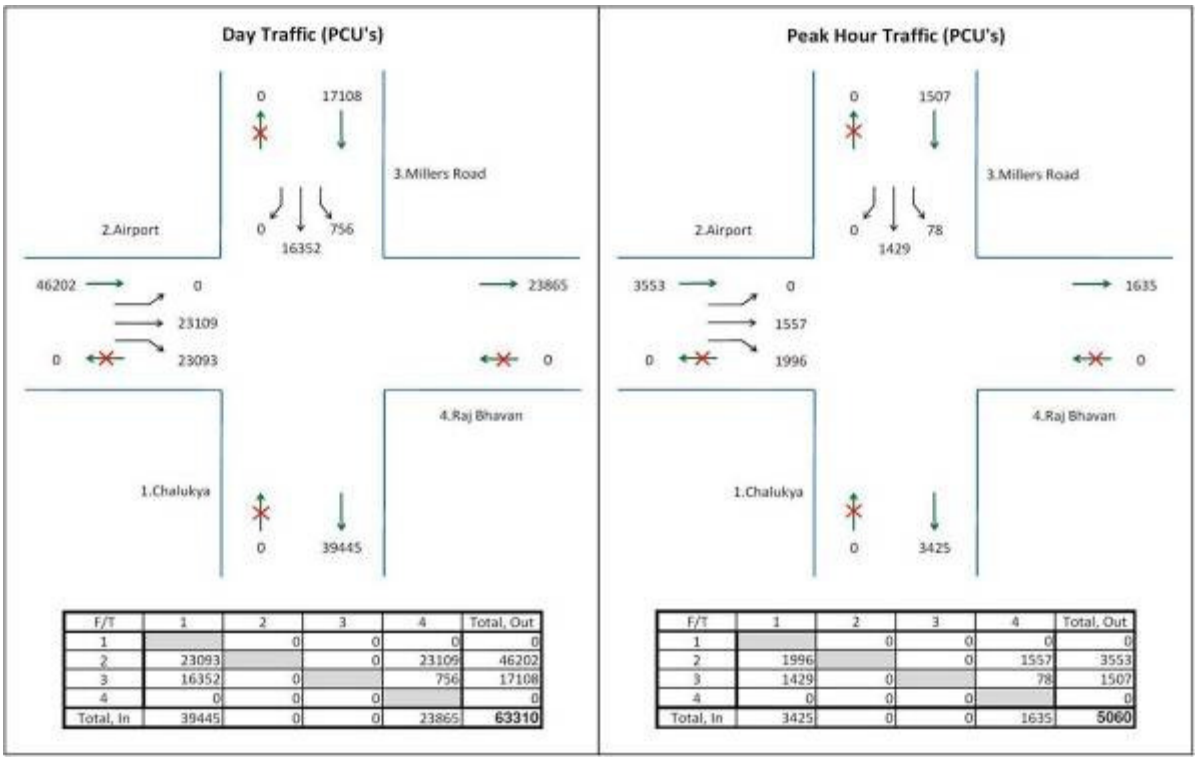
24-hour traffic volume data is used to determine, hourly variation of traffic, peak hour traffic composition, and directional distribution of traffic. Figure 5-1 through Figure 5-9 shows the peak hour (in veh/hr) and daily traffic (in veh/day) at Junctions along the project road.



F/T	1	2	3	4	5	6	Total, Out
1		0	15894	25936	8034	0	49864
2	0		707	1096	19775	24267	45845
3	0	0		0	0	11211	11211
4	0	0	0		14504	24980	39484
5	0	0	2062	11205		30114	43381
6	0	0	0	0	0		0
Total, In	0	0	18663	38237	42313	90572	189785

F/T	1	2	3	4	5	6	Total, Out
1		0	2268	2831	655	0	5754
2	0		49	98	1239	2576	3962
3	0	0		0	0	551	551
4	0	0	0		606	1437	2043
5	0	0	339	662		2527	3528
6	0	0	0	0	0		0
Total, In	0	0	2656	3591	2500	7091	15838

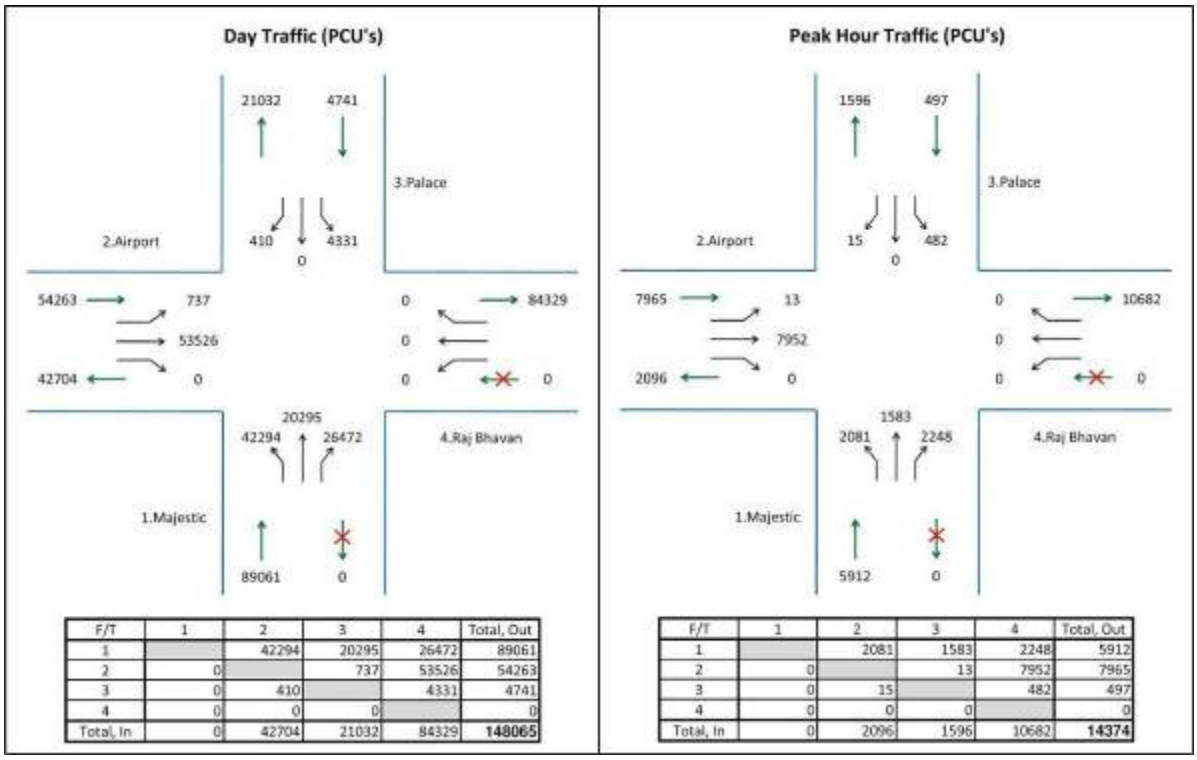
Figure 5-1 Basaveshwara Circle - Peak hour and daily traffic



F/T	1	2	3	4	Total, Out
1		0	0	0	0
2	23093		0	23109	46202
3	16352	0		756	17108
4	0	0	0		0
Total, In	39445	0	0	23865	63310

F/T	1	2	3	4	Total, Out
1		0	0	0	0
2	1996		0	1557	3553
3	1429	0		78	1507
4	0	0	0		0
Total, In	3425	0	0	1635	5060

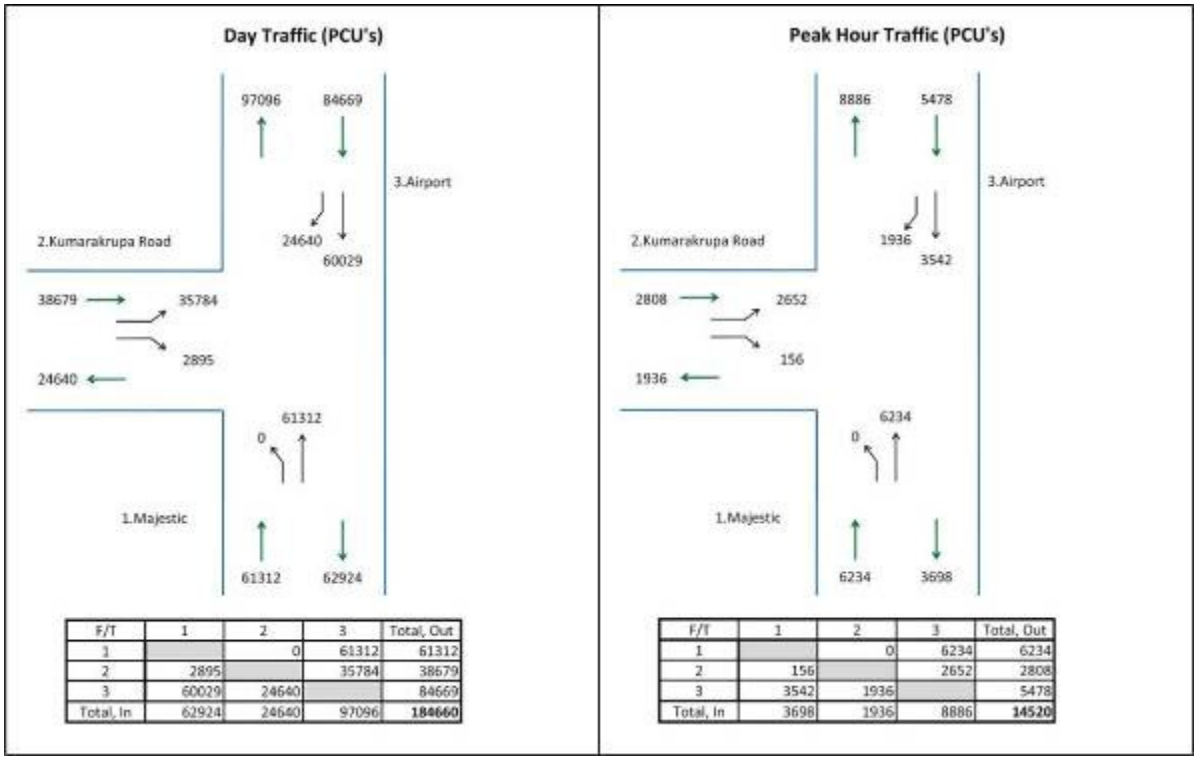
Figure 5-2 Millers Road Junction - Peak hour and daily traffic



F/T	1	2	3	4	Total, Out
1		42294	20295	26472	89061
2	0		737	53526	54263
3	0	410		4331	4741
4	0	0	0		0
Total, In	0	42704	21032	84329	**148065**

F/T	1	2	3	4	Total, Out
1		2081	1583	2248	5912
2	0		13	7952	7965
3	0	15		482	497
4	0	0	0		0
Total, In	0	2096	1596	10682	**14374**

Figure 5-3 Highgrounds Junction - Peak hour and daily traffic

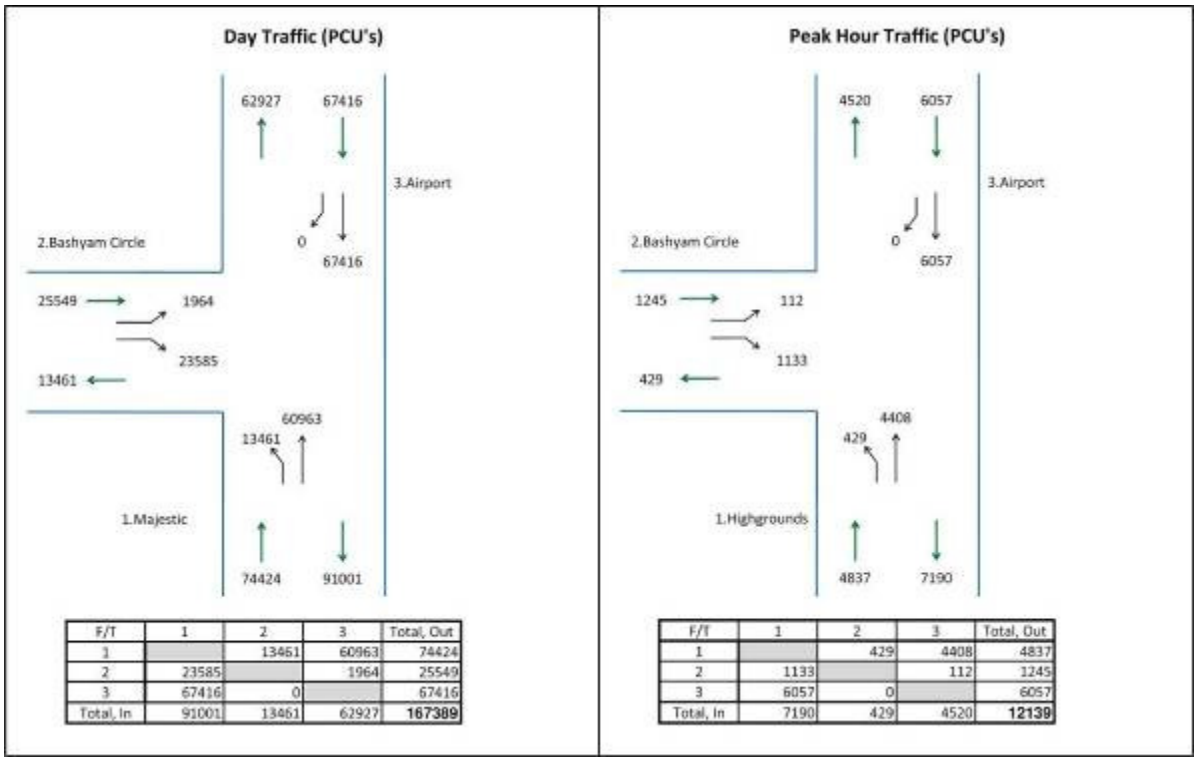


F/T	1	2	3	Total, Out
1		0	61312	61312
2	2895		35784	38679
3	60029	24640		84669
Total, In	62924	24640	97096	**184660**

F/T	1	2	3	Total, Out
1		0	6234	6234
2	156		2652	2808
3	3542	1936		5478
Total, In	3698	1936	8886	**14520**

Figure 5-4 Kumarakrupa Road Junction - Peak hour and daily traffic

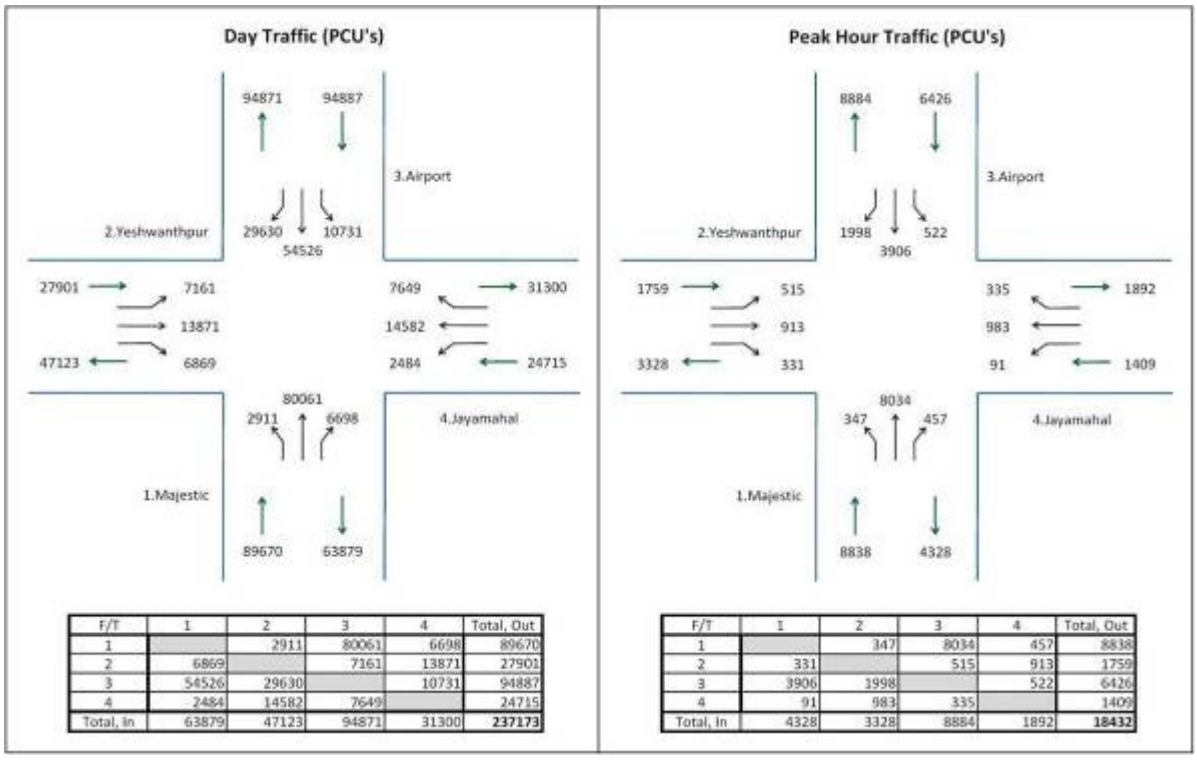
Note : Traffic towards Kumarakrupa road was blocked on the day of the survey



F/T	1	2	3	Total, Out
1		13461	60963	74424
2	23585		1964	25549
3	67416	0		67416
Total, In	91001	13461	62927	**167389**

F/T	1	2	3	Total, Out
1		429	4408	4837
2	1133		112	1245
3	6057	0		6057
Total, In	7190	429	4520	**12139**

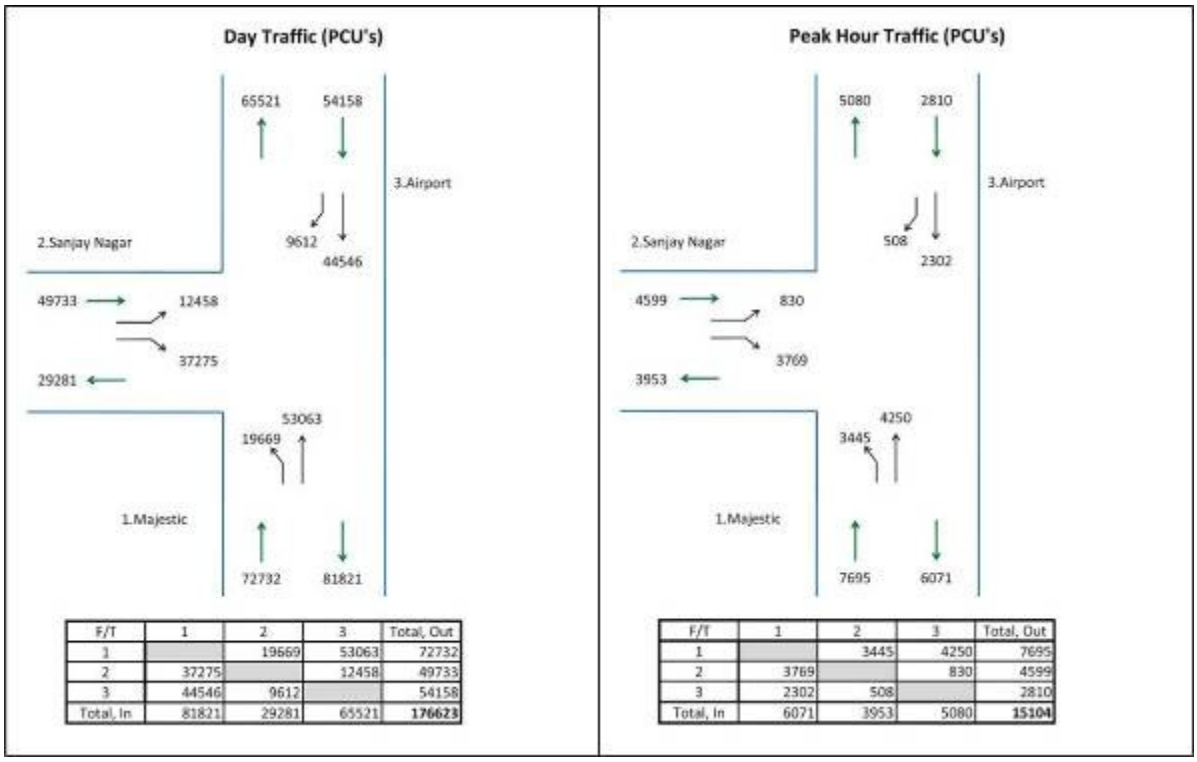
Figure 5-5 Cauvery Junction - Peak hour and daily traffic



F/T	1	2	3	4	Total, Out
1		2911	80061	6698	89670
2	6869		7161	13871	27901
3	54526	29630		10731	94887
4	2484	14582	7649		24715
Total, In	63879	47123	94871	31300	**237173**

F/T	1	2	3	4	Total, Out
1		347	8034	457	8838
2	331		515	913	1759
3	3906	1998		522	6426
4	91	983	335		1409
Total, In	4328	3328	8884	1892	**18432**

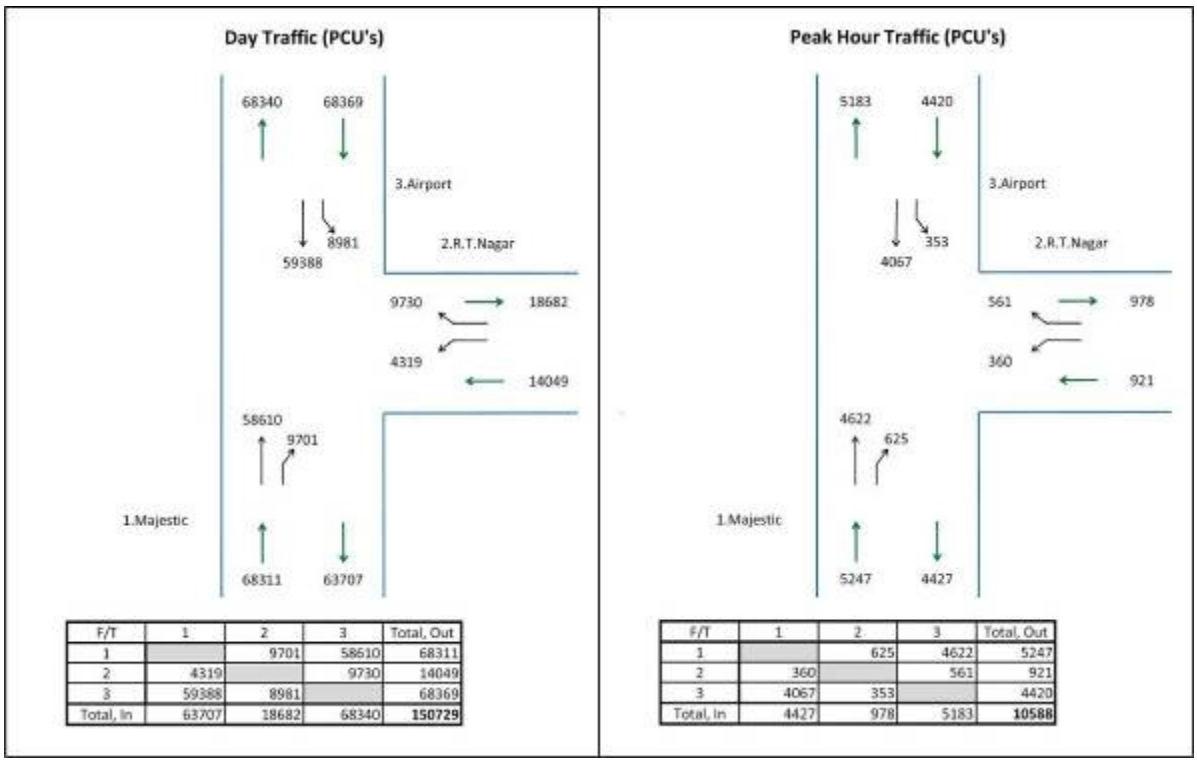
Figure 5-6 Mekhri Circle Junction - Peak hour and daily traffic



F/T	1	2	3	Total, Out
1		19669	53063	72732
2	37275		12458	49733
3	44546	9612		54158
Total, In	81821	29281	65521	**176623**

F/T	1	2	3	Total, Out
1		3445	4250	7695
2	3769		830	4599
3	2302	508		2810
Total, In	6071	3953	5080	**15104**

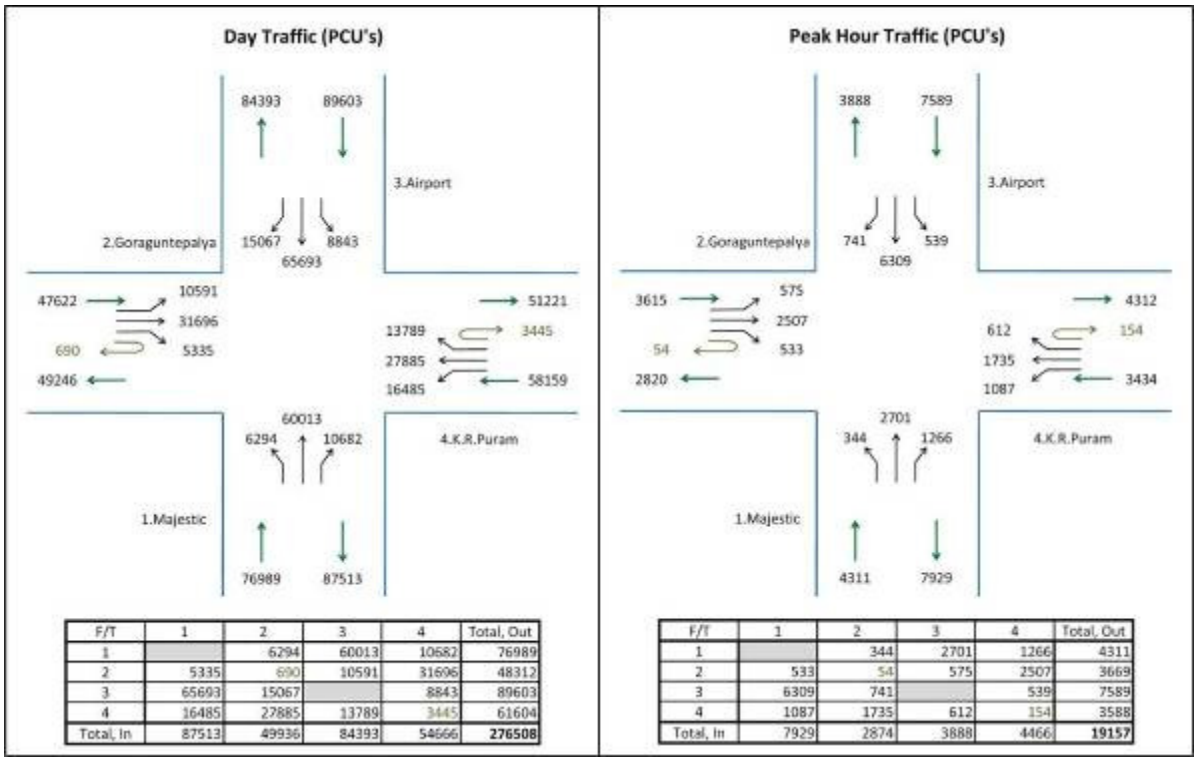
Figure 5-7 Sanjaynagar Road Junction - Peak hour and daily traffic



F/T	1	2	3	Total, Out
1		9701	58610	68311
2	4319		9730	14049
3	59388	8981		68369
Total, In	63707	18682	68340	**150729**

F/T	1	2	3	Total, Out
1		625	4622	5247
2	360		561	921
3	4067	353		4420
Total, In	4427	978	5183	**10588**

Figure 5-8 CBI Junction - Peak hour and daily traffic



F/T	1	2	3	4	Total, Out
1		6294	60013	10682	76989
2	5335	690	10591	31696	48312
3	65693	15067		8843	89603
4	16485	27885	13789	3445	61604
Total, In	87513	49936	84393	54666	**276508**

F/T	1	2	3	4	Total, Out
1		344	2701	1266	4311
2	533	54	575	2507	3669
3	6309	741		539	7589
4	1087	1735	612	154	3588
Total, In	7929	2874	3888	4466	**19157**

Figure 5-9 Hebbal Junction - Peak hour and daily traffic

5.1.3 Hourly Variation of Traffic

The hourly traffic variation with morning, afternoon, & evening peak hour traffic are estimated at major junctions along the project road. The graph indicates total traffic volume in terms of PCUs. The morning, afternoon, evening peak hours and corresponding traffic observed at all the traffic survey locations is tabulated below in Table 5-2. Hourly variation in traffic at all the traffic survey locations is given in Figure 5-10 through Figure 5-19.

Table 5-2 Peak Hour and Daily Traffic Details

Junction Name		Basaveshwara Circle	Millers Road	Highgrounds	Kumarakrupa Road	Cauvery theatre	Mekhri Circle	Sanjay Nagar Road	R.T.Nagar Road	Hebbal
Morning										
Traffic (PCU)		**15838**	**5606**	**14374**	**12636**	**11721**	**15688**	**14105**	**10588**	**19157**
Time	From	10.00	10.00	9.15	9.15	9.45	10.45	11.45	9.45	9.15
	To	11.00	11.00	10.15	10.15	10.45	11.45	12.45	10.45	10.15
Afternoon										
Traffic (PCU)		**13323**	**4392**	**9017**	**12620**	**9608**	**14625**	**15104**	**9185**	**17314**
Time	From	15.15	12.00	12.15	15.45	12.00	15.45	15.00	15.45	13.00
	To	16.15	13.00	13.15	16.45	13.00	16.45	16.00	16.45	14.00
Evening										
Traffic (PCU)		**15033**	**4174**	**9613**	**14520**	**12139**	**18432**	**12970**	**9876**	**17707**
Time	From	18.00	18.00	18.00	18.15	19.00	18.00	16.30	17.00	18.45
	To	19.00	19.00	19.00	19.15	20.00	19.00	17.30	18.00	19.45

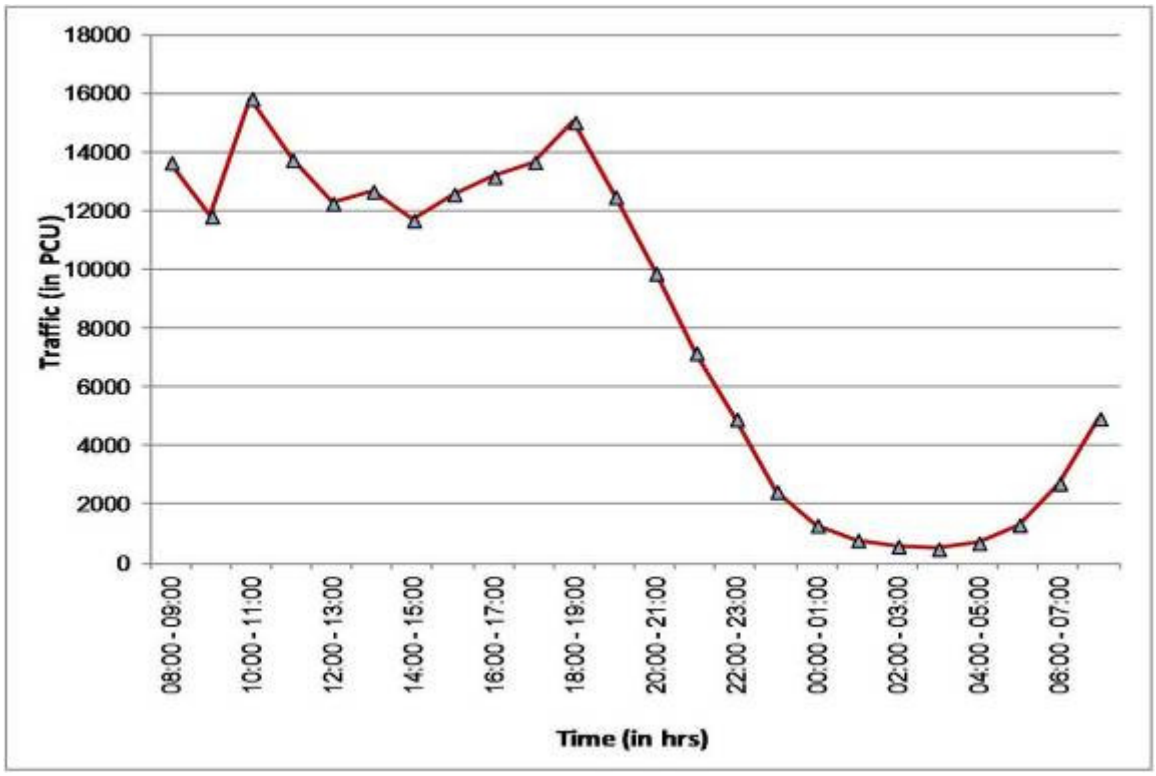


Figure 5-10 Hourly Traffic Variation at Basaveshwara Circle

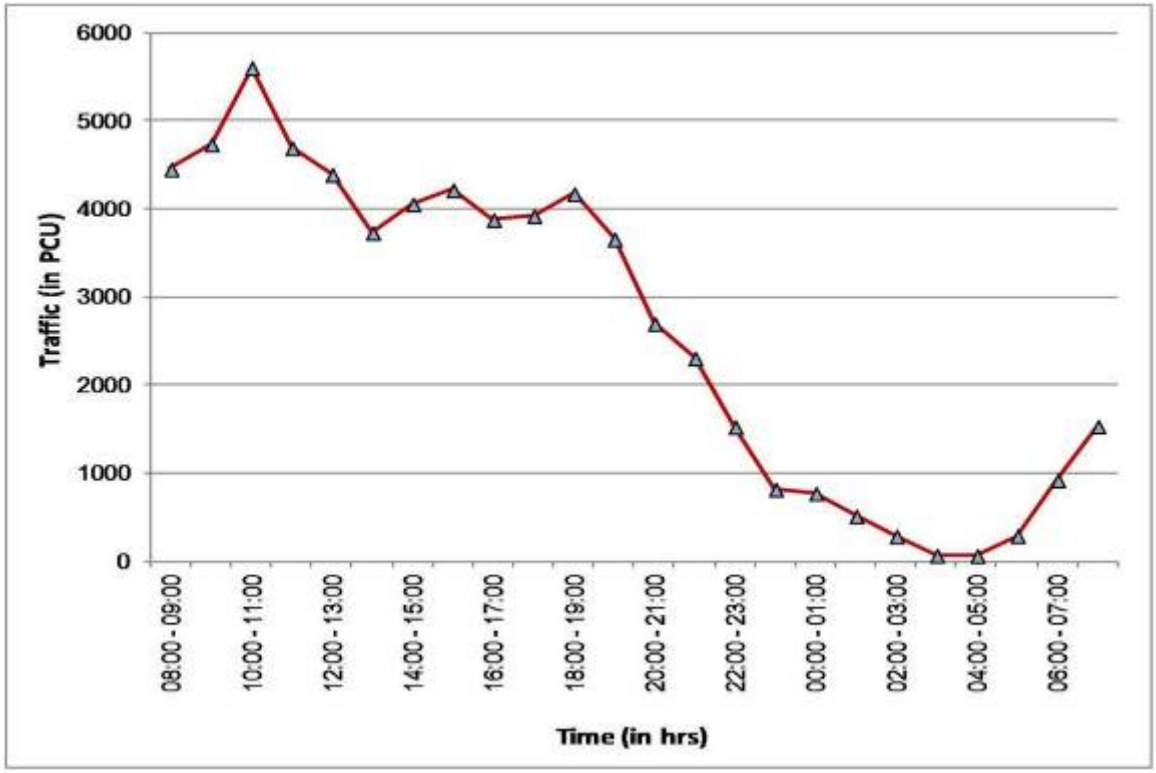


Figure 5-11 Hourly Traffic Variation at Millers Road Junction

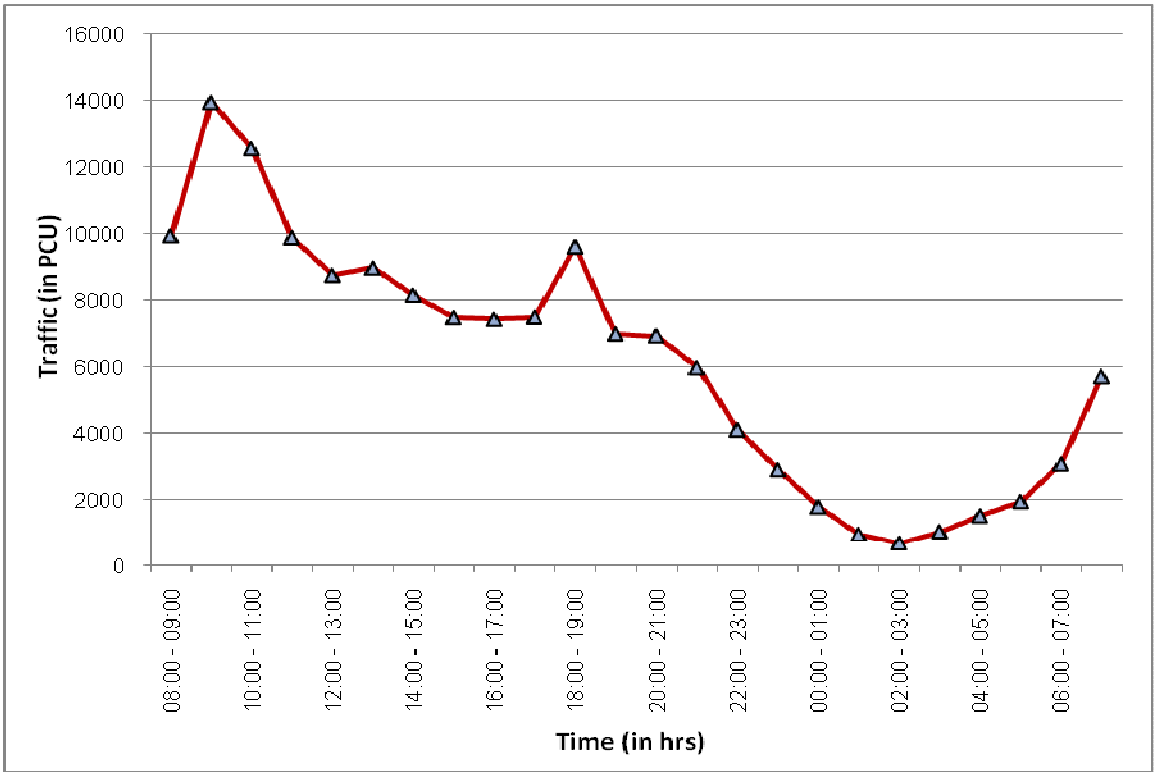


Figure 5-12 Hourly Traffic Variation at Highgrounds Junction

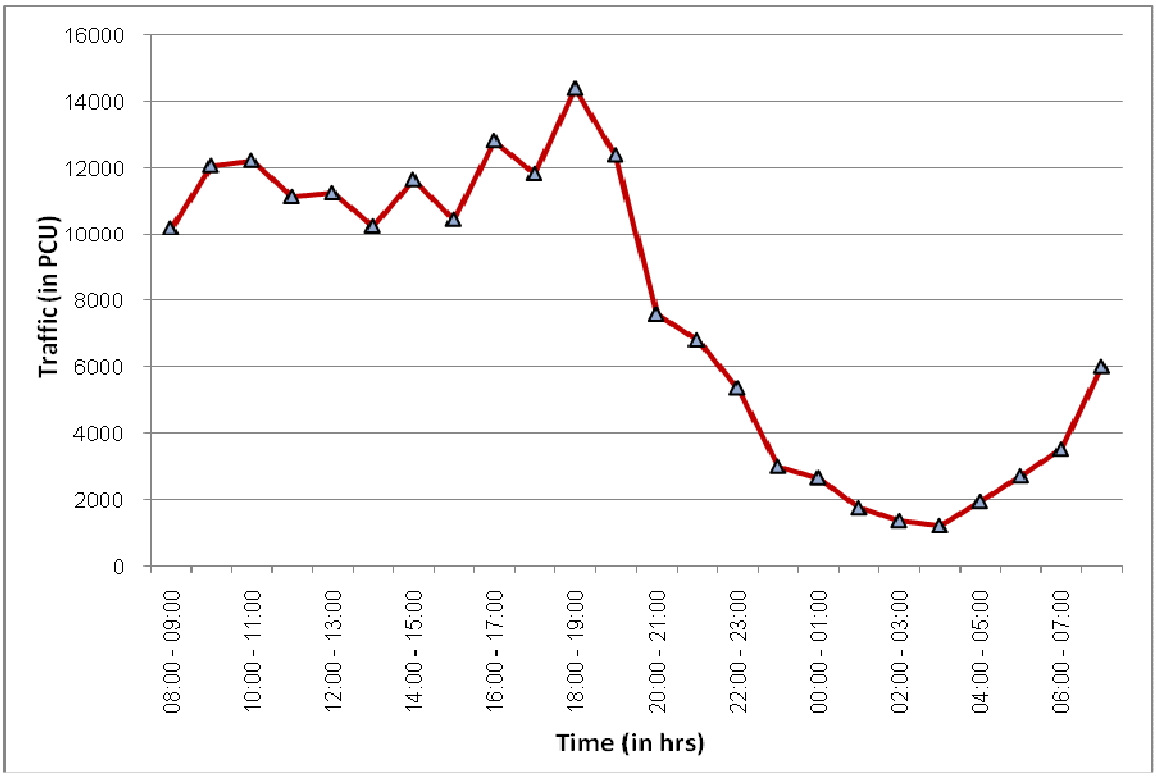


Figure 5-13 Hourly Traffic Variation at Kumarakrupa Road Junction

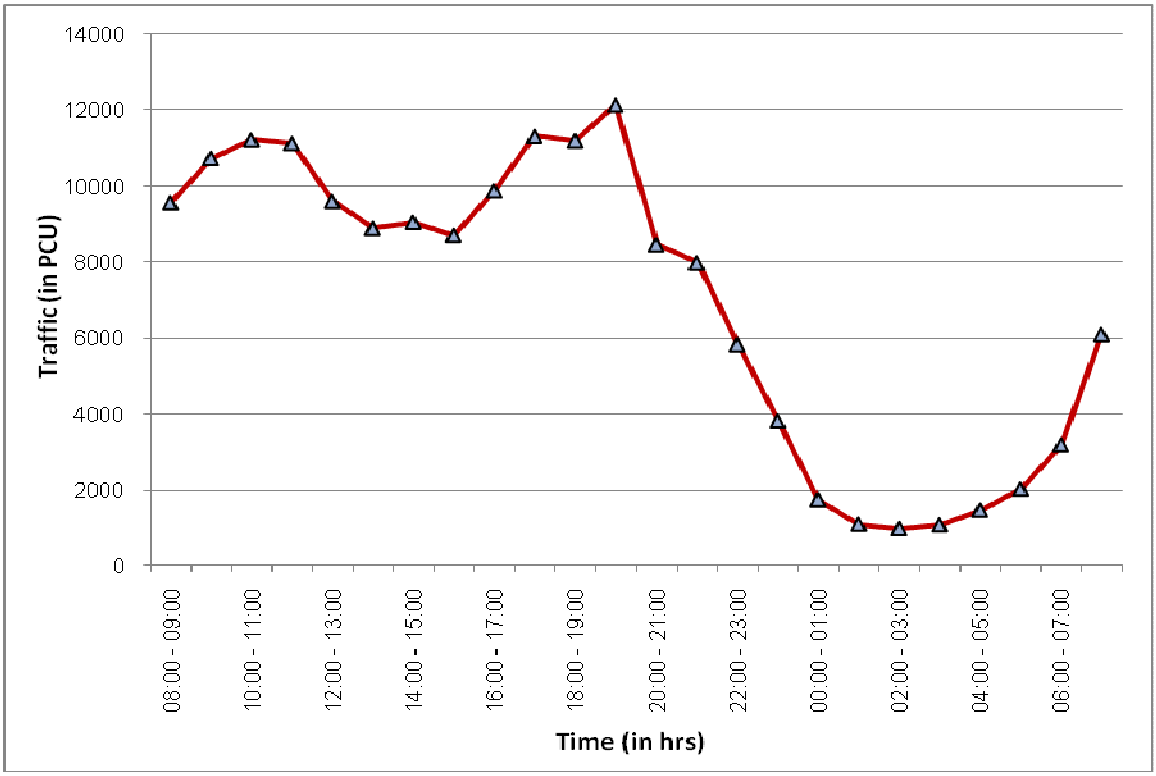


Figure 5-14 Hourly Traffic Variation at Cauvery Junction

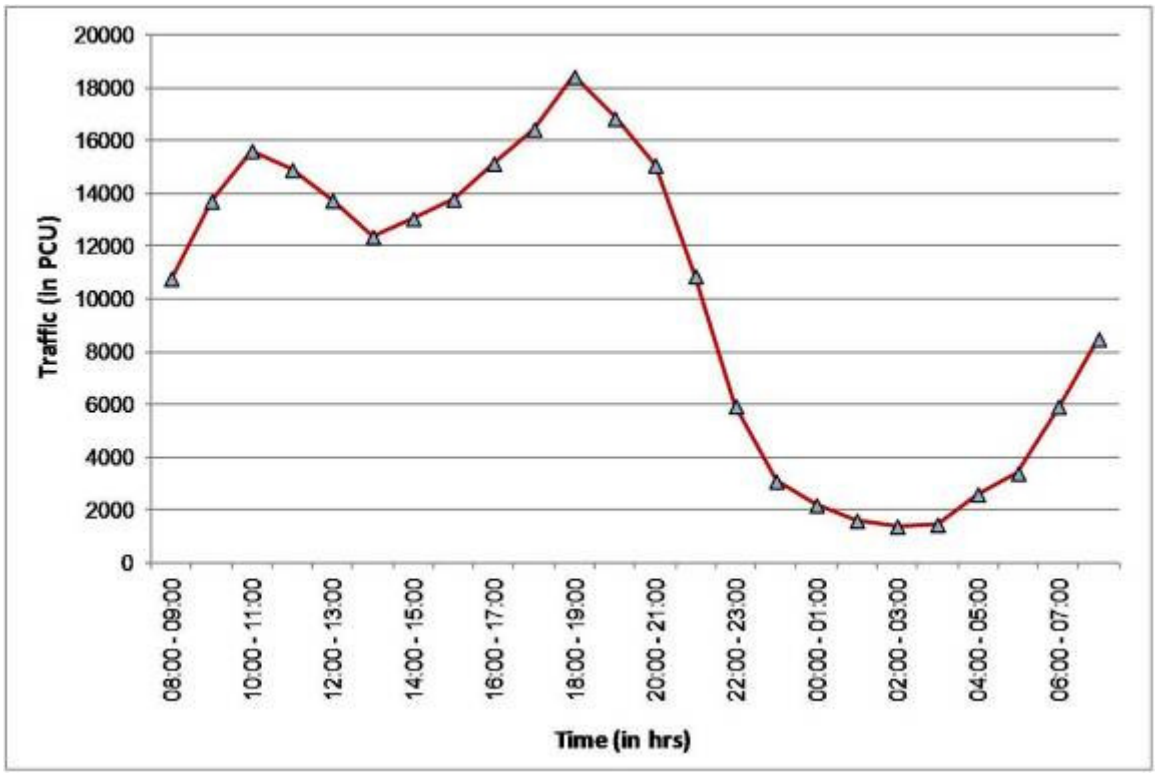


Figure 5-15 Hourly Traffic Variation at Mekhri Circle Junction

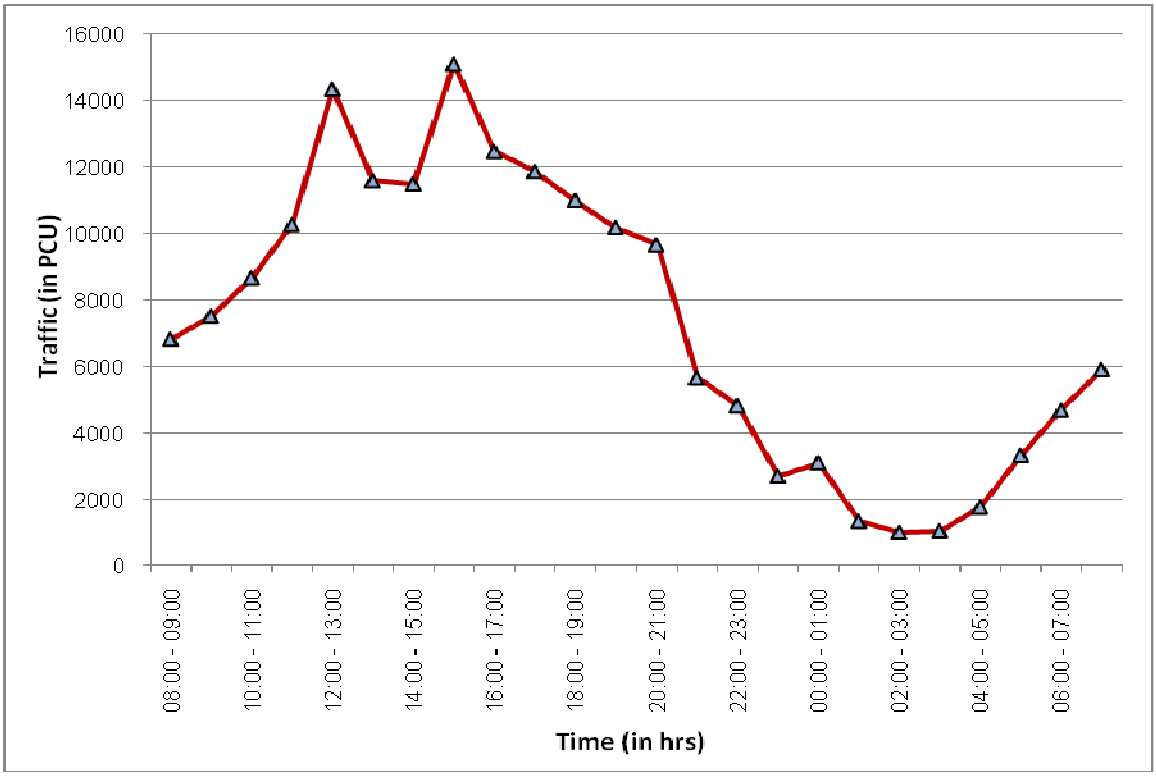


Figure 5-16 Hourly Traffic Variation at Sanjaynagar Road Junction

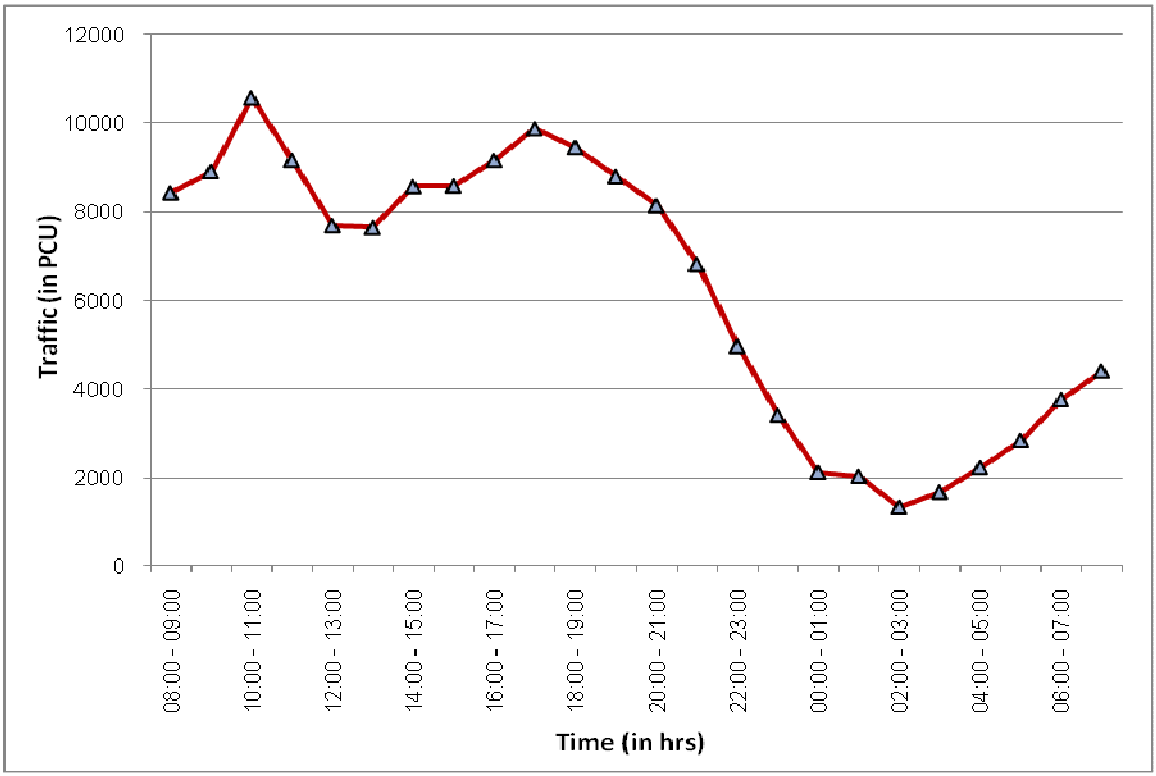


Figure 5-17 Hourly Traffic Variation at CBI Junction

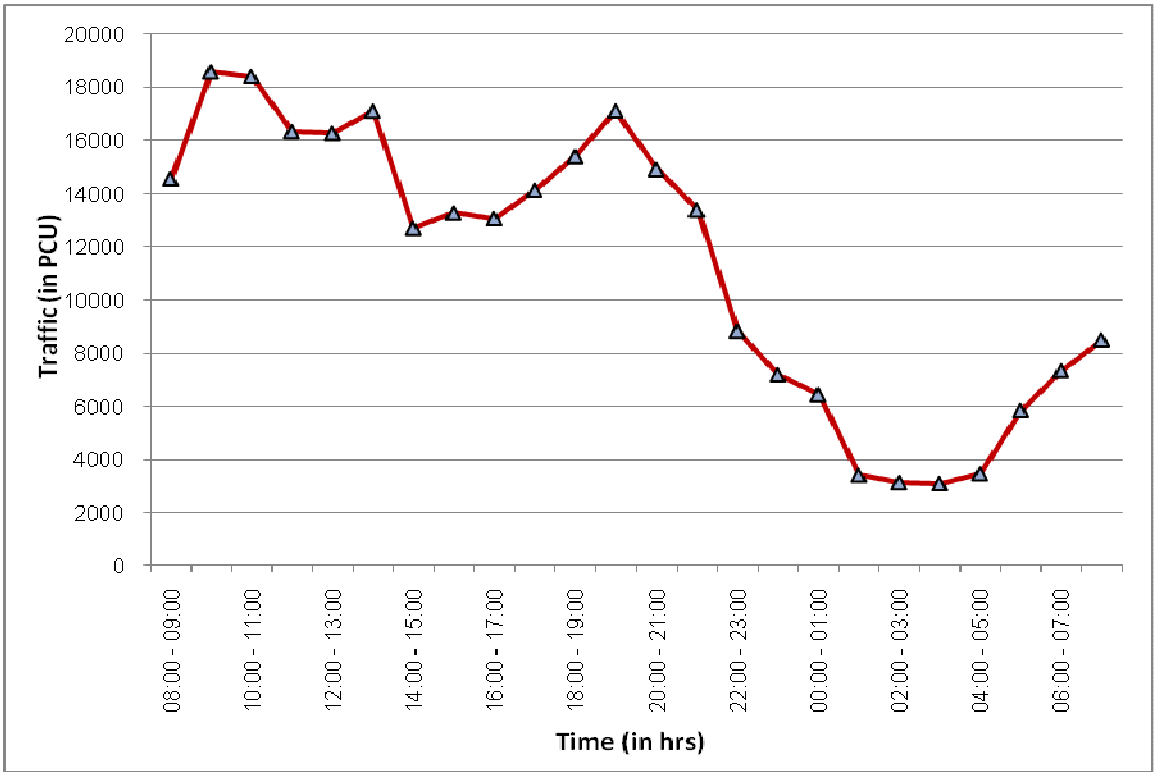


Figure 5-18 Hourly Traffic Variation at Hebbal Junction

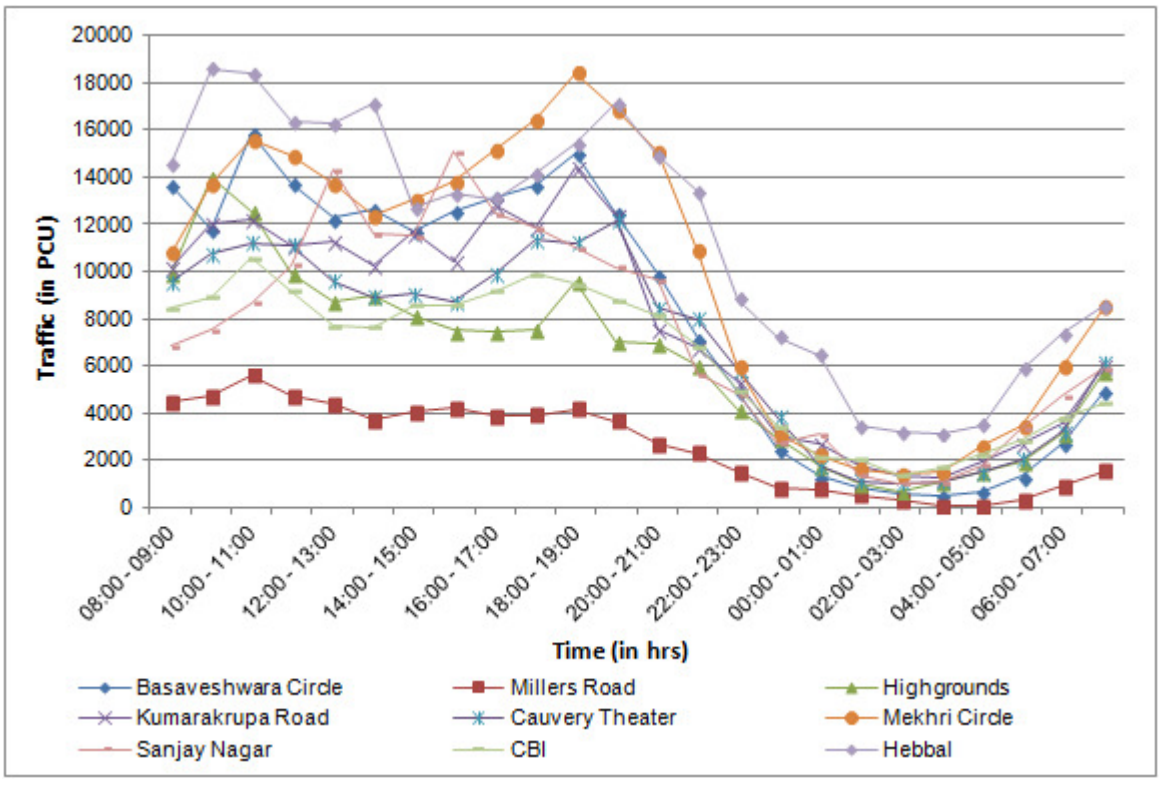


Figure 5-19 Hourly Traffic Variation at All Junction

From the above graphs and table, it has been observed that the morning peak hour (duration) is between 9:00am to 11:00am for all the junctions. Similarly, evening peak hour (duration) is between 5:00pm to 7:00pm for all the junctions.

Further, **19157 PCU's** is obtained at Hebbal junction during morning peak hour (i.e., between 9:15am to 10:15am) which forms highest peak traffic amongst the other junctions.

5.1.4 Traffic Composition

The traffic composition is studied to understand the nature of traffic passing through the junction. The traffic composition at all the junctions along the project corridor is shown in Figure 5-20 through Figure 5-28 and abstract of the same for all junctions is tabulated in Table 5-3.

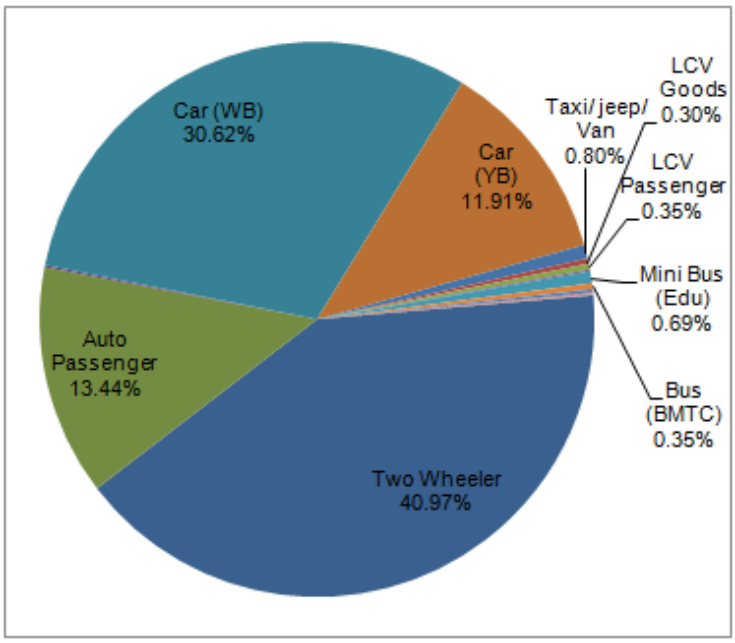


Figure 5-20 Composition of Traffic at Basaveshwara Circle

Two wheelers (40.97%), Cars (42.53%) and Autos (13.44%) together contribute to about 96.94% of the total traffic at this junction. LMV's and Buses together contribute 2.09% and all other vehicles contribute <1% of the total traffic.

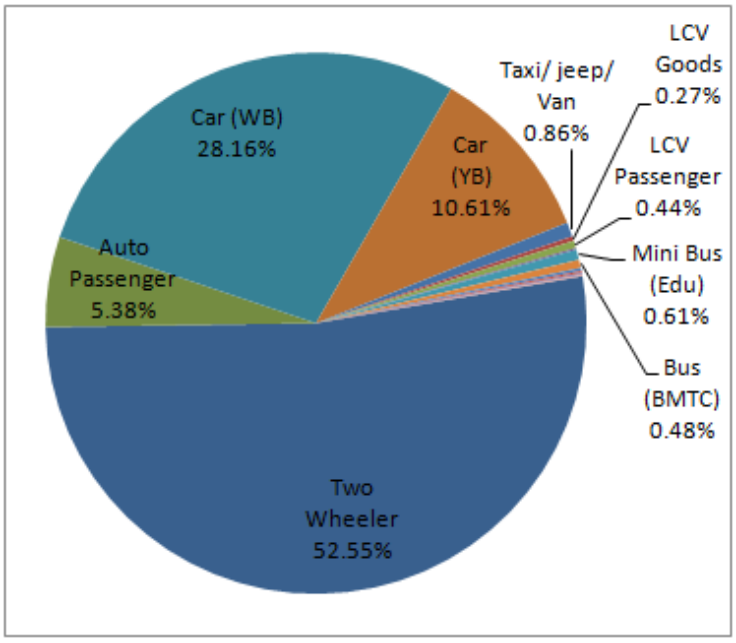


Figure 5-21 Composition of Traffic at Millers Road Junction

Two wheelers (52.55%), Cars (38.77%) and Autos (5.38%) together contribute to about 96.70% of the total traffic at this junction. LMV's and Buses together contribute 2.32% and all other vehicles contribute <1% of the total traffic.

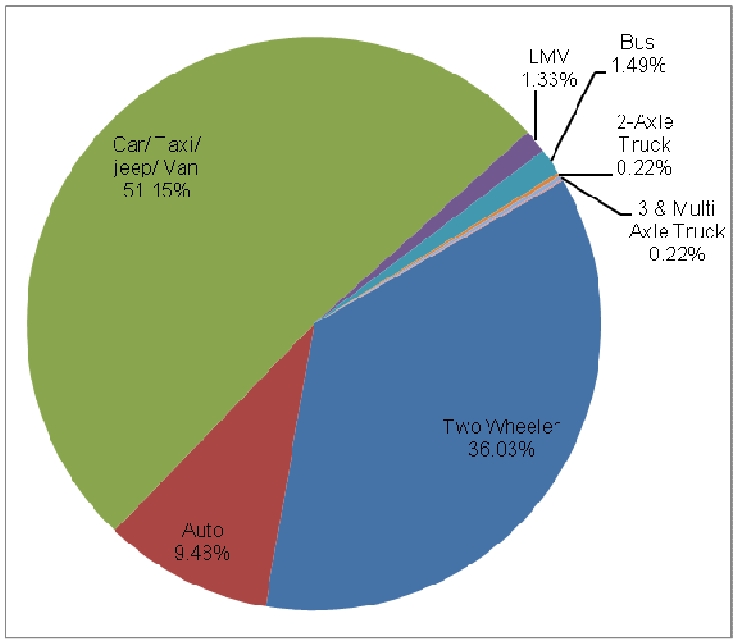


Figure 5-22 Composition of Traffic at Highgrounds Junction

Two wheelers (36.03%), Cars (51.15%) and Autos (9.48%) together contribute to about 96.66% of the total traffic at this junction. LMV's and Buses together contribute 2.82% and all other vehicles contribute <1% of the total traffic.

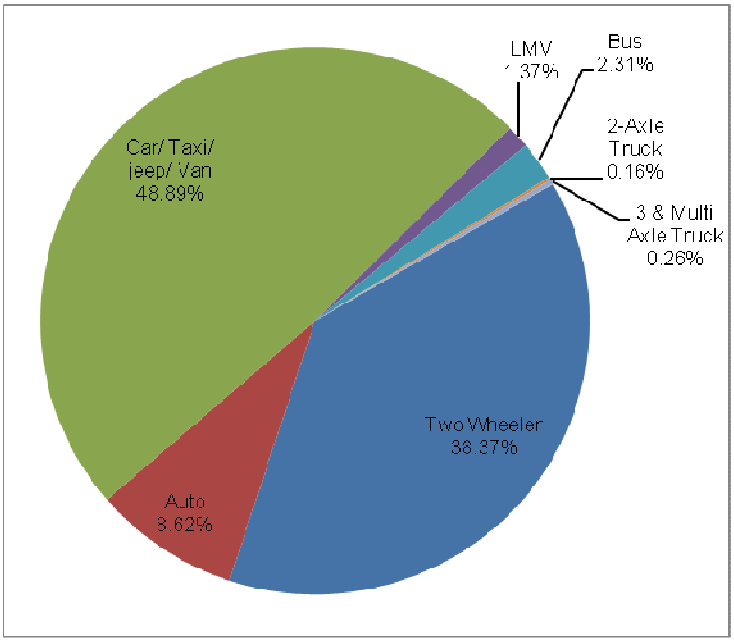


Figure 5-23 Composition of Traffic at Kumarakrupa Road Junction

Two wheelers (38.37%), Cars (48.89%) and Autos (8.62%) together contribute to about 95.88% of the total traffic at this junction. Bus contribute 2.31%, LMV's contribute 1.37% and all other vehicles contribute <1% of the total traffic.

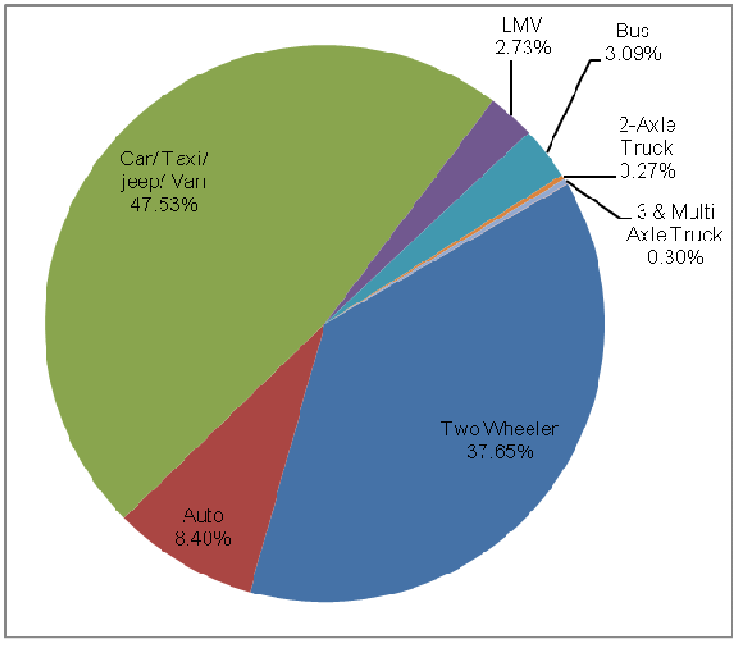


Figure 5-24 Composition of Traffic at Cauvery Junction

Two wheelers (37.65%), Cars (47.53%) and Autos (8.40%) together contribute to about 93.58% of the total traffic at this junction. Bus contribute 3.09%, LMV's contribute 2.73% and all other vehicles contribute <1% of the total traffic.

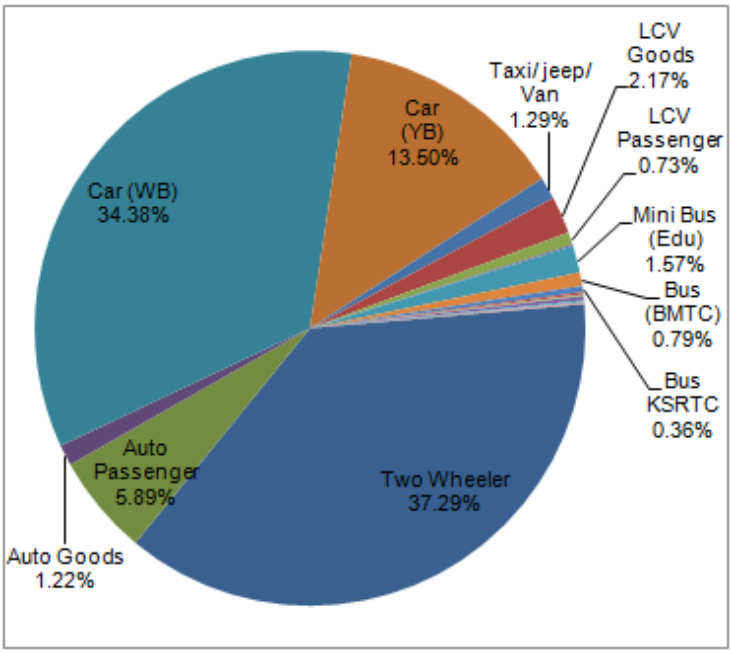


Figure 5-25 Composition of Traffic at Mekhri Circle Junction

Two wheelers (37.29%), Cars (47.88%) and Autos (7.11%) together contribute to about 93.57% of the total traffic at this junction. Bus contribute 3.29%, LMV's contribute 2.90% and all other vehicles contribute <2% of the total traffic.

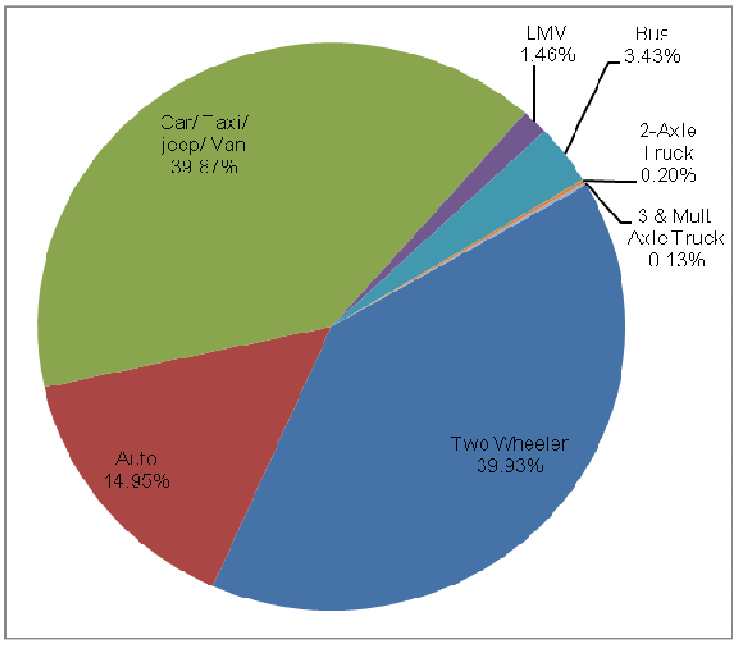


Figure 5-26 Composition of Traffic at Sanjaynagar Road Junction

Two wheelers (39.93%), Cars (39.87%) and Autos (14.95%) together contribute to about 94.75% of the total traffic at this junction. Bus contribute 3.43%, LMV's contribute 1.46% and all other vehicles contribute <0.5% of the total traffic.

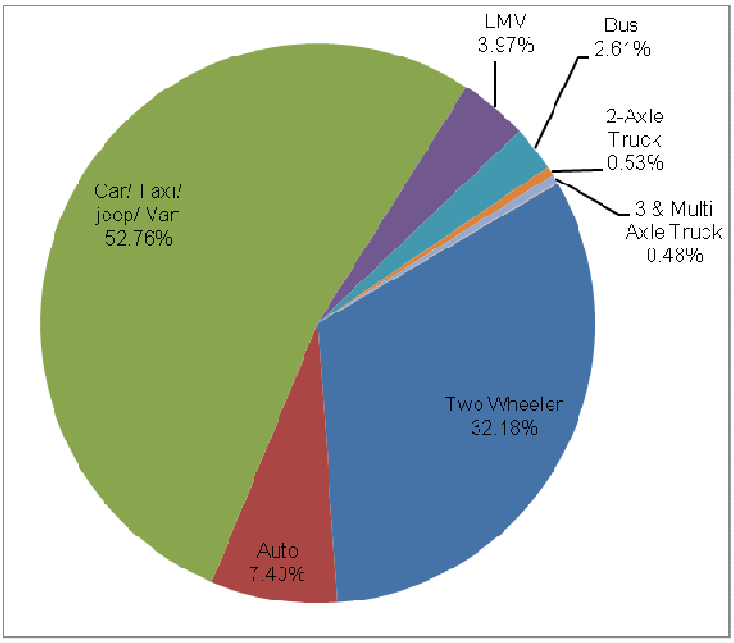


Figure 5-27 Composition of Traffic at CBI Junction

Two wheelers (32.18%), Cars (52.76%) and Autos (7.40%) together contribute to about 92.34% of the total traffic at this junction. Buses contribute 2.61%, LCVs contribute 3.97% and all other vehicles contribute 1.08% of the total traffic.

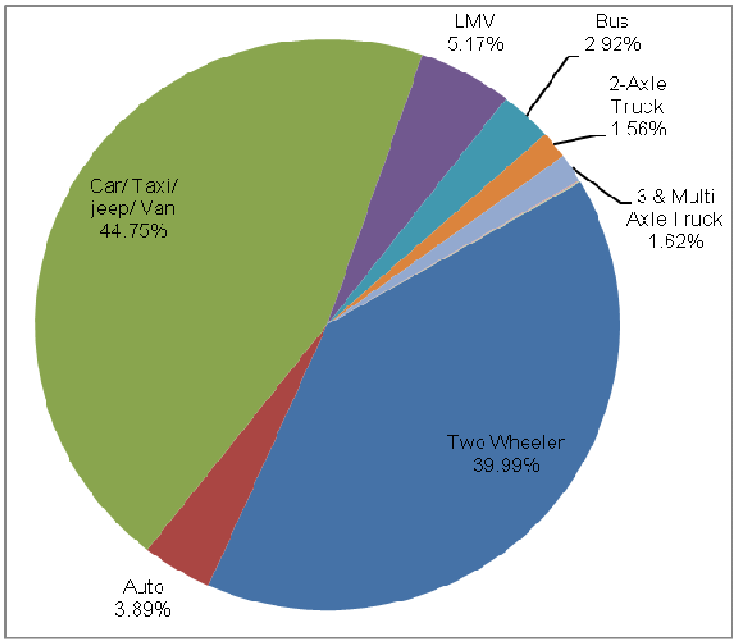


Figure 5-28 Composition of Traffic at Hebbal Junction

Two wheelers (39.99%), Cars (44.75%) and Autos (3.89%) together contribute to about 88.63% of the total traffic at this junction. Buses contribute 2.92%, LMV's contribute 5.17%, Trucks contribute 3.18% and all other vehicles contribute 0.1% of the total traffic.

Table 5-3 Vehicular Composition for All Junctions

Time	Two Wheeler	Auto- 5 Seater	Auto Passenger	Auto Goods	Car (WB)	Car (YB)	Taxi/ jeep/ Van	LCV Goods	LCV Passenger	Mini Bus	Mini Bus (Edu)	Bus (BMTC)	Bus KSRTC	Bus (PVT)	Bus (Other State)	Bus (Edu)	2-Axle Truck	3-Axle Truck	Multi Axle Truck	Tractor	Construction Vehicle	Cycle	Cycle Rickshaw	Animal Drawn Vehicle	Hand Cart	Other Non Motorised vehicle	Total
Basaveshwara Circle	77747	4	25498	240	58121	22606	1519	573	659	193	1301	666	338	139	36	60	10	7	2	65	1	0	0	0	0	0	**189785**
Millers Road	35987	0	3686	5	19285	7267	588	186	298	77	420	332	120	89	11	53	6	0	3	63	0	1	0	0	0	0	**68477**
Highgrounds	53001	1	13917	31	74849	365	35	423	161	1257	110	1079	691	294	107	22	317	306	22	4	1	125	0	0	0	0	**147118**
Kumarakrupa Road	71222	1	15973	18	90626	93	13	694	442	1139	261	2499	763	647	285	90	302	463	22	2	0	44	0	0	0	0	**185599**
Cauvery Theatre	62335	39	13839	28	78695	5	5	2356	398	1422	337	3240	831	749	265	32	451	472	24	8	0	43	3	0	0	0	**165577**
Mekhri Circle	89841	7	14202	2941	82837	32528	3108	5236	1752	230	3783	1900	858	353	205	595	261	15	15	239	3	7	0	1	0	0	**240917**
Sanjay Nagar	65402	11	24248	234	65227	10	57	1047	127	1111	108	3102	1783	522	186	27	329	184	36	2	3	21	3	1	0	1	**163782**
CBI	47659	29	10767	159	77234	841	54	3547	306	1666	357	2222	702	637	181	129	792	699	16	18	4	61	1	7	0	0	**148088**
Hebbal	107130	49	10208	159	119625	14	247	7935	1647	3906	368	5003	1141	1055	429	196	4181	3182	1152	109	10	172	3	0	1	3	**267925**

Note : *Traffic numbers given in the table are in terms of* ***Vehicles per day***

5.2 Origin and Destination Survey

Origin and Destination survey was organised at three locations along the project road on a normal working day. Roadside interview (RSI) method is adopted with random sampling basis.

The objective of the Origin-Destination (O-D) survey is to gather information regarding travel characteristics of different users on the project road. Results of the O-D surveys are used to describe the user characteristics, for different category of vehicles.

5.2.1 Zoning System

For the purpose of the study, in order to estimate the travel pattern, totally 42 zones have been considered. The pre-defined zone indicates the inter-zonal and intra-zonal traffic movement which facilitates in assessing the through traffic on the project road. The zoning system is presented in Table 5-4 and key plan showing the same is given in Figure 5-29.

Table 5-4 Details of the Zones Considered for Study

Zone No	Zone Name
1	Majestic, Gandhi Nagar, Vidhana Soudha
2	Shivaji Nagar, Vasanth Nagar
3	MG Road, Cobbon Park, Richmond Town
4	KR Market, Sultanpet, Chikpet, Upparpet, Balepet
5	Binnypet, Kempapura Agrahara, Jagajeevanram Nagar
6	Rajaji Nagar, Basveswara Nagar
7	Malleshwaram, Kumarapark, Sheshadripura
8	Jayamahal, Fraser Town, Anand Nagar
9	Kavalbyrasandra, Kammanahalli, Lingarajapura
10	Jeevanahalli, Murphy Town, Halsur Lake
11	NGEF, Banasavadi
12	HRBR Lyt, Kalyananagar
13	Sultanpalya, Nagavara, HBR Lyt
14	IISc, Sadashiva Nagara
15	Sanjaynagar, Mattikere, Yeshwanthpura
16	Jalahalli, Peenya 1st Stage, Jarakabande
17	Guddadahalli, Chikkabanavara, Ramagondanahalli
18	Sahakaranagar, Vidyaranyapura, Yelahanka
19	Jalahalli East, BEL, Kodigehalli
20	Jakkur, Kempapura, Byatarayanapura
21	HBR 4th Block, Hennur, Kothnur, B.Narayanapura, Kogilu
22	Horamavu, Ramamurthy Nagar, Channasandra, Bileshivali
23	Halasur, Indiranagar, CV Raman Nagar, Doddanekkundi
24	Neelsandra, Ejipura, Adugodi, Vivek Nagar, Domlur
25	Koramangala, Srinivagilu, Bellandur, Marathalli, Yamalur
26	Madivala, Tavarekere, MICO
27	JP Nagar, Jayanagar, South End, Lal Bagh (Mavalli), Nimhance
28	VV Puram, Basavanagudi, Banashankari, Girinagar, Srinagar
29	Deepanjali Nagar, Vijayanagar, Chandra Lyt, Hampi Nagar
30	Kamakshy Palya, Nandini Lyt, Mahalakshmi Lyt, Basaveshwara Nagar
31	Peenya Ind. Area, Sunkadakatte, Kadabagere, Madanayakanahalli
32	Kengeri Satellite Town, Ullal, Bylakonenahalli, Sunkadakatte
33	UVCE, Nayendanahalli, Nagarabhavi, Malagala, Kamakshipalya
34	Kengeri, BSK 6thStage, Uttarahalli, BSK 2nd & 3rd Stage
35	Puttenahalli, Konanakunte, Gollahalli, Anjanapura, Kothnur
36	BTM Lyt, Bommanahalli, Begur, Mylasandra, Electronic City
37	HSR Lyt, Kudlu, Naganathapura, Rayasandra
38	Kaikondanahalli, Gunjur, Varthur, Munnekolal
39	White Field, Kundalahalli, Mahadevapura, Kadugodi, Sigehalli
40	Airport,Devanahalli,Chikkajala
41	Andhra Pradesh & North India
42	Tamilnadu

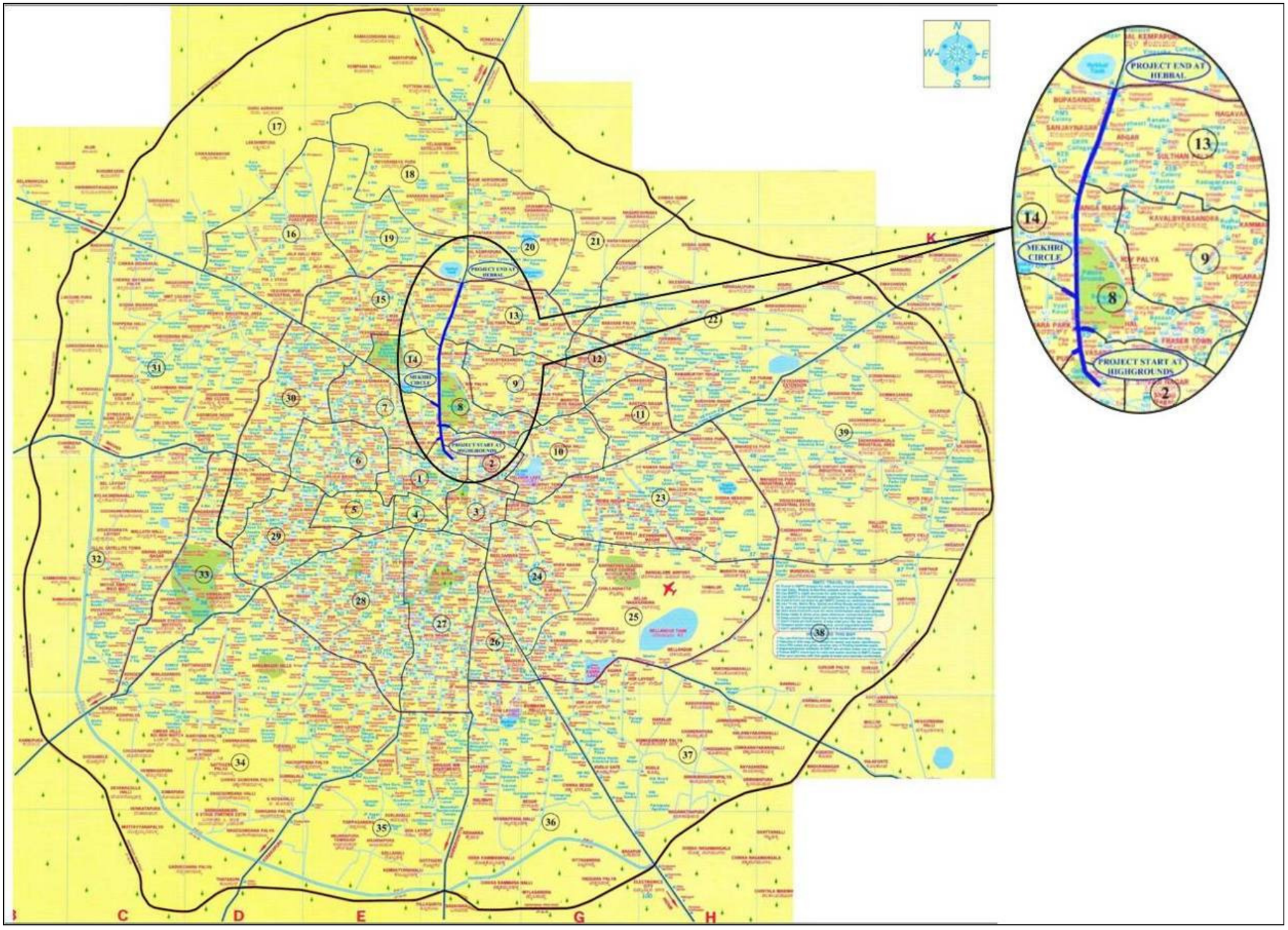


Figure 5-29 Map Showing OD Zoning System Considered

5.2.2 Sample Size of O-D Survey

The sample sizes for various categories of vehicles at Highgrounds Junction, Mekhri Circle and Hebbal Junction are presented in Table 5-5.

Table 5-5 Sample Size of Vehicles

Sl No	Vehicle Type	Highgrounds	Mekhri Circle	Hebbal
1	Two Wheeler	17.47%	16.71%	9.18%
2	Auto-5 Seater	0.00%	44.44%	0.00%
3	Auto-Passenger	31.96%	18.39%	17.84%
4	Auto-Goods	16.13%	25.97%	0.00%
5	Car (White board)	12.07%	14.56%	26.37%
6	Car (Yellow board)	13.46%	29.16%	0.00%
7	Taxi/Jeep/Van	41.18%	15.97%	0.00%
8	LCV (Goods)	15.66%	16.28%	19.00%
9	LCV (Passenger)	17.39%	2.76%	18.34%
10	Mini Bus	26.88%	44.79%	21.84%
11	Mini Bus (Education)	16.51%	17.58%	19.18%
12	Bus(BMTC)	45.41%	34.29%	16.74%
13	Bus(KSRTC)	42.69%	33.87%	43.52%
14	Bus(PVT)	83.62%	22.58%	56.24%
15	Bus (Other State)	37.38%	39.72%	54.13%
16	Bus (Education)	22.73%	54.55%	33.71%
17	2-Axle Truck	81.70%	16.23%	18.45%
18	3-Axle Truck	41.45%	7.40%	16.33%
19	Multi Axle Trucks	50.00%	28.57%	20.17%
Total :		**16.83%**	**16.54%**	**18.32%**

5.2.3 Trips Characteristics

Based on the road side interview method for the Origin – Destination surveys, following information's have been collected. Attempt has been made to collect the information to the maximum extent. The survey was conducted for a period of 24 hours in random manner to avoid any inconvenience to the traffic on the road. The details of the information collected are

- Origin & Destination of the Trip,
- Trip Purpose,
- Trip Frequency,
- Number of Trips made, etc.

Based on the data and information gathered during the survey, the distribution of vehicular trip is compiled and presented in Table 5-6 through

Table **5-8**.

Table 5-6 Distribution of Trips Purpose

Sl No	Purpose of Journey	Highgrounds	Mekhri Circle	Hebbal
1	Work	46.06%	30.96%	41.80%
2	Business / Office	24.17%	25.79%	29.04%
3	Return Home	6.11%	9.85%	11.15%
4	Education	3.72%	2.88%	5.04%
5	Social	4.72%	4.90%	3.26%
6	Airport Drop/Pick	3.13%	16.69%	6.32%
7	Others	12.09%	8.94%	3.39%
	Total :	**100.00%**	**100.00%**	**100.00%**

Table 5-7 Distribution of Trips Frequency

Sl No	Trip Frequency	Highgrounds	Mekhri Circle	Hebbal
1	Daily	71.21%	75.50%	67.48%
2	Alternate day	15.73%	14.15%	16.85%
3	Weekly	6.24%	6.66%	8.51%
4	Fortnightly	2.13%	0.90%	2.01%
5	Monthly	2.57%	1.06%	2.33%
6	Quarterly	0.87%	0.92%	1.41%
7	Twice a year	0.69%	0.29%	0.49%
8	Rarely	0.56%	0.52%	0.92%
	Total :	**100.00%**	**100.00%**	**100.00%**

Table 5-8 Distribution of Trips Distance

Sl No	Trip Distance (kms)	Highgrounds	Mekhri Circle	Hebbal
1	< 5	48.37%	57.14%	25.67%
2	6 - 10	38.62%	33.26%	45.52%
3	11 - 15	4.21%	2.91%	12.64%
4	16 - 20	2.23%	1.32%	3.58%
5	> 20	6.57%	5.37%	12.60%
	Total :	**100.00%**	**100.00%**	**100.00%**

5.2.4 Origin-Destination Matrices

The data collected during survey has been grouped according to the zones mentioned above. With this predefined zones, the origin-destination matrices have been prepared for individual type of vehicles for all the three locations separately.

In order to assess the influence of each zone on its traffic attraction and production of trips, the influence factors have been calculated for each vehicle type. The Influence factor indicates the importance of the zone in the study area. The details of influence factors for all the vehicle types are given in Table 5-9.

Table 5-9 Influence Factors for All Vehicle Type

Zone No	Zone Name	Influence Factor		
		Highgrounds	Mekhri Circle	Hebbal
1	Majestic, Gandhi Nagar, Vidhana Soudha, southern extensions of city	23.85%	13.22%	10.17%
2	Shivaji Nagar, Vasanth Nagar	8.89%	8.72%	1.52%
3	MG Road, Cobbon Park, Richmond Town	6.62%	2.67%	1.07%
4	KR Market, Sultanpet, Chikpet, Upparpet, Balepet	4.35%	3.37%	2.60%
5	Binnypet, Kempapura Agrahara, Jagajeevanram Nagar	0.37%	0.07%	0.07%
6	Rajaji Nagar, Basveswara Nagar	0.64%	1.05%	0.22%
7	Malleshwaram, Kumarapark, Sheshadripura	1.68%	7.96%	2.39%
8	Jayamahal, Fraser Town, Anand Nagar	7.70%	9.80%	3.83%
9	Kavalbyrasandra, Kammanahalli, Lingarajapura	0.14%	0.57%	0.68%
10	Jeevanahalli, Murphy Town, Halsur Lake	0.18%	0.13%	0.04%
11	NGEF, Banasavadi	0.06%	0.26%	1.57%
12	HRBR Lyt, Kalyananagar	0.06%	0.27%	1.27%
13	Sultanpalya, Nagavara, HBR Lyt	1.22%	1.82%	1.93%
14	IISc, Sadashiva Nagara	1.23%	1.63%	0.54%
15	Sanjaynagar, Mattikere, Yeshwanthpura	3.03%	12.39%	4.40%
16	Jalahalli, Peenya 1st Stage, Jarakabande	1.76%	3.54%	3.87%

Zone No	Zone Name	Influence Factor		
		Highgrounds	Mekhri Circle	Hebbal
17	Guddadahalli, Chikkabanavara, Ramagondanahalli	0.18%	0.33%	2.25%
18	Sahakaranagar, Vidyaranyapura, Yelahanka	14.16%	14.99%	16.08%
19	Jalahalli East, BEL, Kodigehalli	1.59%	1.87%	7.99%
20	Jakkur, Kempapura, Byatarayanapura	0.45%	0.41%	5.35%
21	HBR 4th Block, Hennur, Kothnur, B.Narayanapura, Kogilu	0.10%	0.12%	1.54%
22	Horamavu, Ramamurthy Nagar, Channasandra, Bileshivali	0.45%	0.46%	3.95%
23	Halasur, Indiranagar, CV Raman Nagar, Doddanekkundi	1.05%	1.73%	1.27%
24	Neelsandra, Ejipura, Adugodi, Vivek Nagar, Domlur	0.50%	0.23%	0.90%
25	Koramangala, Srinivagilu, Bellandur, Marathalli, Yamalur	1.81%	1.34%	2.17%
26	Madivala, Tavarekere, MICO	0.77%	0.93%	1.11%
27	JP Nagar, Jayanagar, South End, Lal Bagh (Mavalli), Nimhance	4.26%	1.43%	0.39%
28	VV Puram, Basavanagudi, Banashankari, Girinagar, Srinagar	1.04%	0.34%	0.01%
29	Deepanjali Nagar, Vijayanagar, Chandra Lyt, Hampi Nagar	1.26%	0.78%	0.35%
30	Kamakshy Palya, Nandini Lyt, Mahalakshmi Lyt, Basaveshwara Nagar	0.05%	0.12%	0.03%
31	Peenya Ind. Area, Sunkadakatte, Kadabagere, Madanayakanahalli	0.26%	0.32%	2.45%
32	Kengeri Satellite Town, Ullal, Bylakonenahalli, Sunkadakatte	1.48%	0.06%	0.73%
33	UVCE, Nayendanahalli, Nagarabhavi, Malagala, Kamakshipalya	0.06%	0.38%	1.10%
34	Kengeri, BSK 6thStage, Uttarahalli, BSK 2nd & 3rd Stage	0.05%	0.05%	0.15%
35	Puttenahalli, Konanakunte, Gollahalli, Anjanapura, Kothnur	0.33%	0.18%	0.02%
36	BTM Lyt, Bommanahalli, Begur, Mylasandra, Electronic City	0.95%	0.85%	0.62%
37	HSR Lyt, Kudlu, Naganathapura, Rayasandra	0.26%	0.12%	0.48%
38	Kaikondanahalli, Gunjur, Varthur, Munnekolal	0.12%	0.05%	0.05%

Zone No	Zone Name	Influence Factor		
		Highgrounds	Mekhri Circle	Hebbal
39	White Field, Kundalahalli, Mahadevapura, Kadugodi, Sigehalli	0.56%	0.05%	2.24%
40	Airport,Devanahalli,Chikkajala	2.82%	3.35%	9.52%
41	Andhra Pradesh & North India	3.64%	1.99%	2.07%
42	Tamilnadu	0.00%	0.01%	1.01%
	Total :	**100.00%**	**100.00%**	**100.00%**

From the above tables the major influencing zones for the project stretch are identified and presented in Table 5-10.

Table 5-10 Major Influencing Zones

Zone No	Zone Name	Influence Factor		
		Highgrounds	Mekhri Circle	Hebbal
1	Majestic, Gandhi Nagar, Vidhana Soudha, southern extension of city	23.85%	13.22%	10.17%
2	Shivaji Nagar, Vasanth Nagar	8.89%	8.72%	1.52%
4	KR Market, Sultanpet, Chikpet, Upparpet, Balepet	4.35%	3.37%	2.60%
7	Malleshwaram, Kumarapark, Sheshadripura	1.68%	7.96%	2.39%
8	Jayamahal, Fraser Town, Anand Nagar	7.70%	9.80%	3.83%
15	Sanjaynagar, Mattikere, Yeshwanthpura	3.03%	12.39%	4.40%
18	Sahakaranagar, Vidyaranyapura, Yelahanka	14.16%	14.99%	16.08%
40	Airport,Devanahalli,Chikkajala	2.82%	3.35%	9.52%
	Rest of Zones	33.51%	26.19%	49.49%
	Total :	**100.00%**	**100.00%**	**100.00%**

5.3 Integration of Traffic Flow

This is an approximate method adopted to Integrate junction turning traffic volume count data of all the junctions existing along the project road which is presented in the form of flow diagram for better understanding of traffic flow on project corridor.

In this method, peak hour traffic at all junctions in terms of PCU's/hr is considered. The midblock through traffic at any particular section for the project road is taken as average of entry traffic from preceding junction and exit traffic to succeeding junction. All other junction turning traffic movements are customized proportionately to arrive at integrated traffic. At four arm junctions, traffic movement crossing project road in perpendicular direction is not

considered for integration because the proposed elevated road will not affect these traffic movements.

The anticipated traffic flow on project corridor (i.e., on at-grade road and on elevated road) is obtained by multiplying the traffic numbers with appropriate distribution factor. The traffic distribution factor is arrived based on influence factor from Origin & Destination survey results.

The existing traffic flow diagram for the project road is presented in Figure 5-30 and anticipated traffic flow on at-grade road and on elevated road is presented in Figure 5-31 and Figure 5-32. Abstract of the same is given in Table 5-11 through Table 5-13 below.

Table 5-11 Traffic Flow (Nos) on Existing At-Grade Road

Sl No	Junction Name	In Flow From			Out Flow Towards		
		Straight	Left	Right	Left	Right	Straight
Hebbal - Rajbhavan							
1	CBI	6175	254	0	2010	0	4419
2	Sanjay Nagar	4419	0	2951	0	380	6990
3	Mekhri Circle	6990	270	934	432	1826	5936
4	Sankey Road	5936	0	1198	0	0	7134
5	Kumarakrupa Road	7134	0	349	0	851	6632
6	Highgrounds	6632	0	2248	13	0	8867
7	Millers Road	8867	78	0	0	1996	6949
Rajbhavan - Hebbal							
1	Millers Road	0	0	0	0	0	0
2	Highgrounds	0	4165	0	0	0	4165
3	Kumarakrupa Road	4165	2712	0	15	0	6862
4	Sankey Road	6862	315	0	1830	0	5347
5	Mekhri Circle	5347	932	1280	192	523	6844
6	Sanjay Nagar	6844	890	0	2070	0	5664
7	CBI	5664	0	457	0	874	5247

Table 5-12 Traffic Flow (Nos) on Proposed At-Grade Road

Sl No	Junction Name	In Flow From			Out Flow Towards		
		Straight	Left	Right	Left	Right	Straight
Hebbal - Rajbhavan							
1	CBI	3088	254	0	2010	0	1332
2	Sanjay Nagar	1332	0	2951	0	380	3903
3	Mekhri Circle	3903	270	934	432	950	3725
4	Sankey Road	3725	0	1198	0	0	4923
5	Kumarakrupa Road	4923	0	349	0	851	4421
6	Highgrounds	4421	0	674	13	0	5082
7	Millers Road	5082	78	0	0	1038	4122
Rajbhavan - Hebbal							
1	Millers Road	438	0	0	385	0	53
2	Highgrounds	53	2059	0	0	0	2112
3	Kumarakrupa Road	2112	2712	0	15	0	4809
4	Sankey Road	4809	315	0	1830	0	3294
5	Mekhri Circle	3294	932	1280	192	523	4791
6	Sanjay Nagar	4791	890	0	2070	0	3611
7	CBI	3611	0	457	0	874	3194

Table 5-13 Traffic Flow (Nos) on Proposed Elevated Road

Sl No	Junction Name	In Flow From			Out Flow Towards		
		Straight	Left	Right	Left	Right	Straight
Hebbal - Rajbhavan							
1	Mekhri Circle	3087	0	0	0	786	2301
2	Highgrounds	2301	0	0	0	908	1393
Rajbhavan - Hebbal							
1	Highgrounds	1738	1053	0	0	0	2791
2	Mekhri Circle	2791	0	0	0	0	2791

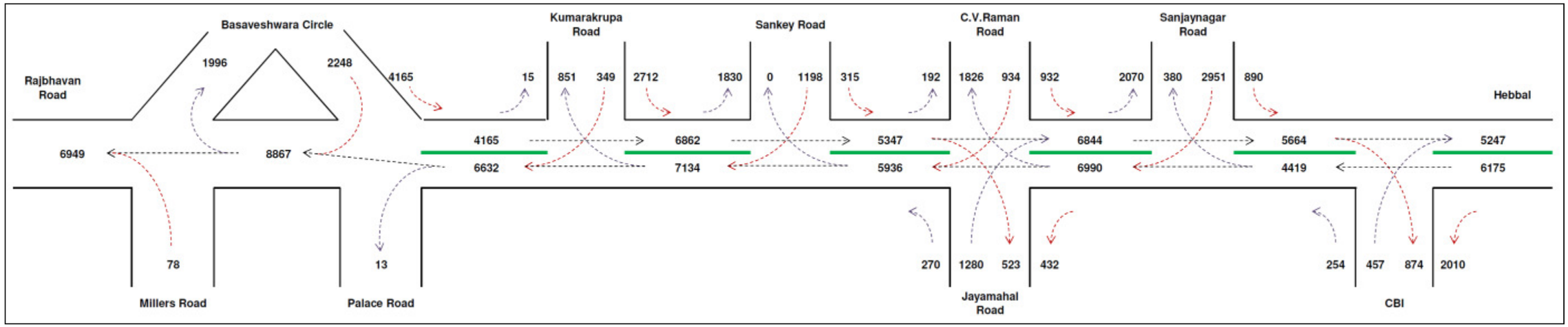


Figure 5-30 Traffic Flow on Existing At-Grade Road

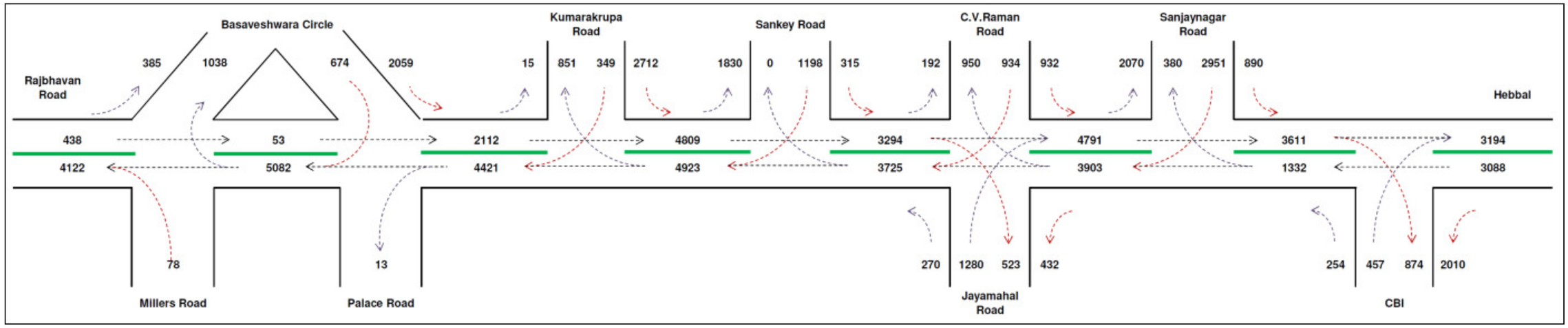


Figure 5-31 Traffic Flow on Proposed At-Grade Road

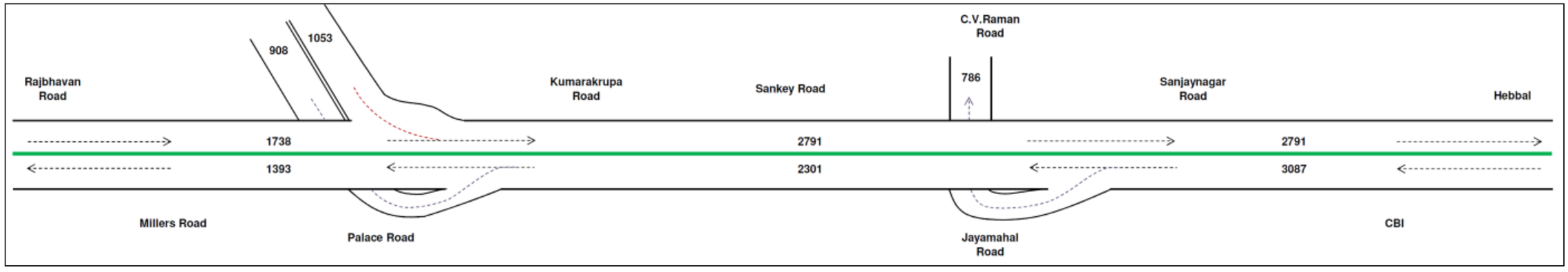


Figure 5-32 Traffic Flow on Proposed Elevated Road

5.4 Speed and Delay Survey

The project road is divided into two different sections, wise one form Highgrounds to Mekhri Circle and the other for Mekhri Circle to Hebbal Junction. Speed and delay studies are carried out for both the sections along the project road. Summary of the findings / analysis is given in Table 5-14 and Table 5-15.

Table 5-14 Speed and Delay Profile - Highgrounds to Hebbal

Control Points	Location		Speed (Kmph)	
	Start	End	Journey	Running
1	Highgrounds	Kumarakrupa Road	19.26	33.09
2	Kumarakrupa Road	Vasanthanagar Road	17.32	30.02
3	Vasanthanagar Road	Cauvery u/pass	18.18	28.03
4	Cauvery u/pass	Mekhri Circle	26.66	46.04
5	Mekhri Circle	Taralabalu Road	19.93	31.51
6	Taralabalu Road	Sanjayanagar Road	27.87	32.01
7	Sanjayanagar Road	CBI	51.03	51.03
8	CBI	Anandanagar Road	42.53	42.53
9	Anandanagar Road	Hebbal Ramp Start	42.18	44.76
10	Hebbal Ramp Start	Hebbal Ramp End	42.81	44.06

Table 5-15 Speed and Delay Profile - Hebbal to Highgrounds

Control Points	Location		Speed (Kmph)	
	Start	End	Journey	Running
1	Hebbal Ramp End	Hebbal Ramp Start	35.56	44.04
2	Hebbal Ramp Start	Anandanagar Road	40.34	40.34
3	Anandanagar Road	CBI	49.10	49.10
4	CBI	Sanjayanagar Road	33.11	33.11
5	Sanjayanagar Road	Taralabalu Road	33.86	41.16
6	Taralabalu Road	Mekhri Circle	32.21	35.41
7	Mekhri Circle	Cauvery u/pass	31.90	38.93
8	Cauvery u/pass	Vasanthanagar Road	21.49	37.59
9	Vasanthanagar Road	Kumarakrupa Road	17.51	35.67
10	Kumarakrupa Road	Highgrounds	21.33	36.04

5.5 Vehicular Conflict Analysis

Vehicular traffic conflict analysis is carried out for peak hour traffic for all the junctions along the project road separately. Existing traffic conflicts are estimated assuming that the existing

traffic flow is un-controlled i.e., theoretically assuming that the junction is not operated with traffic signals and traffic from all directions are free to move at a time.

The traffic that is like to use the proposed elevated road is then deducted from existing traffic to arrive at estimated traffic conflicts at the junction. The existing and estimated traffic conflict for all junctions is shown side-by-side in Figure 5-33 through Figure 5-41.

The existing and estimated traffic conflicts for Basaveshwara circle is 53.77million and 5.62 million, Millers Road junction is 5.2 million and 0.8 million, Highgrounds junction is 35.58 million and 7.64 million, Kumarakrupa road junction is 30.43 million and 3.12 million, Cauvery theater junction is 12.35 million and 3.70 million, Mekhri circle (considering surface level traffic only) is 9.51 million and 5.38 million, Sanjaynagar junction is 34.05 million and 12.78 million, CBI junction is 9.45 million and 3.24 million respectively.

Thus, the reduction in traffic conflicts estimated for Basaveshwara Circle is about 90%, Millers Road junction is about 85%, Highgrounds junction is about 68%, Kumarakrupa road junction is about 90%, Cauvery theater junction is about 70%, Mekhri circle is about 46%, Sanjaynagar junction is about 62% and CBI junction is about 66% respectively.

The existing traffic conflict at Hebbal junction remains unaltered as the proposed elevated road ends before the junction. The existing traffic conflict at the junction is about 9.14 million.

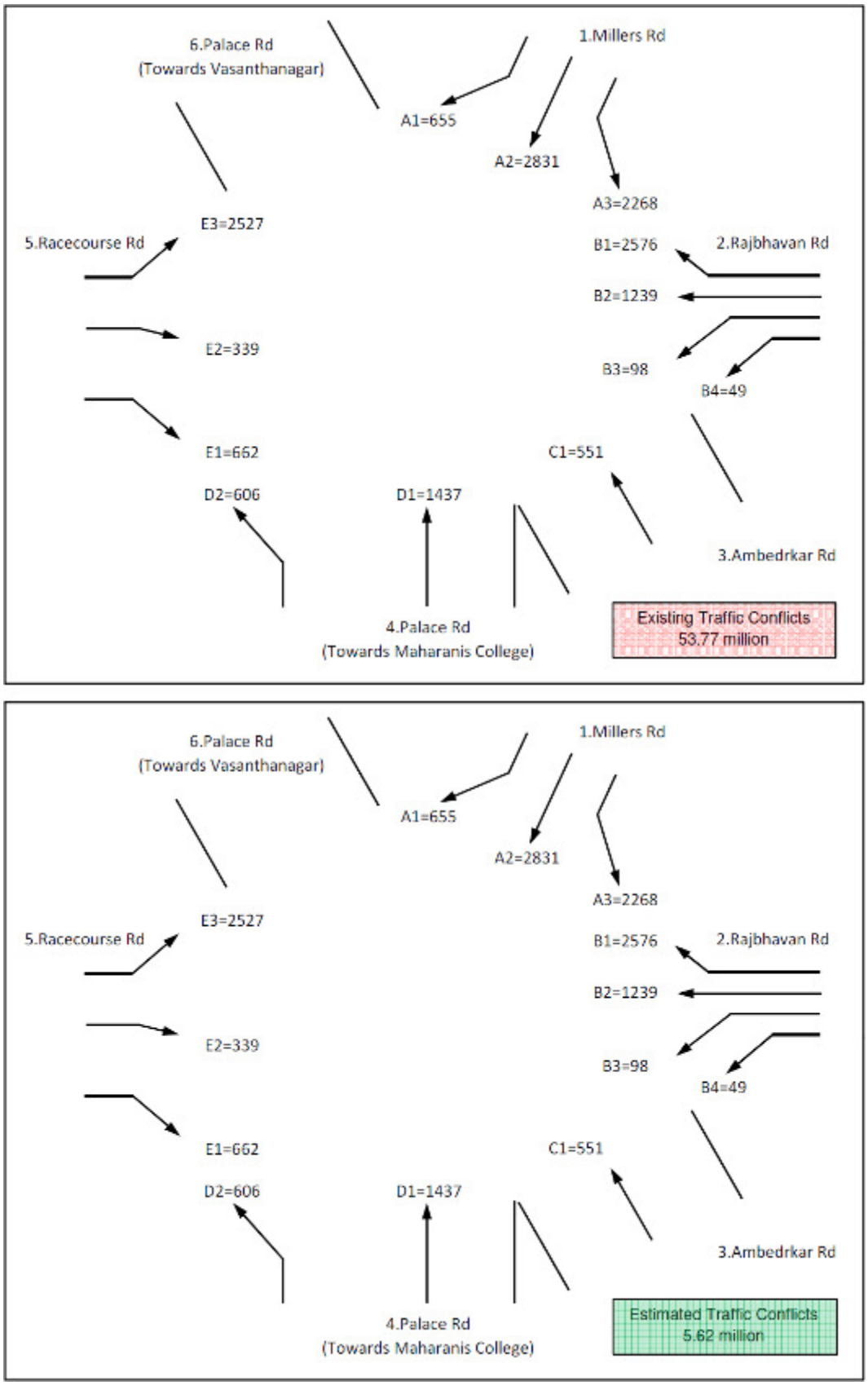


Figure 5-33 Basaveshwara Circle - Traffic Conflicts

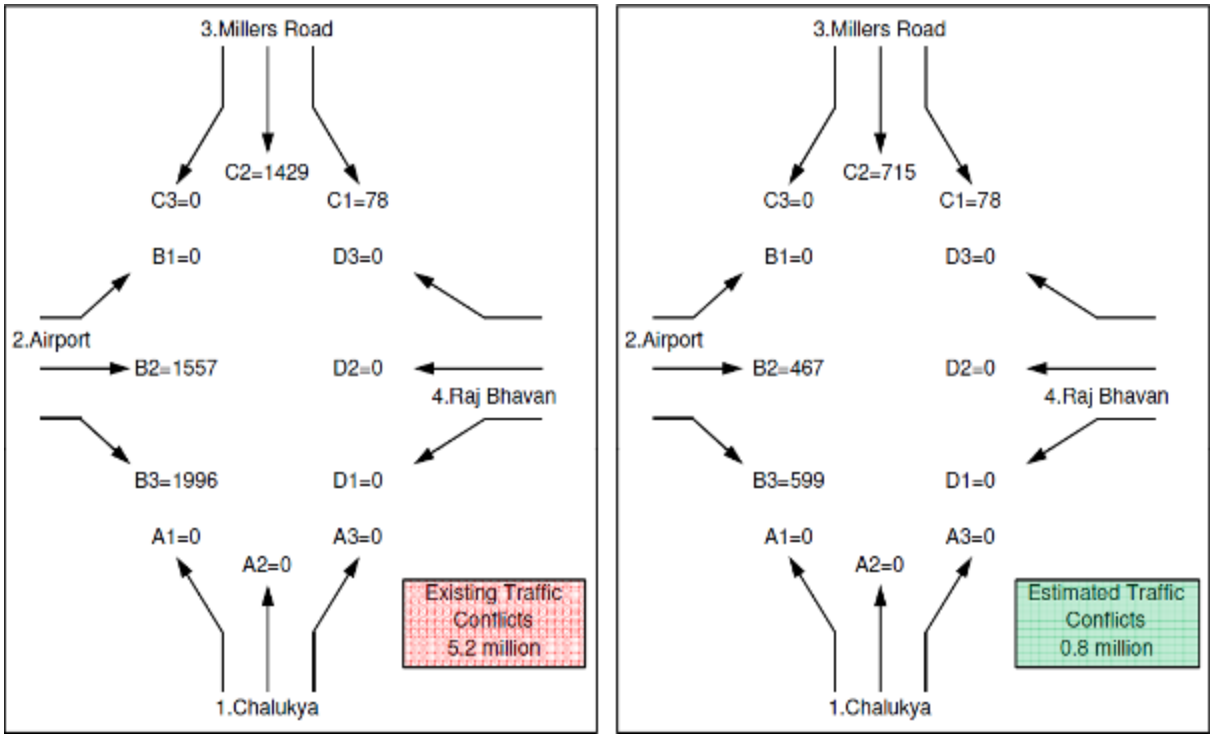


Figure 5-34 Millers Road Junction - Traffic Conflicts

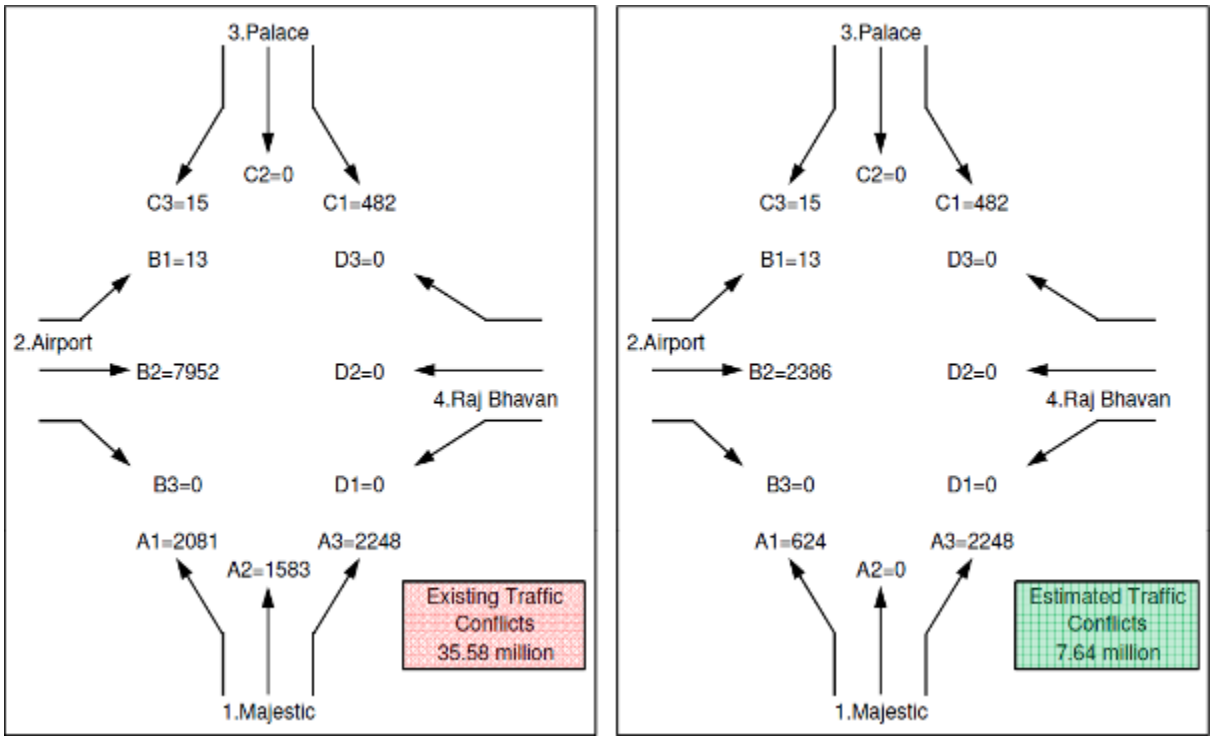


Figure 5-35 Highgrounds Junction - Traffic Conflicts

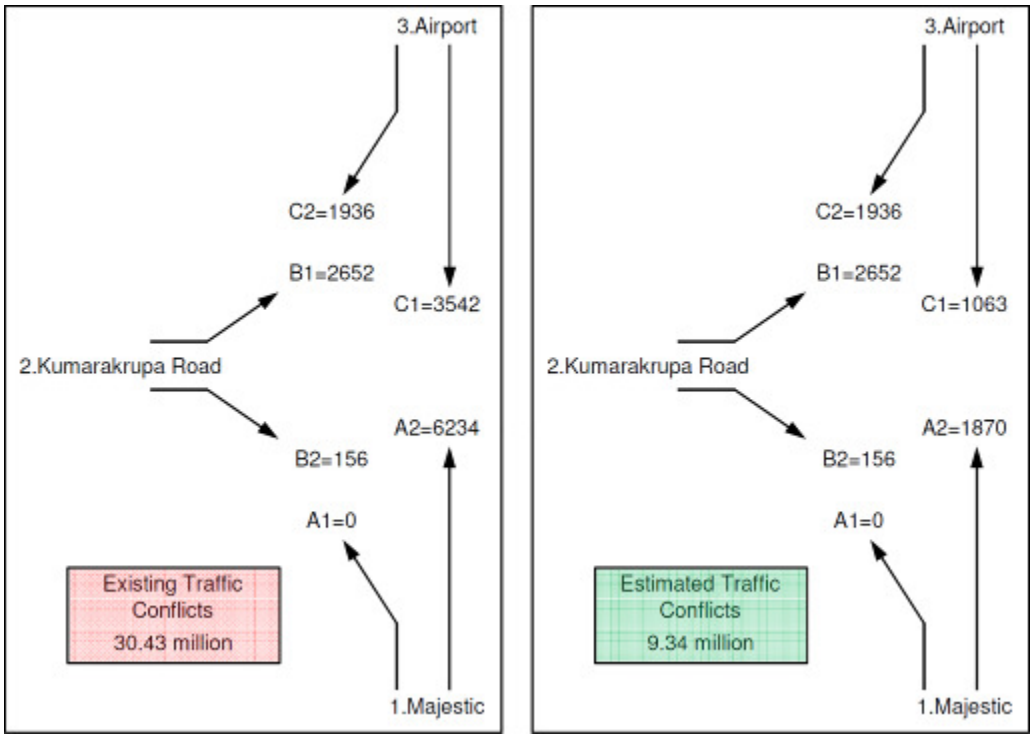


Figure 5-36 Kumarakrupa Road Junction - Traffic Conflicts

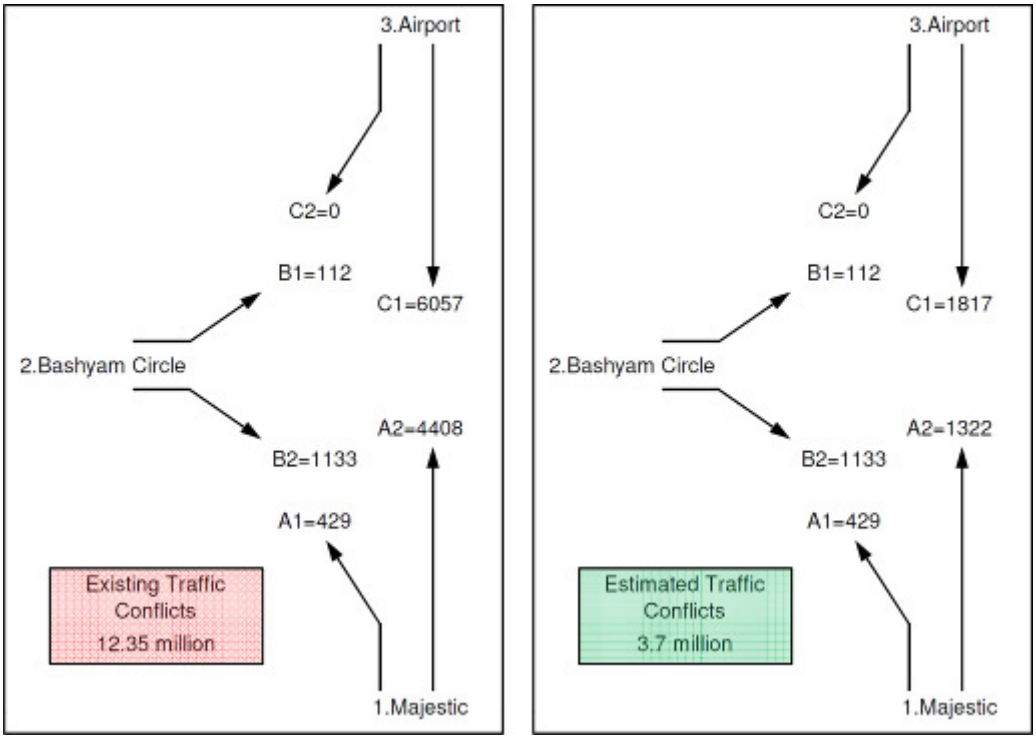


Figure 5-37 Cauvery Junction - Traffic Conflicts

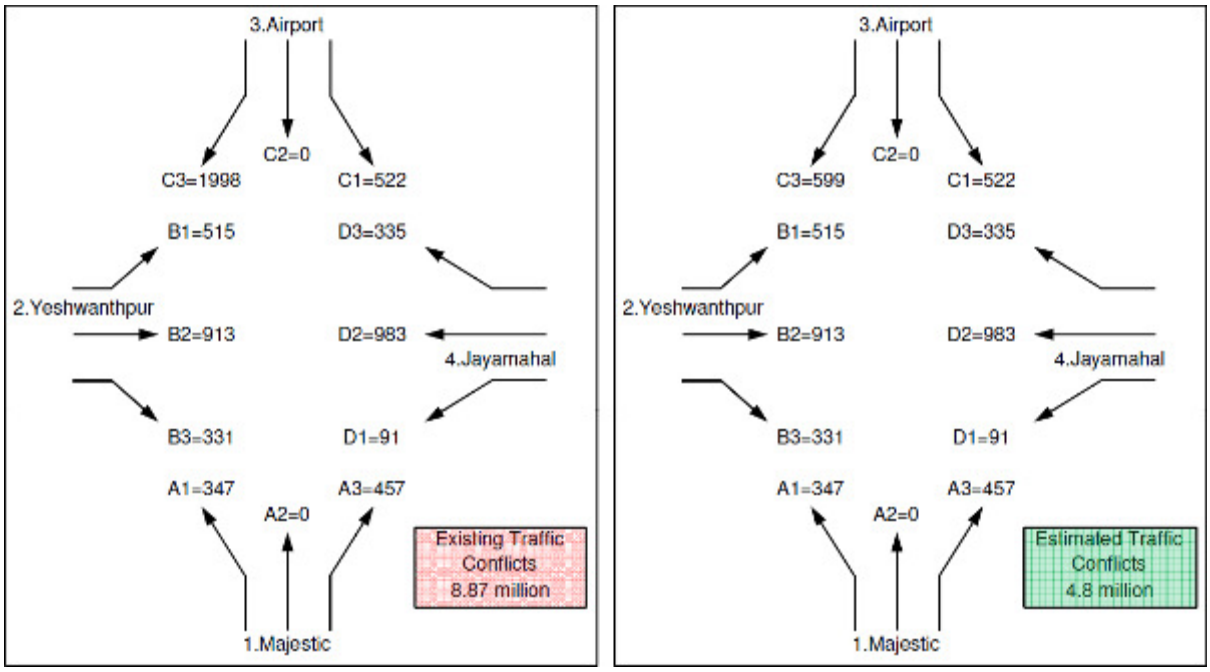


Figure 5-38 Mekhri Circle Junction - Traffic Conflicts

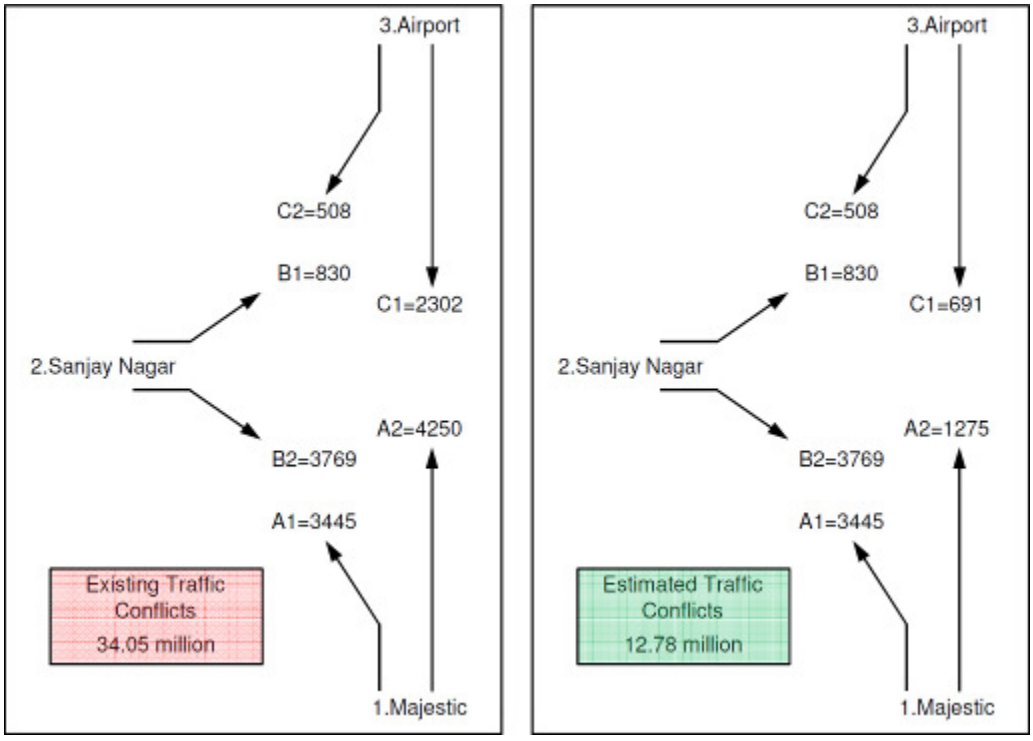


Figure 5-39 Sanjaynagar Road Junction - Traffic Conflicts

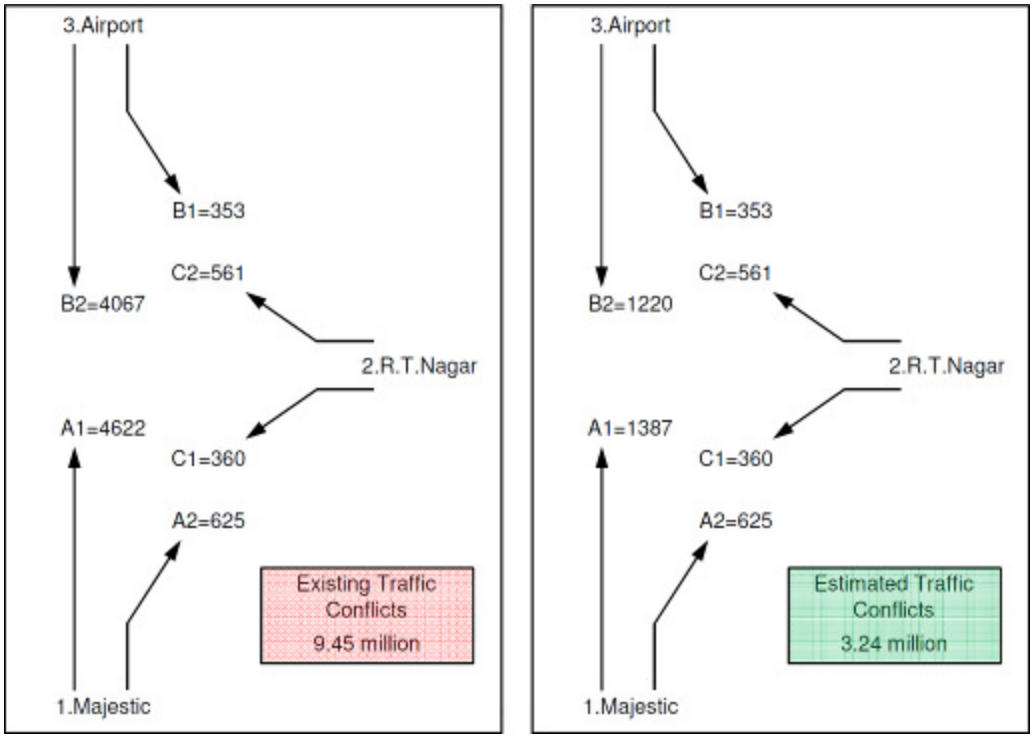


Figure 5-40 CBI Junction - Traffic Conflicts

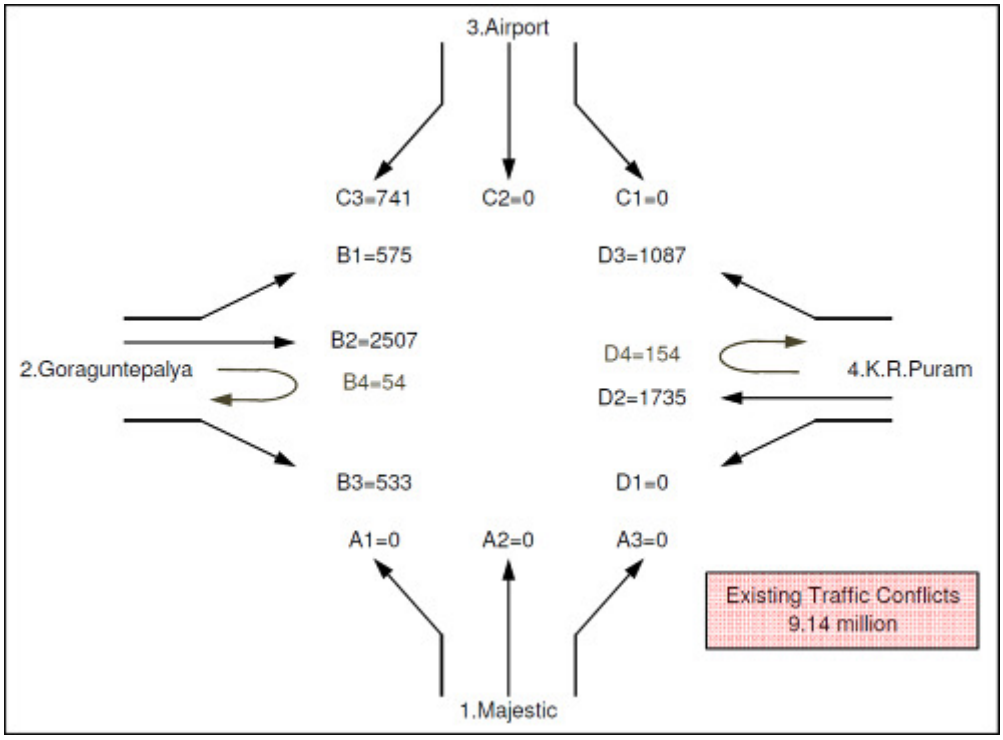


Figure 5-41 Hebbal Junction - Traffic Conflicts

5.6 Junction Delay Analysis

The consultants have captured delays at all arms of the Junction during peak hour (morning and evening) and off peak hour (afternoon). The delays and classified vehicles are estimated for each of the trail. Junction delay is arrived by averaging delay measured for all trials for

the junction. Junction delay measured for both the junctions in terms of time is presented in Table 5-16 and Table 5-17 respectively. Details of delay measurement in terms of classified vehicles for Basaveshwara Circle and Mekhri Circle is presented in Table 5-18 and Table 5-19 respectively.

Table 5-16 Time Delay Measurement at Basaveshwara Circle

Direction	Time of Day			Avg. Delay (sec)
	Morning	Afternoon	Evening	
Millers Road	90	67	132	96
Rajbhavan Road	72	72	68	71
Ambedkar Road	85	71	87	81
Palace Road	124	147	92	121
Racecourse Road	61	58	57	59

Table 5-17 Time Delay Measurement at Mekhri Circle

Direction	Time of Day			Avg. Delay (sec)
	Morning	Afternoon	Evening	
Bellary Road (From Highgrounds)	54	63	53	57
Jayamahal Road	73	137	74	95
Bellary Road (From Airport)	63	70	52	62
CV Raman Road (From IISc)	77	80	79	79

From the above table it can be observed that the junction time delay is more for Palace road and Millers road at Basaveshwara circle and for Jayamahal road at Mekhri circle.

The time delay at these two junctions is alarming for necessity of grade separator. Thus, multi level (four level) grade separation is proposed for both these junctions in order to reduce delay.

In post implementation scenario, substantial traffic at Basaveshwara circle will be segregated with minimum delay due to surface level vehicular traffic. At Mekhri circle, the signal cycle is expected to reduce substantially which reduces junction delay substantially. The option of making this junction signal free was found not workable due to site constraints like existing underpass, Military and Air force base on either side of main road at the junction.

Table 5-18 Average Delay Measurement at Basaveshwara Circle

Direction	Distance, m	Buildup Time, sec	Time Taken for Queue, sec	FAST MOVING VEHICLES, nos									SLOW MOVING VEHICLES, nos			Total
				Two Wheeler	Auto	Car/ Jeep	Mini Bus	Standard Bus	LCV (Passenger)	LCV (Goods)	Two Axle	Multi Axle	Tractors	Cycles	Animal Drawn	
Bellary Road (From Highgrounds)	50	90	90	23	5	13	0	0	0	0	0	0	0	0	0	41
	50	140	50	8	2	7	0	0	0	0	0	0	0	0	0	17
Total :	50	152	12	1	0	0	0	0	0	0	0	0	0	0	0	1
Jayamahal Road	**150**	**382**	**152**	**32**	**7**	**20**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**59**
	50	102	102	26	5	17	0	0	0	0	0	0	0	0	0	48
	50	129	27	4	1	4	0	0	0	0	0	0	0	0	0	9
	100	**231**	**129**	**30**	**6**	**21**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**57**
Total :	50	115	115	19	1	18	0	1	0	0	0	0	0	0	0	39
Bellary Road (From Airport)	50	139	24	6	0	5	0	0	0	0	0	0	0	0	0	11
	100	**254**	**139**	**25**	**1**	**23**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**50**
	50	112	112	72	20	44	1	1	0	0	0	0	0	0	0	138
Total :	50	125	13	3	1	2	0	0	0	0	0	0	0	0	0	6
CV Raman Road (From IISc)	**100**	**237**	**125**	**75**	**21**	**46**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**144**
	25	90	90	31	8	17	0	0	0	0	0	0	0	0	0	56
	25	109	19	12	4	8	0	0	0	0	0	0	0	0	0	24
Total :	**50**	**199**	**109**	**43**	**12**	**25**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**80**

Table 5-19 Average Delay Measurement at Mekhri Circle

Direction	Distance, m	Buildup Time, sec	Time Taken for Queue, sec	FAST MOVING VEHICLES, nos									SLOW MOVING VEHICLES, nos			Total
				Two Wheeler	Auto	Car/ Jeep	Mini Bus	Standard Bus	LCV (Passenger)	LCV (Goods)	Two Axle	Multi Axle	Tractors	Cycles	Animal Drawn	
Bellary Road (From Highgrounds)	25	134	134	19	4	7	1	0	1	0	0	0	0	0	0	32
	25	163	29	2	1	3	0	0	0	0	0	0	0	0	0	6
Total :	**50**	**297**	**163**	**21**	**5**	**10**	**1**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**38**
Jayamahal Road	50	35	35	19	6	10	0	2	1	1	0	0	0	0	0	39
	50	69	34	16	6	12	0	1	0	1	1	0	0	0	0	37
	50	132	63	21	5	10	0	2	0	1	1	0	0	0	0	40
	50	150	18	8	2	5	0	2	0	1	0	0	0	0	0	18
Total :	**200**	**386**	**150**	**64**	**19**	**37**	**0**	**7**	**1**	**4**	**2**	**0**	**0**	**0**	**0**	**134**
Bellary Road (From Airport)	50	92	92	21	8	20	0	0	1	1	0	0	0	0	0	51
	50	124	32	16	7	14	1	1	0	1	1	0	0	0	0	41
	50	136	12	11	3	8	1	1	1	0	0	0	0	0	0	25
Total :	**150**	**352**	**136**	**48**	**18**	**42**	**2**	**2**	**2**	**2**	**1**	**0**	**0**	**0**	**0**	**117**
CV Raman Road (From IISc)	50	90	90	28	6	12	0	1	1	1	0	0	0	0	0	49
	50	153	63	7	5	11	1	1	1	0	0	0	0	0	0	26
	50	177	24	2	1	3	0	0	0	0	1	0	0	0	0	7
Total :	**150**	**420**	**177**	**37**	**12**	**26**	**1**	**2**	**2**	**1**	**1**	**0**	**0**	**0**	**0**	**82**

5.7 Pedestrian Movements

Due to the presence of commercial, business, educational and recreational establishments along the project road, there is a high volume of pedestrian movement. The presence of bus stops in proximity with Junctions and at midblock sections attracts considerable pedestrian movement. This has increased the conflicts between pedestrians and vehicles. In order to determine the conflicts, pedestrian crossing counts were done at three major location (mid block section) along the project road. From the data, pedestrian and vehicle conflicts at peak hour are established and summarized in Table 5-20 through Table 5-22.

Table 5-20 Near Guttahalli Bus Stop – Pedestrian Vehicle Conflicts

Direction	Pedestrian Count, P (nos)	Vehicular Traffic, V (PCU/hr)	PV^2	Warrant as per IRC 103-1988
D-1	248	3960	3.89×10^9	$PV^2 > 2 \times 10^8$ (for divided c/w)
D-2	478	7693	2.83×10^{10}	
Note:- Pedestrian Peak Hour = 09:45 - 10:45				

Table 5-21 Near Taralabalu Road – Pedestrian Vehicle Conflicts

Direction	Pedestrian Count, P (nos)	Vehicular Traffic, V (PCU/hr)	PV^2	Warrant as per IRC 103-1988
D-1	145	5793	4.87×10^9	$PV^2 > 2 \times 10^8$ (for divided c/w)
D-2	134	6369	5.44×10^9	
Note:- Pedestrian Peak Hour = 17:00 - 18:00				

Table 5-22 Near Hebbal Bus Stop – Pedestrian Vehicle Conflicts

Direction	Pedestrian Count, P (nos)	Vehicular Traffic, V (PCU/hr)	PV^2	Warrant as per IRC 103-1988
D-1	767	6245	2.99×10^{10}	$PV^2 > 2 \times 10^8$ (for divided c/w)
D-2	877	4405	1.70×10^{10}	
Note:- Pedestrian Peak Hour = 18:45 - 19:45				

6.0 GEOTECHNICAL INVESTIGATIONS

Geotechnical investigation for the project involves collection of soil sample from site at pre-determined locations along the project corridor and testing the same in laboratory for its property as per standard codal procedure.

The primary objective of this investigation is to obtain information about the sub-surface conditions at the site and obtain net allowable bearing pressure water table along under pass alignment for design of foundations.

6.1 Sample Collection

The soil samples are collected from site by drilling 150 mm diameter bore holes at pre-identified locations along the project corridor. Two methods of drilling were adopted for the project corridor which is given below.

- Auger bore / Manual Drilling
- Rotary bore / Mechanical Drilling

Auger boring is carried out in accordance with IS: 1892 -1979 Code of Practice for sub-surface investigation of foundation (re – affirmed in 1992). Representative / undisturbed samples are collected at different depths as the boring operation progressed. Various laboratory tests are conducted on the samples collected. Standard penetration tests are conducted at every 1.50m interval as per IS: 2131 – 1981.

6.2 Standard Penetration Test

Standard Penetration Test (SPT) is carried out at different depths in all the boreholes & the 'N' values are recorded. The number of blows required to drive a 50mm diameter split spoon sampler for a depth of 30cm using a 65 kg hammer for a drop of 75cm is recorded as 'N' value. The results of all the penetration tests are performed in each of the boreholes and they are shown in their respective Bore logs. The test is halted if,

- 50 blows are required for any 150mm penetration.
- 100 blows are required for 300mm penetration.
- 10 successive blows produce no advance and the N – value is recorded as "REFUSAL".

Key plan showing borehole locations for the project road is shown in Figure 6-1.

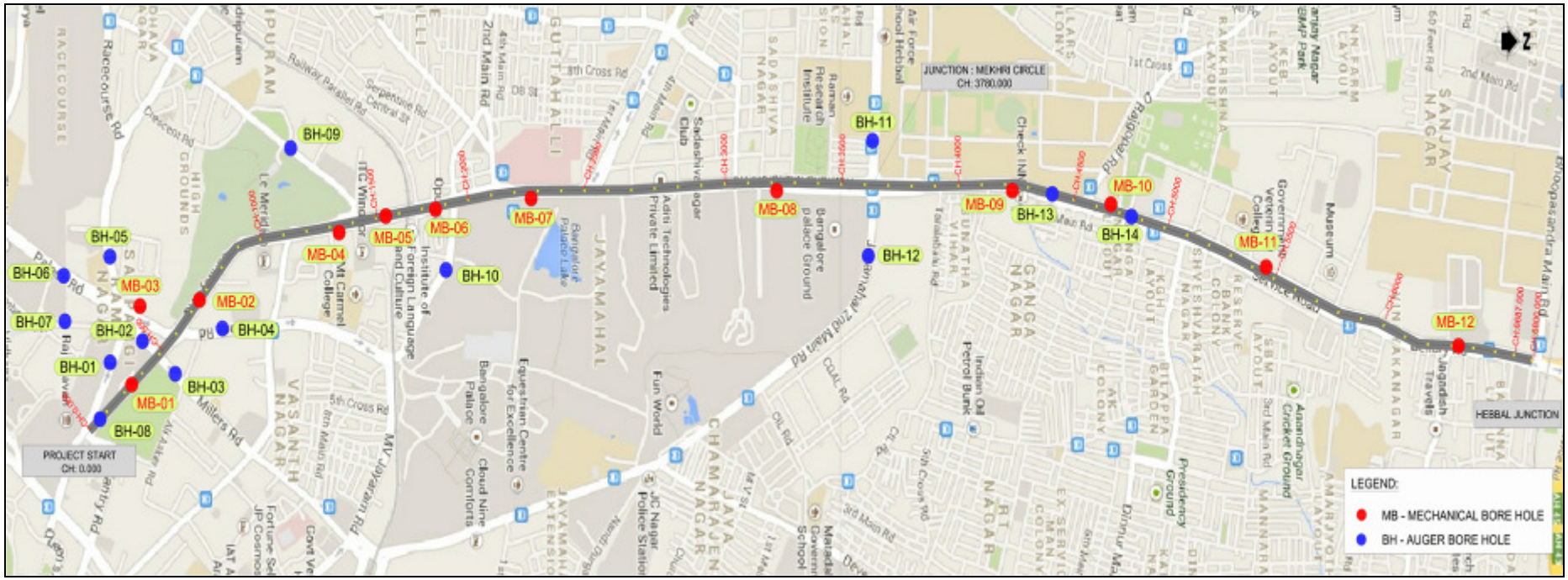


Figure 6-1 Key Plan Showing Bore Hole Locations

6.3 Auger Boring

Auger boring is carried out at 14 locations for the project corridor. Bore log chart for all the bore hole locations is given in Figure 6-2 through Figure 6-15 below. The following conclusions are drawn based on field and laboratory investigations.

- The sub soil varies from top (nil / 0 depth) to 1.5m depth loose soil was observed followed by medium dense to dense strata up to refusal stage.
- During the time of investigation water table was not encountered up to the refusal stage; however the same may be subjected to seasonal fluctuations.
- Liquid limit and Plastic limit indicates that, soil is of low compressibility in nature.

The Net Safe Bearing Capacity (SBC) values obtained for the bore holes are presented in Table 6-1 below.

Table 6-1 SBC of Soil by Auger Boring

Bore Hole No.	SBC (kN/m^2)		
	1.5m below NGL	2.0m below NGL	3.0m below NGL
BH-1	120	150	200
BH-2	120	150	200
BH-3	120	150	200
BH-4	120	150	200
BH-5	120	150	200
BH-6	120	150	200
BH-7	120	150	200
BH-8	120	150	200
BH-9	150	180	220
BH-10	150	180	220
BH-11	150	180	250
BH-12	150	180	250
BH-13	150	180	240
BH-14	150	180	240

DESCRIPTION	Legend	Depth (m)	Sample	N – Value	Remarks
Filled up soil		0.0	--	--	At the time of investigation water table was not encountered up to termination depth.
		0.5	DS	--	
Yellowish brown silty Sand with gravel		1.5	SPT DS	15	
Yellowish red silty Sand		3.0	SPT DS	22	
Greyish to whitish yellow sandy Silt		4.5	SPT DS	30	
		6.0	SPT DS	34	

SPT: Standard penetration test DS: Disturbed sample

Figure 6-2 Bore Log at BH-01

DESCRIPTION	Legend	Depth (m)	Sample	N – Value	Remarks
Yellowish brown sandy Silt		0.0	--	--	At the time of investigation water table was not encountered up to termination depth.
		0.5	DS	--	
Brownish yellow sandy Silt		1.5	SPT DS	15	
		3.0	SPT DS	17	
Greyish to whitish yellow sandy Silt		4.5	SPT DS	22	
		6.0	SPT DS	30	

SPT: Standard penetration test DS: Disturbed sample

Figure 6-3 Bore Log at BH-02

DESCRIPTION	Legend	Depth (m)	Sample	N – Value	Remarks
Filled up soil		0.0	--	--	At the time of investigation water table was not encountered up to termination depth.
		0.5	DS	--	
Yellowish brown sandy Silt		1.5	SPT DS	05	
Reddish yellow sandy Silt		3.0	SPT DS	14	
		4.5	SPT DS	29	
		6.0	SPT DS	43	

SPT: Standard penetration test DS: Disturbed sample

Figure 6-4 Bore Log at BH-03

DESCRIPTION	Legend	Depth (m)	Sample	N – Value	Remarks
Brownish sandy Silt		0.0	--	--	At the time of investigation water table was not encountered up to termination depth.
		0.5	DS	--	
Reddish brown sandy Silt		1.5	SPT DS	06	
Brownish yellow sandy Silt		3.0	SPT DS	09	
		4.5	SPT DS	15	
Greyish yellow sandy Silt		6.0	SPT DS	27	

SPT: Standard penetration test DS: Disturbed sample

Figure 6-5 Bore Log at BH-04

DESCRIPTION	Legend	Depth (m)	Sample	N – Value	Remarks
Filled up soil		0.0 0.5	-- DS	-- --	At the time of investigation water table was not encountered up to termination depth.
Yellowish red silty Sand ***(Refusal Strata)***		1.5	SPT DS	>50	

SPT: Standard penetration test DS: Disturbed sample

Figure 6-6 Bore Log at BH-05

DESCRIPTION	Legend	Depth (m)	Sample	N – Value	Remarks
Filled up soil		0.0 0.5	-- DS	-- --	At the time of investigation water table was not encountered up to termination depth.
(Refusal Strata)		1.5	SPT DS	>50	

SPT: Standard penetration test DS: Disturbed sample

Figure 6-7 Bore Log at BH-06

DESCRIPTION	Legend	Depth (m)	Sample	N – Value	Remarks
Brownish sandy Silt		0.0	--	--	At the time of investigation water table was not encountered up to termination depth.
		0.5	DS	--	
Yellowish brown sandy Silt		1.5	SPT DS	08	
Whitish brown silty Sand with gravel		3.0	SPT DS	13	
Greyish yellow sandy Silt with clay binder		4.5	SPT DS	10	
		6.0	SPT DS	14	

SPT: Standard penetration test DS: Disturbed sample

Figure 6-8 Bore Log at BH-07

DESCRIPTION	Legend	Depth (m)	Sample	N – Value	Remarks
Filled up soil		0.0	--	--	At the time of investigation water table was not encountered up to termination depth.
		0.5	DS	--	
		1.5	SPT DS	05	
Brownish yellow sandy Silt		3.0	SPT DS	17	
		4.5	SPT DS	30	
(Refusal Strata)		6.0	SPT DS	>50	

SPT: Standard penetration test DS: Disturbed sample

Figure 6-9 Bore Log at BH-08

DESCRIPTION	Legend	Depth (m)	Sample	N – Value	Remarks
Filled up soil		0.0	--	--	At the time of investigation water table was not encountered up to termination depth.
		0.5	DS	--	
(Refusal Strata)		1.5	SPT DS	>50	

SPT: Standard penetration test DS: Disturbed sample

Figure 6-10 Bore Log at BH-09

DESCRIPTION	Legend	Depth (m)	Sample	N – Value	Remarks
Filled up soil		0.0	--	--	At the time of investigation water table was not encountered up to termination depth.
		0.5	DS	--	
Yellowish brown silty Sand with gravel		1.5	SPT DS	10	
Brownish yellow sandy Silt		3.0	SPT DS	24	
Whitish yellow silty Sand *(Refusal Strata)*		4.5	SPT DS	>50	

SPT: Standard penetration test DS: Disturbed sample

Figure 6-11 Bore Log at BH-10

DESCRIPTION	Legend	Depth (m)	Sample	N – Value	Remarks
Reddish yellow sandy Silt		0.0	--	--	At the time of investigation water table was not encountered up to termination depth.
		0.5	DS	--	
Yellowish red sandy Silt		1.5	SPT DS	04	
Brownish yellow silty Sand ***(Refusal Strata)***		3.0	SPT DS	>50	

SPT: Standard penetration test DS: Disturbed sample

Figure 6-12 Bore Log at BH-11

DESCRIPTION	Legend	Depth (m)	Sample	N – Value	Remarks
Yellowish red sandy Silt		0.0	--	--	At the time of investigation water table was not encountered up to termination depth.
		0.5	DS	--	
		1.5	SPT DS	06	
Whitish yellow sandy Silt ***(Refusal Strata)***		3.0	SPT DS	>50	

SPT: Standard penetration test DS: Disturbed sample

Figure 6-13 Bore Log at BH-12

DESCRIPTION	Legend	Depth (m)	Sample	N – Value	Remarks
Filled up soil		0.0	--	--	At the time of investigation water table was not encountered up to termination depth.
		0.5	DS	--	
(Refusal Strata)		1.5	SPT DS	>50	

SPT: Standard penetration test DS: Disturbed sample

Figure 6-14 Bore Log at BH-13

DESCRIPTION	Legend	Depth (m)	Sample	N – Value	Remarks
Filled up soil		0.0	--	--	At the time of investigation water table was not encountered up to termination depth.
		0.5	DS	--	
Yellowish brown silty Sand with gravel		1.5	SPT DS	09	
Whitish yellow silty Sand		3.0	SPT DS	26	
Greyish yellow sandy Silt *(Refusal Strata)*		4.5	SPT DS	>50	

SPT: Standard penetration test DS: Disturbed sample

Figure 6-15 Bore Log at BH-14

6.3.1 Laboratory Testing

Samples procured were transported to laboratory for obtaining Index and Engineering properties. In the laboratory, samples were visually classified by Geotechnical Engineer. Laboratory tests are being carried out as per relevant IS: 2720 guidelines. Generally, Soil Samples were tested for following parameters,

- Particle Size analysis
- Bulk Density
- Natural Moisture Content

- Atterberg's limits

The test results are tabulated in Table 6-2 and Grain Size Analysis chart for all the bore hole locations is given in Figure 6-16 through Figure 6-29 below.

Table 6-2 Grain Size Analysis Results

Bore Hole No.	Depth (m)	Water Content (%)	Atterberg's Limit			Grain Size Distribution				
			Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (PI)	Gravel (%)	Sand (%)			Silt & Clay
							Coarse	Medium	Fine	
01	1.5	10.3	--	--	--	1.0	4.7	22.8	34.0	37.5
	3.0	13.0	36.5	19.0	17.5	0.0	1.3	17.3	19.3	62.1
	6.0	16.0	--	--	--	5.3	3.9	23.3	14.6	52.9
02	1.5	11.8	33.6	14.3	19.3	0.0	0.0	17.7	24.3	58.0
	3.0	11.9	--	--	--	0.6	2.9	21.2	18.5	56.8
	6.0	14.9	--	--	--	2.3	6.9	25.2	13.3	52.3
03	1.5	12.4	34.5	16.0	18.5	5.8	8.3	19.0	25.2	41.7
	4.5	17.5	--	--	--	0.0	0.2	19.0	20.3	60.5
	6.0	16.3	--	--	--	0.2	0.8	15.4	14.3	69.3
04	1.5	11.5	32.5	11.3	21.2	14.2	8.4	17.8	28.6	31.0
	3.0	13.6	34.1	14.9	19.2	0.0	0.8	26.0	24.8	48.4
	6.0	16.3	--	--	--	0.1	5.2	35.1	25.4	34.2
05	1.0	7.0	29.0	14.3	14.7	1.8	18.1	41.1	13.4	25.6
	1.5	11.8	33.0	17.4	15.6	2.8	10.2	42.0	17.5	27.5
06	1.5m	6.5	--	--	--	4.5	5.1	27.1	19.4	43.9
07	1.5	11.8	38.6	19.7	19.0	0.0	0.0	17.6	30.4	52.0
	4.5	14.2	--	--	--	0.1	1.4	25.8	31.4	41.3
	6.0	16.7	--	--	--	1.8	1.9	28.4	33.4	34.5
08	1.5	12.3	33.5	16.2	17.3	5.0	7.8	18.8	29.2	39.2
	4.5	13.3	41.8	--	NP	0.0	0.0	17.0	23.0	60.0
	6.0	16.9	--	--	--	0.9	0.0	19.2	15.9	63.9
09	1.5	8.3	--	--	--	11.5	13.0	33.0	24.3	18.2
10	1.5	12.6	29.1	17.7	11.3	1.6	4.4	28.2	30.7	35.1
	4.5	7.2	--	--	--	6.1	9.4	30.2	25.0	29.3
11	1.5	11.6	37.1	19.0	18.0	0.0	2.2	16.8	25.5	55.5

Bore Hole No.	Depth (m)	Water Content (%)	Atterberg's Limit			Grain Size Distribution				
			Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (PI)	Gravel (%)	Sand (%)			Silt & Clay
							Coarse	Medium	Fine	
	3.0	17.8	46.8	--	NP	0.0	0.0	18.0	19.4	62.6
12	1.5	16.0	--	--	--	1.0	3.7	20.8	17.1	57.4
	3.0	17.8	46.1	--	NP	0.0	0.0	16.3	18.0	65.7
13	1.5	20.6	29.0	--	NP	34.3	8.5	24.0	18.0	15.2
14	1.5	12.0	30.7	16.1	14.6	3.0	9.2	33.8	22.8	31.2
	3.0	5.8	--	--	--	1.4	8.8	39.0	26.2	24.6
	4.5	10.8	--	--	--	1.8	3.0	30.3	32.3	32.6

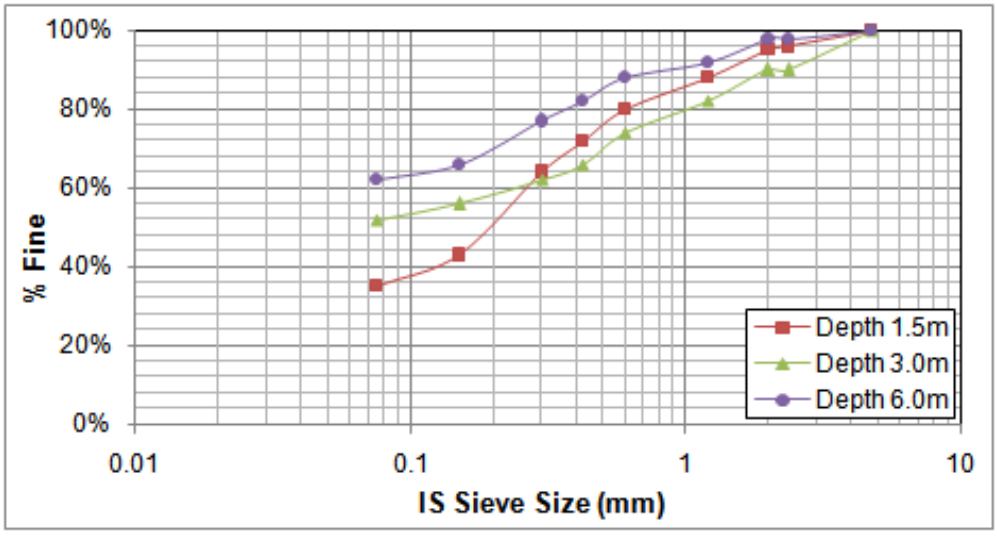


Figure 6-16 Grain Size Analysis for BH-01

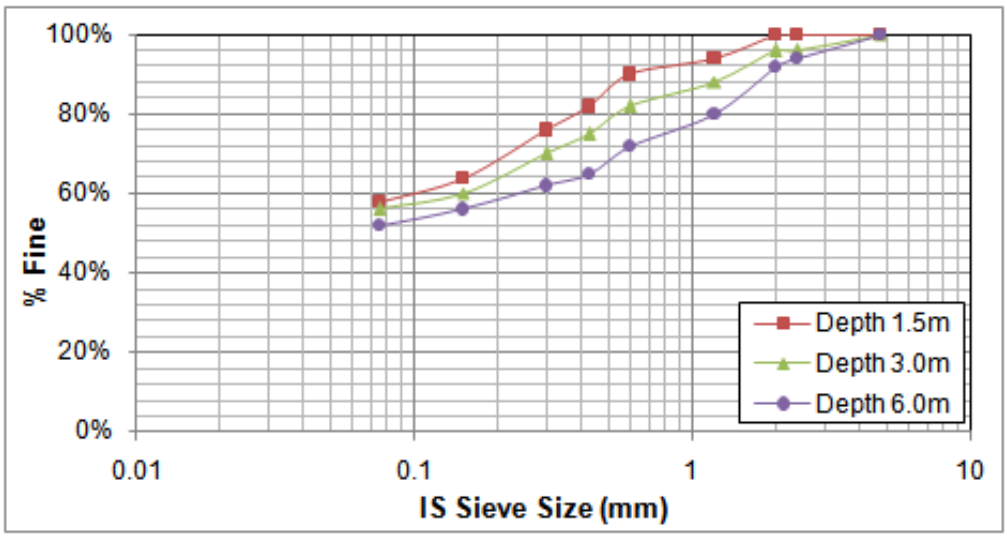


Figure 6-17 Grain Size Analysis for BH-02

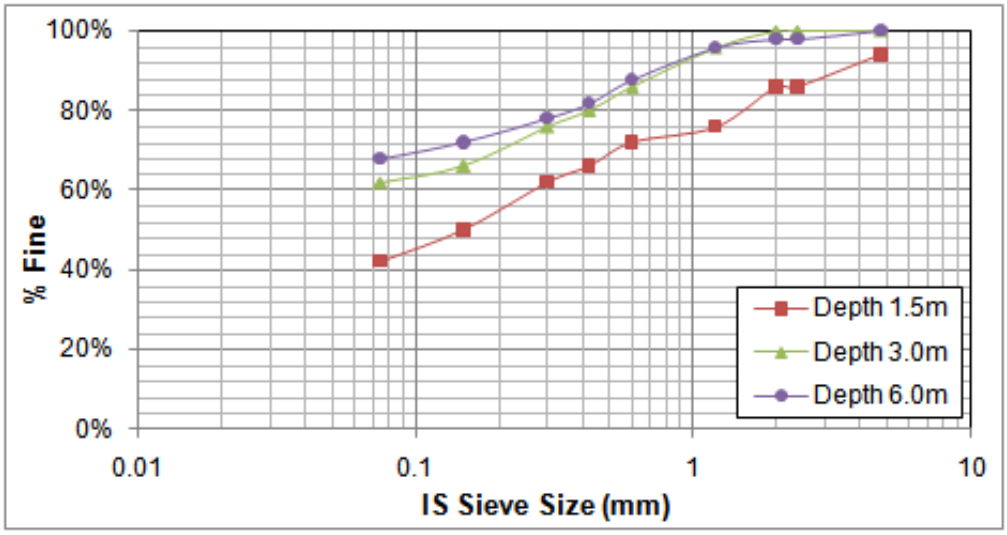


Figure 6-18 Grain Size Analysis for BH-03

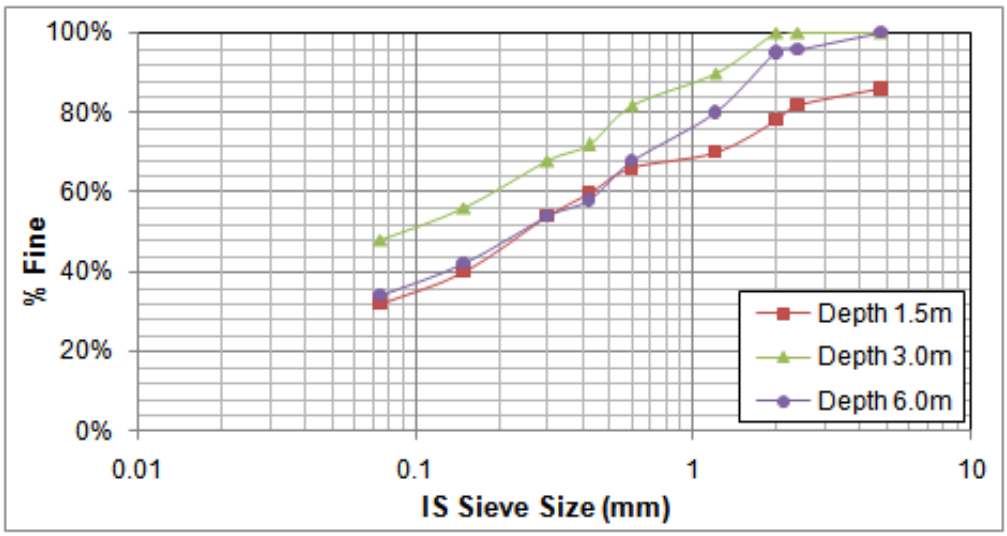


Figure 6-19 Grain Size Analysis for BH-04

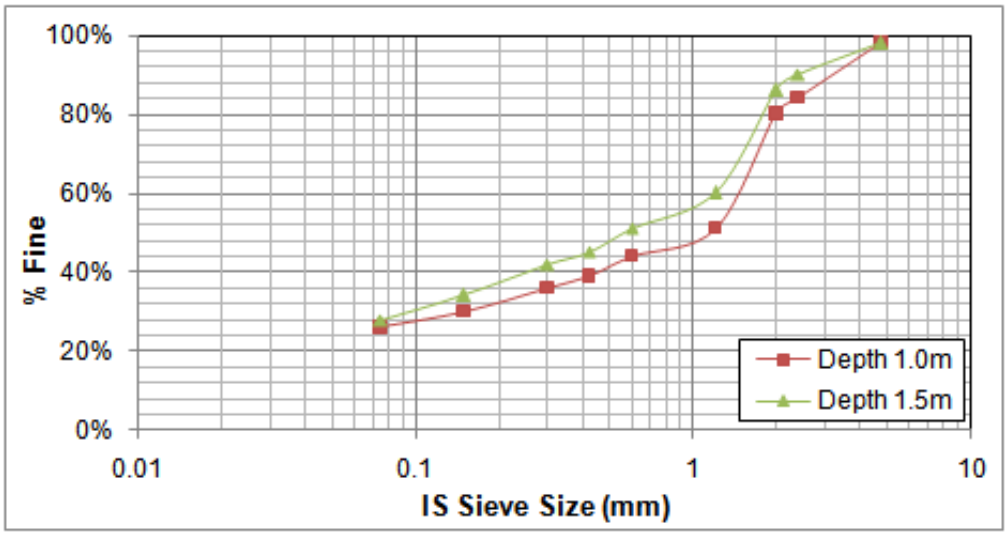


Figure 6-20 Grain Size Analysis for BH-05

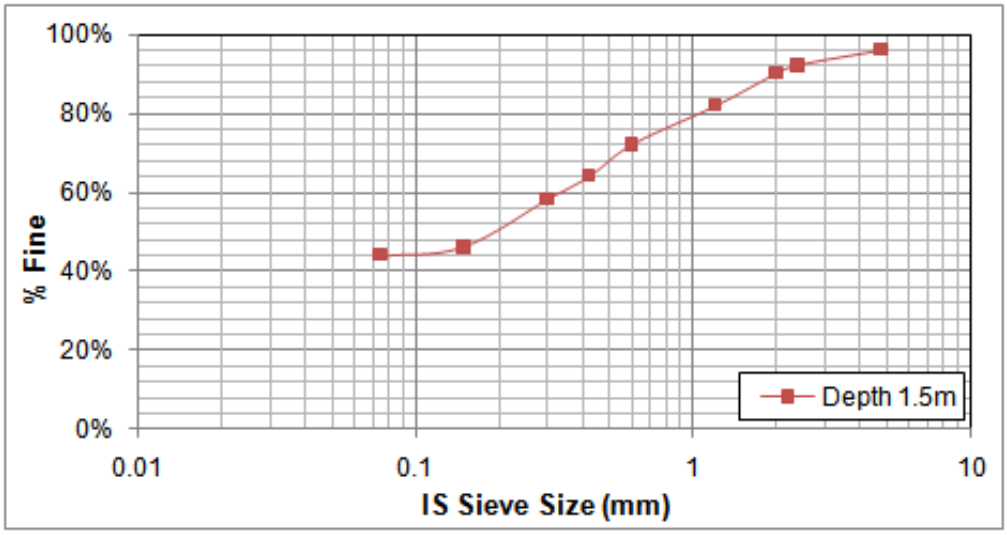


Figure 6-21 Grain Size Analysis for BH-06

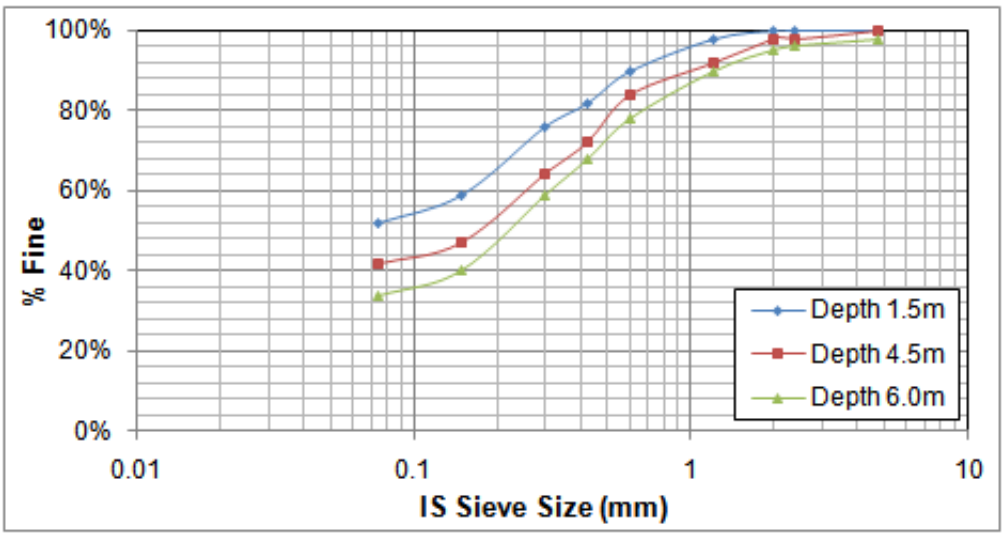


Figure 6-22 Grain Size Analysis for BH-07

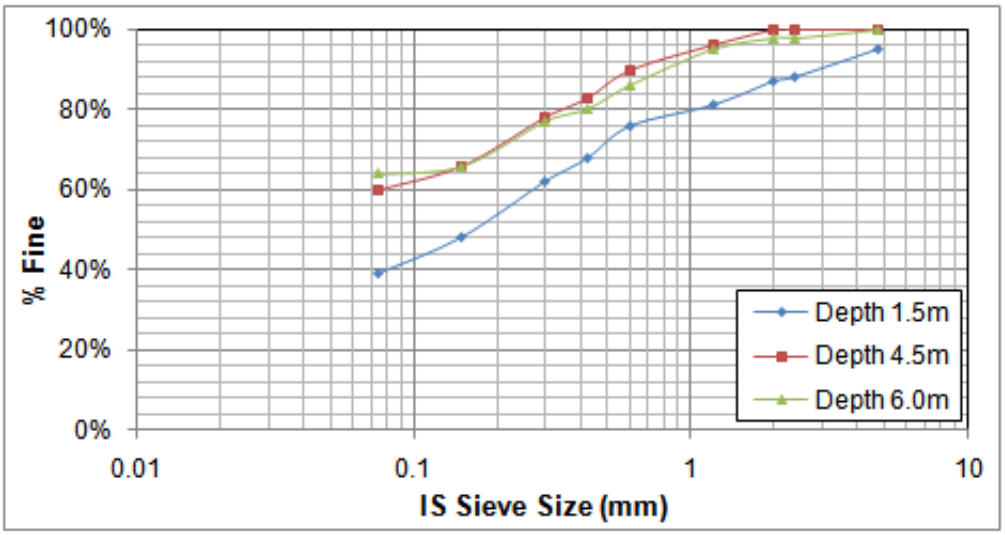


Figure 6-23 Grain Size Analysis for BH-08

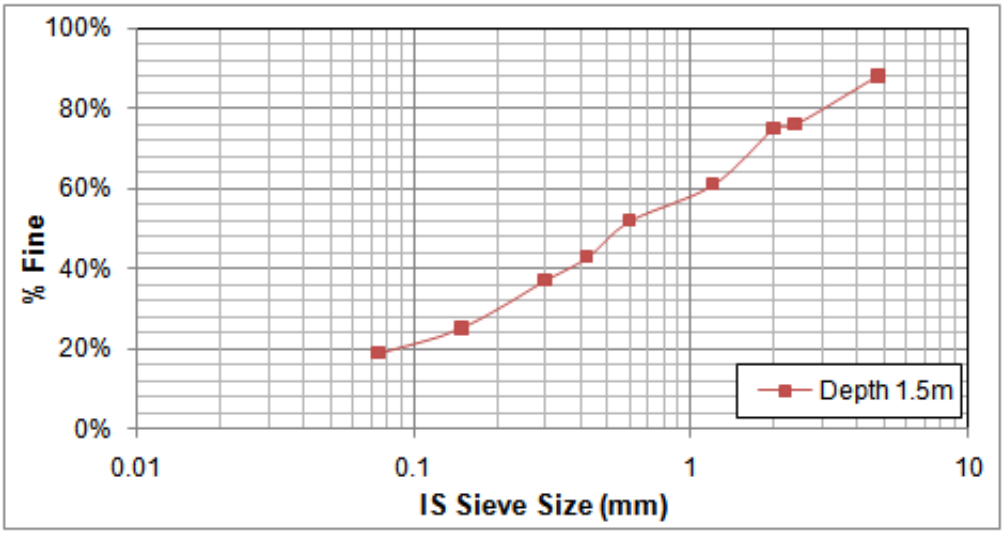


Figure 6-24 Grain Size Analysis for BH-09

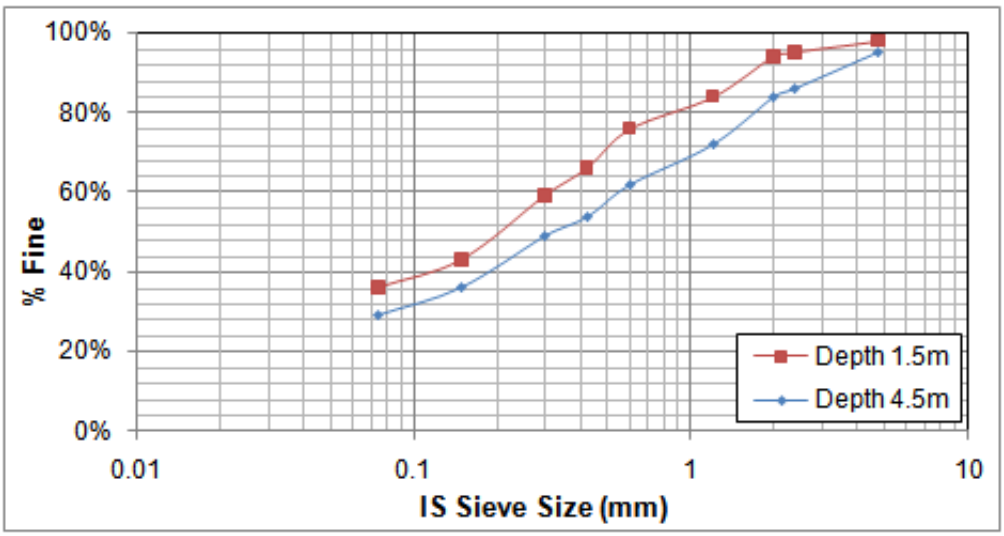


Figure 6-25 Grain Size Analysis for BH-10

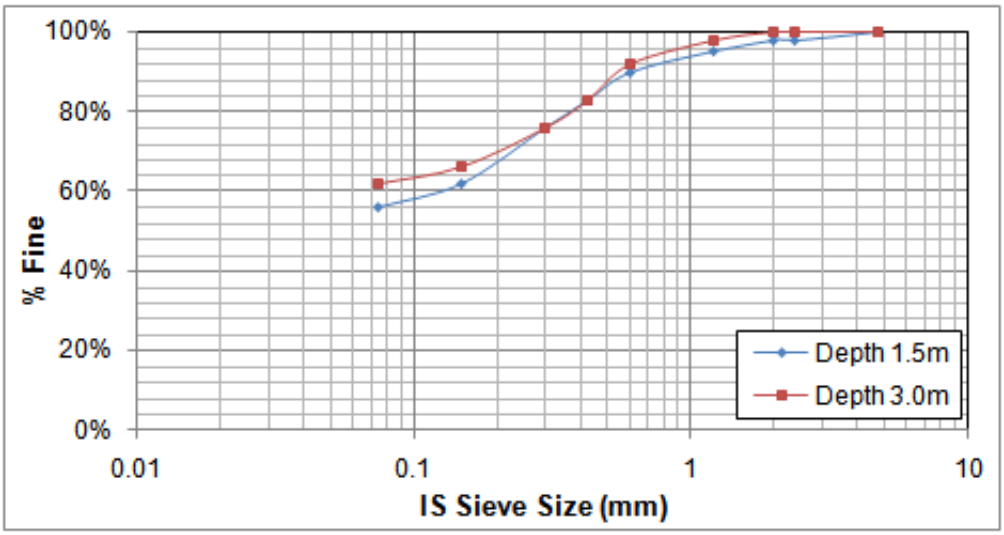


Figure 6-26 Grain Size Analysis for BH-11

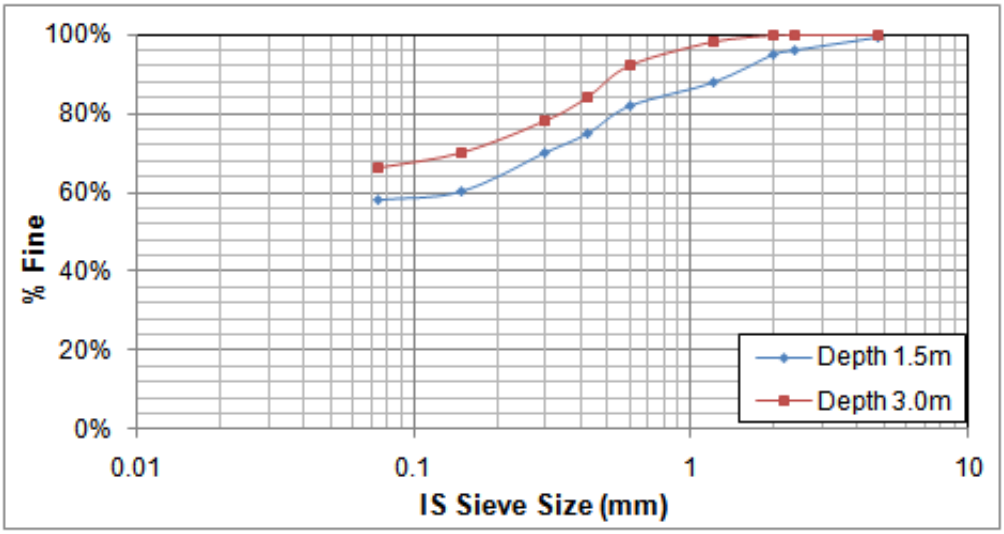


Figure 6-27 Grain Size Analysis for BH-12

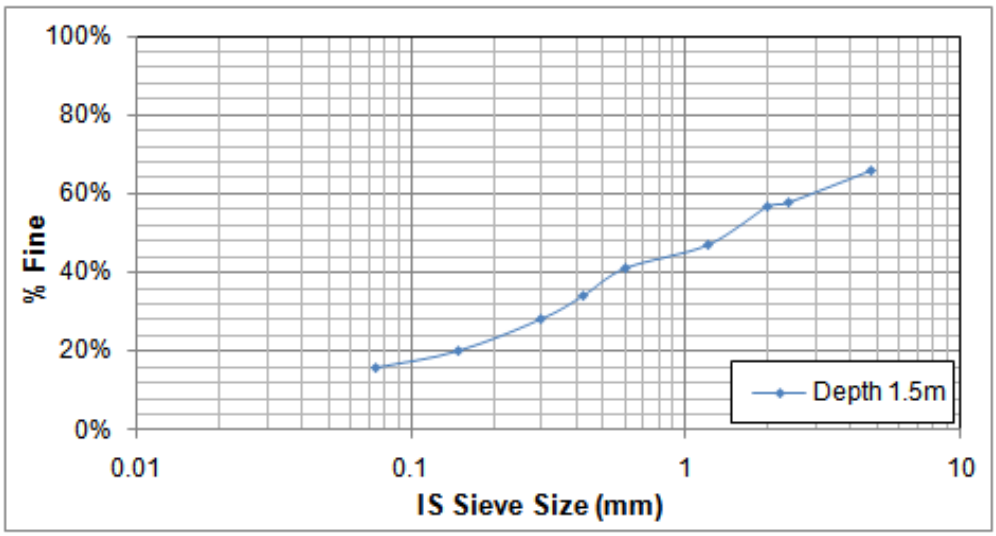


Figure 6-28 Grain Size Analysis for BH-13

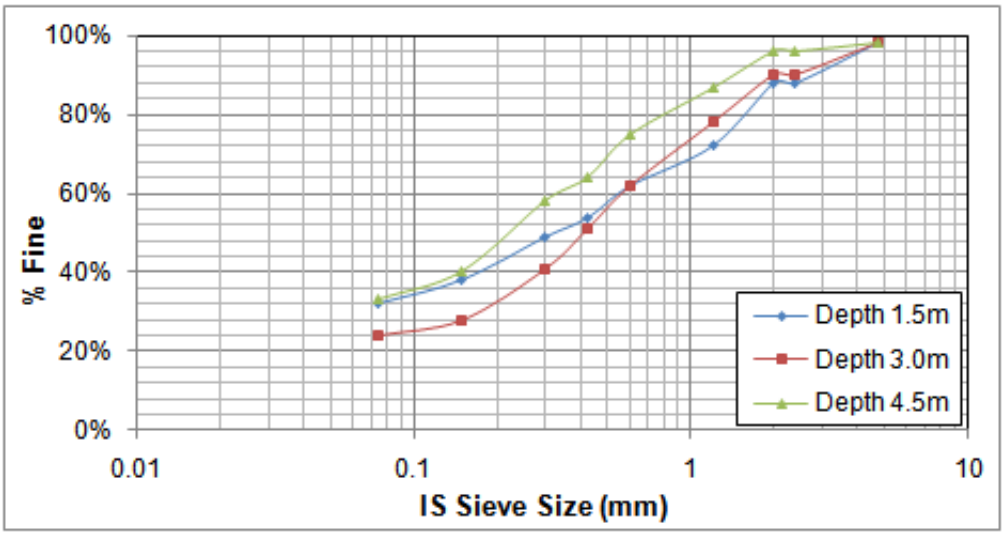


Figure 6-29 Grain Size Analysis for BH-14

Generally, the observations made from field investigations and laboratory tests for all the bore holes are summarized as follows,

- Sub-soil formation comprise of top 0.5m-1.5m depth filled up soil / loose soil
- Followed by Whitish to yellowish brown sandy Silt/silty Sand with presence of Gravel up to 3.0m/4.5m depth
- Extends by Grayish to whitish yellow/Brownish yellow sandy Silt with clay binder up to termination depth.
- All boreholes are terminated at the depth of 6.0m/Refusal stage.
- During the time of investigation water table was not encountered up to termination depth; however the same may be subjected to seasonal fluctuations.
- Liquid limit and Plastic limit indicates that the soil is of low to medium compressibility in nature.

The following recommendations are made based on the detailed investigation conducted at the proposed construction site.

- The foundation for all structure shall be taken to a minimum depth of 1.5m below the natural ground level.
- Isolated/combined footing up to maximum width of 2m/combined foundation may be designed with the following allowable bearing pressure of which gives a factor of safety of 3.0 against shear failure and for an allowable settlement of 25mm

6.4 Mechanical Boring

Mechanical boring is carried out at 12 locations for the project corridor. Bore log chart for all the bore hole locations is given in Figure 6-30 through Figure 6-41 below. The following conclusions are drawn based on field and laboratory investigations.

- Layer-1: The sub soil formation comprises of filled up / manmade soil from ground level to a depth of 1.0/2.0m.
- Layer-2: This layer comprises of sandy silt with SPT 'N' value between 10 and 47, which indicate gradual densification of sub-soil.
- Layer-3: This layer comprises of weathered rock formation from a depth of 12.0m to 20.0m for BH-1 to BH-3 and from a depth of 7.0m to 10.5m for BH-4 to BH-12 respectively. SPT 'N' value was found to be greater than 100 for all bore hole locations.
- Ground water table was not met in any of the boreholes within explored depth below existing ground level at the time of investigation.

Description of Sub-soil stratum	Depth (m)	Legend	Sample	SPT TEST, number of blows recorded			N Value = N_2+N_3	Core recovery (%)	Rock Quality Designation (%)	Remarks
				1st 15cm	2nd 15cm	3rd 15cm				
				N_1	N_2	N_3				
Filled up soil	0.0									
	1.0		DS							
Brownish yellow sandy Silt	1.5		SPT	6	8	10	18			
			DS							
	3.0		SPT	6	9	12	21			
Brownish yellow silty Sand	4.5		DS							
			SPT	10	14	17	31			
	6.0		DS							
			SPT	13	16	19	35			
Grayish pink silty Sand	7.5		DS							
			SPT	12	17	20	37			
	9.0		DS							
			SPT	14	20	20	40			
Brownish gray CWR	10.5		DS							
			SPT	13	20	27	47			
	12.0		DS							
Brownish to yellowish pink silty Sand	13.5		SPT	15	24	28	52			
			DS							
	15.0		SPT	12	20	23	43			
			DS							
	16.5		SPT	10	16	20	36			
			DS							
Brownish to yellowish pink CWR	18.0		SPT	13	18	22	40			
			DS							
	20.0		SPT	16	21	25	46			
			DS	17	28	32	60			*Refusal Strata*

SPT=Standard Penetration test Refusal means SPT N>50

DS=Disturbed Sample B= No. of blows R=Rebound

*Ground water table is as recorded at the time of soil investigation CWR=Completely weathered rock

Figure 6-30 Bore Log at MB-01

Description of Sub-soil stratum	Depth (m)	Legend	Sample	SPT TEST, number of blows recorded			N Value = N_2+N_3	Core recovery (%)	Rock Quality Designation (%)	Remarks
				1st 15cm	2nd 15cm	3rd 15cm				
				N_1	N_2	N_3				
Filled up soil	0.0		DS							
	1.0									
Reddish brown sandy Silt	1.5		SPT	4	6	7	13			
			DS							
	3.0		SPT	6	8	9	17			
			DS							
Brownish to yellowish white sandy Silt	4.5		SPT	6	7	7	14			
			DS							
	6.0		SPT	10	12	15	27			
			DS							
	7.5		SPT	14	14	19	33			
Greyish to pinkish white silty Sand			DS							
	9.0		SPT	17	19	24	43			
			DS							
	10.5		SPT	21	24	27	51			*Refusal Strata*
			DS							
	12.0		SPT	18	25	26	51			
Brownish to yellowish pink CWR			DS							
	13.5		SPT	22	27	31	58			
			DS							
	15.0		SPT	20	30	32	62			
			DS							
	16.5		SPT	24	31	34	68			
			DS							
Brownish to pinkish yellow CWR	18.0		SPT	50B/10cm			>100			
			DS							
	20.0		SPT	48B/8cm			>100			
			DS							

SPT=Standard Penetration test Refusal means SPT N>50

DS=Disturbed Sample B= No. of blows R=Rebound

*Ground water table is as recorded at the time of soil investigation CWR=Completely weathered rock

Figure 6-31 Bore Log at MB-02

Description of Sub-soil stratum	Depth (m)	Legend	Sample	SPT TEST, number of blows recorded			N Value = N_2+N_3	Core recovery (%)	Rock Quality Designation (%)	Remarks
				1st 15cm	2nd 15cm	3rd 15cm				
				N_1	N_2	N_3				
Filled up soil	0.0		DS							
	1.0									
Reddish sandy Silt	1.5		SPT	4	4	6	10			
Brownish yellow sandy Silt			DS							
	3.0		SPT	5	6	8	14			
			DS							
	4.5		SPT	7	10	10	20			
			DS							
	6.0		SPT	8	12	13	25			
Brownish to yellowish white sandy Silt	7.5		DS							
			SPT	10	14	16	30			
			DS							
Brownish yellow silty Sand	9.0		SPT	15	18	20	38			
			DS							
Grayish to brownish yellow silty Sand	10.5		SPT	19	20	24	44			
			DS							
Grayish to pinkish yellow CWR	12.0		SPT	21	24	30	54			*Refusal Strata*
			DS							
	13.5		SPT	18	26	33	59			
Brownish to grayish yellow CWR			DS							
	15.0		SPT	24	28	36	64			
			DS							
	18.0		SPT	27	30	40	70			
			DS							
	20.0		SPT	50B/6cm			>100			
			DS							

SPT=Standard Penetration test Refusal means SPT N>50
DS=Disturbed Sample B= No. of blows R=Rebound
*Ground water table is as recorded at the time of soil investigation CWR=Completely weathered rock

Figure 6-32 Bore Log at MB-03

Description of Sub-soil stratum	Depth (m)	Legend	Sample	SPT TEST, number of blows recorded 1st 15cm N_1	2nd 15cm N_2	3rd 15cm N_3	N Value = N_2+N_3	Core recovery (%)	Rock Quality Designation (%)	Remarks
Filled up soil	0.0		DS							
	1.0									
Grayish red sandy Silt	1.5		SPT	5	7	8	15			
			DS							
	3.0		SPT	7	9	11	20			
Grayish to yellowish white sandy Silt			DS							
	4.5		SPT	16	21	28	49			
Greyish yellow silty Sand			DS							
	6.0		SPT	15	20	29	49			
Whitish yellow silty Sand with boulders			DS							
	7.5		SPT	18	21	30	51			
			DS							
	9.0		SPT	12	17	31	48			
Blackish grey CWR			DS							
	10.5		SPT	22	50B/10cm		>100			*Refusal Strata*
			DS							
	12.0		SPT	28	50B/9cm		>100			
			DS							
	13.5		SPT	48B/8cm			>100			
Grayish to whitish yellow CWR			DS							
	15.0		SPT	48B/8cm			>100			
			DS							
	18.0		SPT	45B/6cm			>100			
			DS							
	20.0		SPT	42B/5cm			>100			
			DS							

SPT=Standard Penetration test Refusal means SPT N>50
DS=Disturbed Sample B= No. of blows R=Rebound
*Ground water table is as recorded at the time of soil investigation CWR=Completely weathered rock

Figure 6-33 Bore Log at MB-04

Description of Sub-soil stratum	Depth (m)	Legend	Sample	SPT TEST, number of blows recorded			N Value = N_2+N_3	Core recovery (%)	Rock Quality Designation (%)	Remarks
				1st 15cm	2nd 15cm	3rd 15cm				
				N_1	N_2	N_3				
Filled up soil	0.0		DS							
	1.0									
Grayish red sandy Silt	1.5		SPT	4	6	8	14			
			DS							
	3.0		SPT	5	5	9	14			
Grayish yellow sandy Silt	4.5		DS							
			SPT	12	17	20	37			
			DS							
	6.0		SPT	10	16	21	37			
Whitish yellow silty Sand	7.5		DS							
			SPT	14	20	28	48			
			DS							
	9.0		SPT	15	23	29	52			*Refusal Strata*
Grayish black CWR	10.5		DS							
			SPT	30	50B/10cm		>100			
			DS							
	12.0		SPT	50B/8cm			>100			
Grayish yellow CWR	13.5		DS							
			SPT	48B/6cm			>100			
	15.0		DS							
			SPT	50B/6cm			>100			
	18.0		DS							
			SPT	48B/5cm			>100			
	20.0		DS							
			SPT	44B/3cm			>100			
			DS							

SPT=Standard Penetration test Refusal means SPT N>50
DS=Disturbed Sample B= No. of blows R=Rebound
*Ground water table is as recorded at the time of soil investigation CWR=Completely weathered rock

Figure 6-34 Bore Log at MB-05

Description of Sub-soil stratum	Depth (m)	Legend	Sample	SPT TEST, number of blows recorded			N Value = N_2+N_3	Core recovery (%)	Rock Quality Designation (%)	Remarks
				1st 15cm	2nd 15cm	3rd 15cm				
				N_1	N_2	N_3				
Filled up soil	0.0		DS							
	1.0									
Brownish red sandy Silt	1.5		SPT	4	6	8	14			
Grayish yellow sandy Silt	3.0		DS							
			SPT	5	8	16	24			
			DS							
	4.5		SPT	10	12	18	30			
Grayish to whitish yellow silty Sand	6.0		DS							
			SPT	17	18	27	45			
Whitish yellow CWR	7.5		DS							
			SPT	21	27	29	56			*Refusal Strata*
	9.0		DS							
			SPT	24	50B/12cm		>100			
Greyish to yellowish brown CWR	10.5		DS							
			SPT	50B/10cm			>100			
	12.0		DS							
			SPT	48B/8cm			>100			
			DS							

SPT=Standard Penetration test Refusal means SPT N>50
DS=Disturbed Sample B= No. of blows R=Rebound
*Ground water table is as recorded at the time of soil investigation CWR=Completely weathered rock

Figure 6-35 Bore Log at MB-06

Description of Sub-soil stratum	Depth (m)	Legend	Sample	SPT TEST, number of blows recorded			N Value = N_2+N_3	Core recovery (%)	Rock Quality Designation (%)	Remarks
				1st 15cm	2nd 15cm	3rd 15cm				
				N_1	N_2	N_3				
Filled up soil	0.0		DS							
	2.0									
Greyish to brownish white sandy Silt	3.0		SPT	10	10	11	21			
			DS							
	4.5		SPT	14	17	20	37			
Greyish brown sandy Silt			DS							
	6.0		SPT	12	15	20	35			
Whitish grey sandy Silt			DS							
	7.5		SPT	9	13	20	33			
Grayish to whitish brown silty Sand			DS							
	9.0		SPT	16	19	24	43			
Grayish brown CWR	10.5		DS							
			SPT	18	23	27	50			*Refusal Strata*
	12.0		DS							
			SPT	50B/12cm			>100			
Grayish white MWR	13.5		DS							
			CR							
	15.0		CR					24	10	
Grayish brown MWR	18.0		CR							
	20.0		CR					26	10	

SPT=Standard Penetration test
DS=Disturbed Sample
*Ground water table is as recorded at the time of soil investigation
Refusal means SPT N>50
B= No. of blows
MWR=Medium weathered rock
R=Rebound
CWR=Completely weathered rock

Figure 6-36 Bore Log at MB-07

Description of Sub-soil stratum	Depth (m)	Legend	Sample	SPT TEST, number of blows recorded			N Value = N_2+N_3	Core recovery (%)	Rock Quality Designation (%)	Remarks
				1st 15cm	2nd 15cm	3rd 15cm				
				N_1	N_2	N_3				
Filled up soil	0.0		DS							
	2.0									
Grayish brown sandy Silt	3.0		SPT	8	9	11	20			
			DS							
	4.5		SPT	17	17	20	37			
			DS							
	6.0		SPT	14	16	21	37			
Whitish gray silty Sand			DS							
	7.5		SPT	12	17	24	41			
			DS							
	9.0		SPT	14	18	26	44			
Greyish to whitish brown CWR			DS							
	10.5		SPT	19	26	36	62			*Refusal Strata*
			DS							
	12.0		SPT	50B/4cm			>100			
			DS							
Greyish white MWR	13.5		CR							
	15.0		CR							
	16.5		CR					20	12	

SPT=Standard Penetration test
DS=Disturbed Sample
*Ground water table is as recorded at the time of soil investigation
Refusal means SPT N>50
B= No. of blows
MWR=Medium weathered rock
R=Rebound
CWR=Completely weathered rock

Figure 6-37 Bore Log at MB-08

BORELOG

Client: M/S Stup Consultants Pvt Ltd
Borehole No : BH-9
Project :Construction of Flyover from Hebbala to Basaveshwar circle
Location:Taralabalu road junction

Size of Borehole : 150mm
Ground water table : Nil*
Commenced : 02 /10/2014
Completed : 02 /10/2014

Description of Sub-soil stratum	Depth (m)	Legend	Sample	SPT TEST, number of blows recorded			N Value = N_2+N_3	Core recovery (%)	Rock Quality Designation (%)	Remarks
				1st 15cm	2nd15cm	3rd15cm				
				N_1	N_2	N_3				
Filled up soil	0.0		DS							
	2.0									
Pinkish white sandy Silt	3.0		SPT	8	10	16	26			
			DS							
	4.5		SPT	7	9	13	22			
Grayish yellow white sandy Silt	6.0		DS							
			SPT	10	14	17	31			
	7.5		DS							
			SPT	12	16	18	34			
Grayish yellow CWR	9.0		DS							
			SPT	18	24	28	52			*Refusal Strata*
Yellowish gray CWR	10.5		DS							
			SPT	50B/10cm			>100			
			DS							
	12.0		CR							
Grayish white MWR	13.5		CR							
	15.0		CR					21	NIL	

SPT=Standard Penetration test Refusal means SPT N>50 MWR=Medium weathered rock
DS=Disturbed Sample B= No. of blows R=Rebound
*Ground water table is as recorded at the time of soil investigation CWR=Completely weathered rock

Figure 6-38 Bore Log at MB-09

Description of Sub-soil stratum	Depth (m)	Legend	Sample	SPT TEST, number of blows recorded			N Value = N_2+N_3	Core recovery (%)	Rock Quality Designation (%)	Remarks
				1st 15cm	2nd 15cm	3rd 15cm				
				N_1	N_2	N_3				
Filled up soil	0.0		DS							
	1.0									
Reddish yellow sandy Silt	1.5		SPT	4	4	6	10			
			DS							
	3.0		SPT	5	7	8	15			
Brownish yellow sandy Silt	4.5		DS							
			SPT	8	9	9	18			
	6.0		DS							
			SPT	7	10	12	22			
Grayish yellow silty Sand	7.5		DS							
			SPT	14	18	20	38			
Yellowish grey CWR	9.0		DS							
			SPT	21	38	50B/10cm	>100			*Refusal Strata*
	10.5		DS							
			SPT	50B/8cm			>100			
	12.0		DS							
			SPT	48B/6cm			>100			
			DS							

SPT=Standard Penetration test Refusal means SPT N>50
DS=Disturbed Sample B= No. of blows R=Rebound
*Ground water table is as recorded at the time of soil investigation CWR=Completely weathered rock

Figure 6-39 Bore Log at MB-10

Description of Sub-soil stratum	Depth (m)	Legend	Sample	SPT TEST, number of blows recorded			N Value = N_2+N_3	Core recovery (%)	Rock Quality Designation (%)	Remarks
				1st 15cm	2nd15cm	3rd15cm				
				N_1	N_2	N_3				
Filled up soil	0.0		DS							
	2.0									
Reddish yellow sandy Silt	3.0		SPT	7	8	10	18			
Brownish yellow sandy Silt	4.5		DS							
			SPT	9	10	12	22			
	6.0		DS							
			SPT	9	12	14	26			
Whitish yellow sandy Silt	7.5		DS							
			SPT	12	15	16	31			
	9.0		DS							
			SPT	9	16	18	34			
Yellowish gray silty Sand	10.5		DS							
			SPT	18	27	40	67			*Refusal Strata*
	12.0		DS							
			SPT	28	50B/12cm		>100			
	13.5		DS							
			SPT	50B/12cm			>100			
Brownish yellow CWR	15.0		DS							
			SPT	50B/10cm			>100			
	16.5		DS							
			SPT	48B/8cm			>100			
	18.0		DS							
			SPT	48B/8cm			>100			
	20.0		DS							
			SPT	45B/6cm			>100			
			DS							

SPT=Standard Penetration test Refusal means SPT N>50
DS=Disturbed Sample B= No. of blows R=Rebound
*Ground water table is as recorded at the time of soil investigation CWR=Completely weathered rock

Figure 6-40 Bore Log at MB-11

Description of Sub-soil stratum	Depth (m)	Legend	Sample	SPT TEST, number of blows recorded			N Value = N_2+N_3	Core recovery (%)	Rock Quality Designation (%)	Remarks
				1st 15cm	2nd 15cm	3rd 15cm				
				N_1	N_2	N_3				
Filled up soil	0.0									
	0.5									
Brownish red sandy Silt	1.5		SPT	4	5	8	13			
			DS							
	3.0		SPT	8	10	13	23			
			DS							
	4.5		SPT	10	14	14	28			
			DS							
Brownish yellow sandy Silt	6.0		SPT	9	15	16	31			
			DS							
	7.5		SPT	11	17	18	35			
			DS							
Whitish yellow silty Sand	9.0		SPT	9	15	15	30			
			DS							
	10.5		SPT	8	15	18	33			
			DS							
Yellowish white CWR	12.0		SPT	40	50B/12cm		>100			*Refusal Strata*
			DS							
	13.5		SPT	44	50B/12cm		>100			
			DS							
Yellowish gray CWR	15.0		SPT	48B/10cm			>100			
			DS							
	18.0		SPT	45B/8cm			>100			
			DS							

SPT=Standard Penetration test Refusal means SPT N>50
DS=Disturbed Sample B= No. of blows R=Rebound
*Ground water table is as recorded at the time of soil investigation CWR=Completely weathered rock

Figure 6-41 Bore Log at MB-12

7.0 PLANNING AND DESIGN CRITERIA

7.1 Planning of Flyover

The considerations which guide the decision making in planning and design of elevated road in urban areas are:

- Elimination / reduction of conflicting traffic streams
- Hierarchy of the intersecting roads
- Feasibility with respect to available space and minimum land acquisition
- Intersection traffic characteristics including junction delay considerations
- Present development level and proposed development pattern for the influence area
- Lack of alternative routes / modes
- Utilities present at the project location, feasibility of shifting / relocation
- Other major infrastructure projects planned and integration of same
- Cost and Economic considerations
- Traffic diversions and management during construction

7.2 Planning Criteria

The following paragraphs briefly highlight the various design considerations and standards used for the present proposal. It is important to review the design criteria in the context of urban development – especially with due consideration to traffic flow, existing road networks, development pattern, right of way, existing road geometric conditions etc.

The Indian Roads Congress and the Ministry of Surface Transport and Highways specify various guidelines and specifications for elevated roads, flyovers, junctions and other facilities pertaining to elevated roads. These specifications are largely based on the theoretical considerations and ideal situations which are seldom available in urban situation for a city like Bangalore. Hence, in the present proposal, certain changes and modifications in the design standards are reviewed and adopted under extreme conditions keeping in view the site constraints.

7.3 Design Standards - Roads

Design standards for the Design of Horizontal and Vertical Geometry and other road elements are used referring following guidelines of Indian Roads Congress:

- IRC:SP:90-2010 “Manual for Grade Separators & Elevated Structures”
- IRC: 92-1985 “Guidelines for the Design of Interchanges in Urban Areas”
- IRC: 86-1983 “Geometric Design Standards for Urban Roads in Plains”
- IRC:106-1990 “Guidelines for Capacity of Urban Roads in Plain Areas”

Various Design standards considered in the project are briefly stated below.

7.3.1 Geometry

The horizontal geometry will be designed in accordance with Clause 10 of IRC: 86-1983 generally. Following considerations are made in horizontal geometry design

- Minimum disturbance to existing structures which are already constructed based on inputs from BDA in various meetings / discussions.
- To maintain existing road horizontal geometry to the extent possible.
- Road widening considering building lines / compound walls on either side of existing carriageway.
- Vertical alignment / grade to be governed by immediate access to properties / adjoining junctions and road ends.
- Rise and fall of existing road in design of the facility.

The geometric design parameters were discussed with BDA and presented to Technical Advisory Committee to obtain approval. The consultant had explained various site specific issues / constraints which would affect planning and design of grade separator and opinion of the experts were taken in further designs.

7.3.2 Design Speed

The design speed for grade separator in urban stretch is generally governed by the existing road plan, building lines, possible land acquisition extents, utilities and heterogeneous traffic flow. The most critical sections governing the design speed is the turning movement of vehicles on curves and available sight distance to plying traffic. As per IRC, design speed for sub arterial road is 60 Kmph and collector street is 50 Kmph. For the project stretch, most of length is on straight reach with very flat horizontal curve. However, one or two short section on the project road is with very sharp curvature where increased design speed cannot be followed without land acquisition. Considering above factors, design speed of 50 Kmph is adopted for design of geometry at this section of road. For underpass and ramps, design speed of 30 Kmph is adopted.

7.3.3 Horizontal Alignment

Horizontal alignment for the grade separator is designed in accordance with IRC: 38-1988 "Guidelines of Design of Horizontal Curves for Highways and Design Tables". Clause 10.3 of IRC: 86-1983 specifies minimum curve radius of horizontal curve for 50 Kmph as 105 m for 4% super-elevation. These guidelines will be followed for reasonably flat and less winding alignments. Depending on existing road geometry and site constraints modifications are made to provide sharper curve radius wherever required based on site specific considerations. For ramps, curve radius corresponding to 30 Kmph design speed is proposed. Design speed of about 40 Kmph would be maintained on the surface level road of the project.

7.3.4 Super Elevation on Curves

Super-elevation on horizontal curves will be attained as per IRC: 38-1988. The super elevation will be limited to 4 % as per Clause 10.2 of IRC: 86-1983 as the project area is in urban section.

7.3.5 Cross-Sectional Elements

Width of grade separator has a direct relationship with the traffic volume it is expected to serve and width available at ground level based on land acquisition and future widening of surface level road. The cross sectional elements considered in designing the proposed elevated road are shown in Table 7-1.

Table 7-1 Cross Sectional Elements

Sl No	Description	Particulars	Unit	Value
1	Main Elevated Road	Carriageway	m	2 x 11.0
		Median	m	1.2
		Crash Barrier	m	2 x 0.5
2	Up & Down Ramps	Carriageway	m	7.5
		Median	m	-
		Crash Barrier	m	2 x 0.5
3	Cunningham Road Underpass	Carriageway	m	3.0
4	Race course side Underpass Approach	Carriageway	m	9.0
5	Others Underpass	Carriageway	m	7.5

7.3.6 Surface Level Road

The surface level road will carry local traffic (traffic using shops and commercial establishment, cross road, adjoining localities). The width of surface level road will depend

on the traffic at the surface level after the flyover is constructed and mostly on space availability between building lines / compound walls. However, for the existing traffic at different sections in the corridor, the lane requirement will be enormous. This involves land acquisition to larger extent and considering the highly developed area with many high raised buildings, land acquisition is practically not possible. The footpaths available will have to be re-planned to provide the required space. Considering all these aspects, the surface level road has been designed. The design considerations for surface level road are shown in Table 7-2.

Table 7-2 Surface Level Road

Sl No	Particulars	Unit	Value (m)
1	Under Main Elevated Road	m	9.0
2	Service Road	m	7.5
3	Basaveshwara Circle cross Roads	m	11.0 / 7.5 / 5.5
4	Central Median	m	4.5
5	Separator Median	m	1.0
6	Footpath	m	2.25 / 1.5

7.3.7 Cross Slope

The cross slope / camber value adopted are shown in Table 7-3.

Table 7-3 Cross Slope

Sl No	Particulars	Unit	Value
1	Main Elevated Road	%	2.5 *(Inverted)*
2	Up & Down Ramps	%	2.5
3	Surface Level Road	%	2.5

7.3.8 Vertical Alignment

The vertical geometry of the flyover / underpass is designed as per guidelines given in IRC: 92-1985. Clause 5.1.2 of IRC: 92-1985 states that the vertical gradient should be desirably kept at 4.0%, but in no case exceed 6.0%. Vertical curves are provided at locations of change in gradient. The length of vertical curves is dependent on change in grade between two vertical straight and this will be as per IRC SP: 23-1993 “Vertical Curves for Highways”. Considering the rolling terrain along the project stretch, the consultants opine that it may not be practically possible to limit the vertical grade to 4.0%. This is basically considering provision of access to adjoining junctions / cross roads and road side facilities. These elements were discussed with BDA and Technical Advisory Committee with presentation of plan and profile drawings.

7.4 General

Within the scope of services, all activities related to field studies, design and drawings for alignment, pavement, cross drainage works and road furniture will be carried out as per the latest guidelines / circulars of MoRT&H and relevant publications of the Indian Roads Congress (IRC). Modifications, if required will be made from the codes of practice suitable for urban environment, suiting to ongoing/ existing facilities and to minimize land acquisitions on private land as much as possible in consultation and approval from BDA.

7.5 Level of Service (LOS) for Urban Roads

Level of Service (LOS) along project corridor is greatly influenced by heterogeneity mix of traffic, speed and travel time, presence of bus stops close to intersection, roadside commercial activities and pedestrian volumes. Adoption of a higher level of service like A or B requires higher facility cost and is generally governed by additional land requirement which may be difficult in urban environment. Hence as per Clause 8.1 of IRC 106 – 1990, it is recommended to adopt LOS C. At this level, volume of traffic will be around 0.70 to 0.72 times the maximum capacity and this is taken as the "design service volume" for adopting design values. The design service volumes for different categories of arterial and sub arterial roads are given in Table 7-4. It may however be noted that it is not practicable to propose road widening which would involve demolition of many multi storied buildings, acquisition of land and green belt area in the prime area. In such circumstances, it may be more appropriate to design the facility for higher V/C ratio than at Level of Service "C". Over a period of time, when the traffic increases, the volume to capacity ratio of both elevated road and surface level road increases beyond 0.72 and LOS tends towards D.

Table 7-4 Recommended Design Service Volumes (PCUs per Hour)

Sl No	Type of Carriageway	Total Design Service Volumes for Different Categories of Urban Roads	
		Arterial	Sub-Arterial
1	2-Lane (One-Way)	2400	1900
2	2-Lane (Two-Way)	1500	1200
3	3-Lane (One-Way)	3600	2900
4	4-Lane Undivided (Two-Way)	3000	2400
5	4-Lane Divided (Two-Way)	3600	2900
6	6-Lane Undivided (Two-Way)	4800	3800
7	6-Lane Divided (Two-Way)	5400	4300
8	8-Lane Divided (Two-Way)	7200	---

7.6 PCU Equivalents

The traffic data collected will be analyzed and converted to a common unit of Passenger Car Unit (PCU). The recommended PCU values for different vehicles given in Cl.7.2, Table 1 of IRC 106 – 1990, would be considered for the design purpose in converting the various traffic streams into passenger car equivalent.

7.7 Structural Design Basis

The project consists of elevated road between Basaveshwara circle and Hebbal flyover with entry and exit ramps at ends of the corridor. There are underpasses proposed below ground level at Basaveshwara circle. The elevated ramps at Basaveswara circle are supported on Portal type structure. The substructure and superstructure elements are with prefabricated structural steel.

The pile foundation, pile cap and deck slab in superstructure shall be with cast in place concrete.

7.7.1 Aim of the design basis report

The main aim of this report is to consider the design parameters consistently in the analysis and design of various structural elements. All the structural elements in the project are designed based on the latest revisions of IRC Codes.

7.7.2 Salient features of the project

The salient features of the various structural elements in the project are as below

a) Superstructure in Main elevated road & ramps

RCC Cast in Place deck slab supported on prefabricated structural steel I-girders and diaphragms. Sacrificial shutter supported on top of girder shall be used to support the weight of green concrete during concreting. The bearings supporting the superstructure are of Pot cum PTFE type.

b) Foundation

Foundations are with 1200mm dia bored cast in place piles and pile cap. The foundation bolts at the bottom of pier shall be anchored inside the pile cap. The crash barrier to protect the pier will be provided on the sides of pier supported on pile cap top to protect the pier.

c) Pier and Pier Cap

The piers are with pre fabricated structural steel supported on pile cap. The pier cap is with prefabricated structural steel supported and cantilevered from vertical pier.

d) Underpasses

The closed portion of underpass is with RCC frame resting on soil below the base slab. The open portion of underpass is with RCC retaining walls resting on strip foundation.

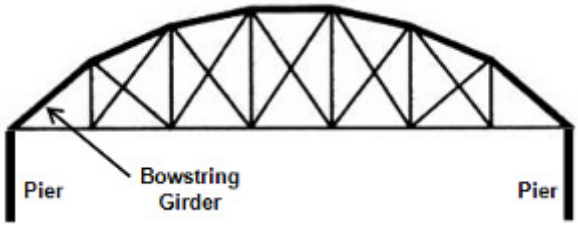
e) Approaches in Elevated Road

The walls on either sides of embankment in approaches will be with RE walls.

f) Bowstring Girder

Considering the requirement of vertical clearance, bowstring girder is proposed at Basaveshwara Circle for Maharani College and Vidhana Soudha side up-ramps (i.e at second level between PP1 and PP4).

The bowstring girders are with structural steel supported on pot bearings. The deck slab will be in RCC resting on cross steel girders supported on bow string. Typical bowstring girder arrangement is shown here.



7.7.3 Design Loads

a) Dead Loads & Super Imposed Dead Loads

Dead load includes self weight of structure and super imposed dead load includes wearing coat, crash barriers, median etc. The weight of wearing coat shall be considered as 200 kg/sqm, construction live load as 0.36T/sqm and crash barrier as 1 T/m for the purpose of design.

b) Live Loads

Main superstructure each carriageway of the flyover will be designed for three lanes of class A or single lane of class 70R + single lane of class A loading whichever produces the worst effect.

Ramp – carriageway will be designed for two lanes of Class A or single lane of class 70R loading.

c) Wind forces

Wind forces will be considered as per the provisions of IRC-6.

d) Seismic Force

Flyover will be designed for appropriate seismic forces as per the provisions of IRC-6.

e) Earth Pressure

The soil properties for earth pressure calculation will be in accordance with MORT&H specification. The properties of embankment like Dry density of soil 1.85 T/cum. Saturated density 2.00 T/Cum: ø= 30 degree & C=0 shall be considered for design purpose.

f) Temperature forces

For design of structure to account for temperature in formula for movement (δL) = α| |Lt, the value of "t" will be calculated based on IRC-6

- α = Coefficient of expansion or contraction
- L = Length of the member
- (δL) = Expansion / contraction due to temperature variation in appropriate units.

The superstructure will also be designed for effects of distribution of temperature across the depth as per Cl 215.3 of IRC-6 codal provisions.

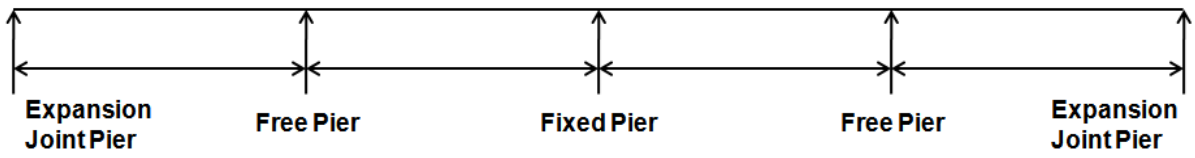
7.7.4 Super Structure span configurations

The total deck width outer to outer of crash barrier in main elevated road is 24.2m and in ramp is 8.5m.

The superstructure consists of continuous deck slab as one module between expansion joints. The superstructure prefabricated structural steel girders shall be simply supported on the bearings and continuous deck is achieved with deck continuity slab at continuous piers location. Based on the type of bearing, the piers are classified as

- Expansion joint pier
- Free pier
- Fixed pier

The arrangement of piers shall be as shown below



The salient structural component of proposed elevated corridor is given in Table 7-5 below.

Table 7-5 Structural Details of the Elevated Corridor and Ramp

Sl No	Span Length	Super Structure	Sub Structure	Foundation
1	20 / 25 m (Standard Spans)	Composite section with prefabricated Steel I girders and cast in situ RCC deck slab.	Prefabricated structural Steel pier and pier cap.	Bored cast in situ Piles.
2	30 / 50 / 75m (For Obligatory spans)	Composite section with prefabricated Steel I girders and cast in situ RCC deck slab.	Prefabricated structural Steel pier and pier cap.	Bored cast in situ Piles.
3	25 m (Ramp)	Composite section with prefabricated Steel I girders and cast in situ RCC deck slab.	Prefabricated structural Steel pier and pier cap.	Bored cast in situ Piles.

7.7.5 Vertical Clearance

The vertical clearance at road crossing shall be as per IRC: 54-1974 requirements and at railway crossings as per Railways requirement.

7.7.6 Approach Ramp

It is proposed to adopt “Reinforced Earth” type retaining structure for the approach ramps. The reinforced earth facia made of precast concrete panels offers great scope for a variety of aesthetic treatments in the form of panel shapes and color. Apart from aesthetics, it improves the speed of construction.

7.7.7 Foundation

It is proposed to provide 1200mm dia Bored cast in situ vertical piles. A pile cap with minimum thickness of 1.5 times the dia of pile shall be provided over the piles. The top of pile cap shall be kept at 0.5m below existing ground level.

7.7.8 Substructure

- Structural steel pier is proposed to reduce the construction time. The fabricated steel piers is brought and erected on the already cast pile cap in the required location.
- Scope for accessibility for inspection of bearings and arrangement for lifting of the superstructure for future replacement of bearings shall be provided for in the design of substructure and superstructure. The positions of flat jacks shall be distinctly marked on the drawings.

7.7.9 Superstructure

a) Deck Slabs

Deck slab is with cast in situ RCC. It shall be cast on the already erected steel girders. The minimum thickness of deck slab shall be 200 mm. Sacrificial shuttering sheets shall be used to support the deck slab during concreting.

b) Pre fabricated Steel Girders

- No of steel girders = 8 Nos per span (Main elevated road).
- No of steel girders = 3 Nos per span (Ramps).
- The cross diaphragms shall be minimum one number at each support. The end diaphragm girders shall be supported on Pot bearings.
- The longitudinal steel girders shall be supported on temporary structural frame supported on pile cap top. The temporary frame shall be removed after connecting the longitudinal girders with the end cross diaphragm.

7.7.10 Material

The material requirement is briefed in the following paragraph

- Minimum Grade of Concrete
  - Pile - M35 Grade
  - Pile cap - M35 Grade
  - RCC Deck Slab - M35 Grade
  - PCC Levelling Course - M15 Grade
  - Approach Slab - M30 Grade
- Reinforcement - Fe 500
- Structural steel - Grade B of Fe 410 W & Fe-540 W
- Condition of Exposure - Moderate

7.7.11 Bearings below Superstructure

a) POT – PTFE bearings manufactured by MORT&H approved manufacturer is proposed.

b) The bearings shall be easily accessible for inspection / maintenance.

c) Wherever bearings have to resist uplift force, it shall be of spherical knuckle type and shall be designed as per AASHTO code (Section 14) unless specified otherwise.

d) Scope for lifting the superstructure for future replacement of bearings shall be provided for in the design of bearing. The scheme of lifting shall be indicated on the drawing.

- The bearings shall conform to the requirements of the MORT&H specifications / IRC 83 Part III. The pots shall be of cast steel of approved grade unless specified otherwise. The minimum thickness of the stainless steel sliding plate shall be 3.0mm.
- The dimensions of top plate of bearing shall be such that the contact surface of superstructure projects beyond the edge of bearing plate by a minimum distance of 150 mm at any location.
- All the bearings need to be tested as per the provision of MORTH/ IRC specifications.

7.7.12 Expansion Joints

Modular / strip seal type expansion joint conforming to Clause 2607 of MORT&H Specifications shall be provided. Expansion joints shall be provided with loop anchors. The expansion joint locations shall be carefully treated and harmonized to ensure aesthetics.

7.7.13 Construction of composite superstructure

Following aspects shall be taken into account while designing and constructing.

a) All girders in a span shall be of prefabricated.
b) Temporary structural frame near the pier shall be used for supporting the girders, till the girder is integrated with end diaphragm.
c) Sacrificial shuttering shall be used for casting the deck slab. The shuttering shall be supported on the girders, to allow unobstructed movement of the traffic below.

7.7.14 Specifications for Design and Codes to be followed

The design of various structural components in the project shall conform to the criteria laid down in the latest revisions and editions of the following codes of Practice.

MORT&H specifications for Road and Bridge Works (Fifth Revision) published by Indian Roads Congress, New Delhi published in 2014 along with subsequent amendments on behalf of Govt. of India, Ministry of Surface Transport. IRC standard specifications and code of practice for Road Bridges - with amendments issued

The various codes of practice in general to be followed are as:

- IRC-5 - General features of design

- IRC-6 - Loads and stresses
- IRC-22 - Composite construction
- IRC-24 - Steel Road Bridges
- IRC-78 - Foundation & Substructure
- IRC-83 - Standard specifications and code of practice for road bridges, Part II: Elastomeric bearings and Part III: POT CUM PTFE Bearings
- IRC-112 - Code of practice Concrete Road Bridges
- IS: 2911 - (All parts) pile foundations.
- IS:13920 - Ductile Detailing of Reinforced Concrete Structures subjected to Seismic forces

The latest revision of the above codes shall be followed.

8.0 ALIGNMENT OPTIONS

The project road will generally be congested throughout the day, except for some duration in the afternoon. The project road presently caters for high volume of personalised traffic movement towards Airport and Bellary road and also provides connectivity for Airport, inter-city and intra-city bus traffic. The corridor also carries considerable commercial vehicles along Outer Ring Road (ORR) connecting towards Tumkur road and Old Madras road. The project road is also crowded due to presence of educational, business and commercial establishment.

8.1 General

With the implementation of elevated road along the project corridor, the through traffic towards KIAL and beyond Hebbal will be segregated from local city traffic, thereby reducing the traffic congestion at surface level (intersections and midblock sections). With the implementation of elevated road together with surface level traffic improvements traffic congestion will reduce considerably and bring about orderly traffic movement in the area. Few of the surface level improvements include remodelling of junction, pedestrian crossover facility across the project road at identified locations, parking measures etc. However, the existing surface level road has already exceeded its capacity and hence, the construction of elevated road will be a necessity in order to ease the vehicular traffic flow.

8.1.1 Ongoing/Planned Projects along the Project Corridor

Various Government agencies have taken up traffic improvement schemes in and around the project area covering Elevated road for NH-7 from Bangalore International Airport to Hebbal Junction. Since the ongoing/planned projects along the project corridor will involve coordination with grade separated schemes and vice-versa, all the technical parameters governing various projects should be integrated for better results. This will ensure the proposed project will not cause interference to other planned / ongoing works, thus retaining the effective purpose of the project. This will also ensure compatibility while planning future projects / stage wise development of infrastructure works at future. Some of the ongoing / existing / planned projects along the project corridor are:

- Additional flyover towards KIAL constructed by NHAI
- Proposed underpass at Hebbal junction by BDA
- Proposed widening of existing 2 lane Hebbal flyover towards city side by BDA

8.2 Project Specific Considerations

The project road is within the urban limits of the city, wherein the proposed elevated road scheme will have to be planned considering the existing roadside developments. Some of site specific features influencing planning and design of grade separator or improvement scheme are mentioned below:

- Presence of built up and high raised building on either sides of carriageway, especially the presence of Airforce and Defence establishments between Mekhri circle and Sanjaynagar road junction restricts development of surface level roads to required design standards and lane configuration.
- Presence of Windsor Manner Bridge & Railway ROB near Vasanthanagar and RUB at Mekhri circle restricts expansion of surface level road.

8.3 Alignment Alternatives

The alignment options are worked out keeping in view the existing traffic flow and future projections on elevated road and surface level roads, road side developments and other site constraints.

8.3.1 Option-1: *Up & down ramps at all junctions*

This was the very first option proposed for the project corridor. In this option main flyover will start from near Rajbhavan and end before Hebbal flyover approach. Up and down ramps were provided at all major junctions which are listed below,

- Up & down ramp at Basaveshwara circle - towards Maharanis College
- Up & down ramp at Basaveshwara circle - towards Vidhana Soudha
- Down ramp at Basaveshwara circle - towards Race course
- Up & down ramp at Kunarakrupa road junction
- Down ramp at Vasanthanagar road junction
- Down ramp at Cauvery theatre junction
- Up & down ramp before Mekhri circle underpass
- Up & down ramp at Mekhri circle
- Up & down ramp at Sanjaynagar junction
- Up & down ramp before Hebbal flyover approach

In addition to this, underpass was proposed at Basaveshwara circle to make the junction signal free. Key plan for this proposal is shown in Figure 8-1 and concept plan drawing RD-20 Rev R(0) was submitted to BDA vide letter no. 11480/E/TRJ/SSKR/249 dated 24th June-2014.

The total length of main flyover, all up & down ramps including underpass was about **15345m** for this option. And the additional land acquisition area required for this options was about **48503 sqm** (Govt. land 41966 sqm & Pvt. land = 6537sqm)

This proposal was submitted to BDA, subsequently several round of discussions were made with BDA officials to optimize this option which includes Technical Advisory Committee (TAC) meeting and meeting with Addl. Commissioner of Police (ACP) - Bangalore Traffic.

The major drawback of this proposal was land acquisition area and more number of up and down ramps which would cause hindrance to construction. Thus, this proposal was revised and proposed as Option-2.

8.3.2 Option-2: *Less number of up and down ramps*

In this option main flyover will start from near Rajbhavan and end integrating with existing Hebbal flyover approach. Up and down ramps were provided at following locations,

- Up & down ramp at Basaveshwara circle - towards Maharanis College
- Up & down ramp at Basaveshwara circle - towards Vidhana Soudha
- Down ramp at Basaveshwara circle - towards Race course
- Up & down ramp at Kunarakrupa road junction
- Down ramp at Vasanthanagar road junction
- Down ramp at Cauvery theatre junction
- Up & down ramp before Mekhri circle underpass
- Up & down ramp at Mekhri circle

The proposed underpass at Basaveshwara circle is extended further towards Millers road. Further, reconstruction of Cunningham road underpass with better geometrical improvement than existing one is also considered in the project scope.

Key plan for this proposal is shown in Figure 8-2 and concept plan drawing RD-20 Rev R(1) was submitted to BDA vide letter no. 11480/E/TRJ/SSKR/339 dated 11th July-2014.

The total length of main flyover, all up & down ramps including underpass was about **14746m** for this option. Additional land acquisition area required for this was reduced to about **26394 sqm** (Govt. land 20388 sqm & Pvt. land = 6006 sqm)

This proposal was presented to BDA, TAC and Addl. Chief Secretary (ACS) - Urban Development. Based on the suggestions, reviews and comments given in the above forum the proposal is further optimised to reduce land acquisition area and the number of up ramps.

8.3.3 Option-3: *No intermediate up ramps*

The proposal is same as that of Option-2 except for the revision that there are no intermediate up ramps for the main flyover.

Key plan for this proposal is shown in Figure 8-3 and concept plan drawing RD-20 Rev R(2) was submitted to BDA vide letter no. 11480/E/TRJ/SSKR/492 dated 12th August-2014. This is the basis for the improvement scheme.

Total length of main flyover, all up & down ramps including underpass is about **12364m** for this option. Additional land acquisition area required for this was reduced to about **16489 sqm** (Govt. land 13979 sqm & Pvt. land = 2510 sqm)

8.3.4 Option-4: Intermittent Down Ramps

This proposal is same as that of Option-3 with provision of down ramps (i) at Vasanthnagar for traffic from Airport towards Vasanthnagar and (ii) at Sanjay Nagar for traffic from Basaveshwara Circle towards Sanjay Nagar. Key Plan for this proposal is given in Figure 8-4. This facility was proposed based on direction from BDA during review meeting on 09/09/2015. Plan and profile drawings RD-30 Rev (0) for Vasanthanagar and RD-34 Rev R(0) for Sanjay Nagar was submitted to BDA by email dated 15/10/2015. The total land acquisition required for including this facility will be 19115 Sqm (Govt. land 13979 sqm & Pvt. land = 5136 sqm).

Figure 8-1 Key Plan for Alignment Option-1

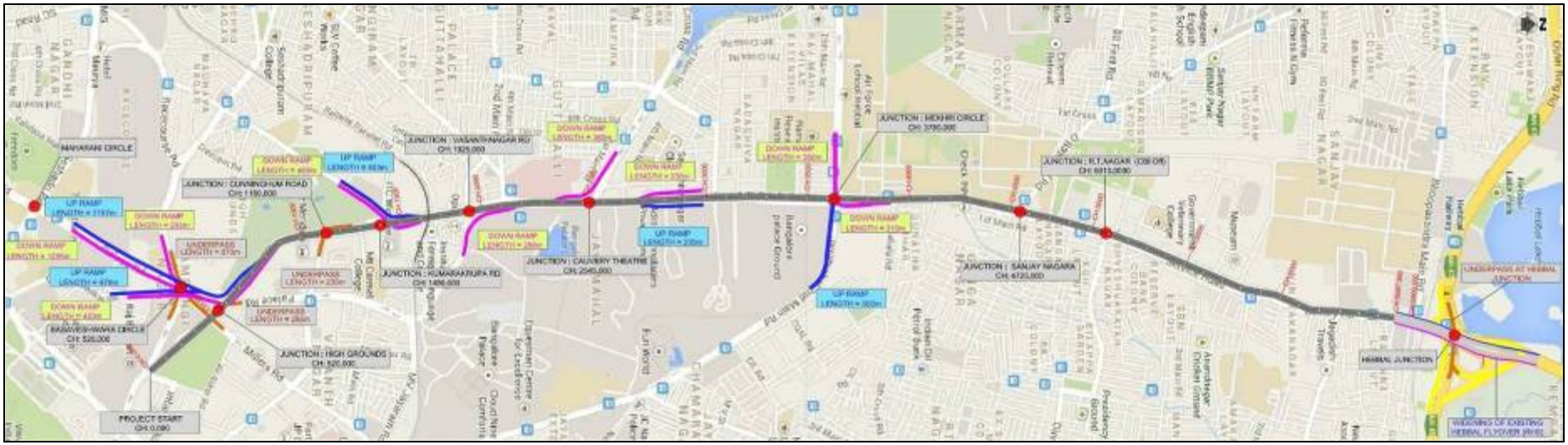


Figure 8-2 Key Plan for Alignment Option-2

Figure 8-3 Key Plan for Alignment Option-3

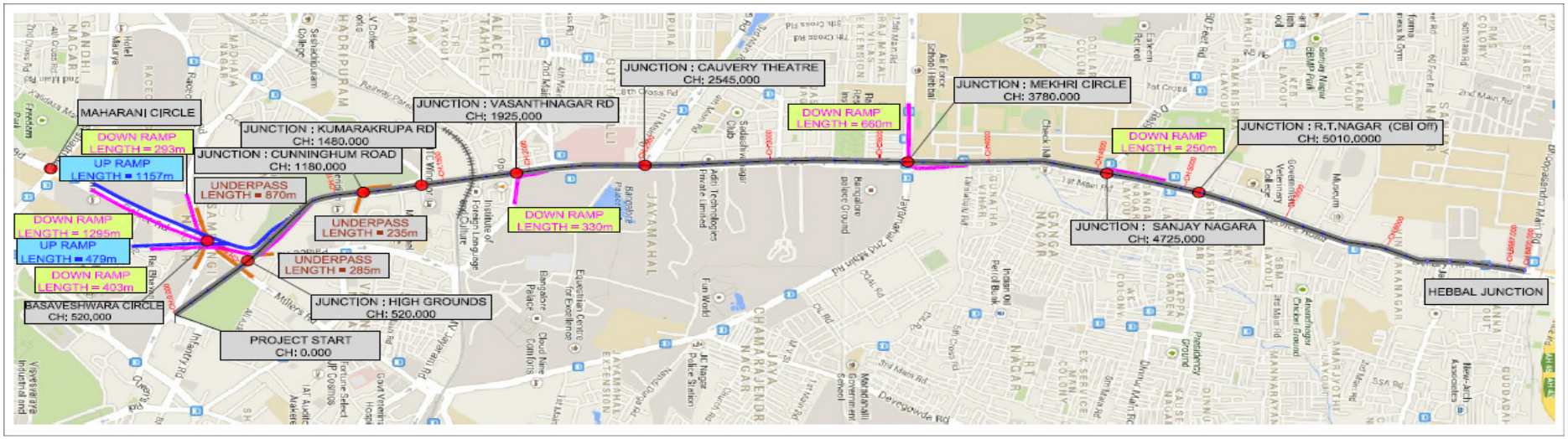


Figure 8-4 Key Plan for Alignment Option-4

9.0 IMPLEMENTATION PLAN

9.1 General

Road infrastructure facilities planned for a fast growing city like Bangalore should be reliable, affordable, sustainable and environmentally friendly. The facility should reduce traffic congestion problem including at surface level with minimum obstruction to traffic during construction.

Elevated roads are proposed to meet general traffic needs and to eliminate or reduce negative impacts caused by traffic. A new elevated road will be proposed when the existing road network no longer meets the requirements of traffic demand and when these requirements cannot be satisfactorily met or eliminated through road improvements.

Generally, project execution is associated with a number of problems and limitations. In order to overcome the risks associated with project execution, it is very much essential to have proper project implementation program that could ensure better control over all aspects of the project including costing and resources mobilization.

Project implementation planning is the process of identifying the list of activities involved in a project arranged in sequence and fixing time frame for successful execution of the project. It also includes periodic monitoring of the activities from start till end. Implementation planning is critical to ensure that the outcomes are delivered as per schedule.

9.2 Implementation Plan

The implementation plan should provide the following information in a clear, easy-to-read format

- Project phases and timelines (note that the implementation plan does not require a detailed timeline—and 'at-a-glance' timeline that provides a summary of key milestones and decision points would be more useful)
- The deliverables associated with each phase
- The major activities for each deliverable
- Key milestones
- Who is responsible for the delivery of each major activity
- Any interdependencies

Portfolio business and program delivery managers must check the implementation plan to ensure that targets are achievable and appropriate.

An effective implementation plan should

- Be concise
- Be capable of being understood by non-expert users
- Present a clear line of sight from the Government's objective through inputs and outputs to expected outcomes and benefits
- Outline the assumptions made in planning
- Clearly outline timeframes and project phases, especially where there are interdependencies with other programs/measures or critical requirements
- Clearly articulate the decision objectives of the planning
- Identify standards and quality controls to be used during implementation
- Explicitly identify and address the implementation challenges and how change will be managed (including risks and issues)
- Be precise about source of risks, likelihood of occurrence, consequence and mitigation strategies

9.3 Project Phasing

The proposed elevated road project will be implemented in three stages starting from conceptualization including funding, execution and management. The three main stages of implementation are

Stage-1: Preparation of DPR

Stage-2: Submission and Project Approval

Stage-3: Construction

It is proposed that Stage - I activities will be carried out by Design Consultants, Stage II shall be largely within the purview of BDA and the Project Implementation Unit and finally Stage - III activities will be carried out by the contractor which shall be monitored by the Project Management Consultants and the same will be over seen by BDA. The details are explained below.

9.3.1 Stage-1: Preparation of DPR

The first stage of the project consists of conducting field surveys and investigations for data collection, analysis of field investigation data, project conceptualization with alternative options and other design related activities. This stage of activity also involves finalizing land acquisition ventures, development strategy, architectural guidelines and tendering. The scope of services to be rendered by the design consultants has already been listed out in

Chapter 2 of this report. The time frame envisaged for this stage is about 3 months from the date of issue of work order.

9.3.2 Stage-2: Submission and Project Approval

The next stage of project implementation deals with review and approval of project report and proposal by various agencies involved with the project, including Stage Level Nodal Agency KUIDFC, State Level Steering Committee and later on by Central Ministry MoUD. External consultant's role will be limited to providing clarifications on Technical issues and related information as necessitated by the reviewing agencies.

The proposal should include project structure, timeline, cost-benefit analysis and budget which are necessary in assigning a dedicated budget to the project. The proposal has to be approved against

- Concept, design and project proposals
- administrative and financial approval
- land acquisition
- others (including Police approval for temporary road closure and traffic diversion)

9.3.3 Stage-3: Construction

The third and last stage of project implementation deals with construction of the proposed elevated road. On approval of project proposal and allocation of fund, eligible contractor is selected for construction work through tendering activities. The actual construction work starts after signing of Contract agreement and issuing of work order to the contractor. The entire construction activity can be classified into eight sub-sections as follows

Phase-1: Includes mobilization of men, material and construction machineries to the project site. Construction of site office and appointment of technically skilled site engineers and/or workers also comes under this phase. After mobilization and establishment of site office, designs are standardized, activity schedule shall be prepared and time frame shall be fixed for execution and completion of each of the activities.

Phase-2: This is actually the first stage of construction activity which includes land acquisition, removal of temporary / permanent structures existing within proposed road boundary, shifting of on and underground utilities and site clearance. Traffic diversion and rerouting shall be done before starting foundation excavation and piling.

Phase-3: The next stage of construction activity includes removal of existing grade separator structures, excavation (for pier foundation, underpass and road drains) and back filling.

Phase-4: This stage mainly deals with foundation related works like boring & casting of piles, construction of pile in all soils with/ without permanent steel liner, routine & lateral load test on piles etc.,

Phase-5: After construction of pile cap, steel piers are erected with pier cap and bearings. During the course of action other structural works like construction of Abutments, retaining walls and RE walls are also performed.

Phase-6: The next stage of construction activity deals with superstructure work which involves erection of girders and bracings, construction of deck slab for flyover and construction of cover / roof slab for underpass. After deck slab, crash barriers are constructed as a part superstructure work.

Phase-7: On completion of foundation, substructure and superstructure works the next stage of construction activity shall be road works. This includes elevated road overlaying, integrating with Hebbal junction proposed underpass / flyover widening and construction of at-grade road underneath. The components of at-grade road includes construction of central median, main carriageway, separator median, service road, channelizing islands, footpath, drain and bus stops / bus bays.

Phase-8: The last stage of construction activity deals with finishing work like road marking, kerb painting, lighting and electrification, road arboriculture, installation road signs, signals and other road safety appurtenances. Piers, girders and bracings of elevated structure shall be painted with all weather / weather resistant paint. Any other minor works left out shall be completed before handing over the site.

The whole of construction period is expected to last for about 24 months including monsoon period from the date of handing over of site to the Contractor.

9.4 Project Execution

It is estimated that the work envisaged under this project would involve a period of 24 months from date of hand over of site. The tendering stage, which will be done as per KTTP act for the execution of civil works, may take another 2 months prior to the construction stage.

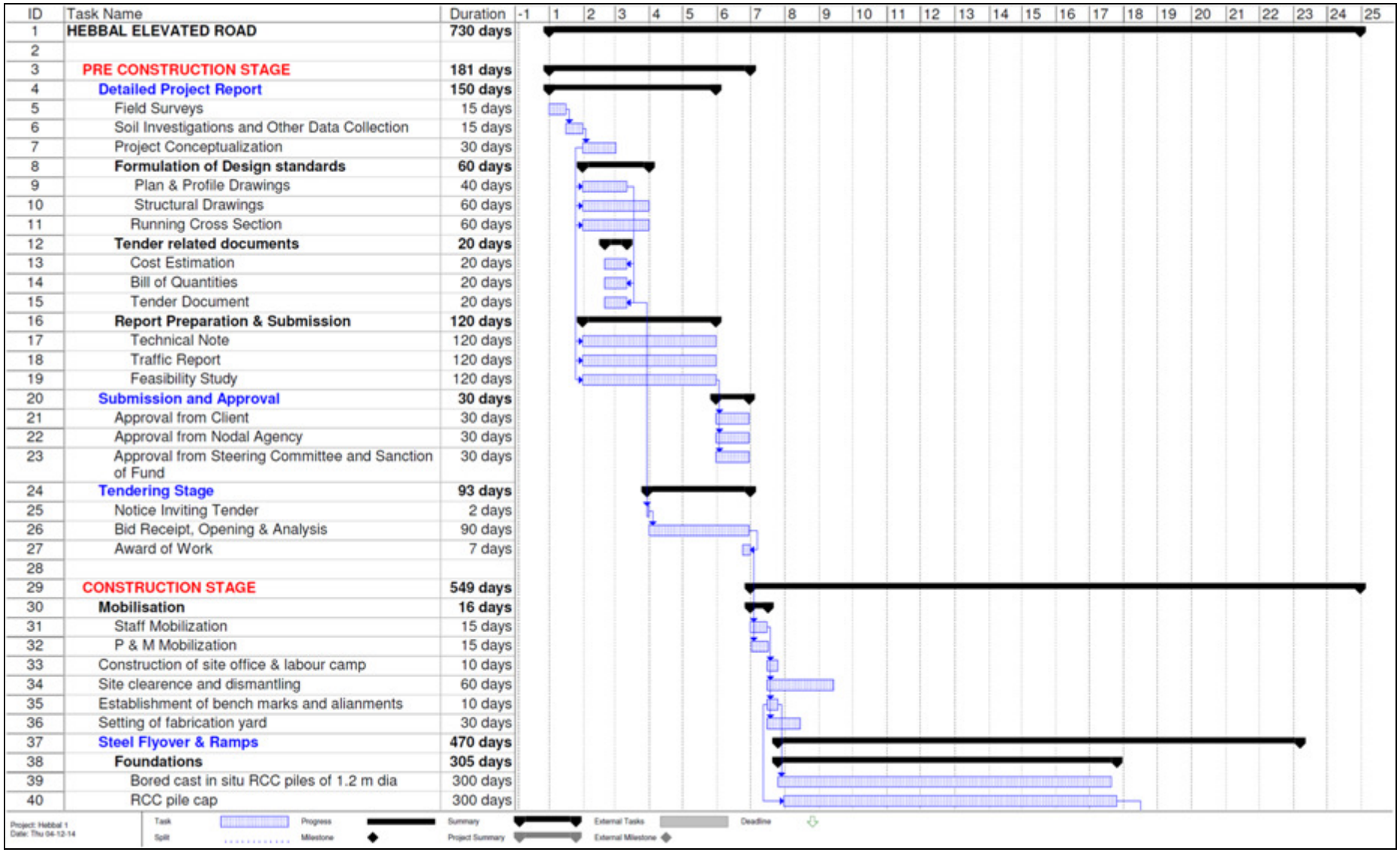
BDA proposes to set up a separate implementation unit whose responsibilities would include ensuring the deployment of adequate staff, usage of quality materials, construction practices of acceptable standards and quality of works carried out, monitoring and reporting the project progress to the project monitoring agencies.

Tender specifications and construction practices are reflected in the bid document issued by BDA for its works related to construction of system components. The contractor would also adhere to the environmental regulations in practices and keep the citizens informed of the scheduled of the project underway in a periodic manner.

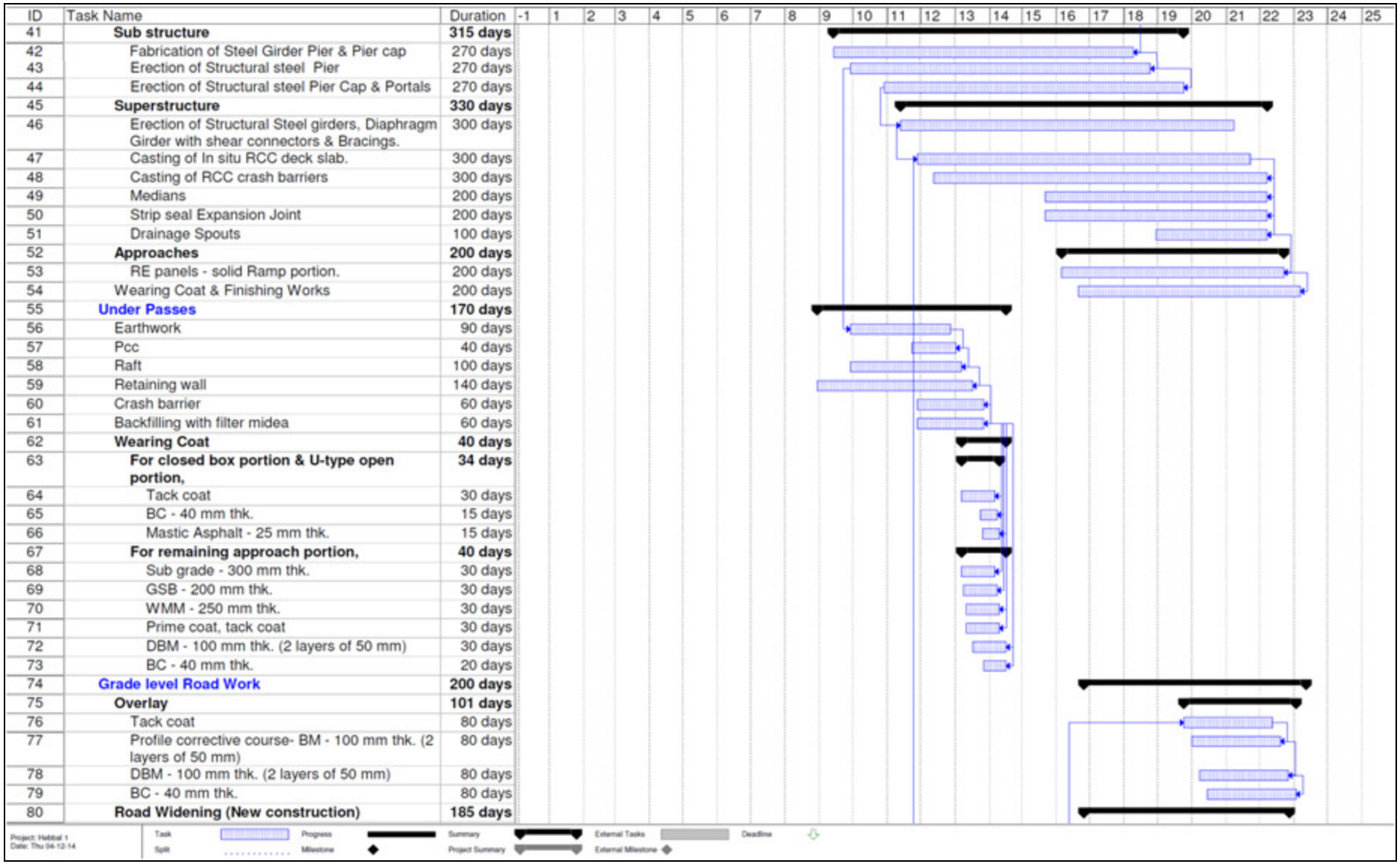
The project implementation schedule chart for construction of proposed elevated road along the project corridor is given in Table 9-1 below. The time duration considered in this chart is tentative. it may vary according to ground reality and site constraint at the time of execution.

Table 9-1 Project Implementation Schedule

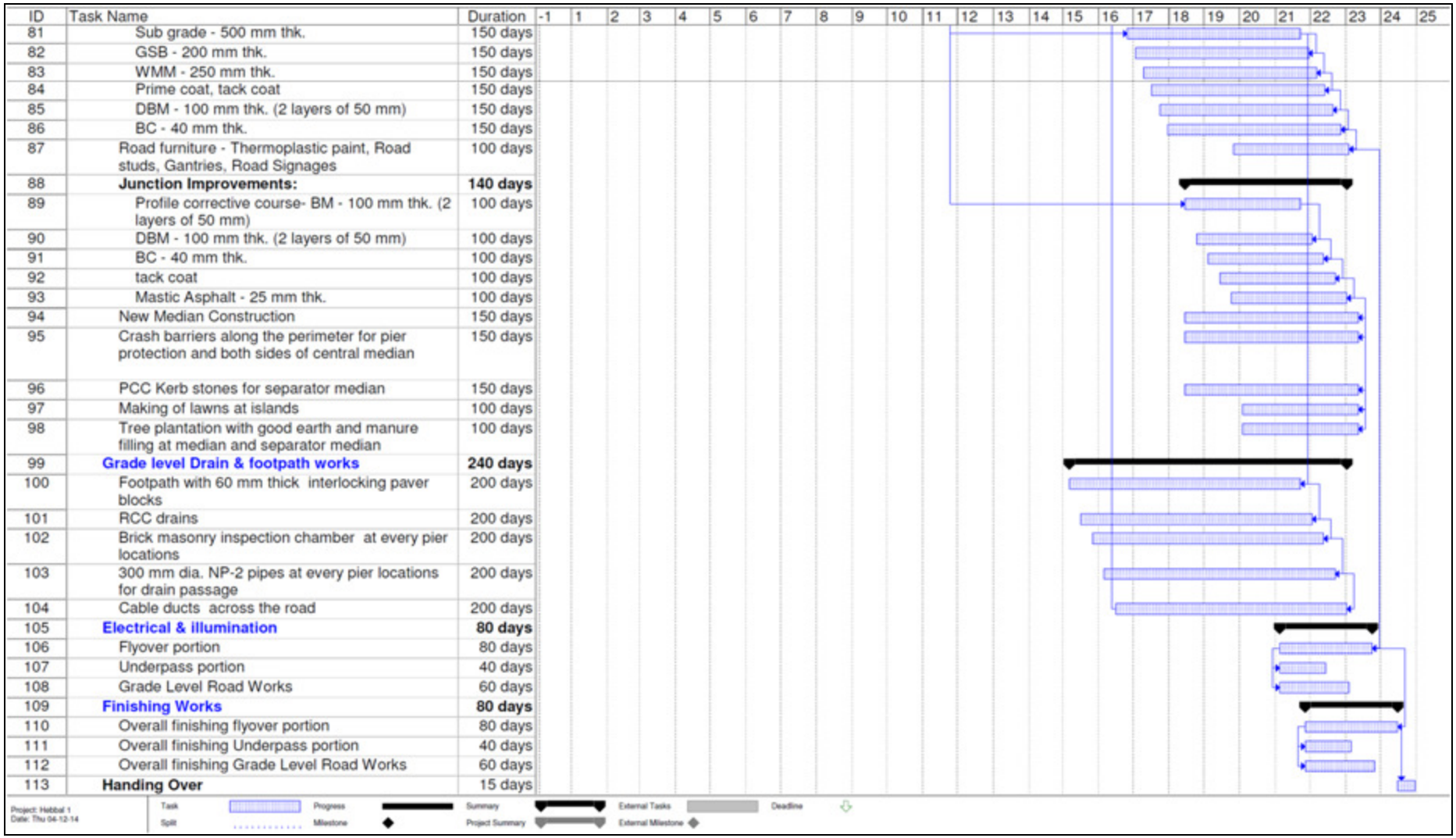
ID	Task Name	Duration
1	**HEBBAL ELEVATED ROAD**	**730 days**
2		
3	**PRE CONSTRUCTION STAGE**	**181 days**
4	**Detailed Project Report**	**150 days**
5	Field Surveys	15 days
6	Soil Investigations and Other Data Collection	15 days
7	Project Conceptualization	30 days
8	**Formulation of Design standards**	**60 days**
9	Plan & Profile Drawings	40 days
10	Structural Drawings	60 days
11	Running Cross Section	60 days
12	**Tender related documents**	**20 days**
13	Cost Estimation	20 days
14	Bill of Quantities	20 days
15	Tender Document	20 days
16	**Report Preparation & Submission**	**120 days**
17	Technical Note	120 days
18	Traffic Report	120 days
19	Feasibility Study	120 days
20	**Submission and Approval**	**30 days**
21	Approval from Client	30 days
22	Approval from Nodal Agency	30 days
23	Approval from Steering Committee and Sanction of Fund	30 days
24	**Tendering Stage**	**93 days**
25	Notice Inviting Tender	2 days
26	Bid Receipt, Opening & Analysis	90 days
27	Award of Work	7 days
28		
29	**CONSTRUCTION STAGE**	**549 days**
30	**Mobilisation**	**16 days**
31	Staff Mobilization	15 days
32	P & M Mobilization	15 days
33	Construction of site office & labour camp	10 days
34	Site clearence and dismantling	60 days
35	Establishment of bench marks and alianments	10 days
36	Setting of fabrication yard	30 days
37	**Steel Flyover & Ramps**	**470 days**
38	**Foundations**	**305 days**
39	Bored cast in situ RCC piles of 1.2 m dia	300 days
40	RCC pile cap	300 days



ID	Task Name	Duration
41	**Sub structure**	**315 days**
42	Fabrication of Steel Girder Pier & Pier cap	270 days
43	Erection of Structural steel Pier	270 days
44	Erection of Structural steel Pier Cap & Portals	270 days
45	**Superstructure**	**330 days**
46	Erection of Structural Steel girders, Diaphragm Girder with shear connectors & Bracings.	300 days
47	Casting of In situ RCC deck slab.	300 days
48	Casting of RCC crash barriers	300 days
49	Medians	200 days
50	Strip seal Expansion Joint	200 days
51	Drainage Spouts	100 days
52	**Approaches**	**200 days**
53	RE panels - solid Ramp portion.	200 days
54	Wearing Coat & Finishing Works	200 days
55	**Under Passes**	**170 days**
56	Earthwork	90 days
57	Pcc	40 days
58	Raft	100 days
59	Retaining wall	140 days
60	Crash barrier	60 days
61	Backfilling with filter midea	60 days
62	**Wearing Coat**	**40 days**
63	**For closed box portion & U-type open portion,**	**34 days**
64	Tack coat	30 days
65	BC - 40 mm thk.	15 days
66	Mastic Asphalt - 25 mm thk.	15 days
67	**For remaining approach portion,**	**40 days**
68	Sub grade - 300 mm thk.	30 days
69	GSB - 200 mm thk.	30 days
70	WMM - 250 mm thk.	30 days
71	Prime coat, tack coat	30 days
72	DBM - 100 mm thk. (2 layers of 50 mm)	30 days
73	BC - 40 mm thk.	20 days
74	**Grade level Road Work**	**200 days**
75	**Overlay**	**101 days**
76	Tack coat	80 days
77	Profile corrective course- BM - 100 mm thk. (2 layers of 50 mm)	80 days
78	DBM - 100 mm thk. (2 layers of 50 mm)	80 days
79	BC - 40 mm thk.	80 days
80	**Road Widening (New construction)**	**185 days**



ID	Task Name	Duration
81	Sub grade - 500 mm thk.	150 days
82	GSB - 200 mm thk.	150 days
83	WMM - 250 mm thk.	150 days
84	Prime coat, tack coat	150 days
85	DBM - 100 mm thk. (2 layers of 50 mm)	150 days
86	BC - 40 mm thk.	150 days
87	Road furniture - Thermoplastic paint, Road studs, Gantries, Road Signages	100 days
88	**Junction Improvements:**	**140 days**
89	Profile corrective course- BM - 100 mm thk. (2 layers of 50 mm)	100 days
90	DBM - 100 mm thk. (2 layers of 50 mm)	100 days
91	BC - 40 mm thk.	100 days
92	tack coat	100 days
93	Mastic Asphalt - 25 mm thk.	100 days
94	New Median Construction	150 days
95	Crash barriers along the perimeter for pier protection and both sides of central median	150 days
96	PCC Kerb stones for separator median	150 days
97	Making of lawns at islands	100 days
98	Tree plantation with good earth and manure filling at median and separator median	100 days
99	**Grade level Drain & footpath works**	**240 days**
100	Footpath with 60 mm thick interlocking paver blocks	200 days
101	RCC drains	200 days
102	Brick masonry inspection chamber at every pier locations	200 days
103	300 mm dia. NP-2 pipes at every pier locations for drain passage	200 days
104	Cable ducts across the road	200 days
105	**Electrical & illumination**	**80 days**
106	Flyover portion	80 days
107	Underpass portion	40 days
108	Grade Level Road Works	60 days
109	**Finishing Works**	**80 days**
110	Overall finishing flyover portion	80 days
111	Overall finishing Underpass portion	40 days
112	Overall finishing Grade Level Road Works	60 days
113	**Handing Over**	15 days



10.0 TRAFFIC DIVERSION AND MANAGEMENT

10.1 General

The project corridor is one of the busiest road in the city. This road connects CBD and southern part of Bangalore with northern part of greater Bangalore (i.e., outside outer ring road). Further, it takes the traffic towards Yelahanka satellite town and beyond.

Bangalore Airport was from HAL to Devanahalli and upgraded to International Civil Aviation Organisation (ICAO) standards. This shift and transformation of Bangalore Airport into Kempegowda International Airport Limited (KIAL) has increased traffic on the project road tremendously.

Interrupting this traffic and constructing elevated road will be nightmare to any contractor. Thus, it is essential to plan alternative routes and divert the traffic before starting construction work. The consultant has studied road network around project corridor and identified some roads where full / part of the project road traffic can be diverted during construction. Figure 10-1 shows various alternative roads identified for diverting project road traffic during construction.

The alternative roads identified include outer ring road which can take care of traffic coming from east, west and southern areas of Bangalore which are away from project road. But construction of grade separator work is in progress even in outer ring road at Kanteerava studio junction, Goraguntepalya junction and Nagawara Junction. This is congesting the outer ring road traffic due to which it cannot handle addtional (project road) traffic completely. Thus, some alternative roads were identified close to project road which can accommodate most of the project road traffic during construction. However, these alternative routes for diversion shall be jointly identified by BDA, Traffic Police, BMTC and Contractor.

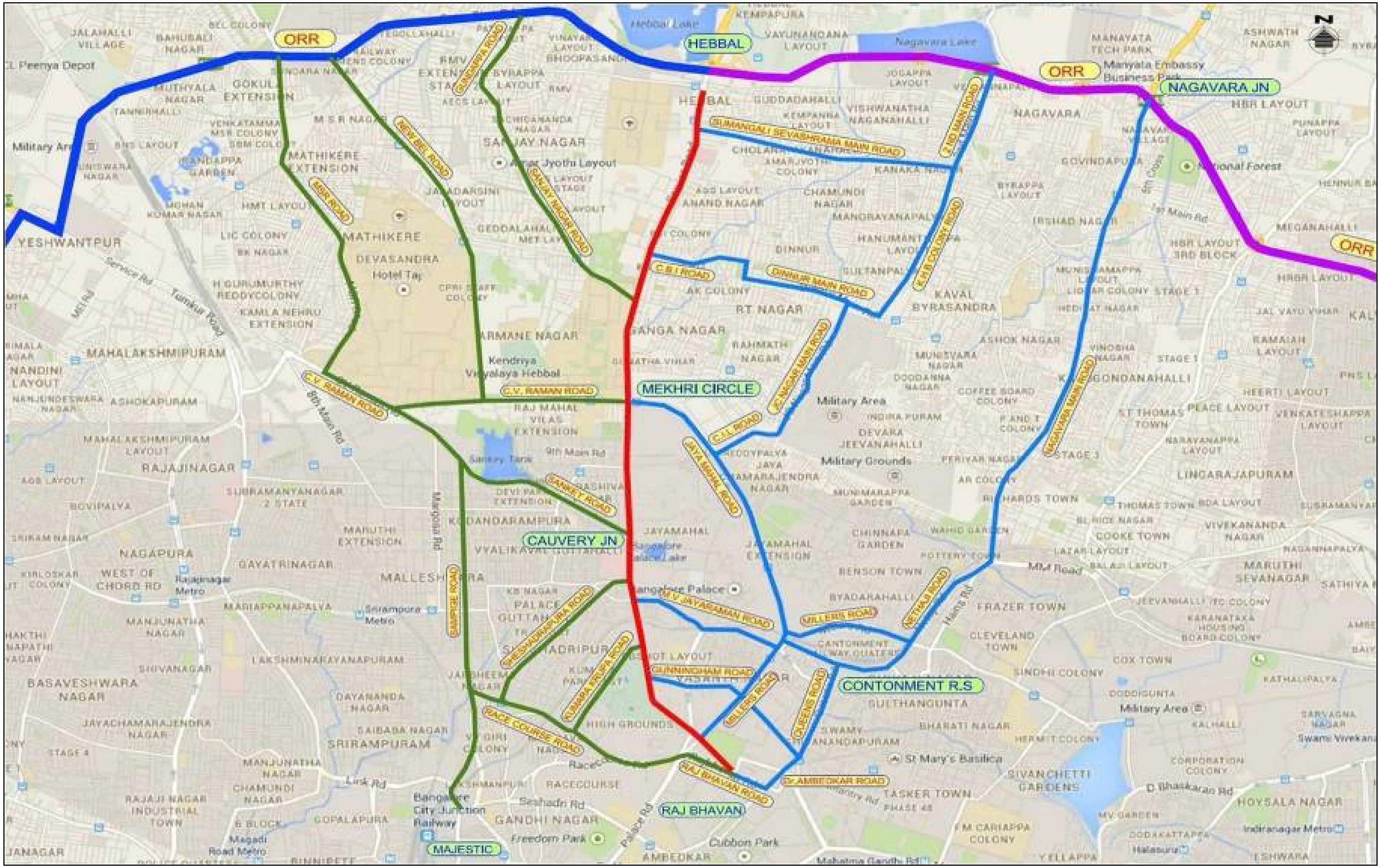


Figure 10-1 Traffic Alternative Route Plan

11.0 ECONOMIC ANALYSIS

11.1 General

Economic analysis is a project appraisal technique wherein the costs of and benefits from a scheme are quantified over selected period of time. It aims at determining the monetary benefit due to expenditure on improvement schemes. It also helps to decide appropriate and economical proposal to be chosen for implementation among various alternatives. The proposed project improvements results in several benefits to the road users such as

- Reduction in vehicle operation cost covering reduction in fuel and oil consumption, reduction in wear and tear of tyres and maintenance.
- Savings in travel time.
- Reduction in accident rates due to better facility.
- Increased level of service / comfort level to passengers.

Economic analysis is carried out as per IRC:SP:30-2009 guidelines. Economic analysis is carried out considering various parameters and design considerations which are given in following sections.

11.2 Methods of Economic Analysis

There are three basic methods of economic evaluation which is given below. All the three methods are based on the discounted cash flow technique of discounting all the future costs and benefits to a common year.

- Net Present Value Method (NPV)
- Benefit / Cost Ratio Method (B/C)
- Internal Rate of Return Method (IRR)

The main aim to carry out economic feasibility is maximising the returns on investment by determining improvement proposals that lead to minimum total transport costs. Economic evaluation is carried out based on incremental costs & benefits comprising the total net benefits in "Without Improvement" situation with " With Improvement" situation for various alternatives mentioned below. The term "Without Improvement" is defined as the base strategy for economic analysis i.e., without proposed elevated road for project corridor. The term "With Improvement" is defined as upgrading the existing road in terms of capacity handling or eliminating delays by constructing proposed elevated road.

11.3 Parameters considered

Following parameters are considered in computing vehicle operation cost and in economic analysis.

11.3.1 Considerations for Economic Analysis

The methodology used is based on Updated Road User Cost Study – 2001 and IRC-SP-30-2009 guidelines. The economic feasibility is based on the Net Present Value (NPV) and Internal Rate of Return (IRR). It compares the total NPV of all costs and benefits of "Without Improvement" scenario with "With Improvement" scenario.

In "Without Improvement" scenario the project road is assumed to be operating without proposed elevated road. That means only at-grade level road operation and maintenance cost is considered along with vehicle operation cost. In this scenario, the future projected traffic is assumed to be operating fully on existing at-grade road.

On the other hand in "With Improvement" the cost and benefits of construction of proposed elevated road along with vehicle operation cost, at-grade level improvements, operation and maintenance cost is considered. The Origin & Destination survey results revealed that through traffic (excluding buses & two wheelers) for the project road is about 60-70% which is expected to use the proposed elevated road. Thus, In this scenario about 60-70% of future projected traffic is considered to be operating on proposed elevated road and remaining 30-40% of future projected traffic is considered to be operating on existing at-grade road.

11.3.2 Project cost

The total project cost for construction of proposed elevated road between Basaveshwara circle to Hebbal and grade level road including annual maintenance and periodic maintenance cost is given in Table 11-1.

Table 11-1 Project Cost (in Crores)

Sl No	Description	Cost (in Crores)
1	Construction of Elevated Road & Improvement of At-Grade Road	1350
2	Annual Maintenance for 20yrs = {(9+5)x20}	280
3	Annual Accident for 20yrs = {(3+1)x20}	80

11.3.3 Traffic Data

Turning traffic volume count was conducted at all major junction existing along the project corridor. The duration of survey was 24 hours on regular working day of the week. For the purpose of economic analysis weighted average of peak hour traffic at all these junctions is considered. The present day traffic is projected for next 23 years including planning, Design and Construction time period of 3 years. The traffic growth rates for the project road has been derived using econometric method and from past trends of vehicle registration. Ideally, traffic data for past years would indicate the correct growth rates. The traffic growths obtained from econometric method is in fair comparison with the traffic growth from past trends. Hence, average of traffic growth obtained from past traffic data and econometric method is used as the base in adopting traffic growth rates for the project which is given below in Table 11-2

Table 11-2 Traffic Growth Rates for Project Road (2012)

Vehicle Type	Two Wheeler	Three Wheeler	Car/ Jeep	Bus	Truck
Vehicle Registration - Karnataka	4.51%	4.16%	4.98%	5.94%	3.89%
Econometric Method	3.10%	2.38%	5.16%	8.06%	5.35%
Average (*Adopted Value*)	**3.80%**	**3.27%**	**5.07%**	**7.00%**	**4.62%**

The suggested growth rates have been further decreased at 2.00% per annum (assumed) for the future years during the construction period and entire design life. The growth factors thus estimated are presented in the table below in Table 11-3

Table 11-3 Growth Rates for Future

Year	Two Wheeler	Three Wheeler	Car/ Jeep	LCV	Mini Bus	Bus	2 Axle Truck	3 Axle Truck	Multi Axle Truck
2014	3.65%	3.14%	4.87%	6.72%	6.72%	6.72%	4.44%	4.44%	4.44%
2015	3.58%	3.08%	4.77%	6.59%	6.59%	6.59%	4.35%	4.35%	4.35%
2016	3.51%	3.02%	4.68%	6.46%	6.46%	6.46%	4.26%	4.26%	4.26%
2017	3.44%	2.96%	4.59%	6.33%	6.33%	6.33%	4.18%	4.18%	4.18%
2018	3.37%	2.90%	4.49%	6.20%	6.20%	6.20%	4.09%	4.09%	4.09%
2019	3.30%	2.84%	4.40%	6.08%	6.08%	6.08%	4.01%	4.01%	4.01%
2020	3.24%	2.78%	4.32%	5.96%	5.96%	5.96%	3.93%	3.93%	3.93%
2021	3.17%	2.73%	4.23%	5.84%	5.84%	5.84%	3.85%	3.85%	3.85%
2022	3.11%	2.67%	4.14%	5.72%	5.72%	5.72%	3.77%	3.77%	3.77%
2023	3.05%	2.62%	4.06%	5.61%	5.61%	5.61%	3.70%	3.70%	3.70%
2024	2.98%	2.57%	3.98%	5.49%	5.49%	5.49%	3.63%	3.63%	3.63%

Year	Two Wheeler	Three Wheeler	Car/ Jeep	LCV	Mini Bus	Bus	2 Axle Truck	3 Axle Truck	Multi Axle Truck
2025	2.92%	2.51%	3.90%	5.38%	5.38%	5.38%	3.55%	3.55%	3.55%
2026	2.87%	2.46%	3.82%	5.28%	5.28%	5.28%	3.48%	3.48%	3.48%
2027	2.81%	2.42%	3.75%	5.17%	5.17%	5.17%	3.41%	3.41%	3.41%
2028	2.75%	2.37%	3.67%	5.07%	5.07%	5.07%	3.34%	3.34%	3.34%
2029	2.70%	2.32%	3.60%	4.97%	4.97%	4.97%	3.28%	3.28%	3.28%
2030	2.64%	2.27%	3.53%	4.87%	4.87%	4.87%	3.21%	3.21%	3.21%
2031	2.59%	2.23%	3.46%	4.77%	4.77%	4.77%	3.15%	3.15%	3.15%
2032	2.54%	2.18%	3.39%	4.67%	4.67%	4.67%	3.08%	3.08%	3.08%
2033	2.49%	2.14%	3.32%	4.58%	4.58%	4.58%	3.02%	3.02%	3.02%
2034	2.44%	2.10%	3.25%	4.49%	4.49%	4.49%	2.96%	2.96%	2.96%
2035	2.39%	2.05%	3.19%	4.40%	4.40%	4.40%	2.90%	2.90%	2.90%
2036	2.34%	2.01%	3.12%	4.31%	4.31%	4.31%	2.84%	2.84%	2.84%

Based on the derived traffic growth rates, the peak hour traffic is projected for future scenario which is presented below in Table 11-4

Table 11-4 Projected Traffic

Year	Two Wheeler	Three Wheeler	Car/ Jeep	LCV	Mini Bus	Bus	2 Axle Truck	3 Axle Truck	Multi Axle Truck	Total Vehicles	Total PCU's
2014	4559	751	6376	189	130	406	42	46	2	**12501**	**12233**
2015	4722	774	6680	201	139	433	44	48	2	**13043**	**12787**
2016	4888	797	6993	214	148	461	46	50	2	**13599**	**13351**
2017	5056	821	7314	228	157	490	48	52	2	**14168**	**13932**
2018	5226	845	7643	242	167	520	50	54	2	**14749**	**14527**
2019	5399	869	7980	257	177	552	52	56	2	**15344**	**15135**
2020	5574	893	8324	272	188	585	54	58	2	**15950**	**15759**
2021	5751	917	8676	288	199	619	56	60	2	**16568**	**16392**
2022	5930	942	9036	304	210	654	58	62	2	**17198**	**17041**
2023	6111	967	9403	321	222	691	60	64	2	**17841**	**17703**
2024	6293	992	9777	339	234	729	62	66	2	**18494**	**18379**
2025	6477	1017	10158	357	247	768	64	68	2	**19158**	**19067**
2026	6663	1042	10546	376	260	809	66	70	2	**19834**	**19766**
2027	6850	1067	10941	395	273	851	68	72	2	**20519**	**20478**
2028	7039	1092	11343	415	287	894	70	74	2	**21216**	**21203**
2029	7229	1117	11751	436	301	938	72	76	2	**21922**	**21937**
2030	7420	1142	12165	457	316	984	74	78	2	**22638**	**22686**

Year	Two Wheeler	Three Wheeler	Car/ Jeep	LCV	Mini Bus	Bus	2 Axle Truck	3 Axle Truck	Multi Axle Truck	Total Vehicles	Total PCU's
2031	7612	1167	12585	479	331	1031	76	80	2	**23363**	**23443**
2032	7805	1192	13011	501	346	1079	78	82	2	**24096**	**24210**
2033	7999	1218	13443	524	362	1128	80	84	2	**24840**	**24992**
2034	8194	1244	13880	548	378	1179	82	86	2	**25593**	**25782**
2035	8390	1270	14322	572	395	1231	84	88	2	**26354**	**26584**
2036	8586	1296	14769	597	412	1284	86	91	2	**27123**	**27395**

11.4 Savings in Vehicle Operation Cost

The economic analysis is mainly used in assessing the benefits to the user by the project implementation. The benefits are of two types one is Tangible (which can be accounted) and other one is Non Tangible (which cannot be accounted but gives benefits to user). However presently, the tangible benefits in terms of vehicle operation cost to the user have been calculated in deciding the economic feasibility of the project implementation of the project. The following table shows the vehicle operation cost with project and without project which will contribute to the benefits to the road user.

Table 11-5 Vehicle Operation Cost

Year	Vehicle Operation Cast (in Crore Rs.)			
	Existing Road (Without Improvement)	(With Improvement)		Annual VOC Savings
		At-Grade Road	Elevated Road	
2014	442	442	0	0
2015	472	472	0	0
2016	502	502	0	0
2017	531	135	176	220
2018	564	144	189	231
2019	597	154	200	243
2020	633	162	209	262
2021	670	172	220	278
2022	710	183	234	293
2023	749	194	247	308
2024	791	206	260	325
2025	837	217	274	346
2026	883	232	289	362
2027	933	245	304	384
2028	982	258	319	405
2029	1037	274	336	427

Year	Vehicle Operation Cast (in Crore Rs.)			
	Existing Road (Without Improvement)	(With Improvement)		Annual VOC Savings
		At-Grade Road	Elevated Road	
2030	1092	288	353	451
2031	1148	305	370	473
2032	1207	321	389	497
2033	1270	339	406	525
2034	1333	358	426	549
2035	1398	376	445	577
2036	1468	395	467	606

11.5 Summary of Economic Analysis

The economic analysis is carried out for the project road for "Without Improvement" and "With Improvement" scenario. Based on the analysis Internal Rate of Return (IRR), Project Net Present Value (NPV) and Benefit Cost ration (B/C) have been arrived to check the project feasibility which is given Table 11-6 in below.

Table 11-6 Summary of Economic Analysis

Sl No	Description	Value
1	Internal Rate of Return (IRR)	17.07%
2	Project Net Present Value (NPV)	1209.59
3	Project Benefit Cost Ration (B/C)	1.90

From the above table it can be observed that ***NPV is positive*** and ***B/C is greater than 1.00*** for the proposal. This justifies that the project proposal is economically feasible when compared to "Without Improvement" scenario.

From the analysis it is observed the benefits are more in improvement scenarios against without improvement scenario. The benefits observed in with improvement scenarios are due to elimination of delay at all the existing junctions, reduction in signal timings and increasing the capacity by means of providing additional lanes for each direction of traffic at elevated level there by increasing the speed of the through traffic without getting conflict with local & slow moving traffic.

Hence, there will be less congestion effect with this option there by reducing the vehicle operation cost and increase in the benefits to the users. Thus, construction of proposed elevated road is proved to be economically feasible.

12.0 PROJECT INSTITUTIONAL FRAMEWORK

12.1 Roles and Responsibilities of Govt Agencies

There are many government agencies that have to work in tandem with BDA for betterment of the project. The roles / responsibilities of government agencies in implementing the proposed elevated road are listed below,

12.1.1 Bangalore Development Authority (BDA)

The roles / responsibilities of BDA are

- Owner of this project
- Allocating design consultants for preparation of DPR, BOQ, Cost estimate and Tender document for the project
- Get technical, financial and administrative approval for the project from concerned government bodies
- Get funds for the project from funding authority (GOK)
- Selection of contractor for execution of the project through tendering activity
- Selection of PMC consultants for quality control and quality assurance of construction work
- Monitoring the project till completion of the work
- Performance evaluation of design consultant, PMC consultant and contractor

Under the absence of coordinating agency, BDA has to communicate with other government agencies to create awareness about the proposed elevated road project. give them necessary information about the proposal and facilitate them in removing / relocating utilities existing within the project corridor. Also to facilitate them in integrating other infrastructure projects existing / planned in and around the project corridor.

12.1.2 Bruhat Bengaluru Mahanagara Palike (BBMP)

The roles / responsibilities of BBMP are

- Provide necessary information to BDA about infrastructure development activities happening / planned within the project vicinity
- To prepare comprehensive development plan to integrate this project with other infrastructure projects existing / planned in and around the project corridor

- Periodic maintenance of proposed elevated corridor.
- Monitoring performance of the proposed elevated road and conduct performance assessment studies (if required) to improve the capacity / performance.

12.1.3 Bangalore Water Supply & Sanitary Board (BWSSB)

The roles / responsibilities of BWSSB are

- To get project proposal / concept details from BDA
- Check existing water supply / sanitary lines that are existing within proposed project boundary
- Make necessary arrangement to remove / relocate the utility lines
- If required, preparation of costing to get inter departmental fund transfer (deposit for relocation of utility)
- Removal / relocation of utilities and give clearance for construction of proposed elevated road.

12.1.4 Bangalore Electric Supply Company Limited (BESCOM)

The roles / responsibilities of BESCOM for removing / relocating underground electrical lines is same as that of BWSSB.

12.1.5 Bharat Sanchar Nigam Limited (BSNL)

The roles / responsibilities of BSNL for removing / relocating underground telephone / network cables is same as that of BWSSB.

12.1.6 Bangalore Metropolitan Transport Corporation (BMTC)

The roles / responsibilities of BMTC are

- Rerouting the busses during and till completion of construction work for proposed elevated road
- Shifting of bus stops wherever necessary with least hindrance to passengers

12.1.7 Bangalore Traffic Police

The roles / responsibilities of Bangalore Traffic Police are

- Traffic diversion during and till completion of construction work

- Rerouting and channelizing the traffic (both at surface level and on the elevated road) after construction of proposed elevated road
- Changing signal timing at all the junctions to cater for design traffic at surface level road.
- If required, removal of traffic signals wherever design traffic at surface level road is not governing for the same.
- Traffic management during and after completion of construction work.

12.1.8 Government of Karnataka (GOK)

The roles / responsibilities of GOK are

- Decision making and approving authority
- Define and assign roles / responsibilities to all local government agencies (BDA, BBMP, BWSSB, BESCOM, BMTC and Bangalore Traffic Police)
- Get grants for the project from central government and/or world bank or private agencies
- Get periodic status report about construction work from BDA and making part payment
- After completion of work transferring to BBMP for periodic maintenance and performance evaluation

12.2 Roles and Responsibilities of Pvt Agencies

Private agencies involved in various stages of the project include design consultants, contractor and project management consultants (PMC). The roles / responsibilities of each of them are given below

12.2.1 Design Consultant

The detailed roles / responsibilities of design consultant is explained in Chapter-2.0.

12.2.2 Contractor

The roles / responsibilities of contractor are

- Mobilisation of men, material and construction machineries to site on receiving work order

- Construction of site office with necessary infrastructure
- Deploy physical and skilled labours along with technically sound supervisors at different level
- Construction of casting / fabrication yard well equipped with men and material
- Construction of Ready Mix Concrete (RMC) yard well equipped with men and material
- Identification of dumping yard for dumping excavation material and debris
- Safety measures for men, material and machineries during construction
- Preparation of organogram, skill matrix and schedule of execution charts
- Execution of work as per schedule and completion
- De-mobilisation of men, material and machineries from site after completion of work
- Shut down casting / fabrication yard and RMC; de-mobilisation of men, material and machineries
- Handing over of project site to BDA on completion of work
- Partial maintenance till completion of work and hand over

12.2.3 Project Management Consultant (PMC)

The roles / responsibilities of PMC consultant are

- Monitoring construction activity from start till end
- Checking and controlling quality of construction materials
- Checking condition and calibration of construction equipments used by the contractor
- Evaluation of contractor's organogram, skill matrix and schedule of execution charts
- Prepare quality control report periodically to give statue update of construction activity to BDA
- Inform / caution contractor and BDA about shift in target dates from schedule of execution. Also to Inform / caution contractor and BDA about any shift from design standards immediately during construction

13.0 LEAGAL ASSESSMENT

13.1 Land Acquisition

The Project corridor lies within city limits. The area around project corridor is well developed with residential, commercial, business and institutional establishments. About **16489 sqm** of land needs to be acquired under Transfer of Development Rights (TDR) Scheme for the proposed elevated road. Details of Land Acquisition are given in Plan & Profile drawing {RD-20 Rev(4)}. There is no scope for parking of the vehicles on main carriageway at surface level.

However, service road and wide footpaths are provided along the project road wherever adequate space is available. Part of this service road and footpath can be used for providing parking facility. Parking facility has to be provided with no interruption to main road traffic and with very less interruption to service road traffic.

13.2 Enforcement Measures

Bangalore Development Authority has planned to take precautionary measures during the construction phase to enforce traffic diversion and minimizing the effects of various pollutions. Through the Institutional Framework suggested, BDA will coordinate with the traffic police, BMTC and utility operators like BESCOM, BWSSB for the shifting of existing utility lines, which are going to obstruct the execution of the project. Since BDA is the obligatory provider of citizen services in the city, it has powers by statue to require other government and non government agencies to implement plans in public interest.

Bangalore Development Authority has also notified the list of underpasses and flyovers that it proposes to construct under JNNURM and thus it is making the residents and commercial establishments aware of the possible disturbances that could emerge on account of the implementation of the projects.

14.0 RISK ASSESSMENT

Risks is a situation where the outcomes are unknown but the probability distributions of such outcomes are known or can be assessed. Road Projects are associated with considerable risks starting from concept stage till execution stage, operation and maintenance.

14.1 Risk Associated with EPC Work

Generally, the risks associated with road project taken for improvement under Engineering Procurement and Construction (EPC) mode can be grouped into five main classifications. They are listed below and explained in detail in Table 14-1

- Pre Completion risk
- Post Completion risk
- Technical risk
- Financial risk
- Political risks

Table 14-1: Risk associated with EPC work

Type of Risk	Bearing Party	Remarks
Pre Completion Risk		
Design	BDA	BDA have to finalise the concept and designs. Any delay in approval will affect the project commencement.
Land Availability	Government/ BDA	Government/ BDA will provide the physical possession of the project site free from all encroachments and encumbrances. Necessary arrangements have to be made to provide alternative place for living or compensation for the affected people. Any delay will lead to extension in construction period and project completion.
Utility shifting	BDA & Contractor	BDA is required to get approval for utility shifting from concerned government agencies. Contractor is required to shift the utilities as per schedule. Any delay will affect project completion.
Time and Cost Overruns	BDA & Contractor	Any unforeseen difficulties occurring during construction has to be resolved at the earliest with least possible expenses by the contractor. BDA is required to give approval for the same. Failure in overcoming the difficulty will delay the milestone to be achieved.

Type of Risk	Bearing Party	Remarks
Funding	BDA	BDA is required to arrange for finance or get finance from funding agency.
Traffic Diversion & Management	BDA, Traffic Police & Contractor	A well coordinated traffic management plan has to be prepared before commencement of the work. The contractor has to develop alternative routes first. Traffic police play major role in traffic diversion and management.
Change in Scope	BDA / Government	Change in scope can be initiated by either the Authority or the BDA. In either cases, the reduction or increase in cost due to change in scope is determined in mutual consultation. There is always an upper limit in terms of change in scope i.e. change of scope cannot exceed some percent of the project cost. It varies on project basis.
Sub Contractor's Obligation (if any)	Contractor	The Contractor has to ensure that the sub contractors comply with all the applicable permits and laws related to the project.
Post Completion Risk		
Performance	BDA / BBMP	Prior to start date of the Project, BDA / BBMP shall operate and maintain the project corridor by itself or through sub contractors and if required, modify, repair or otherwise make improvements to the project corridor to comply with Specifications and Standards. Post start date, BDA / BBMP would maintain the project corridor at its own cost and expense.
Traffic Management	BDA & Traffic Police	Traffic police has to re-route and manage traffic on completion of constructing proposed elevated road.
EPC Fees	BDA / funding agency	EPC fees would be made by BDA or funding agency periodically as per the EPC contract terms and conditions. If the BDA / funding agency do not make the payments as per the time period stated, then there is a risk of delay in project completion.
Environmental and Social Issues	Government / BDA	Applicable permits relating to environmental protection and conservation of the site to be obtained by Government / BDA.
Technology Risk		
Design and Performance	BDA	The BDA is responsible for any technology upgradation during or after construction phase or during operations phase. The additional cost would be borne by BDA.
Financial Risk		
Interest rate and Inflation	Contractor	The interest rate and inflation risk is factored in the lump sum contract price quoted by the contractor.

Type of Risk	Bearing Party	Remarks
Insolvency and outside creditor risk	Contractor	It is borne by the BDA and is factored in various costs pertaining to construction, operation and maintenance phase.
Political Risk		
Change in Law	BDA & Contractor	If there is an increase in capital expenditure or increase in taxes owing to change in law, the additional amount shall be calculated and shared with the Authority for escalation of cost. PMC consultant appointed by the Authority shall review and will determine any addition or reduction or change in contract price due to Change in Law
Government reneging	BDA & Contractor	No pre fixed penalty or compensation decided and it would be mutually decided depending upon the situation.

14.2 Project Risk

The risks during the operation phase are minimal and restricted to over use of the road (against Design Assumptions) by heavier vehicles and damage to road surface by accidents and by vehicles carrying overload. In the current road projects undertaken by BDA, the time frame for completion varies between 18 to 24 months after mobilization of site resources. The major risk relates to buy in of the project from all stakeholders, especially those affected by the construction itself. These are residential and commercial establishments who are close to the construction site. They are exposed to noise pollution, dust pollution and inconvenience caused due to inability to use their vehicles on account of temporary closure of the roads.

Internal Risks come mainly from three sources: the Project, the Organizations Involved and the Relationships among Partners. Most projects suffer at least temporarily from a deficient project structure. Many are launched even though objectives are not clear, a business case had not been completed, and milestones were only vaguely defined, if defined at all. These instances of lack of or inadequacy in definition of scope occur due to pressure to complete the planning stage and to go ahead with the construction early. On the organizational side, lack of project control mechanisms is the factor that most impede many projects. Finally, risks associated with the relationships among partners have been the major source of concern present in all projects, lack of definition of role and responsibility as the most important problem for project implementation.

14.2.1 Stakeholders

The stakeholders involved in this road project are

- BDA
- Contractor
- Design & PMC Consultants
- Utility Companies - BBMP, BWSSB, BESCOM, BSNL, etc
- Transportation Departments - BMTC, KSRTC, APSRTC, SETC, other Government and Private transports
- Traffic police
- Public Works Department
- Localities - Residents, Shop Owners, Commercial and Business Establishment Owners
- Pollution Control Board

14.2.2 Role Traffic Police

Coordination with the Traffic Police, Liaison with Residents, Shop Owners, Commercial and Business Establishment Owners is a pre requisite before commencing the Construction Phase. Traffic Police will have to plan for Diversions, Construction of Temporary Structures, and Regulation of Traffic during Peak Hours with Extra Resources, etc. Communication through press and media (door to door Campaign if required) in the affected areas are proposed to ensure smooth Construction Phase.

Traffic Police will also have to develop alternate routing for the BMTC Buses that ply in the roads proposed for revamping. They need to mark the zones near the Construction Site as ‘No Parking’ and allocate Routes and Space for the Vehicles engaged in the Construction Work.

14.2.3 Utility Shifting

In Bangalore Road Network, the common Utilities that are encountered during the revamping or widening are

- Water Supply Line and Valves
- Sanitary Lines and Manholes
- Road Drains and CD Structures

- Street Lights
- Electricity Lines and Structures (Mounted Transformers)
- Telecommunication Lines and Structures
- Road Signs and Signals
- Post Boxes and others

The utilities are to be shifted in coordination with the Concerned Departments. The key is in sending them advance communication and obtaining their sign off for proposed shifting well ahead of the Construction Phase. Underground utilities are the main concern and pose a major challenge that will need the commitment and cooperation of all the associated Departments. Shifting of underground utilities are to be executed in coordination with BWSSB, KPTCL, BESCOM, BSNL and other private Telecom Operators like Bharti, Tata, Reliance, etc., which have led OFC cables along the existing roads.

15.0 OTHER COMPONENTS DURING CONSTRUCTION PHASE

15.1 Afforestation / Tree Cutting

The construction of proposed elevated road requires about **19,115 sqm** of additional land to be acquired. Out of this, major portion is government land including some open land / setback area of the building where compound / trees are existing. There are about **548 trees** coming within proposed project boundary that need to be cut / shifted. In addition to this some part of greenery (i.e., bushes, architectural plants, etc) has to be cleared from the project boundary.

To compensate this afforestation about **75,968 sqm** of landscaping area has been proposed for the project corridor which includes **35,433 sqm** of central median area below the elevated structure, **2,960 sqm** of channelizing island area and **37,560 sqm** of additional green area beyond footpath. Within this additional green area some place has been identified for planting new / shifted trees. The area is identified in such a way that there is sufficient space for the tree to grow without touching / hampering the elevated structure. It is estimated that small to medium size trees with canopy and/or root spread area diameter not more than 6m can be planted in this area. The entire **75,968 sqm** area is proposed to be covered with grass mat and show plants. In addition to this, small trees and architectural plants can be planted in channelizing island area.

15.1.1 Air Pollution

Generally air pollution level will be high during construction stage for any infrastructure project. The various construction activities that are going to cause air pollution include

- Demolition of structures during land acquisition
- Removal of existing flyover (magic box) structures
- Excavation and foundation work
- Shifting of excavated earth and other construction materials
- Loading and unloading of construction materials from truck
- Movement of construction vehicles on project site during construction
- Emission of carbon monoxide and other toxic gases from construction vehicles and traffic

In order to minimize the effect of air pollution during construction the contractor or sub contractor has to take some precautions like watering the project site and covering trucks

with plastic / polythene cover during transportation of construction materials. Construction materials have to be transported during night time to reduce emission of carbon monoxide from trucks due to waiting at signals. Keeping health / fitness of the site engineers and labours in view they have to be provided with air filter masks to stay protected from air pollution.

The air pollution level at post-construction scenario will be less as emission of carbon monoxide from vehicular traffic will reduce due to reduction in waiting time at signals. Further, the landscaping area provided along the project corridor, plants and trees planted in that area is going to observe the toxic gases emitted and filter the air to a greater extent.

15.1.2 Water Pollution

Two open water sources are present in and around the project corridor namely Bangalore palace lake and Hebbal lake. Water from both these lakes is not used for drinking / domestic purpose. But these lakes are contributing in recharging ground water and reducing atmospheric temperature. More over these lakes have their own aesthetic importance in Bangalore. People residing around Hebbal come to Hebbal lake for morning and evening walk. During week end and holidays people from all parts of Bangalore come here for recreation. Thus, Hebbal lake has become one of the landmark in Bangalore city.

The construction activity around palace ground and Hebbal flyover is going to generate dust, debris and sludge which may join the these lakes causing water pollution. Aesthetic of these lakes will be spoiled once the water gets polluted. It will cause inconvenience to the people coming to Hebbal lake for walking and recreation. The pollutant may affect the aquatic life existing within the lakes and / or induce water related diseases in people residing close to the lakes

Hence, the contractor should do construction work carefully near these two lakes. Necessary measures need to be taken to see that the dust, debris and sludge generated from construction activity should not go to these lakes. Unused excavated earth should not be dumped in and around these lakes.

15.1.3 Noise Pollution

Generally construction machineries used for any infrastructure project will increase noise pollution level at construction site. In a road infrastructure project sound emitted from machineries and transportation vehicles / trucks will increase noise pollution level along with the diverted traffic moving along the project corridor.

The construction activity should be carried out with utmost care. Transportation of construction materials uniformly distributed during night time will be done with easy and relatively fast. This will cause least disturbance to the traffic and road users. Earplugs should be given to heavy machinery operators and workers working around them for safety against noise pollution.

Noise pollution level will be less in post-construction scenario as the idling period will reduce considerably due to reduction in waiting time at signal and least hindrance for the movement of vehicular traffic.

15.2 Social Impact

The project does not involve any displacement of people and habitants.

16.0 CONCLUSION AND WAY FORWARD

16.1 Conclusion

The consultant has prepared the Detailed Project Report based on Terms of Reference issued by BDA in 2012. In addition, review / comments given by BDA for Feasibility Study Report submitted earlier are also included. Further, necessary changes are made in this DPR based on the outcome of series of meeting held with BDA and other officials / government bodies.

The consultant has carried out economic evaluation of the project and found out that the project is economically viable. Therefore the Construction of Elevated Road from Basaveshwara circle to Hebbal Junction coupled with the traffic management will have the following additional benefits

- Reduced junction delays and pollution
- Reduction in idle fuel consumption
- Improved level of service at the Junction
- Substantial savings in travel time of road users
- Reduces the number of conflicts.

The elevated road is proposed to be with composite construction with pile foundation in concrete and structure above road in steel. The advantages of having steel flyover are listed below

- Light weight segments ensure easy transportation and handling.
- Heavy machineries are not required for lifting and transporting the segments
- Faster to construct which will cause less hindrance to the traffic flow.
- Life cycle cost is less in comparison with concrete flyover.

16.2 Way Forward

The consultant has prepared and submitted Detailed Project Report on approval of Feasibility Study Report. This project is not a stand alone project and should be part of overall Bangalore Traffic Management Plan. Following are some of the activities proposed to be taken up on approval of DPR:

- Preparation of Tender Document as per KTPP Act 1999 by the consultant as advised by BDA.

- Detailed interaction with Traffic Police Department to plan and manage traffic diversion during construction on identified traffic diversion routes. Initial discussions on project proposal, alignment with traffic police department has already been carried out.
- Identification of major intersections and midblock road sections beyond the battery limits is not in the present scope of work. It is required to develop master plan of the area for traffic decongestion by means of road widening / grade separators / traffic management plans or combination of above for consideration by various agencies like BDA / BBMP. This is required to avoid traffic congestion to / from elevated road after its implementation.
- Grade separators / elevated road which will be proposed by other agencies at future will be required to integrate the proposed flyover
- Completion of on-going grade separator projects on routes identified for traffic diversion during construction by various agencies.

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