CHAPTER 1
INTRODUCTION

Background

Bangalore, the Capital of Karnataka is the Fifth Largest City in the Country and is growing at a rate, which is significantly higher than that of others. Due to the Growth in Economic Activities, the City is attracting migrants. To serve this Influx of Population, Residential Layouts are being developed. But adequate Transport Infrastructure Facilities such as Roads, Grade Separators, Subways, Mass Transit System, etc. to match this demand are conspicuously absent. The additional demand is to be catered by the already Saturated Road Network. Due to the Inherent Road Network in Bangalore, there are on the average 2 Major and 2 Minor Junctions per kilometer of Road Length. This has resulted in increase in Travel Time due to frequent Bottlenecks and Breakdowns.

1.1.2 The Urban Form of Bangalore is characterized by a Radio – Concentric System structured by Ring Roads, Five Major Radial Roads and Five Secondary Radial Roads. The Five Major Radial Roads are Mysore Road (SH – 17) in the South / South West, Old Madras Road (NH – 4) in the North / North East, Bellary Road in the North, Hosur Road (NH – 7) in the South – East and Tumkur Road in the North – West. Similarly, the Five Secondary Radial Roads include Magadi Road (SH – 17E) in the West, Kanakapura Road (NH – 209) in the South, Bannerghatta Road (SH – 48) in the South, Varthur Road and Whitefield Road (SH – 37) in the East. The differentiated development of the City based on Geographical Sectors and the Star like Growth Array along the Major Roads, mark the change from a Concentric Spatial Growth to a Sectorial and Linear Radial Development.

1.1.3 The City had a population of 24.75 Lakh in 1981 and 65.00 Lakh in 2001. The extent of Developed Area has also increased considerably, in 1971 the Area was 174.7 Sq. km. and today it is about 800 Sq. km. In absence of Adequate Mass Transportation System, the use of personal motor vehicles for intra – city travel has increased substantially. This has resulted in growth of motor vehicles, which is four times the rate of population growth in the last two decades (1.91 Lakh vehicles in 1981 and 23 Lakh vehicles in 2005). The Public Transport System (Bus) is overstressed carrying about 50 Lakh Commuters in a daily basis. Congested Streets and Longer Route Length due to Urban Sprawl have only served to reduce Bus Frequencies further. In a recent study done by CRRI, it has been reported that annual traffic growth rates vary in the range of 2 – 4% in the central zone, 5 – 7% in the intermediate zone and 8 – 9% on the regional roads in Bangalore City. CRRI study also reported delays of 26.8 sec per km of travel and 9.9 seconds per minute of travel.

1.1.4 The combined effect of all these on the Road Network of Bangalore is Delay and Congestion beyond Tolerable Limits. Vehicular Conflicts at the Intersections are being eliminated by Traffic Signals but at the Expense of Delays and Long Queues. The Peak Hour has spread over a longer period of time, since there are no Perceptible Capacity Augmentation / Conflict Reduction Measures. Traffic related Problems have become Regular Phenomena on Bangalore Roads, due to the Vast Developments. This fact is substantiated by the Traffic Study Results at various Road Networks and Intersections of the City. Most of the Major Junctions of the Core City have crossed the mark of 10000

PCUs in the Peak Hour. Though number of Grade Separators have been constructed and are being constructed, most of them are located in the Developed Part of the City and causing a Trigger of Congestion at adjacent Junctions. Traffic Management Measures such as One Way Systems, Parking Restrictions, Junctions Improvements, etc. are being implemented to ease the Congested Street Network. But the ever increasing Traffic is fast deteriorating the Limited Improvement in Level of Service these Traffic Management Measures can offer.

1.1.5 As a Comprehensive Development Programme for Improvement of Road Network, the Bruhat Bangalore Mahanagara Palike (BBMP) has planned Grade Separated Junction, Widening of Roads, Strengthening of Pavement Base and Sub – Base, Improvement to Pedestrian Facilities, Provision for Car Parking, etc. BBMP has constituted a separate cell to coordinate the Widening of Major Roads in Bangalore City in the face of Land Acquisition Challenges. This Response is the Answer to the severe strain on the Urban Infrastructure, which is inevitable due to the very rapid rate of growth in traffic. Travel Demands of Passengers have increased many folds in the last two decades. Unfortunately, Growth in the Infrastructure is not commensurate with the growing demands of traffic. There is an exigent need to effectively manage the Traffic and Transportation Systems to optimize the Solutions with Short Term and Long Term Measures.

1.1.6 One of the Practical Steps towards Optimal Solutions that will also give an Immediate Relief to Traffic Scenario is Capacity Augmentation. Capacity Augmentation is not possible without widening the high – density corridors. Increasing the capacity of important corridors is inescapable in the long run even if it entails Land Acquisition at high cost. The Land Acquisition is proposed through a Process of Conferring Development Rights (Transfer of Development Rights), by which the owner of the land who has surrendered the part of the land towards infrastructure projects would be allowed to carry out construction based on enhanced Floor Space Index (FSI) conferred by the TDRs.

1.1.7 The existing Road Network System of Bangalore is a major concern, both in terms of Conditions of Roads and the Structure of the Network. The Basic Structure is Radio – Concentric with about Ten Major Roads converging on the Centre. The Roads themselves are crowded and their Convergence creates Heavy Congestion. In order to ease the Traffic related Problems, the Bangalore Development Authority (BDA) constructed the Outer Ring Roads (ORR) connecting all Major Roads and Highways in and around Bangalore. The newly developed areas on the outer side of the Ring Road have caused much increase in Traffic across the Ring Road, which in turn is obstructing Flow of Traffic along the Ring Road and the ORR is currently heading towards a Saturated State of Flow, leading to Planning of New Road Infrastructure Development. With the introduction of Bruhat Bangalore Mahanagara Palike in January 2007, the City Development Area has increased considerably in the Outer Part of this Stretch of Ring Road and this in turn is increasing the Traffic Load in the Junctions.

1.1.8 The Project Corridor acts as a Radial Road in Southern Part of Bangalore City and connects the Central Business District with Bannerghatta. The Study Area caters to considerable local and through amount of traffic especially at peak hours due to the traffic that plies to the Central Parts of Bangalore and also towards Bannerghatta Road (SH – 48). Further, being a parallel Road to NH – 7 and Kanakapura Road, this Corridor acts as a link between National Highways. With the setting up of Software Companies like Infosys, Oracle, IBM, Accenture, Adobe Systems India Pvt. Ltd., Honeywell Technology Solutions Lab, BPL Software Centre, etc along the Project Corridor, the growth of the techno polis has led to increase in traffic. The traffic originating from the various quarters of the City passes through this Corridor to reach Bannerghatta, Arakere, Bilekahalli. Further, many large Residential Sites have been / are being converted into Apartments / Flats along this Corridor and a site that would house either a family or two now will be able to house multiple number of families and with this the number of Vehicle / Traffic also has increased manifold in last 10 years. The Corridor is located in the developing part of the City and hence the future traffic growth along this Corridor will be quite significant. The other main traffic attraction points along this Corridor are various Educational Institutes; Commercial Complexes; high end Residential Apartments; Wockhardt Hospital; Indian Institute of Management; Meenakshi Temple; Bannerghatta Biological Park; etc. Further, with the spurt in the economy, the Land Use Patterns of this Part of the City Area have been changing at a very fast pace since 10 years. Many of the Residential Areas in and around this Corridor, such as Shanti Nagar, Wilson Garden, Jayanagar, Koramangala, etc. are being converted into Commercial Establishments. With this change in the Land Use Pattern, traffic along this Corridor has been increased considerably in last 10 years time. Apart from this, many large Residential Sites have been / are being converted into Apartments / Flats along this Corridor and a site that would house either a family or two now will be able to house multiple number of families and with this the number of Vehicle / Traffic also has increased manifold in last 10 years. These being the Background, the Bruhath Bangalore Mahanagara Palike has proposed to construct Grade Separator using Pre Cast Element Technology at Major Junctions and to close Median at Minor Junctions with Appurtenant Link Improvements from Hosur Luskar road Junction to Hulimavu Gate Junction along Bannerghatta Road covering a total of 12 Junctions (out of which, 5 Junctions have been taken for improvement) for a total length of 10 km in order to provide Uninterrupted, Seamless Traffic Flow and to Increase Level of Service along the Corridor.

1.2 Existing Junctions along the Project Corridor

The following Junctions are present along the Project Corridor.

- Hosur Luskar Road Junction – Three Arm ('T' Shaped) Junction.
- Hosur Road – Bannerghatta Road Junction – Three Arm ('Y' Shaped) Junction.
- New Mico Road Junction – Three Arm ('T' Shaped) Junction.
- Dairy Circle – Four Arm Junction.
- Swagath Road – Bannerghatta Road Junction – Three Arm ('T' Shaped) Junction.
- Jayadeva Hospital Junction – Four Arm Junction.
- Sarakki Road – Bannerghatta Road Junction – Three Arm ('T' Shaped) Junction.
- Outer Ring Road – Bannerghatta Road Junction – Three Arm ('Y' Shaped) Junction.
- Bilekahalli Road Junction – Three Arm ('T' Shaped) Junction.
- Arakere Road Junction– Four Arm Junction.
- Hulimavu Road Junction – Three Arm ('T' Shaped) Junction.
- Hulimavu Gate Junction – Three Arm ('T' Shaped) Junction.

1.3 Junctions proposed for Improvements

The following Junctions have been taken for the proposed Improvements.

- Outer Ring Road – Bannerghatta Road Junction.
- Bilekahalli Road Junction.
- Arakere Road Junction.
- Hulimavu Road Junction.
- Hulimavu Gate Junction.

Key Map of the Project Corridor proposed for Improvements is enclosed in **Annexure A.1.1**.

1.4 Contents of the Report

The Methodology, as detailed in the Project Proposal, has been followed for carrying out the necessary Investigations and Preparation of this Detailed Project Report.

This Report includes the following.

- Chapter 2: Objectives and Scope of Study
- Chapter 3: Study Corridor
- Chapter 4: Field Studies and Analysis
- Chapter 5: Planning and Design Considerations
- Chapter 6: Corridor Improvement Scheme
- Chapter 7: Design of Grade Separator
- Chapter 8: Traffic Management / Diversion and Traffic Engineering Schemes
- Chapter 9: Project Cost
- Chapter 10: Implementation Plan
- Chapter 11 Conclusion
- Chapter 12: Photographs
- Chapter 13: Drawings

CHAPTER 2
OBJECTIVES AND SCOPE OF STUDY

2.1 Objectives

The Project has been taken up to address the Traffic related Problems on the Project Corridor. The Study Area spans from Hosur Luskar Road Junction to Hulimavu Gate Road Junction along Bannerghatta Road. This Stretch has been selected primarily keeping in mind that this Stretch acts as a Radial Road in Southern Part of Bangalore City and connects the Central Business District with Bannerghatta. The Study Area caters to considerable local and through amount of traffic especially at peak hours due to the traffic that plies to the Central Parts of Bangalore and also towards Bannerghatta Road (SH – 48). Further, being a parallel Road to NH – 7 and Kanakapura Road, this Corridor acts as a link between National Highways.

The Primary Objectives of the Study are

- To effectively and optimally manage Traffic on the Corridor.
- To conduct necessary Surveys and Investigations to arrive at Alignment Alternatives for Traffic Improvement along the Corridor.
- To suggest Optimal and Feasible Grade Separation Schemes and Appurtenant Link Improvement Measures to reduce travel time.
- To improve the existing Junctions to streamline Traffic Flow at Grade Level.
- To improve the Environmental Conditions of the Corridor by reducing Idle Time.
- To reduce the Vehicle Operation Cost of the Road Users.
- To reduce Traffic Accidents.

To summarise, the Main Objective of the Study of this Corridor is to offer to the Road Users commuting through this Corridor Comprehensive Connectivity, Convenience, Comfort, Affordability, Safety and Aesthetics.

2.2 Project Scope

The Scope of the Study to be carried out by the Consultant involves the following.

- Review of Available Data and Reports.
- Topographical Survey of the Corridor.
- Necessary Traffic Survey to obtain Data and its Analysis for the Concept Proposal.
- Geotechnical Investigation.
- Work out Traffic Management / Diversion and Traffic Engineering Schemes during Project Execution.
- Work out Land Acquisition Details.
- Engineering Designs along with Detailed Estimate of the approved Concept.
- Project Scheduling.
- Preparation of Bid Documents to finalise Execution Agency.

2.3 Approach Methodology

The Activities that are involved in the Preparation of Detailed Project Report for Signal Free Corridor from Hosur Luskar Road Junction to Hulimavu Gate Junction along Bannerghatta Road are briefed below.

2.3.1 Stage 1

- To define the Objective and Scope of Work.
- To plan Approach and Methodology, Data Collection.
- Carry out Field Reconnaissance Survey that includes Site Appreciation, Identification of Survey Locations and Site Constraints.

2.3.2 Stage 2

- Data Collection
  - Engineering Surveys and Investigations
    1. Classified Turning Traffic Volume Survey.
    2. Origin Destination Survey.
    3. Vehicular Delay and Accumulation Survey.
    4. Occupancy Survey.
    5. Topographic Survey.
    6. Geotechnical Investigation.
  - Secondary Data
    1. Economic Indicators affecting Traffic Growth.
    2. Past Accident Data.
    3. Details of on going Road Improvements, Junction Improvements, Grade Separator Schemes, Footpath Improvement Schemes and Metro Rail Alignment along the Project Stretch.

- Analysis of Traffic Volume Count in deciding the Alignment of Grade Separation Scheme and other Corridor Improvement Schemes.
- Analysis of Surface Level Improvements based on the Traffic Data and Proposed Grade Separation Scheme.
- Analysis of Traffic Circulation at Surface Level on Proposed Scheme.
- Design suitable Traffic Improvement Measures to reduce Conflicting Traffic Stream.
- Preparation of Layout Drawings and Longitudinal Sections of all the Proposals conceptualized.
- Work out Land Acquisition Details, if any, for the Proposed Alternatives.
- Costing based on Block / Line Estimate.
- Analysis of Traffic Diversion and Management Scheme during Project Execution.

2.3.3 Stage 3

- Engineering Designs, Drawings and Longitudinal Sections of the Approved Concept.
- Land Acquisition Details for the Approved Concept.
- Detailed Cost Estimate.
- Traffic Diversion and Management Scheme during project execution.

2.3.4 Stage 4

- Preparation of Tender and Contract Documents.

2.4 Design Philosophy

The Design Standards that will be adopted in the Design of Corridor Improvement Schemes shall be in accordance with the Codal Provisions of India as stipulated by the

Indian Road Congress (IRC), Indian Standard Specifications (IS) and the Ministry of Road Transport & Highways (MoRT&H). Deviations may be considered in planning parameters, if absolutely necessary, considering the Dense Urban Conditions from the present Codal Provisions. These Modifications in the Design shall be adopted based on Sound Engineering Practices.

The Designs and Drawings of the Approved Concept that will be presented as part of the Detailed Project Report shall be based on the Studies and Investigations carried out at site, i.e. Traffic Data, Existing Utilities, Geotechnical Data, Soil Profile, etc.

CHAPTER 3
STUDY CORRIDOR

3.1 Study Corridor

The Study Corridor is located in the South Quadrant of Bangalore City and connects Hosur Road (NH – 7) on the Northern Side with Bannerghatta Road (State Highway – 86A) on the Southern Side. It starts from Hosur Luskar Road Junction and ends at Hulimavu Gate Junction on Bannerghatta Road.

3.2 Salient Features of the Corridor

1. Total Length of the Corridor – 10 km.
2. Important Junctions along the Corridor
   - Hosur Luskar Road Junction – Three Arm ('T' Shaped) Junction.
   - Hosur Road – Bannerghatta Road Junction – Three Arm ('Y' Shaped) Junction.
   - New Mico Road Junction – Three Arm ('T' Shaped) Junction.
   - Dairy Circle – Four Arm Junction.
   - Swagath Road – Bannerghatta Road Junction – Three Arm ('T' Shaped) Junction.
   - Jayadeva Hospital Junction – Four Arm Junction.
   - Sarakki Road – Bannerghatta Road Junction – Three Arm ('T' Shaped) Junction.
   - Outer Ring Road – Bannerghatta Road Junction – Three Arm ('Y' Shaped) Junction.
   - Bilekahalli Road Junction – Three Arm ('T' Shaped) Junction.
   - Arakere Road Junction– Four Arm Junction.
   - Hulimavu Road Junction – Three Arm ('T' Shaped) Junction.
   - Hulimavu Gate Junction – Three Arm ('T' Shaped) Junction

   Key Map of the Study Corridor is enclosed in **Annexure A.1.1** and the Existing Views of the Junctions are enclosed in **Chapter 12 – Photographs**.

3. Two Way Movements with at least four lane are seen along this Corridor. Some Stretches are wider with Road Divider. Footpath is present on either side throughout the Corridor.
4. The Study Area caters to considerable local and through amount of outside traffic commuting between City Centre and SH – 86A. Further, being a parallel Road to NH – 7 and Kanakapura Road, this Corridor acts as a link between National Highways.
5. With the setting up of Software Companies like Infosys, Wipro Systems, Oracle, IBM, Accenture, Adobe Systems India Pvt. Ltd., Honeywell Technology Solutions Lab, BPL Software Centre, etc. along the Project Corridor, the growth of the techno polis has led to increase in traffic. The traffic originating from the various quarters of the City passes through this Corridor to reach Bannerghatta, Arakere, Bilekahalli. Further, many large Residential Sites have been / are being converted into Apartments / Flats along this Corridor and a site that would house either a family or two now will be able to house multiple number of families and with this the number of Vehicle / Traffic also has increased manifold.
6. The Study Area is located in Thickly Developed Residential and Commercial Area and is surrounded by some of the well known establishments like Bangalore Dairy, Forum

Mall, Sagar Apollo Hospital, Jayadeva Institute of Cardiology, Indian Institute of Management, Shoppers' Stop Mall, Wockhardt Hospital, Meenakshi Temple, Bannerghatta Biological Park, etc.

7. The Local Public Transportation is primarily being met by the Bangalore Metropolitan Transport Corporation (BMTC), originating at Majestic Bus Stand, Banashankari Bus Stand, Indira Nagar Bus Stand and Kalasipalya Bus Stand, Shivaji Nagar Bus Stand and destined to Wilson Garden, Koramangala, Jayanagar, Adugodi, Banashankari, JP Nagar, BTM Layout, Marathalli, MICO Layout, Bannerghatta.
8. This Corridor caters to the movement of heavy commercial traffic moving via Bangalore to other part of National Highways.
9. The Study Corridor interfaces with Hosur Road (NH – 7) at Hosur Luskar Road Junction, Bannerghatta Road (SH – 86A) near Hosur Road Christian Cemetery, Outer Ring Road at Jayadeva Hospital Junction and near JP Nagar, NICE Road near Gottigere.

3.3 Junction Details

3.3.1 Outer Ring Road – Bannerghatta Road Junction

3.3.1.1 Physical Details

Outer Ring Road – Bannerghatta Road Junction is one of the most important and busiest Junctions on the Outer Ring Road in Southern Part of Bangalore City and is 1km away from the Jayadeva Hospital. This is a three legged ('Y' Shaped) Intersection. The Details of the Arms forming this Intersection are as follows.

Arm towards J. P. Nagar Side of the Intersection

This part of the Road is divided bi directional with 1m wide Central Median. The Width of Carriageway of this Arm varies between 17m and 18.5m near the Junction whereas the ROW of this Road varies between 30m and 31m. The Gradient is slopping away from the Junction. Well Developed Commercial and Residential Establishments, a Temple very close to the Junction are present on this Stretch of Road.

Arm towards Jayadeva Hospital Side of the Intersection

This part of the Road is divided bi directional with 0.3m wide Central Median. The Width of Carriageway of this Arm varies between 17m and 20m near the Junction whereas the ROW of this Road varies between 36.35m and 44.5m. The Gradient is slopping towards the Junction. This stretch of Road passes through Major Residential and Commercial Establishment with Well Established Temples on both the sides.

Arm towards Bannerghatta Road Side of the Intersection

This part of the Road is divided bi directional with 1.5m wide Central Median. The Width of Carriageway of this Arm varies between 16.5m and 18m near the Junction whereas the ROW of this Road varies between 20.6m and 24.5m. The Gradient is slopping away from the Junction. Either side of this stretch is populated with Thick Residential and Commercial Establishments.

3.3.1.2 Existing Traffic Regulations

Two directional movements are permitted in all the three arms of the Junction. It is permitted to move from each arm towards all other two arms in the Junction.

3.3.1.3 Constraints

- BESCOM Lines are present along all the three arms near the Junction and close to ROW.
- Transformer is present near the Junction on Ring Road Axis.
- Well Established Temples are present along all the three arms near the Junction.

3.3.2 Bilekahalli Road Junction

3.3.2.1 Physical Details

This Junction is located at about 600m away from the Outer Ring Road – Bannerghatta Road Junction. This is a typical three legged ('T' Shaped) Intersection. The Details of the Arms forming this Intersection are as follows.

Arm towards Outer Ring Road – Bannerghatta Road Junction Side of the Intersection

This part of the Road is divided bi directional with 1.3m wide Central Median. The Width of Carriageway of this Arm varies between 16m and 17m near the Junction whereas the ROW of this Road varies between 24m and 25m. The Gradient is slopping away from the Junction. Either side of this Stretch is thickly populated with Residential and Commercial Establishments.

Arm towards Arakere Road Junction Side of the Intersection

This part of the Road is divided bi directional with 1.2m wide Central Median. The Width of Carriageway of this Arm varies between 17.5m and 20m near the Junction whereas the ROW of this Road varies between 26m and 31m. The Gradient is slopping towards the Junction. Either side of this Stretch passes through thickly developed Residential and Commercial Establishments.

Arm towards Bilekahalli Road Junction

This part of the Road is undivided bi directional. The Width of Carriageway of this Arm varies between 6m and 8m near the Junction whereas the ROW of this Road varies between 9m and 10m. The ground profile is almost level towards the Junction. Well Developed Residential and Commercial Establishments are present on either side of this Stretch of Road.

3.3.2.2 Existing Traffic Regulations

Two directional movements are permitted in all the three arms of the Junction. It is permitted to move from each arm towards all other two arms in the Junction. The Flow of Vehicles is controlled by Automated Traffic Signal manned with Traffic Police Personnel.

3.3.3 Arakere Road Junction

3.3.3.1 Physical Details

This Junction is located at about 1.3 km away from the Bilekahalli Road Junction. This is a typical four legged intersection. The Details of the Arms forming this Intersection are as follows.

Arm towards Bilekahalli Road Junction Side of the Intersection

This part of the Road is divided bi directional with 1m wide Central Median. The Width of Carriageway of this Arm varies between 19m and 20m near the Junction whereas the ROW of this Road varies between 24m and 28m. The Gradient is slopping away from the Junction. Either side of this Stretch is populated with Residential and Commercial Establishments.

Arm towards Arakere Road Side of the Intersection

This part of the Road is undivided bi directional. The Width of Carriageway of this Arm varies between 6.5m and 8m near the Junction whereas the ROW of this Road varies between 12m and 14m. The Gradient is slopping away from the Junction. Either side of this Stretch is populated with Residential and Commercial Establishments.

Arm towards Hulimavu Road Junction Side of the Intersection

This part of the Road is divided bi directional with 1.2m wide Central Median. The Width of Carriageway of this Arm varies between 19m and 20m near the Junction whereas the ROW of this Road varies between 27m and 30m. The Gradient is slopping away from the Junction. Thickly Developed Residential and Commercial Establishments are present on either side of this Stretch of Road.

Arm towards Puttenahalli Side of the Intersection

This part of the Road is undivided bi directional. The Width of Carriageway of this Arm varies between 8m and 9m near the Junction whereas the ROW of this Road varies between 10m and 12m. The Gradient is sloping towards the Junction. This Arm passes through thickly populated Residential and Commercial Establishments on either side.

3.3.3.2 Existing Traffic Regulations

Two directional movements are permitted along all the four arms of the Junction. It is permitted to move from each arm towards all other three arms in the Junction. The Flow of Vehicles is controlled by Automated Traffic Signal manned with Traffic Police Personnel.

3.3.4 Hulimavu Road Junction

3.3.4.1 Physical Details

This Junction is located at about 1.3 km away from the Arakere Road Junction. This is a typical three legged ('T' Shaped) Intersection. The Details of the Arms forming this Intersection are as follows.

Arm towards Arakere Road Junction Side of the Intersection

This part of the Road is divided bi directional with 1.3m wide Central Median. The Width of Carriageway of this Arm varies between 16m and 18m near the Junction whereas the ROW of this Road varies between 24m and 25m. The Gradient is slopping towards the Junction. Either side of this Stretch is populated with Residential and Commercial Establishments.

Arm towards Hulimavu Road Side of the Intersection

This part of the Road is undivided bi directional. The Width of Carriageway of this Arm varies between 9.5m and 10.5m near the Junction whereas the ROW of this Road varies between 18m and 21m. The Gradient is slopping away from the Junction. Either side of this Stretch is populated with Commercial Establishments.

Arm towards Hulimavu Gate Junction Side of the Intersection

This part of the Road is divided bi directional with 1.2m wide Central Median. The Width of Carriageway of this Arm varies between 16m and 17m near the Junction whereas the ROW of this Road varies between 25m and 27m. The Gradient is sloping away from the Junction. Either side of this Stretch is populated with Residential and Commercial Establishments.

3.3.4.2 Existing Traffic Regulations

Two directional movements are permitted in all the three arms of the Junction. It is permitted to move from each arm towards all other two arms in the Junction. The Flow of Vehicles is controlled by Automated Traffic Signal manned with Traffic Police Personnel.

3.3.5 Hulimavu Gate Junction

3.3.5.1 Physical Details

This Junction is located at about 300m away from the Hulimavu Road Junction. This is a typical three legged ('T' Shaped) Intersection. The Details of the Arms forming this Intersection are as follows.

Arm towards Hulimavu Road Junction Side of the Intersection

This part of the Road is divided bi directional with 1.2m wide Central Median. The Width of Carriageway of this Arm varies between 16m and 17.5m near the Junction whereas the ROW of this Road varies between 23m and 28m. The Gradient is slopping away from the Junction. Either side of this Stretch is populated with Residential and Commercial Establishments.

Arm towards Hulimavu Gate Side of the Intersection

This part of the Road is undivided bi directional. The Width of Carriageway of this Arm varies between 7.5m and 8.5m near the Junction whereas the ROW of this Road varies between 17m and 18m. The Gradient is slopping away from the Junction. Either side of this Stretch is populated with Commercial Establishments.

Arm towards Bannerghatta Side of the Intersection

This part of the Road is divided bi directional with 1.2m wide Central Median. The Width of Carriageway of this Arm varies between 16m and 17.5m near the Junction whereas the ROW of this Road varies between 22m and 24m. The Gradient is uniform towards the Junction. Either side of this Stretch is populated with Residential and Commercial Establishments.

3.3.5.2 Existing Traffic Regulations

Two directional movements are permitted in all the three arms of the Junction. It is permitted to move from each arm towards all other two arms in the Junction. The Flow of Vehicles is controlled by Automated Traffic Signal manned with Traffic Police Personnel.

Topographical Maps of all the Junctions are enclosed in Chapter 13 – Drawings.

Existing Vehicle Turning Movements at the Junctions are enclosed in Annexure A.3.1.

Existing Views of the Junctions are enclosed in Chapter 12 – Photographs.

3.4 Street Lighting Pattern

Road Side Street Lighting Arrangement along the Project Stretch is not adequate. Provision for the same will be incorporated in the Corridor Improvement Scheme.

3.4 Bus Stops

The presence of Bus Stops in the Carriageway on the Intersecting Arms of the Junctions hinders the smooth Traffic Movement along the Intersecting Arms of the Junctions.

3.6 Pedestrian Movement

The presence of Bus Stops, Well Developed Commercial Areas, Institutional Buildings, Hospitals, Recreational Facilities and their related activities in the vicinity of the Junctions leads to hazardous movement pattern of the Pedestrians across the Road, thus reducing the Safety Aspects. Further, presence of Trees and other Utilities, Commercial Activities on the Footpath reduces the Effective Width of the Footpath and in turn obstructs the Pedestrian Movement.

3.7 Scope for Improvement

The Project Corridor does not have the uniform width. Footpath Width is also not uniform. Footpaths are wide at some locations where pedestrian movements are very less, while Footpaths are highly insufficient at some locations. Bus Movement is high along this Corridor. The need for Bus Bays is very essential at some Critical Locations such as near Outer Ring Road – Bannerghatta Road Junction, Hulimavu Junction, etc. Service Road is also very much essential near thickly developed Residential Areas.

Land Acquisition is a major issue along this Corridor. Due to the Land Constraint, the Corridor Improvement Scheme has been limited to only the above mentioned 5 Junctions by proposing Grade Separator using Pre Cast Element Technology at Major Junctions and closing of Median at Minor Junctions. BBMP has proposed to widen the Stretch from

Outer Ring Road Junction – Bannerghatta Road Junction to Hulimavu Gate Junction by 45m and then to take up the Junction Improvements along with 3m wide Footpath on either side throughout the Stretch. Other Proposals such as Improvement to Drainage System; Provision of Effective Illumination, etc. can be accommodated in the Project Proposal.

CHAPTER 4
FIELD STUDIES AND ANALYSIS

4.1 General

This chapter presents the various Studies (Reconnaissance Survey, Traffic Survey, Topographical Survey, Geotechnical Investigation, etc.) and thereafter the Data, obtained as a Result of these Studies, Analysis carried out by the Consultant. The Results of Analysis form Inputs for Planning and Design of Proposed Corridor Improvement Scheme, Traffic Forecast and Economic Analysis.

4.2 Reconnaissance Survey

Reconnaissance Survey has been carried out along the Corridor and at the Junctions and the Physical Characteristics of the Corridor and Junctions such as Road Geometrics, Pavement Structure, Traffic Controls (Signs, Signals, Road Markings and Parking Restrictions), Side Walks, Shoulders, Adjacent Land Use, Service Lines (For Example Water, Electricity, Telephone), Storm Water Drains and the Intensity of Non – Traffic Activities, which encroach upon Road Space (such as Hawkers, Builder's Materials, Market Stalls, etc.) have been studied. The Data recorded have been detailed out in **Chapter 3 – Study Corridor**.

4.3 Traffic Surveys

To establish the Vehicular Traffic Flow Characteristics such as Hourly variation, Composition, Peak Hour Flows along the Corridor and at the Junctions, Turning Movement Survey of Vehicles at Junctions has been conducted.

4.3.1 Methodology for Traffic Surveys

4.3.1.1 Turning Movement Survey of Vehicles at Junctions

24 hours Manual Traffic Counts have been conducted to cover all the Vehicular Movements at the Junction. The Vehicle Classification System adopted for the Study is given in **Table 4.1**.

Table 4.1
Vehicle Classification System

Motorised Traffic		Non – Motorised Traffic
2 – Wheelers, Auto Rickshaw, Passenger Car: Car, Taxi and Jeep		Bicycle, Cycle Rickshaw, Animal Drawn Vehicle, Hand Drawn Cart
Utility Vehicle: Van and Tempo		
Bus	Mini Bus Standard Bus	
Truck	Light Commercial Vehicle (LCV)	
	Heavy Commercial Vehicle (HCV)	
Farm Vehicle	Agricultural Tractor (AgT)	
	Agricultural Tractor & Trailer (AgTT)	

The Turning Movement Survey has been conducted to obtain Information on Mode wise and Direction wise Turning Movement of Traffic at the Intersection. The Survey has been conducted for 24 hours (0600 hrs. to 0600 hrs.) covering morning and evening peak hours.

Traffic Counting has been carried out manually in two twelve – hour shifts by trained enumerators, using hand tally. The Count Data have been recorded at 15 minute intervals using hand tallies and total per hour for each vehicle category has been computed. The Traffic Volume Count Data has been processed using the commonly used Spreadsheet Package. The processed Hourly Traffic Volume Data has been compiled Direction wise.

The Peak Hourly Directional Vehicular Movement Data has been used to plan and design the Improvement Scheme such as Grade Separation and At Grade Intersections with Traffic Signals.

4.4 Analysis of Traffic Study Data

The Data and Pertinent Information collected from the Traffic Surveys have been analysed using the Utility Software Packages (MS – EXCEL) to obtain the required Information concerning Traffic Characteristics at the Intersections in the Corridor. Findings and the brief Discussions thereon are presented in this Section.

4.4.1 Analysis of Turning Movement Count Data

Data have been processed on quarter hourly basis to establish the most appropriate Peak Hours. Data collected from Surveys have been computerised and analysed to study Hourly Variation of Traffic, Peak Hour Flows, Traffic Composition, etc. and are presented Junction wise below. The Counts have been classified by Category of Vehicles and by Direction of Movement. The various Vehicle Types having different Sizes and Characteristics have been converted into Equivalent Passenger Car Units. The Passenger Car Unit (PCU) Factors recommended by Indian Road Congress in “Guidelines for Capacity of Urban Roads in Plain Areas” (IRC: 106 – 1990) have been used. The same are detailed in **Table 4.2**.

Table 4.2

Recommended PCU Factors for Various Types of Vehicles in Urban Roads

Sl. No.	Vehicle Type	Equivalent PCU Factors	
		% Composition of Vehicle Type	
		Up to 10%	10% and above
A	Fast Vehicles		
1	Two wheelers, Motorcycle or Scooter, etc.	0.5	0.75
2	Passenger car, Pick – up Van	1.0	1.0
3	Auto Rickshaw	1.2	2.0
4	Light Commercial Vehicle	1.4	2.0
5	Truck or Bus	2.2	3.7
6	Agricultural Tractor Trailer	4.0	5.0
B	Slow Vehicles		

1	Cycle	0.4	0.5
2	Cycle Rickshaw	1.5	2.0
3	Tonga (Horse drawn vehicle)	1.5	2.0
4	Hand Cart	2.0	3.0

(Source: IRC: 106 – 1990)

4.5 Outer Ring Road – Bannerghatta Road Junction

4.5.1 Hourly Variation of Traffic

Hourly Variation of Traffic Flow is presented in **Fig. 4.1**. The Hourly Traffic Volume observed at the Junction varied in the range of 698 – 10889 PCUPH (Passenger Car Unit per Hour). Peak Hour Flows are observed during 0900 – 1000 hrs. in the morning (9687 PCU) and 1800 – 1900 hrs. in the evening (10889 PCU). This Junction handles more than 5750 PCU / hr. for most part of the day (0800 – 2000 hrs.). This is due to prolonged congestion, which has "forced" the Peak Hour Flows over several hours giving Near Peak Flow for more periods of the day. The Detailed Direction wise Traffic Flow at Outer Ring Road – Bannerghatta Road Junction is given in **Annexure A.4.1**.

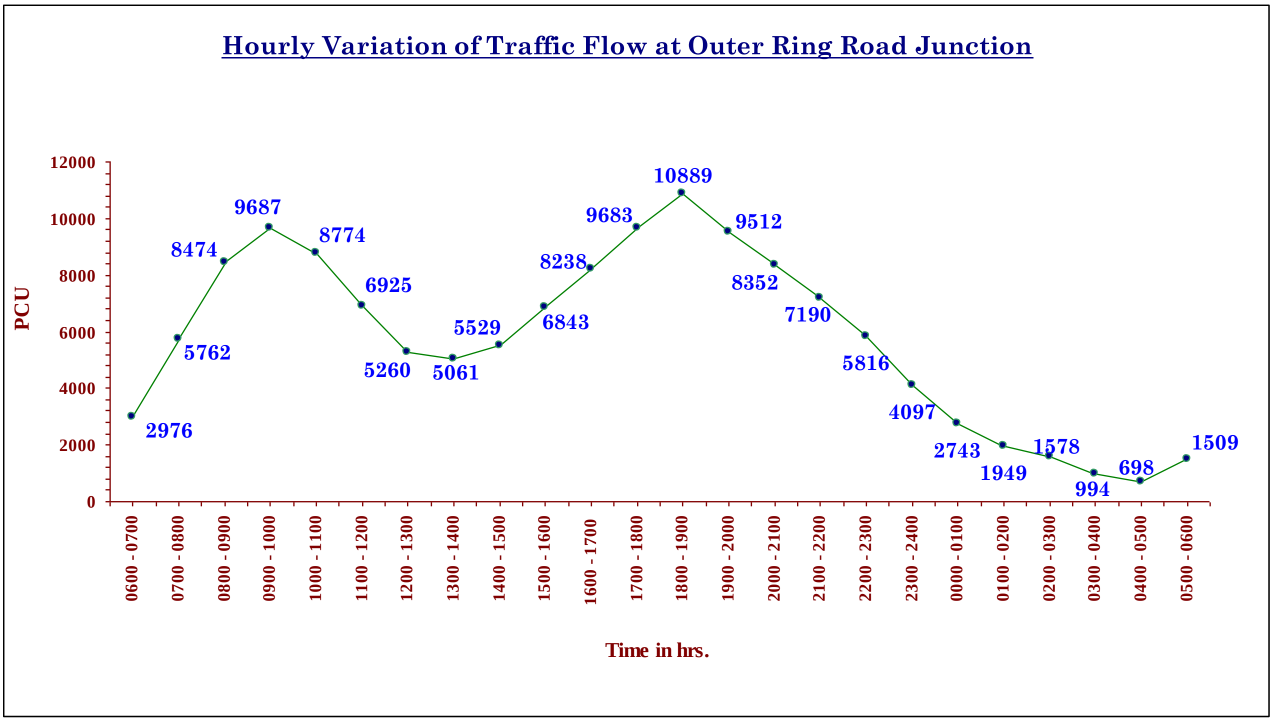

Fig. 4.1

4.5.2 Direction wise Traffic

Peak Hour Direction wise Flow is presented in **Fig. 4.2** for Outer Ring Road – Bannerghatta Road Junction. The major flow is along Bannerghatta Road in which current Peak Hour Flow is 5358 PCU, which amounts to 49.2% of Junction Volume.

4.5.3 Traffic Composition

Composition of Traffic (on 24 hour basis) has been observed at Outer Ring Road – Bannerghatta Road Junction and is shown in **Fig. 4.3**. Share of Two Wheelers is high

(31.55%). The Analysis of Composition of Vehicles in the Traffic Stream at the Junction brings out the following.

- **Passenger Vehicle Category:** Two Wheelers along with Cars / Taxi / Jeep constitute 57.95% while Buses account for 5.20%.
- **Freight Vehicle Category:** LCV constitutes 2.43%.
- **Non Motorised Vehicle Category:** Cycle constitutes 0.61%.

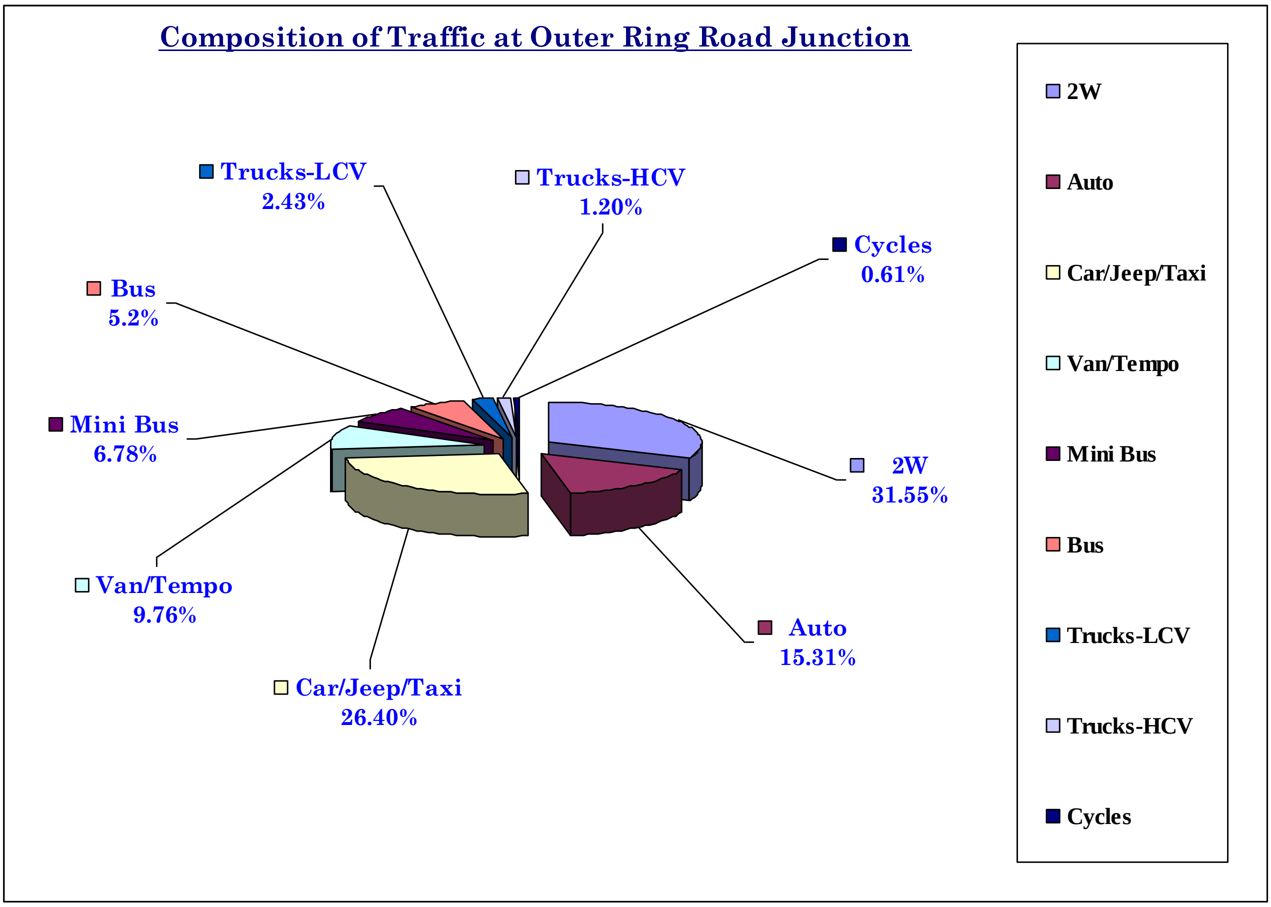

Fig. 4.3

4.6 Bilekahalli Road Junction

4.6.1 Hourly Variation of Traffic

Hourly Variation of Traffic Flow is presented in **Fig. 4.4**. The Hourly Traffic Volume observed at the Junction varied in the range of 432 – 8363 PCUPH (Passenger Car Unit per Hour). Peak Hour Flows are observed during 0900 – 1000 hrs. in the morning (8363 PCU) and 1800 – 1900 hrs. in the evening (8028 PCU). This Junction handles more than 5000 PCU / hr. for most part of the day (0800 – 2000 hrs.). This is due to prolonged congestion, which has "forced" the Peak Hour Flows over several hours giving Near Peak Flow for more periods of the day. The Detailed Direction wise Traffic Flow at Bilekahalli Road Junction is given in **Annexure A.4.2**.

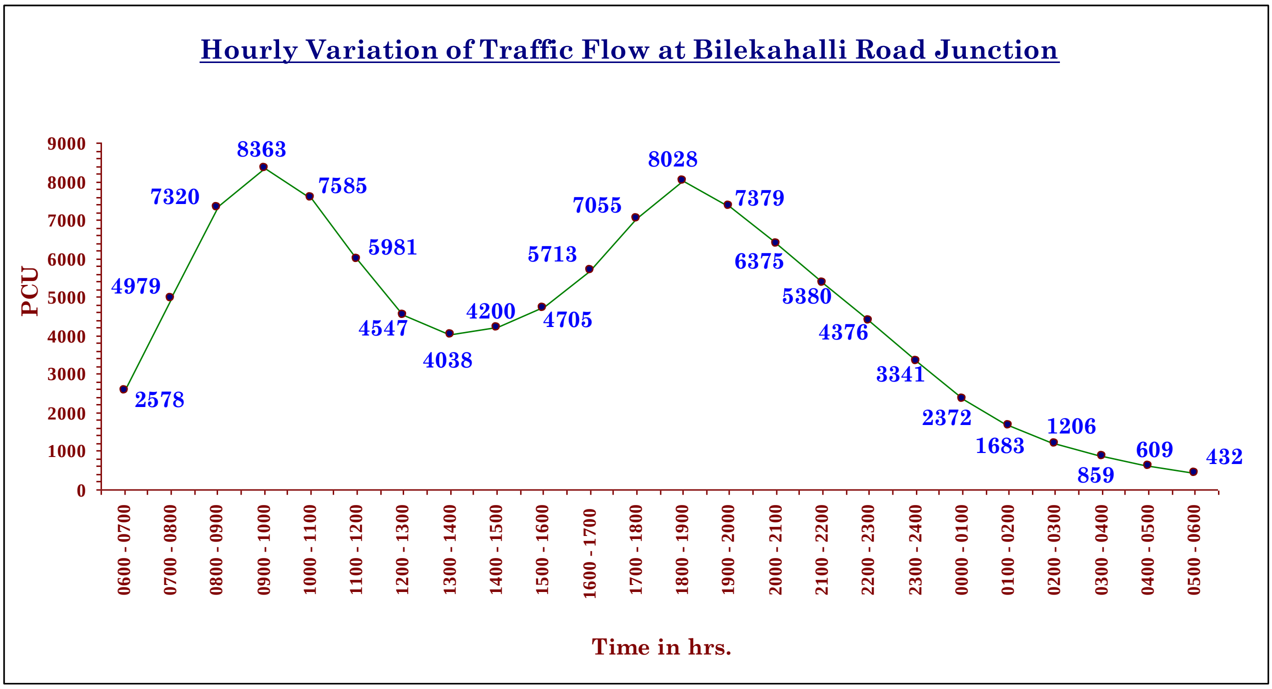

Fig. 4.4

4.6.2 Direction wise Traffic

Peak Hour Direction wise Flow is presented in **Fig. 4.5** for Bilekahalli Road Junction. The major flow is along Bannerghatta Road in which current Peak Hour Flow is 5889 PCU, which amounts to 70.41% of Junction Volume.

4.6.3 Traffic Composition

Composition of Traffic (on 24 hour basis) has been observed at Bilekahalli Road Junction and is shown in **Fig. 4.6**. Share of Two Wheelers is high (31.5%). The Analysis of Composition of Vehicles in the Traffic Stream at the Junction brings out the following.

- **Passenger Vehicle Category:** Two Wheelers along with Cars / Taxi / Jeep constitute 57.32% while Buses account for 5.2%.
- **Freight Vehicle Category:** LCV constitutes 2.19%.
- **Non Motorised Vehicle Category:** Cycle constitutes 0.69%.

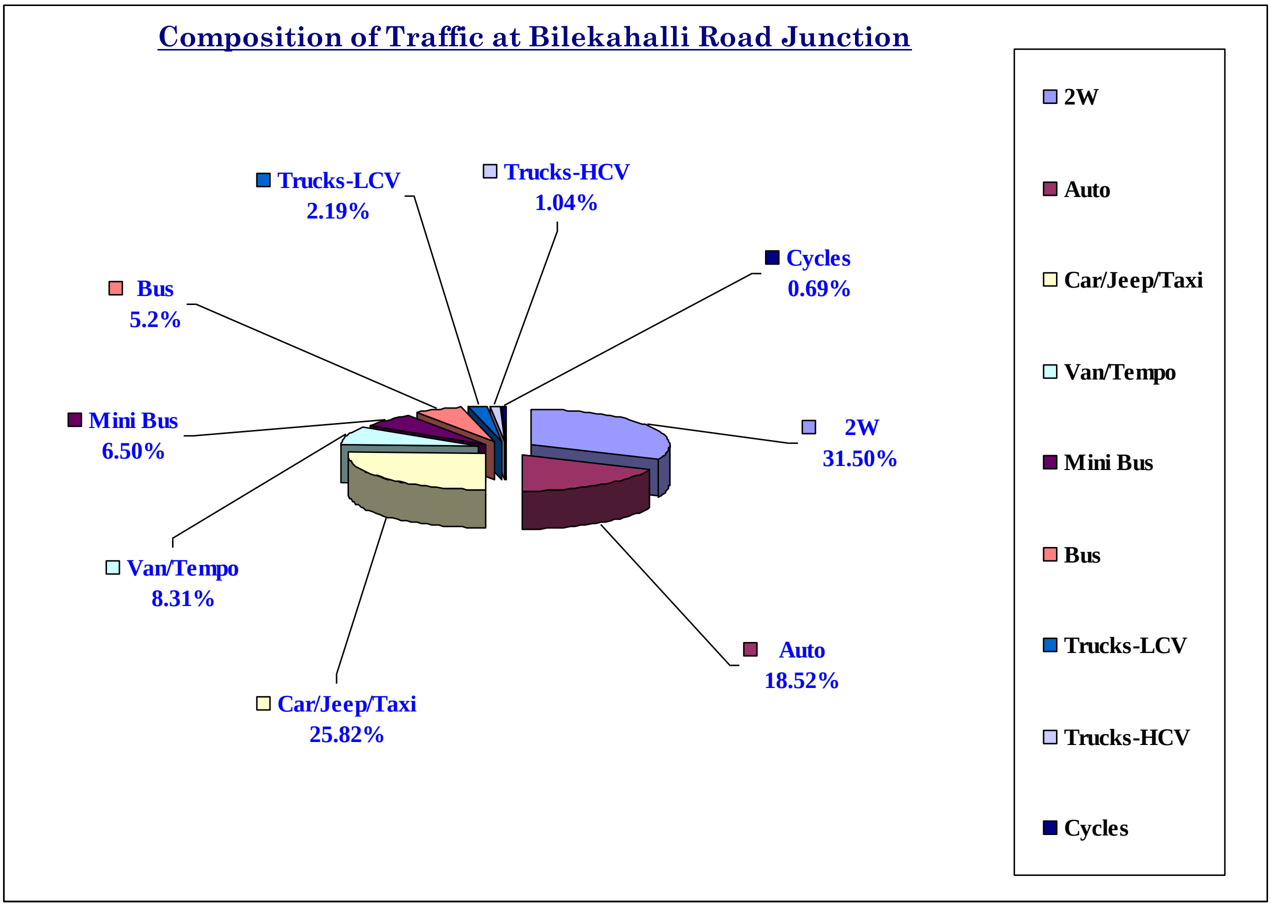

Fig. 4.6

4.7 Arakere Road Junction

4.7.1 Hourly Variation of Traffic

Hourly Variation of Traffic Flow is presented in **Fig. 4.7**. The Hourly Traffic Volume observed at the Junction varied in the range of 446 – 8584 PCUPH (Passenger Car Unit per Hour). Peak Hour Flows are observed during 0900 – 1100 hrs. in the morning (8584 PCU) and 1800 – 1900 hrs. in the evening (8240PCU). This Junction handles more than 5000 PCU / hr. for most part of the day (0800 – 2000 hrs.). This is due to prolonged congestion, which has "forced" the Peak Hour Flows over several hours giving Near Peak Flow for more periods of the day. The Detailed Direction wise Traffic Flow at Arakere Road Junction is given in **Annexure A.4.3**.

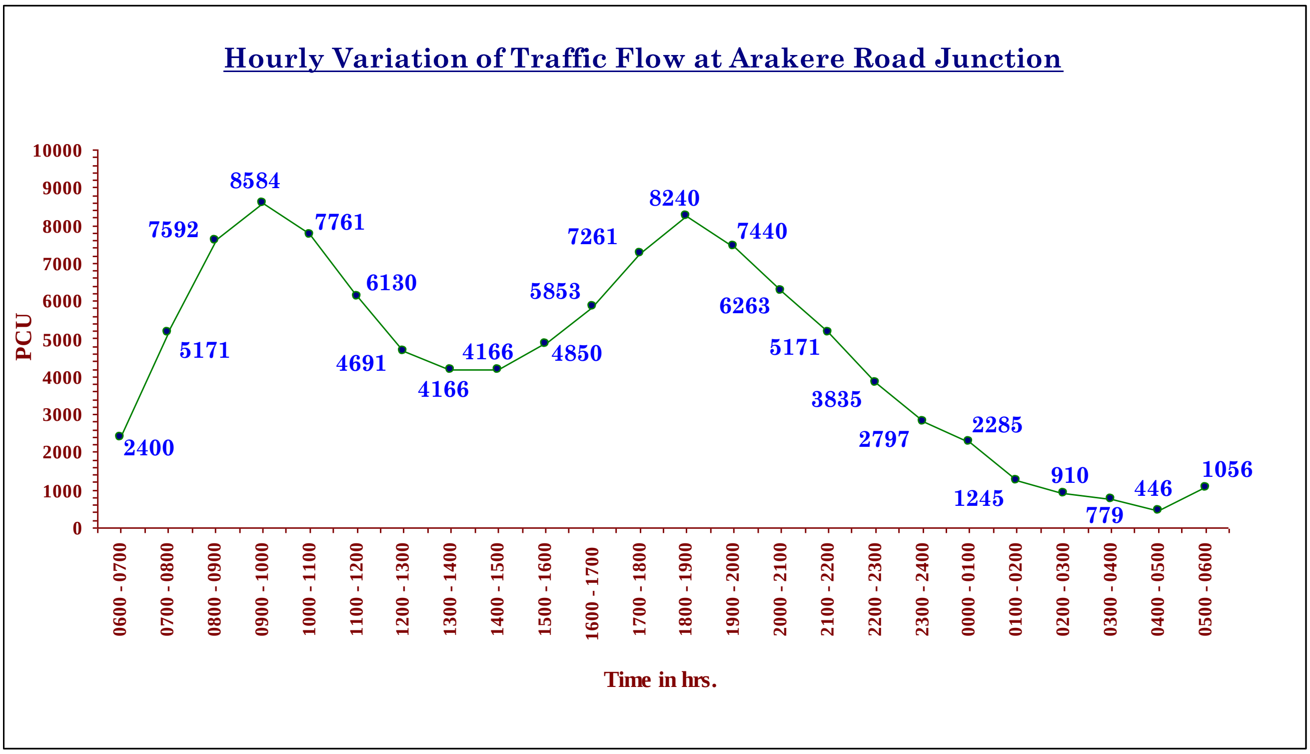

Fig. 4.7

4.7.2 Direction wise Traffic

Peak Hour Direction wise Flow is presented in **Fig. 4.8** for Arakere Road Junction. The major flow is along Bannerghatta Road in which current Peak Hour Flow is 5269 PCU, which amounts to 61.38% of Junction Volume.

4.7.3 Traffic Composition

Composition of Traffic (on 24 hour basis) has been observed at Arakere Road Junction and is shown in **Fig. 4.9**. Share of Two Wheelers is high (37.49%). The Analysis of Composition of Vehicles in the Traffic Stream at the Junction brings out the following.

- **Passenger Vehicle Category:** Two Wheelers along with Cars / Taxi / Jeep constitute 54.65% while Buses account for 4.63%.
- **Freight Vehicle Category:** LCV constitutes 1.36%.
- **Non Motorised Vehicle Category:** Cycle constitutes 0.6%.

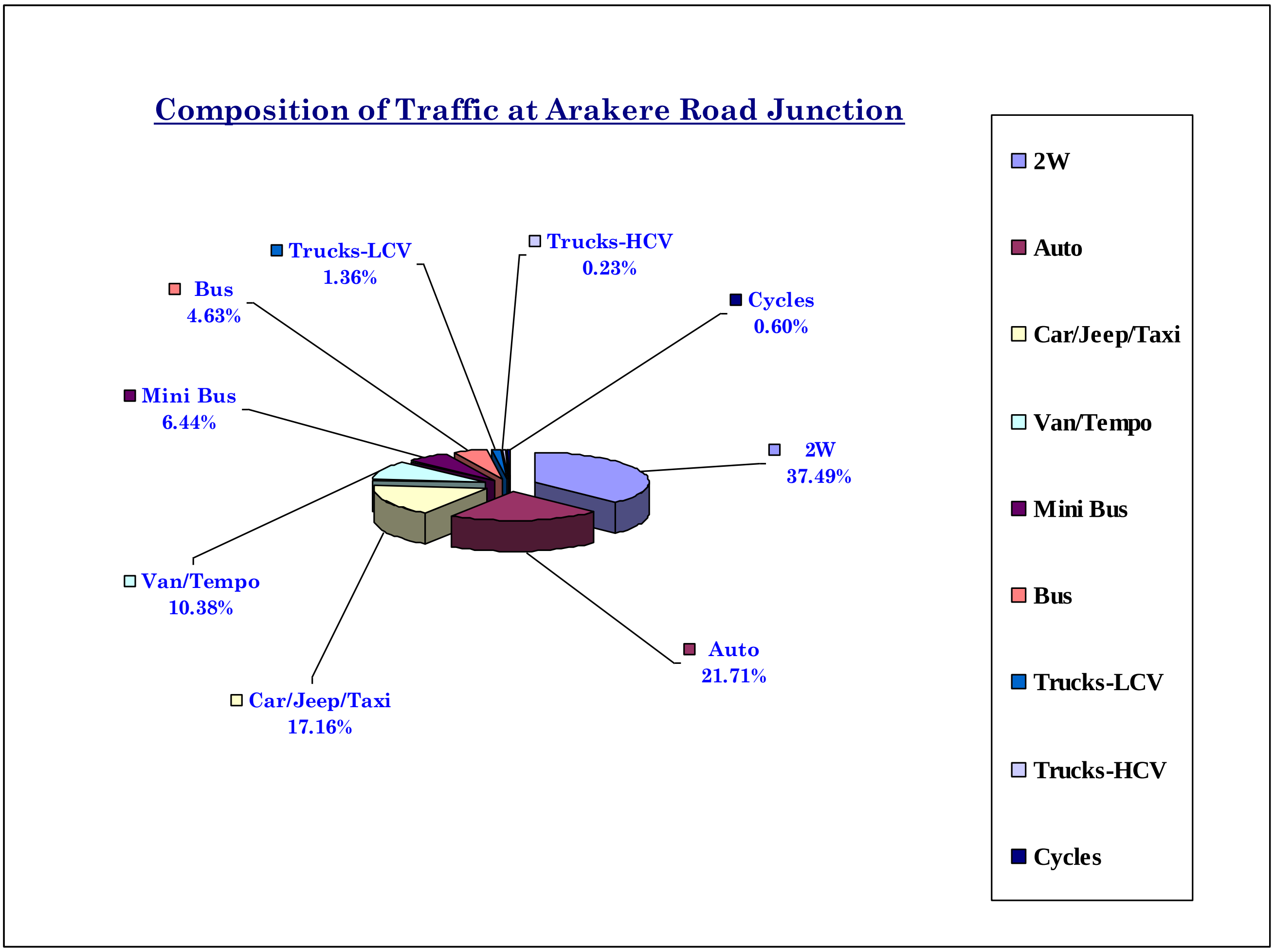

Fig. 4.9

4.8 Hulimavu Road Junction

4.8.1 Hourly Variation of Traffic

Hourly Variation of Traffic Flow is presented in **Fig. 4.10**. The Hourly Traffic Volume observed at the Junction varied in the range of 568 – 7856 PCUPH (Passenger Car Unit per Hour). Peak Hour Flows are observed during 0900 – 1100 hrs. in the morning (7856 PCU) and 1800 – 1900 hrs. in the evening (7539PCU). This Junction handles more than 5000 PCU / hr. for most part of the day (0800 – 2000 hrs.). This is due to prolonged congestion, which has “forced” the Peak Hour Flows over several hours giving Near Peak Flow for more periods of the day. The Detailed Direction wise Traffic Flow at Hulimavu Road Junction is given in **Annexure A.4.4**.

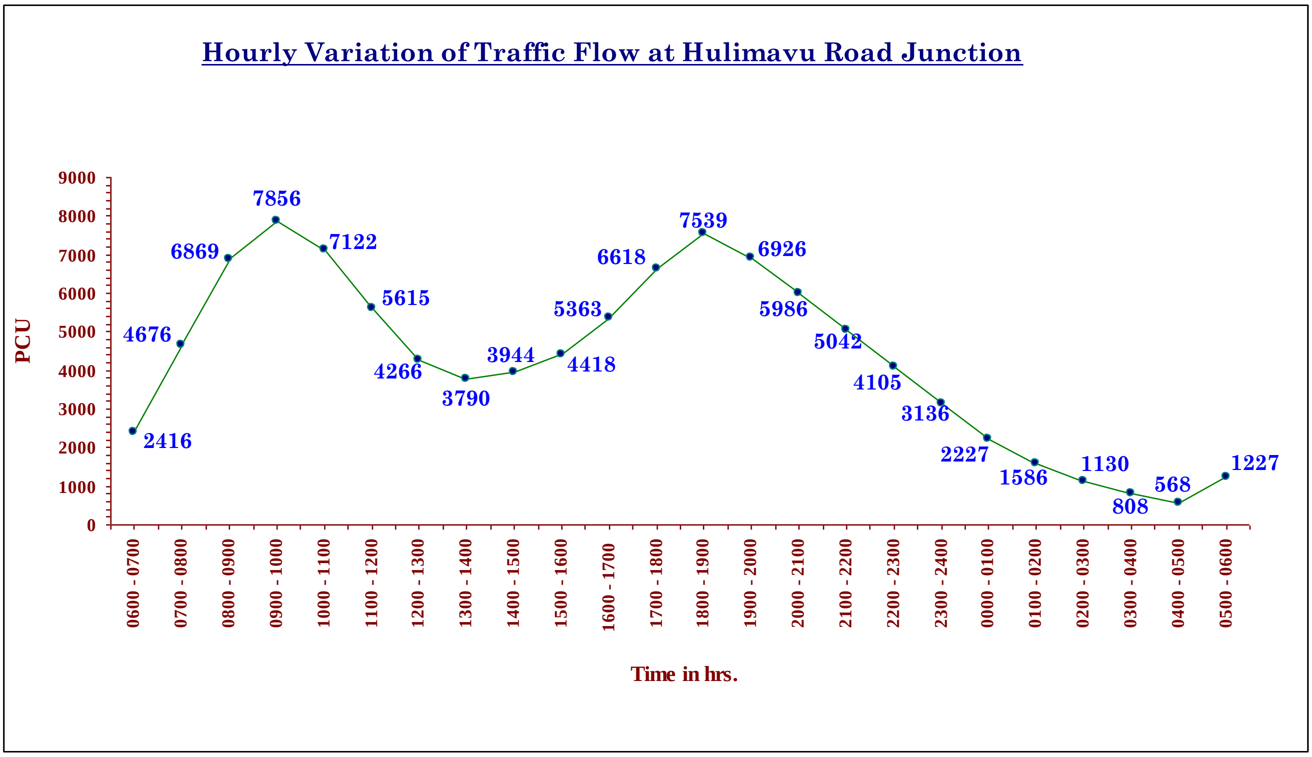

Fig. 4.10

4.8.2 Direction wise Traffic

Peak Hour Direction wise Flow is presented in **Fig. 4.11** for Hulimavu Road Junction. The major flow is along Bannerghatta Road in which current Peak Hour Flow is 5363 PCU, which amounts to 68.26% of Junction Volume.

4.8.3 Traffic Composition

Composition of Traffic (on 24 hour basis) has been observed at Hulimavu Junction. and is shown in **Fig. 4.12**. Share of Two Wheelers is high (32.19%). The Analysis of Composition of Vehicles in the Traffic Stream at the Junction brings out the following.

- **Passenger Vehicle Category:** Two Wheelers along with Cars / Taxi / Jeep constitute 57.19% while Buses account for 5.07%.
- **Freight Vehicle Category:** LCV constitutes 2.15%.
- **Non Motorised Vehicle Category:** Cycle constitutes 0.53%.

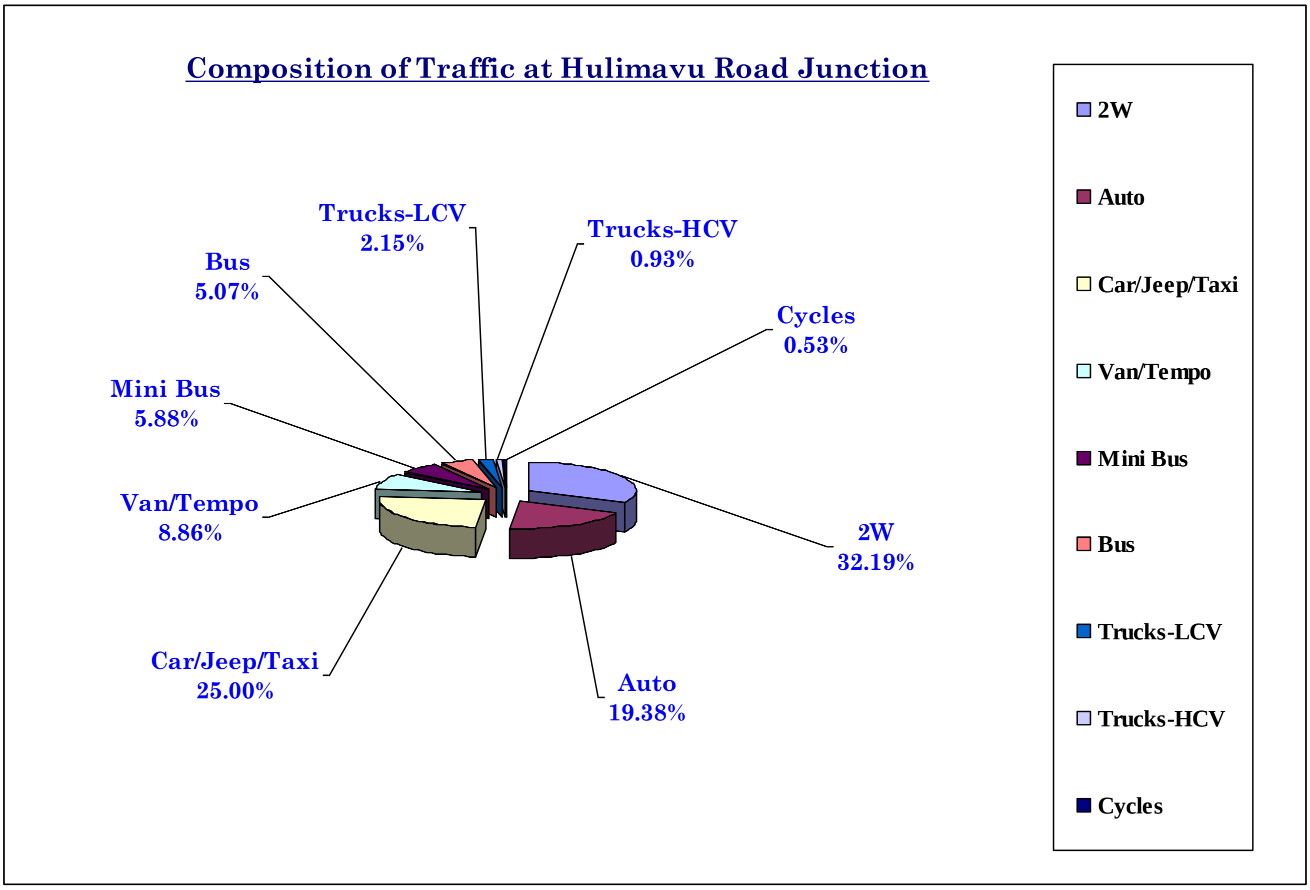

Fig. 4.12

4.9 Topographic Survey

A Comprehensive Topographic Survey has been conducted all along the Corridor using Total Station Equipment to accurately map the Area and obtain the Present Information on Road Width, Adjoining Land Use, Building Offsets and Levelling Data using Auto Level. The GTS Bench Mark has been transferred to the Site by carrying out Fly Leveling and the Bench Marks have been established at Site. The entire Levelling has been carried out using GTS Bench Mark. The Profiles and Levels of the Road Network within the Study Area have been also captured by taking Longitudinal and Cross Section Levels. The Extent of Survey has been limited to 100m beyond the Battery Limit on both the sides of the Corridor and to 200m on all the Cross Roads joining with the Corridor. The Details have been captured adequately for Planning and Designing of proposed Corridor Improvement Scheme. The Data captured is in 3 – D Format, which have been directly downloaded to Computers and is compatible for Modern Design Softwares. Topographical Map is given in **Chapter 13 – Drawings**.

The Existing Site Features collected during Topographical Survey are enumerated in **Chapter 3 – Study Corridor.**

4.10 Geotechnical Investigation

Geotechnical Investigation has been carried out with the Primary Objective of establishing the Ground Condition at the Site for Major Junctions coming along the

Corridor and evaluating the Bearing Pressure and other Engineering Design Parameters through the Field and Laboratory Tests.

Geotechnical Investigation Reports for each of the following Junctions are enclosed in **Annexure A.4.5**.

- Outer Ring Road – Bannerghatta Road Junction.
- Bilekahalli Road Junction.
- Arakere Road Junction.
- Hulimavu Road and Hulimavu Gate Junction.

CHAPTER 5
PLANNING AND DESIGN CONSIDERATIONS

5.1 General

Planning and Design of Grade Separated Facility comprising of Grade Separator, Surface Level Roads, At Grade Junction, Pedestrian Facilities, etc. are essentially based on the Design Standards as stipulated in relevant IRC Standards and MoRT&H Specifications. Whenever, the Codes / Standards are silent on some of the Aspects, the same will be planned / designed based on Sound Engineering Practices. Design Standards relevant to the Project Corridor along with the Broad List of Design Parameters and the relevant IRC Codes / Specifications have been detailed in **Table 5.1**.

Design Standards (as appropriate) have been further elaborated under the following heads:

- Geometric Design.
- Drainage.
- Road Furniture and Appurtenances.
- Grade Separated Structure.

5.2 Factors Considered in Planning

The Important Factors considered in the Planning of Grade Separated Facility are detailed below.

- Grade Separated Facility has been planned in such a way that it blends well with the existing Transport Infrastructure Facilities in the City.
- Grade Separated Facility has been planned in such a way that it not only provides Traffic Relief but also enhances the Capacity of the Junctions.
- Grade Separated Structure should have no / minimum Impact on the existing environment and its surroundings. It should not mask the Buildings of Historical Importance.
- Layout of Grade Separated Facility and the Shape / Size of its Components will be harmonized so that to result in Aesthetically Pleasing Structure.
- Drainage and Illumination of the Grade Separated Facility and the Surface Level Roads have been properly planned as per Relevant Provisions of IRC / IS Codes and
- Distance between Expansion Joints would be kept at about 60 – 75m to provide Better Riding Comfort.

5.3 Design Standards Related to Geometric Design

Design Standards related to Road Geometric along with the suggested Design Values / Standards and Recommended Values based on Site Conditions and Data Analysis are detailed in **Table 5.1**.

Table 5.1
Geometric Design Standards

Sl. No.	Design Parameters	Reference Code / Design Values
1.	Design Speed	IRC: 69 – 1977 – "Space Standards for Roads in Urban Areas". IRC: 86 – 1983 – "Geometric Design Standards for Urban Roads in Plains". IRC: 92 – 1985 – "Guidelines for the Design of Interchanges in Urban Areas".
2.	Geometric Design Standards	
	• Median	1m
	• Footpath at grade level	3m
	• Camber (Bi – directional)	2.5% for Paved Carriageway
	• Super elevation	Limited to 5% (1 in 20).
	• Horizontal Curves	IRC: 38 – 1988 – "Guidelines for Design of Horizontal Curves for Highways and Design Tables" (First Revision).
	• Vertical Curves	IRC: SP: 23 – 1983 – "Vertical Curves for Highways"
	• Gradient	Entry and Exit Ramps – 5% (1 in 20) Minimum Permissible Gradient for Drainage – 0.5% (lined) and 1% (unlined)
	• Vertical Clearance	4.5m
	• At – grade junction	IRC: SP: 41 – 1994 – "Guidelines on Design of At Grade Intersections in Rural and Urban Areas".
3.	Road Traffic Signal	IRC: 93 – 1985 "Guidelines on Design and Installation of Road Traffic Signals".

5.4 Design Standards Related to Drainage

Drainage of Storm Water collected in / on Grade Separator and on Surface Level Roads are essentially based on the Guidelines given in IRC: SP: 42 – 1994 – "Guidelines on Road Drainage" and in IRC: SP: 50 – 1999 – "Guidelines on Urban Drainage". The Suggested Design Values / Standards and Recommended Values based on Site Conditions are detailed in **Table 5.2**.

Table 5.2
Design Standards Related to Drainage

Design Parameters	Reference Code / Design Values
• Camber	2.5% (bi – directional) for carriageway
• Longitudinal Gradient	Minimum 0.3% for satisfactory drainage
• Drain Type	RCC Box Drain covered with Precast RCC Slab

5.5 Design Standards Related to Road Furniture and Appurtenances

Utility and Importance of the Grade Separated Facility (Grade Separator, Surface Level Roads and Junction) is greatly enhanced by installing Road Furniture and Appurtenances at appropriate locations, which ensures Improved Safety. Planning and Design of Road Furniture and Appurtenances are as per the Guidelines stipulated in IRC. Detailing of each of these Components has been done so that to integrate the same with the Grade Separator Scheme. The Suggested Design Values / Standards are detailed in **Table 5.3**.

Table 5.3
Design Standards Related to Road Furniture and Appurtenances

Sl. No.	Design Parameters	Reference Code / Design Values
1	Road Markings	IRC: 35 – 1997 – "Code of Practice for Road Markings (with Paints)".
2	Road Signs	IRC: 67 – 2001 – "Code of Practice for Road Signs".
3	Road Delineators	IRC: 79 – 1981 –"Recommended Practice for Road Delineators"
4	Pedestrian Facilities *	IRC: 103 – 1988 – "Guidelines for Pedestrian Facilities".

(*– Footpath, Pedestrian Crossing, Zebra Crossing, etc.)

5.6 Design Standards Related to Grade Separated Structure

The Design Standards and Loading considered for Grade Separated Structure have been as stipulated in latest IRC Codes / Special Publications supplemented by appropriate MoRT&H Circulars and / or IS Codes.

5.7 Lighting

The Preparation of Lighting Scheme, Installation and Maintenance of Street Lights in / on the Grade Separator and at Surface Level are essentially based on IS: 1994 (Part I and II) – 1970.

CHAPTER 6
CORRIDOR IMPROVEMENT SCHEME

6.1 General

Due to the Land Constraint, the Scope of the Corridor Improvement Scheme is very limited. Hence, the Proposal has been limited to only Junction Improvements by proposing Grade Separator using Pre Cast Element Technology for Underpass and Conventional Method for Flyovers at Major Junctions and closing of Median at Minor Junctions. Link Improvements couldn't be proposed in terms of Widening of Roads but other Improvements such as Improvements to Footpath, Median, Drainage System; Provision of Effective Illumination, etc. have been accommodated in the Project Proposal.

The Concept proposed for each Project Junction has been presented to the Technical Advisory Committee (TAC), BBMP and based on the suggestion / instruction by the TAC, the Concepts for each Junction has been finalised and accordingly approved by the TAC. The Approved Concept for each Junction is briefly explained below.

6.2 Outer Ring Road – Bannerghatta Road Junction

At this Junction, a 4 lane divided bi directional Underpass has been proposed along Bannerghatta Road with 11m wide Slip Road and 3m wide Footpath on either side of Road at grade level. In addition to this, a 2 lane unidirectional Flyover has been proposed across the Corridor to facilitate the Traffic Movement from Jayadeva Hospital Junction Side to J. P. Nagar Side with 5.5m wide Slip Road and 3m wide Footpath for the Traffic Movement from Bannerghatta Road Side to J. P. Nagar Side.

Following are the Salient Features of the Underpass at Outer Ring Road – Bannerghatta Road Junction.

• Length of Underpass	328.45m
• Number of Lane	4 lane divided bi directional
• Carriageway Width	2 X 7.5m
• Length of Covered Portion	30m
• Vertical Clearance	4.5m
• Gradient	5% (1 in 20)
• Length of Approach Ramp towards Jayadeva Hospital Jn.	208.96m
• Length of Approach Ramp towards Bilekahalli Road Jn.	89.49m
• Width of Slip Road	11m.
• Width of Footpath	3m.

Following are the Salient Features of the Flyover at Outer Ring Road – Bannerghatta Road Junction.

• Length of Flyover	289.79m
• Number of Lane	2 lane uni directional
• Vertical Clearance	4.5m
• Carriageway Width	7.5m

• Length of Obligatory Span	32m
• Ruling Gradient	5%
• RCC Viaduct towards J.P.Nagar	60m
• Solid Ramp towards J.P.Nagar	46.9m
• RCC Viaduct towards Jayadeva Hospital Jn.	80m
• Solid Ramp towards Jayadeva Hospital Jn.	70.89m
• Width of Slip Road	11m
• Width of Footpath	3m

Layout Plan and Longitudinal Section are presented in **Drawing No. MC / BBMP / BR - ORR / GAD / 202**.

6.3 Bilekahalli Road Junction

At this Junction, a 4 lane divided bi directional Underpass has been proposed along Bannerghatta Road with 11m wide Slip Road and 3.0m wide Footpath on either side of Road at grade level.

Following are the Salient Features of the Flyover at Bilekahalli Road Junction.

• Length of Flyover	290.32m
• Number of Lanes	4 lane divided bi directional
• Vertical Clearance	4.5m
• Carriageway Width	2 X 7.5m
• Length of Obligatory Span	30m
• Ruling Gradient	5%
• RCC Viaduct towards Outer Ring Road Jn.	60m
• Solid Ramp towards Outer Ring Road Jn.	87.1m
• RCC Viaduct towards Arekere Road Jn.	45m
• Solid Ramp towards Arekere Road Jn.	68.24m
• Width of Slip Road	11m
• Width of Footpath	3m

Layout Plan and Longitudinal Section are presented in **Drawing No. MC / BBMP / BRJ / GAD / 302**.

6.4 Arakere Road Junction

At this Junction, a 4 lane divided bi directional Underpass has been proposed along Bannerghatta Road with 11m wide Slip Road and 3m wide Footpath on either side of Road at grade level.

Following are the Salient Features of the Underpass at Arakere Road Junction.

• Length of Underpass	319.9m
• Number of Lane	4 lane divided bi directional
• Carriageway Width	2 X 7.5m
• Length of Covered Portion	30m
• Vertical Clearance	4.5m
• Gradient	5% (1 in 20)

- Length of Approach Ramp towards Bilekahalli Road Jn. 62.8m
- Length of Approach Ramp towards Hulimavu Road Jn. 227.1m
- Width of Slip Road 11m
- Width of Footpath 3m

Layout Plan and Longitudinal Section are presented in **Drawing No. MC / BBMP / ARJ / GAD / 402**.

6.5 Hulimavu Road Junction and Hulimavu Gate Junction

A 4 lane divided bi directional Flyover has been proposed along Bannerghatta Road by integrating Hulimavu Road Junction and Hulimavu Gate Junction with 11m wide Slip Road and 3m wide Footpath on either side of Road at grade level.

Following are the Salient Features of the Integrated Flyover at Hulimavu Road and Hulimavu Gate Junctions.

- Length of Flyover 548.65m
- Number of Lanes 4 lane divided bi directional
- Vertical Clearance 4.5m
- Carriageway Width 2 X 7.5m
- Length of Obligatory Span
  1. Hulimavu Road Junction 30m
  2. Hulimavu Gate Junction 30m
- Ruling Gradient 5%
- RCC Viaduct towards Arekere Road Jn. 45m
- Solid Ramp towards Arekere Road Jn. 48.49m
- Integrated RCC Viaduct 185m
- Integrated Solid Ramp 90m
- RCC Viaduct towards NICE Corridor 60m
- Solid Ramp towards NICE Corridor 60.16m
- Width of Slip Road 11m
- Width of Footpath 3m

Layout Plan and Longitudinal Section are presented in **Drawing No. MC / BBMP / HR&HGJ / GAD / 502**.

6.6 Pedestrian Crossing

The Pedestrian Crossing across the Study Corridor is considerable and the No. is quite significant at Critical Junctions. But, due to Land Constraint, no separate facility can be accommodated in this Corridor Improvement Scheme. Hence, Pedestrian Crossing has been proposed to be managed by Signalled Zebra Crossing at present.

CHAPTER 7
DESIGN OF GRADE SEPARATOR

7.1 Planning and Investigations

The Corridor Improvement Scheme has been discussed in detail in Chapter 6. Diversion of the Underground Services like Water, Sewer, Electricity, etc., which will affect the Construction Activities will be programmed prior to the Excavation Work.

7.2 General Arrangement

Care has been taken while designing so that the structure generally fulfills the following requirements.

- The Soundness of the Structure and its Durability are of the highest standards.
- Aesthetics is in harmony with the surroundings.
- Speedy and Practicable Construction.
- Economy in Construction.

7.3 Design Loads

1. **Live Load**

   Class 70R Loading has been considered.

2. **Wind Force**

   Wind Forces have been considered in the following two ways. The design shall be governed by the one producing the worst effect.

   - Full wind force at right angles to the superstructure.
   - 65% of wind force as calculated above acting perpendicular to the superstructure and 35% acting in traffic direction.

   The appropriate wind force on 10m high Lighting Poles @ 30m c/c. has been considered in the design.

3. **Seismic Force**

   The Grade Separator has been designed for the Seismic Force as per the provisions of IS: 1893 (Latest Edition).

4. **Earth pressure**

   - The Soil Properties for Embankment like Dry Density of Soil 1.85 t / cum.; Saturated Density 2.00 t / cum.; $\Phi = 30^0$ and c = 0 have been considered for Estimation Purpose.
   - Saturated Density of the Backfill (minimum 2 t / cum) has been considered for calculating Active Earth Pressure for Estimation Purpose.

5. **Temperature Range**

   - For Design of Structure, to account for temperature, the following Formula has been considered.

     $(DL) = \alpha Lt$,

The value of "t" shall be ±17^{0}C.
Where α = Coefficient of expansion or contraction
L = Length of the member
(DL) = Expansion / Contraction due to Temperature Variation in appropriate units.

The Superstructure has been designed for Effects of Distribution of Temperature across the Deck Depth as per the relevant Codal Provisions. For Calculation, Thermal Force Effect (E) of 50% of the Insulation Value has been considered so that to account for Effect of Creep on Thermal Strain.

7.4 Design of Underpass

7.4.1 General

The Length of the Underpass has been determined based on the Depth of Deck Slab, where a minimum Vertical Clearance of 4.5m has to be provided. By considering the Economy of the Project, Open Cut System has been considered both for Ramp and Covered Portion of the Underpass. Based on the Economy of the Project and Site Condition, the Covered Portion of the proposed Underpass has been designed as Precast RCC Closed Box Section. For Approaches, Open Box and Conventional RCC Retaining Structure have been adopted. The Drawings for Covered and Open Portions of the Underpass at respective Junctions are enclosed in **Chapter 13 – Drawings**.

7.4.2 Foundation

a) Retaining Walls
The Retaining Walls for the Approaches have been proposed to be of RCC appropriate with the Site Conditions. The Depth of the Foundation has been determined based on the Soil Investigation Report. Maximum Settlement allowed is 10mm. Adequate Protection has been given to Reinforcement against Corrosion.

b) Underpass
Closed and Open Portions of the Underpass including Retaining Walls shall be of minimum M35 grade Ready Mix Concrete.

7.5 Design of Flyover

7.5.1 General

The length of the Flyover has been determined by the depth of the superstructure of the Obligatory Span, where a minimum vertical clearance of 4.5m has to be provided. The roads in the project area have a number of underground services like water, sewer, electricity, etc. and diverting these service lines are not so easy and hence the foundation has been designed in such a way that there will be minimum obstruction for executing the work. Hence, Open Foundation, though economical is not considered, as it requires shoring as well as temporary support to service lines in addition to prolonged time of construction. Further, diversions of these services have been programmed to carry out prior to the execution work.

The depth of pile has been taken as 15m in the cost estimate upon the cut off level. The boreholes shall be taken at the time of execution one at each pier and one at each abutment prior to the commencement of the work. The termination level of the borehole shall be determined by conducting SPT tests. Three consecutive SPT tests at an interval of 1.5m each with 'N' values greater than 100 shall be carried out before termination. If rock is encountered, drilling shall continue upto 3m in rock with rock samples taken for testing. All the soil / sub soil investigations shall be strictly in accordance with the relevant code provisions.

While checking the stresses at the base of foundations it has to be ensured that under the worst combination of forces no tension is permitted. The safe bearing capacity at the foundation level shall be verified during construction so that to ensure that the stresses imposed on the foundation strata are within permissible limits.

7.5.2 Foundation

With the presence of underground services and foundation of adjoining existing structures, Open Foundation is not permitted considering the time for execution, importance from traffic point of view and location of the Flyover. Pile Foundation is considered for speedy construction and minimum traffic disruption. As far as possible, the Piles will be installed by bypassing the underground services and the Pile Caps will be constructed below the ground level at a minimum depth of 0.75m form the surface. The piles are of bored cast – in – situ type and resting on hard strata, where 'N' values are more than 100. The construction of pile foundation design has been done as per the relevant specifications of IS: 2911.

The Piles are essentially end bearing and are socketed into the hard strata at least to a depth equal to 1.5 times the diameter of the pile. The presence of hard strata shall be established by conducting SPT Tests in the pile bore. On ascertaining the hard strata through SPT, further chiseling shall be done for socketing. The number of drops of a given chisel falling at a constant fall for a specific depth of penetration shall be noted and these chiseling criteria (in terms of number of drops) shall be used to ascertain hard strata in the surrounding bores. Based on the available soil data for the area, a pile length of 15m has been assumed for the purpose of estimation. The capacity has to be derived by working out the actual load capacity of a laterally supported, freestanding column. However, the Construction Agency shall submit the Design Calculation for Pile Load Capacity to the Engineer on the basis of the results of initial load test on piles. The test piles shall be installed as directed by the Engineer.

Metal Casings with thickness not less then 6mm has been proposed to support the unstable sides at the top of the borehole.

- **Minimum Length of the Embedment**
  A minimum depth of embedment of 9m (including socket length) in soil has been proposed to be maintained where the pile cannot be driven any further. However, the termination level of the pile shall be as per specific instructions of the Engineer – in – Charge or his authorized representative. In the event of presence of rock or very hard strata at a shallow depth, the Construction Agency shall be advised by the Engineer regarding the termination level and the same shall be in conformity with the code provisions.

- **Pile Diameters**

  1200mm dia Piles have been proposed for Obligatory Span and 1000mm dia Piles for Standard Spans. Pile groups with 10 nos. of piles for abutments and 4 to 6 nos. of piles for pier locations have been proposed.

  The grade of concrete for the pile is M35. The cement content for pilling work has been assumed as 400 kg/m3 with Ordinary Portland Cement of grade 43. However, the Pile Foundations shall satisfy the following requirements.

  - Only bored cast in situ piles will be accepted.
  - The pile foundations shall be designed as per the requirements of IS: 2911 (Part I / Section – 2) – Latest Revision.
  - The design capacity assumed for the piles shall be verified by the initial load testing of test piles in non working areas, in the vicinity of the flyover site. These piles shall be tested for 2.0 times the design load and number of such tests shall be done for each diameter of pile. Additional one pile for each diameter, which is actually going to be used for piers and abutments, shall be tested for 1.5 times the design load.
  - Annular Piles filled or unfilled shall not be accepted.
  - Design with single row of piles shall not be accepted.
  - Design shall ensure that no pile is subjected to tension.
  - Concreting shall be done by Tremie Method after ensuring proper tip zone cleaning by flushing only.
  - The top of concrete in piles shall be brought above the cut off level by minimum 750mm to permit removal of all laitance and week concrete before pile is laid.

7.5.3 Ramps / Retaining Walls

The adoption of Reinforced Earth Wall is economical and the construction can be faster compared to Conventional Retaining Walls. Hence, Solid Ramp Portion of the Flyover has been proposed to be constructed with Reinforced Earth Retaining Structure. This Work consists of reinforced soil structures as per Terramesh Reinforced Soil Wall with Concrete Panel / Segmental Block Fascia comprising of Mechanically Woven Double Twisted Hexagonal shape, (Zn + PVC) Coated Wire Mesh as per detailed specifications.

The work is generally done in conformity to the MORT&H Specification / BS: 8006 Specifications. The detailed design and drawings of the work have been done in accordance with the MORT&H Specification and Guidelines contained in the IRC. Patentee's Specifications has been incorporated wherever relevant.

The Materials shall be procured from the supplier of the Reinforced Soil Technology approved by the Engineer. The Designs and Drawings shall be got approved from BBMP before execution of work.

7.5.4 Substructure

The Substructure shall satisfy the following Requirements.

- **Dimensions**
  - Dimension of any Element of Substructure shall not be less than 300mm.
  - All RCC Piers shall be of solid type.
  - The height of pedestals on pier cap supporting bearings shall not be more than 300mm.

- **Layout and Design**
  - All Bearings shall be supported directly on Pier Stem. However, bearings resting on overhangs are acceptable provided the differential deflection of pier cap is accounted in the transverse analysis of superstructure.
  - Scope for accessibility for inspection of bearings and arrangement for lifting of the superstructure for future replacement of bearings shall be provided in the design of Substructure and Superstructure.

7.5.4.1 Abutments

The Abutments and Returns have been designed for live load surcharge equivalent to earthfill of 1.2m height. The minimum density of filling for calculations of Surcharge Pressure has been considered as 2 T / cum. The Surcharge Effect has been considered for the purpose of evaluating Earth Pressure and not for Vertical Loads.

7.5.4.2 Piers

The Piers considered for design is of two types. One type is for Standard Spans and other type is for Obligatory Span. The Design has been based on the Combination of Design Loads producing the worst effect. One span dislodged condition has also been taken into consideration while designing the piers.

7.5.5 Superstructure

The choice of Superstructure mainly depends on the Span and the Aesthetic Importance. The Spans are determined based on the Superstructure and feasibility of transporting long span Precast Girders. It is advisable that construction of superstructure proceeds with surface level construction like pier or abutment construction.

For standard spans, Precast Pre Tensioned I girders of 16.75m with Cast – in – Situ Concrete Deck Slab have been adopted. Geometrical Variation like Curvature of the Deck can be easily constructed with Concrete Decks using Straight Precast Girders.

The Selection of the type of Obligatory Span depends on Availability of Space, Curvature and Aesthetic Importance. The minimum thickness of 200mm for Deck Slab has been proposed to be maintained.

7.5.5.1 Prestressed Concrete Girder and Slab

For ease and speed of construction, Precast Concrete Superstructure has been proposed to be adopted for the Standard Span. While designing such element / structure, Aspects of Durability and Minimum Maintenance have been kept in view. Precast Panel Slab Deck /

Girders and Cast – in – Situ Slab Construction shall be designed as Composite Construction.

Concrete Girder and Slab Type Superstructure shall satisfy following stipulations.

- Minimum Thickness of Slab shall be 200 mm.
- Minimum Thickness of Web shall be 250 mm.
- Where Prestressed Cables pass through the webs, the thickness shall be same as that stipulated for Webs of Box Girder.

The Components shall be designed for Lifting and Erection Loads and Stresses. Proper Lifting Arrangements shall be arranged by the Construction Agency for handling the Precast Unit.

7.5.5.2 Post Tensioned PSC Box Girder

For Obligatory Span Box Girder has been proposed. The following Method has been adopted for Analyzing and Designing the Box Girder.

- Calculate the Main Girder Moments, Shear Forces and Torsional Moments for a single beam for all loading conditions.
- Also add to above, the Forces due to the Restraint of Warping Torsion at the ends.
- In addition, calculate the Bending Moments in the Roadway Slab considering the Slab, the Web and Soffit Slab as a closed frame.
- Reinforcement in the Slabs and Webs due to the Transverse Moments shall be provided in addition to the Steel, which is required for Shear or Torsion in the Box as a Main Girder.
- Distortion of Box Girder due to Transverse Moment can be neglected if minimum numbers of Diaphragms are provided.
- In the absence of Rigorous Analysis (A) for the Torsional Moment (B) for Forces due to Restraints of Warping Torsion at ends, the Design Live Load Moments and Shear Force in the Longitudinal Direction shall be increased by 20% and Transverse Reinforcement Steel be increased by 5%.
- For Prestressed Concrete Structure, where Cables pass through Webs, minimum Web Thickness shall be greater of 150mm + outer dia of Duct or 250mm whichever is greater.
- The Cross Diaphragms shall be minimum one number at each support and at ends of cantilever, if any. In addition, for Abrupt Change in Soffit Geometry, Stiffening Frame or Diaphragm shall be provided to cater to Forces arising out of Change in Direction.
- Minimum Thickness of Diaphragms at Supports shall be 500mm and those of other Locations shall be 300mm.
- Minimum Untensioned Reinforcement shall be as per Clause 15 of IRC: 18 – 2000. The Spacing of the Bars shall not exceed 200mm c/c. The Minimum Diameter of Bars to be used is 10mm.
- No Tension under Full Permanent Design Load is allowed.

7.5.5.3 Precast Pretensioned Girders

These Girders are not specifically covered in IRC Specification. The Preliminary Design carried out herein follows AASHTO Specification. Some of the important Guidelines are given below.

- Pretensioned Girders shall be designed as Simple Span Girders for Positive Moments, without regard to Live Load Continuity. The Girders shall be designed to account for Live Load Continuity for Shear and Negative Moment Design. The Girders are assumed to be continuous because they are embedded into the Continuity Diaphragm that is poured in place with the Deck Slab. Additional Reinforcement Steel shall be placed in the cast – in – place Deck Slab to resist the Continuous Live Load Negative Moments.
- The Temporary Tension Stress in the Top Fibre near the ends of the Prestressed Girders shall be deduced as much as possible by debonding.
- A future Wearing Surface of 600N / m^2 in Dead Load shall be added to the Clear Roadway Width for Design.

7.5.6 Bearing below Superstructure

Bearing controls the Transfer of the Forces from Superstructure to Substructure. Bearings under superstructure shall be within the external line of the Pier / Abutment. The Bearings shall be provided below the Diaphragm at Suitable Locations.

- The Type of Bearing generally allowed is as below.

Span	Type of Bearing
For effective spans upto 20m	Restrained Elastomeric / POT cum PTFE / POT
For effective spans more than 20m	POT cum PTFE / POT

- The Bearing shall be easily accessible for Inspection / Maintenance.
- Scope for Lifting the Superstructure for Future Replacement of Bearing shall be provided in the Design of Bearing. The Scheme of Lifting shall be indicated on the Drawing to be submitted along with the Technical Bid.
- Inspection of Bearing by Director General of Supplies and Disposal (DGSD) during manufacturing is essential. The Construction Agency shall have to produce necessary Certificate and Inspection Marks from the DGSD at his own cast.
- The bearing shall conform to the requirements of the MoRT&H Specifications.
- The Dimensions of Top Plate of Bearing shall be such that the Contact Surface of the Superstructure projects beyond the Edge of Bearing Plate by a minimum distance of 50mm at any location.

7.5.7 Expansion Joints

Elastomeric Strip Seal Type Expansion Joint conforming to Clause 2607 of MoRT&H Specifications has been considered. Calculations for the Adequacy of the Expansion Extent for which the Joint is selected by the Engineer shall be submitted along with the Name of Manufacturer and their Technical Details. During installation of these Joints, Manufacturer's Engineer shall be required to supervise the same including the Thermal Presetting, if required.

7.6 Crash barriers

Concrete Crash Barriers shall conform to Clause 809 of MoRT&H Specifications. The Height of the Concrete Crash Barrier is 1000mm above the Finished Road Level. It has been designed to resist an Impact of 30t Axle Loads.

7.7 Wearing Coat

Wearing Coat conforming to Clause 2702.1 of MoRT&H Specifications for Road and Bridge Works (latest edition) has been provided for Smooth Riding Surface.

7.8 Approach Slab

The Approach Slab conforming to Clause 2704 of MoRT&H Specifications for Road and Bridge Works (Latest Edition) has been provided.

7.9 Durability

From the Durability Consideration, the following minimum Grades of Concrete are to be considered for Plain Cement Concrete (PCC) and Reinforced Cement Concrete (RCC).

a) Minimum Grade of Concrete shall be as below.

PCC for Levelling Course	M15
RCC for Open Foundation, Substructure and Superstructure	M35

b) Minimum Cement Content, Diameter of Bar and Cover Requirements
For PCC and RCC, the value given below regarding minimum Cement Content and maximum Water Cement Ratio shall be followed.

PCC		RCC	
Minimum cement Content Kg / cum.	Maximum Water Cement Ratio	Minimum cement Content Kg / cum.	Maximum Water Cement Ratio
360	0.45	400 / 400	0.45 / 0.40

The minimum Nominal Diameter of Reinforcement is 10 mm.

7.10 Drainage

Drainage of Storm Water collected in / on the Grade Separator and at Surface Level Roads are essentially based on
IRC: SP: 42 – 1994 – "Guidelines on Road Drainage".
IRC: SP: 50 – 1999 – "Guidelines on Urban Drainage".

The Drainage Spouts conform to Clause 2705 of MoRT&H Specifications.

7.11 Traffic Signs, Markings and other Road Appurtenances

Traffic Signs, Markings and other Road Appurtenances shall conform to Clause 800 of the MoRT&H Specifications for Road and Bridges (latest edition). Road Markings shall conform to IRC: 35 – 1997 and Road Signs shall confirm to IRC: 67 – 2001.

7.12 Medians, Kerbs and Footpaths

Medians, Kerbs and Footpaths shall conform to Clause 407, 408 and 409 of the MoRT&H Specifications for Road and Bridges (latest edition).

7.13 Lighting

The Lighting in / on the Grade Separator, Service Roads, Junction at Surface Level above / below the Grade Separator, etc. has been provided as per relevant Codal Provisions. The Illumination proposed is an average 125 lux through out.

7.14 Specification and Design Codes

The Designs of Structural Components have been in conformation to the Criteria laid down in the Latest Editions of the following Codes of Practice and Standard Specifications.

a. IRC Standard Specifications and Code of Practice for Road Bridges with amendments issued upto the Date of Issue of Tender Notice.

IRC: 5	General Features of Design
IRC: 6	Loads and Stresses
IRC: 18	Design Criteria for Prestressed Concrete Road Flyovers (Post Tensioned Concrete). This Code will also be applicable to Continuous Structures with Pertinent Particulars.
IRC: 21	Cement Concrete (Plain and Reinforced)
IRC: 35	Code of Practice for Road Markings
IRC: 78	Foundation and Substructure
IRC: 83 (All Parts)	Standard Specifications and Code of Practice for Road Bridges – Bearings
IRC: 92	Guidelines for the Design of Interchanges in Urban Areas
IS: 875 (Part 3)	Code of Practice for Design Loads (Wind Load)
IS: 1893	Criteria for Earthquake Resistant Design of Structures
IS: 2911 (All Parts)	Pile Foundations

b. IRC – SP: 33 Guidelines on Supplemental Measures for Design, Detailing and Durability of Important Bridge Structures (if applicable).
c. Specification for Roads and Bridge Works (Latest Edition), published by IRC, New Delhi on behalf of Govt. of India, Ministry of Shipping, Road Transport and Highways.

7.15 Boring Data and Soil Investigation at Site

The Details of Boring Data and Soil Investigation Report have been enclosed in **Chapter 4**.

CHAPTER 8
TRAFFIC MANAGEMENT / DIVERSION DURING CONSTRUCTION AND TRAFFIC ENGINEERING SCHEMES

8.1 General

Traffic Management / Diversion during construction of Grade Separation Scheme is essential for smooth flow of traffic. Traffic Diversion / Management during Construction has been planned so that not to cause inconvenience for Traffic Movement and the Width of Carriageway available for Traffic Movement during Construction is adequate.

8.2 Traffic Management during Construction

Work on the entire length of the Grade Separator for each Junction has been planned continuously for 6 months in case of Underpass and 12 months in case of Flyover and the Construction of Grade Separator at each Junction has been planned to tackle separately, phase wise. Wherever land is available for the proposed Slip Road, the available land will be strengthened to allow the traffic. Otherwise alternative routes will be worked out for the diversion of traffic in concurrence with the concerned Departments. The proposed scheme shall ensure the smooth flow of traffic during the entire Construction Period. During the entire Construction Period, Street Parking on all the approach arms of the junction shall be strictly prohibited.

8.3 Necessary Improvements

For Effective Implementation of Traffic Diversion Scheme, Diversion Routes shall be kept in Traffic Worthy Condition (Free from Pot Holes, Ruts, Undulation, etc.) during the entire Construction Period.

Necessary Signboards for guiding the Road Users shall be located as per IRC Norms. The Traffic Management Scheme and Traffic Diversion Plans proposed shall be discussed with Police Authorities before Implementation. All the Necessary Improvements and Location of Signboards shall be finalized during Implementation in discussion with Police Authorities.

8.4 Traffic Engineering Schemes Components

Design of At Grade Junction is essential for proper dispersion of traffic retained at Surface Level in the Post Grade Separator Scenario. The Various Components of At Grade Junction and in the Grade Separator that need to be Planned, Designed and Built Integrally in the Grade Separation Scheme are detailed in Table 8.1. Planning and Design of these Components are as per the Guidelines stipulated in IRC.

Table 8.1
Components of At Grade Junction and Grade Separation Scheme

Sl. No.	Components	Description	Standards
1.	Traffic Signals	Fully Automatic Traffic Signal with Timer (Solar)	IRC: 93 – 1985
2.	Road Markings	On Grade Separator and at Surface Level Roads	IRC: 35 – 1997
3.	Road Signs	On Grade Separator and at Surface Level Roads	IRC: 67 – 1977 & IRC: SP – 31 – 1992
4.	Road Delineators	On Grade Separator and at Surface Level Roads	IRC: 79 – 1981
5.	Geometrics	Surface Level Roads	IRC: 86 – 1983
6.	Geometrics	Junction	IRC: SP – 41 – 1994
7.	Pedestrian Facilities	At Surface Level Roads and near the Junction (Footpaths, Railing & Zebra Crossing)	IRC: 103 – 1988

The Drawings for the proposed Traffic Signage and Road Marking for the Post Grade Separator Scenario are enclosed in **Chapter 13 – Drawings**.

CHAPTER 9
PROJECT COST

9.1 Rate Analysis

As part of the Detailed Project Report (DPR), Rate Analysis of each of the item has been prepared by adopting PW, P & IWTD SR 2009 – 10, Bangalore Circle and NHSR 2009 – 10, National Highways Circle, Bangalore. The Rates as given in PW, P & IWTD SR are to be enhanced by 6% for additional weightages for the Works to be executed under Extra Ordinary Conditions for Bangalore Metropolitan Limits. Items not covered in NHSR / PW, P & IWTD SR have been based on Market Rates.

9.2 Detailed Cost Estimate

As part of DPR, Detailed Cost Estimate has been prepared for the Grade Separated Structure and Surface Level Roads based on Detailed Engineering Design.

9.3 Project Cost

The Rates of the various Items of Works analysed keeping in view of the basic rates as per SR and their respective lead.

The Abstract of the Project Cost is detailed in **Table 9.1**. For the proposed Corridor Improvement Scheme, total Cost of the Project has been worked out as **Rs. 95.516 Crore**. Further, the Abstract of the Junction wise Project Cost is detailed in **Table 9.2, 9.3, 9.4, 9.5 and 9.6** respectively.

The Detailed Cost Estimate is presented in **Annexure A.9.1**.

Table 9.1
Abstract of Project Cost

Sl. No.	Particulars	Cost in Rs.
1.	Proposed Construction of Vehicular Underpass at Bannerghatta Road – Outer Ring Road Junction	153050000.00
2.	Proposed Construction of Flyover at Bannerghatta Road – Outer Ring Road Junction	69500000.00
3.	Proposed Construction of Flyover at Bilekahalli Road Junction	220500000.00
4.	Proposed Construction of Vehicular Underpass at Arakere Road Junction	152610000.00
5.	Proposed Construction of Integrated Flyover at Hulimavu Road and Hulimavu Gate Junction	359500000.00
	Total	**955160000.00**

Table 9.2
Abstract of Project Cost for Bannerghatta Road – Outer Ring Road Junction Underpass

Sl. No.	Particulars	Cost in Rs.
1.	Procurement of Pre Cast RCC Box Segments of Size 7.5m X 4.5m X 1.0m	19300000.00
2.	Lowering the Segments and other Allied Works	7880000.00
3.	Construction of Retaining Wall	38040000.00
4.	Formation of Service Road, Concreting of Ramps	39340000.00
5.	Providing Drainage Facility to Underpass	11000000.00
6.	Construction of Approach Road to Underpass and Other Allied Works	8050000.00
	Sub Total	123610000.00
7.	Add for Consultancy Charges for DPR Preparation, PMC and Quality Assurance Charges @ 1.5%	1854150.00
8.	Add for Utility Shifting Charges @ 20%	24722000.00
9.	Add Cost for Topographical Survey	40000.00
10.	Add Cost for Soil Investigation	120000.00
11.	Add Cost for Electrical Works	2680000.00
		153026150.00
12.	Miscellaneous and Rounding Off	23850.00
	Total	153050000.00

Table 9.3
Abstract of Project Cost for Bannerghatta Road – Outer Ring Road Junction Flyover

Sl. No.	Particulars	Cost in Rs.
1.	Site Clearance and Dismantling	514379.00
2.	Surface Level Roads / Slip Roads	5469077.00
3.	For Road Side Drains	1752614.00
4.	Footpath and Kerb	1092211.00
5.	Road Furniture and other Works	2651926.00
6.	Flyover Works	40878915.00
7.	Electrical Works for Flyover	2800980.00
	Construction Cost	55160102.00
8.	Utility Shifting Charges	11032020.00
9.	Add Cost for Topographical Survey and Soil Investigation	250000.00
10.	Add Cost for Landscaping Works	1000000.00
11.	Contingencies (@ 3% of Construction Cost)	1654803.00
	Sub Total	69096925.00
12.	Miscellaneous and Rounding Off	403075.00
	Total	69500000.00

Table 9.4
Abstract of Project Cost for Bilekahalli Road Junction

Sl. No.	Particulars	Cost in Rs.
1.	Site Clearance and Dismantling	1601610.00
2.	Surface Level Roads / Slip Roads	22601089.00
3.	Drain Works	
	a. For Road Side Drains	4997973.00
	b. For Storm Water Drain across Ring Road and Retaining Wall	9243972.00
	c. For Culvert	869113.00
4.	Footpath, Median, Kerb and Compound	5100952.00
5.	Road Furniture and other Works	3849540.00
6.	Flyover Works	127147348.00
7.	Electrical Works for Flyover	2300650.00
	Construction Cost	177712247.00
8.	Utility Shifting Charges	35542449.00
9.	Add Cost for Topographical Survey and Soil Investigation	250000.00
10.	Add Cost for Landscaping Works	1500000.00
11.	Contingencies (@ 3% of Construction Cost)	5331367.00
	Sub Total	220336063.00
12.	Miscellaneous and Rounding Off	163937.00
	Total	220500000.00

Table 9.5
Abstract of Project Cost for Arakere Road Junction

Sl. No.	Particulars	Cost in Rs.
1.	Procurement of Pre Cast RCC Box Segments of Size 7.5m X 4.5m X 1.0m	19300000.00
2.	Lowering the Segments and other Allied Works	7880000.00
3.	Construction of Retaining Wall	36760000.00
4.	Formation of Service Road, Concreting of Ramps	38740000.00
5.	Providing Drainage Facility to Underpass	11280000.00
6.	Construction of Approach Road to Underpass and Other Allied Works	9930000.00
	Sub Total	123890000.00
7.	Add for Consultancy Charges for DPR Preparation, PMC and Quality Assurance Charges @ 1.5%	1858350.00
8.	Add for Utility Shifting Charges @ 20%	24778000.00
9.	Add Cost for Topographical Survey	40000.00
10.	Add Cost for Soil Investigation	120000.00
11.	Add Cost for Electrical Works	1900000.00
		152586350.00
12.	Miscellaneous and Rounding Off	23650.00
	Total	152610000.00

Table 9.6
Abstract of Project Cost for Integrated Flyover at Hulimavu Road Junction and Hulimavu Gate Junction

Sl. No.	Particulars	Cost in Rs.
1.	Site Clearance and Dismantling	2256712.00
2.	Surface Level Roads / Slip Roads	39290264.00
3.	Drain Works	
	a. For Road Side Drains	6599989.00
	b. For Storm Water Drain across Ring Road and Retaining Wall	21696668.00
	c. For Culvert	1112036.00
4.	Footpath, Median, Kerb and Compound	7312877.00
5.	Road Furniture and other Works	4731006.00
6.	Flyover Works	205030669.00
7.	Electrical Works for Flyover	2733710.00
	Construction Cost	290763931.00
8.	Utility Shifting Charges	58152786.00
9.	Add Cost for Topographical Survey and Soil Investigation	250000.00
10.	Add Cost for Landscaping Works	1500000.00
11.	Contingencies (@ 3% of Construction Cost)	8722918.00
	Sub Total	359389635.00
12.	Miscellaneous and Rounding Off	110365.00
	Total	359500000.00

CHAPTER 10
IMPLEMENTATION PLAN

The entire Project Period for each Junction has been divided into two parts viz.

1. **Tendering Stage and Finalisation of Contract.**
2. **Execution of the Project including Utility Shifting.**

The 1st Part will entail a period of **45 Days** whereas the 2nd Part will entail a period of **180 Days** in case of Underpass and **365 Days** in case of Flyover.

Further, each Junction will be tackled in Phase wise so that not to cause inconvenience to the Flow of Traffic throughout the Corridor.

The Total Time to handover the Project for each Junction to the BBMP will thus be **225 Days** in case of Underpass and **410 Days** in case of Flyover from the Date of Notice Inviting Tender.

The Detailed Implementation Plans for all the Project Junctions are attached in **Annexure A.10.1**.

CHAPTER 11
CONCLUSION

11.1 The Project Corridor acts as a Radial Road in Southern Part of Bangalore City and connects the Central Business District with Bannerghatta. The Study Area caters to considerable local and through amount of traffic especially at peak hours due to the traffic that plies to the Central Parts of Bangalore and also towards Bannerghatta Road (SH – 48). Further, being a parallel Road to NH – 7 and Kanakapura Road, this Corridor acts as a link between National Highways. With the setting up of Software Companies like Infosys, Oracle, IBM, Accenture, Adobe Systems India Pvt. Ltd., Honeywell Technology Solutions Lab, BPL Software Centre, etc. along the Project Corridor, the growth of the techno polis has led to increase in traffic. The traffic originating from the various quarters of the City passes through this Corridor to reach Bannerghatta, Arakere, Bilekahalli. Further, many large Residential Sites have been / are being converted into Apartments / Flats along this Corridor and a site that would house either a family or two now will be able to house multiple number of families and with this the number of Vehicle / Traffic also has increased manifold in last 10 years. The Corridor is located in the developing part of the City and hence the future traffic growth along this Corridor will be quite significant. The other main traffic attraction points along this Corridor are various Educational Institutes; Commercial Complexes; high end Residential Apartments; Wockhardt Hospital; Indian Institute of Management; Meenakshi Temple; Bannerghatta Biological Park; etc. Further, with the spurt in the economy, the Land Use Patterns of this Part of the City Area have been changing at a very fast pace since 10 years. Many of the Residential Areas in and around this Corridor, such as Shanti Nagar, Wilson Garden, Jayanagar, Koramangala, etc. are being converted into Commercial Establishments. With this change in the Land Use Pattern, traffic along this Corridor has been increased considerably in last 10 years time. Apart from this, many large Residential Sites have been / are being converted into Apartments / Flats along this Corridor and a site that would house either a family or two now will be able to house multiple number of families and with this the number of Vehicle / Traffic also has increased manifold in last 10 years. These being the Background, the Bruhath Bangalore Mahanagara Palike has proposed to construct Grade Separator using Pre Cast Element Technology at Major Junctions and to close Median at Minor Junctions with Appurtenant Link Improvements from Hosur Luskar road Junction to Hulimavu Gate Junction along Bannerghatta Road covering a total of 12 Junctions (out of which, 5 Junctions have been taken for improvement) for a total length of 10 km in order to provide Uninterrupted, Seamless Traffic Flow and to Increase Level of Service along the Corridor.

11.2 Existing Junctions along the Project Corridor

The following Junctions are present along the Project Corridor.

- Hosur Luskar Road Junction – Three Arm ('T' Shaped) Junction.
- Hosur Road – Bannerghatta Road Junction – Three Arm ('Y' Shaped) Junction.
- New Mico Road Junction – Three Arm ('T' Shaped) Junction.
- Dairy Circle – Four Arm Junction.
- Swagath Road – Bannerghatta Road Junction – Three Arm ('T' Shaped) Junction.
- Jayadeva Hospital Junction – Four Arm Junction.

- Sarakki Road – Bannerghatta Road Junction – Three Arm ('T' Shaped) Junction.
- Outer Ring Road – Bannerghatta Road Junction – Three Arm ('Y' Shaped) Junction.
- Bilekahalli Road Junction – Three Arm ('T' Shaped) Junction.
- Arakere Road Junction– Four Arm Junction.
- Hulimavu Road Junction – Three Arm ('T' Shaped) Junction.
- Hulimavu Gate Junction – Three Arm ('T' Shaped) Junction

11.3 Junctions proposed for Improvements

The following Junctions have been taken for the proposed Improvements.

- Outer Ring Road – Bannerghatta Road Junction.
- Bilekahalli Road Junction.
- Arakere Road Junction.
- Hulimavu Road Junction.
- Hulimavu Gate Junction.

11.4 For the proposed Corridor Improvement Scheme, total Cost of the Project has been worked out as **Rs. 95.516 Crore** with Implementation Period for each Junction as **225 Days** in case of Underpass and **410 Days** in case of Flyover from the Date of Notice Inviting Tender.

11.5 To keep pace with the High Density of Traffic, it is Techno Economically Feasible to take up this Project along the mentioned stretches from Hosur Luskar Road Junction to Hulimavu Gate Junction along Bannerghatta Road.