PROJECT MANAGEMENT CONSULTANCY FOR IMPLEMENTATION OF SMART CITY MISSION PROJECTS FOR MANGALURU CITY

SMART ROAD PACKAGE - 04

DETAILED PROJECT REPORT - VOLUME I

The purpose of the Detailed Project Report is to provide details of various considerations made towards the elements proposed for the project as mentioned in the title above. It aims to give a basic design idea to all the stakeholders before proceeding for final design and estimates.

MANGALORE SMART CITY PROJECT

Lalbaug, M.G. Road, Mangalore – 575003

12/17/2018

ISSUE AND REVISION RECORD

Revision	Date	Originator	Checker	Approver	Description	Standard
0	17/12/2018	WTESL/LBI/ CDAC	Nitin Bhavsar	URVI BHATT/ KAVITA WAKADE	DETAILED PROJECT REPORT	

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ABBREVIATIONS

ABD	Area Based Development
ATM	Automated Teller Machine
MCC	Mangaluru City Corporation
MSCL	Mangaluru Smart City Limited
GoI	Government of India
GoK	Government of Karnataka
SCP	Smart City Proposal
SPV	Special Purpose Vehicle
IRC	Indian Road Congress
IUT	Institute of Urban Transport
KUIDFC	Karnataka Urban Infrastructure Development & Finance Corporation Limited
SCP	Smart City Proposal
SLNA	State Level Nodal Agency
ROW	Right of Way
MESCOM	Mangalore Electricity Supply Company Limited
KSRTC	Karnataka State Road Transport Corporation
LED	Light Emitting Diode
CCTV	Closed-circuit Television
GCP	Ground Control Points
DTM	Digital Terrain Model
LCV	Light Commercial Vehicle
ADT	Average Daily Traffic
PCU	Passenger Car Units
MoUD	Ministry of Urban Development
IT	Information Technology
ICT	Information and Communication Technology
ITS	Intelligent Transport System
ITMS	Intelligent Traffic Management System
OFC	Optical Fiber Cable

O&M	Operation and Maintenance
DPR	Detailed Project Report
RFP	Request for Proposal
SOR	Schedule of Rates
PWD	Public Works Department
RTO	Regional Transport Office

LIST OF REFERENCE CODES, STANDARDS, AND GUIDELINES

The following Codes and Standards have been referred in preparing the document

1. Indian Roads Congress (IRC) Codes & Standards
   - IRC: 86-1983 - Geometric Design Standards for Urban Roads in Plains
   - IRC: 106-1990 - Guidelines for Capacity of Urban Roads in Plain Areas
   - IRC: 58-2015 - Guidelines for the Design of Plain Jointed Rigid Pavements for Highways (Fourth Revision)
   - IRC: 15-2017 - Code of Practice for Construction of Jointed Plain Concrete Pavements (Fifth Revision)
   - IRC: SP:23-1983 - Vertical Curves for Highways
   - IRC: 65-2017 - Guidelines for Planning and Design of Roundabouts (First Revision)
   - IRC: 69-1977 - Space Standards for Roads in Urban Areas
   - IRC: 99-2018 - Guidelines for Traffic Calming Measures in Urban and Rural Areas (First Revision)
   - IRC: 103-2012 - Guidelines for Pedestrian Facilities
   - IRC: SP:12-2015 - Guidelines for Parking Facilities in Urban Roads
   - IRC: SP:41-1994 - Guidelines on Design of At-Grade Intersections in Rural & Urban Areas
   - IRC: 35-2015 - Code of Practice for Road Markings
   - IRC: 67-2012 - Code of Practice for Road Signs

2. Documents prepared by Institute of Urban Transport, Ministry of Urban Development
   - Code of Practice Part I – Cross Section
   - Code of Practice Part II – Intersections
   - Code of Practice Part III – Road Marking
   - Code of Practice Part IV – Signage
   - Code of Practice Part V – Traffic Calming

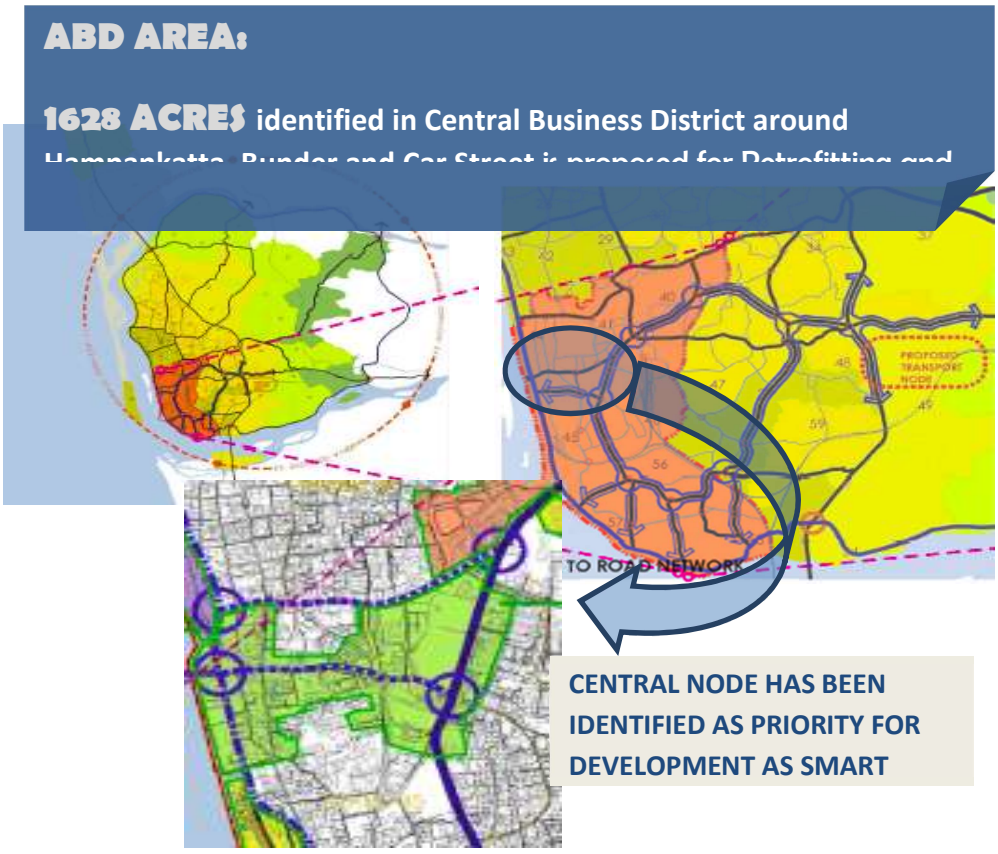
1. INTRODUCTION

1.1 Mangaluru Smart City Proposal

Karnataka Urban Infrastructure Development & Finance Corporation Limited (KUIDFC) is the State Level Nodal Agency (SLNA) for the Smart Cities Mission in Karnataka. ***Mangaluru was a proud Participant in second round of this Challenge and now aspires to translate the vision i.e. the broad components across both 'area-based' and 'pan-city' heads identified in the Smart City Proposal (SCP) into Reality.***

Mangaluru Smart City Proposals (SCP) is considered as Area Based Development Proposals (ABD) and Pan City Proposals. The SCP has identified 65 projects/sub projects to be taken up under ABD and Pan City Proposal. Figure 1-1 shows the ABD area considered under Mangaluru Smart City Proposal and the priority roads for development as smart roads

Figure 1-1 ABD area considered under Mangaluru Smart City and Priority Roads Identified for Development as Smart roads



1.2 Smart Road Proposals under Mangaluru Smart City Project

Transforming existing roads into Smart Roads has been envisaged under the Smart City Mission. In this regard, Mangaluru Smart City Ltd (MSCL) intends to develop world class road infrastructure that is efficient mode of transport and inclusive to all strata of society. This entails comprehensive upgrading of the public Right of Way (ROW) of the streets which includes refurbishment of existing carriageway, laying of new footpaths and cycle tracks, creating utility corridors, developing pedestrian facilities, development works for landscape, hardscape, street furniture, signage, lighting, etc.

The following projects proposed under Mangaluru SCP have been clubbed together and considered under Design and Development of Smart Roads.

As per sanctioned SCP earlier, the projects combined to be taken for smart roads package 3 are listed below:

SMART ROADS	Specialized Pedestrian Facilities along certain road sections	S NO. 19	ABD COMPONENT
	Widening of Roads	S NO. 21	ABD COMPONENT
	Upgradation of Roads with footpaths	S NO. 23	ABD COMPONENT
	Provision of Road side plantation	S NO. 25	ABD COMPONENT

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As per the revised SCP, sanctioned recently the smart road Package 3 amounts Rs 48 Crores (Project id KAR-MAN-133).

Smart Roads under Mangaluru Smart City

The development of smart roads has been perceived in phased manner:

Phase I included Maidan road (from Clock Tower Circle to AB Shetty Circle

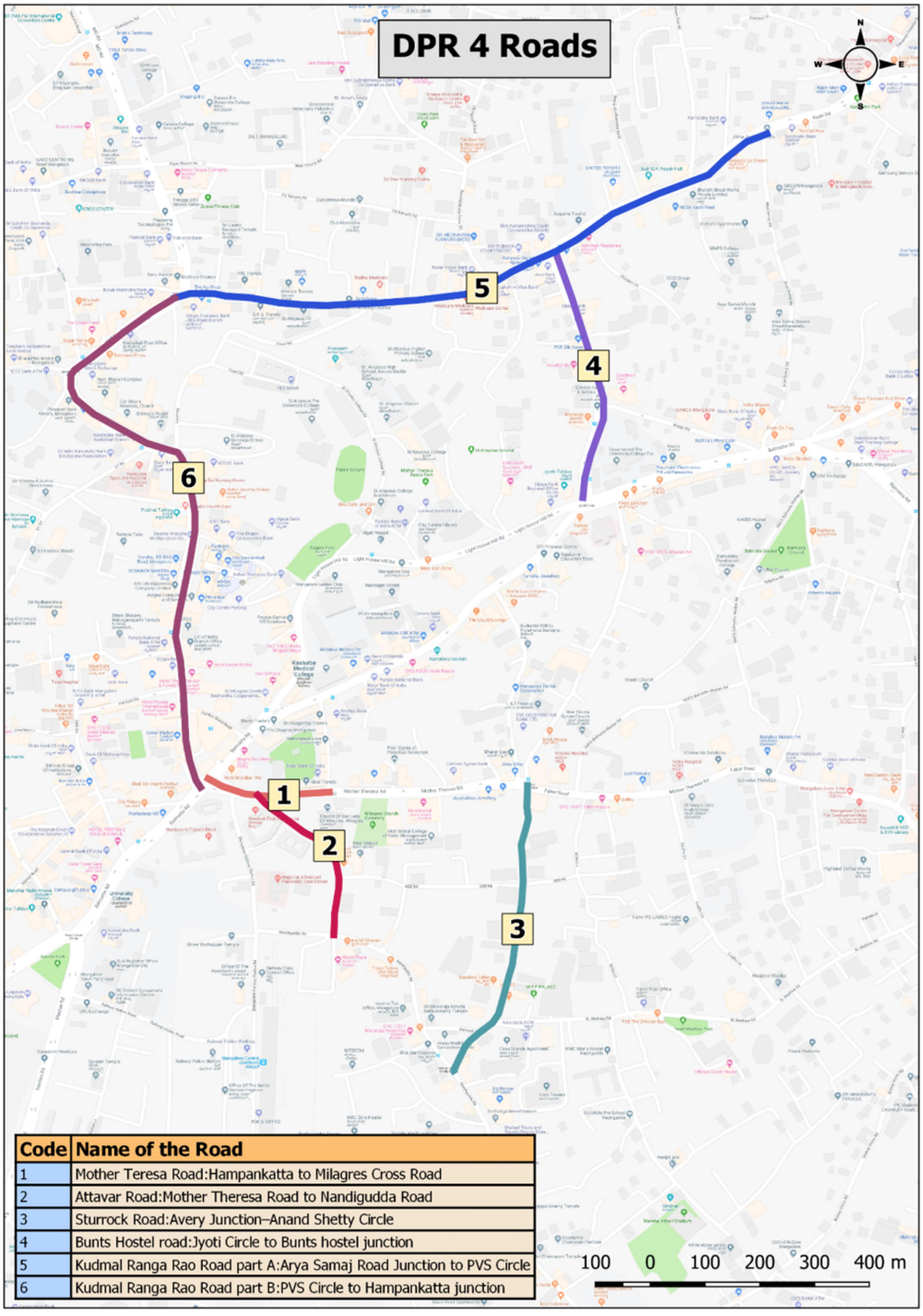
Phase II included Maidan road II (from AB Shetty Circle to Hamilton Circle), 4th Cross road, Mission Street Road and Nellikai road.

DPR 3 included Balmatta road (two way), Balmatta road (one way), Light house hill road, Rosario Church road, Pandeshwar road and Bunder road.

DPR 4 includes the following roads:

1. **Mother Theresa Road: Hampankatta to Milagres cross road**
2. **Attavar Road : Mother Theresa road to Nandigudda road**
3. **Sturrock Road : Avery Junction –Anand Shetty Circle**
4. **Bunts Hostel road: Jyoti Circle to Bunts hostel junction**
5. **KudmalRanga Rao Road part A: Arya Samaj Road Junction to PVS Circle**
6. **KudmalRanga Rao Road part B: PVS Circle to Hampankatta junction**

Other Roads to be developed in future phase(s) include Mangaladevi Road, Car Street (from Sri Venkatramana Temple to Tile Factory), Bibi Alabi Road (from Junction with Nellikai Road to Bengre Ferry), Bunder Road (from Junction with Old Port Road to Hoige Bazaar), Marnamikatta Road. Junction Improvements are considered as integral part of smart roads design and development. Figure 1-2 shows the Roads considered for development as Smart Roads DPR-4



Code	Name of the Road
1	Mother Teresa Road:Hampankatta to Milagres Cross Road
2	Attavar Road:Mother Theresa Road to Nandigudda Road
3	Sturrock Road:Avery Junction–Anand Shetty Circle
4	Bunts Hostel road:Jyoti Circle to Bunts hostel junction
5	Kudmal Ranga Rao Road part A:Arya Samaj Road Junction to PVS Circle
6	Kudmal Ranga Rao Road part B:PVS Circle to Hampankatta junction

Figure 1-2 Selected Roads to be developed as smart roads

1.2.1. Need for Intervention

The existing road infrastructure and transport facilities in Mangalore are proving to be inadequate to meet the requirements of the city. 63% of the roads have speeds below 30 kmph as noted during the Comprehensive Traffic and Transportation Study of Mangalore. The delay is both due to traffic signals and interference of traffic movements, such as turning vehicles, parking and un-parking vehicles, pedestrians etc. Due to substantial increase in the number of city buses in operation in addition to mixed flow of heavy traffic, the city is facing many traffic problems.

Further, with the increase in the commercial activity in some of the important areas like Hampankatta, Bejai, etc., there is an increased demand for better pedestrian facilities. The increase in vehicular traffic has given rise to widening the carriageway width to accommodate the vehicles resulting in reduction in the size of the foot paths. This in turn has given room for pedestrians to spill over to the carriageway, thereby affecting the flow of vehicles. Considering the present scenario the main arterial roads and junctions require up gradation to improve the traffic and transport facilities for the citizens. There is hence a need to transform the existing roads with above concerns into smart roads as depicted in diagram below

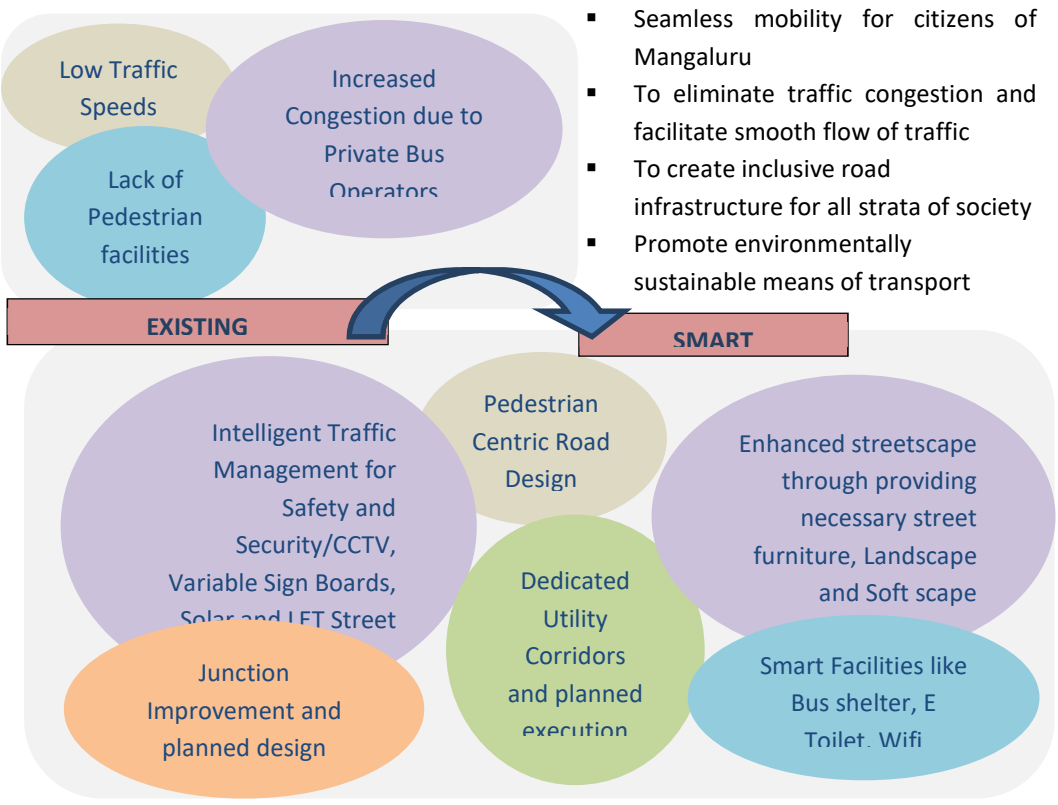


Figure 1-3 Vision methodology for Smart Roads in the city

1.2.2. Proposed Interventions

The proposed intervention aims to achieve the following:

- Seamless mobility for citizens of Mangaluru
- To eliminate traffic congestion and facilitate smooth flow of traffic
- To create inclusive road infrastructure for all strata of society
- Promote environmentally sustainable means of transport

Smart Roads include Four Broad Objectives, namely:

1) **EFFICIENT AND SAFE STREETS**: This involves road re-channelization whereby the effective width of the carriageway is reduced in order to achieve systemic improvements. Roads with clearly demarcated spaces for vehicles, pedestrians, cyclists and dedicated on-street parking to minimize conflicts between vehicular and pedestrian traffic.
2) **RESILIENT STREETS**: Streets with defined utility corridor including undergrounding overhead utilities where upgraded utilities can withstand severe natural and man-made disasters. Streets that provide infrastructure allowing safe walking experience in night through pedestrian lighting and clean public space through dustbins at regular intervals.
3) **INCLUSIVE STREETS**: Universal accessible design that allow safe walking experience with shaded walkways to all citizens and specific facilities for elderly and people with special needs.
4) **STREETS AS PUBLIC SPACES**: Streets that provide spaces outside our homes for social, cultural or intellectual interactions, to walk or to just breathe fresh air.

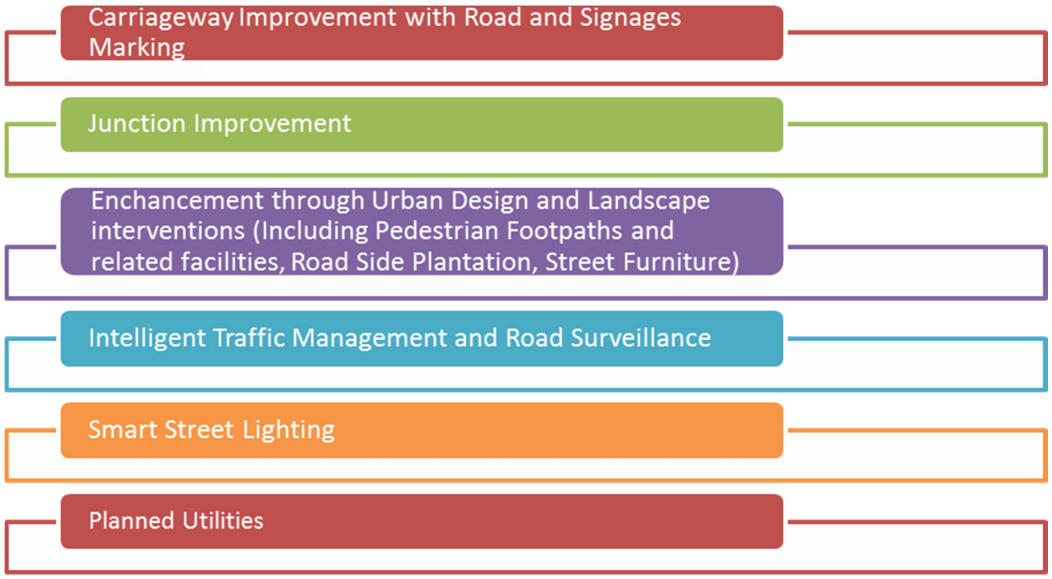


Figure 1-4 Proposed interventions for the Selected Roads to be developed as smart roads

The Smart Road proposal would consist of the following specific interventions:

Details of proposed smart elements along the Road are covered in subsequent sections.

1.2.3. Expected Benefits

The proposed up gradation of roads to Smart Roads would provide the following benefits to Mangaluru city:

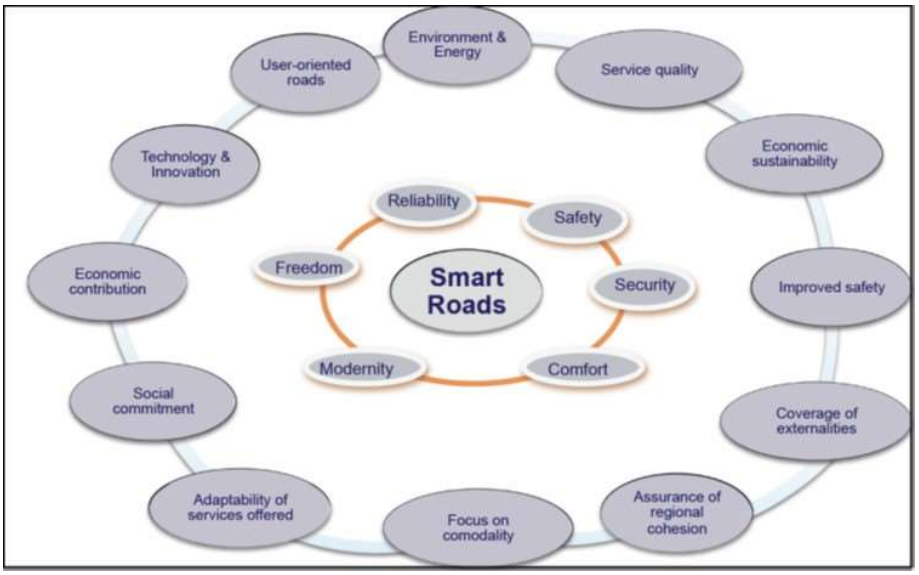


Figure 1-5 Benefits of developing Smart roads

1.2.4. Assumptions/Prerequisites

The assumptions for implementation of the Smart road are:

- There is no land acquisition involved and the selected road stretches are free of unauthorized encroachments
- The information about location of underground utilities and their alignment is available with the local authority
- Mangaluru City Corporation will facilitate the development of this project through facilitation of various statutory approvals and consultation with stakeholders
- 30% of median lighting poles to be replaced by new lighting poles.

1.2.5. Stakeholders/ Organizations involved

- Citizens
- Mangaluru Smart City Limited (MSCL)
- Mangaluru City Corporation (MCC)
- Mangaluru Smart City PMC
- Karnataka Public Works Department – Mangalore Division
- Traffic Police / RTO
- Karnataka Urban Infrastructure Development and Finance Corporation (KUIDFC)
- Mangalore Electricity Supply Company Limited (MESCOM)

- Karnataka State Road Transport Corporation (KSRTC)
- Private Bus Operators Association
- City Level Advisory Forum (CLAF)

1.2.6. Target Beneficiaries

The proposed up gradation of roads to Smart Roads would benefit the following:

- **Citizens**: The citizens would get better transport facilities for their mobility needs. The road improvement project would reduce traffic congestion; thereby result in travel time savings for the citizens. Smart roads also offer multiple mobility options such as walking, cycling, and public transport or through private vehicles. The upgraded roads would be inclusive to all citizens, i.e. would have facilities that would make them accessible to elderly or physically challenged persons.
- **Local Authority/ MCC**: The municipal corporation would get upgraded roads with more traffic handling capacity, smooth traffic flow and lesser congestion. Roads upgraded with state-of-the-art technology would result in fuel savings and lesser maintenance costs. Smart Roads would also help the local government in energy saving through energy efficient LED street lighting.
- **Local Economy**: The improved mobility and reduced travel times would result in improving the productivity of the citizens and thus benefit the local business and the city's economy.

1.2.7. Objective of the Report

The purpose of the Detailed Project Report is to provide details of various considerations and the elements proposed for the DPR-4 Smart Road. It aims to give a basic design idea to all the stakeholders before proceeding for final design and estimates.

1.2.8. Structure of the Report

This report is organized as follows:

- **Chapter 1 – Introduction**
- **Chapter 2 – Site Reconnaissance and Situation Analysis**
- **Chapter 3 – Surveys and Investigations**
- **Chapter 4 - Traffic Analysis and Recommendations**
- **Chapter 5 – Carriageway and Junction Improvement**
- **Chapter 6 – infrastructure and Utilities Planning**
- **Chapter 7 – Proposed Smart Road Components – Urban Design, Landscape and ICT**
- **Chapter 8 – Traffic Management Plan**
- **Chapter 9 –Timeline for Execution**
- **Chapter 10– Monitoring and Evaluation**
- **Chapter 11 – Drawings**
- **Chapter 12 –Cost Estimates**
- **Annexures**

2. SITE RECONNAISSANCE AND SITUATION ANALYSIS

Detailed Site Reconnaissance was carried out along the selected roads to assess the existing situation in terms of pavement condition, traffic situation/movements, existing facilities/structures, smart elements that can be proposed along DPR-4 Smart Road. Section below describes brief of existing condition of DPR-4 Smart Road

2.1 Mother Theresa Road: Hampankatta to Milagress road

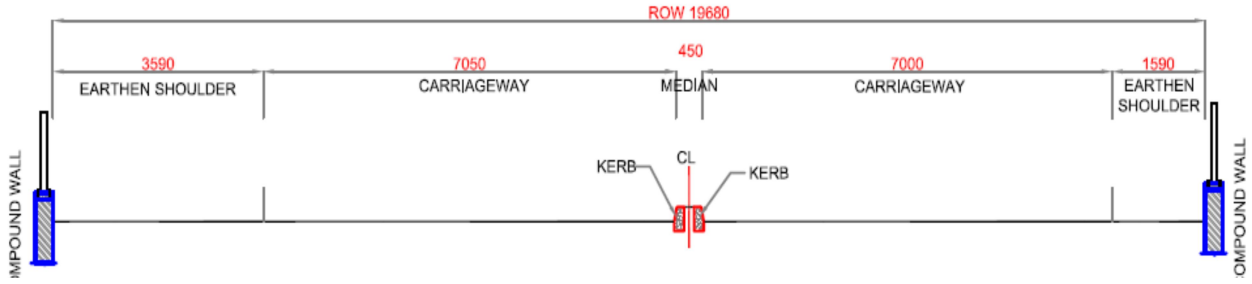
It stretches from Hampankatta circle to Milagress road.

Road Details:

1. Total length of road= 224.06 m
2. Min. width = 18.32 m
3. Max. Width = 21.41 m
4. Slope: 0.3%
5. Type of Carriage way: Flexible at junction and later Rigid pavement, Road condition is very bad.
6. Lane configuration: 4 Lane carriageway two way. Median near junction is not there and later it is there.

Existing Utilities:

1. The electrical lines are present above ground
2. Storm water drains are not present near the Hampankatta junction and later are present on one side of the road towards shopping complex side.
3. Waterline is present on both side of the carriage way.



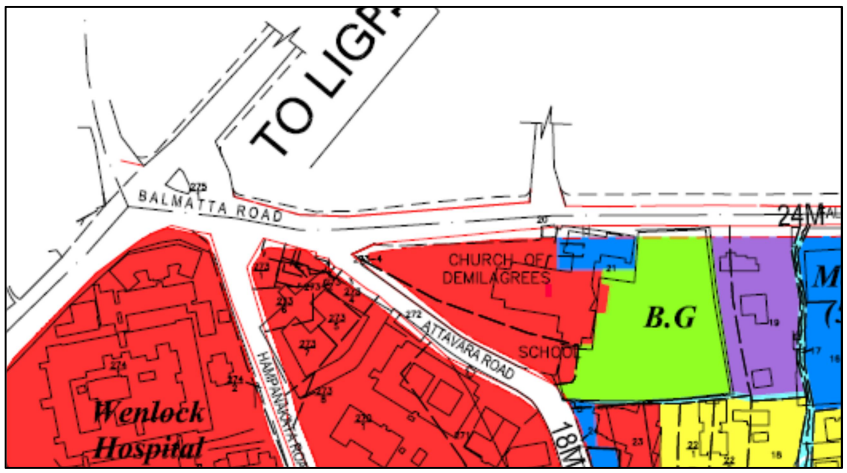


Figure 2-1 Existing Cross Sections, Site Photographs and MUDA Master Plan layout of Mother Theresa Road

OBSERVATIONS:

1. The proposed road width as per MUDA Master Plan is 24m.
2. On the northern side of the road Commercial land use is observed while to the southern side of the road institutional activities (Milagress church) are observed.
3. On street parking are observed on the street which adds to the congestion on the road.

2.2 Attavar Road

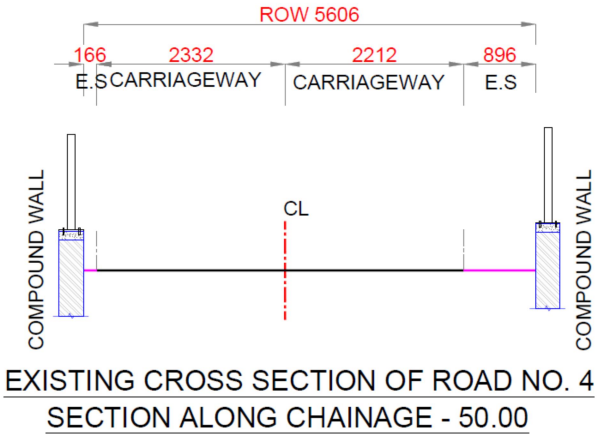
It stretches from Mother Theresa road to Nandigudda Road.

Facts:

- Total Length of road= 332 m
- Min Width = 5.9 m
- Max. Width= 14.9 m
- Slope= 0.93%
- Type of carriageway and condition= Flexible carriageway and the condition is poor.
- Lane Configuration: Two lane one way.

Existing Utilities

- The electrical lines are present above ground
- Storm water drains are present on both sides of the road from Masjid.
- Two water pipe lines are there on one side.
- Parking is observed on both sides of the road on Fridays due to presence of Masjid.



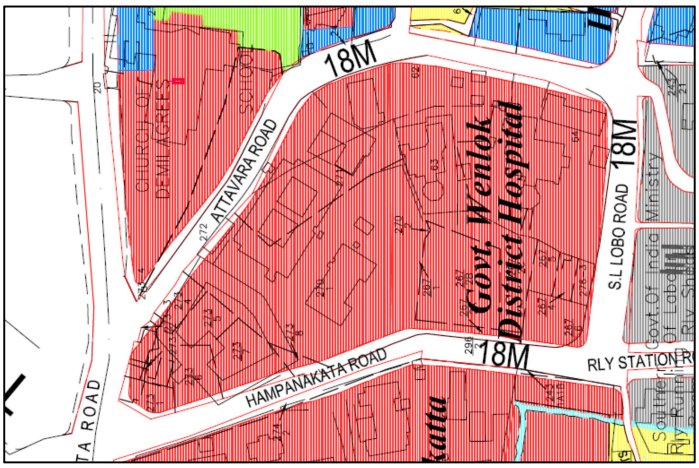


Figure 2-2 Existing Cross Sections, Site Photographs and MUDA Master Plan layout of Attavar Road

The proposed right of way as per the MUDA master plan is 18 m.

2.3 Sturrock Road

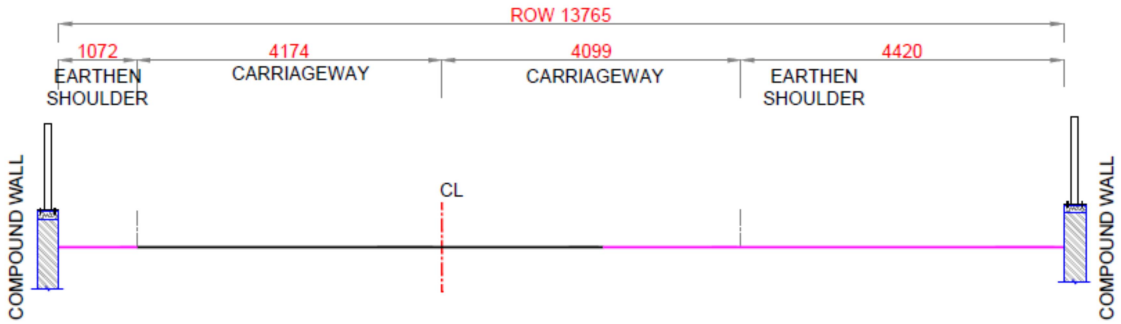
It stretches from Avery Junction to Anand Shetty Circle.

Facts:

- Total Length of road= 558.65 m
- Min Width = 11.20 m
- Max. Width= 15.00 m
- Slope= 1.33%
- Type of carriageway and condition: Flexible carriageway and the condition is poor.
- Lane Configuration: 2 Lane 2 way

Existing Utilities

- The electrical lines are present above ground
- Storm water drains are present on both sides of the road and new drains are being developed by MCC.
- One waterline is present on each side of the carriage way.



EXISTING CROSS SECTION OF ROAD NO. 6
SECTION ALONG CHAINAGE - 50.00

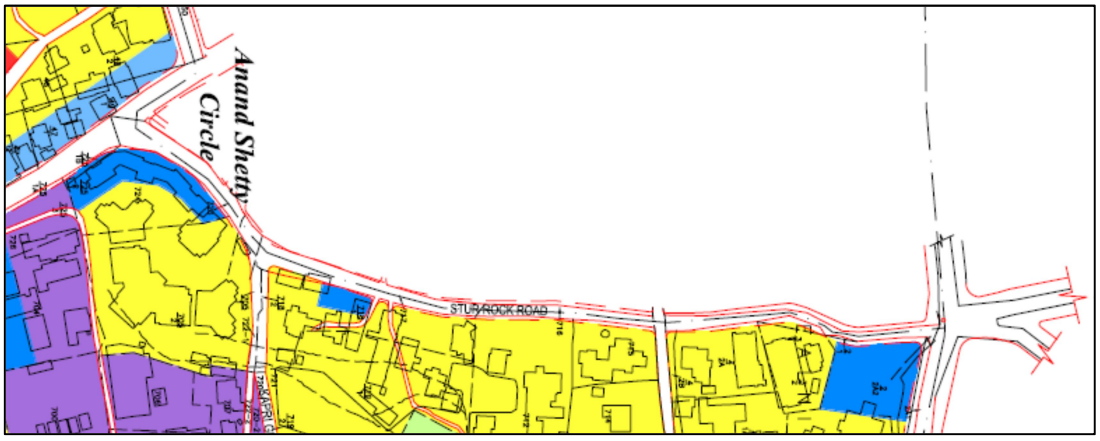


Figure 2-3 Existing Cross Sections, Site Photographs and MUDA Master Plan layout of Sturrock Road

2.4 Bunts Hostel Road

It stretches from Jyoti Circle road to Bunts Hostel.

Facts:

- Total Length of road= 482.38 m
- Min Width = 16.50 m
- Max. Width= 27.40 m
- Slope= 3.36%
- Lane Configuration: 4 Lane 2 way with median

Existing Utilities

- The electrical lines are present above ground.
- Storm water drains are not present.
- One waterline is present on each side of the carriage way.

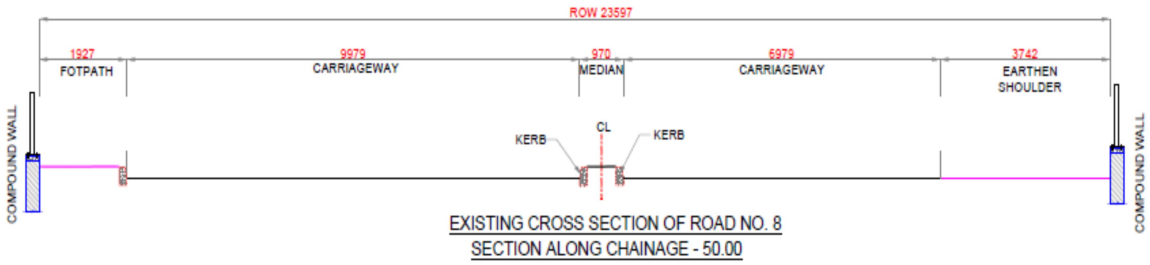


Figure 2-4 Existing Cross Sections, Site Photographs and MUDA Master Plan layout of Bunts Hostel Road

The proposed ROW as per MUDA master plan is 24 m.

2.5 Kudmal Ranga Rao Road: Arya Samaj Junction to PVS Circle

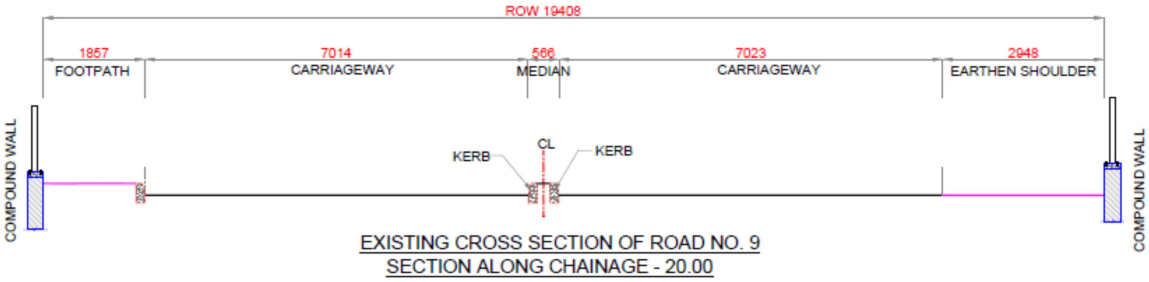
It stretches from Arya Samaj Junction to PVS Circle.

Facts:

- Total Length of road= 1113.76 m
- Min Width = 15.20 m
- Max. Width= 34.10 m
- Slope= 0.36%
- Lane Configuration: 4 Lane divided carriageway, median is present from Arya Samaj road to Bunts hostel junction and later delineators are there at present.

Existing Utilities

- The electrical lines are present above ground
- Storm water drains are present on both sides of the road
- From Arya Samaj road to Bunts hostel road one pipe line is present on south side and from Bunts hostel to PVS circle one water pipe line on each side is present.



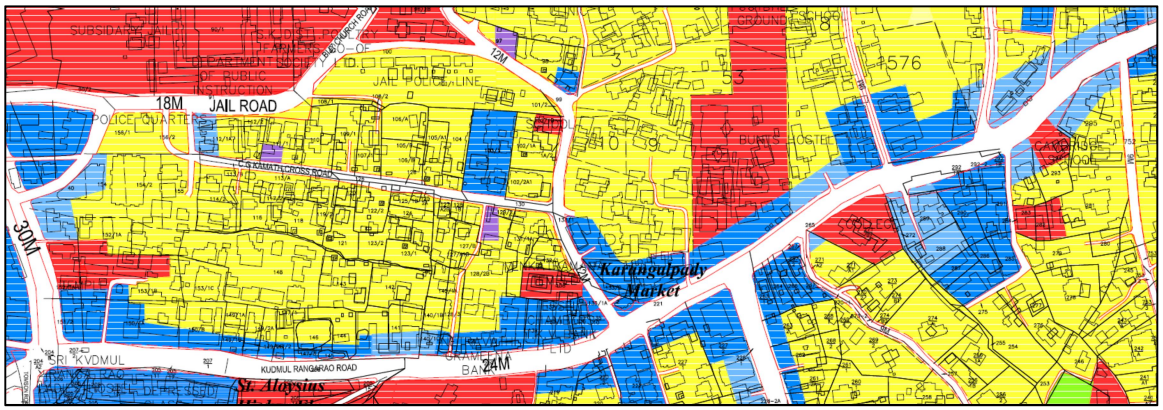


Figure 2-5 Existing Cross Sections, Site Photographs and MUDA Master Plan layout of KRR Road

The proposed ROW as per MUDA master plan is 24 m.

2.6 KS Rao Road: PVS Circle to Hampankatta Junction

It stretches from PVS Circle to Hampankatta Junction.

Facts:

- Total Length of road= 1123.23 m
- Min Width = 15.20 m

- Max. Width= 34.10 m
- Slope= 0.75%
- Type of carriageway and condition= Rigid carriageway and the condition is bad as carriageway is broken at some stretches which should be re-laid fully.
- Lane Configuration: 4 Lane divided carriageway

Existing Utilities

- The electrical lines are present above ground
- Storm water drain is present on east side of the road
- From PVS circle to Navbharat circle one water pipe line on each side of the road. From Nav Bharat circle to Hampankatta there are three pipe lines present, one on each side and the third one near median.

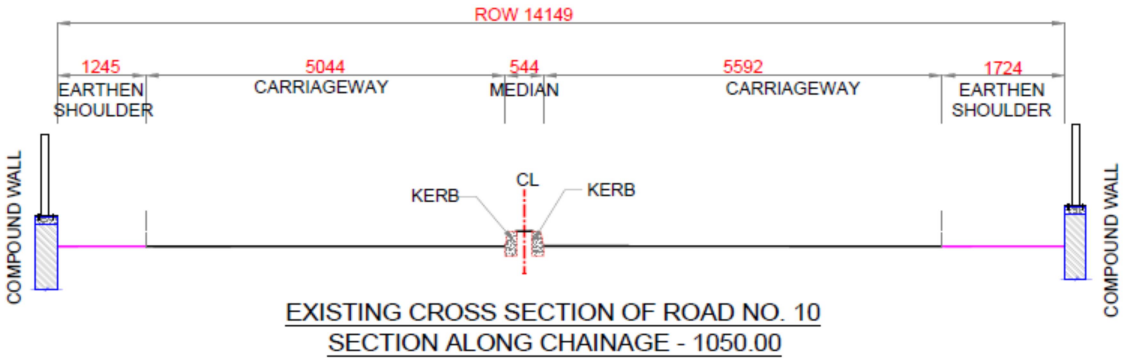


Figure 2-6 Existing Cross Sections, Site Photographs and MUDA Master Plan layout of KSR Road

The proposed ROW as per MUDA master plan is 24 m.

3. SURVEYS AND INVESTIGATIONS

3.1 Road Inventory Survey

A detailed road inventory was done along the selected roads.

At onset, the Ground Control Points (GCPs) were established using precision DGPS at appropriate intervals which shall be captured during DTM (Digital Terrain Model) for further geo referencing and Traversing using Total Station.

All the existing and proposed features, such as land-use, limits of right-of-way, embankment, structures, intersecting roads, existing utilities, electric and telephone installations (both O/H as well as underground), access roads, connectors, wayside amenities, safety structures, buildings, fencing and trees, street lights along the median/road side, oil and gas lines etc. falling within the extent of survey complete and levels were picked up (using Auto Level) at an interval of 10m X 10m grid.

The following drawing in Section 11 of the report shows details of existing features along the DPR-4 roads

DRAWING NO.	DRAWING NAME	NO OF SHEETS
WTE-2292-04-R-1.01 (R0)	EXISTING FEATURES OF MOTHER TERESA ROAD (ROAD NO. 7b) HAMPANKATTA JUNCTION TO MILAGRES CHURCH JUNCTION	**1**
WTE-2292-04-R-1.02 (R0)	EXISTING FEATURES OF MILAGNES NANDIGUDDA ROAD (ROAD NO. 7e) MILAGRES CHURCH TO NANDIGUDDA ROAD	**2**
WTE-2292-04-R-1.03 (R0)	EXISTING FEATURES OF STURROCK ROAD (ROAD NO. 9) AVORY JUNCTION TO ATTAVER ROAD	**2**
WTE-2292-04-R-1.04 (R0)	EXISTING FEATURES OF BUNTS HOSTEL ROAD (ROAD NO. 12) BUNTS HOSTEL JUNCTION TO JYOYHI CIRCLE	**2**
WTE-2292-04-R-1.05 (R0)	EXISTING FEATURES OF KRR ROAD (KUDMAL RANGA RAO ROAD) (ROAD NO. 13a) PVS JUNCTION TO ARYA SAMAJ ROAD JUNCTION	**4**
WTE-2292-04-R-1.06 (R0)	EXISTING FEATURES OF KRR ROAD KSR RAO ROAD (ROAD NO.13b) PVS CIRECLE-KSR ROAD TO HAMPANKATTA JUNCTION	**4**

Table 3-1: List of Drawings of Existing Features

3.2 Trial pits

The bituminous roads are proposed to be replaced with Cement Concrete roads. For this purpose samples are taken for investigations and are being analysed.

The photographs are provided below:

Figure 3-1 Trial Pits Survey Site Photographs

3.3 Traffic Surveys

Based on the roads and junction identified under DPR-4, detailed primary surveys and investigation were carried out. Table 3-1 below defines various Traffic surveys and investigations carried out along the identified Road

The overall objective was to capture traffic flow characteristics, travel pattern; speed characteristics, on traffic passing through the project road and other characteristics related to miscellaneous requirements on the project road

Table 3-2: Traffic Surveys and Investigations conducted along the Priority Roads

S.No.	Location	Survey	Schedule
1	Hampankatta Junction	TMC	26-Mar-18
2	KS Rao Road	TVC	26-29 Mar 18
3	KS Rao Road near City Point	TVC	06-08 Mar 18
4	PVS Junction	TMC	21-Feb-18
5	KRR Road	TVC	21-23 Feb 18
6	Bunts Hostel Junction	TMC	20-Feb-18
7	Jyoti Circle to Bunts Hostel	TVC	19-21 Feb 18
8	Jyoti Circle Junction	TMC	17 Feb 18
9	Sturrock Road	TVC	02-Aug-18
10	Attavar Road	TVC	3-6 Apr-18
*(*TMC – Turning Movement Count, TVC – Traffic Volume Count)*			

Figure 3-2 Survey work in progress

The Traffic Volume Counts were conducted as per guidelines illustrated in IRC: SP: 19 – 2001, 'Manual for Survey, Investigation and Preparation of Road Projects'.

Figure 3-2 shows the traffic survey in progress at the Project site.

For carrying out the counts, the vehicles were grouped under the categories given in Table 3-2 below.

Figure 3-3 Traffic Survey Location

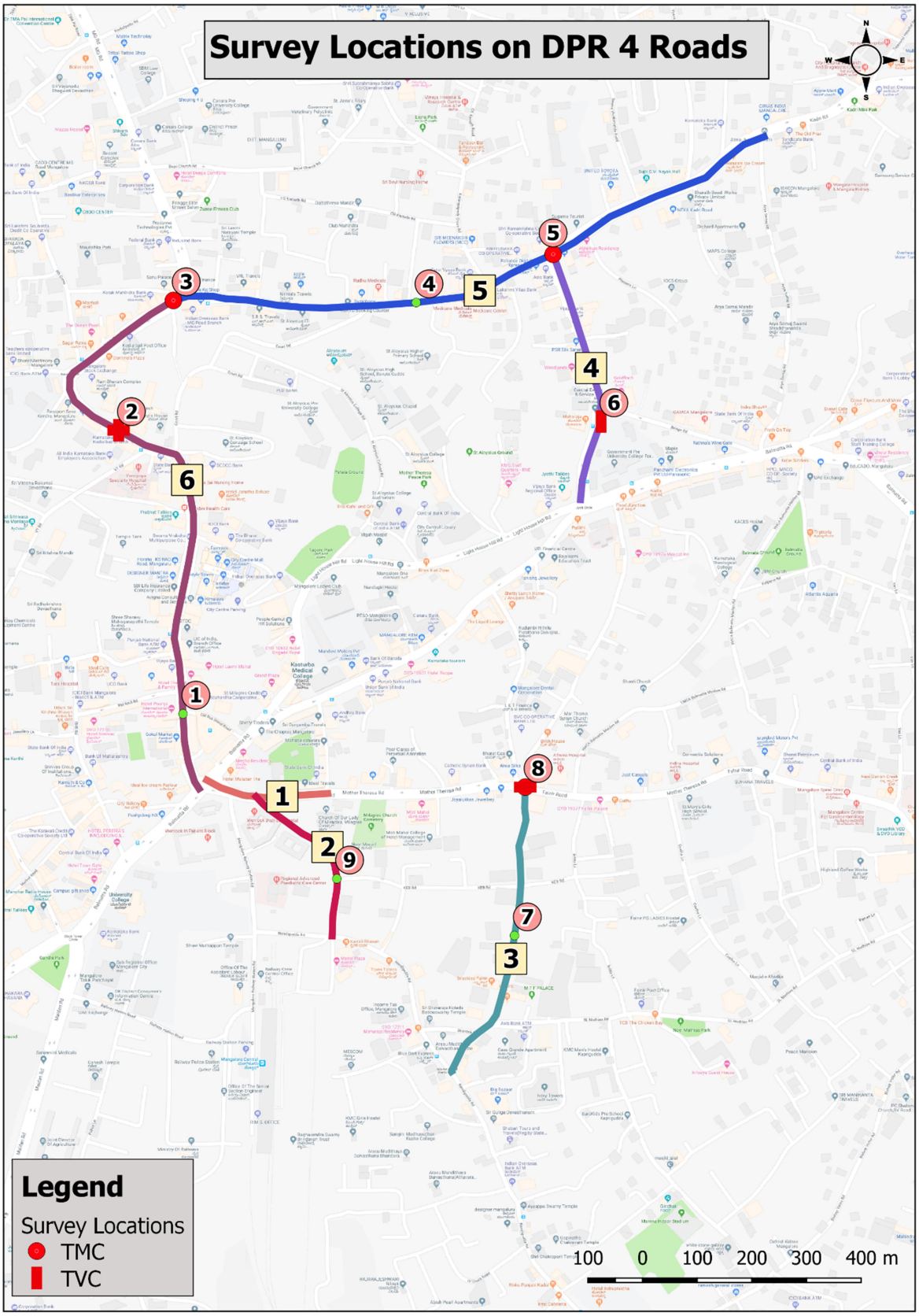


Table 3-3: Traffic Surveys - Vehicle Classification system

Category	Examples of Vehicle Types
Two Wheelers	Scooters, Bikes, Motor cycles and Mopeds
Three Wheelers	Auto Rickshaw
Car	Car, Jeep, Taxi, and Vans
Bus	Mini Bus, Government Bus, Private Bus
Trucks	Light Commercial Vehicle (LCV), 2, 3, 4, 5, 6 and >6 Axle Trucks
Other	Tractor, Tractor & Trailer
Non-Motorized	Bicycle, Cycle Rickshaw, Animal drawn vehicles, Hand Cart

Intersection turning movement surveys have been carried out at all the major intersection locations. Classified traffic volume counts of all types of vehicles have been made separately for each direction including left and right turning traffic. The surveys have been conducted for successive 15 minutes interval for a period 24 hours.

The complete details of above mentioned primary Traffic Survey and Investigations have been enclosed as Annexure-I to the Report

4. TRAFFIC ANALYSIS AND RECOMMENDATIONS

4.1 Introduction

This chapter presents the traffic surveys, analysis and future strategy for Smart Roads under Package 4, referred to as DPR 4.

4.2 Project Background

Mangalore Smart City Limited (MSCL) is implementing the Smart City Proposals with the help of the Project Management Consultant. Development of Smart Roads is one of important projects in the Smart City Proposal. Safe pedestrian movement along with smart features is key in the development of the Smart Roads.

Three Detailed Project Reports (DPR) viz., DPR 1,DPR 2 & DPR 3are prepared and submitted for development of the Smart Roads. This report deals with the DPR 4 for the Smart roads.

4.3 Scope of Work

The scope of the work comprises of development of the following roads:

1. Hampankatta Junction to Milagres Church
2. Attavar Road
3. Sturrock Road – Avery Junction to Attavar Road
4. Bunts Hostel Road
5. Kudmal Ranga Rao Road –Arya samaj junction to PVS circle
6. KS Rao Road – PVS Circle to Hampankatta

4.4 Methodology

The methodology adopted for the study is implemented through the following steps:

1. Establish the base line traffic on the corridor based on the traffic surveys and analysis.
2. Estimate the future traffic levels with appropriate growth rate.
3. Assess the capacity of the road and suggest measures.

4.5 Traffic Analysis

4.5.1 Classified Traffic Volume Counts

Traffic studies are required to assess the intensity of traffic vis-à-vis the capacity (service volume) of the road for the present, as well as, future.

Classified traffic volume counts on project roads and at important junctions were conducted and analyzed for following traffic characteristics of the surveyed roads:

- Average Daily Traffic (ADT)
- Hourly Variation
- Composition of ADT
- Annual Average Daily Traffic (AADT)

The various vehicle types having different sizes and characteristics were 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 for conversion, and are presented in **Error! Reference source not found.**.

Vehicle Type	Equivalent PCU Factors	
	Percentage Vehicle Type in Traffic Stream	
	5%	10% and above
1. Two Wheelers/Motor Cycle or Scooter	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
7. Cycle	0.4	0.5
8. Cycle Rickshaw	1.5	2.0
9. Tonga (Horse drawn vehicle)	1.5	2.0
10. Hand Cart	2.0	3.0

Table 4-1: PCU Factors Adopted for Study

4.5.2 Traffic Surveys

Surveys were conducted at 8 different locations on these roads and the schedule of these traffic surveys is given in **Error! Reference source not found.**

Table 4-2: Schedule of Traffic Surveys

S.No.	Location	Survey	Schedule
1	Hampankatta Junction	TMC	26-Mar-18
2	KS Rao Road	TVC	26-29 Mar 18
3	KS Rao Road near City Point	TVC	06-08 Mar 18
4	PVS Junction	TMC	21-Feb-18

5	KRR Road	TVC	21-23 Feb 18
6	Bunts Hostel Junction	TMC	20-Feb-18
7	Jyoti Circle to Bunts Hostel	TVC	19-21 Feb 18
8	Jyoti Circle Junction	TMC	17 Feb 18
9	Sturrock Road	TVC	02-Aug-18
10	Attavar Road	TVC	3-6 Apr-18

4.5.3 Annual Average Daily Traffic (AADT)

The traffic survey data is analyzed and the Average Daily Traffic (ADT) is presented in **Error! Reference source not found.**.

Table 4-3: Average Daily Traffic

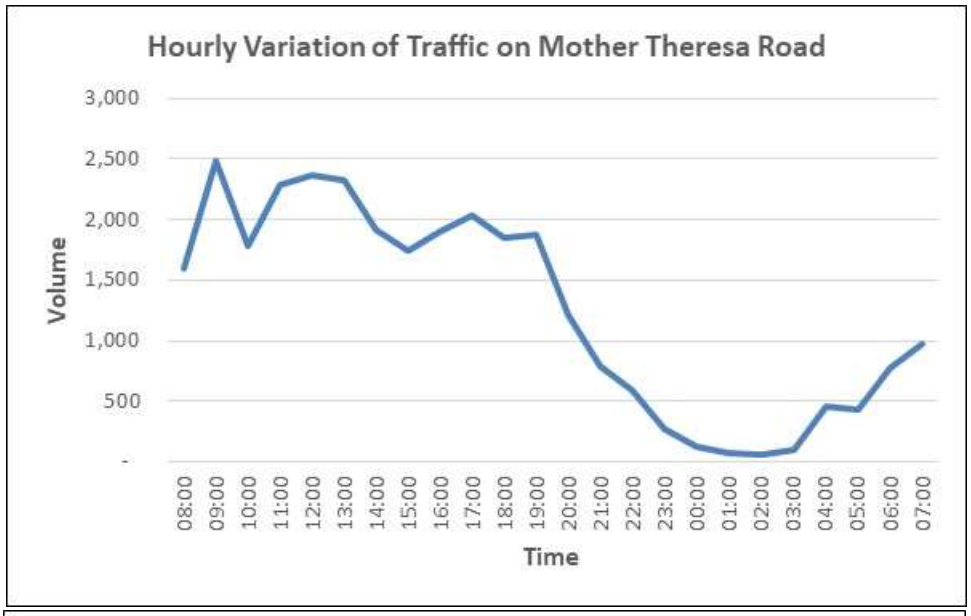
Mode	Mother Theresa Road	KS Rao Road	KS Rao road near City Point	KRR Road	Bunts Hostel Road	Sturrock Road	Attavar Road
2w	12,968	6,820	14,537	20,378	22,798	7,747	3,153
3w	9,525	4,899	6,682	8,348	11,377	3,626	2,560
Car/Van	6,724	4,294	8,145	12,777	17,991	4,497	1,540
Mini Bus	76	39	48	98	190	95	28
Bus	674	65	153	3,591	4,383	194	125
MLCV	539	175	360	850	598	79	83
LCV	-	17	77	3	87	868	8
2 Axle Truck	126	12	16	72	65	36	17
3 Axle Truck	9	2	2	23	27	3	8
MAV	-	3	-	-	-	17	1
Tractor	-	-	-	-	1	-	0
Tractor+Trailer	-	-	-	2	-	9	1
Cycle	6	12	12	70	23	27	10
Cycle rickshaw	-	-	-	-	-	-	-
Animal Drawn	-	-	-	-	-	-	-
Hand Cart	-	-	-	-	-	-	-
Total Veh	**30,647**	**16,339**	**30,033**	**46,214**	**57,539**	**17,198**	**7,534**
Total PCU	**37,928**	**19,646**	**33,329**	**53,896**	**68,684**	**19,583**	**9,499**

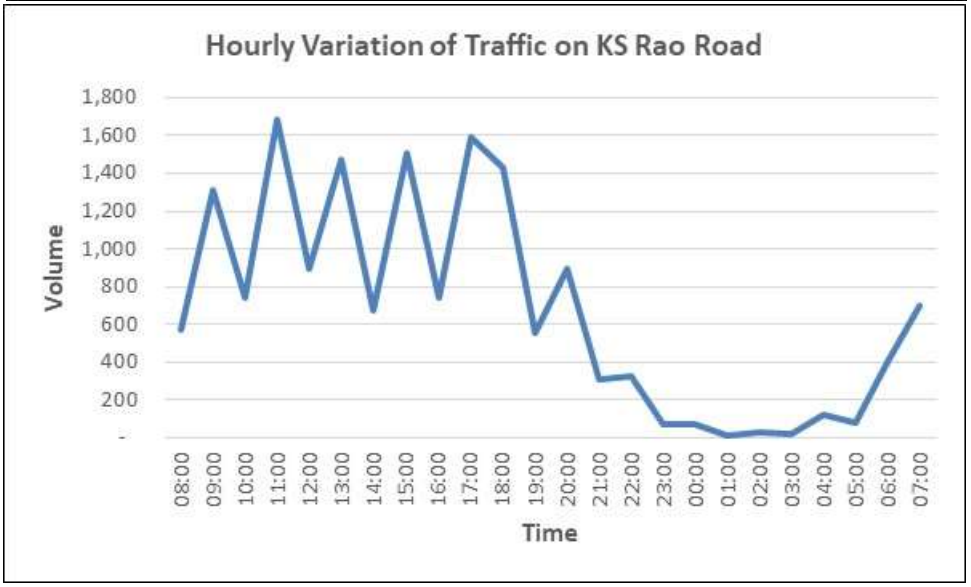
Traffic volume is highest on Bunts Hostel road at 68,684 PCU followed by Kudmal Ranga Rao road at 53,896 PCU and followed by Mother Theresa Road at 37,928 PCU and KS Rao Road at city point at 33,329 PCU. KS Rao road at other location and Sturrock road are about 20,000PCU and Attavar Road at 9,500 PCU.

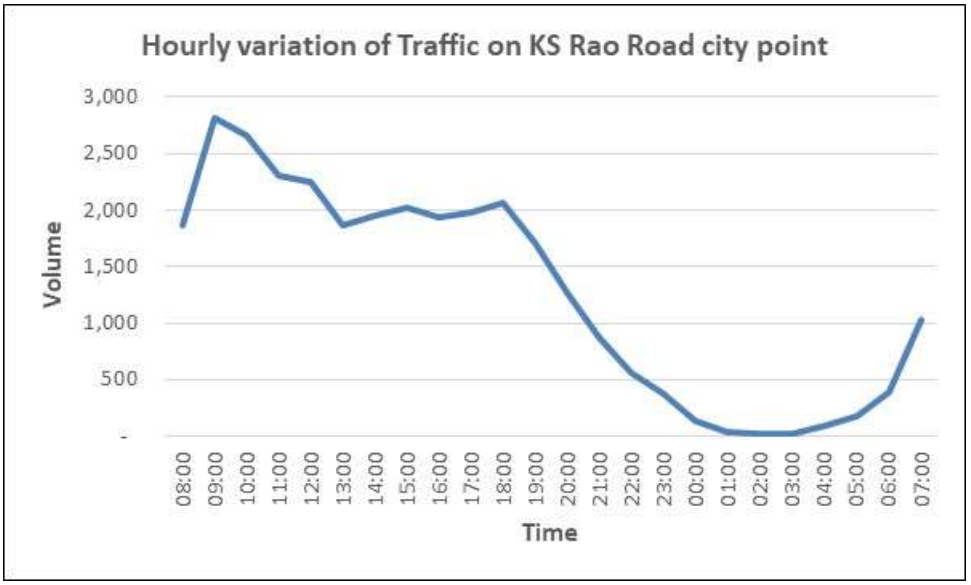
Since these are urban roads seasonal variations are minimal and, hence, ADT is considered as AADT.

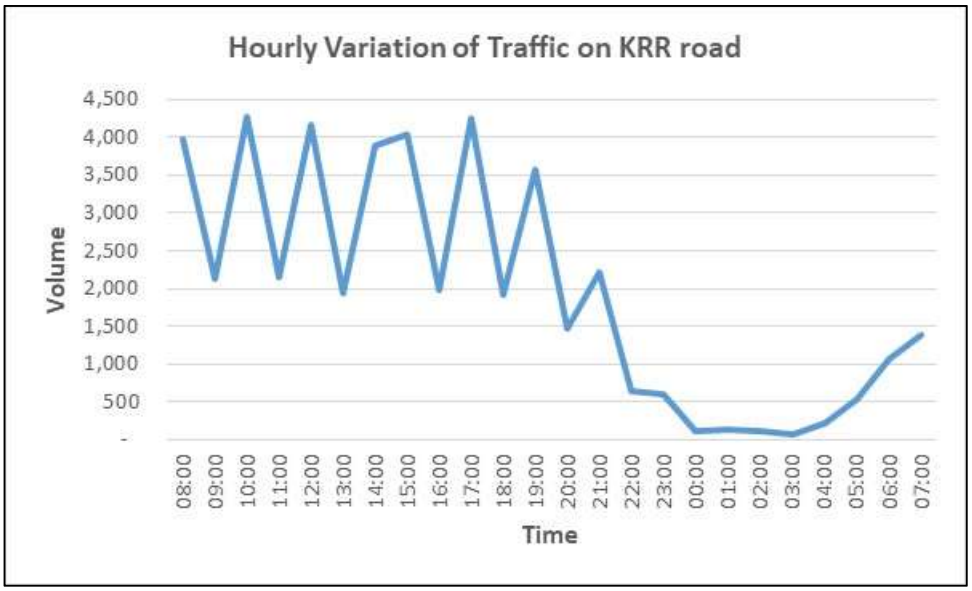
4.5.4 Hourly Variation

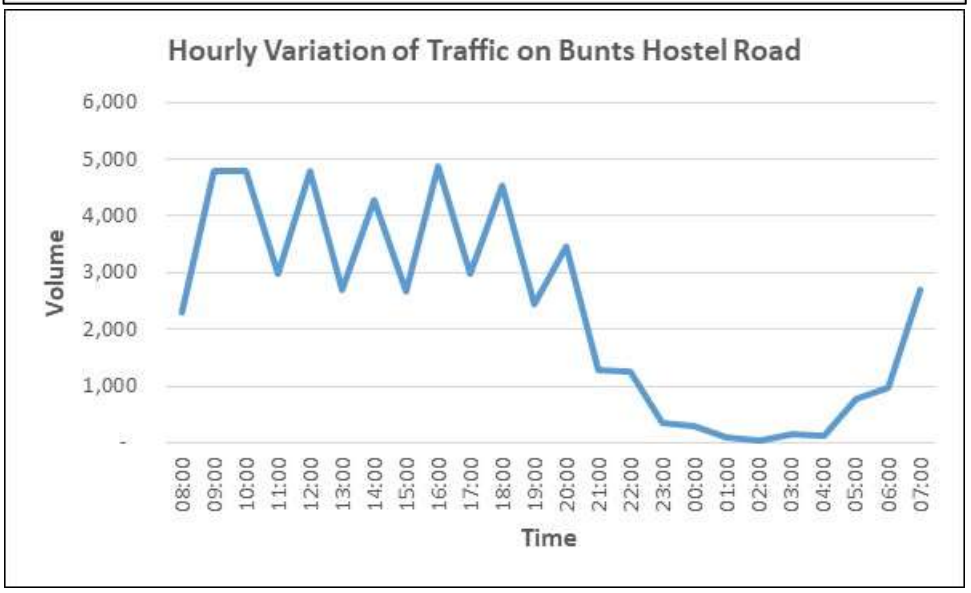
The hourly variation of traffic at survey locations is presented in **Error! Reference source not found.**.






Hourly variation of Traffic on KS Rao Road city point
Volume
3,000
2,500
2,000
1,500
1,000
500
-
08:00 09:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00 20:00 21:00 22:00 23:00 00:00 01:00 02:00 03:00 04:00 05:00 06:00 07:00
Time


Hourly Variation of Traffic on KRR road
Volume
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
-
08:00 09:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00 20:00 21:00 22:00 23:00 00:00 01:00 02:00 03:00 04:00 05:00 06:00 07:00
Time


Hourly Variation of Traffic on Bunts Hostel Road
Volume
6,000
5,000
4,000
3,000
2,000
1,000
-
08:00 09:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00 20:00 21:00 22:00 23:00 00:00 01:00 02:00 03:00 04:00 05:00 06:00 07:00
Time

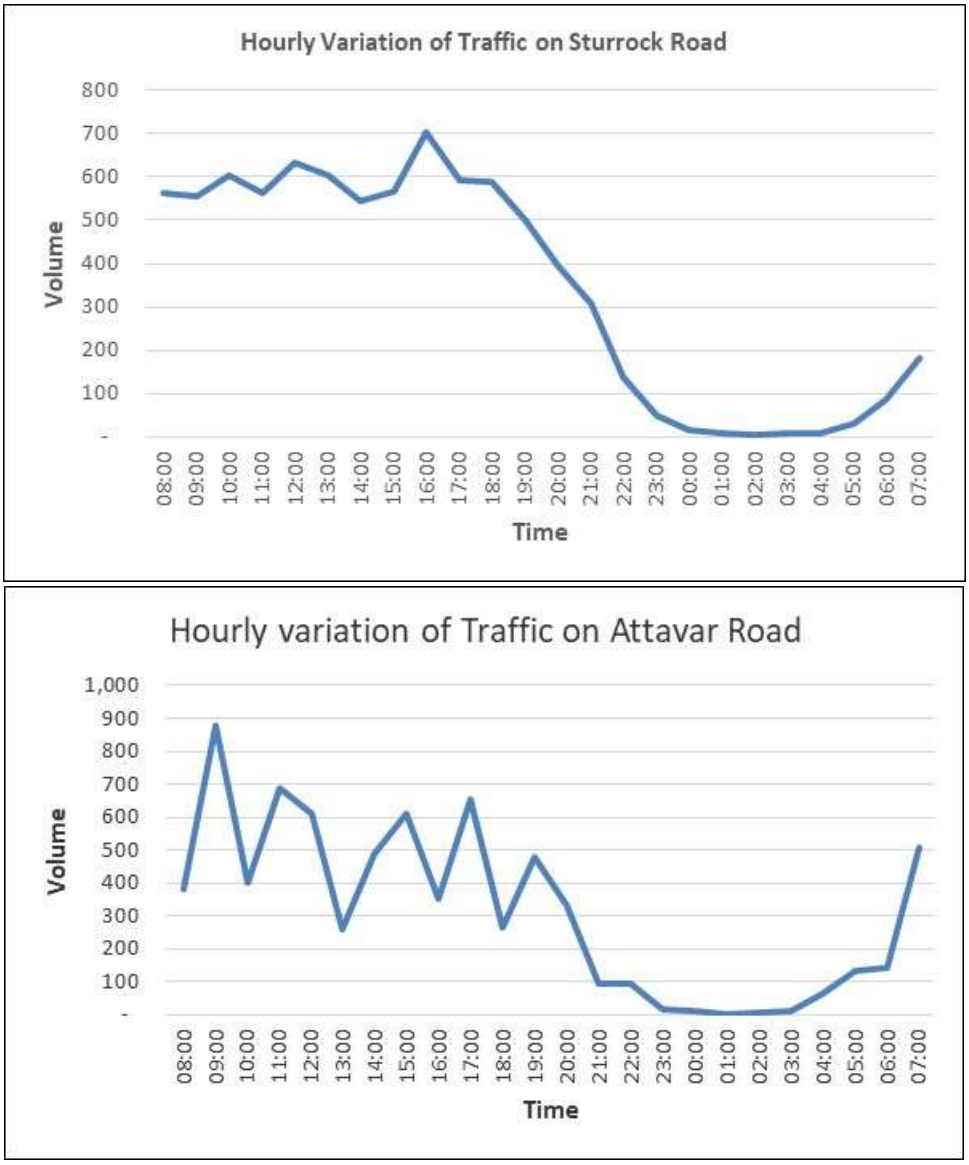
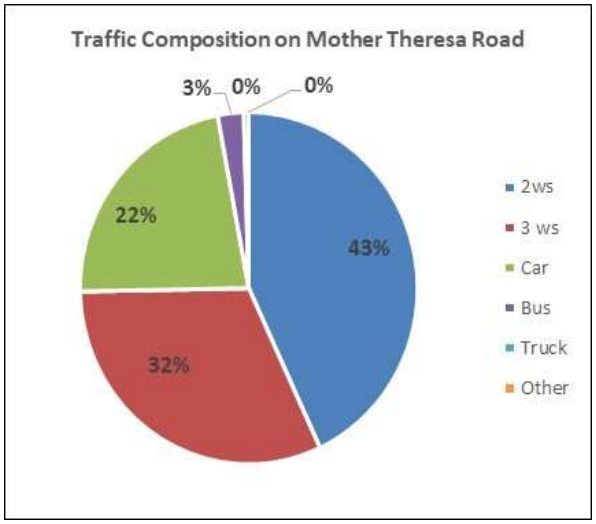
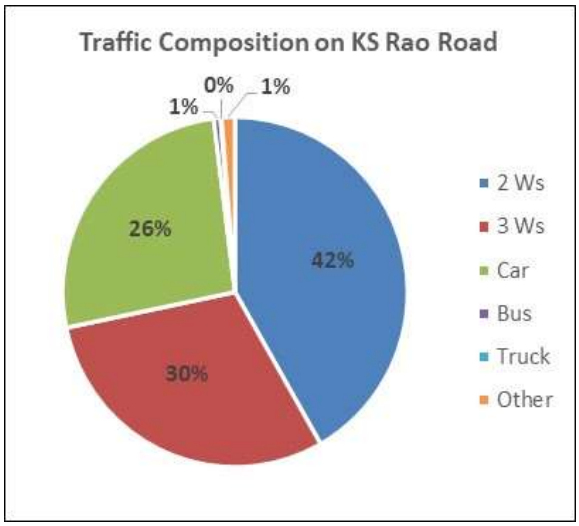


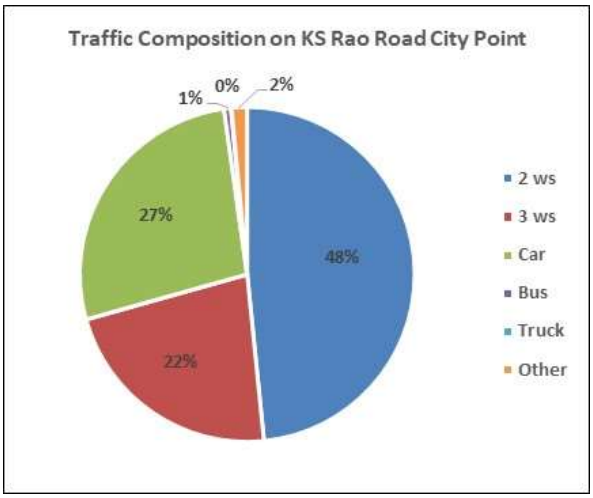
Figure 4-1 Hourly Variation Graphs of Traffic on DPR-4 Smart roads

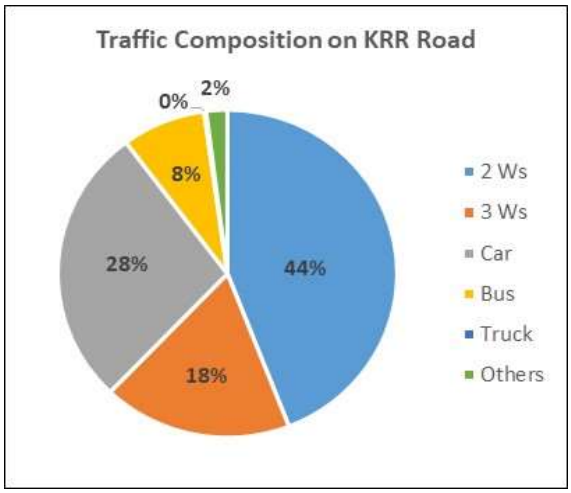
4.5.5 Traffic Composition

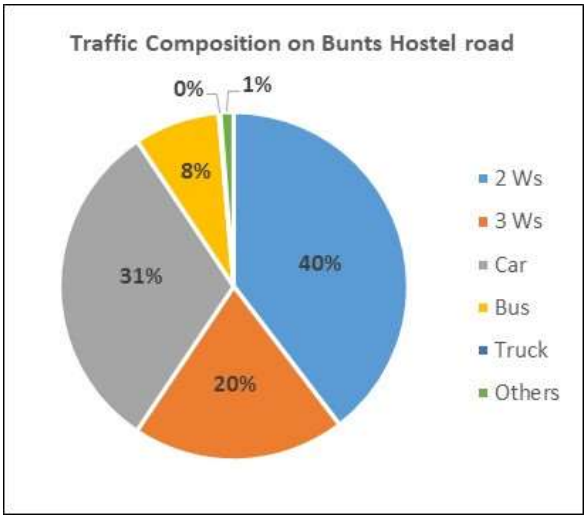
The composition of traffic at the survey locations is presented in **Error! Reference source not found..**

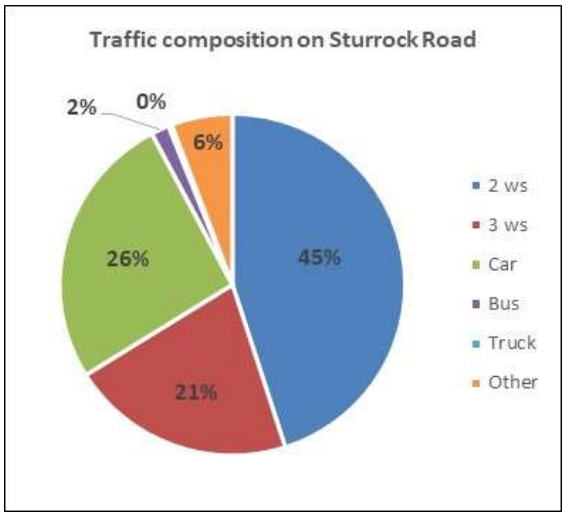












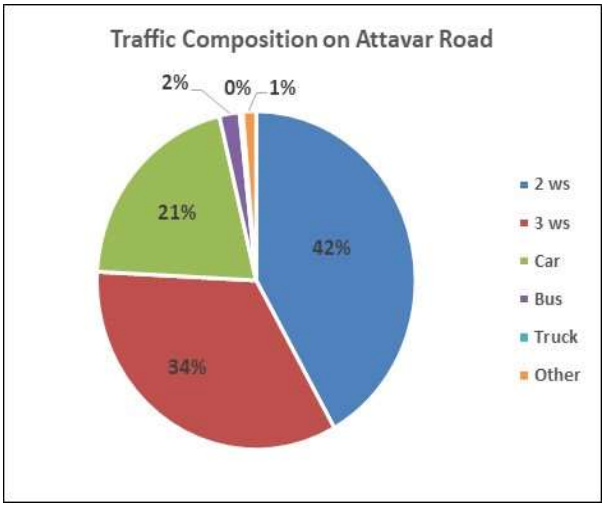


Figure 4-2 Hourly Variation Graphs of Traffic on DPR-4 Smart roads

Traffic composition in terms of Passenger vehicles and Commercial vehicles is also analyzed to understand the impact of commercial vehicles and is presented in **Error! Reference source not found.**.

Table 4-4: Composition of Passenger and Commercial Vehicles

Mode	Mother Theresa Road	KS Rao Road	KS Rao road near City Point	KRR Road	Bunts Hostel Road	Sturrock Road	Attavar Road
Passenger	98%	99%	98%	98%	99%	94%	98%
Commercial	2%	1%	2%	2%	1%	6%	2%

Traffic composition in terms of Public and Private vehicles is also analyzed to understand the private vehicles which will help us to formulate policy and is presented in **Error! Reference source not found.**.

Table 4-5: Composition of Public and Private modes of transport

Mode	Mother Theresa Road	KS Rao Road	KS Rao road near City Point	KRR Road	Bunts Hostel Road	Sturrock Road	Attavar Road
Private Vehicles	97%	99%	99%	92%	92%	98%	98%
Public Vehicles	3%	1%	1%	8%	8%	2%	2%

The observations on the traffic and composition are:

- Passenger vehicles comprise about 94-99% of the total vehicles and commercial vehicles are meagre 1-2% except Sturrock road where the commercial vehicles are higher at 6%.
- Private vehicles are occupying the major portion of the urban road space. About 97%-99% of the vehicles are private vehicles and the balance are public transport vehicles (mini bus + bus).

4.5.6 Peak Hour Analysis

In urban context, the roads are designed to cater to the requirements of peak hour volume. Hence, peak hour traffic analysis is done and presented in **Error! Reference source not found.**.

Table 4-6: Peak Hour Volume and Peak %age

Description	Mother Theresa Road	KS Rao Road	KS Rao road near City Point	KRR Road	Bunts Hostel Road	Sturrock Road	Attavar Road
Peak Hour	9:00-10:00 am	11:00-12:00 pm	9:00-10:00 am	10:00-11:00 am	4:00-5:00 am	4:00-5:00 am	9:00-10:00 am
Peak, Vol	3,113	1,684	2,822	4,266	4,884	1,386	877
Peak,% (Vol)	10.16%	10.31%	9.40%	9.23%	8.49%	8.06%	11.64%
Peak, PCU	3,908	2,048	3,073	4,979	5,880	1,721	1,076
Peak,% (pcu)	10.30%	10.43%	9.22%	9.24%	8.56%	8.79%	11.33%

Three main junctions are falling on these selected roads, viz.,

1. PVS Circle Junction
2. Bunts Hostel Junction
3. Jyoti Circle Junction

Analysis of these junctions is carried out and presented at Figure 5-7.

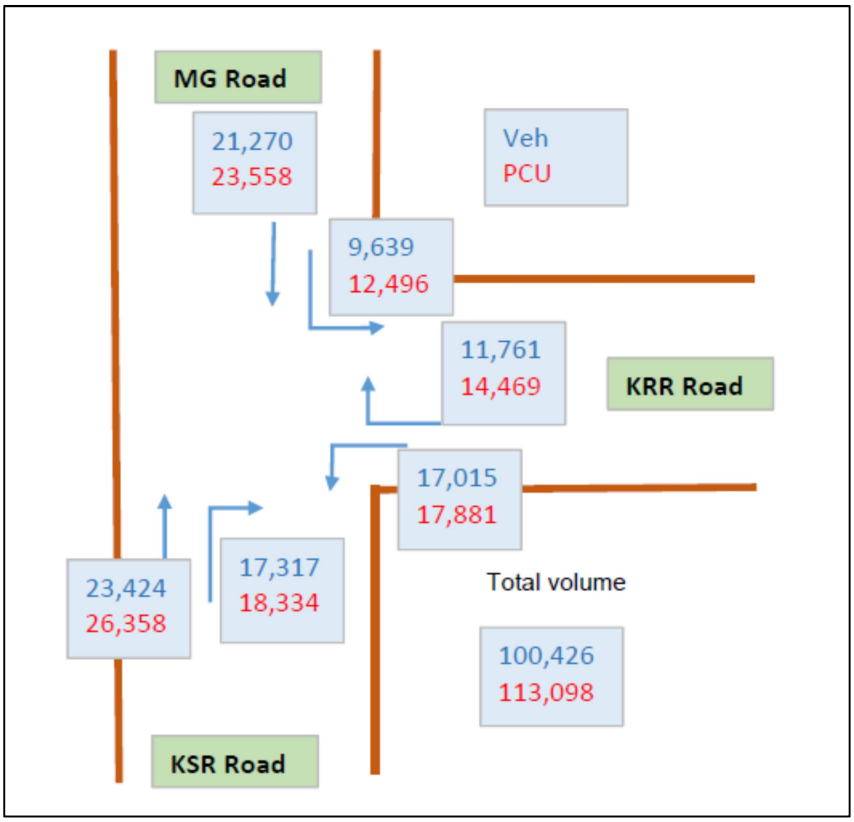


Figure 0-1 Turning Movement Counts at PVS Circle Junction

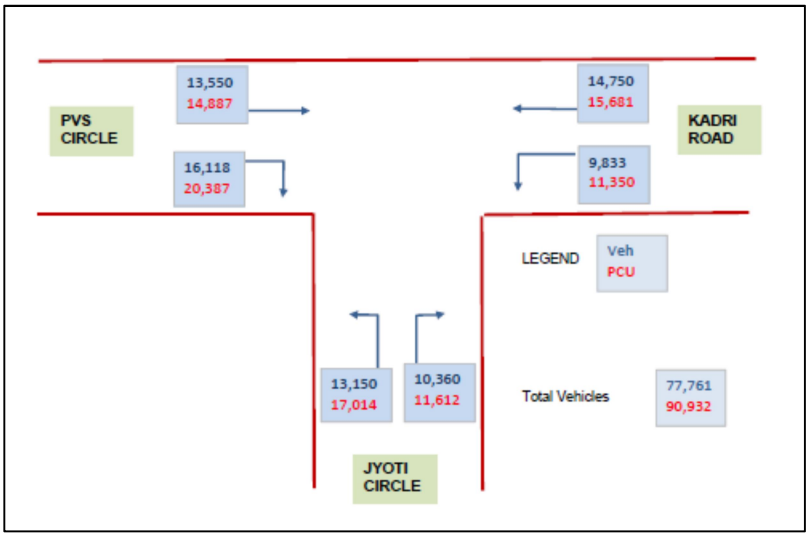


Figure 0-2 Turning Movement Counts at Bunts Hostel Junction

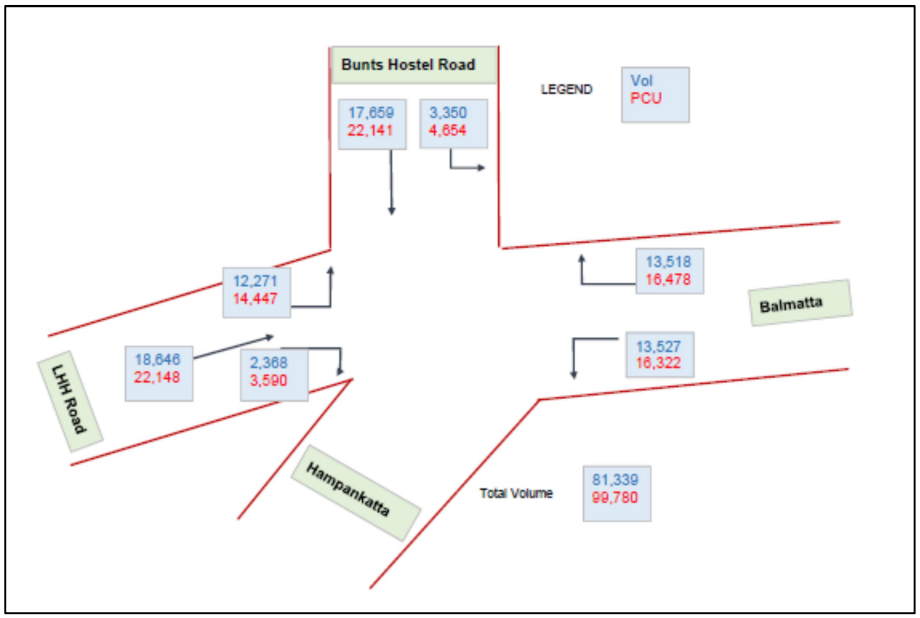


Figure 0-3 Turning Movement Counts at Jyoti Circle Junction

4.6 Traffic Forecast

Traffic Forecast in an Urban scenario is generally done through 4 stage travel demand modelling, which is an intensive exercise and is beyond the scope of this project. It is proposed to use growth rate to assess the capacity requirement of the selected roads. 3% growth rate is considered for the passenger vehicles and 2% is considered for the commercial vehicles. The projected peak hour PCU in different years is presented in **Error! Not a valid bookmark self-reference.**.

Table 0-1: Projected Peak hour volumes in PCU

Year	Mother Theresa Road	KS Rao Road	KS Rao road near City Point	KRR Road	Bunts Hostel Road	Sturrock Road	Attavar Road
2018	3,908	2,048	3,073	4,979	5,880	1,721	1,076
2020	4,141	2,172	3,259	5,265	6,219	1,822	1,141
2025	4,787	2,514	3,772	6,055	7,157	2,102	1,319
2030	5,533	2,910	4,368	6,966	8,238	2,425	1,525
2035	6,396	3,371	5,057	8,016	9,486	2,798	1,762
2038	6,978	3,681	5,521	8,722	10,324	3,049	1,923

Similarly, forecast was prepared for the Junctions and is presented in

.

Table 0-2: Detailed Analysis of Junction Traffic for Present condition and Future Predictions (As per IRC -92)

S.No.	Junction Category	Name of Intersection	Peak Hour PCU (2018)	Peak Hour PCU (2028)	Peak Hour PCU (2038)	Year Grade separation warranted	Remarks
1	3 Leg	PVS Circle Junction	9,312	12,514	16,818	2021	Space Constraint - Signal recommended
2	3 Leg	Bunts Hostel Junction	7,736	10,396	13,971	2027	Space Constraint - Signal recommended
3	4 Leg	Jyoti Circle Junction	10,326	13,877	18,649	2018	Space Constraint - Signal recommended

Table 0-3: Detailed Analysis of Junction as per SP-41

S.No.	Junction Category	Name of Intersection	2018		2028		2038	
			Major Road	Minor Road	Major Road	Minor Road	Major Road	Minor Road
1	3 Leg	PVS Circle Junction	71,650	28,776	95,890	38,501	1,28,869	51,743
2	3 Leg	Bunts Hostel Junction	54,251	23,144	82,002	34,971	1,10,204	46,998
3	4 Leg	Jyoti Circle Junction	57,962	21,009	77,140	27,880	1,02,749	37,035

Similarly pedestrian vehicular conflict is analyzed and presented at Table 10.

Table 0-4: Pedestrian Vehicular Conflict at Major Arm

S.No.	Name of Intersection	Peak Hour	Arm	PV^2X10^8	Proposal
1	PVS Junction	12:00 - 1:00	MG Road	160.39	Control Measure
			Bunts Hostel	66.37	Control Measure
			City Point	154.66	Control Measure
2	Bunts Hostel Junction	12:00 - 1:00	Kadri Road	100.82	Control Measure
			Jyoti Circle	52.03	Control Measure
			PVS Circle	100.93	Control Measure
3	Jyoti Circle Junction	12:00 - 1:00	Bunts Hostel	29.73	Control Measure
			Balmatta Road	68.42	Control Measure
			Hampankatta Road	8.15	Control Measure
			LHH Road	27.22	Control Measure

4.7 Capacity Analysis

4.7.1 Road Standards

IRC:SP:106-1990– "*Guidelines for Capacity of Urban Roads in Plains*" specifies Design Service Volume of different urban roads and is given in **Error! Reference source not found.**.

Table 0-5: Recommended Design Service Volumes (PCU/Hr)

S.No.	Type of Carriageway	Total Design Service volumes for Different Catetories of Urban Roads		
		Arterial	Sub-arterial	Collector
1	2 Lane (One Way)	2,400	1,900	1,400
2	2 Lane (Two Way)	1,500	1,200	900
3	3 Lane (One Way)	3,600	2,900	2,200
4	4 Lane Undivided (Two Way)	3,000	2,400	1,800
5	4 Lane Divided (Two Way)	3,600	2,900	-
6	6 Lane Undivided (Two Way)	4,800	3,800	-
7	6 Lane Divided (Two Way)	5,400	4,300	-
8	8 Lane Divided (Two Way)	7,200	-	-

4.7.2 Junction Standards

IRC SP:41-1994, provides a graph for selection of intersection type based on traffic volumes which is reproduced in **Error! Reference source not found.** for ready reference.

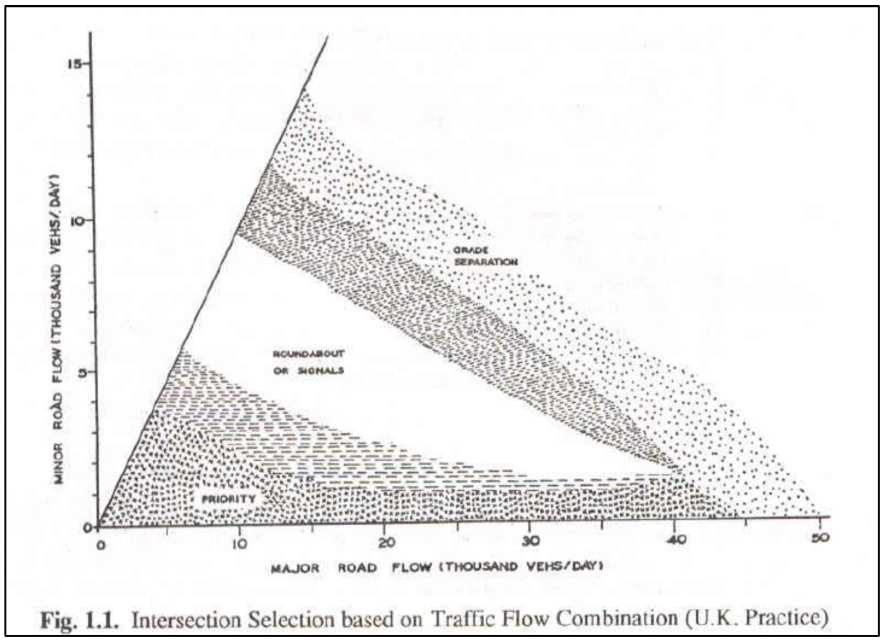


Fig. 1.1. Intersection Selection based on Traffic Flow Combination (U.K. Practice)

Figure 0-4 Intersection selection based on criteria

IRC-92-1985: An interchange may be justified when an **at-grade intersection fails to handle the volume of traffic** resulting in serious congestion and frequent choking of the intersection. This situation may arise when the **total traffic of all the arms of the intersection is in excess of 10,000 PCU/ hours.**

4.7.3 Pedestrian facilities

Intensity of pedestrians crossing the project road will decide the grade separators in the form of RUB, pedestrian crossing.

Pedestrian – vehicular conflict can be effectively studied through the indicator suggested in IRC:103-1988, Guidelines for Pedestrian facilities.

The code suggests some form of control measures at mid-blocks and intersections where the indicator PV^2 is greater than or equal to $2x10^8$ and for Zebra crossing PV^2 should be greater than $1x10^8$ where 'P' is the Peak hour pedestrian volume and 'V' is the number of vehicles in that peak hour.

4.8 Analysis

4.8.1 Roads

The existing lane configuration of roads and capacity is presented at Error! Reference source not found. **is given in Error! Reference source not found.**

Table 0-6: Existing Lane Configuration of Roads

	Mother Theresa Road	KS Rao Road	KS Rao road near City Point	KRR Road	Bunts Hostel Road	Sturrock Road	Attavar Road
No of Lanes	4	4	4	4	4	2	2
Capacity	3,600	3,600	3,600	3,600	3,600	1,00	1,900

The unconstrained capacity (lanes) requirement based on traffic analysis is given in **Error! Reference source not found.**. Please note that this is with the assumption that capacity enhancement is possible. Development strategy would be based on this capacity requirement and the feasibility of expansion, if possible.

Table 0-7: Unconstrained Capacity Requirement Based on Traffic (Lanes)

Year	Mother Theresa Road	KS Rao Road	KS Rao road near City Point	KRR Road	Bunts Hostel Road	Sturrock Road	Attavar Road
2018	6 L	4 L	4 L	6 L	8 L	4 L	2 L
2020	6 L	4 L	4 L	6 L	8 L	4 L	2 L
2025	6 L	4 L	6 L	8 L	8 L	4 L	2 L
2030	8 L	4 L	6 L	8 L	> 8 L	4 L	2 L
2035	8 L	4 L	6 L	> 8 L	> 8 L	4 L	2 L
2038	8 L	4 L	6 L	> 8 L	> 8 L	4 L	2 L

From the above analysis, it can be seen that all the above roads will require capacity enhancement. However, this being a developed town space is a constraint.

4.8.2 Junctions

Based on the junction analysis grade separation is required as per the details given below. However, space constraints are there as this being a developed town. Hence the following recommendations are made:

Table 0-8: Unconstrained Capacity

S.No.	Junction Category	Name of Intersection	Year Grade separation warranted	Remarks
1	3 Leg	PVS Circle Junction	2021	Space Constraint - Signal recommended
2	3 Leg	Bunts Hostel Junction	2027	Space Constraint - Signal recommended
3	4 Leg	Jyoti Circle Junction	2018	Space Constraint - Signal recommended

4.8.3 Pedestrian facilities

Based on the analysis, as the PV^2 values are higher than $2x10^8$ and hence mid-block and at junction control measures are suggested at all the three junctions.

4.9 Future strategy

1) All the roads are reaching capacity during the horizon period. However, this being already developed tow, expansion of the width of the roads is not possible due to development on both ends right now. Based on Master Plan proposals, Mangalore City Corporation has approved certain road widths. As and when the road widening is taken up, capacity augmentation of these roads can be taken up.
2) Moreover, the Design Service Volumes refer to Level of Service (LoS) C, which is, generally, at 0.7 of the Capacity. Further, traffic volume greater than capacity is often observed in Urban areas with lower Level of Service.
3) Considering the above, it is suggested to deploy traffic management strategies, coupled with promotion of the Public Transport System to reduce the number of vehicles on the road.
4) All the junctions require grade separation. Once again space constraints are there to develop these facilities. In view of this signalization of these junctions are proposed as and when the capacity of uncontrolled junctions is reached.
5) Mid block and at junction control measures are proposed for the pedestrians as the PV2 values are higher than 2x108.

4.10 Summary

1) Mangalore Smart City Limited (MSCL) is implementing the Smart City Proposals with the help of the Project Management Consultants. Development of Smart Roads is one of important projects in the Smart City Proposal. Safe pedestrian movement along with smart features is key in the development of the Smart Roads.
2) This report deals with the DPR 4 for the Smart roads. Six roads considered under DPR 4 are: Mother Theresa road, Attavar Road, Sturrock road, Bunts Hostel road, Kudmal Rangarao road from Arya Samaj junction to PVS circle, Kudmal Ranga Rao road from PVS circle to Hampankatta.
3) Traffic surveys are conducted on these roads to get the base year mode wise traffic statistics. These are analyzed and the peak hour traffic volumes both in terms of number of vehicles and PCU are worked out. Projections for future are made applying appropriate growth rates.
4) Capacity Analysis has shown that Mother Theresa Road, Attavar Road, Sturrock Road, Bunts Hostel Road and Kudmal Ranga Rao Road are all reaching their capacity during the horizon period and needs capacity augmentation. However, this being already developed town, expansion of the width of the roads is not possible due to development on both ends right now.
5) Based on Master Plan proposals, Mangalore City Corporation has approved certain road widths. As and when the road widening is taken up, capacity augmentation of these roads can be taken up.
6) Moreover, the Design Service Volumes refer to Level of Service (LOS) C, which is, generally, at 0.7 of the Capacity. Further, traffic volume greater than capacity is often observed in Urban areas with lower Level of Service.
7) Considering the above, it is suggested to deploy traffic management strategies, coupled with promotion of the Public Transport System to reduce the number of vehicles on the road.
8) All the junctions require grade separation. Once again space constraints are there. In view of this, signalization of these junctions is proposed as and when the capacity of uncontrolled junctions is reached.
9) Mid block and at junction control measures are proposed for the pedestrians as the PV2 values are higher than 2x108.

Table 0-9: Road Recommendations as per Traffic Study

Road No.	Description	Traffic Lane Recommendation	Cross sectional slope of the Road	Carriageway width (m)	Bitumen to Concrete	Footpath (Width in m) (Flushed or Raised)		Remarks
						LHS	RHS	
3A	Forum Fiza Mall to Rosario Church Junction	4 Lane 2 Way with Median	2 way	3.1 (Existing)	No	1.8 (Raised)		SWD in carriageway.
3B		4 Lane 2 Way without Median	2 way	3.1	No	1.8 Raised + 2.5 (Interlock & Flushed)		SWD in carriageway
3C		4 Lane 2 Way without Median	2 way	3.1	No	1.0 (Flushed)		SWD in carriageway
1A	Hamilton to Rosario road Junction	4 lane 2 way w/o Median	2 way	3.1	No	1.4 (Raised)		SWD in carriageway
	Rosario Church Road to Railway Gate Bus Stop	2 Lane 2 way	1 way	3.1	Yes	Flushed and included in Carriageway		Interlock Quantities to be considered more so as to execute interlock pavers during Implementation wherever constraints in carriageway
16	Railway Gate Bus Stop to end of railway yard	2 Lane 2 way	1 way	3.1	Yes	Flushed		SWD in carriageway

Road No.	Description	Traffic Lane Recommendation	Cross sectional slope of the Road	Carriageway width (m)	Bitumen to Concrete	Footpath (Width in m) (Flushed or Raised)		Remarks
						LHS	RHS	
	Railway Yard up to Mission Street	2 Lane 2 Way	1 way	3.1	Yes	Flushed and included in Carriageway		Concrete work of pavement already awarded. Scope includes footpath and other works SWD in carriageway
1B	Bunder to Road 20	2 Lane 1 Way	1 way	3.1	Yes	Flushed and included in Carriageway		Dismantling of compound wall (30 m long) and additional width of 1 m to be considered in design SWD in carriageway
	Road 20 to Mangala Corniche	2 Lane 1 Way	1 way	3.1	Yes	Flushed and included in Carriageway		SWD in carriageway
	Bunder Road to Rosario	2 Lane 1 Way	1 way	3.1	Yes	Flushed and included in Carriageway		SWD in carriageway
21	DC Office to Bunder Road	2 Lane 1 Way	1 way	3.1	Yes	Flushed and included in Carriageway		SWD in carriageway
22	Bunder Road towards Port	2 Lane 1 Way	1 way	3.1	Yes	Flushed and included in Carriageway		SWD in carriageway

Road No.	Description	Traffic Lane Recommendation	Cross sectional slope of the Road	Carriageway width (m)	Bitumen to Concrete	Footpath (Width in m) (Flushed or Raised)		Remarks
						LHS	RHS	
23	Mission Street Road to Bunder Road	2 Lane 2 way	1 way	3.1	Yes	Flushed and included in Carriageway		SWD in carriageway
6	Clock Tower to Balmatta road Junction	6 Lane 2 Way with Median	2 way	3.1 and 3.5	No	2.2 (Raised)		SWD in footpath.
	Balmatta road Junction to Syndicate Bank	4 Lane 2 Way without Median	2 way	3.1	No	2.2 (Raised) or 1.4 (Raised)		SWD in footpath. Or SWD in carriageway
11	Light house Hill Road (Syndicate Bank to Jumma Masjid)	2 Lane 1 Way without Median	1 way	3.1 and 3.5	No	2.2 (Raised) and 1.4 (Raised)		SWD in footpath.
	Light house Hill Road (Jumma Masjid to Jyoti Circle)	3 Lane 1 Way without Median	1 way	3.1 and 3.5	No	2.2 (Raised) and 1.4 (Raised)		SWD in footpath.
17	KMC Merkara Trunk Road (Jyoti Circle to Syndicate Bank	3 Lane 1 Way without Median	1 way	3.1 and 3.5	No	2.2 (Raised) and 1.4 (Raised)		SWD in footpath.

5. CARRIAGEWAY, JUNCTION IMPROVEMENT AND PAVEMENT DESIGN

5.1 Carriageway Improvement

5.1.1 Right of Way (ROW)

Total six roads are being improved in this phase namely:

1. Mother Theresa Road – From Hampankatta Junction to Milagres Church Junction,
2. Attavar Road - From Mother Theresa Road to Nandigudda Road,
3. Sturrock Road – From Avery Junction to Anand Shetty Circle,
4. Bunts Hostel Road - From Jyoti Circle to Bunts Hostel Junction,
5. Kudmal Ranga Rao Road - From AryaSamaj Road Junction to PVS Circle
6. KS Rao Road - From PVS Circle to Hampankatta Junction

Details of existing ROW are as follows:

1. Mother Theresa Road – Varies from 17.60m to 19.50m
2. Attavar Road – Varies from 5.20m to 13.70m
3. Sturrock Road – Varies from 11.50m to 15.60m
4. Bunts Hostel Road – Varies from 17.50m to 20.15m
5. Kudmal Ranga Rao Road – Varies from 15.10m to 23.70m
6. KS Rao Road – Varies from 15.90m to 22.00m

Existing Right of Way (ROW) are:

- 22.0m to 37.0m, 9.0m to 12.0m, 8.0m to 21.0m ; 16.0m to 24.0m ; 6 to 17 m; 18 to 23 m and 4 m to 18 m
- For Mother Theresa road four lane divided carriageway two way, Attavar Road two lane one way, Sturrock road two lane two way, Bunts Hostel road four lane divided carriageway two way, Kudmal Ranga Rao road four lane divided carriageway two way respectively.
- MCC proposes to widen the streets, but it is not clear when this will happen. As per the discussion and confirmation with MSCL, the Consultants have prepared the proposals as per the existing RoW.

The following drawings enclosed in Section 11 of the Report provide details of Plan and Profile for DPR 4 roads

Table 5-1: List of all drawings (Existing & Proposed Features)

Drawing Number	Drawing Title
WTE_2292_04_R_1.01	EXISTING FEATURES OF MOTHER THENESA ROAD (ROAD NO. 7b) 1 Sheet
WTE_2292_04_R_1.02	EXISTING FEATURES OF MILAGNES NANDIGUFFA ROAD (ROAD NO. 7e) 2 Sheets
WTE_2292_04_R_1.03	EXISTING FEATURES OF STURROCK ROAD (ROAD NO. 9) 2 Sheets
WTE_2292_04_R_1.04	EXISTING FEATURES OF BUNTS HOSTEL ROAD (ROAD NO. 12) 2 Sheets
WTE_2292_04_R_1.05	EXISTING FEATURES OF KRR ROAD (KUDMAL RANGA RAO ROAD) (ROAD NO. 13a) 4 Sheets
WTE_2292_04_R_1.06	EXISTING FEATURES OF KSR RAO ROAD (ROAD NO.13b) 4 Sheets
WTE_2292_04_R_2.01	PLAN AND PROFILE OF MOTHER THENESA ROAD (ROAD NO. 7b) 1 Sheet
WTE_2292_04_R_2.02	PLAN AND PROFILE OF MILAGNES NANDIGUFFA ROAD (ROAD NO. 7e) 1 Sheet
WTE_2292_04_R_2.03	PLAN AND PROFILE OF STURROCK ROAD (ROAD NO. 9) 1 Sheet
WTE_2292_04_R_3.01	ROAD SIGNAGE - PLAN AND ROAD MARKING OF MOTHER THENESA ROAD (ROAD NO. 7b) 1 Sheet
WTE_2292_04_R_3.02	ROAD SIGNAGE - PLAN AND ROAD MARKING OF MILAGNES NANDIGUFFA ROAD (ROAD NO. 7e) 1 Sheet
WTE_2292_04_R_3.03	ROAD SIGNAGE - PLAN AND ROAD MARKING OF STURROCK ROAD (ROAD NO. 9) 2 Sheets
WTE_2292_04_R_3.04	ROAD SIGNAGE - PLAN AND ROAD MARKING OF BUNTS HOSTEL ROAD (ROAD NO. 12) 2 Sheets
WTE_2292_04_R_3.05	ROAD SIGNAGE - PLAN AND ROAD MARKING OF KRR ROAD (KUDMAL RANGA RAO ROAD) (ROAD NO. 13a) 4 Sheets
WTE_2292_04_R_3.06	ROAD SIGNAGE - PLAN AND ROAD MARKING OF KS RAO ROAD (ROAD NO.13b) 4 Sheets
WTE_2292_04_R_3.07	PROPOSED JUNCTION IMPROVEMENT JYOTHI CIRCLE _ 1 Sheet
WTE_2292_04_R_3.08	PROPOSED JUNCTION IMPROVEMENT BUNTS HOSTEL _ 1 Sheet
WTE_2292_04_R_3.09	PROPOSED JUNCTION IMPROVEMENT PVS Circle _ 1 Sheet
WTE_2292_04_R_4.01	ROAD SIGNAGE AND MARKING DETAILS _ 1 Sheet
WTE_2292_04_R_5.01	PROPOSED CROSS SECTION OF MOTHER THENESA ROAD (ROAD NO. 7b) 2 Sheets

Drawing Number	Drawing Title
WTE_2292_04_R_5.02	PROPOSED CROSS SECTION OF MILAGNES NANDIGUFFA ROAD (ROAD NO. 7e) 3 Sheets
WTE_2292_04_R_5.03	PROPOSED CROSS SECTION OF STURROCK ROAD (ROAD NO. 9) 6 Sheets
WTE_2292_04_R_5.04	PROPOSED CROSS SECTION OF BUNTS HOSTEL ROAD (ROAD NO. 12) 5 Sheets
WTE_2292_04_R_5.05	PROPOSED CROSS SECTION OF KRR ROAD (KUDMAL RANGA RAO ROAD) (ROAD NO. 13a) 11 Sheets
WTE_2292_04_R_5.06	PROPOSED CROSS SECTION OF KSR RAO ROAD (ROAD NO.13b) 11 Sheets

5.1.2 Design Speed

Design speed is related to the function of a road. Keeping in view the type of functions expected on these roads, design speed has been considered as 40 to 50 Kmph.

5.1.3 Cross Sections

Based on the traffic analysis and available ROW, it is proposed to develop these roads as follows:

1. Mother Theresa Road from Hampankatta Junction to Milagres Church Junction is being developed as “4 Lane partly divided carriageway and partly undivided single carriageway”. Lane width has been considered as 3.1 m. Raised footpaths are proposed on both sides considering the space availability.
2. Attavar Road from Mother Theresa Road to Nandigudda Road is being developed as 5.0m wide single carriageway from CH 0+000 to CH 0+150 and two lane with 3.1m lane width from CH 0+150 to CH 0+330”. Raised footpaths are proposed on both sides considering the space availability.
3. Sturrock Road from Avery Junction to Anand Shetty Circle is being developed as “2 Lane two way single carriageway”. Lane width has been considered as 3.1 m. Raised footpaths are proposed on both sides considering the space availability.
4. Bunts Hostel Road from Bunts Hostel Junction to Jyoti Circle is being developed as “4 Lane divided carriageway”. Lane width has been considered as 3.0 m. Raised footpaths are proposed on both sides wherever width of 1.00m or more is available.
5. Kudmal Ranga Rao Road Part-I from PVS Circle to Arya Samaj Road Junction is being developed as “4 Lane divided carriageway and 4 lane single carriageway”. From CH 0+000 to CH 0+696, single carriageway with 3.10m lane width has been proposed and from CH 0+696 to CH 1+110, divided carriageway with 3.50m lane width has been proposed. Raised footpaths are proposed on both sides considering the space availability.
6. Kudmal Ranga Rao Road Part-II from Hampankatta Junction to PVS Circle is being developed as 4 lane divided carriageway. Lane width has been considered as 3.1m from CH 0+000 to CH 0+620 and 3.50m from CH 0+620 to CH 1+120. Raised footpath is proposed on one sides of carriageway considering the space availability.

The following drawings enclosed in Section 11 of the Report provides Plans and details of Road Signage's and Markings along DPR 4 roads

Table 5-2: List of Road Signage Drawings

DRAWING NO.	DRAWING NAME	NO OF SHEETS
WTE-2292-04-R-3.01 (R0)	ROAD SIGNAGE & ROAD MARKING PLAN OF MOTHER TERESA ROAD (ROAD NO. 7B) HAMPANKATTA JUNCTION TO MILAGRES CHURCH JUNCTION	1
WTE-2292-04-R-3.02 (R0)	ROAD SIGNAGE & ROAD MARKING PLAN OF MILAGRES NANDIGUDDA ROAD (ROAD NO. 7E) MILAGRES CHURCH TO NANDIGUDDA ROAD	2
WTE-2292-04-R-3.03 (R0)	ROAD SIGNAGE & ROAD MARKING PLAN OF STURROCK ROAD (ROAD NO. 9) AVERY JUNCTION TO ATTAVER ROAD	2
WTE-2292-04-R-3.04 (R0)	ROAD SIGNAGE & ROAD MARKING PLAN OF BUNTS HOSTEL ROAD (ROAD NO. 12) BUNTS HOSTEL JUNCTION TO JYOYHI CIRCLE	2
WTE-2292-04-R-3.05(R0)	ROAD SIGNAGE & ROAD MARKING PLAN OF KRR ROAD (KUDMAL RANGA RAO ROAD) (ROAD NO. 13A) PVS JUNCTION TO ARYA SAMAJ ROAD JUNCTION	4
WTE-2292-04-R-3.06 (R0)	ROAD SIGNAGE & ROAD MARKING PLAN OF KSR RAO ROAD (ROAD NO.13B) PVS CIRECLE-KSR ROAD TO HAMPANKATTA JUNCTION	4
WTE-2292-04-R-4.01 (R0)	ROAD SIGNAGE AND MARKING DETAILS	1

5.1.4 Camber / Cross Fall

The existing camber is retained for the CC roads and where new CC roads are being developed a camber of 2.5% is being provided.

5.1.5 Geometry / Alignment

Geometric design & Alignment design has been done in accordance with MoUD and IRC guidelines.

5.2 Intersection Improvement

Road intersections are critical element of road section. They are normally a major bottleneck to smooth flow of traffic and a major accident spot. Function of a designed intersection is to control conflicting and merging streams of traffic, to minimize the delay including pedestrian traffic.

Intersection design influences the capacity of the corridor and the safe movement of conflicting directions. The pattern of the traffic movements at the intersection and the volume of traffic on each approach, during peak period of the day determine the lane widths required.

The general design principles of intersection design are the approach speeds, restriction on available land, sight distance available and the presence of the larger volume of all the road users in urban areas.

5.2.1 Function of Intersection Design

The function of an intersection is to enable safe interchange between two directions or two modes.

The aim of the design of an intersection is to achieve with a minimum number of conflict points while following the basic principle to limit the number of conflict points between cars, buses, trucks, bicycles and the pedestrians as much as possible.

5.2.2 Classification of Intersections types

Intersection functions to control conflicting and merging traffic and to achieve this, intersections are designed on certain geometric parameters and are broadly classified into three main heads and are as follows:

- Un signalized intersection,
- Signalized Intersection and
- Roundabouts

A. Un-signalized intersection: There are two types of un-signalized intersections:

- Uncontrolled Intersection: These are the intersections between any two roads with relatively lower volume of traffic and traffic of neither road has precedence over the other.
- Intersection with Primary Control: In this type there are theoretically no delay occurring on the major road and vehicles on the minor road are controlled by 'GIVE WAY' or 'STOP' signs and marking

B. Signalized Intersection:

Signalization is applied at junctions where higher motorized vehicles require control by traffic lights. Traffic movement of different arms entering the intersection is controlled by traffic lights.

C. Roundabouts:

A roundabout is an intersection with a central island around which traffic must travel clockwise and in which entering traffic must 'GIVE WAY' to circulating traffic.

Table 5-1 below depicts the Pros and Cons of type of Intersection Lane Requirement

Table 5-3: Pros and Cons of Signalized Intersection and Roundabout

Signalized Intersection	Roundabout
Pros	
Signalized intersection can handle high traffic volumes	Reduces number of conflicts
Safety is ensured by eliminating conflicts through signalization	Ensures safety through speed reduction by design
	Minimum delays for all road users
Cons	
Higher delays for all road users	Roundabouts are not very effective for more than two circulatory lanes
	Roundabouts have capacity limitations and may not be able to handle a very high volume of traffic.

5.2.3 Objectives for Intersection Design

The main objective of intersection design is to facilitate the convenience, ease and comfort of people traversing the intersection while enhancing the efficient movement of passenger cars, buses, trucks, bicycles and pedestrians. The need for flexibility dictates the choice of the most suitable intersection type.

5.2.4 Consideration for Intersection Design

Design of a safe intersection depends on following major factors:

- Design and actual capacities
- Design hour traffic turning movements
- Variety of movements
- Vehicle Speeds
- Pedestrian movements
- Geometric features
- Traffic control devices
- Cost of improvements
- Energy consumption

5.2.5 Design Traffic Volumes:

Intersections are normally designed for peak hour flows. Turning movement count has been carried out and the data has been used after estimation of future traffic for intersection design.

5.2.6 Capacity of Intersections:

Intersection capacity is the maximum hourly rate at which vehicles can reasonably be expected to pass through the intersection under prevailing traffic, roadway and signalized conditions. Capacity is influenced by traffic and roadway conditions. Traffic conditions includes volumes on

each approach, the distribution of vehicles on each arm of intersection, the vehicle types distribution within each movement, pedestrian traffic flows and parking movements on approaches to the intersection.

Traffic control at intersections limits the capacity of the intersecting roadways, defined as the number of users that can be accommodated within a given time period.

Capacity of an intersection depends on the following factors:

- Physical and operating conditions like width of approach, one way or two way operation and parking conditions etc.
- Traffic characteristics like turning movements, number of commercial vehicles including buses, peak hour factors, number of pedestrians and geometry.

As per IRC: SP: 41-1994 "Guidelines on Design of At-Grade Intersections in Rural & Urban Areas", the intersection capacity is 700 to 1200 PCU's per hour per lane for one way traffic and 450 to 750 PCU's for two way traffic.

5.2.7 Traffic Calming Techniques

Traffic calming and speed management measures such as road humps are considered to discouraging traffic from entering intersection areas with high speed. These measures are always backed up by speed limits of 30 km/hr or less. Management of speed by engineering the road with the purpose to bring the design of the road in accordance with the desired speed is called speed management by design or traffic calming.

Trapezoidal Humps and Raised Pedestrian Crossing (Table Top)

A hump, which constitutes 150 mm, raised, flat section of a carriageway with ramps on both sides is called a trapezoidal hump. Trapezoidal humps can be used as pedestrian crossings.

- Since there is no negotiation in change of level, it improves walking and makes it more comfortable and convenient to the pedestrians.
- Makes the pedestrian alert and safe from entering and exiting vehicles.
- It gives the utmost comfort to people with disability and follows the concept of universal design.

5.2.8 Recommendations for Intersection Design at PVS Circle Intersection

This is three legged Intersection and based on the traffic survey the Average Daily Traffic and Peak traffic are mentioned in Chapter 4 above, it is recommended to go for at grade intersection.

The proposed Junctions Improvement at PVS circle Intersection has been shown in drawing

WTE_2292_00_R_4.01- PROPOSED JUNCTION IMPROVEMENT PVS Circle INTERSECTION (SHEET 1 OF 1) in Section 11 of the Report

5.2.9 Recommendations for Intersection Design at Bunts Hostel Intersection

Bunts Hostel Intersection is a three legged intersection and based on traffic survey the average daily traffic and peak hour traffic at this intersection are mentioned in Chapter 4 above, it is considered for designing for improvement as regular at grade intersection.

The proposed Junctions Improvement at Jyoti Circle intersection has been shown in drawing.

WTE_2292_00_R_4.02- PROPOSED JUNCTION IMPROVEMENT JYOTI CIRCLE INTERSECTION (SHEET 1 OF 1) in Section 11 of the Report.

5.3 Future Strategy

1. All the roads are reaching capacity during the horizon period. However, this being already developed tow, expansion of the width of the roads is not possible due to development on both ends right now. Based on Master Plan proposals, Mangalore City Corporation has approved certain road widths. As and when the road widening is taken up, capacity augmentation of these roads can be taken up.
2. Moreover, the Design Service Volumes refer to Level of Service (LoS) C, which is, generally, at 0.7 of the Capacity. Further, traffic volume greater than capacity is often observed in Urban areas with lower Level of Service.
3. Considering the above, it is suggested to deploy traffic management strategies, coupled with promotion of the Public Transport System to reduce the number of vehicles on the road.
4. All the junctions require grade separation. Once again space constraints are there to develop these facilities. In view of this signalization of these junctions are proposed as and when the capacity of uncontrolled junctions is reached.
5. Mid block and at junction control measures are proposed for the pedestrians as the PV^2 values are higher than $2x10^8$.

5.4 Pavement Design

5.4.1 Mother Theresa Road

Design of Slab Thickness

Input Data:

Road Type: Four Lanes Two Way Dual Carriageway

Design Life: 30 Years

Lane Width: 3.1m with 0.25m shyness width on both sides of carriageway edge.

Transverse joint spacing: 4.5 m

Traffic (as per TVC): 1424 Commercial Vehicles per Day (CVPD)

CBR of Existing Soil: Two samples collected and tested and are 9% and 8%.

CBR (Considered) of Proposed Subgrade: 8%

CBR (Assumed) of Embankment below subgrade: 8%

Effective CBR of Subgrade: 8% (As per Figure 2 of IRC 58-2015)

Axle load Survey (Assumed): Single Axle 98% and Tandem Axle 2%

Axle Load Spectrum (Assumed):

Table 5-4: Axle Load & Frequency Analysis

Sr. No.	Rear Single Axle		Rear Tandem Axle	
	Axle Load KN	Frequency (% of single Axles)	Axle Load KN	Frequency (% of tandem Axles)
1	115-125	20	220-240	90
2	105-115	10	200-220	10
3	95-105	20		
4	< 85	50		
Total		100%		100%

Design:

A. Modulus of Subgrade Reaction:

- Effective CBR of compacted subgrade = 8%. Modulus of subgrade reaction = 52 MPa/m (from Table 2 of IRC 58-2015)
- Provide 150mm thick Granular Sub-Base as drainage layer (Grading VI of Table 400-1 of MoRTH Specifications Fifth Revision)
- Provide a Dry Lean Concrete (DLC) sub-base of thickness 100mm with a minimum 7 day compressive strength of 10 MPa.
- Effective modulus of subgrade reaction of combined foundation of subgrade, granular sub-base and DLC sub-base is 131.5 MPa/m (from Table 4 of IRC 58-2015 by interpolation)
- Provide a de-bonding layer of polythene sheet of 125 micron thickness between DLC and concrete slab.

B. Flexural Strength of Concrete

- 28 day compressive strength of cement concrete ≥ 40 MPa
- 90 day compressive strength of cement concrete ≥ 48 MPa
- 28 day Flexural strength of cement concrete = 4.5 MPa (minimum)
- 90 day Flexural strength of cement concrete = 4.5 X 1.1 = 4.95 MPa

C. Design Traffic for Fatigue Analysis

- Design Period – 30 years
- Assumed Annual rate of growth of commercial traffic = 5 %
- One way commercial traffic volume per day =712 CVPD
- Total commercial vehicles during design period

$C = 365 \times A ((1 + r)^n - 1) / r$

Where,

C –Cumulative number of commercial vehicles during the design period

A – Initial number of commercial vehicles per day in the year when the road is opened to traffic

r – Annual rate of growth of commercial traffic volume (in decimal)

n – Design period in years

$$C = 365 \times 712((1+0.05)^{30}-1)/0.05$$

$$C = 17266128$$

- Average number of axles (steering / single / tandem) per commercial vehicle =2.35
- Total axle load repetitions during the design period –

= 17266128 X 2.35

= 40575400

Design traffic after adjusting for lateral placement of axles (25 per cent of predominant direction traffic for multilane highways) –

= 40575400 X 0.25

= 10143850

- Night time (12 hour) design axles repetitions (Assumed 40% traffic at night time)

= 10143850 X 0.4

= 4057540

- Day time (12 hour) design axles repetitions (100% - 40% = 60%)

= 10143850X 0.6 = 6086310

= Day time six hour axle load repetitions

= 6086310 X 0.5

= 3043155

- Hence, design number of axle load repetitions for bottom-up cracking analysis

= **3043155**

Night time six hour axle load repetitions

= 4057540 X 0.5

= 2028770

% of commercial vehicles having the spacing between the front (steering) axle and the first axle of the rear axle unit less than 4.5m is 55%

- Hence, the six hour night time design axle load repetitions for top-down cracking analysis (wheel base < 4.5m)

= 1840710 X 0.55

= **1115824**

- The axle load category wise design axle load repetitions for bottom up and top down fatigue cracking analysis are given in the following Table

Table 5-5: Fatigue Cracking Analysis

Axle Category	Proportion of the Axle Category	Category wise axle repetitions for Bottom-up cracking analysis	Category wise axle repetitions for Top-down cracking analysis
Front (Steering) single	0.45	1369420	502121
Rear single	0.53	1612872	591387
Tandem	0.02	60863	22316

D. Cumulative Fatigue Damage (CFD) analysis for Bottom-Up Cracking (BUC) and Top-Down Cracking (TDC) and Selection of Slab Thickness

- Effective modulus of subgrade reaction of foundation, k – 131.5 MPa/m
- Elastic Modulus of concrete, E – 30000 MPa
- Poisson's ratio of concrete, μ - 0.15
- Unit weight of concrete, γ – 24 kN/m3
- Design flexural strength of concrete – 4.95 MPa
- Max. day-time Temperature Differential in slab (for bottom-up cracking) – 17.00C
- Night-time Temperature Differential in slab (for top-down cracking) – day-time diff/2 + 5 = 13.500C
- Trial thickness of slab, h = 225 mm
- Radius of relative stiffness, l = (Eh3/(12k(1- μ2))0.25

  Where,

  l – radius of relative stiffness, m

  E – Elastic modulus of concrete, MPa

  h – concrete slab thickness, m

  k – modulus of subgrade reaction, MPa/m

  μ - Poisson's ratio of concrete

  = 0.55556

- 'Beta' factor in the stress equations will be 0.66 for doweled transverse joints for carrying out TDC analysis.

Computation of bottom-up and top-down cumulative fatigue damage is illustrated in following tables.

Table 5-6: Fatigue Damage Analysis

Bottom-up Cracking Fatigue Analysis for Day-time (6 hour) traffic and Positive Temperature Differential											
Rear Single Axle	**Rear Single Axles**					**Rear Tandem Axle**	**Rear Tandem Axles**				
Load Group (kN)	Expected Repetitions (ni)	Flex Stress MPa	Stress Ratio (SR)	Allowable Repetitions (Ni)	Fatigue Damage (ni/Ni)	Load Group (kN)	Expected Repetitions (ni)	Flex Stress MPa	Stress Ratio (SR)	Allowable Repetitions (Ni)	Fatigue Damage (ni/Ni)
115-125	322574	2.87	0.516	485306	0.66	220 - 240	54777	2.06	0.416	Infinite	0.00
105-115	161287	2.42	0.488	1446408	0.11	200 - 220	6086	1.94	0.391	Infinite	0.00
95-105	322574	2.28	0.460	13839397	0.02						
< 85	806436	2.00	0.405	infinite	0.00						
		Fat Dam from Sing. Axles =			0.79			Fat Dam from Tand Axles =			0.00

Table 5-7: Fatigue Damage Analysis

Top-Down Cracking Fatigue Analysis for Night-time (6 hour) traffic and Negative Temperature Differential											
Rear Single Axle	**Rear Single Axles**					**Rear Tandem Axle**	**Rear Tandem Axles**				
Load Group (kN)	Expected Repetitions (ni)	Flex Stress MPa	Stress Ratio (SR)	Allowable Repetitions (Ni)	Fatigue Damage (ni/Ni)	Load Group (kN)	Expected Repetitions (ni)	Flex Stress MPa	Stress Ratio (SR)	Allowable Repetitions (Ni)	Fatigue Damage (ni/Ni)
115-125	118277	2.514	0.508	1653498	0.07	220 - 240	20084	2.36	0.476	3144237	0.001
105-115	59139	2.31	0.467	7003189	0.01	200 - 220	2232	2.26	0.457	20274736	0.000
95-105	118277	2.22	0.448	Infinite	0.000						
< 85	295694	2.03	0.410	Infinite	0.000						
		Fat Dam from Sing. Axles =			0.070			Fat Dam from Tand Axles =			0.001

It can be seen from the calculations given in the tables above that for the slab thickness of 205mmthe total fatigue damage for bottom-up cracking is 0.79 + 0.00 = 0.72. Total fatigue damage for top-down cracking is 0.070 + 0.0001= 0.071 and total cumulative fatigue damage (CFD) = 0.80 which is less than 1.0.

Hence, the trial thickness of 225mm is adequate.30mm thickness is added considering two retexturing in 30 years and 15mm for rounding off and hence a thickness of 270mm is appropriate.

Design of Dowel Bars

As per Table5 'Recommended Dimensions of Dowel Bars' of IRC: 58-2015,

- Diameter in mm - 36
- Length in mm – 450
- Spacing in mm – 300

Design of Tie Bars

Input Data:

- Slab Thickness – 0.270 m
- Lane width, b – 3.1 m
- Coefficient of friction, f – 1.5
- Density of concrete, kN/m3 – 24
- Allowable tensile stress in deformed bars, MPa - 200(As per IRC:15-2017)
- Allowable bond stress for deformed tie bars, MPa – 2.46(As per IRC: 15-2017)

Design for Deformed Bars:

- Select diameter of tie bar, dt – 12 mm
- Area of plain steel bar required per meter width of joint to resist the frictional force at slab bottom, As

$$A_s = bfW / S_{st}$$

Where,

A_s – area of steel in mm^2, required per m length of joint

b – Lane width in meters

f – Coefficient of friction between pavement and the sub-base/base (usually taken as 1.5)

W – Weight of slab in kN/m^2 and

S_{st} – allowable working stress of steel in MPa

=3.1X1.5X0.270X24000/200

=150.66 mm^2/m

- Cross Sectional Area of Tie Bar A = π/4 X $(12)^2$

  = 113 mm^2

- Perimeter of Tie Bar = πd = 37.7mm

- **Spacing of tie bars**, = A/A_s

  = 113/114.39X1000

  = 989 mm

  Say 950mm

- Provide spacing of 950mm c/c
- **Length of tie bar** $L = 2S_{st}A_{cs} / BXP_{ptb}$

  Where,

  L –Length of tie bar, mm

  S_{st} – allowable working stress in steel, MPa

  A_{cs} – cross sectional area of one tie bar, mm^2

  P_{ptb} – perimeter of the tie bar, mm and

  B – Permissible bond stress of concrete, 2.46 MPa

  = 2 X 200 X 113 / (2.46 X 37.7)

  = 487.80 mm

- Increase length by 100mm for loss of bond due to painting and another 50mm for tolerance in placement
- Therefore the required length of tie bar is 640mm

Pavement Composition:

Table 5-8: Pavement Composition

Sr. No.	Description	Thickness in mm
1	Pavement Quality Concrete (PQC)	270
2	Dry Lean Concrete (DLC)	100
3	Granular Sub-Base (GSB) (as Drainage Layer)	150
4	Selected Subgrade (CBR ≥ 8%)	500

5.4.2 Attavar Road

Design of Slab Thickness

Input Data:

Road Type: Two lanes Two Way Single Carriageway

Design Life: 30 Years

Lane Width: 3.1m with 0.25m shyness width on both sides of carriageway edge.

Transverse joint spacing: 4.5 m

Traffic (as per TVC): 269 Commercial Vehicles per Day (CVPD)

CBR of Existing Soil: Two samples collected and tested and are 4% and 4%.

CBR (Considered) of Proposed Subgrade: 4%

CBR (Assumed) of Embankment below subgrade: 4%

Effective CBR of Subgrade: 8% (As per Figure 2 of IRC 58-2015)

Axle load Survey (Assumed): Single Axle 98% and Tandem Axle 2%

Axle Load Spectrum (Assumed):

Table 5-9: Axle Load & Frequency Analysis

Sr. No.	Rear Single Axle		Rear Tandem Axle	
	Axle Load KN	Frequency (% of single Axles)	Axle Load KN	Frequency (% of tandem Axles)
1	115-125	20	220-240	90
2	105-115	10	200-220	10
3	95-105	20		
4	< 85	50		
Total		98%		2%

Design:

A. Modulus of Subgrade Reaction:

- Effective CBR of compacted subgrade = 8%. Modulus of subgrade reaction = 35 MPa / m (from Table 2 of IRC 58-2015)
- Provide 150 mm thick Granular Sub-Base as drainage layer (Grading VI of Table 400-1 of MoRTH Specifications Fifth Revision)

- Provide a Dry Lean Concrete (DLC) sub-base of thickness 100 mm with a minimum 7 day compressive strength of 10 MPa.
- Effective modulus of subgrade reaction of combined foundation of subgrade, granular sub-base and DLC sub-base is 131.5 MPa/m (from Table 4 of IRC 58-2015 by interpolation)
- Provide a de-bonding layer of polythene sheet of 125 micron thickness between DLC and concrete slab.

B. Flexural Strength of Concrete

- 28 day compressive strength of cement concrete ≥ 40 MPa
- 90 day compressive strength of cement concrete ≥ 48 MPa
- 28 day Flexural strength of cement concrete = 4.5 MPa (minimum)
- 90 day Flexural strength of cement concrete = 4.5 X 1.1 = 4.95 MPa

C. Design Traffic for Fatigue Analysis

- Design Period – 30 years
- Assumed Annual rate of growth of commercial traffic = 5 %
- One way commercial traffic volume per day = 135 CVPD
- Total commercial vehicles during design period
  $C = 365 \times A ((1 + r)^n – 1) / r$

  Where,

  C – Cumulative number of commercial vehicles during the design period

  A – Initial number of commercial vehicles per day in the year when the road is opened to traffic

  r – Annual rate of growth of commercial traffic volume (in decimal)

  n – Design period in years

  $C = 365 \times 135 ((1+0.05)^{30} - 1) / 0.05$

  $C = 313312$

  Average number of axles (steering / single / tandem) per commercial vehicle = 2.35

- Total two way axle load repetitions during the design period –

  = 313312X 2.35

  = 7362840

  No. of axles in predominant direction

  = 7362840X 0.5

= 3681420

Design traffic after adjusting for lateral placement of axles (25 per cent of predominant direction traffic for multilane highways) –

= 3681419 X 0.25

= 920355

- Night time (12 hour) design axles repetitions (Assumed 60% traffic at night time)

  = 920355 X 0.6

  = 552213

- Day time (12 hour) design axles repetitions (100% - 60% = 40%)

  = 920355 X 0.4 = 368142

  = Day time six hour axle load repetitions

  = 368142 X 0.5

  = 184071

- Hence, design number of axle load repetitions for bottom-up cracking analysis

  = **184071**

  Night time six hour axle load repetitions

  = 552213 X 0.5

  = 276106

  % of commercial vehicles having the spacing between the front (steering) axle and the first axle of the rear axle unit less than 4.5m is 55%

- Hence, the six hour night time design axle load repetitions for top-down cracking analysis (wheel base < 4.5m)

  = 276106 X 0.55

  = **151858**

- The axle load category wise design axle load repetitions for bottom up and top down fatigue cracking analysis are given in the following Table

Table 5-10: Fatigue Cracking Analysis

Axle Category	Proportion of the Axle Category	Category wise axle repetitions for Bottom-up cracking analysis	Category wise axle repetitions for Top-down cracking analysis
Front (Steering)	0.45	82832	68336

single			
Rear single	0.53	97558	80485
Tandem	0.02	3681	3037

D. Cumulative Fatigue Damage (CFD) analysis for Bottom-Up Cracking (BUC) and Top-Down Cracking (TDC) and Selection of Slab Thickness

- Effective modulus of subgrade reaction of foundation, k – 131.5 MPa/m
- Elastic Modulus of concrete, E – 30000 MPa
- Poisson's ratio of concrete, μ - 0.15
- Unit weight of concrete, γ – 24 kN/m^3
- Design flexural strength of concrete – 4.95 MPa
- Max. day-time Temperature Differential in slab (for bottom-up cracking) – 17.0^{0}C
- Night-time Temperature Differential in slab (for top-down cracking) – day-time diff / 2 + 5 = 13.50^{0}C
- Trial thickness of slab, h = 205 mm
- Radius of relative stiffness, l = $(Eh^3 / (12k (1- \mu^2))^{0.25}$
  Where,

  l – radius of relative stiffness, m

  E – Elastic modulus of concrete, MPa

  h – concrete slab thickness, m

  k – modulus of subgrade reaction, MPa/m

  μ - Poisson's ratio of concrete

  = 0.55556

- 'Beta' factor in the stress equations will be 0.66 for doweled transverse joints for carrying out TDC analysis.

Computation of bottom-up and top-down cumulative fatigue damage is illustrated in following tables.

Table 5-11: Fatigue Damage Analysis

Bottom-up Cracking Fatigue Analysis for Day-time (6 hour) traffic and Positive Temperature Differential											
Rear Single Axle	**Rear Single Axles**					**Rear Tandem Axle**	**Rear Tandem Axles**				
Load Group (kN)	Expected Repetitions (ni)	Flex Stress MPa	Stress Ratio (SR)	Allowable Repetitions (Ni)	Fatigue Damage (ni/Ni)	Load Group (kN)	Expected Repetitions (ni)	Flex Stress MPa	Stress Ratio (SR)	Allowable Repetitions (Ni)	Fatigue Damage (ni/Ni)
115-125	19512	2.621	0.554	233049	0.08	220 - 240	3313	2.451	0.495	972235	0.01
105-115	9756	2.612	0.552	247916	0.04	200 - 220	368	2.234	0.451	49568440	0.00
95-105	19512	2.423	0.522	1324557	0.01						
< 85	48779	2.283	0.461	12450499	0.00						
		Fat Dam from Sing. Axles =			0.13		7123	Fat Dam from Tand Axles =			0.01

Table 5-12: Fatigue Damage Analysis

Top-Down Cracking Fatigue Analysis for Night-time (6 hour) traffic and Negative Temperature Differential											
Rear Single Axle	**Rear Single Axles**					**Rear Tandem Axle**	**Rear Tandem Axles**				
Load Group (kN)	Expected Repetitions (ni)	Flex Stress MPa	Stress Ratio (SR)	Allowable Repetitions (Ni)	Fatigue Damage (ni/Ni)	Load Group (kN)	Expected Repetitions (ni)	Flex Stress MPa	Stress Ratio (SR)	Allowable Repetitions (Ni)	Fatigue Damage (ni/Ni)
115-125	16097	2.514	0.508	531243	0.03	220 - 240	2733	2.537	0.513	436916	0.01
105-115	8049	2.479	0.501	732975	0.01	200 - 220	304	2.411	0.487	1526722	0.00
95-105	16097	2.333	0.471	4649023	0.00						
< 85	40243	2.161	0.437	infinite	0.000						
	155737	Fat Dam from Sing. Axles =			0.04		5877	Fat Dam from Tand Axles =			0.01

It can be seen from the calculations given in the tables above that for the slab thickness of 205mm the total fatigue damage for bottom-up cracking is 0.13 + 0.01 = 0.14. Total fatigue damage for top-down cracking is 0.04 + 0.01 = 0.05 and total cumulative fatigue damage (CFD) = 0.19 which is less than 1.0.

Hence, the trial thickness of 205mm is adequate. 30mm thickness is added considering two retexturing in 30 years and 15mm for rounding off and hence a thickness of 250mm is appropriate.

Design of Dowel Bars

As per Table 5 'Recommended Dimensions of Dowel Bars' of IRC: 58-2015,

- Diameter in mm - 32
- Length in mm – 450
- Spacing in mm - 300

Design of Tie Bars

Input Data:

- Slab Thickness – 0.205 m
- Lane width, b – 3.1 m
- Coefficient of friction, f – 1.5
- Density of concrete, kN/m^3 – 24
- Allowable tensile stress in deformed bars, MPa - 200 (As per IRC: 15-2017)
- Allowable bond stress for deformed tie bars, MPa – 2.46 (As per IRC: 15-2017)

Design for Deformed Bars:

- Select diameter of tie bar, d_t – 12 mm
- Area of plain steel bar required per meter width of joint to resist the frictional force at slab bottom, A_s

$$A_s = bfW / S_{st}$$

Where,

A_s – area of steel in mm^2, required per m length of joint

b – Lane width in meters

f – Coefficient of friction between pavement and the sub-base/base (usually taken as 1.5)

W – Weight of slab in kN/m^2 and

S_{st} – allowable working stress of steel in MPa

=3.1 X 1.5 X 0.205 X 24000 / 200

$= 114.39\ mm^2 / m$

- Cross Sectional Area of Tie Bar A = $\pi/4 \times (12)^2$

  $= 113\ mm^2$

- Perimeter of Tie Bar = πd = 37.7mm

- **Spacing of tie bars**, = A/A_s

  = 113 / 114.39 X 1000

  = 989 mm

  Say 950mm

- Provide spacing of 950mm c/c

- **Length of tie bar**

  $L = 2S_{st}A_{cs} / B \times P_{ptb}$

  Where,

  L – Length of tie bar, mm

  S_{st} – allowable working stress in steel, MPa

  A_{cs} – cross sectional area of one tie bar, mm^2

  P_{ptb} – perimeter of the tie bar, mm and

  B – Permissible bond stress of concrete, 2.46 MPa

  = 2 X 200 X 113 / (2.46 X 37.7)

  = 487.80 mm

- Increase length by 100mm for loss of bond due to painting and another 50mm for tolerance in placement
- Therefore the required length of tie bar is 640mm

Pavement Composition:

Table 5-13: Pavement Composition

Sr. No.	Description	Thickness in mm
1	Pavement Quality Concrete (PQC)	250
2	Dry Lean Concrete (DLC)	100
3	Granular Sub-Base (GSB) (as Drainage Layer)	150
4	Selected Subgrade (CBR ≥ 8%)	500

5.4.3 Bunts Hostel Road

Design of Slab Thickness

Input Data:

Road Type: Two lanes Two Way Single Carriageway

Design Life: 30 Years

Lane Width: 3.1m with 0.25m shyness width on both sides of carriageway edge.

Transverse joint spacing: 4.5 m

Traffic (as per TVC): 5349 Commercial Vehicles per Day (CVPD)

CBR of Existing Soil: Two samples collected and tested and are 8% and 8%.

CBR (Considered) of Proposed Subgrade: 8%

CBR (Assumed) of Embankment below subgrade: 8%

Effective CBR of Subgrade: 8% (As per Figure 2 of IRC 58-2015)

Axle load Survey (Assumed): Single Axle 98% and Tandem Axle 2%

Axle Load Spectrum (Assumed):

Table 5-14: Axle & Frequency Analysis

Sr. No.	Rear Single Axle		Rear Tandem Axle	
	Axle Load KN	Frequency (% of single Axles)	Axle Load KN	Frequency (% of tandem Axles)
1	115-125	20	220-240	90
2	105-115	10	200-220	10
3	95-105	20		
4	< 85	50		
Total		98%		2%

Design:

E. Modulus of Subgrade Reaction:

- Effective CBR of compacted subgrade = 8%. Modulus of subgrade reaction = 50.3 MPa / m (from Table 2 of IRC 58-2015)
- Provide 150 mm thick Granular Sub-Base as drainage layer (Grading VI of Table 400-1 of MoRTH Specifications Fifth Revision)
- Provide a Dry Lean Concrete (DLC) sub-base of thickness 100 mm with a minimum 7 day compressive strength of 10 MPa.

- Effective modulus of subgrade reaction of combined foundation of subgrade, granular sub-base and DLC sub-base is 231.3 MPa/m (from Table 4 of IRC 58-2015 by interpolation)
- Provide a de-bonding layer of polythene sheet of 125 micron thickness between DLC and concrete slab.

F. Flexural Strength of Concrete

- 28 day compressive strength of cement concrete ≥ 40 MPa
- 90 day compressive strength of cement concrete ≥ 48 MPa
- 28 day Flexural strength of cement concrete = 4.5 MPa (minimum)
- 90 day Flexural strength of cement concrete = 4.5 X 1.1 = 4.95 MPa

G. Design Traffic for Fatigue Analysis

- Design Period – 30 years
- Assumed Annual rate of growth of commercial traffic = 5 %
- One way commercial traffic volume per day = 2675 CVPD
- Total commercial vehicles during design period

  $C = 365 \times A ((1 + r)^n – 1) / r$

  Where,

  C – Cumulative number of commercial vehicles during the design period

  A – Initial number of commercial vehicles per day in the year when the road is opened to traffic

  r – Annual rate of growth of commercial traffic volume (in decimal)

  n – Design period in years

  $C = 365 \times 2675 ((1+0.05)^{30} - 1) / 0.05$

  $C = 595588750$

- Average number of axles (steering / single / tandem) per commercial vehicle = 2.35
- Total two way axle load repetitions during the design period –

  = 595588750 X 2.35

  = 1399633563

  No. of axles in predominant direction

  = 1399633563X 0.5

  = 69981678

  Design traffic after adjusting for lateral placement of axles (25 per cent of predominant direction traffic for multilane highways) –

= 69981678 X 0.25

= 17495419

- Night time (12 hour) design axles repetitions (Assumed 60% traffic at night time)

= 17495419 X 0.6

= 10497251

- Day time (12 hour) design axles repetitions (100% - 60% = 40%)

= 17495419 X 0.4

= 6998167

- Day time six hour axle load repetitions

= 6998167 X 0.5

= 3499083

- Hence, design number of axle load repetitions for bottom-up cracking analysis

= **3499083**

- Night time six hour axle load repetitions

= 10497251 X 0.5

= 5248625

- % of commercial vehicles having the spacing between the front (steering) axle and the first axle of the rear axle unit less than 4.5m is 55%
- Hence, the six hour night time design axle load repetitions for top-down cracking analysis (wheel base < 4.5m)

= 5248625 X 0.55

= **2886744**

- The axle load category wise design axle load repetitions for bottom up and top down fatigue cracking analysis are given in the following Table

Table 5-15: Fatigue Cracking Analysis

Axle Category	Proportion of the Axle Category	Category wise axle repetitions for Bottom-up cracking analysis	Category wise axle repetitions for Top-down cracking analysis
Front (Steering) single	0.45	1574587	1299035
Rear single	0.53	1854514	1529974
Tandem	0.02	69982	57735

H. Cumulative Fatigue Damage (CFD) analysis for Bottom-Up Cracking (BUC) and Top-Down Cracking (TDC) and Selection of Slab Thickness

- Effective modulus of subgrade reaction of foundation, k – 231 MPa/m
- Elastic Modulus of concrete, E – 30000 MPa
- Poisson's ratio of concrete, μ - 0.15
- Unit weight of concrete, γ – 24 kN/m^3
- Design flexural strength of concrete – 4.95 MPa
- Max. day-time Temperature Differential in slab (for bottom-up cracking) – 17.0^{0}C
- Night-time Temperature Differential in slab (for top-down cracking) – day-time diff / 2 + 5 = 13.50^{0}C
- Trial thickness of slab, h = 250 mm
- Radius of relative stiffness, $l = (Eh^3 / (12k (1- \mu^2))^{0.25}$
  Where,

  l – radius of relative stiffness, m

  E – Elastic modulus of concrete, MPa

  h – concrete slab thickness, m

  k – modulus of subgrade reaction, MPa/m

  μ - Poisson's ratio of concrete

  = 0.15

- 'Beta' factor in the stress equations will be 0.66 for doweled transverse joints for carrying out TDC analysis.

Computation of bottom-up and top-down cumulative fatigue damage is illustrated in following tables.

Table 5-16: Fatigue Damage Analysis

Bottom-up Cracking Fatigue Analysis for Day-time (6 hour) traffic and Positive Temperature Differential											
Rear Single Axle	**Rear Single Axles**					**Rear Tandem Axle**	**Rear Tandem Axles**				
Load Group (kN)	Expected Repetitions (ni)	Flex Stress MPa	Stress Ratio (SR)	Allowable Repetitions (Ni)	Fatigue Damage (ni/Ni)	Load Group (kN)	Expected Repetitions (ni)	Flex Stress MPa	Stress Ratio (SR)	Allowable Repetitions (Ni)	Fatigue Damage (ni/Ni)
115-125	370903	2.24	0.563	38176672	0.030	220 - 240	6411	1.79	0.362	Infinite	0.000
105-115	185451	2.13	0.431	Infinite	0.000	200 - 220	712	1.69	0.342	infinite	0.000
95-105	370903	1.95	0.394	Infinite	0.000						
< 85	927257	1.80	0.408	Infinite	0.000						
	188772	Fat Dam from Sing. Axles =			0.03		7123	Fat Dam from Tand Axles =			0.000

Table 5-17: Fatigue Damage Analysis

Top-Down Cracking Fatigue Analysis for Night-time (6 hour) traffic and Negative Temperature Differential											
Rear Single Axle	**Rear Single Axles**					**Rear Tandem Axle**	**Rear Tandem Axles**				
Load Group (kN)	Expected Repetitions (ni)	Flex Stress MPa	Stress Ratio (SR)	Allowable Repetitions (Ni)	Fatigue Damage (ni/Ni)	Load Group (kN)	Expected Repetitions (ni)	Flex Stress MPa	Stress Ratio (SR)	Allowable Repetitions (Ni)	Fatigue Damage (ni/Ni)
115-125	699817	2.20	0.444	Infinite	0.000	220 - 240	5289	2.09	0.422	Infinite	0.000
105-115	349908	2.12	0.429	Infinite	0.000	200 - 220	588	2.05	0.414	Infinite	0.000
95-105	699817	2.05	0.414	Infinite	0.000						
< 85	1749542	1.90	0.383	Infinite	0.000						
	155737	Fat Dam from Sing. Axles =			0.000		5877	Fat Dam from Tand Axles =			0.000

It can be seen from the calculations given in the tables above that for the slab thickness of 205mm the total fatigue damage for bottom-up cracking is 0.03 + 0.000 = 0.003. Total fatigue damage for top-down cracking is 0.000+ 0.000 = 0.000 and total cumulative fatigue damage (CFD) = 0.003 which is less than 1.0.

Hence, the trial thickness of 250mm is adequate. 30mm thickness is added considering two retexturing in 30 years and 15mm for rounding off and hence a thickness of 260mm is appropriate.

Design of Dowel Bars

As per Table 5 'Recommended Dimensions of Dowel Bars' of IRC: 58-2015,

- Diameter in mm - 36
- Length in mm – 450
- Spacing in mm - 300

Design of Tie Bars

Input Data:

- Slab Thickness – 0.250 m
- Lane width, b – 3.1 m
- Coefficient of friction, f – 1.5
- Density of concrete, kN/m^3 – 24
- Allowable tensile stress in deformed bars, MPa - 200 (As per IRC: 15-2017)
- Allowable bond stress for deformed tie bars, MPa – 2.46 (As per IRC: 15-2017)

Design for Deformed Bars:

- Select diameter of tie bar, d_t – 12 mm
- Area of plain steel bar required per meter width of joint to resist the frictional force at slab bottom, A_s

$$A_s = bfW / S_{st}$$

Where,

A_s – area of steel in mm^2, required per m length of joint

b – Lane width in meters

f – Coefficient of friction between pavement and the sub-base/base (usually taken as 1.5)

W – Weight of slab in kN/m^2 and

S_{st} – allowable working stress of steel in MPa

=3.1 X 1.5 X 0.205 X 24000 / 200

= 114.39 mm^2 / m

- Cross Sectional Area of Tie Bar A = $\pi/4$ X $(12)^2$
  = 113 mm^2
- Perimeter of Tie Bar = πd = 37.7mm
- **Spacing of tie bars**, = A/A_s
  = 113 / 114.39 X 1000
  = 989 mm
  Say 950mm
- Provide spacing of 950mm c/c
- **Length of tie bar**
  $L = 2S_{st}A_{cs} / B X P_{ptb}$

  Where,

  L – Length of tie bar, mm

  S_{st} – allowable working stress in steel, MPa

  A_{cs} – cross sectional area of one tie bar, mm^2

  P_{ptb} – perimeter of the tie bar, mm and

  B – Permissible bond stress of concrete, 2.46 MPa

  = 2 X 200 X 113 / (2.46 X 37.7)

  = 487.80 mm
- Increase length by 100mm for loss of bond due to painting and another 50mm for tolerance in placement
- Therefore the required length of tie bar is 640mm

Pavement Composition:

Table 5-18: Pavement Composition

Sr. No.	Description	Thickness in mm
1	Pavement Quality Concrete (PQC)	260
2	Dry Lean Concrete (DLC)	100
3	Granular Sub-Base (GSB) (as Drainage Layer)	150
4	Selected Subgrade (CBR ≥ 8%)	500

5.4.4 Sturrock Road

Design of Slab Thickness

Input Data:

Road Type: Two lanes Two Way Single Carriageway

Design Life: 30 Years

Lane Width: 3.1m with 0.25m shyness width on both sides of carriageway edge.

Transverse joint spacing: 4.5 m

Traffic (as per TVC): 1292 Commercial Vehicles per Day (CVPD)

CBR of Existing Soil: Two samples collected and tested and are 4% and 4%.

CBR (Considered) of Proposed Subgrade: 4%

CBR (Assumed) of Embankment below subgrade: 4%

Effective CBR of Subgrade: 8% (As per Figure 2 of IRC 58-2015)

Axle load Survey (Assumed): Single Axle 98% and Tandem Axle 2%

Axle Load Spectrum (Assumed):

Table 5-19: Axle & Frequency Analysis

Sr. No.	Rear Single Axle		Rear Tandem Axle	
	Axle Load KN	Frequency (% of single Axles)	Axle Load KN	Frequency (% of tandem Axles)
1	115-125	20	220-240	90
2	105-115	10	200-220	10
3	95-105	20		
4	< 85	50		
Total		98%		2%

Design:

I. Modulus of Subgrade Reaction:

- Effective CBR of compacted subgrade = 8%. Modulus of subgrade reaction = 35 MPa / m (from Table 2 of IRC 58-2015)
- Provide 150 mm thick Granular Sub-Base as drainage layer (Grading VI of Table 400-1 of MoRTH Specifications Fifth Revision)
- Provide a Dry Lean Concrete (DLC) sub-base of thickness 100 mm with a minimum 7 day compressive strength of 10 MPa.
- Effective modulus of subgrade reaction of combined foundation of subgrade, granular sub-base and DLC sub-base is 131.5 MPa/m (from Table 4 of IRC 58-2015 by interpolation)

- Provide a de-bonding layer of polythene sheet of 125 micron thickness between DLC and concrete slab.

J. Flexural Strength of Concrete

- 28 day compressive strength of cement concrete ≥ 40 MPa
- 90 day compressive strength of cement concrete ≥ 48 MPa
- 28 day Flexural strength of cement concrete = 4.5 MPa (minimum)
- 90 day Flexural strength of cement concrete = 4.5 X 1.1 = 4.95 MPa

K. Design Traffic for Fatigue Analysis

- Design Period – 30 years
- Assumed Annual rate of growth of commercial traffic = 5 %
- One way commercial traffic volume per day = 646 CVPD
- Total commercial vehicles during design period

  $C = 365 \times A ((1 + r)^n - 1) / r$

  Where,

  C – Cumulative number of commercial vehicles during the design period

  A – Initial number of commercial vehicles per day in the year when the road is opened to traffic

  r – Annual rate of growth of commercial traffic volume (in decimal)

  n – Design period in years

  $C = 365 \times 646 ((1+0.05)^{30} - 1) / 0.05$

  $C = 15665616$

- Average number of axles (steering / single / tandem) per commercial vehicle = 2.35
- Total two way axle load repetitions during the design period –

  = 15665616X 2.35

  = 36814198

  No. of axles in predominant direction

  = 36814198X 0.5

  = 18407099

  Design traffic after adjusting for lateral placement of axles (25 per cent of predominant direction traffic for multilane highways) –

  = 18407099 X 0.25

  = 4601775

- Night time (12 hour) design axles repetitions (Assumed 60% traffic at night time)

  = 4601775 X 0.6

  = 2761065

- Day time (12 hour) design axles repetitions (100% - 60% = 40%)

  = 4601775X 0.4 = 1840710

  = Day time six hour axle load repetitions

  = 1840710 X 0.5

  = 356175

- Hence, design number of axle load repetitions for bottom-up cracking analysis

  = **920355**

  Night time six hour axle load repetitions

  = 2761065 X 0.5

  = 1380533

  % of commercial vehicles having the spacing between the front (steering) axle and the first axle of the rear axle unit less than 4.5m is 55%

- Hence, the six hour night time design axle load repetitions for top-down cracking analysis (wheel base < 4.5m)

  = 1380533 X 0.55

  = **759293**

- The axle load category wise design axle load repetitions for bottom up and top down fatigue cracking analysis are given in the following Table

Table 5-20: Fatigue Cracking Analysis

Axle Category	Proportion of the Axle Category	Category wise axle repetitions for Bottom-up cracking analysis	Category wise axle repetitions for Top-down cracking analysis
Front (Steering) single	0.45	414160	341682
Rear single	0.53	487788	402425
Tandem	0.02	18407	15186

L. Cumulative Fatigue Damage (CFD) analysis for Bottom-Up Cracking (BUC) and Top-Down Cracking (TDC) and Selection of Slab Thickness

- Effective modulus of subgrade reaction of foundation, k – 131.5 MPa/m
- Elastic Modulus of concrete, E – 30000 MPa
- Poisson's ratio of concrete, μ - 0.15
- Unit weight of concrete, γ – 24 kN/m^3
- Design flexural strength of concrete – 4.95 MPa
- Max. day-time Temperature Differential in slab (for bottom-up cracking) – 17.0^{0}C
- Night-time Temperature Differential in slab (for top-down cracking) – day-time diff / 2 + 5 = 13.50^{0}C
- Trial thickness of slab, h = 205 mm
- Radius of relative stiffness, $l = (Eh^3 / (12k (1- \mu^2))^{0.25}$
  Where,

  l – radius of relative stiffness, m

  E – Elastic modulus of concrete, MPa

  h – concrete slab thickness, m

  k – modulus of subgrade reaction, MPa/m

  μ - Poisson's ratio of concrete

  = 0.55556

- 'Beta' factor in the stress equations will be 0.66 for doweled transverse joints for carrying out TDC analysis.

Computation of bottom-up and top-down cumulative fatigue damage is illustrated in following tables.

Table 5-21: Fatigue Damage Analysis

Bottom-up Cracking Fatigue Analysis for Day-time (6 hour) traffic and Positive Temperature Differential											
Rear Single Axle	**Rear Single Axles**					**Rear Tandem Axle**	**Rear Tandem Axles**				
Load Group (kN)	Expected Repetitions (ni)	Flex Stress MPa	Stress Ratio (SR)	Allowable Repetitions (Ni)	Fatigue Damage (ni/Ni)	Load Group (kN)	Expected Repetitions (ni)	Flex Stress MPa	Stress Ratio (SR)	Allowable Repetitions (Ni)	Fatigue Damage (ni/Ni)
115-125	97558	2.621	0.554	233049	0.420	220 - 240	16566	2.451	0.495	972235	0.017
105-115	48779	2.612	0.552	247916	0.20	200 - 220	1841	2.234	0.451	49568440	0.001
95-105	97558	2.423	0.522	1324557	0.07						
< 85	243894	2.283	0.461	12450499	0.02						
		Fat Dam from Sing. Axles =			0.71		7123	Fat Dam from Tand Axles =			0.018

Table 5-22: Fatigue Damage Analysis

Top-Down Cracking Fatigue Analysis for Night-time (6 hour) traffic and Negative Temperature Differential											
Rear Single Axle	**Rear Single Axles**					**Rear Tandem Axle**	**Rear Tandem Axles**				
Load Group (kN)	Expected Repetitions (ni)	Flex Stress MPa	Stress Ratio (SR)	Allowable Repetitions (Ni)	Fatigue Damage (ni/Ni)	Load Group (kN)	Expected Repetitions (ni)	Flex Stress MPa	Stress Ratio (SR)	Allowable Repetitions (Ni)	Fatigue Damage (ni/Ni)
115-125	80485	2.514	0.508	531243	0.15	220 - 240	13667	2.537	0.513	436916	0.031
105-115	40243	2.479	0.501	732975	0.05	200 - 220	1519	2.411	0.487	1526722	0.001
95-105	80485	2.333	0.471	4649023	0.02						
< 85	201213	2.161	0.437	infinite	0.000						
	155737	Fat Dam from Sing. Axles =			0.220		5877	Fat Dam from Tand Axles =			0.032

It can be seen from the calculations given in the tables above that for the slab thickness of 205mm the total fatigue damage for bottom-up cracking is 0.71 + 0.018 = 0.728. Total fatigue damage for top-down cracking is 0.220 + 0.032 = 0.252 and total cumulative fatigue damage (CFD) = 0.97 which is less than 1.0.

Hence, the trial thickness of 205mm is adequate. 30mm thickness is added considering two retexturing in 30 years and 15mm for rounding off and hence a thickness of 250mm is appropriate.

Design of Dowel Bars

As per Table 5 'Recommended Dimensions of Dowel Bars' of IRC: 58-2015,

- Diameter in mm - 32
- Length in mm – 450
- Spacing in mm - 300

Design of Tie Bars

Input Data:

- Slab Thickness – 0.205 m
- Lane width, b – 3.1 m
- Coefficient of friction, f – 1.5
- Density of concrete, kN/m^3 – 24
- Allowable tensile stress in deformed bars, MPa - 200 (As per IRC: 15-2017)
- Allowable bond stress for deformed tie bars, MPa – 2.46 (As per IRC: 15-2017)

Design for Deformed Bars:

- Select diameter of tie bar, d_t – 12 mm
- Area of plain steel bar required per meter width of joint to resist the frictional force at slab bottom, A_s

$$A_s = bfW / S_{st}$$

Where,
As – area of steel in mm2, required per m length of joint
b – Lane width in meters
f – Coefficient of friction between pavement and the sub-base/base (usually taken as 1.5)
W – Weight of slab in kN/m2 and
Sst – allowable working stress of steel in MPa

$$= 3.1 \times 1.5 \times 0.205 \times 24000 / 200$$

$$= 114.39 \text{ mm}^2 / \text{m}$$

- Cross Sectional Area of Tie Bar $A = \pi/4 \times (12)^2$

$$= 113 \text{ mm}^2$$

- Perimeter of Tie Bar = πd = 37.7mm
- **Spacing of tie bars**, = A/A_s

  = 113 / 114.39 X 1000

  = 989 mm

  Say 950mm
- Provide spacing of 950mm c/c
- **Length of tie bar**

  $L = 2S_{st}A_{cs} / B X P_{ptb}$

  Where,

  L – Length of tie bar, mm

  S_{st} – allowable working stress in steel, MPa

  A_{cs} – cross sectional area of one tie bar, mm^2

  P_{ptb} – perimeter of the tie bar, mm and

  B – Permissible bond stress of concrete, 2.46 MPa

  = 2 X 200 X 113 / (2.46 X 37.7)

  = 487.80 mm
- Increase length by 100mm for loss of bond due to painting and another 50mm for tolerance in placement
- Therefore the required length of tie bar is 640mm

Pavement Composition:

Table 5-23: Pavement Composition

Sr. No.	Description	Thickness in mm
1	Pavement Quality Concrete (PQC)	250
2	Dry Lean Concrete (DLC)	100
3	Granular Sub-Base (GSB) (as Drainage Layer)	150
4	Selected Subgrade (CBR ≥ 8%)	500

6. INFRASTRUCTURE AND UTILITIES PLANNING

6.1 Planned Utilities

Dedicated and planned utilities are one of the key features of smart roads. Various utilities planned under DPR-4 Smart Road include wet utilities include Water Supply, sewerage and storm water drainage system as well as dry utilities like Street Lights, Power Distribution and OFC.

Water Supply Distribution lines are proposed under ADB funding as a separate Project and funding. Necessary coordination with the Consultants working on ADB project and MCC has been carried out to ensure integration of proposals in a holistic manner.

Similarly; UGD (Underground sewerage network) and LED Street lighting are proposed as separate Project under Mangaluru Smart City. The proposal under UGD and LED project have been integrated while planning the utility corridor along DPR-4 Smart Road.

6.1.1 Electrical Infrastructure

The detailed survey of existing electrical utilities has been carried out along with MESCOM officials and same is included in drawings along with the report. The space planning for electrical services in the proposed utility corridor is based on the assessment and requirement of MESCOM Following details are as per assessment.

Table 6-1: Existing Transformer locations

Road no.	Name of Road	Road		Transformer Number	Location of Transformer	Transformer
		From	To			Pole No.
7b	**Mother Theresa Road**	Hampankatta Jn.	Milagres Cross Road Jn.	0		
7e	**Attavar Road**	Milagres Church Jn.	Nandigudda Road	TR-1	Rotary Physiotherspy Center	-
				TR-2	Hotel Residency Park	20030261245 DTC
				TR-3	IMA House Bldg.	20030261268
9	**Sturrock Road**	Avery Junction	Attavar Anand Shetty Jn.	TR-1	Near Saphire Gate Bldg.	20030260407 DTC
				TR-2	Saphire Bldg. Compond	20030260400
				TR-3	Prestige west Kolme Bldg.	20030360827
				TR-4	Sturrock Apmts.	20030260390 DTC
				TR-5	Roshini Building	20030260385 DTC
				TR-6	Lawns view Apmts.	

				TR-7	West gate Hieght Bldg.	20030260379
				TR-8	Nishika Super Market	200302603600
				TR-9	Little Rock Bldg.	
				TR-10	Shalimar Hieghts Bldg.	20030260348
				TR-11	Road end.	20030260109
12	Bunts hostel road	Bunts hostel	Jyoti circle	TR-1	PAI INTERNATIONAL BLDG.	
				TR-2	Road Edge	20030262063
				TR-3	Road Edge	200302621890 DTC
				TR-4	Road Edge	20030262077 DTC
				TR-5	Road Edge	20030263082 DTC
				TR-6	Road Edge	20030262091 DTC
13a	**KRR Road (Kudmal Ranga Rao Road)**	PVS Junction	Arya Samaj Road Junction	TR-1	City Plaza Bldg.	20030265951
				TR-2	St. Alosyis Traning Center	
				TR-3	Mahindra Arcade Training Center	20030265941
				TR-4	Opp : Asian Paints	
				TR-5	Radha Medical bldg.	20030265968-60 DTC
				TR-6	Pramod Auto bldg.	20030266348
				TR-7	Pramod Auto bldg.	20030265914 DTC
				TR-8	Janvi Plaza Bldg.	200302612618
				TR-9	Pai International bldg.	KB-342/D-89
				TR-10	Mobile Arcade Bldg.	20030262591 DTC
				TR-11	Ramakrishna Education Institute	20030262586
				TR-12	Electrical Point Bldg.	
				TR-13	Nexa Showroom	
				TR-14	Shreya Hearing clinic	
				TR-15	Opp: Inland Monarch Bldg.	
13b	**KS Rao Road**	PVS Circle-KS Rao Road	Hampankatta Junction	TR-1	Opp: Canara Bank	20030281117 DTC
				TR-2	IOB Bank	2003028118
				TR-3	Opp: Prabhat Cinema	20030280393 20030280391 DTC
				TR-3A	Classic Arcade Bldg.	
				TR-4	Maroor House	
				TR-5	Topaz Complex	

				TR-6	Hotel Lakshmi Mahal Lodging & Boarding	c
				TR-7	Bus Stand -1	
				TR-8	Bus Stand -2	
				TR-2	Opp: PRESIDENCY AVENUE BLDG.	
				TR-3		20030262545 DTC 20030262544
				TR-4	Mothisham Oasis Bldg.	20030262541
				TR-5	Tranqil Heights Bldg.	20030262535 DTC
				TR-6	Classic legacy Bldg.	20030262528 DTC 20030262529
				TR-7	Mothisham Galaxy Bldg.	20030262871
				TR-8	Happy Home Apmts.	
				TR-9	Inland ExcllencyApmts.	20030262520 DTC
				TR-10	Parvathi Bldg.	20030262516 DTC
				TR-11	Geern View Bldg.	20030262554 DTC
				TR-12	Green Orcade Bldg.	-

Base on existing survey and discussion with MESCOM, space requirement for Electrical cables were finalized as per below mentioned table which is also included space for spare pipe for HT cable as per MESCOM recommendation and the same is accommodated in Road sections.

Table 6-2: Existing Electric Cable/Pipes locations

Road no.	Name of Road	Road		Left side Electrical space	Right side Electrical space	No of cables/Pipes with size (LEFT SIDE)		No of cables/pipes with size (RIGHT SIDE)	
		From	To			415V	11kV	415V	11kV
7b	**Hampankatta Signal (Loop Road)**	Milagres Church	Avery Junction	1020 (w) x 1170(D)	1020 (w) x 1170 (d)			**L.T. :-2**	**H.T. :-2**
7e	**Hampankatta Signal (Loop Road)**	Milagres Church	Nandigudda Road	1020(w) x 1360 (D)	1020(w) x 1360 (D)	**L.T. :- 2**	**H.T. :-2**	**L.T. :-2**	**H.T. :-2**
9	Sturrock Road	Avery Juction	Attavar Road	1020 (w) x 1360 (D)	1020 (w) x 1170 (D)	**L.T. :- 2**	**H.T. :-2**	**L.T. :-2**	
12	Bunts hostel road	Bunts hostel road	Jyoti circle	600 (w) x 1170(D)	1020 (w) x 1170 (D)			**L.T. :-1**	**H.T. :-2**

13a	KRR Road (KudmalRanga Rao Road)	PVS Junction	Arya Samaj Road Junction	1200 (W) x 1920 (D)	1020 (w) x 1360(D)	**L.T. :-** 4	**H.T. :-**8	**L.T. :-**2	**H.T. :-**2
13b	KRR Road (KudmalRanga Rao Road)	PVS Circle-KSR road	Hampankatta Junction	1020 (w) x 1360 (D)	1020 (w) x 1170(D)	**L.T. :-** 2	**H.T. :-**2	**L.T. :-**1	

6.1.2 Street Light

Location of lighting poles are considering base on following requirement to achieve desire lux level.

1. Total ROW
2. Type or category of roads
   a. Main roads carrying mixed traffic like city main roads/streets, arterial roads, throughways
   b. Secondary roads with considerable traffic like local traffic routes, shopping streets
   c. Secondary roads with light traffic
3. Visibility of Roads and surroundings.
4. Visual guidance of the shape of the road. Motorist should be able to identify bends and curves and change in roads
5. The visual comfort of the driver/pedestrian.
6. Uniformity of lighting

Lighting design is considered based on standard lux level as per the BIS standards & BEE guidelines as per below mention table

Table 6-3: Classification of lighting installation

Classification of lighting installation	Type of Road	Average level of illumination on road surface
Group A1	Important traffic roads carrying traffic/	30
Group A2	Other main road carrying mixed traffic likes main city stations, arterial road, throughways etc	15
Group B1	Secondary road with considerable traffic like principle local traffic routes, shopping street etc.	8
Group B2	Secondary road with light traffic	4

All roads in this package is falls under Group A2 classification so while placing of light fixtures minimum Average lux level considered 15 Lux.

6.1.3 Lighting Poles:

In existing scenario, majorly light fixtures are installed on Electrical poles and some of the light fixtures are installed on 7 meter high poles. Existing 7 meter poles area retain and only location will shifted as per Road plan and width and in addition to existing poles new poles are used base on requirement. Locations of poles are marked in Electrical drawing.

6.1.4 Centralized street lighting control

"Conversion of Conventional Street Lights into LED with Smart Lighting Solutions" is one of the projects under MSC with an objective of reducing energy consumption as well as to reduce impact on environment by conventional lamps. The existing street lights are proposed to be converted into LED on PPP basis under a separate project.

Smart LED street lighting system adopts centralized control system which will result in further saving of electrical energy. This system offers following Merits –

1. Central control, fault detection
2. Generation of burn hours reports
3. Automatic operation with astronomical timers
4. Manual operation from a central location through GPRS / GSM system
5. Remote metering
6. Voltage stabilization

Energy consumed by the LED lighting is much less as compared to the sodium vapour lighting. This will reduce the energy bill of street lights to great extent.

SMART STREET LIGHTING SOLUTIONS PROPOSED UNDER SMART ROADS WILL BE TAKEN UP UNDER SEPARATE TENDER FOR LED STREET LIGHTS PPP PROJECT COMPONENTS.

6.1.5 Wet Utilities

The wet utilities include Water Supply, sewerage and storm water drainage system. Majority of the underground drainage system in the ABD area had been executed under the 1961 scheme by Public Health Department. The underground drainage system is exhausted/lived its design life and a necessity has arisen to replace the existing lines with the new pipelines. Considering the above conditions, the Government of Karnataka has decided to take up underground drainage system for the ABD area of Mangalore under Smart city.

In order to achieve this objective, GoI / GoK in its Smart city program, has approved a underground drainage project to MCC for an estimated cost of 37.5 crores to meet the intended objective. Considering the economics of the repair of concrete roads, the sewerage network is not planned for concrete roads. So the existing sewerage network is retained in Roads 7a, 7b,7c,7d,7e,10,12, 13a, 13b and 13c. New Sewer network is proposed along the roads 8,9 and 19. 200mm diameter upvc pipe is provided for laterals and circular RCC manholes with SFRC cover and frame ranging from 1.2m to 1.5m in diameter has been provided in the proposed scheme.

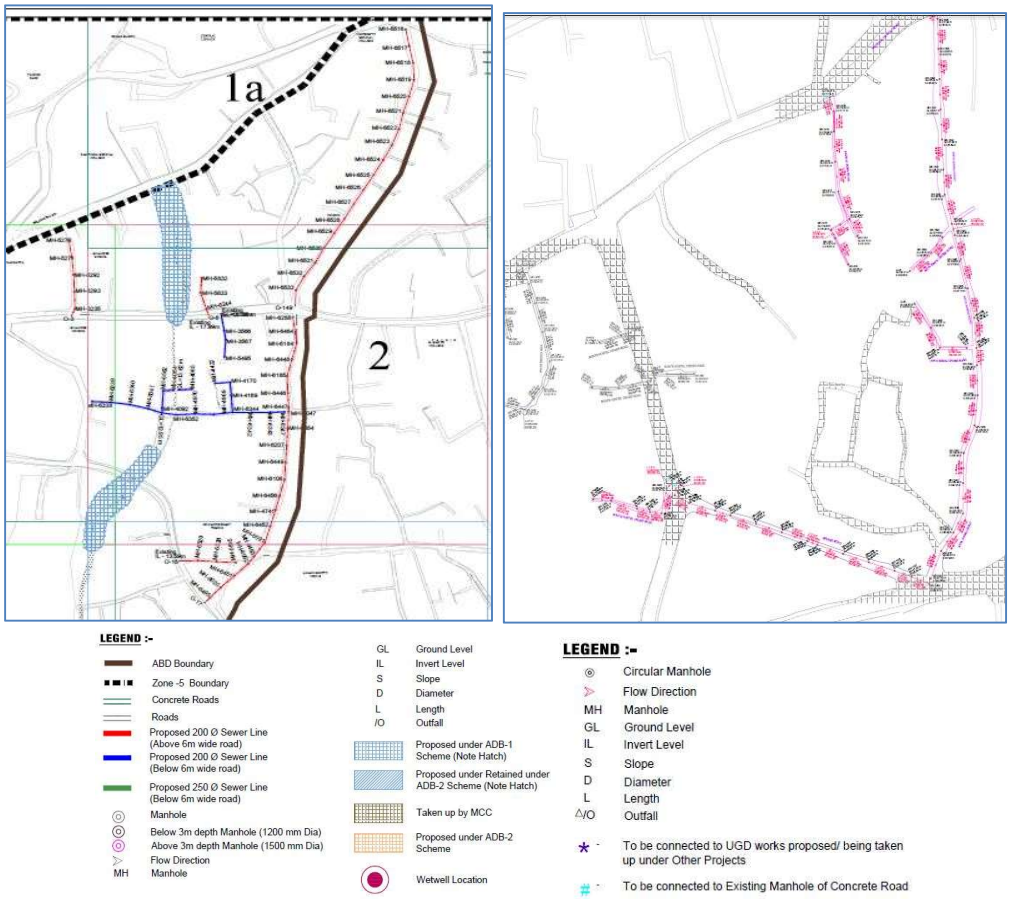


Figure 6-1 Mark-up showing the UGD lines proposed in Roads 8,9 & 19

Mangaluru city has a well planned water distribution network. Several augmentation works have been proposed under various infrastructure development schemes to improve the transmission and distribution of water supply in the city. The details of the same have been incorporated during the planning of smart roads so that all the utilities shall be implemented in co-ordination.

Storm water drains are provided along the road side to collect the runoff during rainfall. The drains are designed for a rainfall intensity of 80mm/hr as obtained from the IDF-curve using Manning's equation for flow through open channels. Rectangular RCC drains 600mm to 1200mm in width has been proposed to collect storm water by gravity. The existing storm water drains in good condition and newly constructed drains shall be retained. The existing drains shall be desilted and refurbished to enhance the carrying capacity of the drain. The following figure shows the output of the design for storm water drainage.

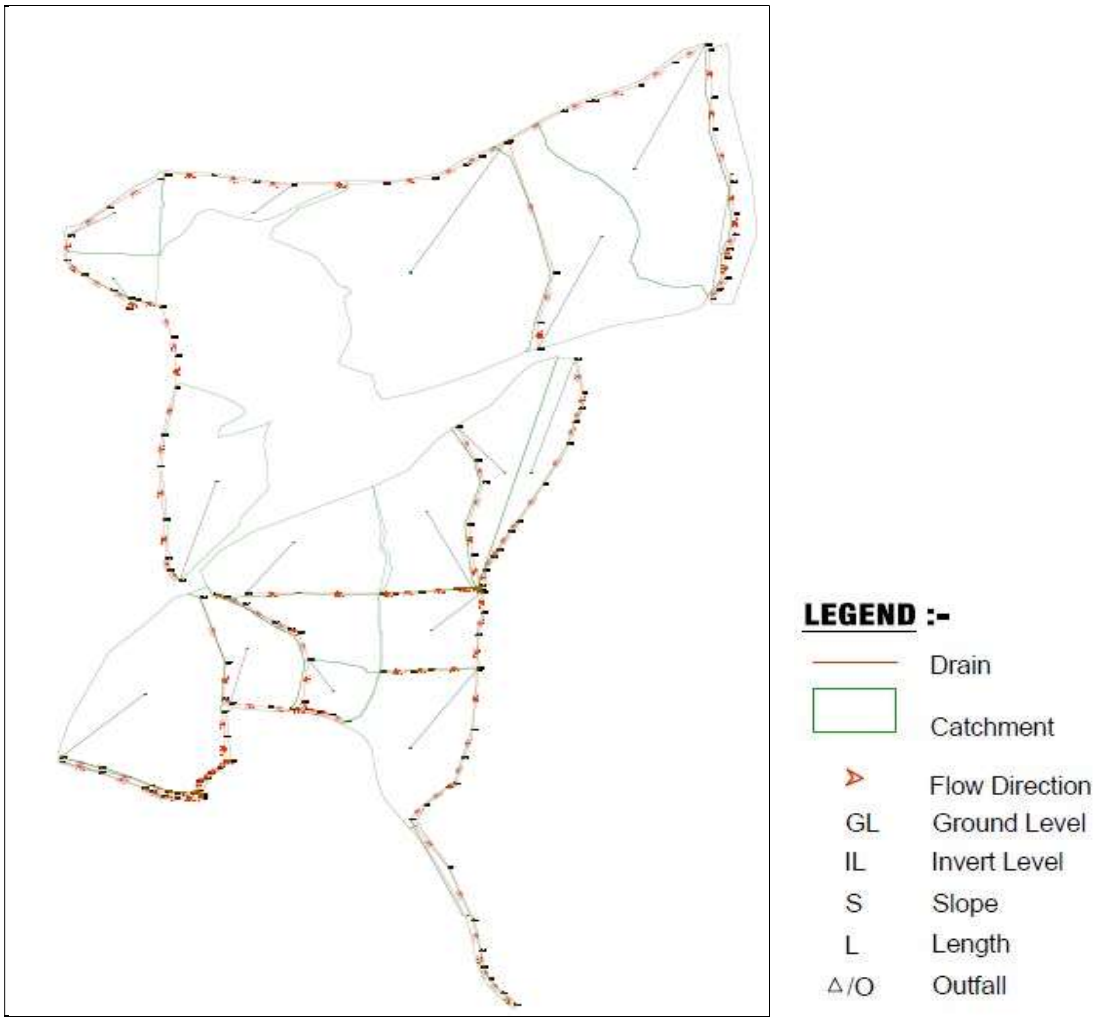


Figure 6-2 Storm water drainage on the considered roads

Existing drain and newly constructed drain along Road 7d

Drains in New Balmatta Road

New drains being constructed along Road-10

Existing drains and new concrete laying along Road-13a

Existing discontinuous drain along Road-13b

Table 6-4 Details of Utilities along DPR-4 Roads

S.NO	Road ID	Sewer				Water Supply			SWD		
		Length(m)	Diameter(mm)	Manhole Size(m)	Qty(Nos)	Dia(mm)	Qty(Nos)	Sluice Valve Qty (Nos)	Width(mm)	Orientation	Retain
1	7b	Existing Network to be retained				350	1		600	both sides	
						160	1				
						63	1				
2	7e	Existing Network to be retained				200	1		600	one side	
						160	1				
						63	2				
3	9	504.2	200	1.2	21	200	1	1		both sides	Retain
						110	1				
						63	2				
4	12	Existing Network to be retained				500	1		600	both sides	
						160	1	1			
						110	1				
5	13a	Existing Network to be retained				500	1		900	both sides	
						110	1	1			
6	13b	Existing Network to be retained				500	1		900	both sides	
						300	1	1			
						110	2	1			
						90	1				
						63	1				

Majority of the Sewer lines in the present DPR has been taken up under UGD Package -4 which includes Zone-5 & Zone-6 in ABD area. The total cost of UGD Package -4 is 24.50 Crores. The cost abstract of this package is mentioned in **Error! Not a valid bookmark self-reference.**

Table 6-5 Cost Abstract-UGD Package-4

Sr.No.	Description	Estimate cost in Rs.
A	**Underground Drainage**	
i	Zone 5 (Road width >6m)	5,66,39,402.00
ii	Zone 5 (Road width <6m)	8,32,19,273.00
iii	Zone 6 (Road width <6m)	3,62,86,901.00
B	**Utility Shifting – Compound Wall, Culvert and RCC Drain**	
i	Zone 5 (Road width >6m)	16,21,728.00
ii	Zone 5 (Road width <6m)	23,80,523.00
iii	Zone 6 (Road width <6m)	10,81,089.00
C	**Electrical Pole Shifting**	
i	Zone 5 (Road width >6m)	19,94,179.00
ii	Zone 5 (Road width <6m)	33,26,214.00
iii	Zone 6 (Road width <6m)	12,87,912.00
	Total Rs.	**18,78,37,220.00**
	Escalation	1,87,83,722.00
	Contingency at 3%	56,35,117.00
	Tax as applicable ,	2,25,40,466.00
	Administrative charges, Miscellaneous and rounding off (LS)	1,02,03,475.00
	Grand Total Rs.	**24,50,00,000.00**

The following table provides the cost of different components and their percentage contribution to the total cost of the UGD Package-4 DPR.

Table 6-6 Components of UGD Package-4 DPR

DESCRIPTION	COST IN INR	% CONTRIBUTION
Excavation	1,60,29,900.00	10%
Pipe	1,66,63,764.00	10%
Manholes	4,70,14,640.00	30%
House Service Connections	55,56,233.00	4%
Inspection Chambers	86,95,792.00	5%
Road Restoration	5,30,51,706.00	33%
Utility Shifting	1,16,91,645.00	7%

The roads 12, 13a, 13b and 19 are a part of Zone-3 in UGD DPR-2. This package includes a part of Zone-4 and a part of Zone-3. The cost abstract of this package is provided in **Table 6-7**

Table 6-7 Cost Abstract-UGD Package-2

Sr.No.	Description	Estimate cost in Rs.
I	Underground Drainage	68,619,965.00
II	Utility Shifting – Compound Wall, Culvert and RCC Drain	1,811,827.00
III	Electrical Pole Shifting	2,242,472.00
	Total Rs.	**72,674,264.00**
	Escalation	72,67,426.00
	Contingency at 3%	2,180,228.00
	Tax as applicable ,	8,720,912.00
	Administrative charges, Miscellaneous and rounding off (LS)	4,157,170.00
	Grand Total Rs.	**95,000,000.00**

Table 6-8 Components of UGD Package-2 DPR

DESCRIPTION	COST IN INR	% CONTRIBUTION
Excavation	23,27,238.00	10%
Pipe	19,32,973	8%
Manholes	70,71,534	30%
House Service Connections	7,71,019	3%
Inspection Chambers	16,06,154	7%
Road Restoration	75,33,870	32%
Utility Shifting	20,70,106	9%

Thus the utilities shall be planned and co-ordinated in conjunction with the design and construction of smart roads.

7. PROPOSED SMART ROAD COMPONENTS – URBAN DESIGN, LANDSCAPE AND ITMS

7.1 Urban Design and Landscape

Transforming existing roads into Smart Roads has been envisaged under the Smart City Mission. The design of Smart roads intends to develop world class road infrastructure inclusive to all strata of society with consideration for pedestrian safety and security as a prime importance. This entails comprehensive upgrading of the public Right of Way (ROW) of the streets which includes refurbishment of existing carriageway, laying of new footpaths and cycle tracks, creating utility corridors, developing pedestrian facilities, development works for landscape, hardscape, street furniture, signage, lighting, etc.

The proposed intervention aims to achieve the following:

- Seamless mobility for citizens of Mangaluru
- To eliminate traffic congestion and facilitate smooth flow of traffic
- To create inclusive road infrastructure for all strata of society
- Promote environmentally sustainable means of transport

As mentioned in Chapter 1, the Smart Road proposal would consist of the following specific interventions:

Proposals for Carriageway Improvement, Roads and Signage's, Junction Improvement have been covered under Chapter 4 and 5 of the Report. The Subsequent Sections provide details of other proposed smart elements, mentioned above, including Junctions.

Design of Smart roads in Mangaluru is with compliance to following guidelines:

7. Indian Road Congress code
8. MoUD – Indian Urban Transport Guidelines.

7.1.1 Proposed Design Considerations

The main parameters considered here are as follows:

1. Continuous footpath
2. Tactile paving present on the roads where footpath more than 1.5m is available.
3. LED street lights

Due to constraints of the adjacent buildings and narrow ROW, landscape spaces and street furniture are not considered in these roads. The following table shows the summary of the pedestrian facilities and smart elements considered in DPR 4.

7.1.2 Urban Design Features

Salient Features of Smart Roads for DPR 4 ROADS:

Road Cross Section:

Carriage way: As per MoUD code for Urban roads, the lane widths proposed in the DPR roads varies between 3.0-3.5. In most of the roads Concrete roads are developed recently about 3-5 years back. Since further road widening is not possible at this point of time, it is proposed to retain the existing roads judiciously and add necessary width of for the footpaths for the safe movement of pedestrians.

Parking Lane: The parking lane of 2.5m is proposed. Wherever space constraints were observed, parking lane was planned by adopting the Parking Norms as per the Mangalore Zonal Regulations (1.25 m). Permeable grass pavers are proposed at the parking lane so that it helps to percolate the rain water and increase the ground water table.

a. **Median:** Medium height shrubs are proposed at the median where ever adequate width of the median is available. However, no shrubs are proposed near median opening to provide for necessary line of sight.

Pedestrian Facilities and Smart Elements:

a. **Footpath:** Wide footpath of minimum width 1.5m to maximum 4m are proposed taking into consideration the pedestrian count on the selected roads.

b. **Barrier free design:** Tactile paving is proposed at the centre of the footpath on all the DPR-4 Smart Roads. Curb ramps are present at the property entrances and parking bays for wheel chair access. Audio visual signals for blind people at the junctions.

c. **Bollards:** Bollards are proposed at the property entrances and parking bays in order to avoid two wheeler movements on the footpath.

d. **Footpath lighting**: Pole lights are proposed at a distance of 10m c/c for illumination of footpath for pedestrian safety and security. The pole lights are incorporated with the advertisement panels which is one of the means for revenue generation.

e. **Street furniture**: Street Furniture includes some interactive seating spaces, benches along the footpath. Dustbins, SIGNAGE like parking sign, stop sign, pedestrian crossing, bus stop are proposed at proper locations.

f. **Table top crossing**: Table top crossing is proposed at junctions so as to have a smooth pedestrian

g. **Other smart features** included are LED street lights to illuminate the carriage way, smart poles at the junction and audio-visual signals at the pedestrian crossings for differently-abled people.

Figure 7-1 Typical Proposed Model of Pedestrian Crossing and Smart Elements

Following are the list of drawings prepared for Urban Design elements of DPR-4 Smart Roads

Table 7-1: List of Cross Sections

DRAWING NO.	DRAWING NAME	NO OF SHEETS
WTE_2292_00_UD_6.01	URBAN DESIGN PROPOSAL OF MOTHER THERESA (ROAD NO. 7b)	**1**
WTE_2292_00_UD_6.02	URBAN DESIGN PROPOSAL OF MILAGES NANDIGUDDA ROAD (ROAD NO. 7e)	**1**
WTE_2292_00_UD_6.03	URBAN DESIGN PROPOSAL OF STURROCK ROAD. (ROAD NO 9)	**1**
WTE_2292_00_UD_6.04	URBAN DESIGN PROPOSAL OF BUNTS HOSTEL ROAD	**1**

	(ROAD NO 12)	
WTE_2292_00_UD_6.05	URBAN DESIGN PROPOSAL OF KUDMAL RANGA RAO ROAD (ROAD NO. 13a)	**1**
WTE_2292_00_UD_6.06	URBAN DESIGN PROPOSAL OF KSR ROAD (ROAD NO13b)	**3**

Table 7-2: Proposed Pedestrian Facilities

Road no	Road Name	Smart Features					Pedestrian Facilities					
		MUBs (trench)	Bus Shelter with E-Toilet	LED lights	Street furniture like signage, dustbins, benches, advt boards	Audi-visual signals	Road side plantation with tree grates	Pedestrian Crossing	Tactile paving and wheel chair access	Spaces for informal commercials	Subways or FOBs	Parking for Auto rickshaws
7b	Mother Theresa Road	√	x	√	√	x	x	√	√	x	x	x
13b	KS Rao Road near City Point	√	√	√	√	x	x	√	√	x	x	x
13a	KRR Road	√	√	√	√	x	x	√	√	x	x	x
12	Bunts Hostel Road	√	√	√	√	x	√	√	√	x	x	x
9	Sturrock Road	√	x	√	√	x	x	x	√	x	x	x
7e	Attavar Road	√	x	√	√	x	x	x	√	x	x	x

The following drawings enclosed in Section 11 of the Report provides details of various Urban Design Proposals along the proposed roads

7.1.3 Landscaping

Roads like the any other transportation hub gives an identity to the place. It plays a vital role in visual experience of user. Mangaluru city has a composition of terrain from plains towards the coastal region to undulating topography toward the Western Ghats on the east. Owing to which the road also has varying gradient and character.

The Road side landscape would enhance the experience of the commuter in terms of microclimate and aesthetics along with ensuring safety. Further it would enrich the experience of the commuters with the natural seasonal dynamism of the plant species

Roads in Central node are one of the prominent roads in the city and encircle the eminent open space along the Town hall. This road also has some of the very old and huge rain trees which give it an identity.

Landscape design has been deliberated with understanding the complex nature of the site, the dynamic relationship between the natural and built environment and overlaying cultural context.

Landscape intervention has been proposed considering the above principle; consequently, have carved out green spaces between the carriage way and footpath to refrain and restrict pedestrian crossing at random locations. This would ensure systematic and swift pedestrian and vehicular circulation.

The median has been designed with a thick green hedge with appropriate height to ensure sight of vehicle in the adjacent lane and cut the glare. This would also restrict pedestrian movement to cross at vulnerable spots.

Further, following aspects should be considered while proposing landscape design

- Use landscape and aesthetics tools to reduce the visual complexity at intersections
- Focus on the use of visual contrasts in material textures and colors to make the functional components of the highway intersection visually prominent.
- Accessibility for maintenance must also be considered
- Select plant materials that will not obstruct critical views as they mature
- Provide a neutral visual background to the intersection where possible Shall have distinct features than the adjacent to mark the entrance
- Plants should help focus the view on the intersection
- Shrubs should be avoided within the appropriate sight triangle at an intersection

The roads considered under DPR 4 have very little open space to properly landscape. And many of the roads are having less RoW. In view of this only shrubs are proposed in the medians where possible.

The details of various Landscape Proposals along Proposed Roads is provided at Section 11

7.1.4 Centralized street lighting control

"Conversion of Conventional Street Lights into LED with Smart Lighting Solutions" is one of the projects under MSC with an objective of reducing energy consumption as well as to reduce impact on environment by conventional lamps. The existing street lights are proposed to be converted into LED on PPP basis under a separate project.

Smart LED street lighting system adopts centralized control system which will result in further saving of electrical energy. This system offers following Merits –

- Central control, fault detection
- Generation of burn hours reports
- Automatic operation with astronomical timers
- Manual operation from a central location through GPRS / GSM system
- Dimming operation
- Remote metering
- Voltage stabilization

Energy consumed by the LED lighting is much less as compared to the sodium vapour lighting. This will reduce the energy bill of street lights to great extent.

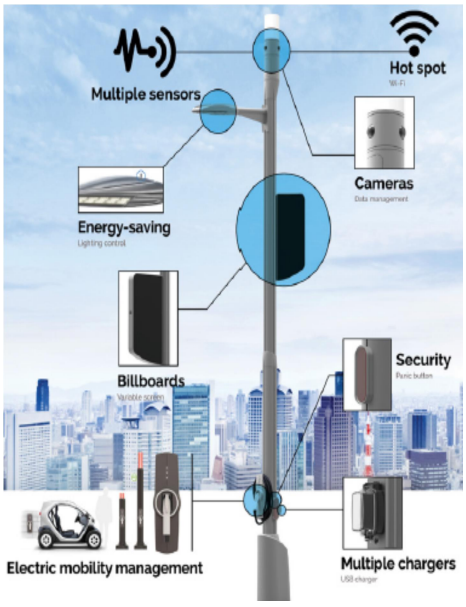
The 9 m lighting poles are provided only in the median. To illuminate the footpaths, 4 m high lighting poles with 40 w LED lighting fixtures has been considered at an interval of 10 m

SMART STREET LIGHTING SOLUTIONS PROPOSED UNDER SMART ROADS WILL BE TAKEN UP UNDER SEPARATE TENDER FOR LED STREET LIGHTS PPP PROJECT COMPONENTS. FOOTPATH LIGHTING IS PART OF THIS TENDER

7.1.5 IT/ICT Elements

The following IT/IC Elements are considered along the Bus Shelter and Smart Pole

- IT/ICT components in Smart Bus Shelter
  - CCTV (dome camera)
  - Wifi Access Point
  - Display units
- IT/ICT component in Smart Pole at Traffic Junction
  - Wifi Access Point
  - Environment Sensor
  - Possible push button for the pedestrian crossing
- PTZ CCTV at Junction



7.1.6 Planned Utilities

Dedicated and planned utilities are one of the key features of smart roads. Various utilities planned under DPR-4 Smart Road include wet utilities include Water Supply, sewerage and storm water drainage system as well as dry utilities like Street Lights, Power Distribution and OFC.

Water Supply Distribution lines are proposed under ADB funding as a separate Project and funding. Necessary coordination with the Consultants working on ADB project and MCC has been carried out to ensure integration of proposals in a holistic manner. Annexure-III shows details of water supply proposals along DPR-4 Smart Road under ADB funder project

Similarly; UGD (Underground sewerage network) and LED Street lighting are proposed as separate Project under Mangaluru Smart City. The proposal under UGD and LED project have been integrated while planning the utility corridor along DPR-4 Smart Road

The detailed inventory of existing electrical utilities has been carried out along with MESCOM officials and same is included as following drawings in Section 11 of the report. The space planning for electrical services in the proposed utility corridor is based on the assessment of existing services to be shifted and considered future provisioning for additional lines.

The design for storm water has been carried out and calculations of the same are attached as Annexure-IV to the report. Based on above holistic and planned approach, an integrated utility corridor is proposed for the DPR-4 Smart Road.

Further, detailed cross section at every 15 m have been prepared and included in the DPR, including details of underground utilities and above ground road, urban design and street light, parking and other details. The drawings provided at Section 11gives detailed cross section at every 15 m interval

Table 7-3: List of Cross Sections

DRAWING NO.	DRAWING NAME	NO OF SHEETS
WTE-2292-04-R-5.01 (R0)	MOTHER TERESA ROAD (ROAD NO.7b) CROSS SECTIONS OF CH:30.00M & CH:80.00M	2
WTE-2292-04-R-5.02 (R0)	MILAGNES NANDIGUDDA ROAD (ROAD NO. 7e) CROSS SECTIONS OF CH:30.00M & CH:80.00M	3
WTE-2292-04-R-5.03 (R0)	STURROCK ROAD (ROAD NO. 9) CROSS SECTIONS OF CH:20.00M & CH:70.00M	6
WTE-2292-04-R-5.04 (R0)	BUNTS HOSTEL ROAD (ROAD NO. 12) CROSS SECTIONS OF CH:30.00M & CH:80.00M	5
WTE-2292-04-R-5.05 (R0)	KRR ROAD (KUDMAL RANGA RAO ROAD) (ROAD NO. 13a) CROSS SECTIONS OF CH:1090.00M	11
WTE-2292-04-R-5.06 (R0)	KSR RAO ROAD (ROAD NO.13b) CROSS SECTIONS OF CH:30.00M & CH:80.00M	11

7.2 Intelligent Traffic Management and Road Surveillance

ITMS is distributed across / coupled with mainly, Intelligent Transport System and Road Surveillance:

7.2.1 Intelligent Transport System (ITS)

The Intelligent Transport along the proposed roads will have the following features

1. **Vehicle Tracking (Buses) System**

The Buses with mounted GPS will be tracked by the Vehicle Tracking System so that their movement data can be fed to the ITS and the information can be disseminated to the Public Mobility App and Display at the Bus Shelters

2. **Information on Bus Transport**

The Vehicle Tracking System + Road Surveillance System + the Schedule fed in the Database of ITS will relay the information for the Public on the next scheduled buses on the particular route, the delay in the buses running, next available bus to arrive, traffic congestion on particular routes etc.

3. **Portable Ticketing**

The bus tickets can be purchased either online or at bus-shelters. Online payment to be availed as well

4. **Public Mobility App**

The bus schedule, the buses actual movements and available buses on the routes, to be made available for the passengers in the app or in the bus-shelter

5. **Synchronized Signaling**

Green Corridor Creation for Disaster Mitigation / Emergency Response Team / Medical Emergency

7.2.2 Road Surveillance

1. **Traffic Rule Violation Detection**

- Red Light Violation
- Speed Violation
- e-Challan (if integrated with RTO Database)

The traffic violation detection by the Camera's to be analysed by the Video Analytics Software in the CCC and the ANPR to detect the vehicle number of the vehicles that violate the traffic rule. The identified vehicle number details then to be fetched from the RTO / Vahan -Sarathi

systems and e-Challan to be sent to the contact details of the person against whose name the vehicle is registered.

2. **Automatic Number Plate Recognition**

3. **Object Detection (for suspicious objects)**

If any object is detected to be static / suspicious (based on the rules configured in the Video Analytics Software system) then the alert to be sent to the competent authority defined in the Standard Operating Procedure for such events.

4. **Road Disaster Alert**

If any accident is detected by the camera or sensitive situation is SOSed by citizen(s) then the alert to be sent to the competent authority defined in the Standard Operating Procedure for such events. The subsequent alert to Emergency Response Team to receive as well

ITMS AND IT/ICT COMPONENTS PROPOSED UNDER SMART ROADS WILL BE TAKEN UP UNDER SEPARATE TENDER FOR ICT COMPONENTS

8. Traffic Management Plan

8.1 Traffic Management during Construction and Upgradation Works

The basic upgradation of roads are considered for developing these roads and the same are listed below

Table 8-1: Road Upgradation Features

Rd. No	Road	Type of Pavement	Quality of Pavement	Road Upgradation
7b	**Mother Theresa Rd.**	Flexible	Good	Conversion to Rigid Pavement`, Utility development
7e	**Milagres Nandigudda Rd.**	Flexible	Poor	Conversion to Rigid Pavement`, Utility development
9	**Sturrock Rd.**	Flexible	Poor	Conversion to Rigid Pavement`, Utility development
12	**Bunts Hostel Rd.**	Rigid	Good	Utility development only
13a	**KRR Rd. (Kudmal Ranga Rao Rd.)**	Rigid	Good	Utility development and in some portion Conversion Flexible to Rigid Pavement
13b	**KSR Rao Rd.**	Rigid	Good	Utility development only

8.1.1 Mother Theresa Road

At present, 30647 vehicles (37928 PCUs) ply on Mother Theresa Road. Southward traffic can be diverted towards Nandigudda Road from Church Jn. Traffic management plan for traffic towards Hamilton circle is required to be formulated during construction of Mother Theresa Road.

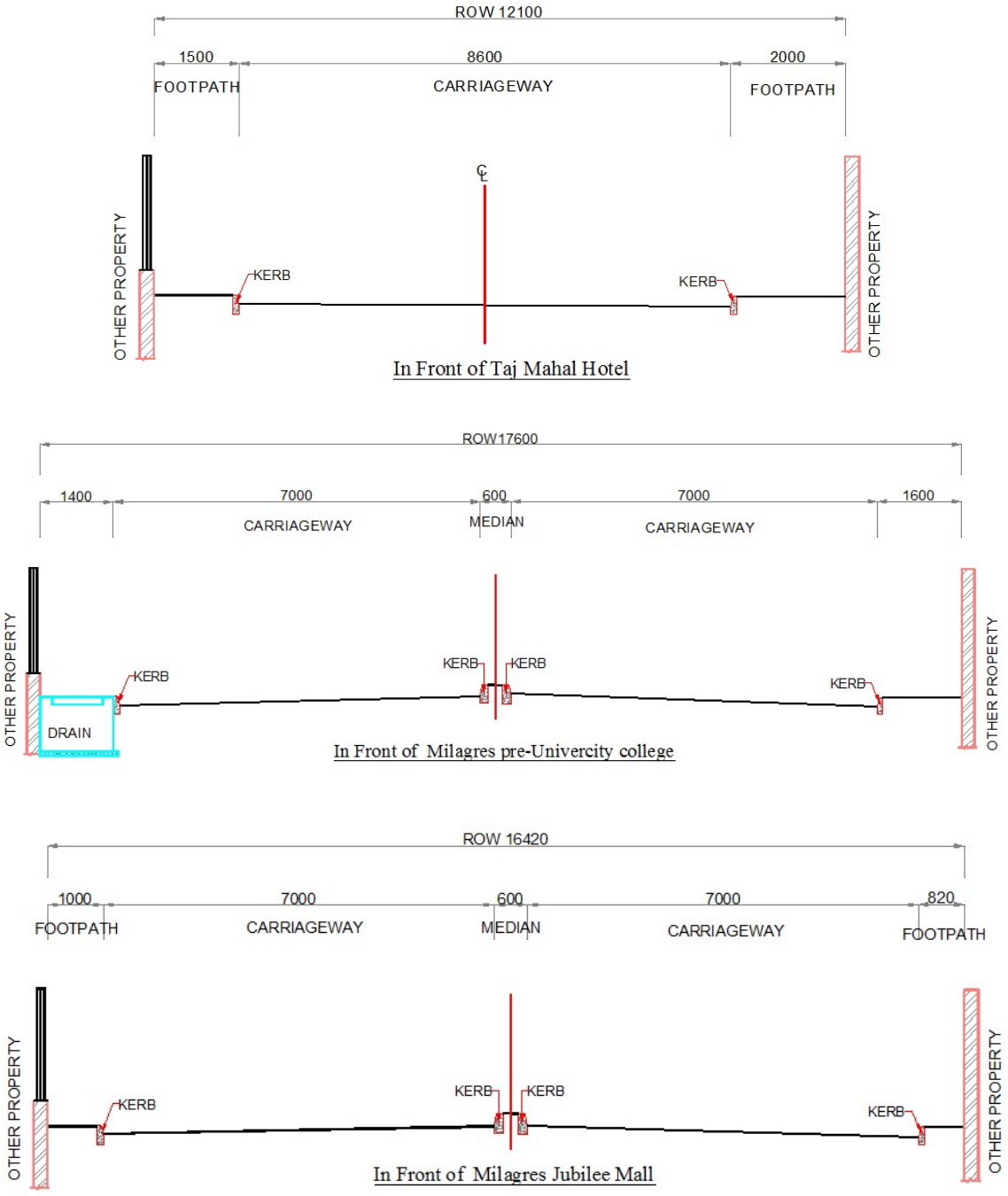
Following table gives the composition of peak traffic of Mother Theresa Road Section A.

Table 8-2: Modal Split of Mother Theresa Road

2 Wheeler	3 Wheeler	Car	LCV	Bus/Truck	Other (MT)	Other (NMT)	Total Vehicles	Total PCUs
12968	9525	6724	539	885	0	6	30647	37928

Following figure gives the existing cross-section of Rosario Church Road

Figure 8-1 Existing Cross Sections of Mother Theresa Road



8.1.2 Attavar Road

At present, 7534 vehicles (9499 PCUs) ply on Attavar Road. Northward traffic can be diverted towards Sturrock Road and also through Railway Station road. Traffic management plan for traffic towards Hamilton circle is required to be formulated during construction of Mother Theresa Road.

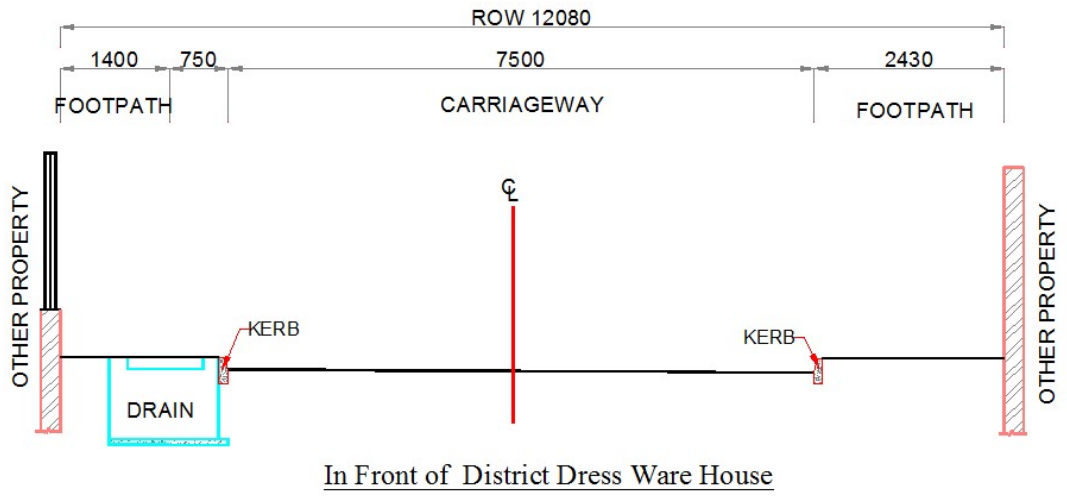
Following table gives the composition of peak traffic of Attavar Road.

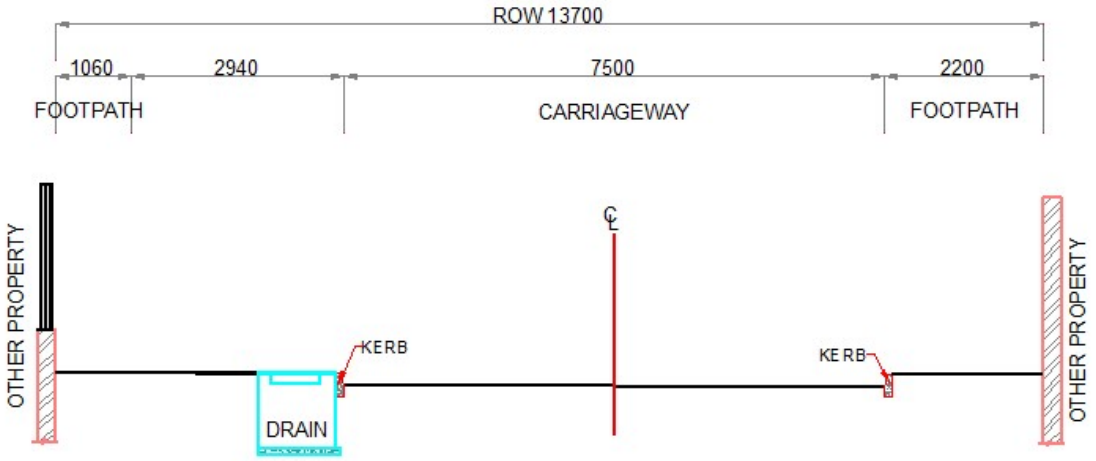
Table 8-3: Modal Split of Attavaar Road

2 Wheeler	3 Wheeler	Car	LCV	Bus/Truck	Other (MT)	Other (NMT)	Total Vehicles	Total PCUs
3153	2560	1540	91	179	1	10	7534	9499

Following figure gives the existing cross-section of Rosario Church Road

Figure 8-2 Existing Cross Section of Attavar Road





In Front of Hotel Shamoon Palace

8.1.3 Sturrock Road

At present, 17198 vehicles (19583 PCUs) ply on Sturrock Road. Southward traffic can be diverted towards Mother Theresa Road from Avery Jn. and Northward traffic can be diverted towards Nandigudda road. Traffic management plan for traffic from Attavar Jn is required to be formulated during construction of Mother Theresa Road.

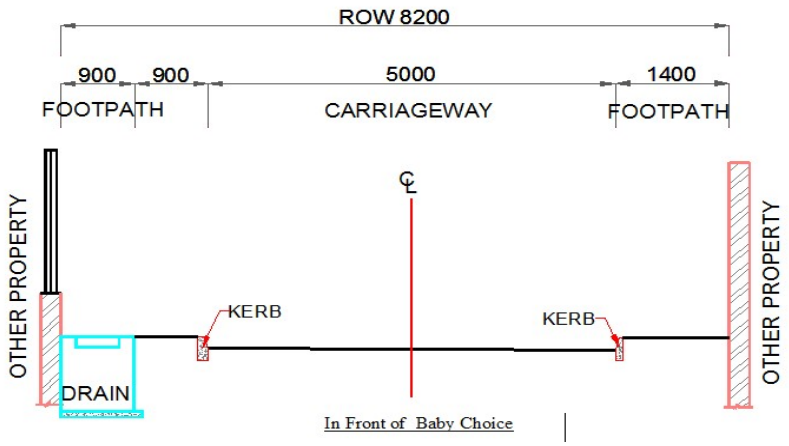
Following table gives the composition of peak traffic of Sturrock Road.

Table 8-4: Modal Split of Sturrock Road

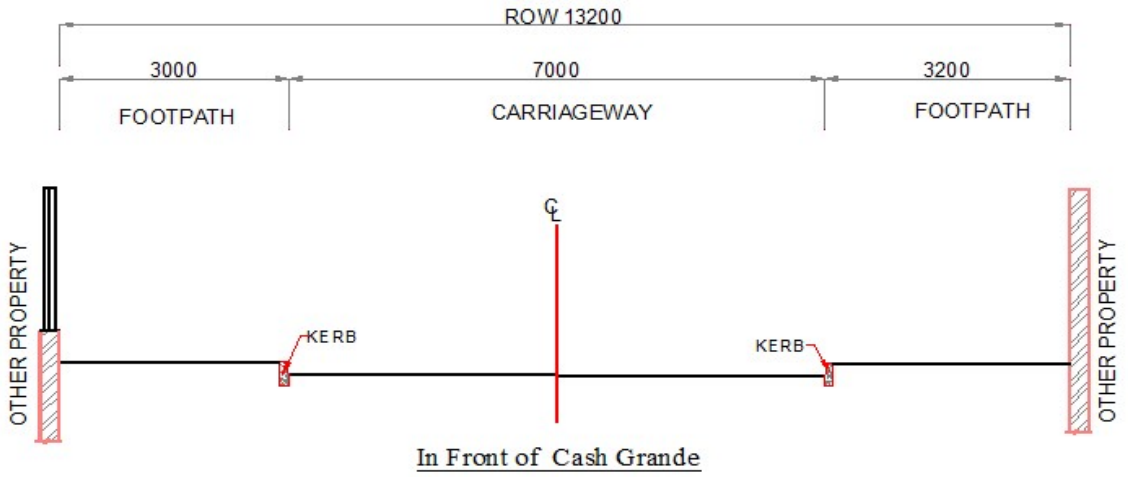
2 Wheeler	3 Wheeler	Car	LCV	Bus/Truck	Other (MT)	Other (NMT)	Total Vehicles	Total PCUs
7747	2560	1540	947	947	9	27	17198	19583

Following figure gives the existing cross-section of Rosario Church Road

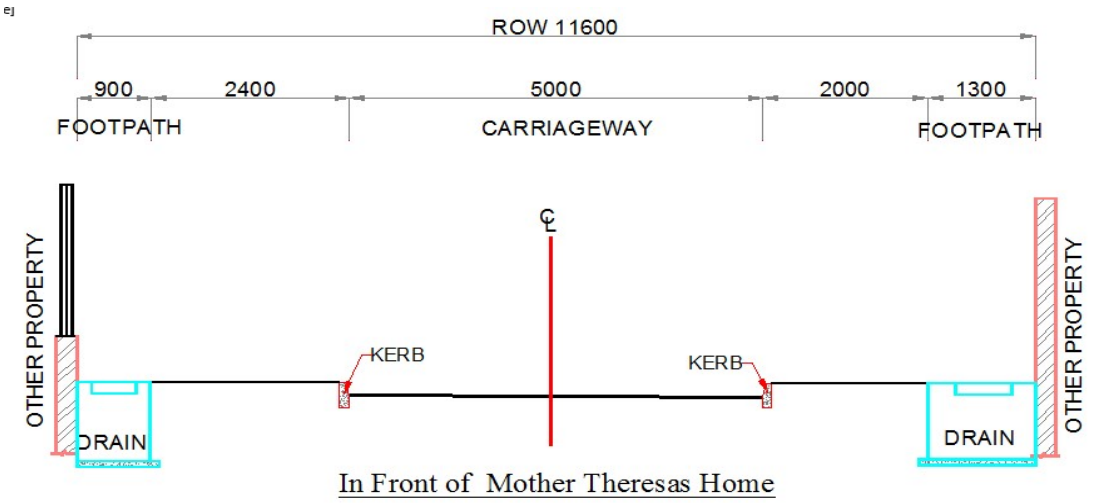
Figure 8-3 Existing Cross Section of Sturrock Road



In Front of Baby Choice



In Front of Cash Grande



In Front of Mother Theresas Home

8.1.4 Balmatta Road, KMC Marcara Trunk Road, Light House Hill Road

Bunts Hostel Road, KS Rao Road and KRR Road are already concrete roads and are not needed for any pavement development. Even the quality of the roads are in good condition so mostly repairing works are also minimal. As part of up gradation to make smart roads, it is proposed to carry joint filling and utility development improvements in carriageway of these roads.

For KRR Road, Utility development and in some portions conversion of surface from Flexible to Rigid Pavement would be necessary.

Since these roads are predominantly busy, repairs works will be done at night time with proper safety and barricades. These roads will be open for public use in daytime.

8.2 Safety Measure during Construction

Lanes Closure is the operation in which one or more traffic lanes and any adjacent shoulder are closed to traffic, in case of a multi-lane Roads, for carrying out the necessary repair/up gradation works. Guidelines provided by **(IRC: SP55 GUIDELINES ON TRAFFIC MANAGEMENT IN WORK ZONES)** needed to be followed for safe traffic movement during construction.

For road, having less than 20 trucks per hour and speed limit less 50 km/h or less, following figure gives the arrangement required at construction zone.

Length of the works from the start of the lead-in taper to the end of the exit taper should not be more than 50 meters .Drivers approaching from either direction can see both the ends of the site.

Subsequent paragraphs and figure explain the arrangement can be applicable at Junction during Construction

The regulatory signs to be used in work zones are subdivided as normal regulatory signs and Work zones specific regulatory sign. Regulatory signs are to instruct road users of traffic laws or regulations and to indicate the applicability of legal requirements that would not otherwise be apparent.

For ensuring legibility and emphasis at night, the signs shall be retro-reflective of at least Grade Type III, i.e. high intensity grade conforming to 801 of Specifications for Roads & Bridges, Ministry of Road Transport and Highways.

The material shall be smooth, sealed outer surface or illuminated to depict the same shape and similar color for both day and night. Sign illumination may be either internal or external and the signboards may be made of rigid or flexible material.

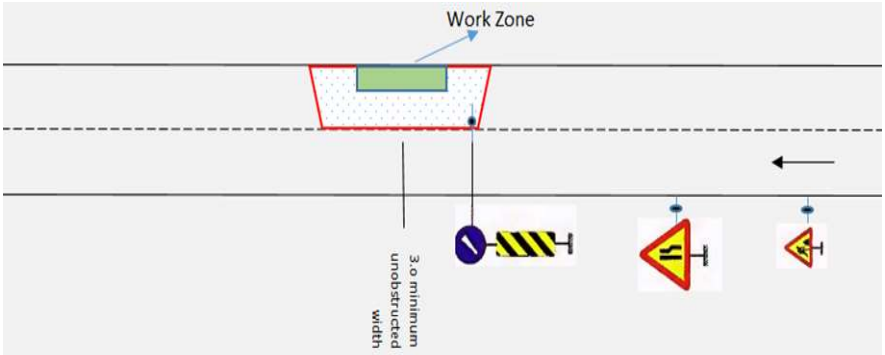


Figure 8-4 Traffic Control System along the road during Construction

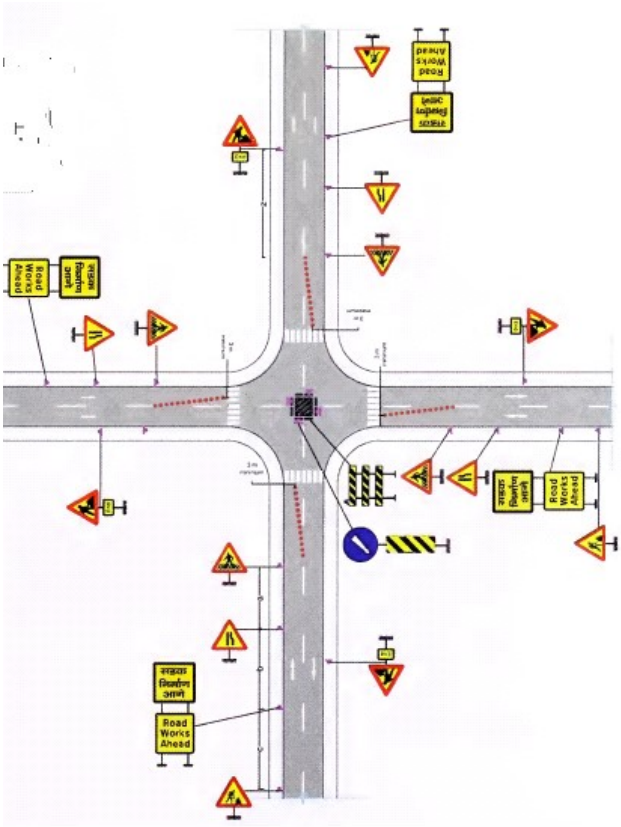


Figure 8-5 Traffic Control System along the road during Construction

8.3 Conclusion

As mentioned above lane closure alternately can adequately handle traffic at on these roads during construction period. Night time construction is preferred alternative for up gradation works at other road on the loop.

IRC 55 guideline diagrams as given in this section need to be adhered for safe traffic movement.

9. Timeline for execution

The Total timeline for project are divided into 3 broad categories:

9.1 Construction Phase

The construction phase is considered as **18 months**

9.2 Defect Liability

The Defect Liability period is considered as **12 months**

9.3 Maintenance Period

The Maintenance Period is considered as **36 months** from date of construction completion

Note: Detailed schedule shall be during the final DPR and RFP Stage

10. Monitoring and Evaluation

The key components under smart road to be monitored are listed below:

- Development and strengthening of carriage way with uniform lane widths and geometric designs of roads and junctions as per street design standards.
- Development of footpath and cycle lanes wherever feasible - with uniform footpath widths, pedestrian friendly ways and barrier-free designs.
- Construction of utility ducts for water, sewerage, drainage, power, gas and optical fibre cables (OFC), wherever essential – with suitable provision for O&M.
- Construction bus bays, auto bays and on-street parking wherever essential.
- Beautification and landscaping including greenery and carbon sinking,
- Provision of smart street furniture and public utilities such as including communicative signage, lane marking. (passenger shelters, bus stops, parking, green toilets, first aid care, traffic police booth etc), public leisure spaces etc.
- Smart street-poles with LED lights, CCTV and various sensors as per city requirement.
- Accessibility standards as prescribed by the MoUD, etc.
- Particular focus on safety of women, children, elderly, etc

Risk assessment and mitigation strategy: Any project development is averse to various types of risks during the life cycle of the project. Identifying these risks and allocating them to the stakeholders who are able to address them the best is the most acceptable form of mitigation.

In this context, key risk associated with the project along with assessment is presented below:

Table 10-1: Risks Mitigation Strategies

Sl. No	Risk Type	Degree (High/ Moderate/ Low)	Mitigation Strategy
1	Construction Phase Risks		
1a	Land Acquisition Delay	Low	Upgradation of roads does not involve any land acquisition. Therefore there is no land acquisition risk for this sub-project
1b	Delay in receipt of statutory approvals to the project	Moderate	The statutory requirements of the project would include approval of traffic management plan and for utility shifting. MCC can provide the requisite facilitation to MSCL for obtaining the necessary approvals for the proposed project.
1c	Time and Cost Over runs during construction	Moderate	The project involves upgradation of urban roads wherein no engineering or structural challenges are foreseen. PMC would monitor the overall progress

			of the project and suggest appropriate remedies/ actions to be taken by MSCL.
2	Regulatory risk		
	Change in law/ policy	Low	Change in policies leading to material adverse impact on the urban infrastructure sector is not envisaged. The present policies in force are expected to pave the way for Smart City development over the long term.
3	Force Majeure.		
	Act of God (Fire, earthquake, etc)	Low	Such risks shall be mitigated through insurance cover. The contractor would be mandated to keep in force insurance covering all project assets during the construction and contract liability phase for insurable events.

11. DRAWINGS

Table 10-1 below provides list of drawings included as volume 2 of the DPR

Table 11-1: List of Drawings

DRAWING NO.	DRAWING NAME	NO OF SHEETS
WTE-2292-04-R-1.01 (R0)	EXISTING FEATURES OF MOTHER TERESA ROAD (ROAD NO. 7b) HAMPANKATTA JUNCTION TO MILAGRES CHURCH JUNCTION	**1**
WTE-2292-04-R-1.02 (R0)	EXISTING FEATURES OF MILAGNES NANDIGUDDA ROAD (ROAD NO. 7e) MILAGRES CHURCH TO NANDIGUDDA ROAD	**2**
WTE-2292-04-R-1.03 (R0)	EXISTING FEATURES OF STURROCK ROAD (ROAD NO. 9) AVORY JUNCTION TO ATTAVER ROAD	**2**
WTE-2292-04-R-1.04 (R0)	EXISTING FEATURES OF BUNTS HOSTEL ROAD (ROAD NO. 12) BUNTS HOSTEL JUNCTION TO JYOYHI CIRCLE	**2**
WTE-2292-04-R-1.05 (R0)	EXISTING FEATURES OF KRR ROAD (KUDMAL RANGA RAO ROAD) (ROAD NO. 13a) PVS JUNCTION TO ARYA SAMAJ ROAD JUNCTION	**4**
WTE-2292-04-R-1.06 (R0)	EXISTING FEATURES OF KRR ROAD KSR RAO ROAD (ROAD NO.13b) PVS CIRECLE-KSR ROAD TO HAMPANKATTA JUNCTION	**4**
WTE-2292-04-R-2.01 (R0)	PLAN AND PROFILE OF MOTHER TERESA ROAD (ROAD NO. 7b) HAMPANKATTA JUNCTION TO MILAGRES CHURCH JUNCTION	**1**
WTE-2292-04-R-2.02 (R0)	PLAN AND PROFILE OF MILAGNES NANDIGUDDA ROAD (ROAD NO. 7e) MILAGRES CHURCH TO NANDIGUDDA ROAD	**1**
WTE-2292-04-R-2.03 (R0)	PLAN AND PROFILE OF STURROCK ROAD (ROAD NO. 9) AVERY JUNCTION TO ATTAVER ROAD	**1**
WTE-2292-04-R-3.01 (R0)	ROAD SIGNAGE & ROAD MARKING PLAN OF MOTHER TERESA ROAD (ROAD NO. 7b) HAMPANKATTA JUNCTION TO MILAGRES CHURCH JUNCTION	**1**
WTE-2292-04-R-3.02 (R0)	ROAD SIGNAGE & ROAD MARKING PLAN OF MILAGNES NANDIGUDDA ROAD (ROAD NO. 7e) MILAGRES CHURCH TO NANDIGUDDA ROAD	**2**
WTE-2292-04-R-3.03 (R0)	ROAD SIGNAGE & ROAD MARKING PLAN OF STURROCK ROAD (ROAD NO. 9) AVERY JUNCTION TO ATTAVER ROAD	**2**
WTE-2292-04-R-3.04 (R0)	ROAD SIGNAGE & ROAD MARKING PLAN OF BUNTS HOSTEL ROAD (ROAD NO. 12) BUNTS HOSTEL JUNCTION TO JYOYHI CIRCLE	**2**
WTE-2292-04-R-3.05(R0)	ROAD SIGNAGE & ROAD MARKING PLAN OF KRR ROAD (KUDMAL RANGA RAO ROAD) (ROAD NO. 13a) PVS JUNCTION TO ARYA SAMAJ ROAD JUNCTION	**4**

WTE-2292-04-R-3.06 (R0)	ROAD SIGNAGE & ROAD MARKING PLAN OF KSR RAO ROAD (ROAD NO.13b) PVS CIRECLE-KSR ROAD TO HAMPANKATTA JUNCTION	**4**
WTE-2292-04-R-4.01 (R0)	ROAD SIGNAGE AND MARKING DETAILS	**1**
WTE-2292-04-R-5.01 (R0)	MOTHER TERESA ROAD (ROAD NO.7b) CROSS SECTIONS OF CH:30.00M & CH:80.00M	**2**
WTE-2292-04-R-5.02 (R0)	MILAGNES NANDIGUDDA ROAD (ROAD NO. 7e) CROSS SECTIONS OF CH:30.00M & CH:80.00M	**3**
WTE-2292-04-R-5.03 (R0)	STURROCK ROAD (ROAD NO. 9) CROSS SECTIONS OF CH:20.00M & CH:70.00M	**6**
WTE-2292-04-R-5.04 (R0)	BUNTS HOSTEL ROAD (ROAD NO. 12) CROSS SECTIONS OF CH:30.00M & CH:80.00M	**5**
WTE-2292-04-R-5.05 (R0)	KRR ROAD (KUDMAL RANGA RAO ROAD) (ROAD NO. 13a) CROSS SECTIONS OF CH:1090.00M	**11**
WTE-2292-04-R-5.06 (R0)	KSR RAO ROAD (ROAD NO.13b) CROSS SECTIONS OF CH:30.00M & CH:80.00M	**11**
WTE_2292_00_UD_6.01	URBAN DESIGN PROPOSAL OF MOTHER THERESA (ROAD NO. 7b)	**1**
WTE_2292_00_UD_6.02	URBAN DESIGN PROPOSAL OF MILAGES NANDIGUDDA ROAD (ROAD NO. 7e)	**1**
WTE_2292_00_UD_6.03	URBAN DESIGN PROPOSAL OF STURROCK ROAD. (ROAD NO 9)	**1**
WTE_2292_00_UD_6.04	URBAN DESIGN PROPOSAL OF BUNTS HOSTEL ROAD (ROAD NO 12)	**1**
WTE_2292_00_UD_6.05	URBAN DESIGN PROPOSAL OF KUDMAL RANGA RAO ROAD (ROAD NO. 13a)	**1**
WTE_2292_00_UD_6.06	URBAN DESIGN PROPOSAL OF KSR ROAD (ROAD NO13b)	**3**

12. COST ESTIMATES

The section of the report deals with the Cost Estimates for DPR-4 Smart Roads

12.1 Assumptions

- SOR rates as per Karnataka PWD SOR-Mangalore Circle.
- 12% weightage has been added to SOR rates of Mangalore Circle PWD Circle
- Non SOR Items based on Rate Analysis OR on Vendor Quotations
- Landscaping rates as per Karnataka PWD and As per EOI.
- Water Supply Package are to be executed under ADB Project and as separate package, hence cost not to be considered in smart road tender cost
- UGD (sewer network) Package will be floated as separate tender, hence cost not to be considered in smart road tender cost
- LED Street Light Package will be floated as separate tender, hence cost not to be considered in smart road tender cost
- ICT Package will be floated as separate tender, hence not to be considered in smart road tender cost

12.2 Summary of Estimate

Summary of the estimate is as stated in tale 11-1 below:

Table 12-1: DPR4 Smart Roads – Summary of Estimate

Grand Summary for DPR 4 Smart Roads

Sr. No.	Description	Cost In INR
1	Road and Other Works	38,33,14,264
2	Street Lighting	41,97,776
3	Landscape Work	5,16,481
	Sub Total	**38,80,28,521**
	Maintenance Cost	1,32,46,483
	Provision for Third Party Damages and Maintenance at 1 st Year(DLP)	29,47,192
	Escalation and Tender Premium at 10%	388,02,852
	Add 3% Contengency	116,40,856
	Miscellaneous and Rounding off	28,122
	Grand Total	**45,46,94,026**

12.3 Detailed BOQ

Detailed BOQ has been enclosed as Volume III of the Detailed Project Report

ANNEXURES I – DETAILS OF TRAFFIC SURVEY AND INVESTIGATIONS

ANNEXURES II – SPECIFICATIONS

ALL THE WORKS TO BE EXECUTED AS PER RELEVANT MORTH, IRC, KSRB DETAILED SPECIFICATION & NATIONAL BUILDING CODE & AS PER RELEVANT BUREAU OF INDIAN STANDARD SPECIFICATIONS

LANDSCAPE DETAILS AS PER SPECIFICATIONS MENTIONED IN DRWINGS FOR PLANTING DETAIL

SOME SPECIFIC SPECIFICATIONS CONSIDERED ARE AS MENTIONED BELOW

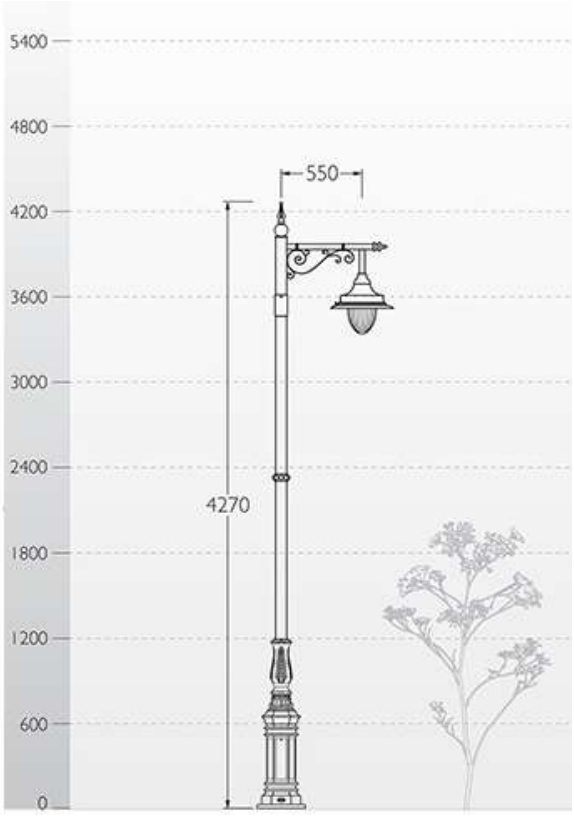
LIGHT FIXTURE FOR FOOTPATH

Make : K-LITE

MODEL : VICENT LIGHTING POLE

Code : KP-450

HT : 4270MM



PERMEABLE ECO-FRIENDLY PAVERS DETAILS

PAVER OPTION FOR CAR PARK AREA: UNILOCK - ECO-OPTILOC

Description:

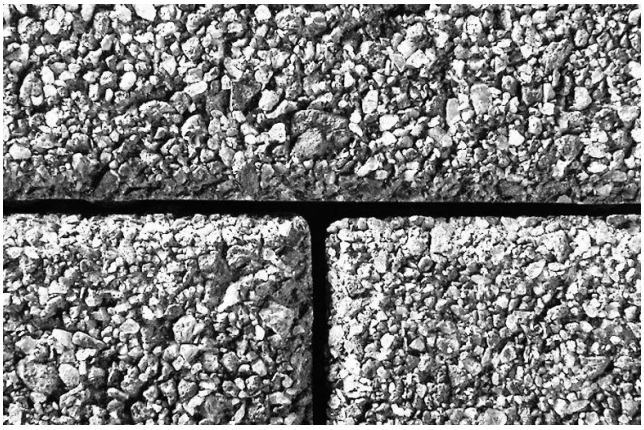


Figure 1 washed finish

This paver has gained world-wide acceptance as the paver-of-choice for performance, and as an environmental solution for drainage. Only the patented "L" shaped design allows you to achieve a superior lock-up that can withstand even the heaviest of loads residentially and commercially. The innovative design creates small voids between the pavers providing drainage into the sub-base.

Standard size: 26 cm x 26 cm x 8 cm i.e. 10.25" X 10.25" X 3.125".

Handling and Installation

- A protective pad is recommended when doing the final paver compaction. These products can be installed mechanically or by hand.
- Jointing Material and Joint Stabilization
- Use only select graded stone chips for void filling UnilockEasyPro
- Product may be sealed but it is not absolutely required Unilock, Unicare, Surebond, BP Pro and Techniseal sealers can be used.
- Select type for desired aesthetics.
- Product must be cleaned before sealing
- Cleaners – Any paver cleaner may be used for colour restoration or general cleaning. Follow manufacturer's dilution rates and application procedures.

PAVER OPTION FOR FOOTPATHS: **BASANT BETONS - ECOLOC**

Description:

Ecoloc permeable interlocking concrete pavers are aimed to reduce storm water runoff. It is an ideal choice for driveways & parking lots. They can also be used for heavy duty applications for ports and storage yards. They form good usage for pavement in all sorts of landscapes including residential dwellings for water harvesting, as these offer great environmental benefits of being able to infiltrate water through the pavement surface into the ground below.

- Maximizes ground water recharge enabling water harvesting for reuse.

- Reduces nonpoint source pollutants in storm water thereby mitigating impact on surrounding surface waters and also would reduce downstream flooding and earth erosion.
- Facilitates efficient land use planning and productive use of land for greater financial benefits offering great help where land prices are high.
- To lessen project costs by reducing or eliminating retention and drainage systems.
- Useful in designing variety of storm water management requirements.

Dimensions:

Thickness: 3 1/8 inches (80mm)

Outside Length : 8 7/8 inches (225mm)

Inside Length : 4 ½ inches (112.5mm)

Pavers Per Sft: 2.41

Percentage of drainage “opening” area per sft : 12.18%

Figure 2 Terracotta 70%-grey 30%

PEDESTRIAN SIGNAL:

Salient features of Traffic Signal Heads

- Special Quality LEDs for uniform high output for extended period and much longer overall life
- Uniformly spaced LEDs give larger and uniform view for dot matrix & high Flux
- Light Intensity & Colour wavelength of LEDs are measured at our optical lab to comply with International specifications
- Complies minimum viewing angel specifications
- The Assemblies use no reflector and LEDs have no colour in off condition eliminates sun phantom effects.
- Available in different voltage versions in AC and DC
- Optical unit and housing protected to IP65/IP54
- Better than 0.9 power factor in AC mains version
- Intensity loss on single LED failure less than 2%
- CE Certified & in compliance with BSEN12368

Pedestrian Traffic Light

ROADSIDE DUSTBIN:

Product Name	Outdoor Dustbin Steel 55L
Size	55liters
Capacity	55L /75L /100L
Material	SS 304 Steel

BOLLARDS:

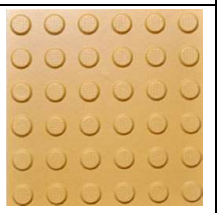
- 304/ 316 grade polished stainless steel
- Machined flat cap
- Optional cover skirts available
- Versatile products for decorative covers, removable traffic parking control, bike parking and safety security

Features

1. Higher resistance to corrosion
2. Greater resistance to pitting and staining
3. Low Maintenance
4. Recyclable

TACTILE PAVING

Table 0-1: Tactile Paving

Parameter	*Specification*	*Area*	*Photo*
Directional Tile	Size: 300x 300 x 60 mm Colour: Yellow Grade of Concrete: M-30	356 sq.m.	
Stop tile	Size: 300x 300 x 60 mm Colour: Yellow Grade of Concrete: M-30	100 sq.m.	

ANNEXURES III – DESIGN PROPOSALS FOR WATER SUPPLY UNDER ADB FUNDED PROJECT

ANNEXURES IV – DESIGN CALCULATIONS FOR STORM WATER DRAINAGE