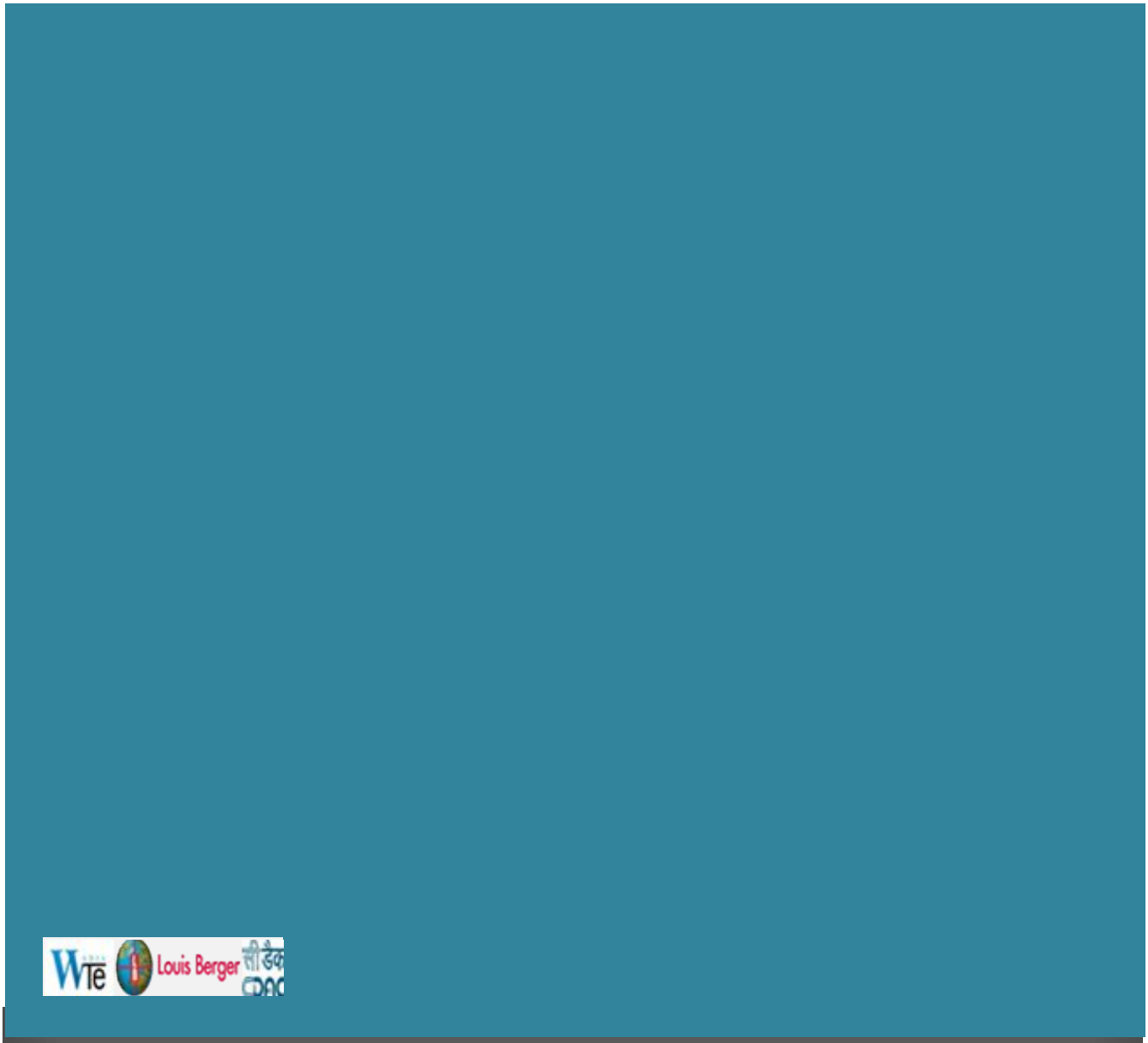

## ISSUE AND REVISION RECORD

| Revision | Date | Originator | Checker | Approver | Description | Standard |
|---|---|---|---|---|---|---|
| 3 | 25/01/2019 | WTESL/LBI/ CDAC | MANI NARAYAN | 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

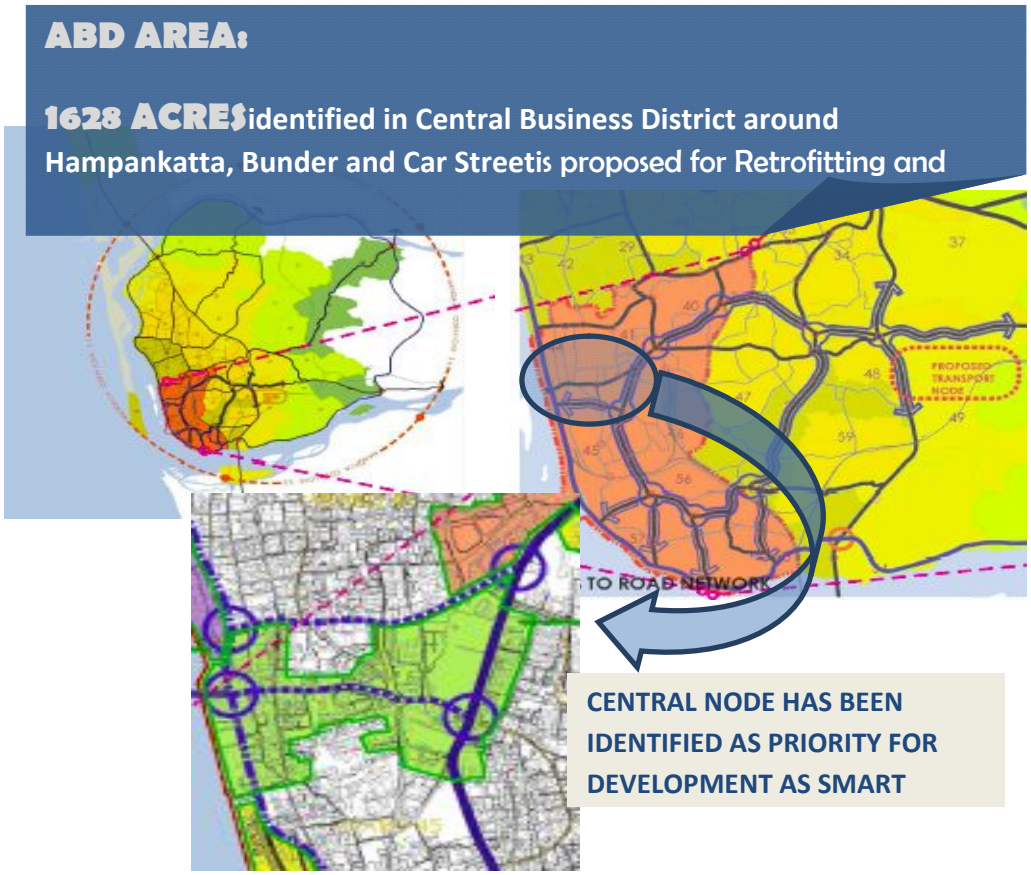
## 1.1. Mangaluru Smart City Proposal

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 |

A

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he revised SCP, sanctioned recently the smart road Package 3 amounts Rs 49 Crores which may please be approved.

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

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

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 DPR 3RoadS considered for development as smart road and are part of this DPR

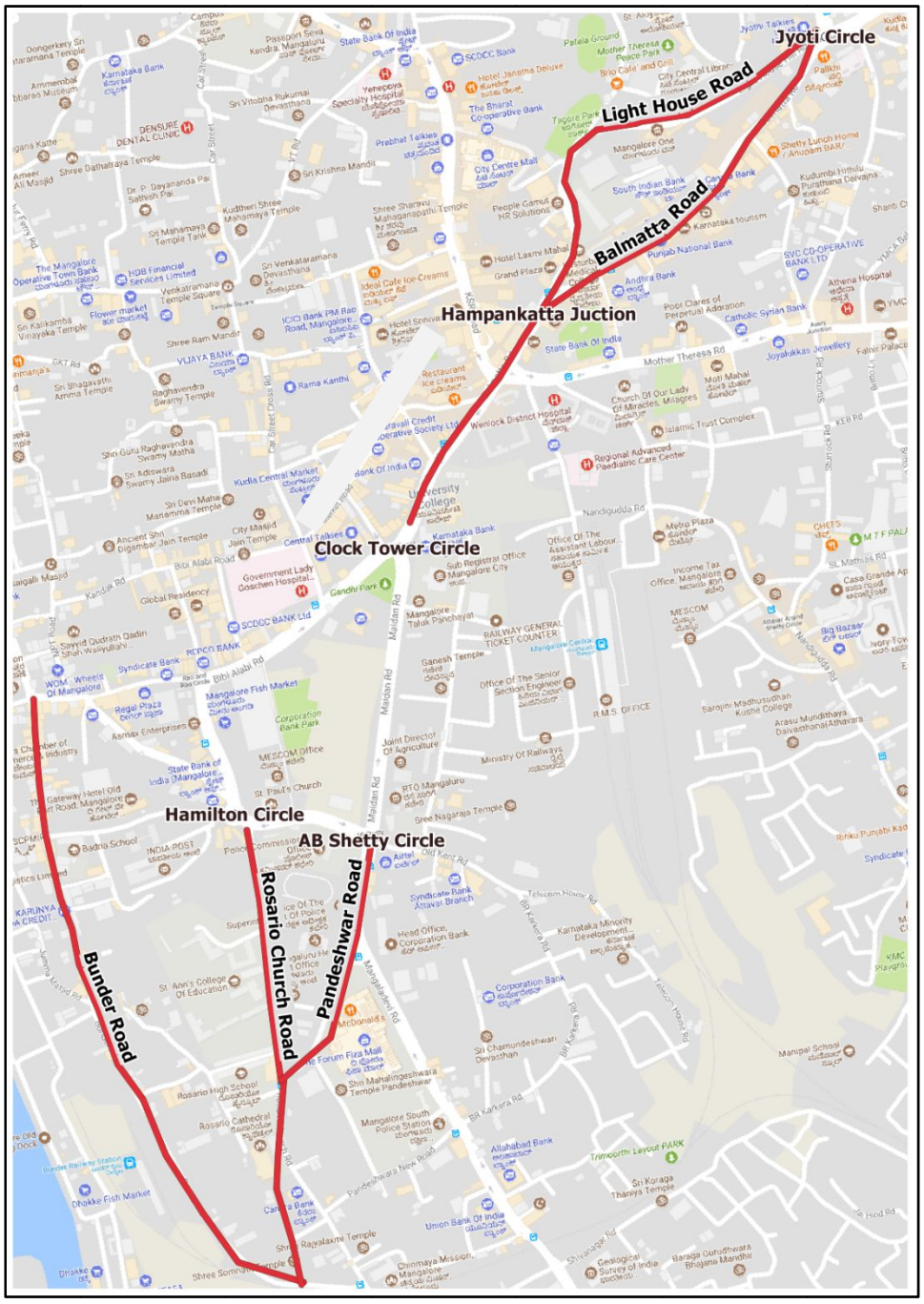



**Figure 1-2Phase I/Priority Smart Road considered for development as smart road**

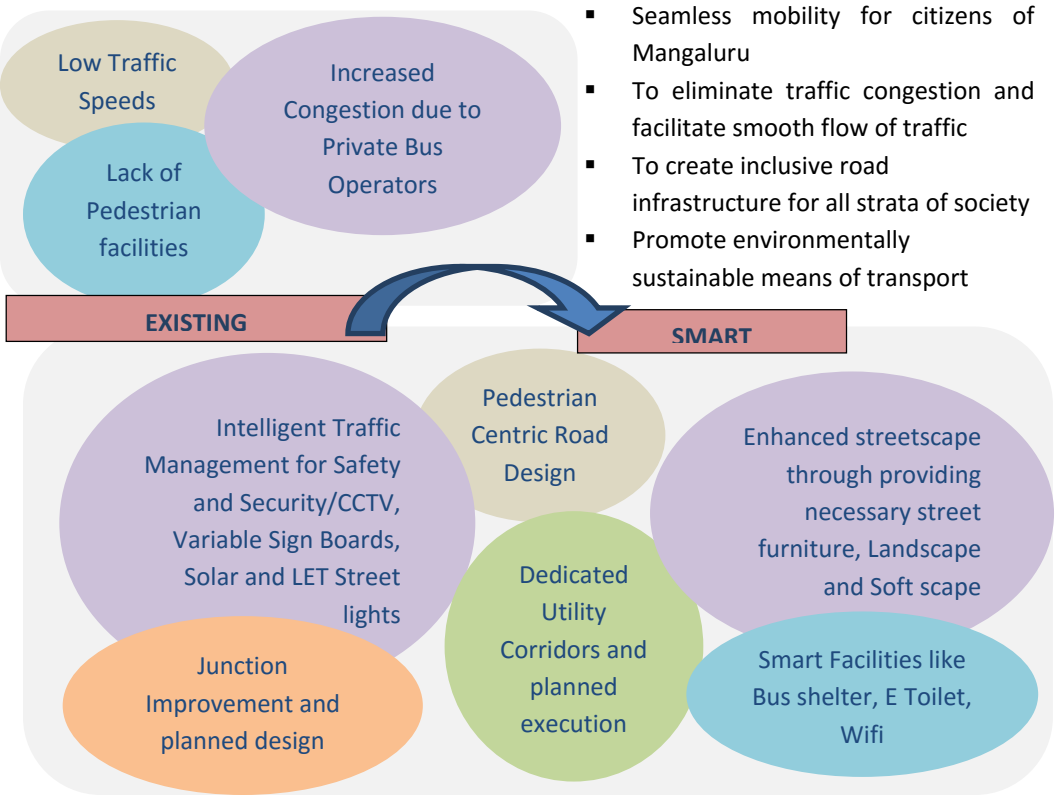
### *1.2.1. Need for Intervention*

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



### *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:

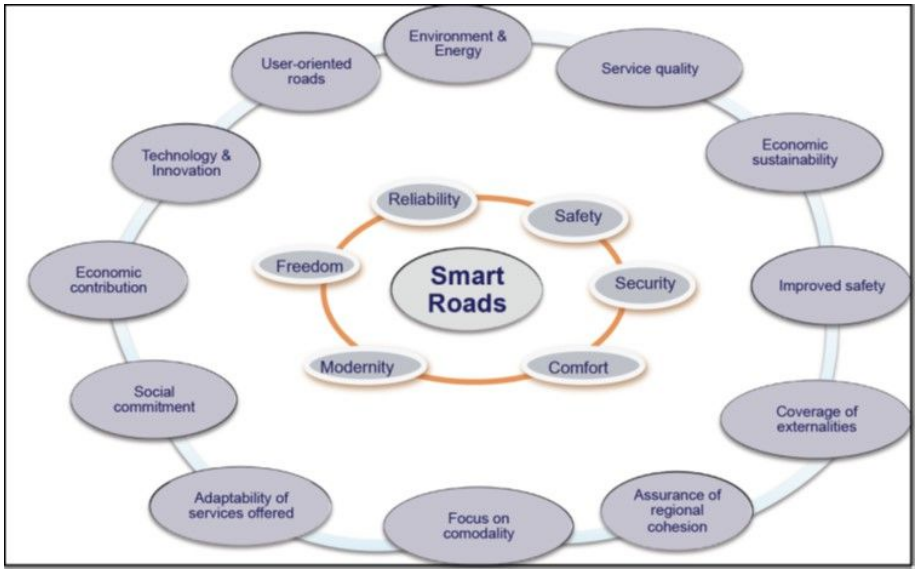
1) **EFFICIENT AND SAFE STREETS**: This involves road re-channelization whereby the effective width of the carriageway is reduced in order to achieve systemic improvements. Roads with clearly demarcated spaces for vehicles, pedestrians, cyclists and dedicated on-street parking to minimize conflicts between 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.

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:




### *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

### *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.

## 1.3. Objective of the Report

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

## 1.4. Structure of the Report

This report is organized as follows:

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

## 2. SITE RECONNAISSANCE AND SITUATION ANALYSIS

Detailed Site Reconnaissance was carried out along the selected roadsto assess the existing situation in terms of pavement condition, traffic situation/movements, existing facilities/structures, smart elements that can be proposed along Priority Loop Road. Section below describes brief of existing condition of Priority Loop Road

### 2.1. Rosario Church Road

It stretches from Hamilton circle to Railway crossing.


**Facts:**

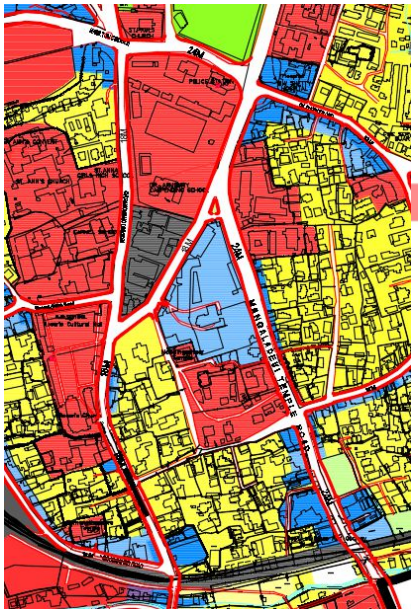
- Total length of road= 480m
- Min. width = 16.30m
- Max. Width = 24.94
- Slope: 1.69%;
- Type of Carriage way: Bituminous in a poor condition

**Existing Utilities:**

- The electrical lines are present above ground
- Storm water drains are present on both sides of the road
- Waterline is present on both side of the carriage way.

**OBSERVATIONS:**

1. The proposed road width as per MUDA Masterplan are as follows for different roads:
    1. Rosario Church Road = 18m
    2. Pandeshwar Road = 18m
    3. Mangaladevi Road = 24m
2. Predominantly institutional and residential landuse is observed along this road
3. The ROW varies drastically from 15.7m to 6.8m towards the south.

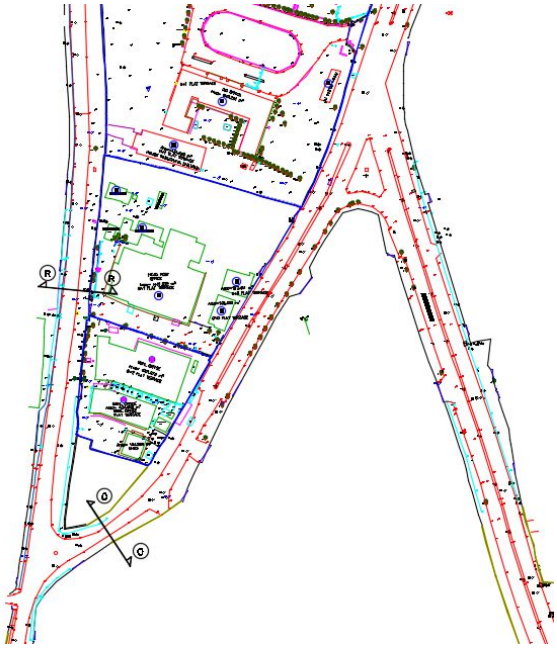


## 2.2. Pandeshwar Road

It stretches from Hamilton circle to Railway crossing.

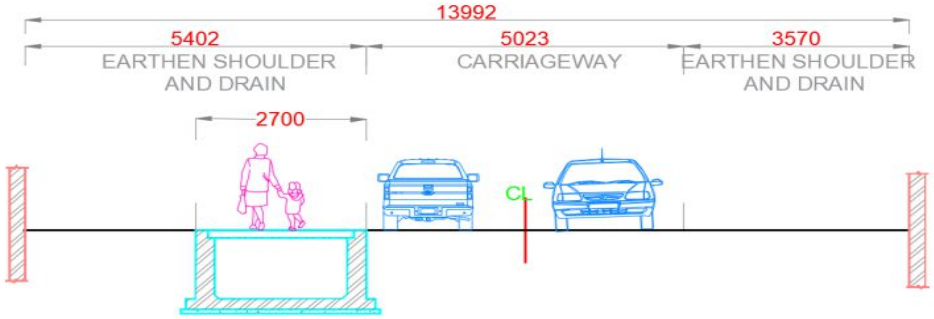
**Facts:**

1. Total length of road= 303.41m
2. Min. width = 18.60m
3. Max. Width = 23.12m
4. Slope: 3%; 1:28
5. Type of Carriage way: Bituminous in a poor condition



**Existing Utilities:**

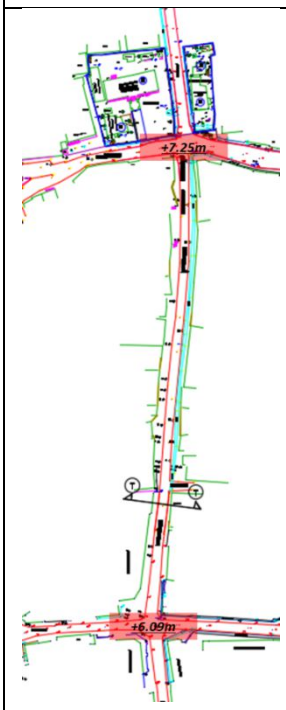
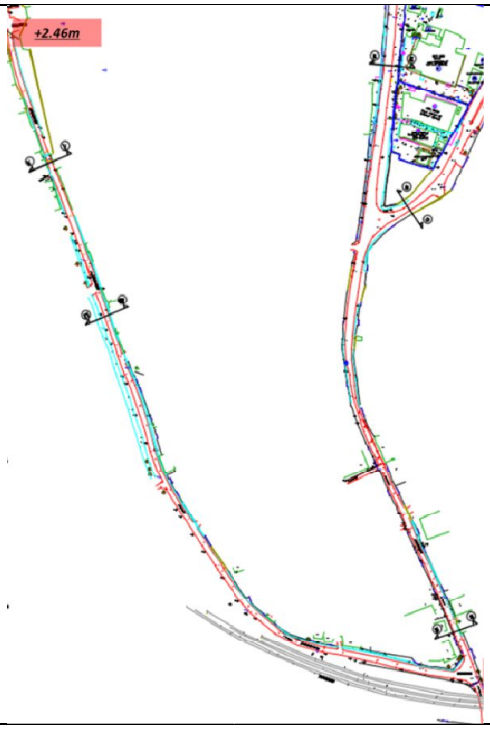
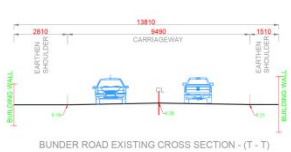
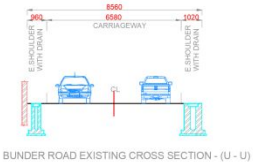
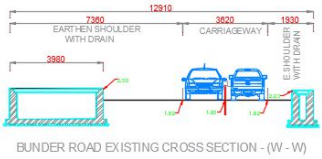
1. The electrical lines are present above ground
2. Storm water drains are present on both sides of the road
3. Waterline is present on both side of the carriage way.




PANDESHWAR ROAD EXISTING CROSS SECTION - (O - O)

## 2.3. Bunder Road

It stretches from Hamilton circle to Railway crossing.

| | | |
|---|---|---|
| **Facts:**<br>1. Total length of road= 250m<br>2. Min. width = 9.49m<br>3. Max. Width = 12.01m<br>4. Slope: 0.5%;<br>5. Type of Carriage way: Bituminous in a poor condition | **Facts:**<br>1. Total length of road= 326.82m<br>2. Min. width = 8.66m<br>3. Max. Width = 21.90m<br>4. Slope: 4%;<br>5. Type of Carriage way: Bituminous in a poor condition | **Facts:**<br>1. Total length of road= 759.76m<br>2. Min. width = 3.63m<br>3. Max. Width = 18.56m<br>4. Type of Carriage way: Bituminous in a poor condition |
|  |  |  |
|  |  |  |
| **Existing Utilities:**<br>1. The electrical lines are present above ground<br>2. Storm water drains are present on both sides of the road. | **Existing Utilities:**<br>1. The electrical lines are present above ground<br>2. Storm water drains are present on both sides of the road. | **Existing Utilities:**<br>1. The electrical lines are present above ground.<br>2. Footpath is absent<br>3. Narrow ROW |

# 3. SURVEYS AND INVESTIGATIONS

## 3.1. Road Inventory Survey

A detailed road inventory was done along the Smart 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 14 of the report shows details of existing features along the DPR-3 roads

| No | Drawing no | Drawing Title | No of Sheets |
|---|---|---|---|
| 1 | WTE_2292_03_R_1.01 | EXISTING FEATURES OF PANDESHWAR ROAD (ROAD NO. 3) | 1 |
| 2 | WTE_2292_03_R_1.02 | EXISTING FEATURES OF ROSARIO CHURCH ROAD (ROAD NO. 1a) | 2 |
| 3 | WTE_2292_03_R_1.03 | EXISTING FEATURES OF BUNDER ROAD (ROAD NO. 16) | 2 |
| 4 | WTE_2292_03_R_1.04 | EXISTING FEATURES OF LIGHT HOUSE HILL ROAD (ROAD NO.11) | 2 |
| 5 | WTE_2292_03_R_1.05 | EXISTING FEATURES OF KMC MERKARA TRUNK ROAD (ROAD NO.17) | 2 |
| 6 | WTE_2292_03_R_1.06 | EXISTING FEATURES OF MOHAMMED ALI ROAD | 1 |

## 3.2. Traffic Surveys

Based on the roads and junction identified under DPR 3, detailed primary surveys and investigation were carried out. Table 3-1 below defines various Traffic surveys and investigations carried out along the Priority Loop 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 3-1: Traffic Surveys and Investigations conducted along the Priority Loop Road**

| S.No. | Location of Traffic Survey | Survey* | Dates |
|---|---|---|---|
| 1 | Balmatta Road (1-Way) | TVC | 15 Feb 2018 |
| 2 | Light House Hill road | TVC | 15 Feb 2018 |
| 3 | Balmatta Road (2-Way) | TVC | 27-29 Mar 2018 |

| S.No. | Location of Traffic Survey | Survey* | Dates |
|---|---|---|---|
| 4 | Pandeshwar Road | TMC | 10 Jul 2018 |
| 5 | Rosario Church Road (A) | TVC | 14-20 Jul 2017 |
| 6 | Rosario Church Road (B) | TMC | 18 Jul 2017 |
| 7 | Bunder Road | TVC | 24-26 July 2018 |

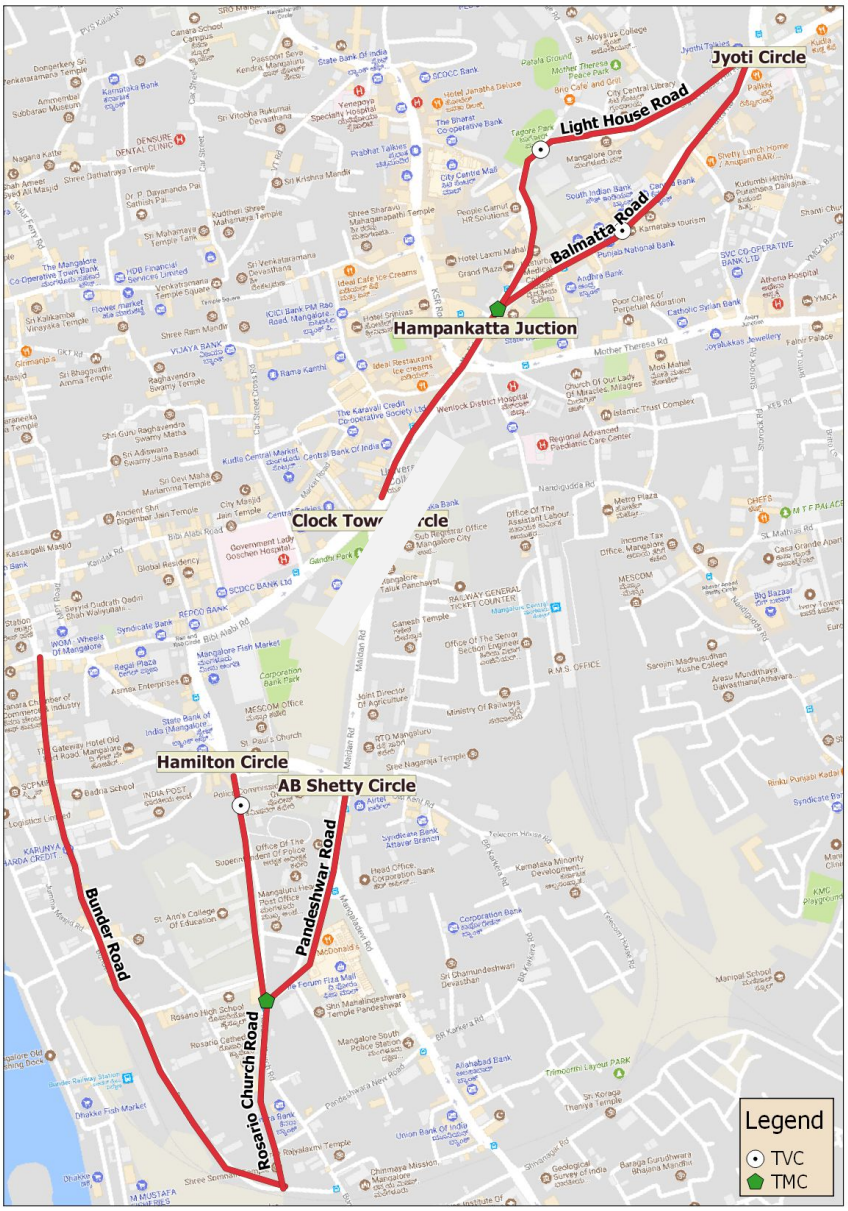



Figure 3-1 Traffic Survey Location

Figure 3-2Survey 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.

**Table 3-2: 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 1 to the Report

# 4. TRAFFIC ANALYSIS AND RECOMMENDATIONS

## 4.1. Traffic Analysis

### *4.1.1. Classified Traffic Volume Counts*

The classified traffic volume survey data for two count locations was analyzed in order to obtain the following traffic characteristics:

- Average hourly variation of traffic volume
- Daily variation of traffic volume
- Average Composition of traffic
- Directional distribution of traffic
- Average Daily Traffic (ADT) volume

Daily and hourly variation of classified traffic flow is recorded by conducting traffic counts at two strategically selected traffic count stations. Recorded traffic data has been converted into Passenger Car Units using PCU factors as shown in table 4-1 below.

These equivalency factors are extracted from IRC: 106 – 1990, 'Guidelines for Capacity of Roads in Urban Areas'.

**Table 4-1: Traffic Surveys - Vehicle Classification system**

| | | PCU Factors | |
|---|---|---|---|
| **S.No.** | **Vehicle Type** | **Percentage Composition of Vehicle Type in Traffic Stream** | |
| | | **5%** | **10% and Above** |
| **1** | Two Wheeler | 0.50 | 0.75 |
| **2** | Car | 1.00 | 1.00 |
| **3** | Auto Ricksaw | 1.20 | 2.00 |
| **4** | LCV | 1.40 | 2.00 |
| **5** | Truck or Bus | 2.20 | 3.70 |
| **6** | Agricultural Tractor Trailer | 4.00 | 5.00 |
| **7** | Cycle | 0.40 | 0.50 |
| **8** | Cycle Rickshaw | 1.50 | 2.00 |
| **9** | Tonga | 1.50 | 2.00 |
| **10** | Hand Cart | 2.00 | 3.00 |

### *4.1.2. Average Daily Traffic (ADT)*

Traffic volume count data for 7 days at two locations were carried out to determine Average Daily Traffic (ADT) and is shown in table 4-2 below

**Table 4-2: Average Daily Traffic at Priority Roads**

| Mode | Balmatta one way | Light House Hill Road | Rosario Church Road Sec A | Rosario Church Road Sec B | Pandesh-war Road | Bunder Road |
|---|---|---|---|---|---|---|
| 2w | 9,008 | 14,096 | 3,338 | 2,779 | 2,157 | 2,300 |
| 3w | 5,799 | 6,819 | 1,558 | 1,363 | 1,094 | 457 |
| Car/Van | 5,905 | 10,776 | 1,279 | 1,229 | 1,127 | 193 |
| Mini Bus | 56 | 76 | 33 | 23 | 29 | 9 |
| Bus | 3,306 | 2,912 | 123 | 105 | 52 | 3 |
| LCV upto 4 | 513 | 581 | - | - | - | 69 |
| LCV | - | 2 | 208 | 153 | 133 | 134 |
| 2 Axle Truck | 130 | 119 | 127 | 81 | 66 | 24 |
| 3 Axle Truck | 12 | 7 | 6 | 4 | 1 | 74 |
| MAV | - | - | 3 | - | - | 3 |
| Tractor | - | - | - | - | - | - |
| Tractor+Trailer | - | - | - | - | - | 1 |
| Cycle | - | 1 | 5 | 16 | 10 | 27 |
| Cycle rickshaw | - | - | - | - | - | - |
| Animal Drawn | - | - | - | - | - | - |
| Hand Cart | - | - | - | - | - | - |
| **Total Veh** | **24,729** | **35,389** | **6,679** | **5,753** | **4,669** | **3,294** |
| **Total PCU** | **37,395** | **42,360** | **7,806** | **6,710** | **5,425** | **3,345** |

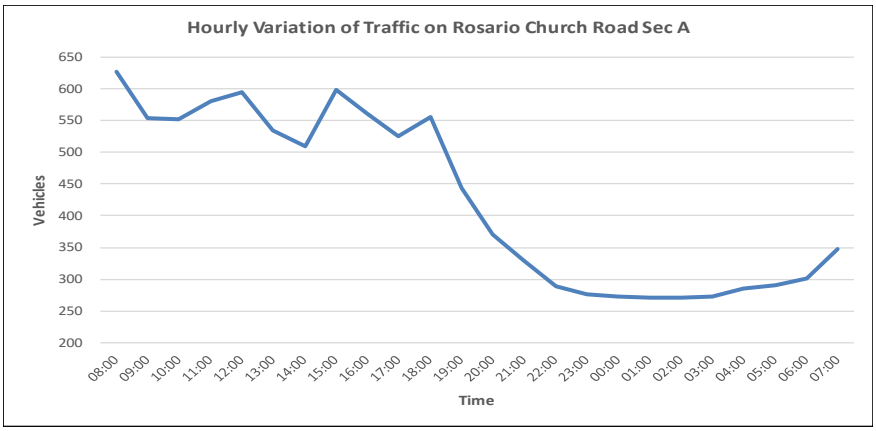
(2W: Two Wheeler, 3W: Three Wheeler, P: Passenger, F: Freight, M: Mini, LCV: Light Commercial Vehicle)

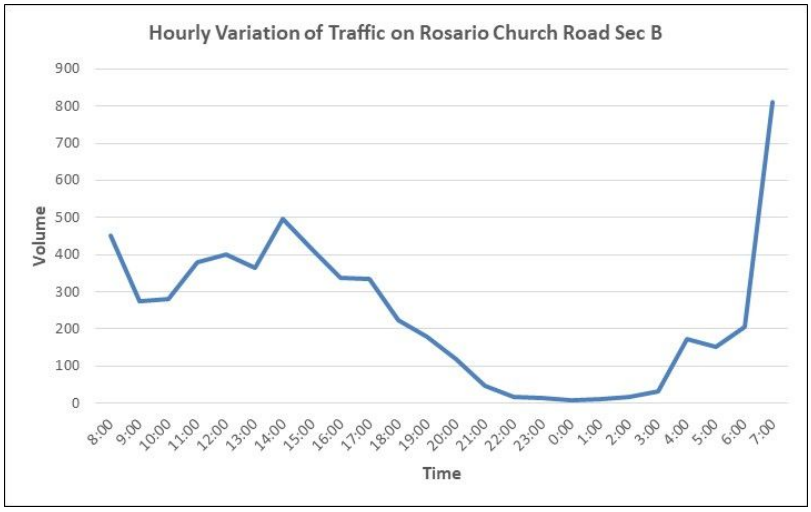
Traffic volume is highest on Lighthouse Hill Road at 43,360 PCU and Balmatta Road (1-Way) at 37,395 PCU. Traffic volume on other roads is less at about 5,500-8,000 PCU.

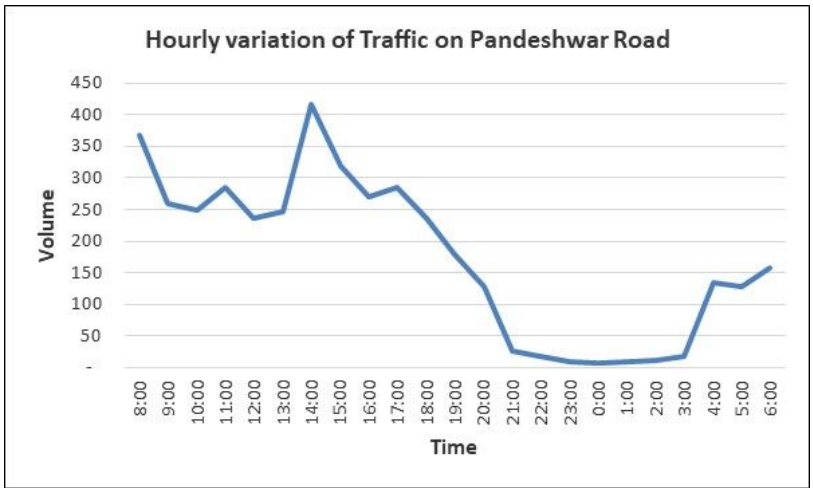
Since these are urban roads seasonal variations are minimal and, hence, ADT is considered as AADT.

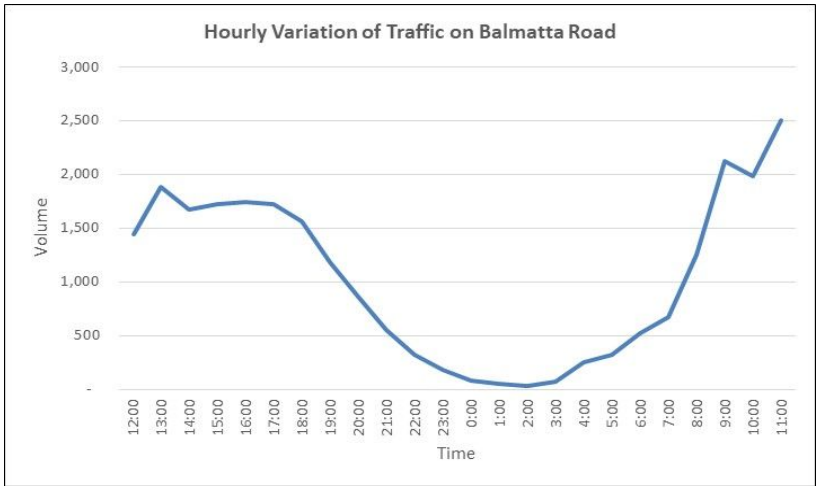
### *4.1.3. Hourly Variation*

The hourly variation of traffic at survey locations is presented in **Figure 3**.




Hourly Variation of Traffic on Rosario Church Road Sec B
Volume
900
800
700
600
500
400
300
200
100
0
8:00 9:00 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 0:00 1:00 2:00 3:00 4:00 5:00 6:00 7:00
Time


Hourly variation of Traffic on Pandeshwar Road
Volume
450
400
350
300
250
200
150
100
50
-
8:00 9:00 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 0:00 1:00 2:00 3:00 4:00 5:00 6:00
Time


Hourly Variation of Traffic on Balmatta Road
Volume
3,000
2,500
2,000
1,500
1,000
500
-
12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00 20:00 21:00 22:00 23:00 0:00 1:00 2:00 3:00 4:00 5:00 6:00 7:00 8:00 9:00 10:00 11:00
Time

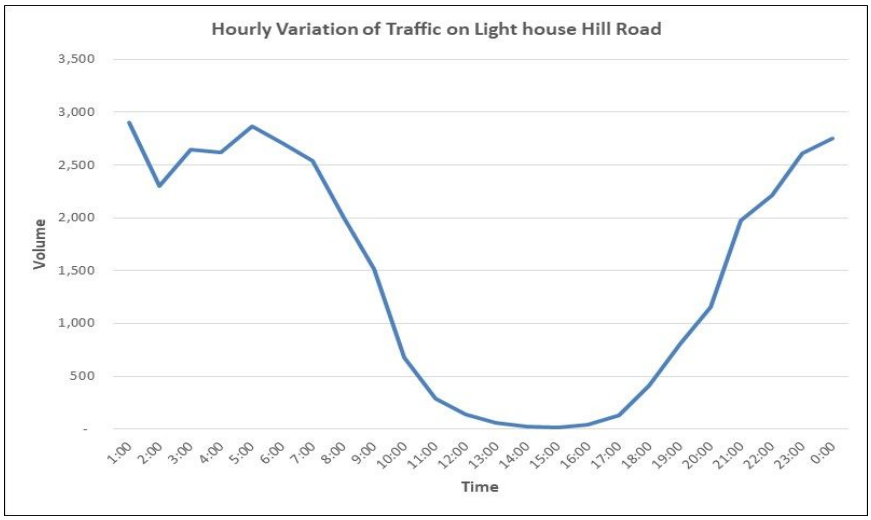
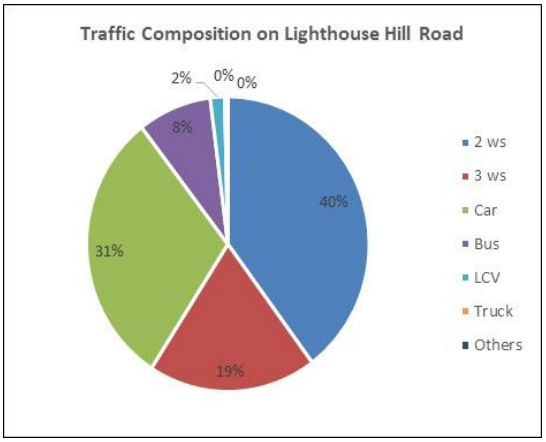



**Figure 3: Hourly variation of Traffic**

### *4.1.4. Traffic Composition*

The composition of traffic at the survey locations is presented in



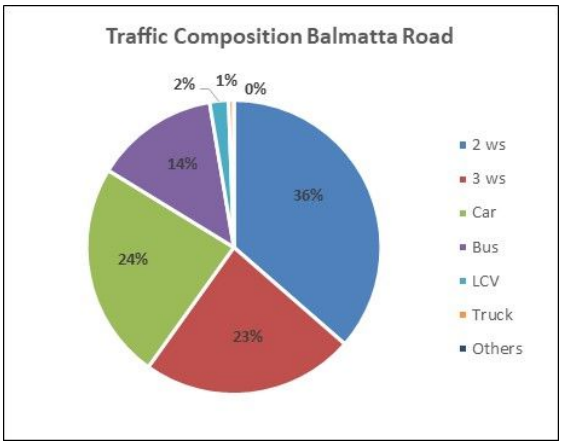
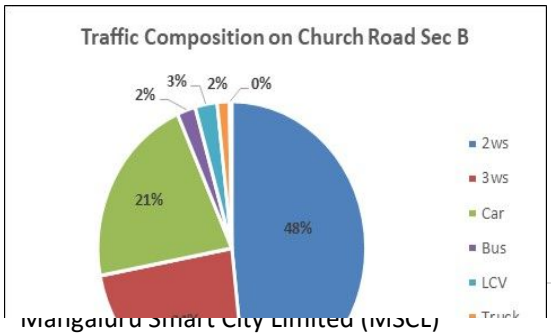
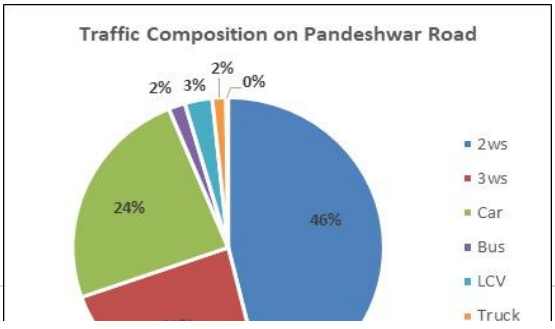




**Figure 4.**



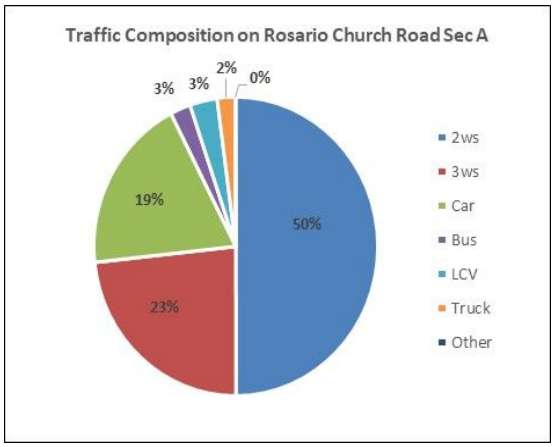



**Figure 4: Composition of Traffic**

Traffic composition in terms of Passenger vehicles and Commercial vehicles is also analyzed to understand the impact of commercial vehicles and is presented in Table 3.

**Table 3:Composition of Passenger and Commercial Vehicles**

| Mode | Balmatta one way | Light House Hill Road | Rosario Church Road Sec A | Rosario Church Road Sec B | Pandeshwar Road | Bunder Road |
|---|---|---|---|---|---|---|
| Passenger | 97% | 98% | 95% | 96% | 96% | 91% |
| Commercial | 3% | 2% | 5% | 4% | 4% | 9% |

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 **Table 4**.

**Table 4: Composition of Public and Private modes of transport**

| Mode | Balmatta one way | Light House Hill Road | Rosario Church Road Sec A | Rosario Church Road Sec B | Pandeshwar Road | Bunder Road |
|---|---|---|---|---|---|---|
| Private Vehicles | 86% | 91% | 98% | 98% | 98% | 100% |
| Public Vehicles | 14% | 9% | 2% | 2% | 2% | 0% |

The observations on the traffic and composition are:

- Passenger vehicles comprise about 97% of the total vehicles and commercial vehicles are meagre 3%. Goods shed road is the exception where commercial vehicles are higher at 9%.

- Private vehicles are occupying the major portion of the urban road space. About 86%-100% of the vehicles are private vehicles and balance 0-14% of the vehicles are public transport vehicles (mini bus + bus).
- On Light house hill road, Rosario Church road and Pandeshwar road the volume of public transport vehicles is minimal at about 2%. This may be due to very few bus routes plying on these roads. Goodsshed road carries no public vehicles.

### *4.1.5. 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 **Table 5**.

**Table 5: Peak Hour Volume and %**

| Description | Balmatta one way | Light House Hill Road | Rosario Church Road Sec A | Rosario Church Road Sec B | Pandeshwar Road | Bunder Road |
|---|---|---|---|---|---|---|
| Peak, Vol | 2,503 | 2,904 | 627 | 812 | 666 | 298 |
| Peak,% (Vol) | 10.12% | 8.21% | 9.39% | 14.11% | 14.26% | 8.97% |
| Peak, PCU | 3,763 | 3,539 | 743 | 944 | 772 | 308 |
| Peak,% (pcu) | 10.06% | 8.36% | 9.51% | 14.06% | 14.24% | 9.34% |

Two junctions are falling on these selected roads. Hence analysis of these junctions is also carried out and presented in **Error! Reference source not found.** and **Figure 5**.

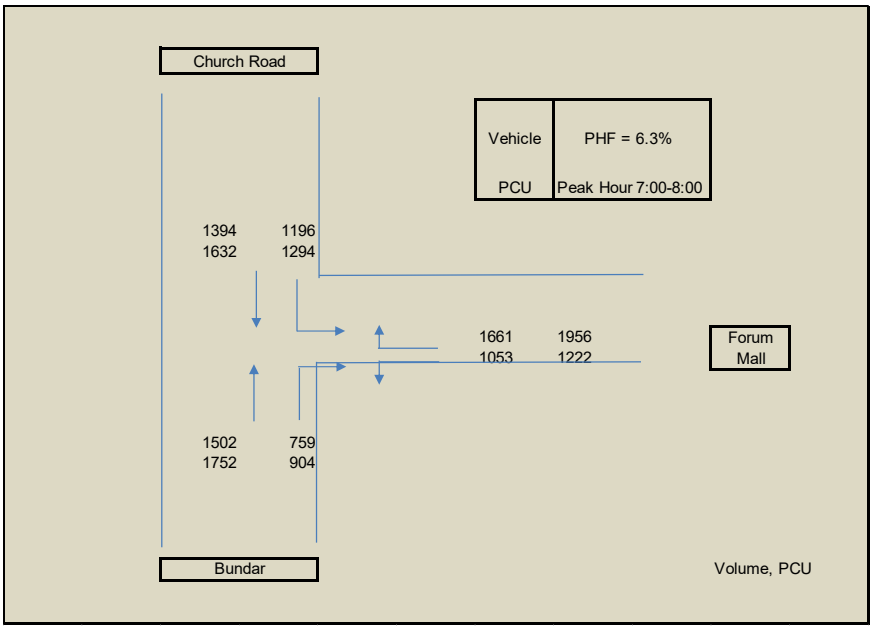



**Figure 5: Rosario Church Road Junction**

## 4.2. 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 **Table 6**.

**Table 6: Projected Peak hour volumes in PCU**

| Year | Balmatta one way | Light House Hill Road | Rosario Church Road Sec A | Rosario Church Road Sec B | Pandeshwar Road | Bunder Road |
|---|---|---|---|---|---|---|
| 2018 | 3,763 | 3,539 | 743 | 944 | 772 | 312 |
| 2020 | 3,446 | 3,742 | 786 | 999 | 818 | 331 |
| 2025 | 3,947 | 4,303 | 907 | 1,151 | 944 | 381 |
| 2030 | 4,523 | 4,950 | 1,046 | 1,328 | 1,090 | 439 |
| 2035 | 5,185 | 5,695 | 1,207 | 1,533 | 1,259 | 505 |
| 2038 | 5,630 | 6,195 | 1,315 | 1,671 | 1,372 | 550 |

Similarly, forecast was prepared for the Junctions and is presented in **Table 7**.

**Table 7: Traffic Volume Forecast at Junctions**

| Year | Type of Road | PCU per day | |
|---|---|---|---|
| | | Hampankatta Junction | Forum Mall Junction |
| 2018 | Major Road | 88,632 | 5,140 |
| | Minor Road | 29,923 | 2,876 |
| 2020 | Major Road | 93,886 | 5,939 |
| | Minor Road | 31,717 | 3,326 |
| 2025 | Major Road | 108,437 | 6,863 |
| | Minor Road | 36,690 | 3,846 |
| 2030 | Major Road | 125,264 | 7,933 |

| Year | Type of Road | PCU per day | |
|---|---|---|---|
| | | Hampankatta Junction | Forum Mall Junction |
| | Minor Road | 42,446 | 4,448 |
| 2035 | Major Road | 144,725 | 9,171 |
| | Minor Road | 49,111 | 5,145 |
| 2038 | Major Road | 157,836 | 10,005 |
| | Minor Road | 53,604 | 5,615 |

## 4.3. Capacity Analysis

### *4.3.1. 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 **Table 8**.

**Table 8: Recommended Design Service Volumes (PCU/Hr)**

| S. No. | Type of Carriageway | Total Design Service volumes for Different Categories 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 | - | - |

IRC SP:41-1994, provides a graph for selection of intersection type based on traffic volumes which is reproduced in **Figure 6** for ready reference.

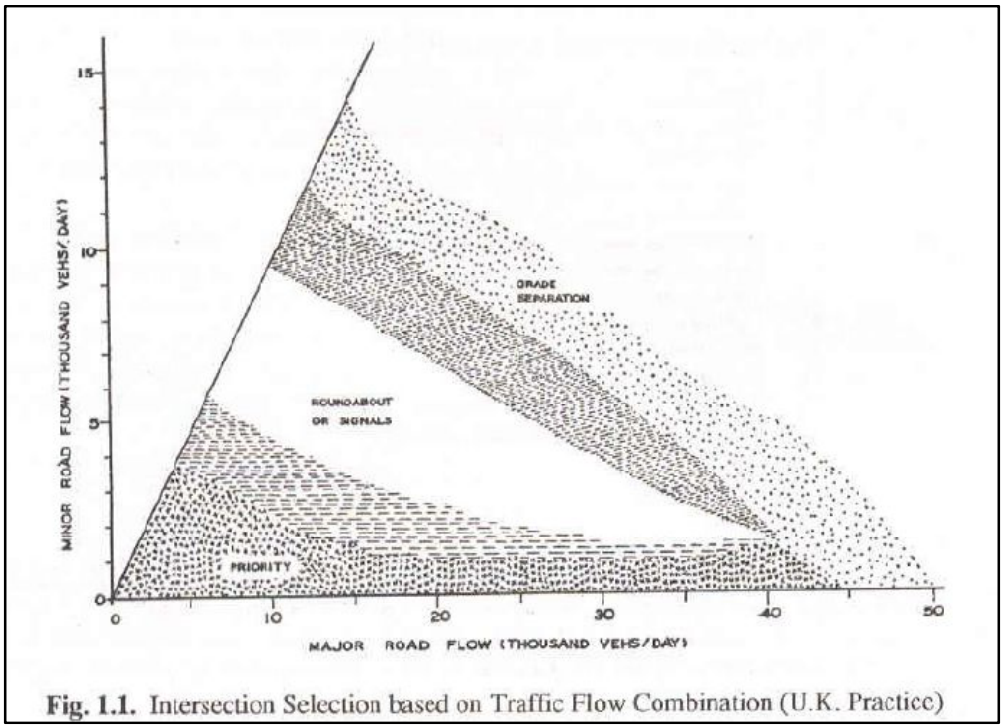



Fig. 1.1. Intersection Selection based on Traffic Flow Combination (U.K. Practice)

**Figure 6: Intersection selection based on criteria**

### *4.3.2. Analysis*

The capacity of roads based on the number of lanes and the values in Table 8 is given in **Table 9**.

**Table 9: Capacity of Roads**

| | Balmatta Road (1-Way) | Light House Hill Road | Rosario Church Road (A) | Rosario Church Road (B) | Pandeshwar Road |
|---|---|---|---|---|---|
| **Lanes** | 3 | 4 | 2 | 2 | 2 |
| **Capacity** | 3,600 | 3,600 | 1,500 | 1,500 | 1,500 |

The unconstrained capacity (lanes) requirement based on traffic analysis is given in

**Table 10**. 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 10: Unconstrained Capacity Requirement Based on Traffic (Lanes)**

| Year | Balmatta Road two way | Balmatta one way | Light House Hill Road | Rosario Church Road Sec A | Rosario Church Road Sec B | Pandeshwar Road | Bunder Road |
|---|---|---|---|---|---|---|---|
| 2018 | > 8 L | 4 L | 6 L | 2 L | 2 L | 2 L | 2 L |
| 2020 | > 8 L | 4 L | 6 L | 2 L | 2 L | 2 L | 2 L |
| 2025 | > 8 L | 5 L | 6 L | 2 L | 2 L | 2 L | 2 L |
| 2030 | > 8 L | > 4 L | 8 L | 2 L | 2 L | 2 L | 2 L |
| 2035 | > 8 L | > 4 L | 8 L | 2 L | 2 L | 2 L | 2 L |
| 2038 | > 8 L | > 4 L | 8 L | 2 L | 2 L | 2 L | 2 L |

From the above analysis it can be seen that Rosario Church Road, Pandeshwar Road AND Bunder road require 2 Lanes during the next 20 years period.

Balmatta Road (both 2-Way, as well as, 1-Way) and Light Hill house road have already reached their capacity.

## 4.4. Future strategy

- Balmatta Road (1-Way) and Light Hill house road have already reached their capacity and would require an expansion to accommodate the current and future traffic volume.
- However, there is no road space to expand the number of lanes.
- Moreover, the Design Service Volumes in **Table 8** 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.
- 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.
- Forum Mall junction does not require any new facilities. However, as part of the development, junction improvement can be proposed.

## 4.5. Summary

1. Mangalore Smart City Limited (MSCL) is implementing the Smart City Proposals with the help of the Project Management Consultants. Smart Roads is one of the important components of the Smart City Proposal.
2. This report deals with the DPR 3 for the Smart roads. Five roads considered under DPR 3 are: Bunder road, Rosario Church Road, Pandeshwar Road, Balmatta Road and Lighthouse Hill road.

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 estimated. Future projects are made applying appropriate growth rates.
4. Traffic is estimated on the each of the selected roads and the summary is provided in **Table 11**.

**Table 11: Traffic Forecast Summary (Peak Hour PCU)**

| Year | Balmatta Road two way | Balmatta one way | Light House Hill Road | Rosario Church Road Sec A | Rosario Church Road Sec B | Pandeshwar Road | Bunder Road |
|---|---|---|---|---|---|---|---|
| 2018 | 7,266 | 3,763 | 3,539 | 743 | 944 | 772 | 312 |
| 2020 | 7,676 | 3,446 | 3,742 | 786 | 999 | 818 | 331 |
| 2025 | 8,808 | 3,947 | 4,303 | 907 | 1,151 | 944 | 381 |
| 2030 | 10,112 | 4,523 | 4,950 | 1,046 | 1,328 | 1,090 | 439 |
| 2035 | 11,613 | 5,185 | 5,695 | 1,207 | 1,533 | 1,259 | 505 |
| 2038 | 12,620 | 5,630 | 6,195 | 1,315 | 1,671 | 1,372 | 550 |

5. Capacity Analysis has shown that Rosario Church Road, Pandeshwar Road and Bunder road would be able to handle the forecasted traffic volume with the existing lane configuration.
6. Balmatta Road ((both 2-Way, as well as, 1-Way) and Light Hill house road have already reached their capacity. However, 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 for the following reasons:
    - There is no road space to expand the number of lanes.
    - The Design Service Volumes in Table 9 refer to Level of Service (LOS) C, which is, generally, at 0.7 of the Capacity.
    - Traffic volume greater than capacity is often observed in Urban areas with lower Level of Service.
7. Hampankatta junction has reached capacity and thus requires grade separation. However, due to lack of space the development of a grade separated structure is not feasible. It is thus proposed to implement geometric improvements coupled with signalization.
8. Forum Mall junction does not require any new facilities. However, as part of the development, junction improvement can be proposed.

| 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 |
| | 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 carriage way |
| | Road 20 to Mangala Corniche | 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 | |
| | 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 |
| 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 AND JUNCTION IMPROVEMENT

## 5.1. Carriageway Improvement

### *5.1.1. Right of Way (ROW)*

Total six roads are being improved in this phase namely:

1. Balmatta road one way
2. Light house hill road
3. Rosario church road A & B
4. Pandeshwar Road
5. Bunder road

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; 4 m to 18 m for Balmatta road one way, Light house hill road, Rosario Church road A & B, Pandeshwar Road and Bunder road respectively. As per the classification as adopted by MoUD for Urban roads, these roads are considered under sub arterial road category. As the name suggests, this category of road follows all the functions of an Arterial Urban road and are characterized by mobility, and cater to through traffic with restricted access from carriageway to the side and hence it carries little less traffic volumes than that of arterial roads. Due to its overlapping nature, Sub arterial roads can act as arterials. This is context specific and is based on the function and the land use development it passes through and caters to a speed limit of 50 km/h.

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 14 of the Report provides details of Plan and Profile for DPR 3 roads***

| No. | Drawing no | Drawing Title | No of Sheets |
|---|---|---|---|
| 1 | WTE_2292_03_R_2.01 | PLAN AND PROFILE OF ROSARIO CHURCH ROAD (Road 1a) | 4 |
| 2 | WTE_2292_03_R_2.02 | PLAN AND PROFILE OF BUNDER ROAD (ROAD NO.16) | 4 |

### *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. Traffic Lanes*

Based on the traffic analysis and recommendation in section 4.2 and 4.3, it is proposed to develop these roads as follows:

1. Blamatta Road (one way) as being developed as “3 Lane one way carriageway”. Lane width has been considered as 3.1 m. Foot paths are being developed based on space availability.

2. Light hill house road is being developed as "3 Lane one way carriageway". Lane width has been considered as 3.1 m. Minimum 2.4 m wide footpaths are provided on both ends. Wider footpath is provided on left hand side.
3. Rosario Church road part A is being developed as "3lane one way carriageway". An additional parking lane is also provided and in this space trees are also there. Hence, where ever space is available that space can be utilized for parking.
4. Rosario Church road part B is being developed as 2 lane carriageway with minimum 2 m foot path on either side. Where space is available wider footpaths are provided.
5. Pandeshwar Road is being developed as 4 lane road divided two way carriageway.
6. Bunder Road is being developed as 2 lane carriageway with foot paths on either side.

**The following drawings enclosed in Section 14 of the Report provides Plans and details of Road Signage's and Markings along DPR 3 roads**

| No. | Drawing no | Drawing Title | No of Sheets |
|---|---|---|---|
| 1 | WTE_2292_03_R_3.01 | ROAD SIGNAGES - PLAN AND ROAD MARKING OF PANDESHWAR ROAD (ROAD NO. 3) | 1 |
| 2 | WTE_2292_03_R_3.02 | ROAD SIGNAGES - PLAN AND ROAD MARKING OF ROSARIO CHURCH ROAD (ROAD NO. 1a) | 2 |
| 3 | WTE_2292_03_R_3.03 | ROAD SIGNAGES - PLAN AND ROAD MARKING OF BUNDER ROAD (ROAD NO. 16) | 2 |
| 4 | WTE_2292_03_R_3.04 | ROAD SIGNAGES - PLAN AND ROAD MARKING OF LIGHT HOUSE HILL ROAD (ROAD NO.11) | 2 |
| 5 | WTE_2292_03_R_3.05 | ROAD SIGNAGES - PLAN AND ROAD MARKING OF KMC MERKARA TRUNK ROAD (ROAD NO.17) | 2 |
| 6 | WTE_2292_03_R_3.06 | ROAD SIGNAGES - PLAN AND ROAD MARKING OF MOHAMMED ALI ROAD | 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 IRC and MoUD 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

**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

**Signalized Intersection:**

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

**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 5-1: 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** | |

| Signalized Intersection | Roundabout |
|---|---|
| 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

**Design Traffic Volumes:**

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

**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.**

### *5.2.5. 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.

### *5.2.6. Recommendations for Intersection Design at Rosario Church Road Intersection*

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

***The proposed Junctions Improvement at Rosorio Church Road intersection has been shown in drawing as attached at Section 14 .***

## 5.3. Alternative Mobility Plan

Area around the clock tower is a part of central node and witness's heavy traffic throughout the day. It is expected that based on various initiatives mentioned in Chapter 6 "6.DECONGESTION STRATEGIES FOR CLOCK TOWER TO JUNCTION OF BALMATTA AND LIGHT HILL HOUSE ROAD" will ease own the busy roads in the central node. However, in event that the initiatives are not able to address the traffic congestion issues, following mobility alternative may be considered beyond 2022

1. Bus Stand in ABD area shifting outside ABD area. – Reduction of 2750Buses
2. Elevated Flyover near Hampankatta
3. Underpass movement from Balmatta to central market and from KSR Rao Road toClock tower.

Considering the space non-availability lower LoS is considered and also improvement of Public Transportation is proposed.

## 5.4. Pavement Design

### *5.4.1. Bunder 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): 470 Commercial Vehicles per Day (CVPD)
- CBR of Existing Soil: Two samples collected and tested and are 8.3% and 15.3%.
- 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):

| 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 = 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.

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 = 250 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

  $C = 365 \times 250 ((1+0.05)^{30} - 1) / 0.05$

  $C = 6062545$

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

  = 6062545 X 2.35

  = 14246981

- No. of axles in predominant direction

  = 14246981 X 0.5

  = 7123491

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

  = 7123491 X 0.25

  = 1780873

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

  = 1780873 X 0.6

= 1068524

- Day time (12 hour) design axles repetitions (100% - 60% = 40%)
  = 1780873 X 0.4

  = 712349

- Day time six hour axle load repetitions
  = 712349 X 0.5

  = 356175

- Hence, design number of axle load repetitions for bottom-up cracking analysis
  = **356175**

- Night time six hour axle load repetitions
  = 1068524 X 0.5

  = 534262

- % 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)
  = 534262 X 0.55= **293844**

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

| 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 | 160279 | 132230 |
| Rear single | 0.53 | 188772 | 155737 |
| Tandem | 0.02 | 7123 | 5877 |

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 – 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/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 = 205 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.

**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 | 37754 | 2.784 | 0.562 | 87857 | 0.430 | 220 - 240 | 6411 | 2.267 | 0.458 | 18320259 | 0.000 |
| 105-115 | 18877 | 2.633 | 0.532 | 214376 | 0.088 | 200 - 220 | 712 | 2.131 | 0.431 | infinite | 0.000 |
| 95-105 | 37754 | 2.483 | 0.502 | 707338 | 0.053 | | | | | | |
| < 85 | 94386 | 2.181 | 0.441 | infinite | 0.000 | | | | | | |
| | | | | | | | | | | | |
| | 188772 | Fat Dam from Sing. Axles = | | | 0.571 | | 7123 | Fat Dam from Tand Axles = | | | 0.000 |

| 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 | 31147 | 2.593 | 0.524 | 284225 | 0.110 | 220 - 240 | 5289 | 2.541 | 0.513 | 423020 | 0.013 |
| 105-115 | 15574 | 2.489 | 0.503 | 665309 | 0.023 | 200 - 220 | 588 | 2.437 | 0.492 | 1125609 | 0.001 |
| 95-105 | 31147 | 2.386 | 0.482 | 2107060 | 0.015 | | | | | | |
| < 85 | 77869 | 2.179 | 0.440 | infinite | 0.000 | | | | | | |
| | | | | | | | | | | | |
| | 155737 | Fat Dam from Sing. Axles = | | | 0.148 | | 5877 | Fat Dam from Tand Axles = | | | 0.013 |

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 0.571 + 0.000 = 0.571. Total fatigue damage for top-down cracking is 0.148 + 0.013 = 0.161 and total cumulative fatigue damage (CFD) = 0.732 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

$$=3.1 \text{ X } 1.5 \text{ X } 0.205 \text{ X } 24000 / 200$$

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

- Cross Sectional Area of Tie Bar A = $\pi/4 \text{ X } (12)^2$

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

- Perimeter of Tie Bar = $\pi d$ = 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:**

| 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 |

### *5.4.2. Light House Hill Road*

**Design of Slab Thickness**

**Input Data:**

Road Type: Three lanes One Way Single Carriageway

Design Life: 30 Years

Lane Width: 3.1m with 0.25m shyness width on either side of carriageway edge.

Transverse joint spacing: 4.5 m

Traffic (as per TVC): 2675 Commercial Vehicles per Day (CVPD)

CBR of Existing Soil: Two Samples have been collected from Balmatta Road and tested and are 8.5% and 13.5%

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 97%, Tandem Axle 2% and Tridem Axle 1%

Axle Load Spectrum (Assumed):

| Sr. No. | Rear Single Axle | | Rear Tandem Axle | | Rear Tridem Axle | |
|---|---|---|---|---|---|---|
| | Axle Load KN | Frequency (% of single Axles) | Axle Load KN | Frequency (% of tandem Axles) | Axle Load KN | Frequency (% of tandem Axles) |
| 1 | 115-125 | 30 | 220-240 | 80 | 410-440 | 100 |
| 2 | 105-115 | 25 | 200-220 | 20 | | |
| 3 | 95-105 | 20 | | | | |
| 4 | < 85 | 25 | | | | |
| Total | | 97% | | 2% | | 1% |

**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

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

  $C = 64869230$

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

  = 64869230 X 2.35

  = 152442691

- No. of axles in predominant direction

  = 152442691 X 0.5

  = 76221346

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

  = 76221346 X 0.25

  = 19055336

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

  = 19055336 X 0.6

  = 11433202

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

  = 19055336 X 0.4

  = 7622134

- Day time six hour axle load repetitions

  = 7622134 X 0.5

= 3811067

- Hence, design number of axle load repetitions for bottom-up cracking analysis
  = **3811067**

- Night time six hour axle load repetitions
  = 11433202 X 0.5

  = 5716601

- % 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)
  = 5716601 X 0.55

  = **3144131**

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

| 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 | 1714980 | 1414859 |
| Rear single | 0.52 | 1981755 | 1634948 |
| Tandem | 0.02 | 76221 | 62883 |
| Tridem | 0.01 | 38111 | 31441 |

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 = 230 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

= 0.60563

- '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.

**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 | 594526 | 2.415 | 0.488 | 1454156 | 0.409 | 220 - 240 | 60977 | 1.949 | 0.394 | infinite | 0.000 |
| 105-115 | 495439 | 2.295 | 0.464 | 9489332 | 0.052 | 200 - 220 | 15244 | 1.841 | 0.372 | infinite | 0.000 |
| 95-105 | 396351 | 2.176 | 0.440 | infinite | 0.000 | | | | | | |
| < 85 | 495439 | 1.936 | 0.391 | infinite | 0.000 | | | | | | |
| | | | | | | | | | | | |
| | 1981755 | Fat Dam from Sing. Axles = | | | 0.461 | | 76221 | Fat Dam from Tand Axles = | | | 0.000 |

| 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** | | | | | **Rear Tridem Axle** | **Rear Tridem 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) | Load Group (kN) | Expected Repetitions (ni) | Flex Stress MPa | Stress Ratio (SR) | Allowable Repetitions (Ni) | Fatigue Damage (ni/Ni) |
| 115-125 | 490484 | 2.343 | 0.473 | 3927605 | 0.125 | 220 - 240 | 50306 | 2.302 | 0.465 | 8254002 | 0.006 | 410-440 | 31441 | 2.521 | 0.509 | 498320 | 0.063 |
| 105-115 | 408737 | 2.261 | 0.457 | 21614377 | 0.019 | 200 - 220 | 12577 | 2.22 | 0.448 | infinite | 0.000 | | | | | | |
| 95-105 | 326990 | 2.179 | 0.440 | infinite | 0.000 | | | | | | | | | | | | |
| < 85 | 408737 | 2.014 | 0.407 | infinite | 0.000 | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | 1634948 | Fat Dam from Sing. Axles = | | | 0.144 | | 62883 | Fat Dam from Tand Axles = | | | 0.006 | | 31441 | Fat Dam from Tridem Axles = | | | 0.063 |

It can be seen from the calculations given in the tables above that for the slab thickness of 230mm the total fatigue damage for bottom-up cracking is 0.461 + 0.000 = 0.461. Total fatigue damage for top-down cracking is 0.144 + 0.006 + 0.063 = 0.213 and total cumulative fatigue damage (CFD) = 0.674 which is less than 1.0.

Hence, the trial thickness of 230mm is adequate. 30mm thickness is added considering two retexturing in 30 years and 20mm for rounding off and hence a thickness of 280mm 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 – 0.260 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

$$=3.1 \text{ X } 1.5 \text{ X } 0.26 \text{ X } 24000 / 200$$

$$= 145.08 \text{ mm}^2 / \text{m}$$

- Cross Sectional Area of Tie Bar A = $\pi/4$ X $(12)^2$
  = 113 $mm^2$
- Perimeter of Tie Bar = $\pi d$ = 37.7mm
- **Spacing of tie bars**, = $A/A_s$
  = 113 / 145.08 X 1000
  = 780 mm
  Say 750mm
- Provide spacing of 750mm 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:**

| Sr. No. | Description | Thickness in mm |
|---|---|---|
| 1 | Pavement Quality Concrete (PQC) | 280 |
| 2 | Dry Lean Concrete (DLC) | 100 |
| 3 | Granular Sub-Base (GSB) (as Drainage Layer) | 150 |
| 4 | Selected Subgrade (CBR ≥ 8%) | 500 |

### *5.4.3. Rosario Church Road*

**Design of Slab Thickness**

**Input Data:**

Road Type: Three lanes Two Way Single Carriageway

Design Life: 30 Years

Lane Width: 3.1m with 0.25m shyness width at carriageway edge.

Transverse joint spacing: 4.5 m

Traffic (as per TVC): 470 Commercial Vehicles per Day (CVPD)

CBR of Existing Soil: Two samples have been collected and tested and are 13.9% and 11.3%.

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):

| 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 | 30 | 220-240 | 10 |
| 2 | 105-115 | 20 | 200-220 | 90 |
| 3 | 95-105 | 25 | | |
| 4 | < 85 | 25 | | |
| Total | | 98% | | 2% |

**Design:**

I. 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.

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 = 470 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

  $C = 365 \times 470 ((1+0.05)^{30} - 1) / 0.05$

  $C = 11397584$

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

  = 11397584 X 2.35

  = 26784322

- No. of axles in predominant direction

  = 26784322 X 0.5

  = 13392161

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

  = 13392161 X 0.25

  = 3348040

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

  = 3348040 X 0.6

  = 2008824

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

  = 3348040 X 0.4

  = 1339216

- Day time six hour axle load repetitions

  = 1339216 X 0.5

  = 669608

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

  = **669608**

- Night time six hour axle load repetitions

  = 2008824 X 0.5

  = 1004412

- % 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)

  = 897560 X 0.55

  = **552427**

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

| 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 | 0.49 | 328108 | 270689 |
| Rear single | 0.49 | 328108 | 270689 |
| Tandem | 0.02 | 13392 | 11049 |

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 – 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) – $17.0^0C$
- Night-time Temperature Differential in slab (for top-down cracking) – day-time diff / 2 + 5 = $13.50^0C$
- Trial thickness of slab, h = 215 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

  = 0.57576

- '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.

**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 | 98432 | 2.621 | 0.529 | 233168 | 0.422 | 220 - 240 | 1339 | 2.127 | 0.430 | infinite | 0.000 |
| 105-115 | 65622 | 2.484 | 0.502 | 699340 | 0.094 | 200 - 220 | 12053 | 2.003 | 0.405 | infinite | 0.000 |
| 95-105 | 82027 | 2.347 | 0.474 | 3702207 | 0.022 | | | | | | |
| < 85 | 82027 | 2.073 | 0.419 | infinite | 0.000 | | | | | | |
| | | | | | | | | | | | |
| | 328108 | Fat Dam from Sing. Axles = | | | 0.538 | | 13392 | Fat Dam from Tand Axles = | | | 0.000 |

| 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 | 81207 | 2.482 | 0.501 | 710680 | 0.114 | 220 - 240 | 1105 | 2.435 | 0.492 | 1154071 | 0.001 |
| 105-115 | 54138 | 2.388 | 0.482 | 2039684 | 0.027 | 200 - 220 | 9944 | 2.341 | 0.473 | 4067101 | 0.002 |
| 95-105 | 67672 | 2.294 | 0.463 | 9766270 | 0.007 | | | | | | |
| < 85 | 67672 | 2.106 | 0.425 | infinite | 0.000 | | | | | | |
| | | | | | | | | | | | |
| | 270689 | Fat Dam from Sing. Axles = | | | 0.148 | | 11049 | Fat Dam from Tand Axles = | | | 0.003 |

It can be seen from the calculations given in the tables above that for the slab thickness of 210mm the total fatigue damage for bottom-up cracking is 0.538 + 0.000 = 0.538. Total fatigue damage for top-down cracking is 0.148 + 0.003 = 0.151 and total cumulative fatigue damage (CFD) = 0.689 which is less than 1.0.

Hence, the trial thickness of 215mm is adequate. 30mm thickness is added considering two retexturing in 30 years and 5mm for rounding of 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 – 0.230 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

$$=3.1 \text{ X } 1.5 \text{ X } 0.23 \text{ X } 24000 / 200$$

$$= 128.34 \text{ mm}^2 / \text{m}$$

- Cross Sectional Area of Tie Bar A = $\pi/4 \text{ X } (12)^2$

$= 113\ mm^2$

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

  = 113 / 128.34 X 1000

  = 881 mm

  Say 900mm
- Provide spacing of 900mm 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:**

| 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 |

### *5.4.4. Rosario Church Road 2*

**Design of Slab Thickness**

**Input Data:**

Road Type: Two lanes Two Way Single Carriageway

Design Life: 30 Years

Lane Width: 3.1m.

Transverse joint spacing: 4.5 m

Traffic (as per TVC): 275 Commercial Vehicles per Day (CVPD)

CBR of Existing Soil: Two samples have been collected and tested and are 13.9% and 11.3%.

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 97%, Tandem Axle 2% and Tridem Axle 1%

Axle Load Spectrum (Assumed):

| Sr. No. | Rear Single Axle | | Rear Tandem Axle | | Rear Tridem Axle | |
|---|---|---|---|---|---|---|
| | Axle Load KN | Frequency (% of single Axles) | Axle Load KN | Frequency (% of tandem Axles) | Axle Load KN | Frequency (% of tandem Axles) |
| 1 | 115-125 | 35 | 220-240 | 10 | 380-410 | 100 |
| 2 | 105-115 | 30 | 200-220 | 90 | | |
| 3 | 95-105 | 10 | | | | |
| 4 | < 85 | 25 | | | | |
| Total | | 97% | | 2% | | 1% |

**Design:**

M. 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.

N. 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

O. 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 = 275 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

  $C = 365 \times 275 ((1+0.05)^{30} - 1) / 0.05$

  $C = 6668799$

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

  $= 6668799 \times 2.35$

  $= 15671678$

- No. of axles in predominant direction

  $= 15671678 \times 0.5$

  $= 7835839$

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

  $= 7835839 \times 0.25$

  $= 1958960$

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

  $= 1958960 \times 0.6$

= 1175376

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

  = 1958960 X 0.4

  = 783584

- Day time six hour axle load repetitions

  = 783584 X 0.5

  = 391792

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

  = **391792**

- Night time six hour axle load repetitions

  = 1175376 X 0.5

  = 587688

- % 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)

  = 587688 X 0.55

  = **323228**

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

| 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 | 176306 | 145453 |
| Rear single | 0.52 | 203732 | 168079 |
| Tandem | 0.02 | 7836 | 6465 |
| Tridem | 0.01 | 3918 | 3232 |

P. 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 = 210 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

  = 0.56569

- '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.

**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 | 71306 | 2.700 | 0.545 | 141987 | 0.502 | 220 - 240 | 7052 | 2.194 | 0.443 | infinite | 0.000 |
| 105-115 | 61120 | 2.556 | 0.516 | 374963 | 0.163 | 200 - 220 | 784 | 2.065 | 0.417 | infinite | 0.000 |
| 95-105 | 10187 | 2.412 | 0.487 | 1502178 | 0.007 | | | | | | |
| < 85 | 61120 | 2.125 | 0.429 | infinite | 0.000 | | | | | | |
| | | | | | | | | | | | |
| | 203732 | Fat Dam from Sing. Axles = | | | 0.672 | | 7836 | Fat Dam from Tand Axles = | | | 0.000 |

| 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** | | | | | **Rear Tridem Axle** | **Rear Tridem 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) | Load Group (kN) | Expected Repetitions (ni) | Flex Stress MPa | Stress Ratio (SR) | Allowable Repetitions (Ni) | Fatigue Damage (ni/Ni) |
| 115-125 | 81207 | 2.482 | 0.501 | 710680 | 0.114 | 220 - 240 | 1105 | 2.435 | 0.492 | 1154071 | 0.001 | 380-410 | 3232 | 2.651 | 0.535 | 191723 | 0.017 |
| 105-115 | 54138 | 2.388 | 0.482 | 2039684 | 0.027 | 200 - 220 | 9944 | 2.341 | 0.473 | 4067101 | 0.002 | | | | | | |
| 95-105 | 67672 | 2.294 | 0.463 | 9766270 | 0.007 | | | | | | | | | | | | |
| < 85 | 67672 | 2.106 | 0.425 | infinite | 0.000 | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | 168079 | Fat Dam from Sing. Axles = | | | 0.179 | | 6465 | Fat Dam from Tand Axles = | | | 0.009 | | 3232 | Fat Dam from Tridem Axles = | | | 0.009 |

It can be seen from the calculations given in the tables above that for the slab thickness of 210mm the total fatigue damage for bottom-up cracking is 0.672 + 0.000 = 0.672. Total fatigue damage for top-down cracking is 0.179 + 0.009 + 0.017 = 0.205 and total cumulative fatigue damage (CFD) = 0.877 which is less than 1.0.

Hence, the trial thickness of 210mm is adequate. 30mm thickness is added considering two retexturing in 30 years and 10mm for rounding of 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 – 0.230 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

$$=3.1 \text{ X } 1.5 \text{ X } 0.23 \text{ X } 24000 / 200$$

$$= 128.34 \text{ mm}^2 / \text{m}$$

- Cross Sectional Area of Tie Bar A = $\pi/4 \text{ X } (12)^2$

$= 113\ mm^2$

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

  = 113 / 128.34 X 1000

  = 881 mm

  Say 900mm
- Provide spacing of 900mm 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:**

| 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. Planned Utilities

Dedicated and planned utilities are one of the key features of smart roads. Various utilities planned under priority loop 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 priority loop Road

The detailed inventory 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 of existing services to be shifted and considered future provisioning for additional lines. Following details are as per assessment.

**Existing Transformer Details of Bunder Road, Rosaria Church, Pandeshwar Road**

| Sr. No. | Transformer Number | Rating in KVA | Location of Transformer | Road | MESCOM Identification | Co-ordinates | 11kV Feeder Feeding Trafo | Proposed RMU Location by MESCOM |
|---|---|---|---|---|---|---|---|---|
| 1 | TR 1 | 250 | At CIty Cyber Crime Police Station | Road 16 Bunder Road | Bunder Police Station | 12.86376818/ 74.83379848 | Ansari Feeder | Next to Police Station toward JummaMashid |
| 2 | TR 2 | 63 | Regency Lodge | Road 16 Bunder Road | Regency Square | 12.86365639/ 74.83382564 | Ansari Feeder | |
| 3 | TR 3 | 100 | Opp. Al Azhara office | Road 16 Bunder Road | Partian Points | 12.86281636/ 74.83369086 | Ansari Feeder | |
| 4 | TR 4 | 250 | Opp. Al Azhara office | Road 16 Bunder Road | Medifare Complex | 12.86271895/ 74.83374886 | Ansari Feeder | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 5 | TR 5 | 100 | Ideal Supari Traders | Road 16 Bunder Road | Hotel Narayana | 12.86252904/ 74.8337502 | Ansari Feeder | |
| 6 | TR 6 | 100 | Sultan Auto Accessaries | Road 16 Bunder Road | Darbar Complex | 12.86252904/ 74.8337502 | South walf feeder | |
| 7 | TR 7 | 63 | Indian overseas bank | Road 16 Bunder Road | Badriya | 12.86172234/ 74.8336057 | South walf feeder | On Right side lane of the Bank |
| 8 | TR 8 | 63 | Shree Mahalaxmi Transport | Road 16 Bunder Road | Badriya 3 | 12.86059564/ 74.8337777 | South walf feeder | |
| 9 | TR 9 | 100 | Thasneem Ice Plant | Road 16 Bunder Road | | 12.86004291/ 74.83386252 | South walf feeder | |
| 10 | TR 10 | 250 | Sathya Ice factory | Road 16 Bunder Road | | 12.85976736/ 74.83380049 | South walf feeder | |
| 11 | TR 11 | 250 | Nirakshalaya School | Road 16 Bunder Road | Baby Oil Mill | 12.85911265/ 74.83397886 | South walf feeder | |
| 12 | TR 12 | 250 | Opp. MahaganapatiEngg. works | Road 16 Bunder Road | Bawa Fisheries | 12.85875015/ 74.83404625 | South walf feeder | RMU near Transformer |
| 13 | TR 13 | 100 | PragatiAutharized distributor | Road 16 Bunder Road | Bawa Chambers | 12.85830038/ 74.83416159 | South walf feeder | |
| 14 | TR 14 | 100 | Opp.RohanEnterprizes (In lane for Ratna ice factory) | Road 16 Bunder Road | Ratna Ice Plant | 12.85792775/ 74.8341978 | South walf feeder | |
| 15 | TR 15 | 100 | Opposite RK Diesel and | Road 16 Bunder | Friends Bar | 12.85720079/ 74.834595 | South walf | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | engineering | Road | | 77 | feeder | |
| 16 | TR 16 | 100 | Next to Aspenzip Technology | Road 16 Bunder Road | Sairam | 12.85649998/ 74.83480297 | South walf feeder | |
| 17 | TR 17 | 100 | Opposite Nash Mktg Supplies | Road 16 Bunder Road | Good Shed Road | 12.85381767/ 74.83693767 | Pandeshwar Feeder | |
| 18 | TR 18 | 100 | In campus of colony becide Nash Mktg Supplies | Road 16 Bunder Road | Sanmeer Hostel | 12.85398927/ 74.83687162 | Pandeshwar Feeder | |
| 19 | TR 19 | 63 | At Railway crossing in campus | Road 1a Rosario Church Road | Cannada Goods | 12.85363069/ 74.83770512 | Pandeshwar Feeder | RMU on opposite cormer on this trafo on Police station Road |
| 20 | TR 20 | 100 | Opposite Canada Goods Transport | Road 1a Rosario Church Road | Sea Vista | 12.85396411/ 74.83756397 | Pandeshwar Feeder | |
| 21 | TR 21 | 63 | Yashaswini Beauty Care | Road 1a Rosario Church Road | Kalandar | 12.85418769/ 74.8375167 | Pandeshwar Feeder | |
| 22 | TR 22 | 100 | Yashaswini Beauty Care | Road 1a Rosario Church Road | Rajyalaxmi Temple | 12.85429196/ 74.83747277 | Pandeshwar Feeder | |
| 23 | TR 23 | 100 | In cozy corner Building campus | Road 1a Rosario Church Road | Cozy corner | 12.85469107/ 74.83736213 | Pandeshwar Feeder | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 24 | TR 24 | 100 | Opposite Cozy corner Building | Road 1a Rosario Church Road | Rajyalaxmi 2 | 12.85482771/ 74.8372069 | Pandeshwar Feeder | |
| 25 | TR 25 | 100 | In Canara Bank Campus | Road 1a Rosario Church Road | Arsulus convent | 12.85527944/ 74.83699568 | Pandeshwar Feeder | |
| 26 | TR 26 | 100 | In Copper villa campus | Road 3 Pandeshwar Road | Copper villa | 12.85653463/ 74.8368961 | Pandeshwar Feeder | |
| 27 | TR 27 | 100 | Opposite Vishwas Sahara Height | Road 3 Pandeshwar Road | Rosario church | 12.85715307/ 74.83712677 | Pandeshwar Feeder | |
| 28 | TR 28 | | In campus of Vishwassahara Heights | Road 3 Pandeshwar Road | Vishwas Sahara Heights | 12.85693962/ 74.83701579 | Pandeshwar Feeder | |
| 29 | TR 29 | 100 | Opposite Forum Fiza Mall | Road 3 Pandeshwar Road | Head post office | 12.85767475/ 74.83758643 | Pandeshwar Feeder | |
| 30 | TR 30 | 100 | Opposite corporation office | Road 3 Pandeshwar Road | SP office | 12.85898876/ 74.83832035 | Pandeshwar Feeder | RMU on the road next to corporation bank towards AB circle |
| 31 | TR 31 | 63 | In Carmel Convent Campus | Road 1a Rosario Church Road | Asha Niketan | 12.85787316/ 74.8369142 | South walf feeder | |
| 32 | TR 32 | 63 | Opposite Telephone Exchange | Road 1a Rosario Church Road | St Anns School | 12.85828436/ 74.83700607 | South walf feeder | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 33 | TR 33 | 100 | In campus of Carmel School | Road 1a Rosario Church Road | St Anns PU college | 12.858784 8/ 74.836351 28 | South walf feeder | RMU outside Campus |
| 34 | TR 34 | 100 | In campusof ST Anns PU college | Road 1a Rosario Church Road | St Anns Bed Hostel | 12.859534 96/ 74.836528 64 | South walf feeder | |
| 35 | TR 35 | 100 | In Campus of Govt Ladies hostel | Road 1a Rosario Church Road | Port Quarter | 12.860083 44/ 74.836761 99 | South walf feeder | |
| 36 | TR 36 | 250 | DCP office | Road 1a Rosario Church Road | Hamilton circle | 12.861007 16/ 74.837108 66 | South walf feeder | RMU on the road towards Indian overseas bank Road |

| **Existing Transformer Details of Balmattu Road, Light House Hill Road, KMC Mercara Road** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Sr. No.** | **Transformer Number** | **Rating in KVA** | **Location of Transformer** | **Road** | **MESCOM Identification** | **Co-ordinates** | **11kV Feeder Feeding Trafo** | **Proposed RMU Location by MESCOM** |
| 1 | TR 1 | 100 | Outside Souzas shop | Road 11 Light House Hill Road | Plaza tower | 12.86910/74.843 34 | Mutappa Feeder | |
| 2 | TR 2 | 250 | In campus of Manipal college of Dental science | Road 11 Light House Hill Road | Syndicate bank | 12.8696/74.8438 | Mutappa Feeder | |
| 3 | TR 3 | 100 | Opposite Abhimaan Hills | Road 11 Light | Lobocot 1 | 12.87093/74.843 76 | Light House Feeder | RMU near Transfor |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | House Hill Road | | | | mer |
| 4 | TR 4 | 100 | With TR 3 | Road 11 Light House Hill Road | Lobocot 2 | 12.87093/74.84376 | Light House Feeder | |
| 5 | TR 5 | 63 | Opposite Jumma Masjid | Road 11 Light House Hill Road | Dr. DevdasHegde | 12.87157/74.84517 | Light House Feeder | |
| 6 | TR 6 | 100 | Beside Bites Kati Zone shop | Road 11 Light House Hill Road | KS Rao memorial trust | 12.87159/74.84586 | Light House Feeder | |
| 7 | TR 7 | | In campus of Light House Bldg | Road 11 Light House Hill Road | | 12.87148/74.84598 | Light House Feeder | |
| 8 | TR 8 | 250 | Outside KMC hospital | Road 17 KMC Mercara Trunk Road | Tej Tower | 12.872396/74.848362 | Light House Feeder | RMU near Transformer |
| 9 | TR 9 | 250 | Opposite KTM Showroom | Road 17 KMC Mercara Trunk Road | Kudva | 12.8699/74.8458 | Light House Feeder | |
| 10 | TR 10 | 250 | Near Bank of Baroda | Road 17 KMC Mercara | Mangala | 12.8698/74.8453 | Light House Feeder | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Trunk Road | | | | |
| 11 | TR 11 | 250 | Outside Manipal college of Dental science | Road 17 KMC Mercara Trunk Road | Usha | 12.8694/74.8444 | Light House Feeder | |
| 12 | TR 12 | 100 | Outside Rajendra Palace | Road 17 KMC Mercara Trunk Road | Rajendra Palace | 12.8684/74.8428 | Light House Feeder | |
| **Note:** | | | | | | | | |
| Highlighted Transformers are within Campus of particular Building. Need to Lay pipes till Transformer location | | | | | | | | |
| Highlighted RMU are on feeder feeding Transformers on the selected Road but installed outside ROW of the road | | | | | | | | |

Base on existing survey and discussion with MESCOM, space requirement for Electrical cables were finalized as per below mentioned table and the same is accommodated in Electrical corridor.

| Sr. No. | Road Stretch | | Mtr. (Apprx.) | Left side Pipe (Nos.) | | | Right Side pipe (Nos.) | | |
|---|---|---|---|---|---|---|---|---|---|
| | From | To | | 415V | 11kV | 33kV | 415V | 11kV | 33kV |
| 1 | Hamilton circle | Pandeshwar Junction | 450 | 4 | 0 | 2 | 4 | 5 | 0 |
| 2 | Pandeshwar Junction | Corporation bank junction (on pandeshwar road) | 300 | 5 | 4 | 1 (Till Fizza Mall) | 5 | 4 | 0 |
| 3 | Pandeshwar Junction | Railway Crossing | 400 | 4 | 0 | 0 | 4 | 4 | 0 |
| 4 | Railway Crossing | Asenzip Tech Transformer (TR16) | 200 | 0 | 0 | 0 | 4 | 4 | 0 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 5 | Asenzip Tech Transformer (TR16) | Bunder police chowki | 900 | 4 | 4 | 0 | 4 | 0 | 0 |
| 6 | Ballmattu Road | Starting of hill road | 550 | 5 | 4 | 0 | 5 | 4 | 0 |
| 7 | Via Hill Road | Upto Jyoti circle | 750 | 5 | 4 | 0 | 5 | 4 | 0 |
| 8 | From Jyoti circle | via KMC Mercara Road | 750 | 5 | 4 | 0 | 5 | 4 | 0 |

## 6.1. Street Light

Lighting poles are considering base on following requirement

(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

### *6.1.1. 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. 7 mtr and 4 mtr poles are provided based on ROW to illuminate the carriage way & footpaths.

**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**

## 6.2. 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 Mangaluru Municipal Corporation 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 for the roads from Hampankatta to clock tower, KMC Mercara Road, and Light House Hill road existing sewerage network is retained. The sewer lines for Rosario Church Road and Pandeshwar Road are proposed under other convergence schemes. The Sewer line along Goodshed Road is proposed to be retained under the same scheme. A 600mm diameter sewer pumping main from Wetwell at Pandeshwar to Wetwell at Kandathpalli is proposed along Goodshed Road. 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.

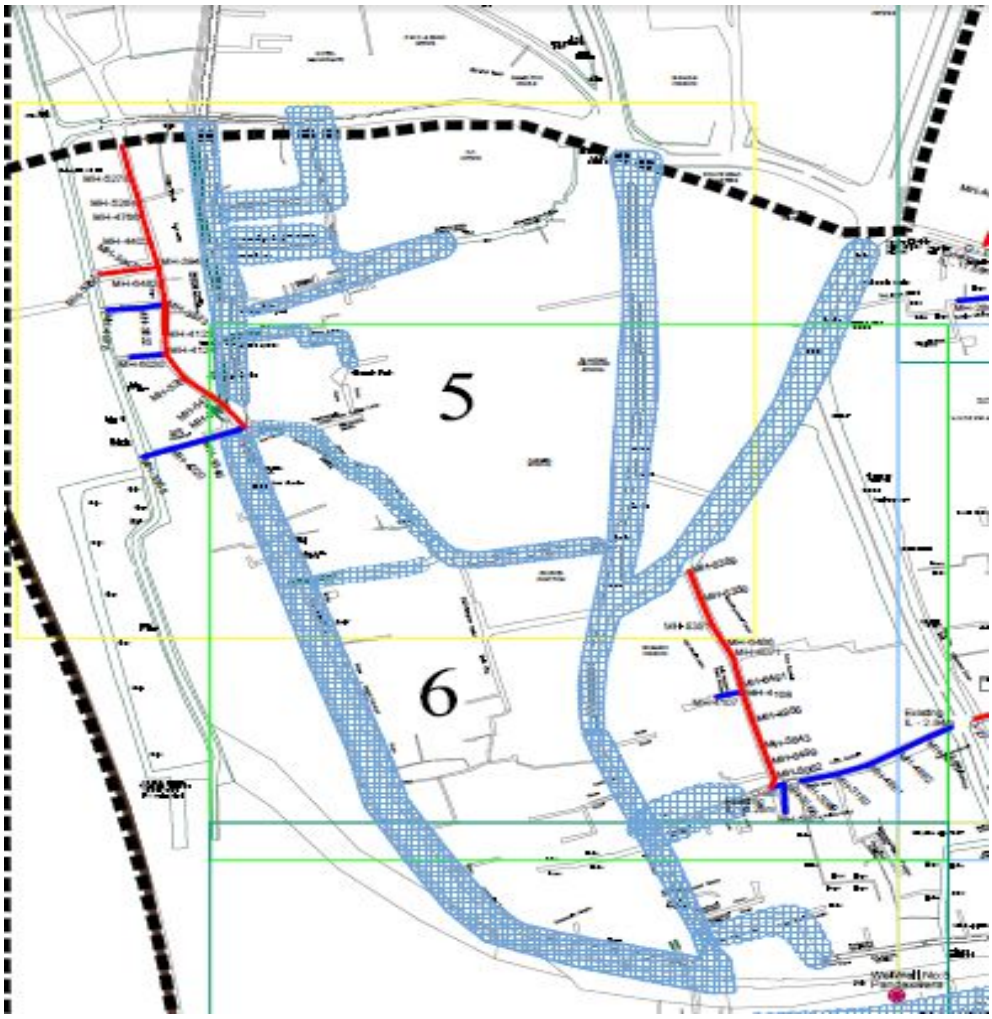



Figure 7Mark-up showing the UGD lines under other convergence schemes

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 have been proposed to collect storm water by gravity.

The details of storm water drainage network along these roads are provided in the proposed cross-sections of the road prepared in co-ordination with all the other utilities.

Figure 8Existing cross drain and Drain in damaged condition along Rosario Road

Figure 9Existing drain in good condition along Rosario Road

Figure 10Drains in Good shed Road

Figure 11Open and unlined Drains leading to backwaters along Good shed Road

# 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:

1. Indian Road Congress code
2. 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 3.

### *7.1.2. Urban Design Features*

Salient Features of Smart Roads for Priority Loop Road:

1. Road Cross Section:
   a. **Carriage way:** As per IRC codes, the lane widths proposed in the priority loop roads is 3.1m.
   b. **Parking Lane:** The parking lane of 2.5m is proposed for priority loop roads. Wherever space constraints were observed, parking lane was planned by adopting the Parking Norms as per the Managalore 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.
   c. **Median:** Tall shrubs are proposed at the median on Maidan Road – 2 to discourage on surface crossing for pedestrian safety.

2. 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 priority loop road.
   b. **Barrier free design:** Tactile paving is proposed at the centre of the footpath on all the priority loop 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.

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

e. **Table top crossing:** Table top crossing is proposed at junctions so as to have a smooth pedestrian movement and subsequently resulting into reduction of speed of the vehicles at the junction.

f. **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.

## Table 7-1: Proposed Pedestrian Facilities

| | | *Urban Street Elements* | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sl no** | **Road details** | **MUBs (trench)** | **Bus shelter with E-toilet** | **LED lights** | **Street furniture like signages, dustbins, benches, advertisement boards** | **Smart poles** | **Audio-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** |
| | | *SMART FEATURES* | | | | | | *PEDESTRIAN FACILITIES* | | | | | |
| 1 | Mangla Devi Road | √ | × | √ | √ | × | √ | × | √ | √ | × | × | × |
| 2 | Rosario Church Road (Hamilton circle to Rosario High School) | √ | × | √ | √ | × | √ | × | √ | √ | × | × | × |
| 3 | Rosario Church Road (Rosario High School to Railway Line) | √ | × | √ | √ | × | √ | × | √ | √ | × | × | × |
| 4 | Pandeshwar Road | √ | × | √ | √ | × | √ | × | √ | √ | × | × | × |
| 5 | Balmatta Road (Clock Tower to Hampankatta) | √ | × | √ | √ | √ | √ | √ | √ | √ | × | × | × |
| 6 | Bunder road (from Mission street junction to Bunder Road Junction)-A | × | × | √ | × | × | × | × | √ | × | × | × | × |
| 7 | Bunder road (from Bunder Road Junction to Jama Masjid road junction)-B | × | × | √ | × | × | × | × | √ | × | × | × | × |
| 8 | Bunder road (from Jama Masjid junction to hoige bazar)-C | × | × | √ | × | × | × | × | √ | × | × | × | × |

***The details of various Urban Design Proposals along the proposed roads are enclosed at Section 14***

### *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 encircles 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 details of various Landscape Proposals along Proposed Roads is provided at Section 14***

### *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.

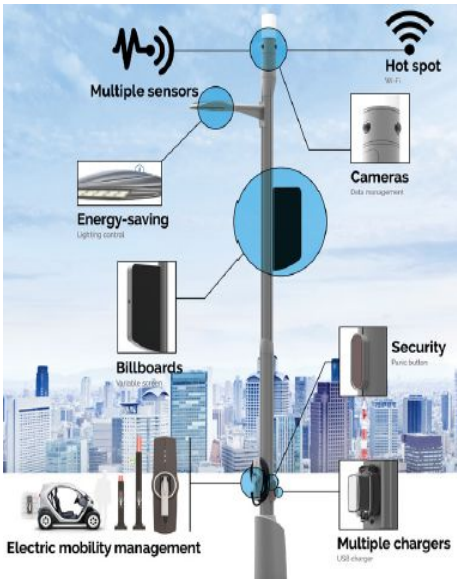
The 9 m lighting poles are provided only in the median. To illuminate the footpaths, 4 m high lighting poles with 40 w LED lighting fixtures has been considered at an interval of 10 m

**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 priority loop 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 3 shows details of water supply proposals along priority loop 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 priority loop 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 14 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 detailed drawings are provided at Section 14 .

The design for storm water has been carried outand calculations of the same are attached as Annexure 4 to the report

Based on above holistic and planned approach, an integrated utility corridor is proposed for the priority loop Road. The following drawings in Section 14 shows details of the proposed utilities along the proposed smart roads are provided at Section 14

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 14 gives detailed cross section atevery 15 m interval

## 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 Nehru Maidan Road will have the following features

- **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

- **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.

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

- **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

- **Synchronized Signaling**
  Green Corridor Creation for Disaster Mitigation / Emergency Response Team / Medical Emergency

### *7.2.2. Road Surveillance*

- **Traffic Rule Violation Detection**
  - Red Light Violation
  - Speed Violation
  - eChallan (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 eChallan to be sent to the contact details of the person against whose name the vehicle is registered.

- **Automatic Number Plate Recognition**

- **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.

- **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 Up gradation Works

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

| Road | Type of Pavement | Quality of Pavement | Road Upgradation |
|---|---|---|---|
| **KMC Marcara Road** | Rigid | Good | Utility development only |
| **Light House Hill Road** | Rigid | Good | Utility development only |
| **Rosario Church Road Sec A** | Rigid | Good | Utility development only |
| **Rosario Church Road Sec B** | Flexible | Poor | Repairing of poor Concrete sections |
| **Pandeshwar Road Two Way** | Rigid | Poor | Repair of poor Concrete sections |
| **Pandeshwar One Way** | Flexible | Poor | Conversion to Rigid Pavement, Utility development |
| **Bunder Road** | Flexible | Poor | Conversion to Rigid Pavement, Utility development |

### *8.1.1. Rosario Church Road*

At present, 6679 vehicles ply on Rosario Church Road towards Hamilton at Section A and 5753 vehicles play at Section B. Southward traffic can be diverted towards AB Shetty Circle from Hamilton. Traffic management plan for traffic towards Hamilton circle is required to be formulated during construction of Rosario Church Road.

Following table gives the composition of traffic of Rosario Church Road Section A.

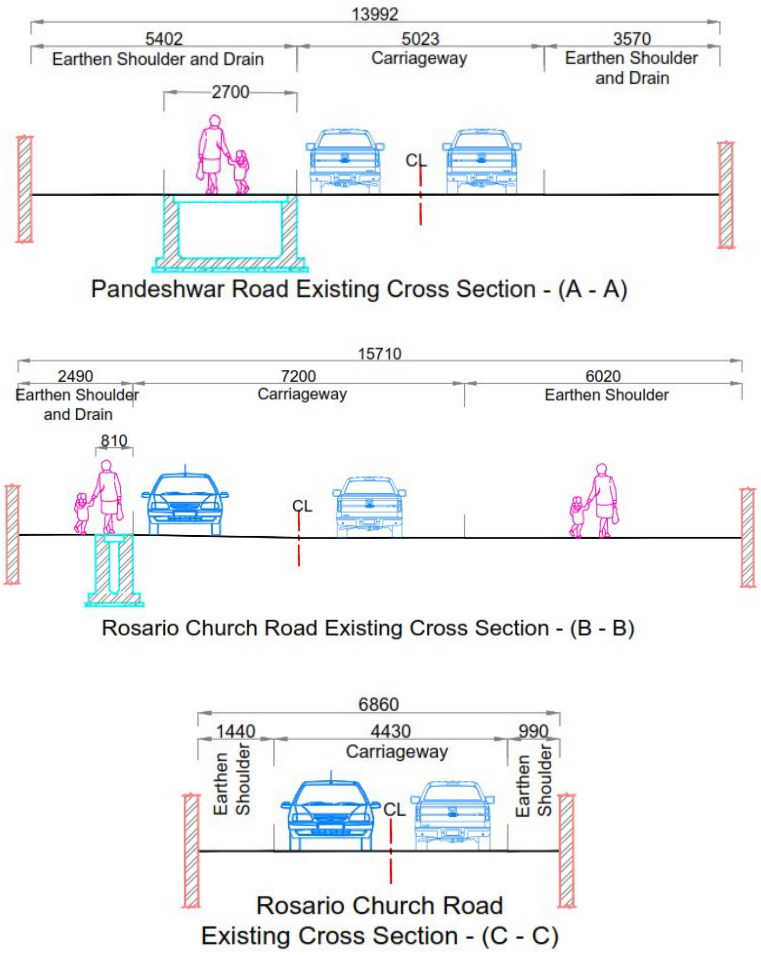
| 2 Wheeler | 3 Wheeler | Car | LCV | Bus/Truck | Other | Total |
|---|---|---|---|---|---|---|
| 3338 | 1558 | 1279 | 208 | 259 | 5 | 6679 |

Following table gives the composition of traffic of Rosario Church Road Section B.

| 2 Wheeler | 3 Wheeler | Car | LCV | Bus/Truck | Other | Total |
|---|---|---|---|---|---|---|
| 2779 | 1363 | 1229 | 153 | 213 | 16 | 5753 |

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

Figure 8-1 Existing Cross Section of Rosario Church Road




It is evident from above figure during construction lane closure is appropriate option for safe mobility of traffic on Rosario Church Road. At peak hour, 627 (743 PCU) vehicles ply towards this direction and most of them are car and two-wheeler. As a single lane have the capacity of carrying 1200 PCU in an hour, ***so lane closure during construction period can withstand the load of traffic.***

Adequate safety arrangement provision will be required at construction zone for easier, safer movement of traffic. Section 7.4 describes the safety measures to be adopted during construction

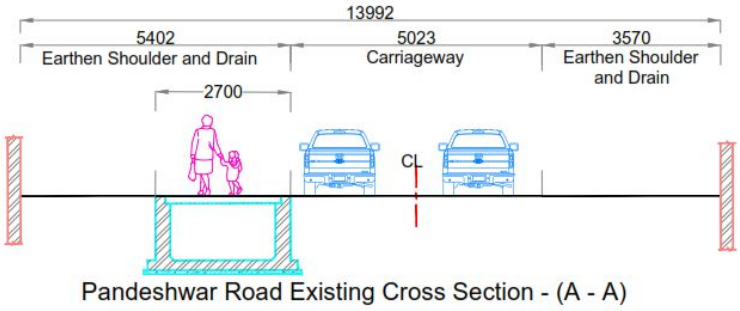
### *8.1.2. Pandeshwar Road*

At present, 4669 vehicles ply on Pandeshwar Road towards Rosario Church. Northward traffic is proposed to be shifted to Pandeshwar Road. Traffic can be diverted towards Hamilton Circle from AB Shetty Circle. Traffic management plan for traffic towards Hamilton circle is required to be formulated during construction of Rosario Church Road.

| 2 Wheeler | 3 Wheeler | Car | LCV | Bus/Truck | Other | Total |
|---|---|---|---|---|---|---|
| 2157 | 1094 | 1127 | 133 | 119 | 16 | 4669 |

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

**Figure 8-2 Existing Cross Section of Rosario Church Road**




It is evident from above figure during construction lane closure is appropriate option for safe mobility of traffic on Pandeshwar Road. At peak hour, 666 (772 PCU) vehicles ply towards this direction and most of them are car and two-wheeler. As a single lane have the capacity of carrying 1200 PCU in an hour, ***so lane closure during construction period can withstand the load of traffic.***

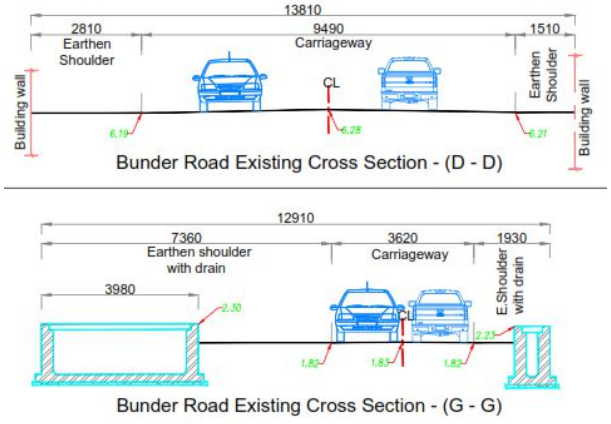
Adequate safety arrangement provision will be required at construction zone for easier, safer movement of traffic. Section 7.4 describes the safety measures to be adopted during construction

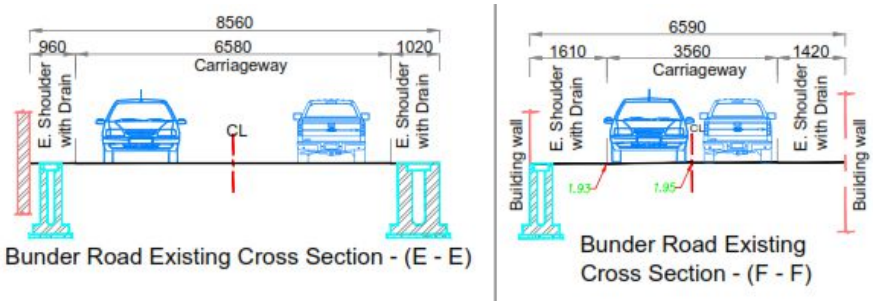
### *8.1.3. Bunder Road*

At present, 4669 vehicles ply on Pandeshwar Road towards Rosario Church. Northward traffic is proposed to be shifted to Pandeshwar Road. Traffic can be diverted towards Hamilton Circle from AB Shetty Circle. Traffic management plan for traffic towards Hamilton circle is required to be formulated during construction of Rosario Church Road.

| 2 Wheeler | 3 Wheeler | Car | LCV | Bus/Truck | Other | Total |
|---|---|---|---|---|---|---|
| 2300 | 457 | 193 | 203 | 104 | 28 | 3294 |

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






It is evident from above figure during construction lane closure is appropriate option for safe mobility of traffic on Pandeshwar Road. At peak hour, 298 (308 PCU) vehicles ply towards this direction and most of them are car and two-wheeler. As a single lane have the capacity of carrying 1200 PCU in an hour, ***so lane closure during construction period can withstand the load of traffic.***

Adequate safety arrangement provision will be required at construction zone for easier, safer movement of traffic. Section 7.4 describes the safety measures to be adopted during construction

### *8.1.4. Balmatta Road, KMC Marcara Trunk Road, Light House Hill Road*

Balmatta Road, KMC Marcara Trunk Road and Light House Hill Road are alredy 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 other improvements in carriageway of these roads.

***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.

**Figure 8-3 Traffic Control System along the road during Construction**

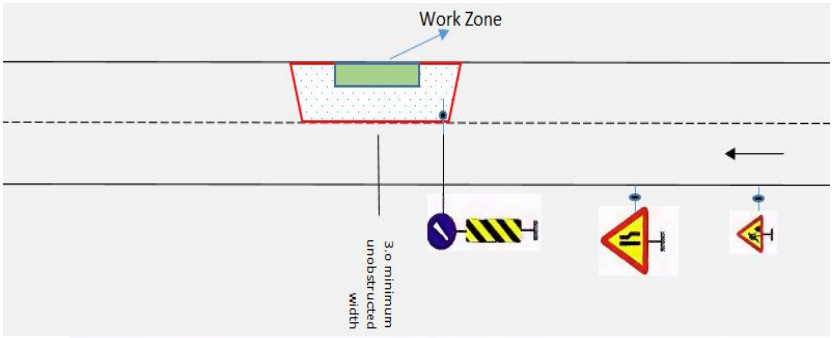
Length of the works from the start of the lead-in taper to the end of the exit taper should not be more than 50 meters .Drivers approaching from either direction can see both the ends of the site.

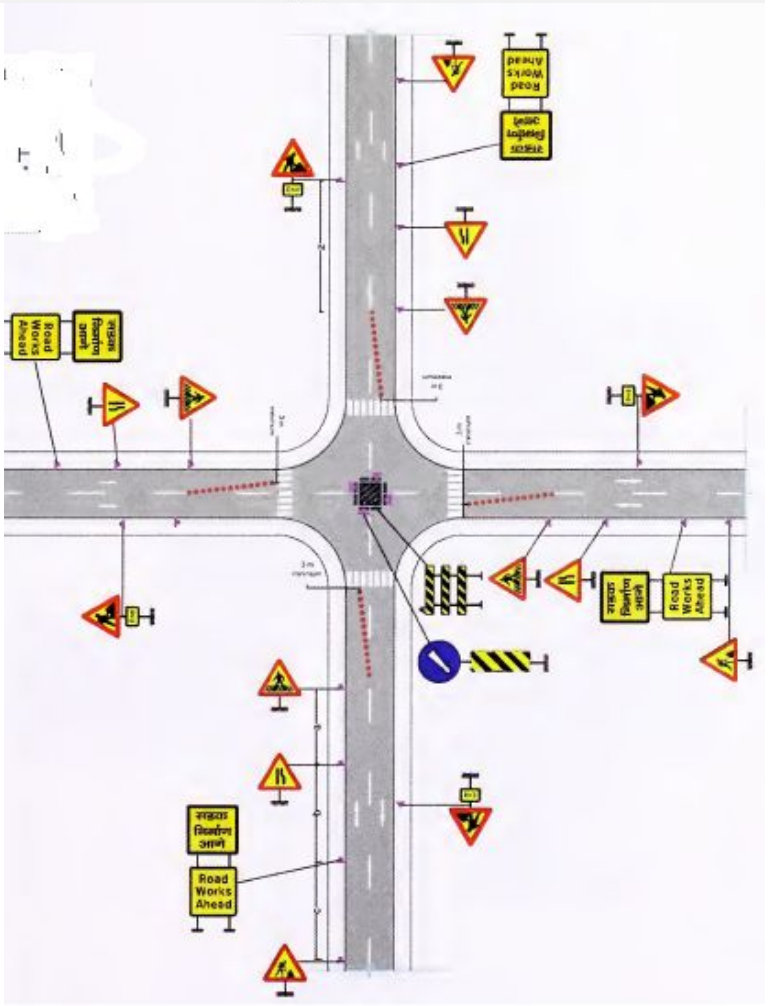
Subsequent paragraphs and figure explain the arrangement can be applicable at Junction during Construction

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.



## 8.3. Conclusion

As mentioned above lane closure alternately can adequately handle traffic at Nellikai, Mission Street Road during construction period. Nighttime 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 1 year

### 9.2. Defect Liability

The Defect Liability period is considered as 2 Years

### 9.3. Maintenance Period

The Maintenance Period is considered as 5 years 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, a key risk associated with the project along with the assessment is presented below:

| 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.<br><br>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.<br><br>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**

| No. | Drawing no | Drawing Title | No of Sheets |
|---|---|---|---|
| 1 | WTE_2292_03_R_1.01 | EXISTING FEATURES OF PANDESHWAR ROAD (ROAD NO. 3) | 1 |
| 2 | WTE_2292_03_R_1.02 | EXISTING FEATURES OF ROSARIO CHURCH ROAD (ROAD NO. 1a) | 2 |
| 3 | WTE_2292_03_R_1.03 | EXISTING FEATURES OF BUNDER ROAD (ROAD NO. 16) | 2 |
| 4 | WTE_2292_03_R_1.04 | EXISTING FEATURES OF LIGHT HOUSE HILL ROAD (ROAD NO.11) | 2 |
| 5 | WTE_2292_03_R_1.05 | EXISTING FEATURES OF KMC MERKARA TRUNK ROAD (ROAD NO.17) | 2 |
| 6 | WTE_2292_03_R_1.06 | EXISTING FEATURES OF MOHAMMED ALI ROAD | 1 |
| 7 | WTE_2292_03_R_2.01 | PLAN AND PROFILE OF ROSARIO CHURCH ROAD | 4 |
| 8 | WTE_2292_03_R_2.02 | PLAN AND PROFILE OF BUNDER ROAD (ROAD NO.16) | 4 |
| 9 | WTE_2292_03_R_2.03 | EXISTING FEATURES OF MOHAMMED ALI ROAD | 1 |
| 10 | WTE_2292_03_R_3.01 | ROAD SIGNAGES - PLAN AND ROAD MARKING OF PANDESHWAR ROAD (ROAD NO. 3) | 1 |
| 11 | WTE_2292_03_R_3.02 | ROAD SIGNAGES - PLAN AND ROAD MARKING OF ROSARIO CHURCH ROAD (ROAD NO. 1a) | 2 |
| 12 | WTE_2292_03_R_3.03 | ROAD SIGNAGES - PLAN AND ROAD MARKING OF BUNDER ROAD (ROAD NO. 16) | 2 |
| 13 | WTE_2292_03_R_3.04 | ROAD SIGNAGES - PLAN AND ROAD MARKING OF LIGHT HOUSE HILL ROAD (ROAD NO.11) | 2 |
| 14 | WTE_2292_03_R_3.05 | ROAD SIGNAGES - PLAN AND ROAD MARKING OF KMC MERKARA TRUNK ROAD (ROAD NO.17) | 2 |
| 15 | WTE_2292_03_R_3.06 | ROAD SIGNAGES - PLAN AND ROAD MARKING OF MOHAMMED ALI ROAD | 1 |
| 16 | WTE_2292_03_R_3.07 | PROPOSED JUNCTION IMPROVEMENT HAMPANAKATTA CIRCLE INTERSECTION | 1 |
| 17 | WTE_2292_03_R_3.08 | PROPOSED JUNCTION IMPROVEMENT SYNDICATE BANK CIRCLE INTERSECTION | 1 |
| 18 | WTE_2292_03_R_4.01 | ROAD SIGNAGES AND MARKING DETAILS | 1 |
| 19 | WTE_2292_03_R_5.01 | PROPOSED CROSS SECTION OF PANDESHWAR ROAD (ROAD NO. 3) SHEET 1 OF 7 | 7 |
| 20 | WTE_2292_03_R_5.02 | PROPOSED CROSS SECTION OF ROSARIO CHURCH ROAD (ROAD NO. 1a) 9 | 19 |
| 21 | WTE_2292_03_R_5.03 | PROPOSED CROSS SECTION OF BUNDER ROAD (ROAD NO. 16) 5 | 35 |
| 22 | WTE_2292_03_R_5.04 | PROPOSED CROSS SECTION OF LIGHT HOUSE HILL ROAD (ROAD NO.11) 5 | 15 |
| 23 | WTE_2292_03_R_5.05 | PROPOSED CROSS SECTION OF KMC MERKARA TRUNK ROAD (ROAD NO.17) 7 | 17 |
| 24 | WTE_2292_03_R_5.06 | PROPOSED CROSS SECTION OF MOHAMMED ALI ROAD | 2 |
| 25 | WTE_2292_03_R_5.07 | DETAILS OF MANHOLE FOR POWER CORRIDOR WITH OTHER SERVICES & STREET LIGHT POLES | 1 |
| 26 | WTE_2292_03_R_5.08 | TYPICAL CROSS SECTIONS | 2 |

| | | | |
|---|---|---|---|
| 27 | WTE_2292_03_R_6.01 | PROPOSED UTILITY SERVICES OF PANDESHWAR ROAD (ROAD NO. 3) | 1 |
| 28 | WTE_2292_03_R_6.02 | PROPOSED UTILITY SERVICES OF ROSARIO CHURCH ROAD (ROAD NO. 1a) | 2 |
| 29 | WTE_2292_03_R_6.03 | PROPOSED UTILITY SERVICES OF BUNDER ROAD (ROAD NO. 16) | 2 |
| 30 | WTE_2292_03_R_6.04 | PROPOSED UTILITY SERVICES OF LIGHT HOUSE HILL ROAD (ROAD NO.11) | 2 |
| 31 | WTE_2292_03_R_6.05 | PROPOSED UTILITY SERVICES OF KMC MERKARA TRUNK ROAD (ROAD NO.17) | 2 |
| 32 | WTE_2292_03_R_6.06 | PROPOSED UTILITY SERVICES OF MOHAMMED ALI ROAD | 1 |

# 12. COST ESTIMATES

The section of the report deals with the Cost Estimates for Priority Loop Smart Roads

## 12.1. Assumptions

- SOR rates as per Mangalore Circle SOR (As per New SOR 18-19)
- 10% weightage has been added to SOR rates of Mangalore Circle PWD Circle
- Non SOR Items based on Vendor Quotations
- Landscaping rates as per Delhi SOR (Only Delhi SOR has landscaping rates)
- 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: Priority Loop Smart Road – Summary of Estimate**

| Sr. No. | Description | Cost In INR |
|---|---|---|
| 1 | Road and Other Works | 34,37,96,669 |
| 2 | Street Lighting | 48,82,426 |
| 3 | Landscape Work | 3,55,444 |
| | **Sub Total** | **34,90,34,539** |
| | GST @ 12% on SOR Base Items -Construction Cost | 2,94,63,095 |
| | GST @ 18% on Market Rate Items -Construction Cost | 1,54,23,291 |
| | Provision for Third Party Damages and Maintenance at 1 st Year(DLP) | 30,95,630 |
| | GST @ 12% on SOR Base Items -Construction Cost | 2,24,284 |
| | GST @ 18% on Market Rate Items -Construction Cost | 1,69,240 |
| | Maintenance Cost of 2nd,3rd and 4th Year | 127,08,314 |
| | GST @ 12% on SOR Base Items -Construction Cost | 12,12,260 |
| | GST @ 18% on Market Rate Items -Construction Cost | 2,30,869 |
| | Escalation and Tender Premium at 10% | 3,49,03,454 |
| | Add 3% Contingency | 1,04,71,036 |
| | Miscellaneous and Rounding off | 63,988 |
| | **Grand Total** | **45,70,00,000** |

## 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

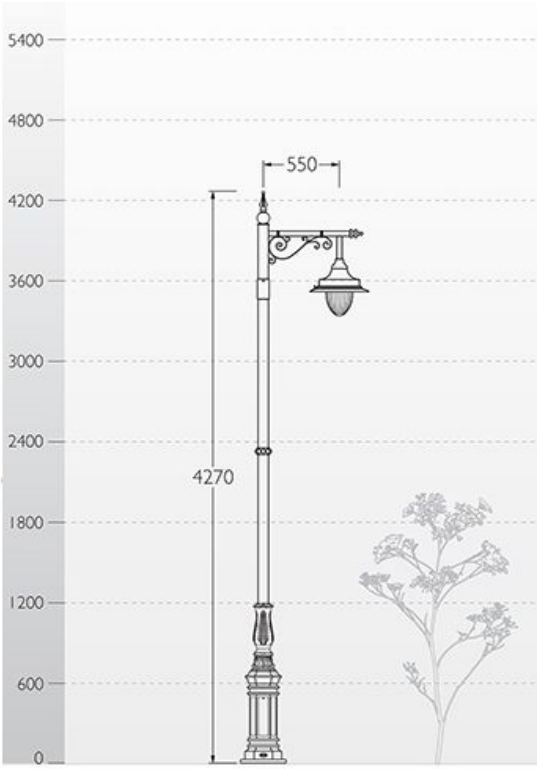
**LIGHT FIXTURE FOR FOOTPATH**

Make : K-LITE

MODEL : VICENT LIGHTING POLE

Code : KP-450

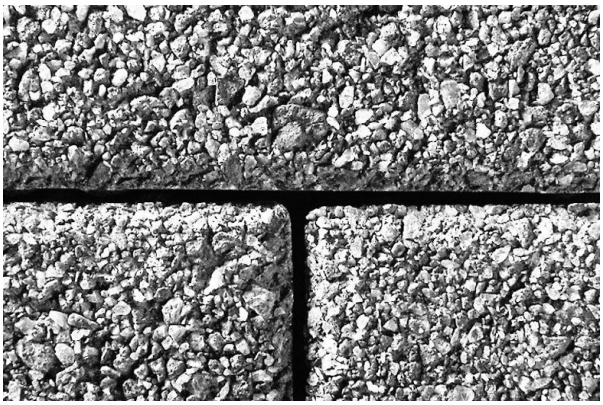
HT : 4270MM




**PERMEABLE ECO-FRIENDLY PAVERS DETAILS**

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

Description: s



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 canbe 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 requiredUnilock, 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 color 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 |

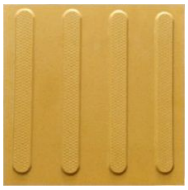
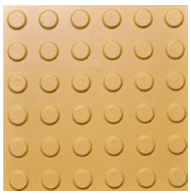
**BOLLARDS:**

- 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

**TACKTILE PAVING**

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