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

SMART ROAD PACKAGE - 06

DETAILED PROJECT REPORT - VOLUME I

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

MANGALORE SMART CITY PROJECT

Lalbaug, M.G. Road, Mangalore – 575003

4/23/2019

ISSUE AND REVISION RECORD

Revision	Date	Originator	Checker	Approver	Description	Standard
1	23/04/2019	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

EXECUTIVE SUMMARY

A) INTRODUCTION OF SMART CITIES MISSION

The Smart City Mission aims at driving economic growth and improving the quality of life of the people by enabling local government and harnessing technology as a means to create smart outcomes for citizens.

The focus is on achieving sustainable and inclusive development in compact arrears and to replicate their success in other aspiring cities

The program strategizes to undertake implementation through area based development approach through Retrofitting (City Improvement), Redevelopment (City Renewal), Greenfield Development (City Extension) and Pan City Initiatives

B) BACKGROUND OF MANGALURU CITY

Mangalore, officially known as Mangaluru, is the chief port city of the Indian state of Karnataka located about 352 km west of the state capital, Bangalore. It is the second major city in Karnataka state in all aspects after the capital city Bangalore. It is the only city in Karnataka to have all modes of transport — Air, Road, Rail and Sea along with 5 other major cities in India and is also known as the Gateway of Karnataka. It is the largest city in the Tulu Nadu region of Karnataka. Mangalore is the second best business destination in Karnataka after Bangalore & 13th best in India. The population of the urban agglomeration was 623,841, according to the provisional results of the 2011 national census of India.

Mangalore is one of the major portsin India which handles 75 per cent of India's coffee and cashew exports. Mangalore is the largest city and administrative headquarters of the Dakshina Kannada district, and is one of the most multicultural non-metro cities of India. The city's landscape is characterised by rolling hills, coconut palms, freshwater streams and hard red-clay tiled-roof buildings.

Mangalore is also included in the Smart Cities Mission list and one among the 100 smart cities to be developed in India. The city has an average elevation of 22 m (72 ft) above mean sea level. Mangalore has a tropical monsoon climate, and is under the influence of the Southwest monsoon.

C) DESCRIPTION OF ABD REGION

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

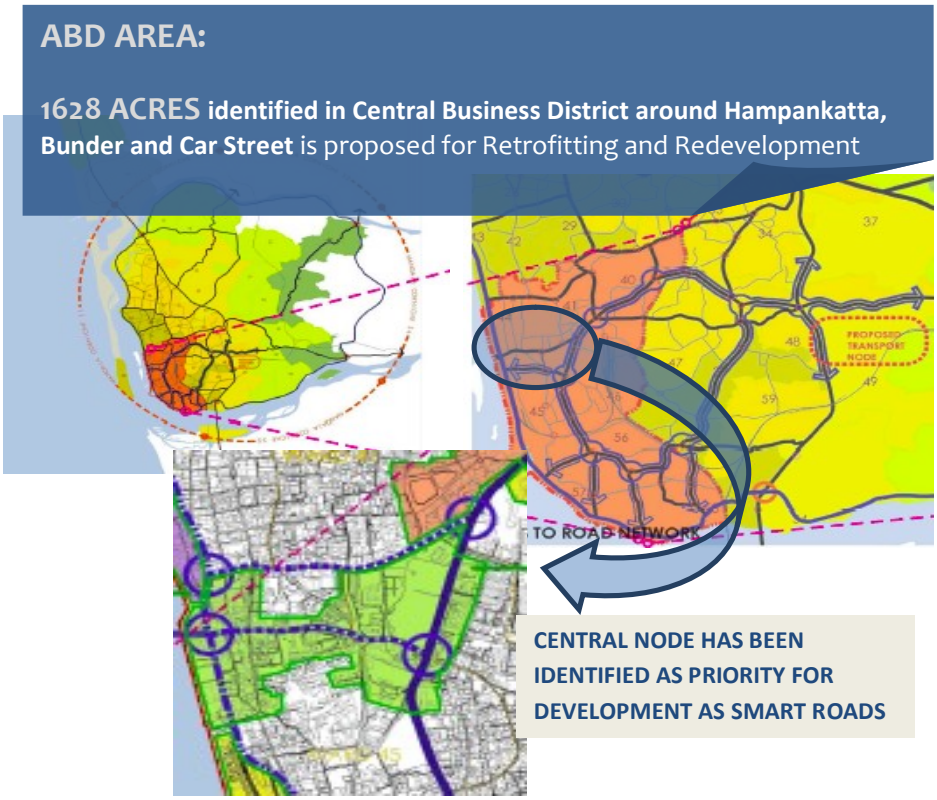


Figure 1 ABD area considered under Mangaluru Smart City and Priority Roads Identified for Development as Smart roads

D) PROPOSED PROJECTS IN SCP

Sr. No.	Name of the Project	Value of the Project (in INR Cr)
1	Improvements to Nehru Maidan Road from Clock Tower to AB Shetty Circle	7.560
2	Development of MLCP with retail space near Hampankatta Junction	94.000
3	Construction of Under Ground Drainage in zone-4 (Part-1) in ABD area Package -01	4.995
4	100% Underground Drainage network in ABD Area - Package 3	3.000
5	Conversion of all the lighting in government building into LED	2.230
6	Installation of Rooftop Solar on Government Buildings in ABD area - Phase 1	7.080
7	Implementation of Command and Control Center Components	38.790
8	Construction of Smart Bus shelter and E-Toilets in PAN City - Phase 1	4.800
9	Construction of Smart Bus shelter and E-Toilets in PAN City - Phase 2	4.600
10	Construction of Under Ground Drainage in Zone IV part 2 and Zone III part 1 in ABD Area Package -02	9.500
11	Redevelopment of Central Market along with Fish Market	145.000
12	LED Street Lights	69.350
13	Smart Road Package 2	12.500
14	Smart Road Package 3	42.060

15	Smart Road Package 4	48.000
16	Smart Road Package 5	49.000
17	Smart Road Package 6	48.000
18	Smart Road Package 7	40.520
19	Smart Road Package 9 – Pedestrian Plaza Underpass near Clock Tower Circle	5.310
20	100% water supply coverage along with residential meters, water quality monitoring and SCADA	10.000
21	Implementation of rain water harvesting in all building having area more than 1000 sqft.	2.000
22	100% Underground Drainage network in ABD Area - Package 4	25.200
23	100% Underground Drainage network in ABD Area - Package 5	49.000
24	100% Underground Drainage network in ABD Area - Package 6	46.010
25	Retrofit Car Street & areas of Sri Venkatramana Temple as Religious Zone	14.590
26	Redevelopment of Vacant Premises of DC office into Hotel, Retail Shops and Speciality Restaurants	10.000
27	Upgradation of Wenlock & Lady Goshen Hospital- Package 1	8.040
28	Skill Development and Safety Training Centre	3.300
29	Implementation of E-smart schools in all government schools - Package 1 - Infrastructure	11.000
30	Implementation of E-smart schools in all government schools - Package 2 – ICT	5.000
31	Waterfront Area Development- Package 1	49.000
32	Waterfront Area Development- Package 2	49.000
33	Waterfront Area Development- Package 3	49.000
34	Waterfront Area Development- Package 4	48.000
35	Waterfront Area Development- Package 5	40.000
36	Retrofitting of tile and Brick factories into Hotel, Auditorium, Convention Centre, Museum, Marina with retail and Speciality Restaurants- Package 1	6.000
37	Retrofitting of tile and Brick factories into Hotel, Auditorium, Convention Centre, Museum, Marina with retail and Speciality Restaurants- Package 2	8.000
38	Retrofitting of tile and Brick factories into Hotel, Auditorium, Convention Centre, Museum, Marina with retail and Speciality Restaurants- Package 3	10.050
39	Development of Green Area along Connector Road	7.020
40	Solar and Recreational Island	86.740
41	Installation of Roof Top Solar on Government Buildings - Package 2	10.000
42	Installation of Roof Top Solar on Government Buildings - Package 3	10.000
43	IPDS Proposals - Package 1	15.000
44	IPDS Proposals - Package 2	15.000
45	Redevelopment of Old Bus Stand Area	25.000
46	Construction of Command and Control Center Building	3.000
47	Command and Control Center - Stage 2	49.000
48	Command and Control Center - Stage 3	23.690
49	Construction of Smart Bus shelter and E-Toilets in PAN City - Phase 3	3.560
Total Project Cost		**1327.495**

Table 1 Smart City Project Details

E) SMART ROAD PROJECT WITHIN ABD

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

p
e
r

As per the revised SCP, sanctioned recently the smart road Packages are listed below:

Sr. No.	Name of the Project	Value of the Project (in INR Cr)
1	Improvements to Nehru Maidan Road from Clock Tower to AB Shetty Circle	7.560
2	Smart Road Package 2	12.500
3	Smart Road Package 3	42.060
4	Smart Road Package 4	48.000
5	Smart Road Package 5	49.000
6	Smart Road Package 6	48.000
7	Smart Road Package 7	40.520

Table 2 Smart Road Packages

Smart Roads under Mangaluru Smart City

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

Package 1 included Maidan road (from Clock Tower Circle to AB Shetty Circle

Package 2 included Maidan road II (from AB Shetty Circle to Hamilton Circle), 4th Cross road, Mission Street Road and Nellikai road.

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

Package 4 included the following roads:

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

Package 5 included the following roads:

1. **Milagres Cross Road (KMC Marcara Road – Mother Theresa Road Junction)**
2. **Nandigudda Attavara Road (Wenlock Railway Node – Attavara KMC Hospital Jn.)**
3. **New Balmatta Road (Jyothi Circle – Avery Junction)**
4. **Don Bosco School Road (KMC Marcara – Avery Junction)**
5. **Azizuddin Road (Lower Car Street – Bunder Police Station)**
6. **Jumma Masjid Road (Lower Car Street – Bombay Lucky Junction)**
7. **Arya Samaj Road (Arya Samaj KRR Rd Jn – Collector's Gate Circle)**
8. **Balmatta Road (Jyothi Circle – Collector's Gate Circle)**
9. **Bengre Ferry Road (Port Rd Ansari Rd Jn – BMS Ferry Line)**

Table 3 Package -05 Road Details

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 below shows the Roads considered for development as Smart Roads for DPR 1, 2, 3, 4, 5, 6A, 6B & 7.

Phase	Rd. no.	Name of Rd.	From	To	Road Length
I - Pilot	1	**Nehru Maidan Rd.**	AB Shetty Circle	Clock Tower	545.00
II - Loop Rd	1	**Maidan Rd.-II**	AB Shetty Circle	Hamilton Circle	248.00
II - Loop Rd	2	**4th Cross Rd.**	Hamilton Circle	Rao & Rao Circle	266.00
II - Loop Rd	4	**Nellikai Rd.**	Hamilton Circle	Missn. St - Nellikai Jn	352.00
II - Loop Rd	3	**Mission St. Rd**	Misn. St-Nellikai Jn	Rao & Rao Circle	206.00
III	1	**Rosario Church Rd.**	Hamilton Circle	Bunder Railway Gate	898.81
III	2	**Pandeshwar Rd.**	AB Shetty Circle	Rosario Church Rd.	479.96
III	3	**Bunder Police Station**	Bombay Lucky Jn.	Railway Gate Bus Stop	1336.57
III	4	**KMC Mercara Trunk**	Hampankatta Jn.	Jyoti circle	984.24

		Rd.			
III	5	**Light house hill Rd.**	Hampankatta Jn.	Jyoti circle	961.14
III	6	**Mohd. Ali Rd.**	Nellikai Jn.	Bombay Lucky Jn.	100.00
IV	1	**Balmatta Rd.**	Clock Tower	Hampankatta	365.32
IV	2	**Mother Theresa Rd.**	Hampankatta Jn.	Milagres Church Jn.	224.06
IV	3	**Milagres Nandigudda Rd.**	Milagres Church	Nandigudda Rd.	322.96
IV	4	**KSR Rao Rd.**	PVS Circle- KSR Rd.	Hampankatta Jn.	1123.23
IV	5	**KRR Rd. (Kudmal Ranga Rao Rd.)**	PVS Jn.	Arya Samaj Rd. Jn.	1118.88
IV	6	**Bunts Hostel Rd.**	Bunts Hostel Jn.	Jyothi Circle	961.14
V	1	**Milagres Cross Rd.**	KMC Central Library Jn	Milagres Church Jn	183.00
V	2	**Attavara-Nandigudda Rd.**	Nandigudda Wenlock Jn	KMC Hospital	1021.00
V	3	**Kudumbi Garden (DBS) Road**	KMC Mercara Trunk Rd.	Avery Juction	375.00
V	4	**New Balmatta Rd.**	Jyoti circle	Avery Juction	577.00
V	5	**Arya Samaj Rd.**	KRR Rd - Arya Samaj Rd Jn.	Balmatta Road Jn.	595.00
V	6	**Balmatta Road**	Jyoti circle	Arya Samaj Road Jn.	330.00
V	7	**Azizuddin Road**	Car Street	Bunder Police Station	717.00
V	8	**Jumma Masjid-Old Port Rd.**	Car Street	Badria School Jn.	966.00
V	9	**Bendre Ferry Rd.**	Jumma Masjid	BMS Ferry Lane	1103.00
VI	1	**OLD KENT ROAD**	Old Kent Rd.	Mangaladaevi Rd Jn.	820.00
VI	2	**PANDESHWARA NEW ROAD**	Rosario Church Rd.	Pandeshwar New Rd.	280.00
VI	3	**BOLAR FISHERIES COLLEGE RD**	Hoigebazar Rd. (KFDC Ltd)	Sea Face (Mangaluru Old Port)	150.00
VI	4	**MULIHITHLU ROAD**	Mangaladevi Temple	Mulihithlu Rd.	920.00
VI	5	**MANGALADEVI TEMPLE ROAD**	Mangaladevi Temple	Marnamikatta Circle	830.00
VI	6	**MONKEYSTAND NEW ROAD**	Mangaladevi Rd (Ramakrishna Math Jn)	Jaihind Circle	539.01
VI	7	**JEPPU MARKET ROAD**	Abhaya Limbs Center	Jeppu Market Jn.	225.00
VI	8	**GUJJARKERE ROAD**	Jeppu Market Jn.	Jappina Mogaru	645.00
VII	1	**G.H.S ROAD (Footpath Only)**	Balmatta Road	Sharavu Temple Jn	370.00
VII	2	**P.M RAO ROAD**	KSR Road	GHS Road Jn (Srinivas College)	145.00
VII	3	**SHARAVU TEMPLE ROAD**	KSR Road	GHS Road Jn (Ganapathi Mandir)	185.00

VII	4	**G.H.S CROSS ROAD (Jewellery Ln)**	GHS Road Jn	Flower Market Rd	180.00
VII	5	**VITOBHA TEMPLE ROAD**	KSR Road (Karnataka Bank)	Venkataramana Temple Sq.	490.00
VII	6	**MAIDAN 1st CROSS ROAD**	Mangala College (via Central Market Rd)	Car Street Cross Rd.	375.00
VII	7	**CENTRAL MARKET BACK SIDE RD**	Clock Tower Circle	Market Road Jn	150.00
VII	8	**MAIDAN 3rd CROSS ROAD**	Bibi Alabi Rd	Bibi Alabi Rd-Kandak Rd Jn	180.00
VII	9	**BIBI ALABI ROAD**	Clock Tower Circle	Rao & Rao Circle	470.00
VII	10	**BIBI ALABI - KANDAK ROAD**	Central Market Parking	MPT Road Jn	460.00
VII	11	**MAIDAN 4TH CROSS ROAD - EXTN**	Rao & Rao Circle	Kandak Road Jn	195.00
VII	12	**MPT ROAD**	Car Street (Viswakarma Bank)	Mohd Ali Road Jn	715.00
VII	13	**KASSAIGALLI MASJID SIDE ROAD**	Kassaigalli Masjid	JM Road	200.00
VII	14	**J.M 1st CROSS ROAD**	Ramachandra Mandir	Jumma Masjid Rd	235.00
VII	15	**MISSION STREET ROAD - EXTN**	Mission Street Azizuddin Jn	Bendre Ferry Rd	245.00
VIII	1	**ARYA SAMAJ RD - KADRI JN**	KRR Rd - Arya Samaj Rd Jn.	Kadri Jn	881.77
VIII	2	**COLLECTORS GATE - PUMPWELL**	Collector's Gate Jn	Pumpwell Jn	1459.36
VIII	3	**FALNIR RD (AVERY - KANKANADY)**	Avery Jn	Kankanady Jn	1207.23
VIII	4	**S.L MATHIAS ROAD**	Sturrock Road Jn	Bendoor Well Jn (MT Road Jn)	976.38
VIII	5	**ATTAVARA KATTE ROAD**	KMC Hospital	Kotichennaya Jn	811.01
VIII	6	**MPHASIS ROAD**	Marnamikatte Jn	Jeppu Market Jn.	545.23
VIII	7	**JEPPU MORGANS GATE ROAD**	Jeppu Market Jn.	Mphasis Jn	334.34
VIII	8	**DONGERKERY ROAD**	Navbharat Circle	Chitra Jn	721.19
SP1	1	**Car Street Road**	Chitra Jn	Lower Car Street	797.92
SP1	2	**Connector Road**	Yemmekere Jn	Bolar Sea Face	934.88
SP1	3	**Mahakali Padpu Road**	Mphasis Jn	Jeppina Mogaru Jn	926.02

Table 4 Mangaluru Smart City: Smart Roads Package- I to V

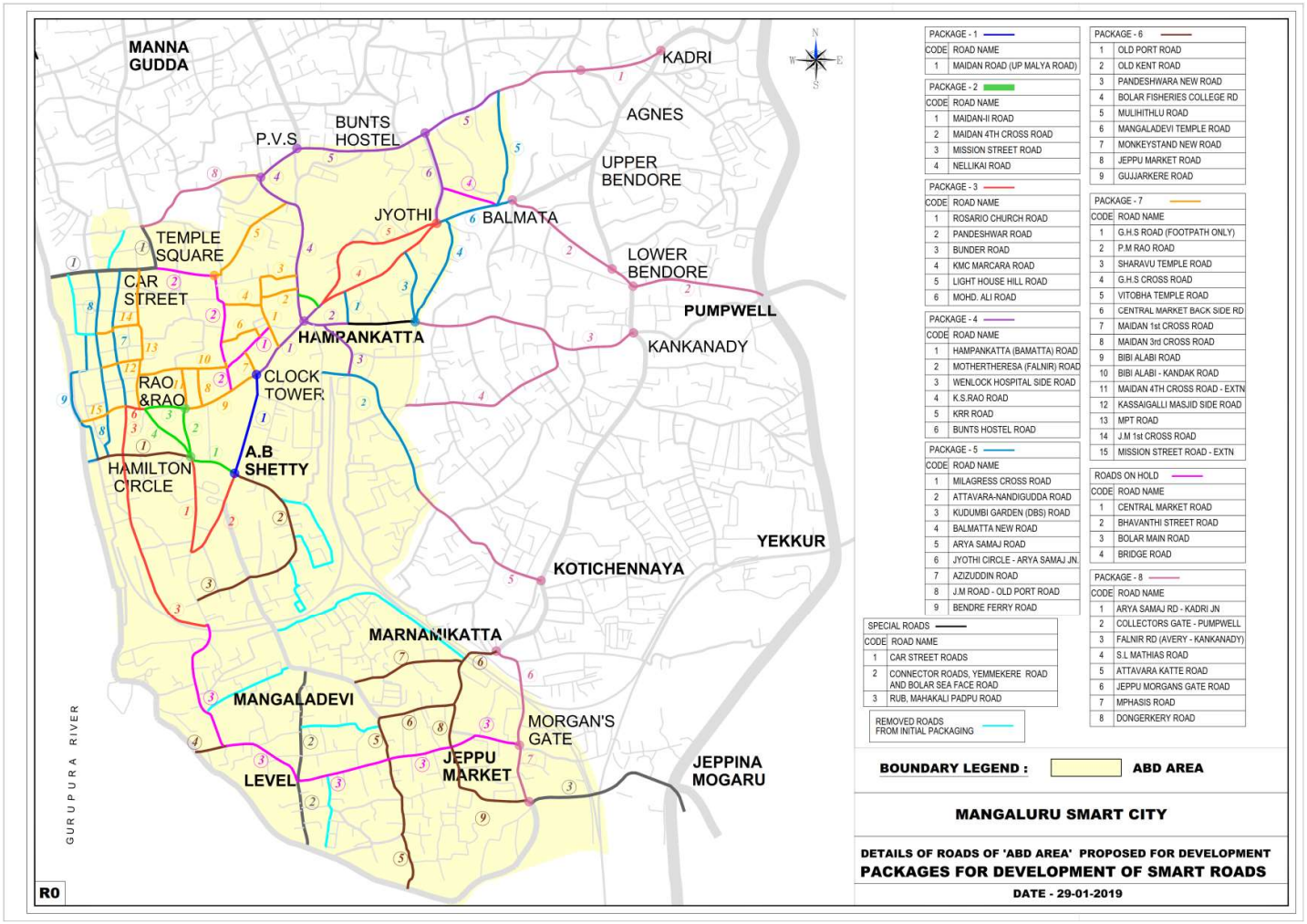


Figure 2 Selected Roads to be developed as smart roads

F) SELECTED ROADS IN THE PRESENT DPR (Package – 06)

The present DPR consist detailed working of 8 number of roads namely

1	OLD KENT ROAD (AB Shetty Circle – Mangaladevi Road)
2	PANDESHWARA NEW ROAD (Mangaladevi Road – RosarioChurch Road)
3	BOLAR FISHERIES COLLEGE RD (Bolar KFDC Jn – KFDC Sea Face)
4	MULIHITHLU ROAD (Mangaladevi Temple Jn – Mulihithulu Residential Area)
5	MANGALADEVI TEMPLE ROAD (Mangaladevi Temple Jn – Jaihind Circle)
6	MONKEYSTAND NEW ROAD (Mangaladevi Road – Jaihind Circle)
7	JEPPU MARKET ROAD (Artificial Limbs Centre Jn – Jeppu Market Jn)
8	GUJJARKERE ROAD (Jeppu Market Jn – Mphasis Jn)

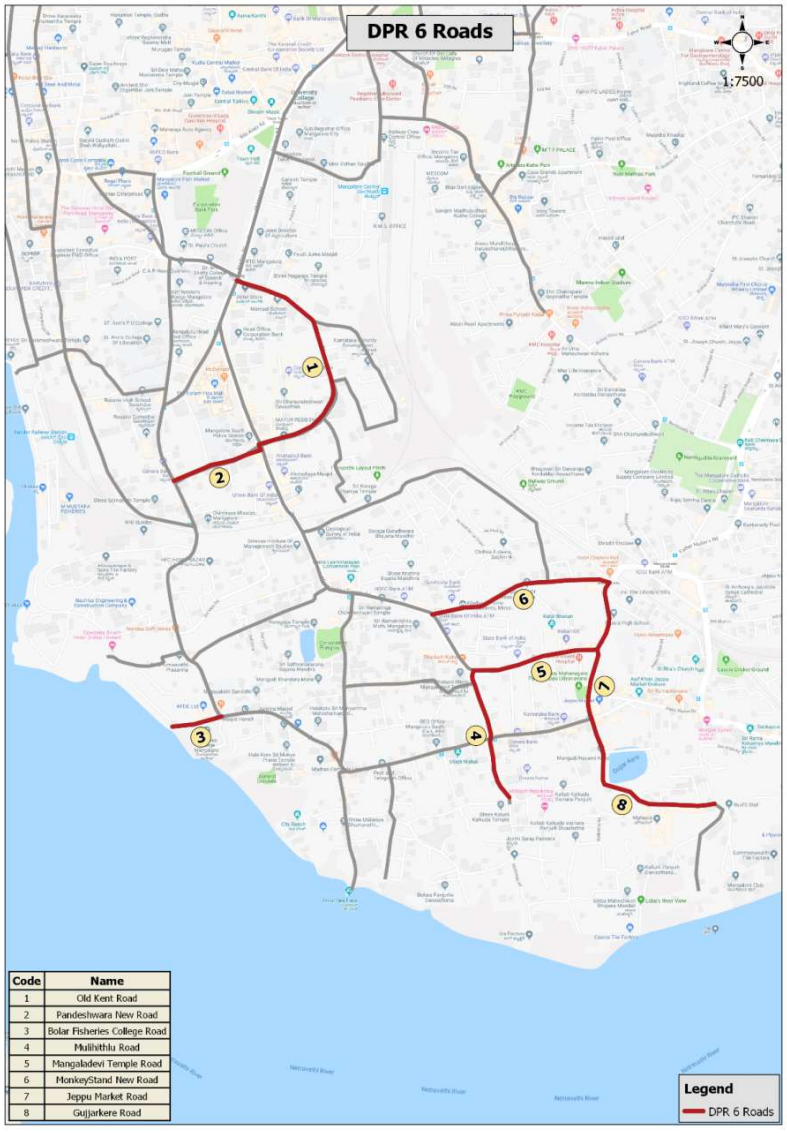


Figure 3 Selected Roads to be developed as smart roads

The Figure 3 shows the roads considered for DPR 6 package.

G) EXISTING COMPONENTS IN THE PRESENT DPR

Rd. no.	Name of Rd.	Rd.		Length	Pavement	Median	SWD Details	Footpath	Street Light
		From	To	Mts	Type				
1	**OLD KENT ROAD**	Old Kent Rd.	Mangaladaevi Rd Jn.	820.00	Flexible / Rigid	NO	YES. BOTH SIDES	YES	YES
2	**PANDESHWARA NEW ROAD**	Rosario Church Rd.	Pandeshwar New Rd.	280.00	Flexible	NO	YES. ONE SIDE (SOUTH)	YES	YES
3	**BOLAR FISHERIES COLLEGE RD**	Hoigebazar Rd. (KFDC Ltd)	Sea Face (Mangaluru Old Port)	150.00	Earthen	NO	YES. ONE SIDE (SOUTH)	YES	YES
4	**MULIHITHLU ROAD**	Mangaladevi Temple	Mulihithlu Rd.	920.00	Flexible / Rigid	NO	YES. ONE SIDE (WEST)	YES	YES
5	**MANGALADEVI TEMPLE ROAD**	Mangaladevi Temple	Marnamikatta Circle	830.00	Flexible	NO	YES. BOTH SIDES	YES	YES
6	**MONKEYSTAND NEW ROAD**	Mangaladevi Rd (Ramakrishna Math Jn)	Jaihind Circle	539.00	Flexible	NO	YES. BOTH SIDES	YES	YES
7	**JEPPU MARKET ROAD**	Abhaya Limbs Center	Jeppu Market Jn.	225.00	Flexible / Rigid	NO	YES. BOTH SIDES	YES	YES
8	**GUJJARKERE ROAD**	Jeppu Market Jn.	Jappina Mogaru	645.00	Flexible	NO	YES. BOTH SIDES	YES	YES
	Total - V			**4874.00**					

Table 5 Existing Component of Smart Road Package – 06

H) PROPOSED COMPONENTS IN THE PRESENT DPR

Rd no	Name of Rd.	Rd.		Length	Pavement	Proposed Median	SWD	Footpath	Utility Conduits	Bus Shelter	Street Light	UGD
		From	To	Mts	Type							
1	**OLD KENT ROAD**	Old Kent Rd.	Mangaladaevi Rd Jn.	820.00	Rigid	NO	Both Side	Raised & Level	Both side	No	YES	YES
2	**PANDESHWARA NEW ROAD**	Rosario Church Rd.	Pandeshwar New Rd.	280.00	Rigid	No	One Side (RHS)	Level (RHS)	Both side	No	YES	YES
3	**BOLAR FISHERIES COLLEGE RD**	Hoigebazar Rd. (KFDC Ltd)	Sea Face (Mangaluru Old Port)	150.00	Rigid	No	One Side (LHS)	Raised & Level	Both side	No	YES	NO
4	**MULIHITHLU ROAD**	Mangaladevi Temple	Mulihithlu Rd.	920.00	Rigid	No	Both Side	Raised & Level	Both side	No	YES	YES
5	**MANGALADEVI TEMPLE ROAD**	Mangaladevi Temple	Marnamikatta Circle	830.00	Rigid	No	Both Side	Raised & Level	Both side	No	YES	YES
6	**MONKEYSTAND NEW ROAD**	Mangaladevi Rd (Ramakrishna Math Jn)	Jaihind Circle	539.00	Rigid	No	One Side (RHS)	Raised & Level	Both side	No	YES	YES
7	**JEPPU MARKET ROAD**	Abhaya Limbs Center	Jeppu Market Jn.	225.00	Rigid	No	Both Side	Raised & Level	Both side	No	YES	YES
8	**GUJJARKERE ROAD**	Jeppu Market Jn.	Jappina Mogaru	645.00	Rigid	No	Both Side	Both side	Both side	No	YES	Existing UGD
	Total - V			**4874.00**								

Table 6 Proposed Components Smart Road Package -06

I) COST (WITH COMPONENT WISE PIE CHART),

Summary of the works broadly summarized below:

Sr. No.	Description	Cost In INR
1	Road and Other Works	39,63,36,592
2	Street Lighting	64,45,368
3	Landscape Work	2,20,184
	Construction Cost Sub Total	**40,30,02,144**
	GST @ 12% on Civil Construction Cost (Refer 1.0 Abstract)	4,72,99,932
	Provision for Third Party Damages and Maintenance at 1 st Year(DLP-	39,63,351
	GST @12% on DLP Cost (Refer 5.1 Abstract)	2,76,713
	Maintenance Cost of 2nd,3rd and 4th Year	1,23,21,456
	GST @12% on Maintenance Cost	11,73,949
	Escalation and Tender Premium @10%	403,00,214
	Add 3 % Contingency	120,90,064
	Miscellaneous and Rounding off	72,177
	Grand Total	**52,05,00,000**

Table 7 Summary of Cost – Smart Road Package - 05

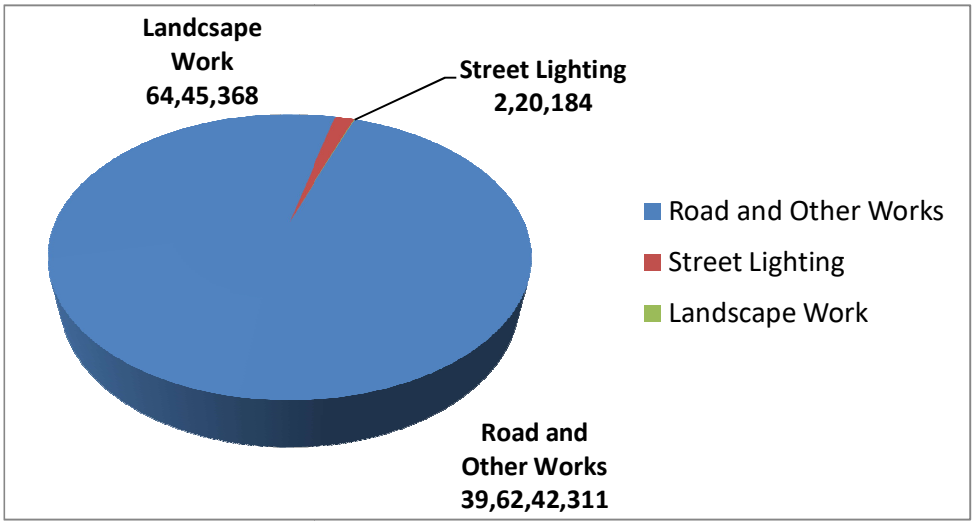


Figure 4 Pie Chart Showing Major Components

J) PROJECT FUNDING

A matrix of the details in the DPR shall be shown as mentioned below for existing situation and proposed components in the executive summary:

Sr. No.	Name of the Project	Value of the Project (in INR Cr)	DPR COST (in INR Cr)
1	Improvements to Nehru Maidan Road from Clock Tower to AB Shetty Circle	7.560	7.560
2	Smart Road Package 2	12.500	13.76
3	Smart Road Package 3	42.060	47.40
4	Smart Road Package 4	48.000	48.00
5	Smart Road Package 5	49.000	49.98
6	Smart Road Package 6	48.000	52.34
7	Smart Road Package 7	40.520	

Table 8 Smart Road Packages – Cost as per SCP and DPR

Chapter 1 PROJECT BACKGROUND

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.***

The implementation of the Mission at the City level will be done by a Special Purpose Vehicle (SPV) i.e. Mangaluru Smart City Limited (MSCL) constituting of board of directors from State Government as well as Mangaluru Municipal Corporation and nominees from the Government of India

M/s Wadia Techno-Engineering Services Limited (Lead Member) in consortium with M/s Louis Berger Consulting Private Limited & Centre for Development of Advanced Computing has been appointed as the Project Management Consultant (PMC) for Implementation of the Smart City Mission Projects in Mangaluru City.

The expected time of completion of the assignment is 60 months.

1.1.1. *The Objective*

The objective of the assignment is to provide direct assistance to Mangaluru Smart City Limited of the Mangaluru City to realize the vision of the city, contemplated in the SCP, by designing developing, managing and implementing the Smart City Projects of Smart City Mission Guidelines on the following two outputs:

- Output1: Area Based Development (ABD)
- Output2: Pan-city Initiative

1.2. Approach towards implementation of Smart Components

1.2.1. *Need for Intervention*

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

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

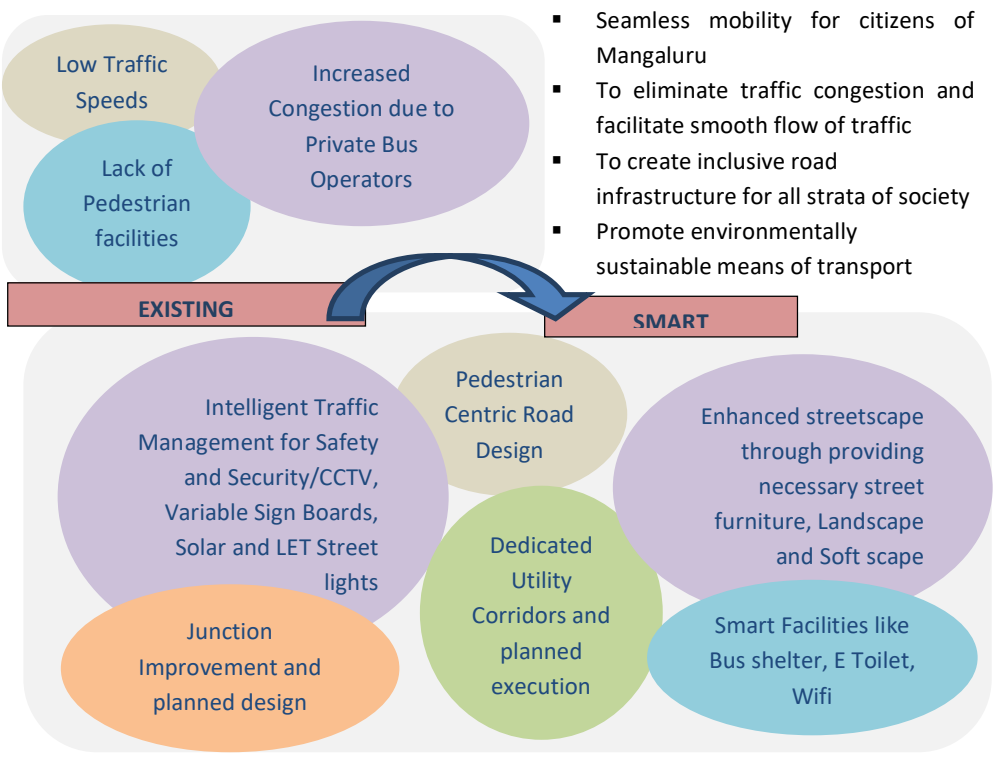


Figure 5: Vision methodology for Smart Roads in the city

1.2.1. Proposed Interventions

The proposed intervention aims to achieve the following:

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

Smart Roads include Four Broad Objectives, namely:

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

Figure 6 Proposed interventions for the Selected Roads to be developed as smart roads

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

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

1.2.2. Expected Benefits

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

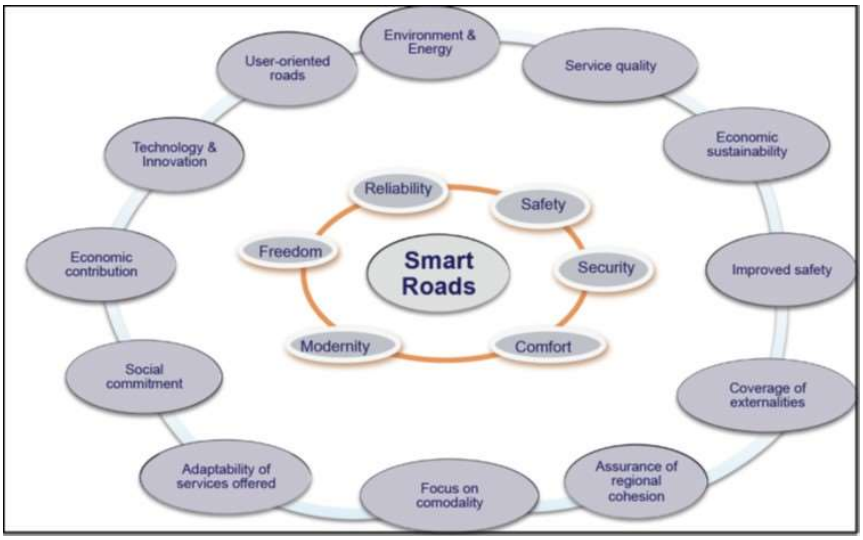


Figure 7 Benefits of developing Smart roads

1.2.3. 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.

1.2.4. Stakeholders/ Organizations involved

- Citizens
- Mangaluru Smart City Limited (MSCL)
- Mangaluru City Corporation (MCC)
- Mangaluru Smart City PMC
- Karnataka Public Works Department – Mangalore Division
- Traffic Police / RTO
- Karnataka Urban Infrastructure Development and Finance Corporation (KUIDFC)
- Mangalore Electricity Supply Company Limited (MESCOM)
- Karnataka State Road Transport Corporation (KSRTC)
- Private Bus Operators Association
- City Level Advisory Forum (CLAF)

1.2.5. Target Beneficiaries

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

- **Citizens**: The citizens would get better transport facilities for their mobility needs. The road improvement project would reduce traffic congestion; thereby result in travel time savings for the citizens. Smart roads also offer multiple mobility options such as walking, cycling, and public transport or through private vehicles. The upgraded roads would be

inclusive to all citizens, i.e. would have facilities that would make them accessible to elderly or physically challenged persons.

- **Local Authority/ MCC**: The municipal corporation would get upgraded roads with more traffic handling capacity, smooth traffic flow and lesser congestion. Roads upgraded with state-of-the-art technology would result in fuel savings and lesser maintenance costs. Smart Roads would also help the local government in energy saving through energy efficient LED street lighting.
- **Local Economy**: The improved mobility and reduced travel times would result in improving the productivity of the citizens and thus benefit the local business and the city's economy.

1.2.6. Objective of the Report

The purpose of the Detailed Project Report is to provide details of various considerations and the elements proposed for the DPR-6 Smart Road. It aims to give a basic design idea to all the stakeholders before proceeding for final design and estimates.

1.2.7. Structure of the Report

This report is organized as follows:

- **EXECUTIVE SUMMARY**
- **Chapter 1 – Introduction**
- **Chapter 2 – Project Background**
- **Chapter 3 – Proposed Design**
- **Chapter 4 – Timeline for Execution**
- **Chapter 5 – Monitoring and Evaluation**
- **Chapter 6 – Cost Estimates**
- **Chapter 7 – Drawings**
- **Annexures**

1.3. Area Description

The details in Nutshell for the ABD area planning as well as few important components are graphically shown below:

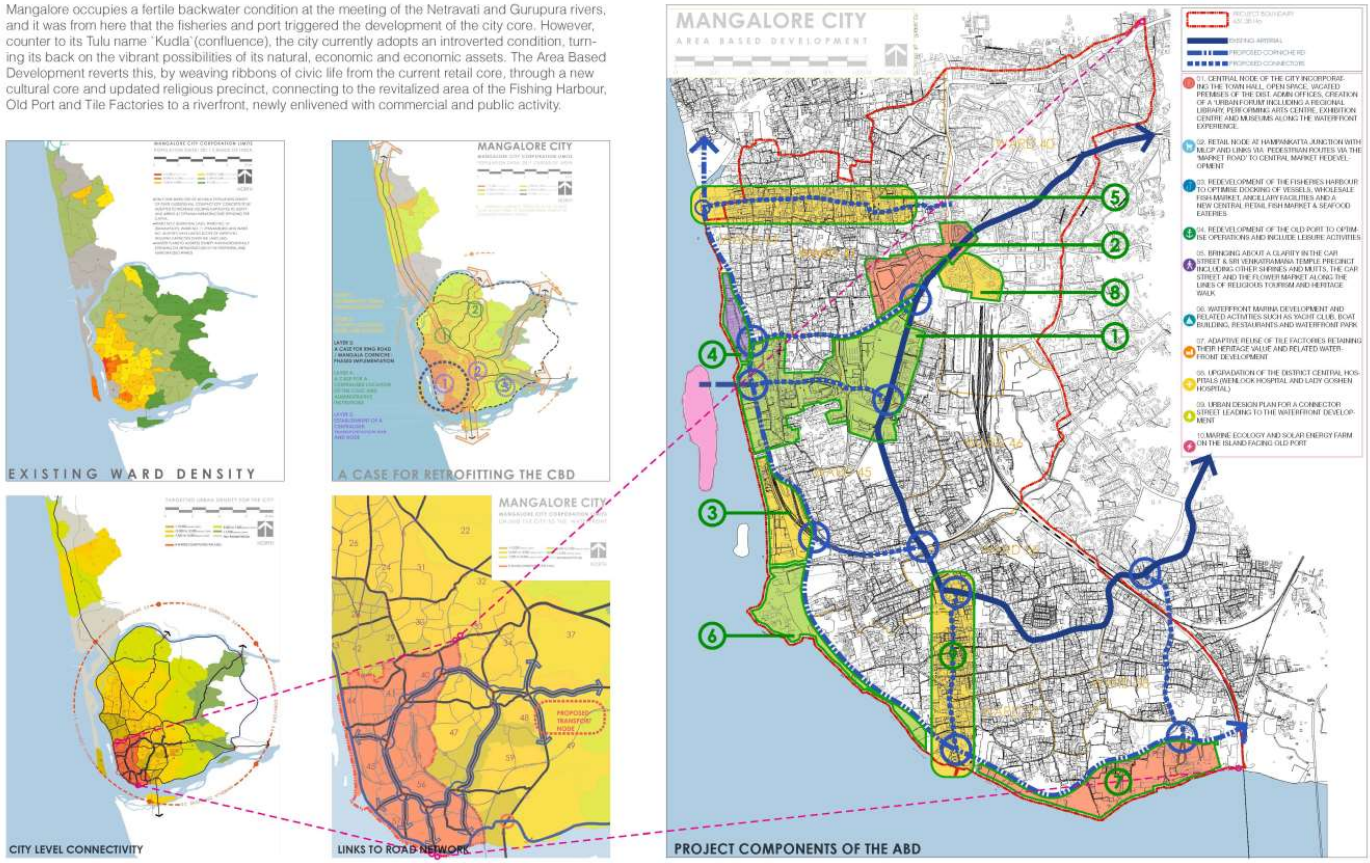


Figure 8 Mangaluru ABD area showing identified project as per smart city proposal

Phasing of Road Packages:

The Entire Road Packages considered are based on the ABD area development to improve the mobility. The Packages initiated with the central part and heart of the city called Maidan road, hence the first package included the Maidan road- starting from Clock Tower to AB Shetty Circle. Package – 02 included the roads surround to the Maidan road as the Maidan is point of attraction and inviting lots of social and cultural activities. However considering one of the important project of Redevelopment of Central market, the Bibi Alabi road and few other roads around Central Market were planned for later packages as the construction of Central Market can affect the roads. The Package -03, 04 and all other projects are conceived in the same fashion, connecting these roads.

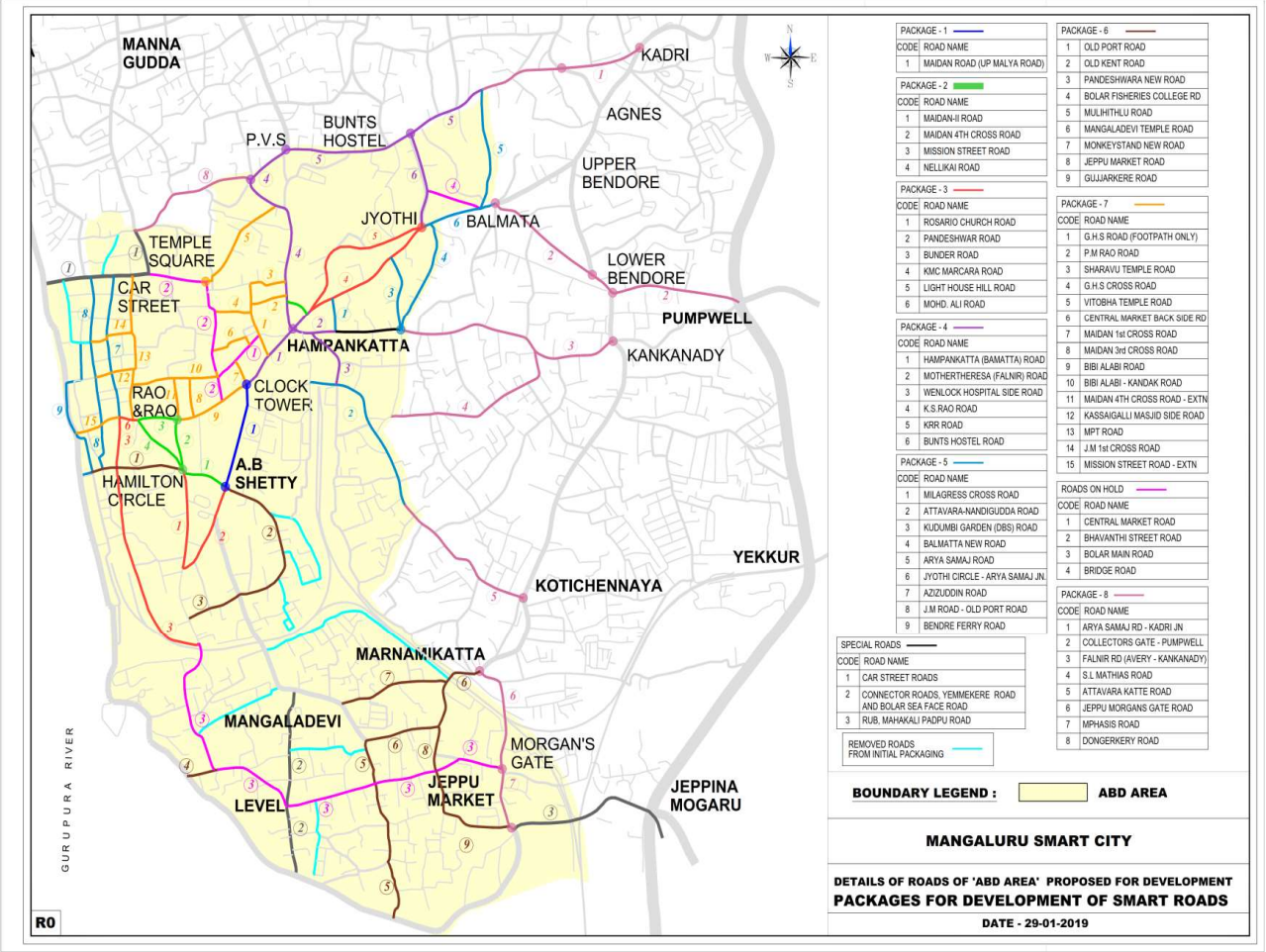


Figure 9 Smart Road Packaging

1.4. Comprehensive plan

Mangalore occupies a fertile backwater condition at the meeting of the Netravati and Gurupura rivers, and it was from here that the fisheries and port triggered the development of the city core. However, counter to its Tulu name 'Kudla' (confluence), the city currently adopts as introverted condition, turning its back on the vibrant possibilities of its natural economic and economic assets. The Area Based Development reverts this, by weaving ribbons of civic life from the current retail core, through a new cultural core and updated religious precinct, connecting to the revitalized area of the Fishing Harbour, Old Port and Tile Factories to a riverfront, newly enlivened with commercial and public activity. The major aim is to connect the Water Front with the city

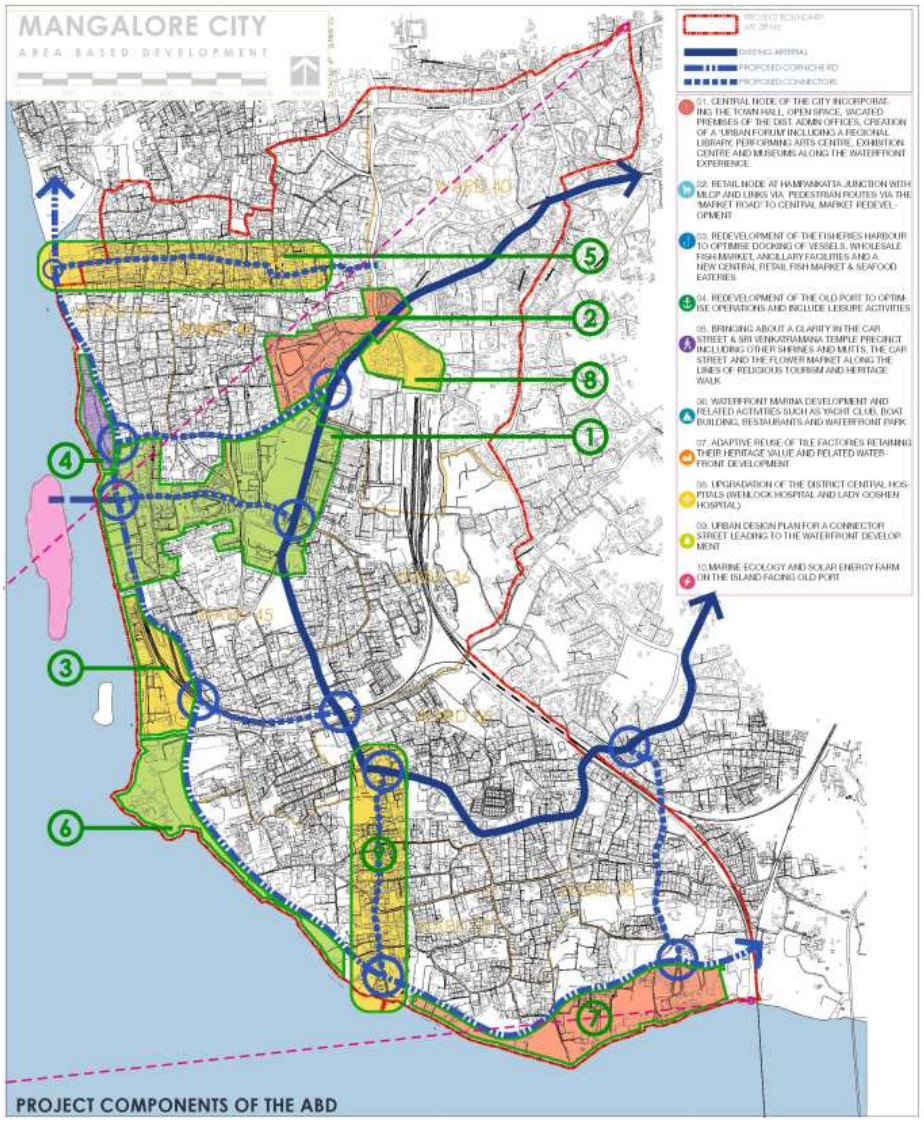


Figure 10 Major Project Components of ABD Area under Smart City

Chapter 2 FIELD INVESTIGATIONS & ANALYSIS

2.1 Site Reconnaissance and Situation Analysis

Detailed Site Reconnaissance was carried out along the selected roads to assess the existing situation in terms of pavement condition, traffic situation/movements, existing facilities/structures, smart elements that can be proposed along DPR-6 Smart Road. Section below describes brief of existing condition of DPR-6 Smart Road

2.1.1 Old Kent Road

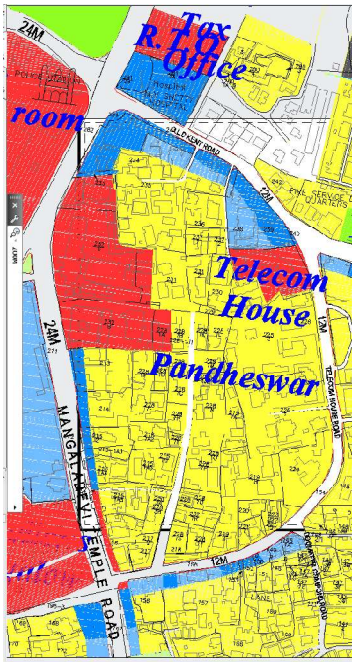
It stretches from AB Shetty circle to Mangaladevi road.

Road Details:

- Total length of road = 820 mts
- Min. width = 9.00 mts
- Max. Width = 12.20 mts
- Slope: 0.25%
- Type of Carriageway: Flexible and partly Rigid Road. Road condition is good. Partially poor at junctions.
- Lane configuration: 2 Lane carriageway two way. 4 lane at Fire Station Junction. No Median.

Existing Utilities:

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



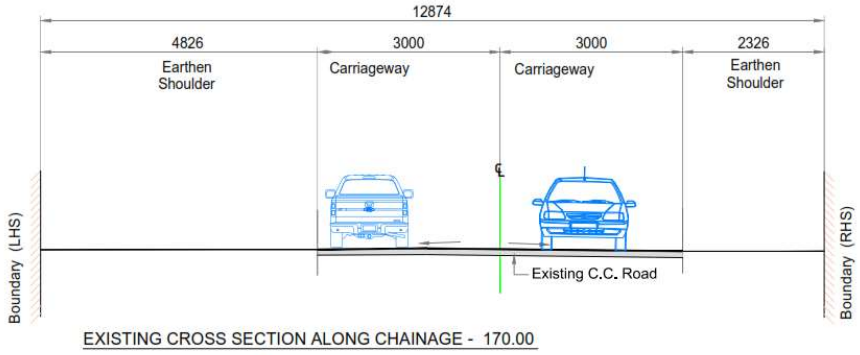


Figure 11 Existing Cross Section, Site Photographs and MUDA Master Plan layout of Old Kent Road

OBSERVATIONS:

- On the northern and southern sides of the road, Commercial land use is observed
- On Southern side, apart from commercial, residential landuse is observed.
- Decent on-street parking is observed on the street as there is ample space beside road.

The proposed ROW as per MUDA master plan is 12 m.

2.1.2 Pandeshwara New Road

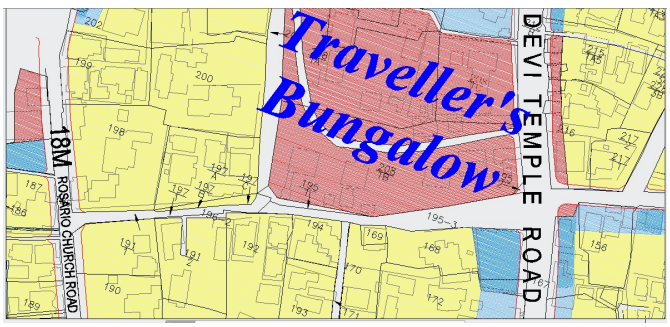
It stretches from Mangaladevi Road to Rosario Church Road.

Road Details:

- Total length of road = 280 m
- Min. width = 6.50 m
- Max. Width = 10.00 m
- Slope: 0.25%
- Type of Carriageway: Flexible road. Road condition is good.
- Lane configuration: 1 Lane & 2 Lane carriageway two way. Median not present.

Existing Utilities:

- The electrical lines are present above ground
- Storm water drain existing on south side of the road.
- Waterline is present on one side (south side) of the carriage way.



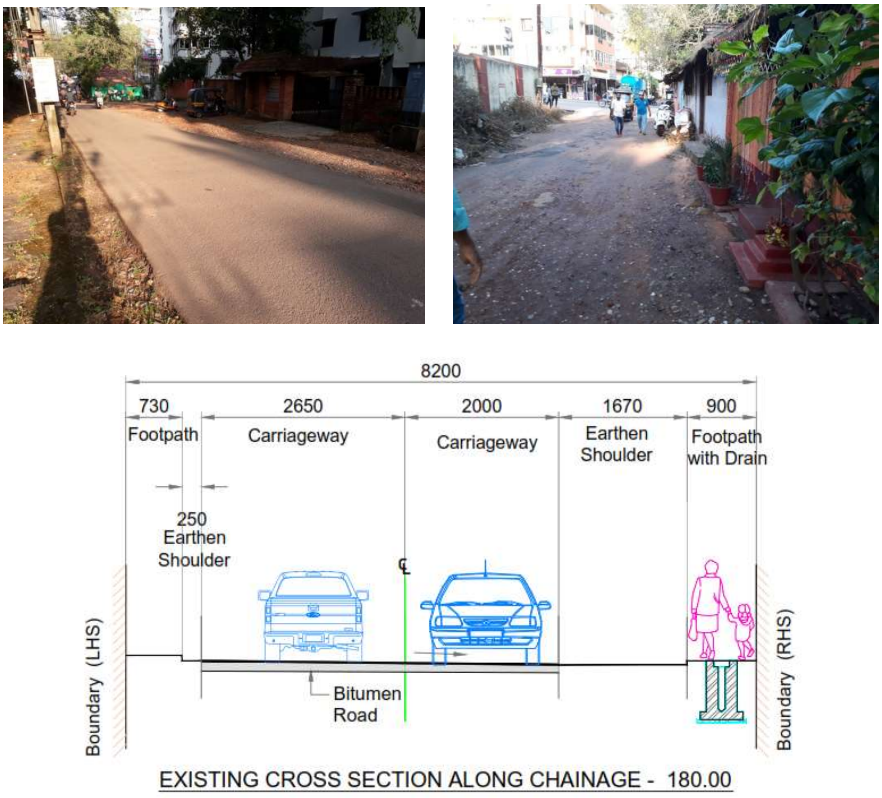


Figure 12 Existing Cross Section, Site Photographs and MUDA Master Plan layout of New Pandeswara Road

OBSERVATIONS:

- North side near junction of Mangaladevi Road, mostly residential landuse is prevalent.
- At junction, the quality of road is BT and poor
- On-street parking is not observed on the street as the road is completely residential.

2.1.3 Bolar Fisheries College Road

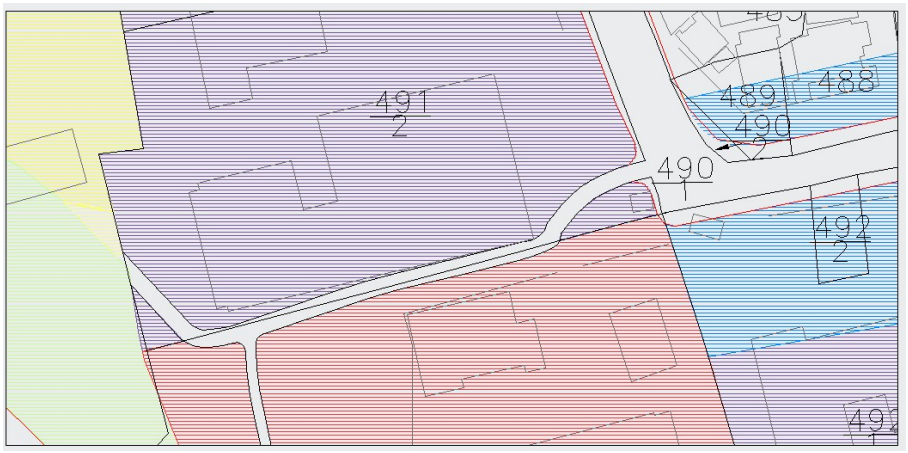
It stretches from KFDC Jn to Port Sea Face.

Road Details:

- Total length of road = 150 m
- Min. width = 6.90 m
- Max. Width = 8.80 m
- Slope: 0.25%
- Type of Carriageway: Earthen road. Road condition is poor.
- Lane configuration: 1 Lane carriageway two way. Median not present.

Existing Utilities:

- The electrical lines are present above ground
- Storm water drain line is present on south side.
- Waterline is present on one side of the carriage way i.e. South side.



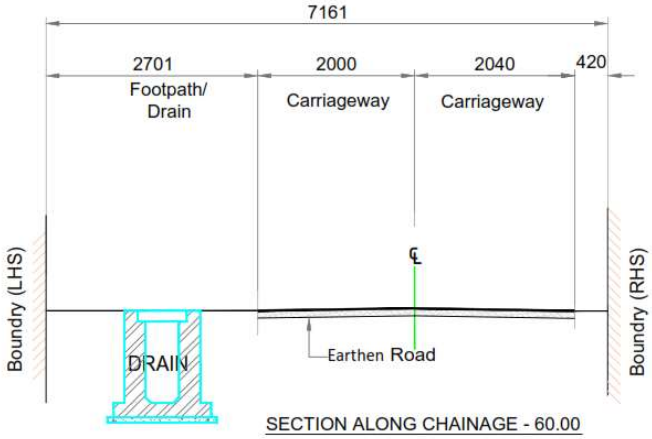


Figure 13 Existing Cross Section, Site Photographs and MUDA Master Plan layout of New Pandeswara Road

OBSERVATIONS:

- Surrounding the road, mostly commercial landuse is prevalent.
- Near junctions, rigid pavement is present.
- On-street parking is observed on the street despite narrow road.
- Road condition is poor

2.1.4 Mulihithulu Road

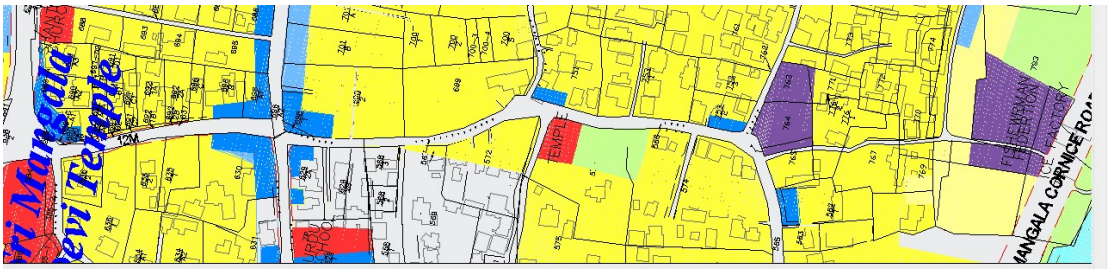
It stretches from Mangaladevi Temple Junction to Mulihithulu Residential Area.

Road Details:

- Total length of road = 920 m
- Min. width = 7.00 m
- Max. Width = 11.40 m
- Slope: 0.25%
- Type of Carriageway: Flexible road. Half BT road is good in condition. Half BT/Earthen Road condition is Poor.
- Lane configuration: 2 Lane carriageway two way. Median not present.

Existing Utilities:

- The electrical lines are present above ground
- Storm water drain line is present on one side i.e. West Side.
- Waterline is present on one side i.e. West Side.



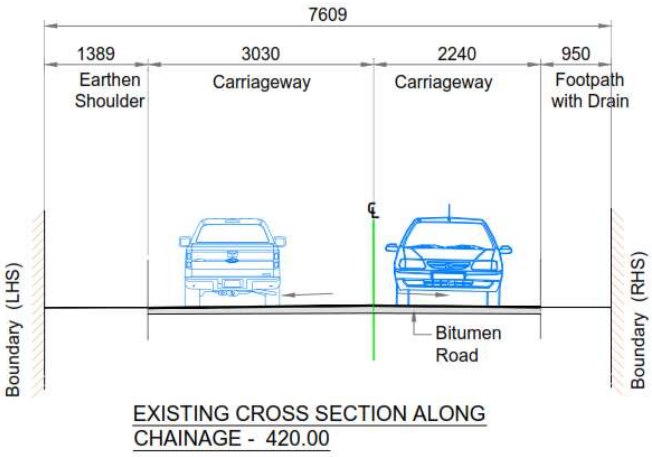


Figure 14Existing Cross Section, Site Photographs and MUDA Master Plan layout of Mulihithulu Road

OBSERVATIONS:

- Surrounding the road, mostly residential landuse is prevalent.
- At junctions, commercial landuse is observed.
- The road near Mangaladevi Temple and Bolar road are in ver good condition. Apart from these, the road that connects Mulihithulu Residential area has worn out and is in bad condition.

2.1.5 Mangaladevi Temple Road

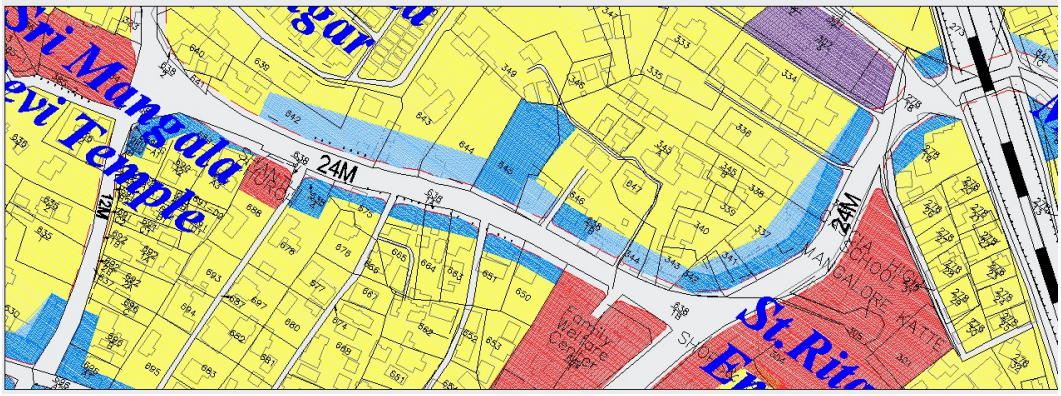
It stretches from Mangaladevi Temple Junction to Jaihind Circle.

Road Details:

- Total length of road = 830 m
- Min. width = 21.60 m
- Max. Width = 27.50 m
- Slope: 0.25%
- Type of Carriageway: Flexible road. Road condition is Good.
- Lane configuration:4 Lane & 6 Lane carriageway two way. Median not present.

Existing Utilities:

- The electrical lines are present above ground
- Storm water drain line is present on both sides.
- Waterline is present on both sides of carriageway.



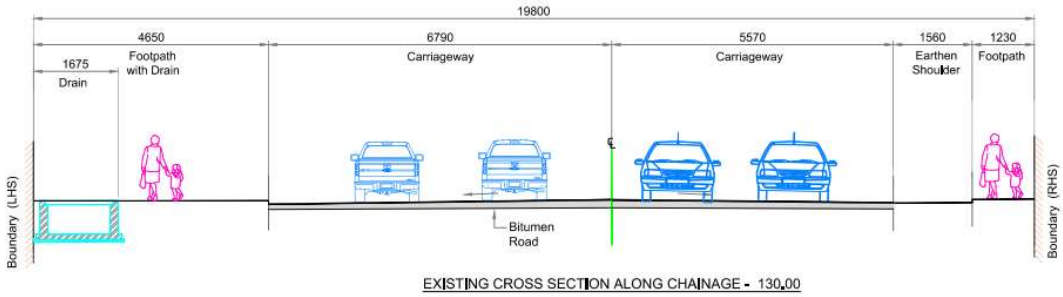


Figure 15 Existing Cross Sections, Site Photographs and MUDA Master Plan layout of Mangaladevi Temple Road

OBSERVATIONS:

- Northside road is mostly lines with institutional buildings.
- Southside road is prevalent with residential landuse.
- On-street parking is observed which Pay & Park at most places.

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

2.1.6 Monkey Stand Road

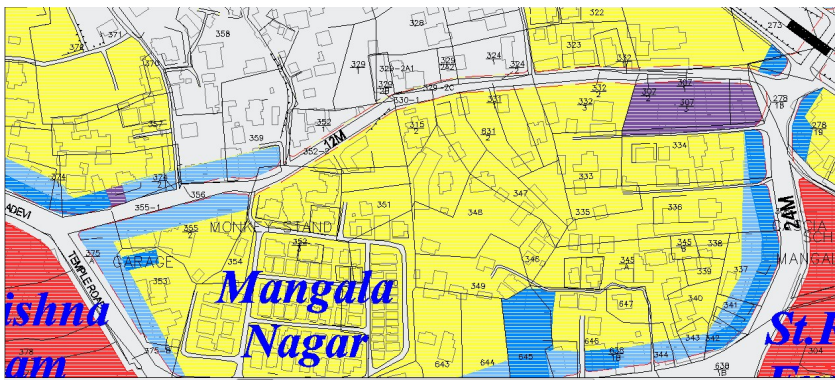
It stretches from Mangaladevi Road to near Jaihind Circle.

Road Details:

- Total length of road = 539 m
- Min. width = 6.50 m
- Max. Width = 18.05 m
- Slope: 0.25%
- Type of Carriageway: Flexible road. Road condition is Good but poor at few places.
- Lane configuration: 2 Lane carriageway two way. Median not present.

Existing Utilities:

- The electrical lines are present above ground
- Storm water drain line is present on both sides of carriageway.
- Waterline is present on both sides of carriageway.



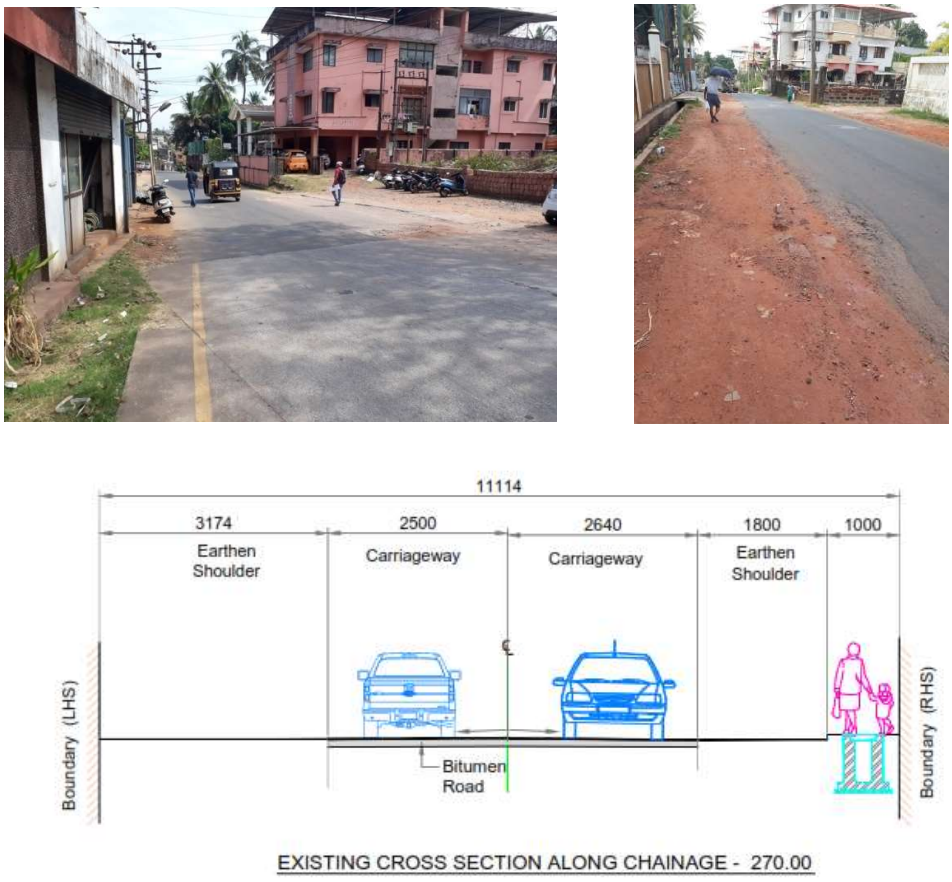


Figure 16 Existing Cross Sections, Site Photographs and MUDA Master Plan layout of Kudumbi Garden (DBS) Road

OBSERVATIONS:

- Surrounding the road, mostly residential landuse is prevalent.
- No much On-street parking observed as there is no ample space beside road.
- Most space near Jaihind Circle beside C/w is earthen.
- At major junctions, Institutional landuse is observed.

The proposed ROW as per MUDA master plan is 12 m.

2.1.7 Jeppu Market Road

It stretches from Artificial Limbs Center Jn to Jeppu Market Jn.

Road Details:

- Total length of road = 225 m
- Min. width = 13.10 m
- Max. Width = 20.35 m
- Slope: 0.25%
- Type of Carriageway: Flexible road. Road Condition is good.
- Lane configuration: 2 Lane carriageway two way. Median not present.

Existing Utilities:

- The electrical lines are present above ground
- Storm water drain line is present on both sides.
- Waterline is present on one side of carriageway.

Figure 17 Existing Cross Sections, Site Photographs and MUDA Master Plan layout of Azizuddin Road

OBSERVATIONS:

- Surrounding the road, mostly commercial landuse is prevalent.
- On-street parking is observed as the road houses lots of commercial shops.
- At Jeppu Jn, a part is existing towards West side. Due to this, there is ample parking beside roadside.

2.1.8 Gujjarakere Road

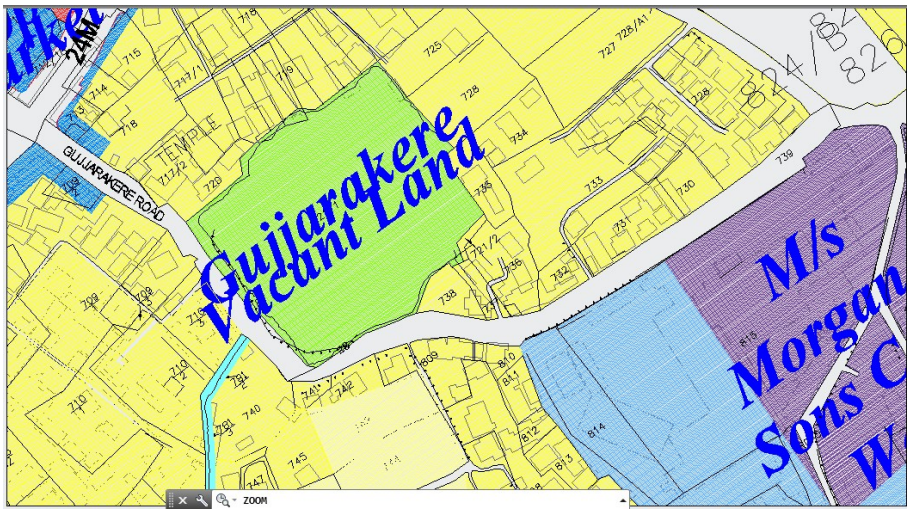
It stretches from Jeppu Market Jn to Mphasis Jn.

Road Details:

- Total length of road = 645 m
- Min. width = 8.30 m
- Max. Width = 16.90 m
- Slope: 0.25%
- Type of Carriageway: Flexible road. Condition is poor at most places.
- Lane configuration: 2 Lane carriageway two way. Median not present.

Existing Utilities:

- The electrical lines are present above ground
- Storm water drain line is present on both sides of carriageway.
- Waterline is present on both sides of carriageway.



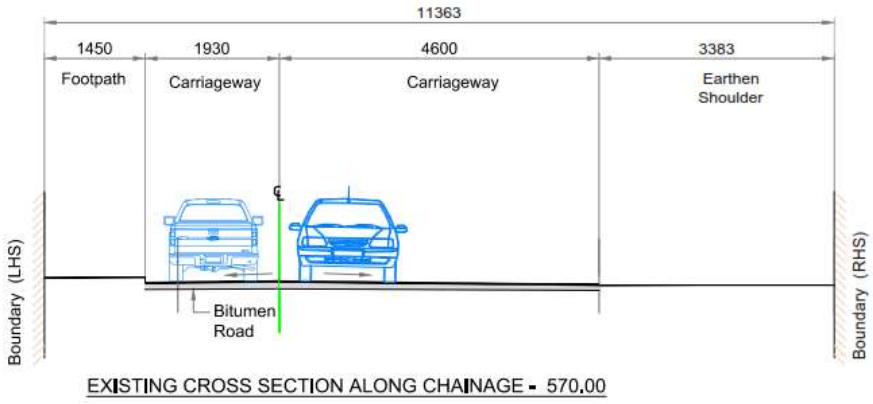


Figure 18 Existing Cross Sections, Site Photographs and MUDA Master Plan layout of Jumma Masjid Road

OBSERVATIONS:

- Surrounding the road, mostly residential landuse is prevalent.
- On-street parking is observed at few places.
- Road becomes narrow at few places due to variable slopes and undulations.
- Road is flexible with potholes at various places and the road near Gujjarekere pond is worn-out.

2.2 Road Inventory Survey

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

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

2.3 Trial pits

The Cement Concrete roads are proposed to be retained as they are constructed recently about 3-5 years back. The bituminous roads are proposed to be replaced with Cement Concrete roads. For this purpose samples are taken for investigations and are being analysed. The photographs are provided below:

Figure 19 Trial Pits Survey Site Photographs Traffic Surveys and Analysis

2.4 Survey Introduction

2.4.1 Project Background

This chapter presents the traffic surveys, analysis and future strategy for Smart Roads under Package 6, referred to as DPR-6.

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

Based on the roads and junction identified under DPR-6, detailed primary surveys and investigation were carried out. Table 9 below defines various Traffic surveys and investigations carried out along the identified Road

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

2.4.2 Scope of Work

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

1. OLD KENT ROAD (AB Shetty Circle – Mangaladevi Road)
2. PANDESHWARA NEW ROAD (Mangaladevi Road – RosarioChurch Road)
3. BOLAR FISHERIES COLLEGE RD (Bolar KFDC Jn – KFDC Sea Face)
4. MULIHITHLU ROAD (Mangaladevi Temple Jn – Mulihithulu Residential Area)
5. MANGALADEVI TEMPLE ROAD (Mangaladevi Temple Jn – Jaihind Circle)
6. MONKEYSTAND NEW ROAD (Mangaladevi Road – Jaihind Circle)
7. JEPPU MARKET ROAD (Artificial Limbs Centre Jn – Jeppu Market Jn)
8. GUJJARKERE ROAD (Jeppu Market Jn – Mphasis Jn)

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

The Figure attached here 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 below in Table 10.

Figure 20 Survey work in progress

2.4.3 Survey Types and Locations

Surveys were conducted at 8 different locations on these roads and the schedule of these traffic surveys is given in table below:

Table 9 Traffic Surveys and Investigations conducted along the DPR-6 Roads

S.No.	Location	Survey	Schedule
1	Hamilton Circle Junction	TMC	25/07/2017
2	Junction of Maidan Road and Old Kent Road	TMC	24/07/2017
3	KFDC Junction	TMC	13/02/2019
4	Mangaladevi Temple Junction	TMC	07/01/2019
5	Mangaladevi Cross Road Junction	TMC	19/12/2018
6	Monkeystand Shivanagar Junction	TMC	17/12/2018
7	Jeppu Market Road Junction	TMC	18/02/2019
*(*TMC – Turning Movement Count, TVC – Traffic Volume Count)*			

Table 10 Traffic Surveys - Vehicle Classification system

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

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

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

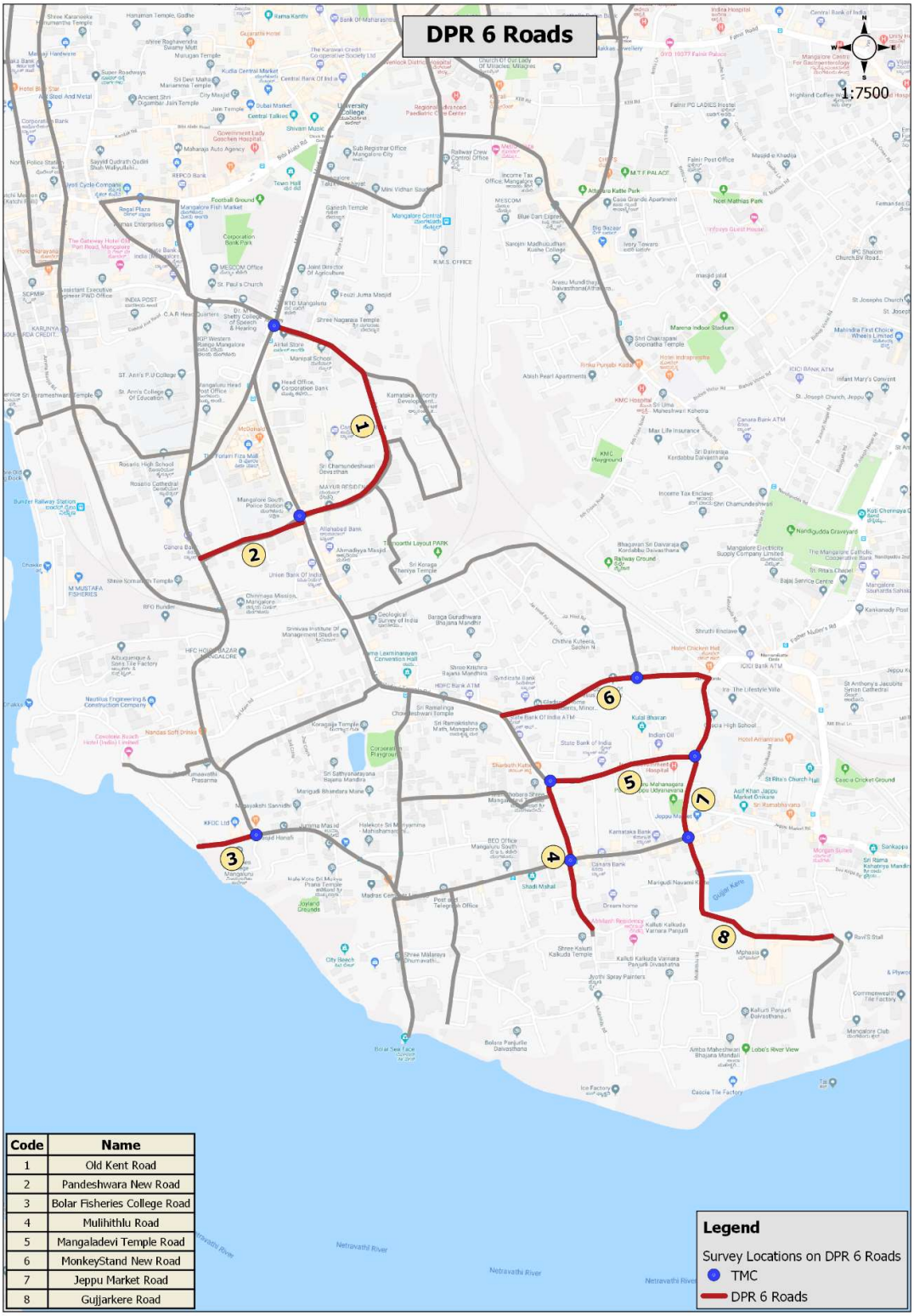


Figure 21: Traffic Survey Location

2.4.4 TRAFFIC ANALYSIS

2.4.4.1 Methodology

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

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

2.4.4.2 Classified Traffic Volume Counts

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

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

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

The various vehicle types having different sizes and characteristics were converted into equivalent Passenger Car Units. The Passenger Car Unit (PCU) factors recommended by Indian Road Congress in "*Guidelines for Capacity of Urban Roads in Plain Areas"* (IRC-106-1990) have been used for conversion, and are presented in table below:.

Vehicle Type	Equivalent PCU Factors	
	Percentage Vehicle Type in Traffic Stream	
	5%	10% and above
1. Two Wheelers/Motor Cycle or Scooter	0.5	0.75
2. Passenger Car, Pick-up van	1.0	1.0
3. Auto-rickshaw	1.2	2.0
4. Light Commercial Vehicle	1.4	2.0
5. Truck or Bus	2.2	3.7
6. Agricultural Tractor Trailer	4.0	5.0
7. Cycle	0.4	0.5
8. Cycle Rickshaw	1.5	2.0
9. Tonga (Horse drawn vehicle)	1.5	2.0
10. Hand Cart	2.0	3.0

Table 11 PCU Factors Adopted for Study

2.4.4.3 Annual Average Daily Traffic (AADT)

The traffic survey data is analyzed and the Average Daily Traffic (ADT) is presented below

Table 12 Average Daily Traffic

Mode	Old Kent Road	Pandeshwara New Road	Bolar Fisheries College Road	Mulihithlu Road
2w	3,915	519	489	8
3w	1,566	283	96	22
Car/Van	2,061	334	46	77
Mini Bus	59	4	-	4
Bus	14	5	-	357
MLCV	1	-	78	7
LCV	87	19	2	2
2 Axle Truck	9	3	8	-
3 Axle Truck	-	-	-	-
MAV	1	1	-	-
Tractor	-	-	-	-
Tractor+Trailer	-	-	-	-
Cycle	8	3	5	1
Cycle rickshaw	-	-	-	-
Animal Drawn	2	-	-	-
Hand Cart	-	-	-	-
Total Veh	**7,723**	**1,171**	**724**	**478**
Total PCU	**8,394**	**1,342**	**705**	**1,440**

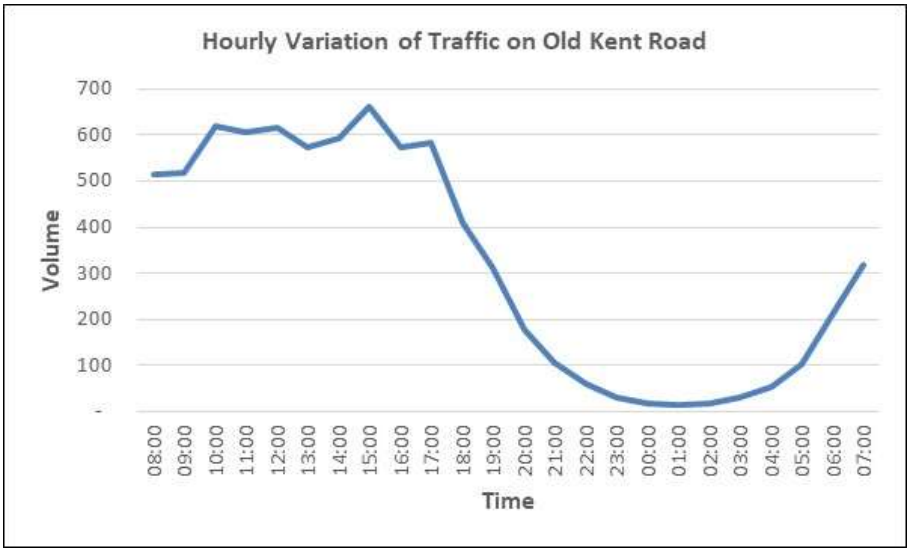
Mode	Mangaladevi Temple Road	Monkeystand New Road	Jeppu Market Road	Gujjarkere Road
2w	22,613	8,592	16,116	2,810
3w	4,301	1,932	2,870	498
Car/Van	6,170	2,428	4,103	549
Mini Bus	105	58	63	17
Bus	591	17	413	18
MLCV	1,806	357	1,304	80
LCV	693	-	419	14
2 Axle Truck	7	134	8	16
3 Axle Truck	4	2	1	1
MAV	-	-	-	-
Tractor	1	-	1	-
Tractor+Trailer	-	-	-	-
Cycle	36	20	26	45
Cycle rickshaw	-	-	-	-
Animal Drawn	-	-	-	-
Hand Cart	-	-	-	-
Total Veh	**36,327**	**13,540**	**25,324**	**4,048**
Total PCU	**35,998**	**13,519**	**24,852**	**3,871**

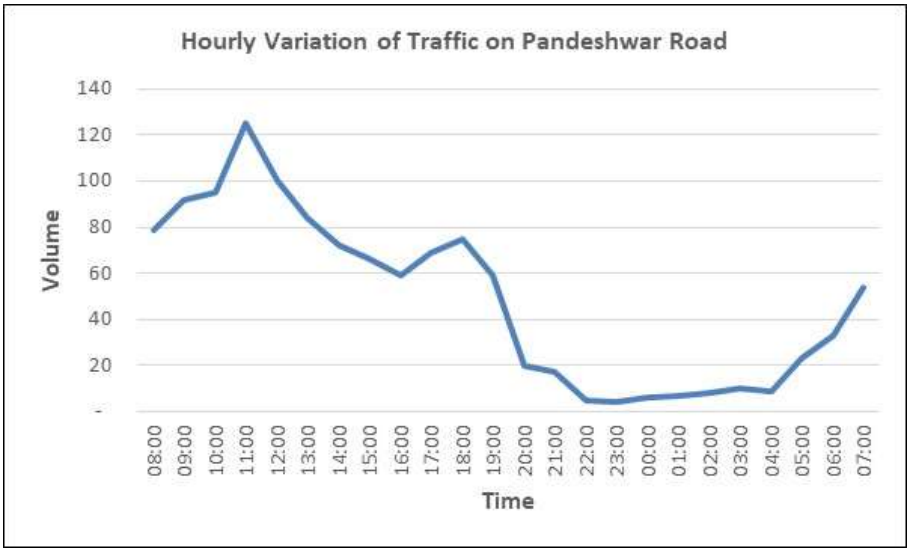
Traffic volume is highest on Mangaladevi Temple Road at 35,998 PCU followed by Jeppu Market road at 24,852 PCU. Bolar fisheries road and Mulihithlu road have very little traffic. The details of rest of the roads is given in the above table.

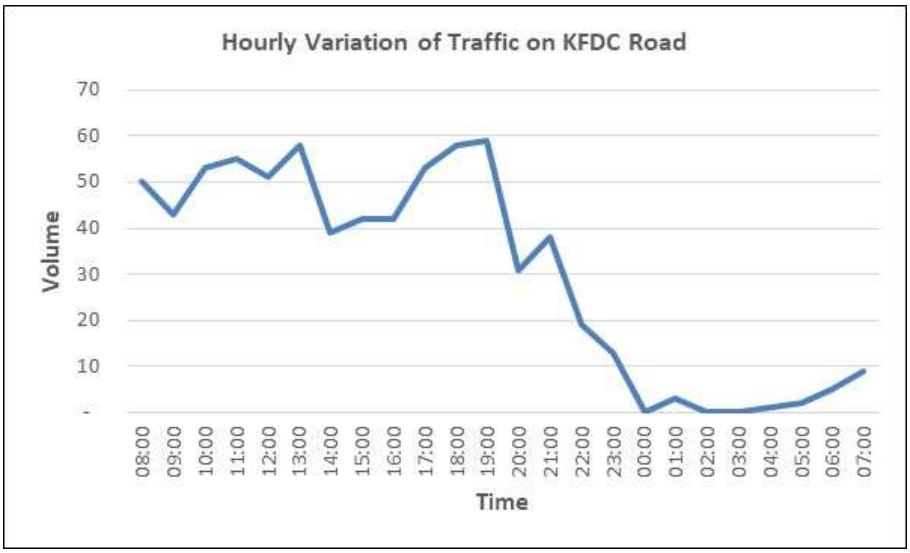
Since these are urban roads seasonal variations are minimal and, hence, ADT is considered as AADT.

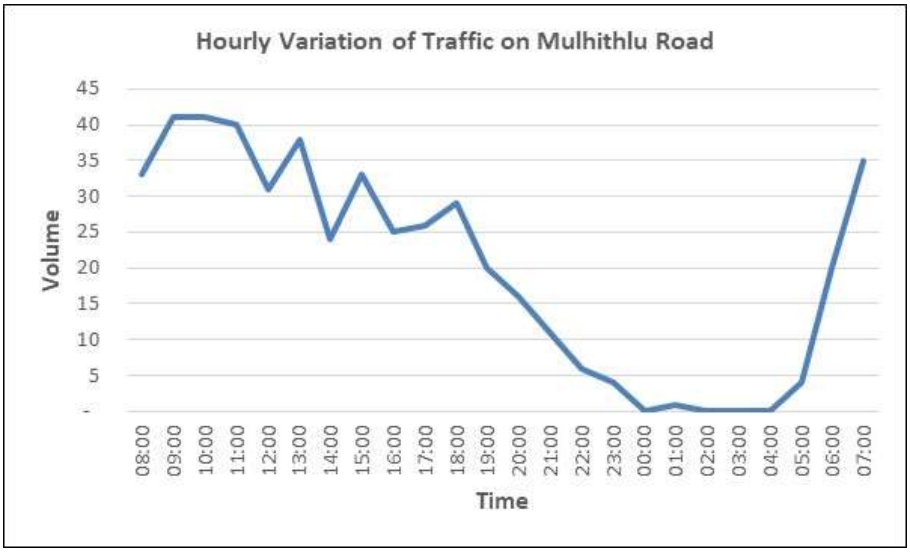
2.4.4.4 Hourly Variation

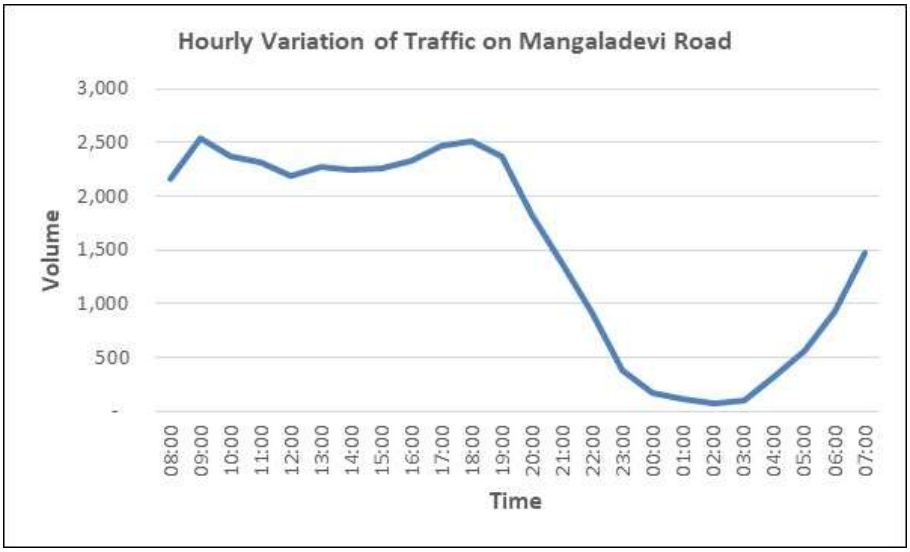
The hourly variation of traffic at survey locations is presented in following Figure .






Hourly Variation of Traffic on KFDC Road
Volume
70
60
50
40
30
20
10
-
08:00
09:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
Time


Hourly Variation of Traffic on Mulhithlu Road
Volume
45
40
35
30
25
20
15
10
5
-
08:00
09:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
Time


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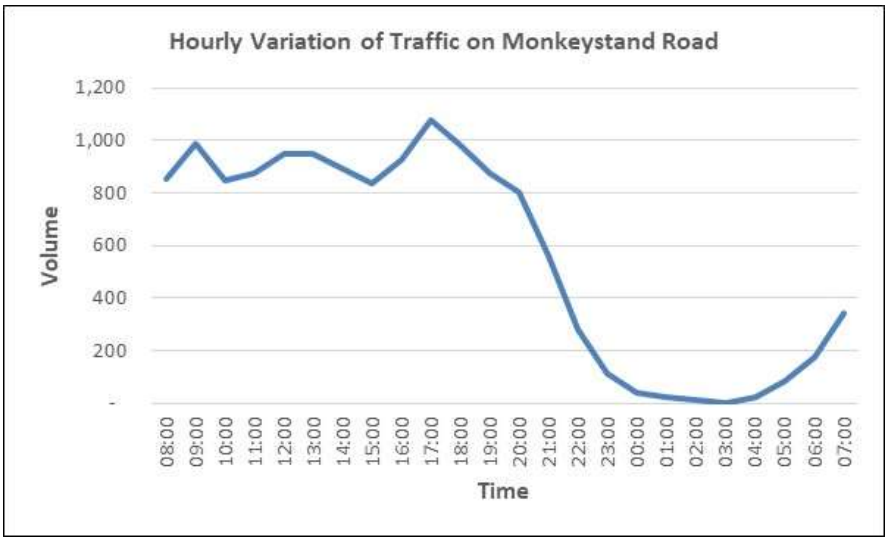
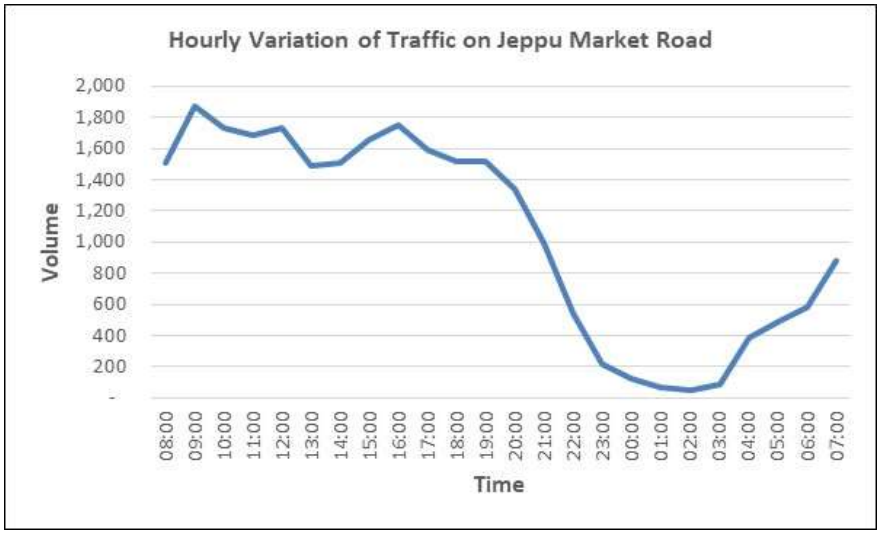
05:00
06:00
07:00
Time





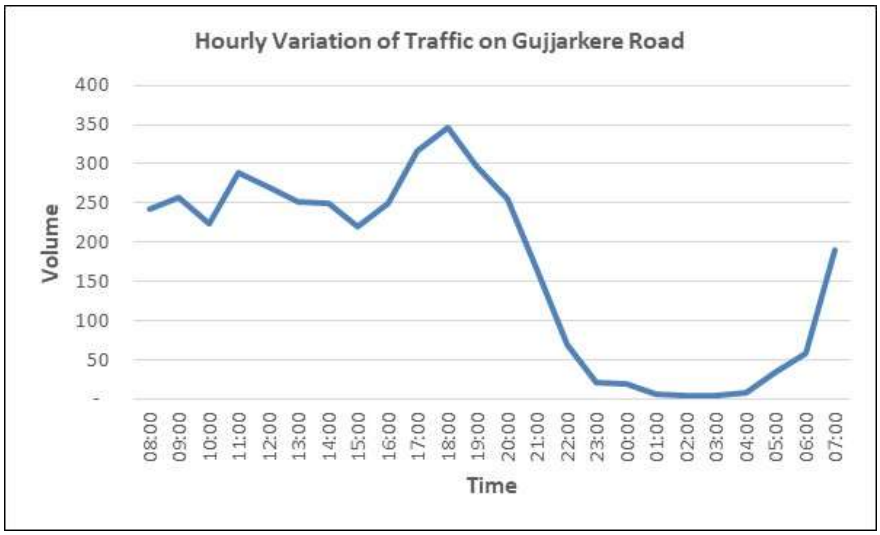
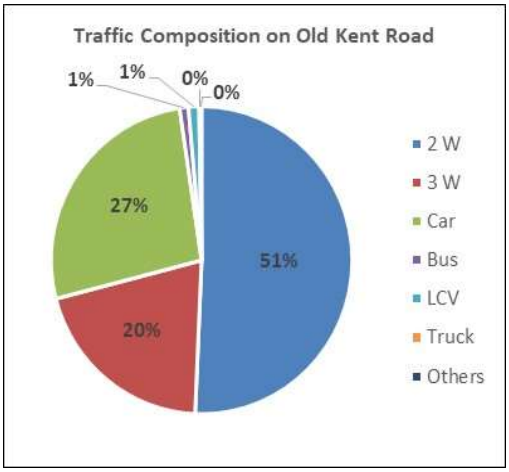
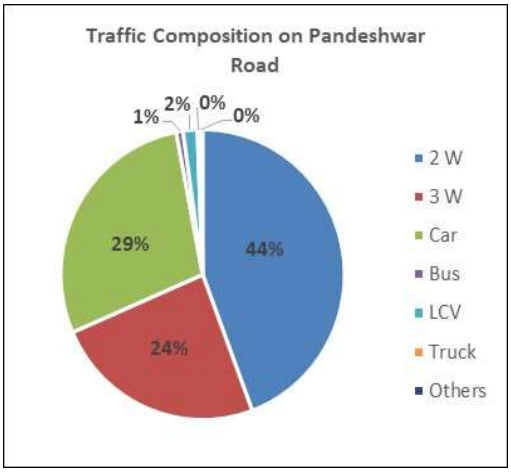


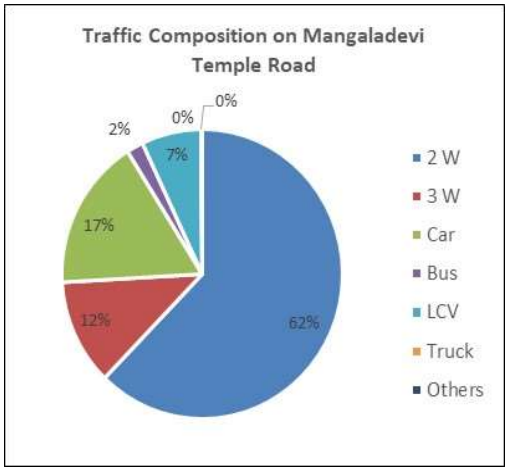
Figure 22 Hourly Variation Graphs of Traffic on DPR-6 Smart roads

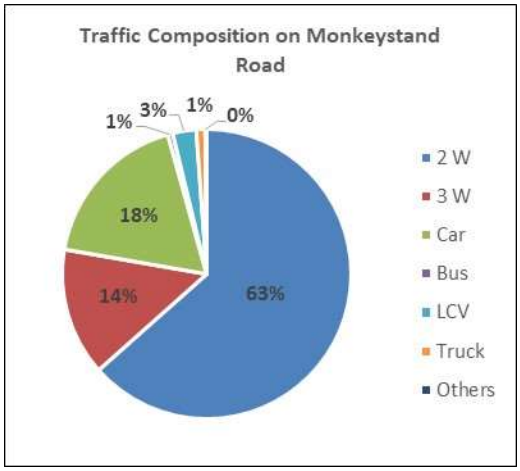
2.4.4.5 Traffic Composition

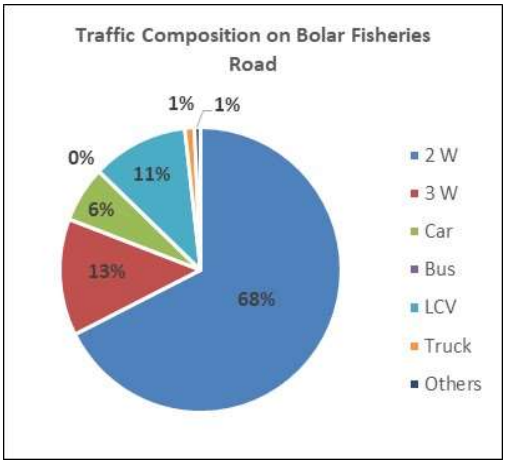
The composition of traffic at the survey locations is presented in Following Figures 23.

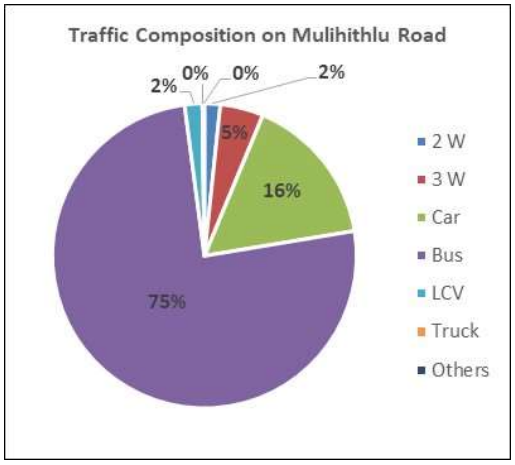












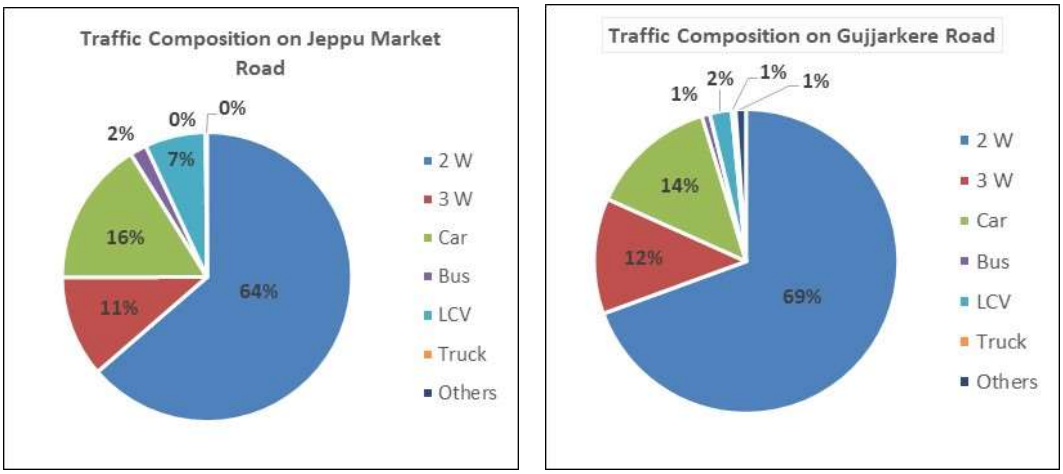


Figure 23 Hourly Variation Graphs of Traffic on DPR-6 Smart roads

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

Table 13 Composition of Passenger and Commercial Vehicles

Mode	Old Kent Road	Pandeshwara New Road	Bolar Fisheries College Road	Mulihithlu Road
Passenger	99%	98%	87%	98%
Commercial	1%	2%	12%	2%

Mode	Mangaladevi Temple Road	Monkeystand New Road	Jeppu Market Road	Gujjarkere Road
Passenger	93%	96%	93%	96%
Commercial	7%	4%	7%	3%

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

Mode	Old Kent Road	Pandeshwara New Road	Bolar Fisheries College Road	Mulihithlu Road
Private Vehicles	99%	99%	100%	23%
Public Vehicles	1%	1%	0%	77%

Mode	Mangaladevi Temple Road	Monkey Stand New Road	Jeppu Market Road	Gujjarkere Road
Private Vehicles	98%	99%	98%	99%
Public Vehicles	2%	1%	2%	1%

Table 14 Composition of Public and Private modes of transport

The observations on the traffic and composition are:

- Passenger vehicles comprise about 87-99% of the total vehicles and commercial vehicles range between1-12%. Bolar Fisheries College road and Mangaladevi Road have higher commercial vehicles.
- Private vehicles are occupying the major portion of the urban road space. About 98-100% of the vehicles except Mulihithlu road are private vehicles and balance are public transport vehicles (mini bus+bus).

2.4.4.6 Peak Hour Analysis

In urban context, the roads are designed to cater to the requirements of peak hour volume. Hence, peak hour traffic analysis is done and presented in following tables

Table 15 Peak Hour Volume and Peak %age

Description	Old Kent Road	Pandeshwara New Road	Bolar Fisheries College Road	Mulihithlu Road
Peak Hour	15:00-16:00	11:00-12:00	19:00-20:00	09:00-10:00
Peak, Vol	662	125	59	41
Peak,% (Vol)	8.57%	10.67%	8.15%	8.58%
Peak, PCU	725	151	65	122
Peak,% (pcu)	8.64%	11.27%	9.22%	8.49%

Description	Mangaladevi Temple Road	Monkeystand New Road	Jeppu Market Road	Gujjarkere Road
Peak Hour	09:00-10:00	17:00-18:00	09:00-10:00	18:00-19:00
Peak, Vol	2,543	1,076	1,874	346
Peak,% (Vol)	7.00%	7.95%	7.40%	8.55%
Peak, PCU	2,520	1,092	1,904	338
Peak,% (pcu)	7.00%	8.08%	7.31%	8.73%

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

1. Hamilton Circle Junction
2. KFDC Junction
3. Mangaladevi Temple Junction
4. Mangaladevi Cross Road Junction
5. Monkeystand Shivanagar Junction
6. Jeppu Market Road Junction

Analysis of these junctions is carried out. The daily turning traffic volumes and PCU are presented at Figure 5-9.

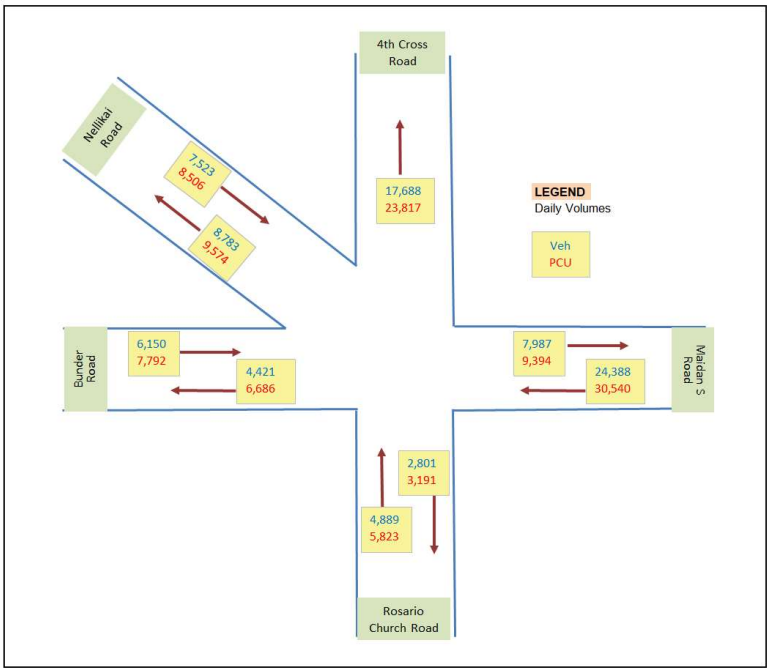


Figure 24: Hamilton Circle Junction

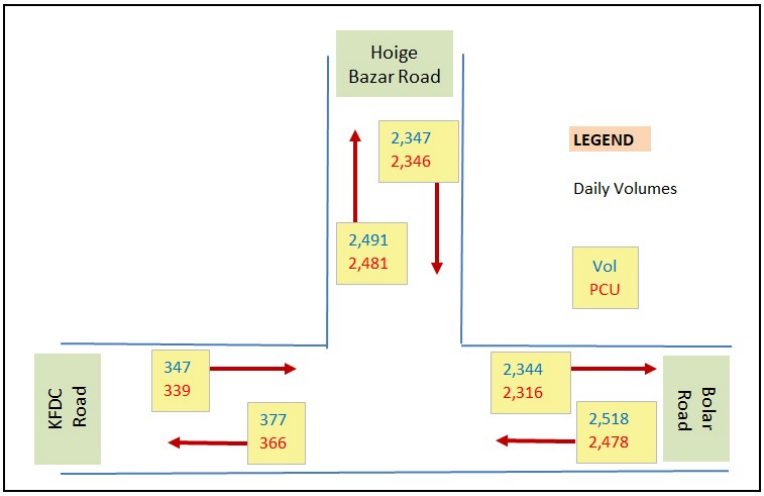


Figure 25: KFDC Circle

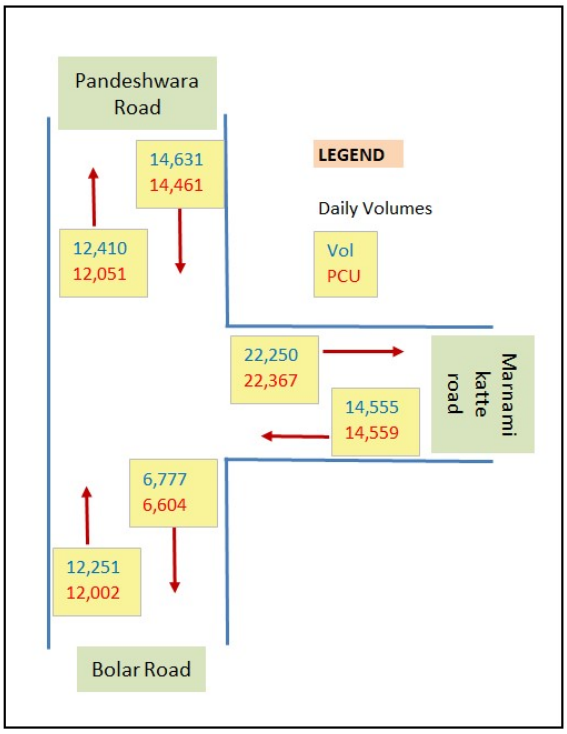


Figure 26: Mangaladevi Temple Junction

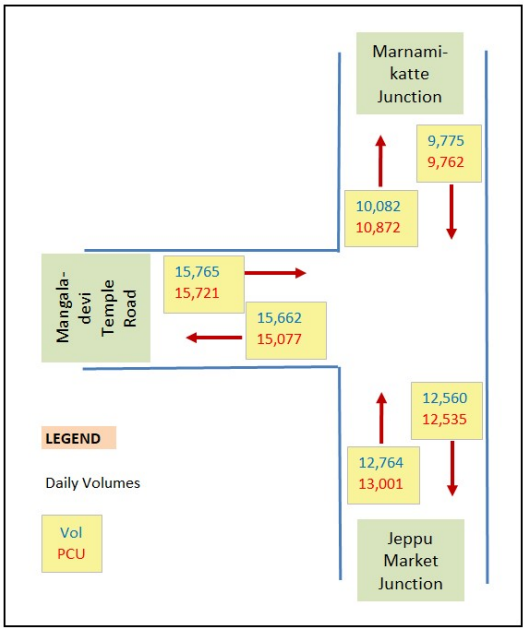


Figure 27: Mangaladevi Cross Road Junction

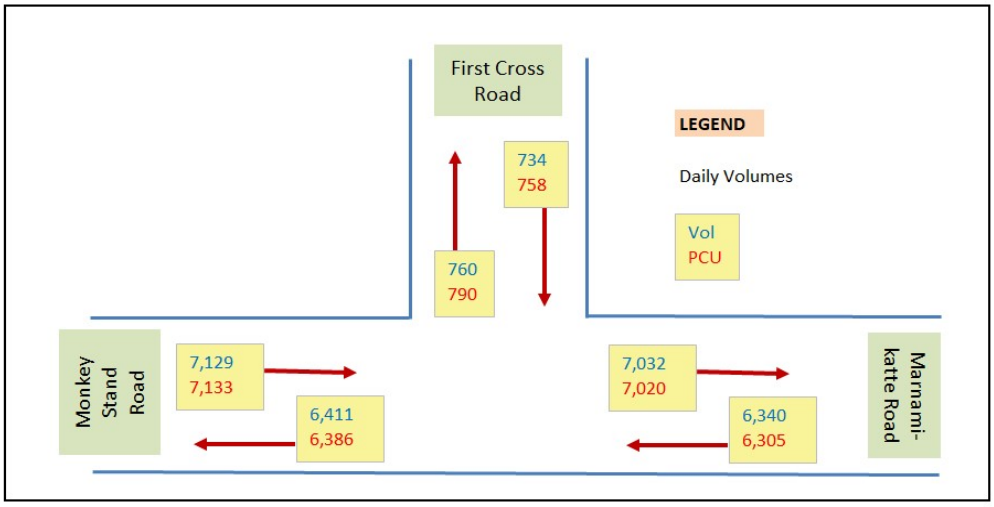


Figure 28: Monkeystand Shivanagar Junction

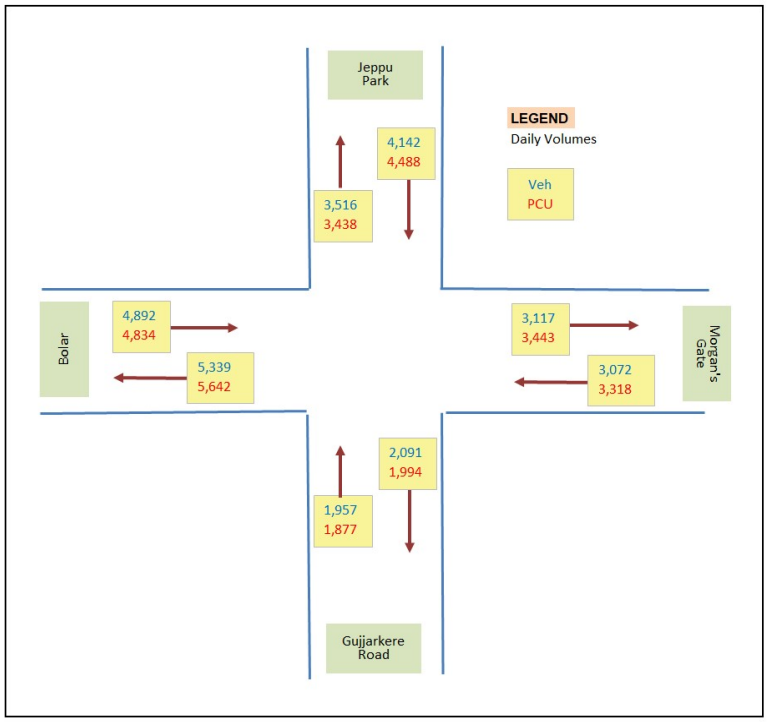


Figure 29: Monkeystand Shivanagar Junction

2.4.5 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 Following tables:

Table 16 Projected Peak hour volumes in PCU

Year	Old Kent Road	Pandeshwara New Road	Bolar Fisheries College Road	Mulihithlu Road
2018	725	151	65	122
2020	768	160	69	127
2025	889	185	79	141
2030	1,028	213	91	156
2035	1,189	246	105	173
2038	1,298	268	114	183

Year	Mangaladevi Temple Road	Monkeystand New Road	Jeppu Market Road	Gujjarkere Road
2018	2,520	1,092	1,817	338
2020	2,667	1,157	1,923	358
2025	3,074	1,337	2,217	413
2030	3,545	1,546	2,556	476
2035	4,088	1,787	2,948	550
2038	4,454	1,950	3,212	599

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

Table 17 Detailed Analysis of Junction Traffic for Present condition and Future Predictions (As per IRC -92)

Junction Traffic Analysis			IRC :SP-41 Criteria (Vehicle Per Day)					
SN	Jn. Category	Name of Intersection	2018		2020		2025	
			Major Rd	Minor Rd	Major Rd	Minor Rd	Major Rd	Minor Rd
1	4 Leg	Hamilton Junction	30,538	12,142	32,302	12,868	37,177	14,882
2	3 Leg	KFDC Junction	4,865	347	5,152	367	5,947	423
3	3 Leg	Mangaladevi Temple Junction	29,186	12,251	30,903	12,990	35,655	15,038
4	3 Leg	Monkeystand Junction	13,469	734	14,278	778	16,519	901
5	3 Leg	Mangaladevi cross road junction	28,529	9,775	30,217	10,356	34,890	11,966

Junction Traffic Analysis			IRC :SP-41 Criteria (Vehicle Per Day)					
SN	Jn. Category	Name of Intersection	2028		2035		2038	
			Major Rd	Minor Rd	Major Rd	Minor Rd	Major Rd	Minor Rd
1	4 Leg	Hamilton Junction	40,454	16,239	49,289	19,909	53,652	21,727
2	3 Leg	KFDC Junction	6,483	461	7,929	562	8,644	612
3	3 Leg	Mangaladevi Temple Junction	38,855	16,420	47,494	20,159	51,768	22,012
4	3 Leg	Monkeystand Junction	18,030	984	22,119	1,208	24,145	1,320
5	3 Leg	Mangaladevi cross road junction	45,107	13,051	54,233	15,984	58,507	17,435

Table 18:Detailed Analysis of Junction as per IRC-92 Criteria

S.No.	Junction Category	Name of Intersection	Peak Hour PCU (2018)	Peak Hour PCU (2028)	Peak Hour PCU (2038)	Year Grade separation warranted	Remarks
1	4 Leg	Hamilton Junction	5,248	7,053	9,478	Grade Separation not required	Junction Improvement along with road development
2	3 Leg	KFDC Junction	510	685	921	Grade Separation not required	Junction Improvement along with road development
3	3 Leg	Mangaladevi Temple Junction	3,437	4,619	6,207	Grade Separation not required	Junction Improvement along with road development
4	3 Leg	Monkeystand Junction	1,217	1,636	2,199	Grade Separation not required.	Junction Improvement suggested
5	3 Leg	Mangaladevi cross road junction	3,299	4,433	5,958	Grade Separation not required.	Junction Improvement suggested

Similarly pedestrian vehicular conflict is analyzed and presented at Table 19.

Table 19: Pedestrian Vehicular Conflict at Major Arm

S.No.	Name of Intersection	Peak Hour	Arm	PV^2X10^8	Proposal
1	KFDC Junction	18:00-19:00	Bolara road	0.18	Control Measure
			Hoigebazar road	0.14	Control Measure
			KFDC road	0.002	Control Measure
2	Mangaladevi Temple Junction	18:00-19:00	Pandeshwara	3.03	Control Measure
			Bolar road	3.26	Control Measure
			Marnamikatte	11.36	Control Measure
3	Monkeystand Junction	17:00-18:00	Marnamikatte road	0.62	Control Measure
			First Cross road	0.01	Control Measure
			Monkeystand road	0.77	Control Measure
4	Mangaladevi cross road junction	09:00-10:00	Marnamikatte Road	1.15	Control Measure
			Mangaladevi Temple	3.39	Control Measure
			Jeppu road	2.25	Control Measure

2.4.6 Capacity Analysis

2.4.6.1 Road Standards

IRC:SP:106-1990– "Guidelines for Capacity of Urban Roads in Plains" specifies Design Service Volume of different urban roads and is given in table 21:

Table 20 Recommended Design Service Volumes (PCU/Hr)

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

2.4.6.2 Junction Standards

IRC SP:41-1994, provides a graph for selection of intersection type based on traffic volumes which is reproduced in Figure 30for ready reference.

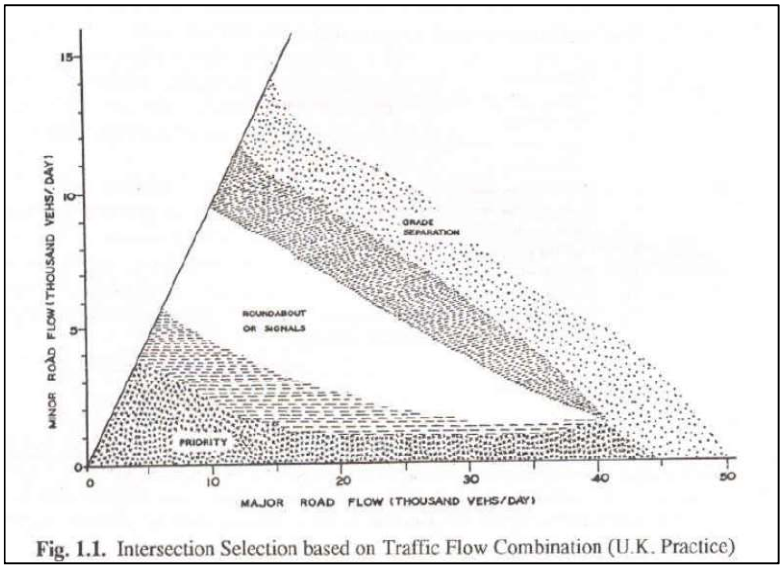


Fig. 1.1. Intersection Selection based on Traffic Flow Combination (U.K. Practice)

Figure 30: Intersection selection based on criteria

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

2.4.6.3 Pedestrian facilities

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

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

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

2.4.6.4 Lane Configuration Analysis

A) Roads

The existing lane configuration of roads and capacity is presented at table below.

Table 21 Existing Lane Configuration of Roads

	Old Kent Road	Pandeshwara New Road	Bolar Fisheries College Road	Mulihithlu Road
No of Lanes	2	2	1	2
Capacity	1,200	1,200	600	1,200

	Mangaladevi Temple Road	Monkeystand New Road	Jeppu Market Road	Gujjarkere Road
No of Lanes	4,6	1,2	2	1,2
Capacity	3600 , 5400	600 , 1200	1,200	1,200

The unconstrained capacity (lanes) requirement based on traffic analysis is given in table below. 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 22 Unconstrained Capacity Requirement Based on Traffic (Lanes)

Year	Old Kent Road	Pandeshwara New Road	Bolar Fisheries College Road	Mulihithlu Road
2018	2 L	2 L	2 L	2 L
2020	2 L	2 L	2 L	2 L
2025	2 L	2 L	2 L	2 L
2030	2 L	2 L	2 L	2 L
2035	2 L	2 L	2 L	2 L
2038	4 L	2 L	2 L	2 L

Year	Mangaladevi Temple Road	Monkeystand New Road	Jeppu Market Road	Gujjarkere Road
2018	4 L	2 L	4 L	1 L
2020	4 L	2 L	4 L	1 L
2025	4 L	4 L	4 L	1 L
2030	4 L	4 L	4 L	1 L
2035	6 L	4 L	4 L	1 L
2038	6 L	4 L	4 L	1 L

From the above analysis it can be seen that Pandeshwara new road, Mulihithlu road, Gujjarkere road do not require any capacity augmentation. Balance roads require capacity augmentation. Old Kent road requires capacity augmentation in the fag end which can be considered at a later date based on the ramp-up of the traffic. Even otherwise this road can function with little less LOS and hence can operate without capacity augmentation. Considering this Bolar fisheries college road, Monkey stand new road, Jeppu Market road require capacity augmentation. However, this being a developed town, space is a constraint.

B) Junctions

As per IRC 92 grade separation is not warranted as traffic at all the junctions is not more than 10,000 PCU/hr.

However as per IRC 41, grade separation is warranted if the traffic on major road crosses more than 45,000 vehicles and minor road traffic crosses more than 12,000 vehicles per day.

Hamilton Junction, Mangaladevi Temple Junction and Mangaladevi Cross road Junction qualify for grade separation. Since Hamilton Junction is already discussed in the earlier DPR it is not being discussed in this DPR.

However, space is a constraint. Considering this, grade separation is recommended as and when space is available at these locations and for the time being improvement of the junctions is suggested.

2.4.6.5 Pedestrian facilities

Based on the analysis, at many locations the PV2 values are higher than $2x10^8$ and hence mid-block and at junction control measures are suggested.

2.5 CARRIAGEWAY, JUNCTION IMPROVEMENT AND PAVEMENT DESIGN

2.5.1 Carriageway Improvement

2.5.1.1 Right of Way (ROW)

There are total of nine roads being improved in this phase namely:

1. Old Kent Road – From Old Kent Rd. to Mangaladevi Rd Jn.
2. Pandeshwara new Road – From Rosario Church Rd. to Pandeshwar New Rd.
3. Bolar Fisheries College Road – From Hoigebazar Rd. (KFDC Ltd) to Sea Face (Mangaluru Old Port)
4. Mulihithlu Road – From Mangaladevi Temple to Mulihithlu Rd.
5. Mangaladevi Temple Road – From Mangaladevi Temple to Marnamikatta Circle.
6. Monkeystand New road – From Mangaladevi Rd(Ramakrishna Math Jn) toJaihind Circle
7. Jeppur Market Road – From Abhaya Limbs Center to Jeppu Market Jn.
8. Gujjarkara Road – From Jeppu Market Jn. To Jappina Mogaru.

Details of existing ROW are as follows:

1. Old kent Road – Varies from 7.01 to 20.50 m
2. Pandeshwara new Road – Varies from 5.88 to 8.25 m
3. Bolar Fisheries College Road – Varies from 7.10 to 10.95 m
4. Mulihithlu Road – Varies from 6.57 to 14.10 m
5. Mangaladevi Temple Road – Varies from 19.40 to 32.90 m
6. Monkeystand New road – Varies from 7.39 to 15.65 m
7. Jeppur Market Road – Varies from 12.75 to 20.55 m
8. Gujjarkara Road – Varies from 8.27 to 19.50 m

MCC proposes to widen the streets, but it's 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 Annexure the Report provides details of Plan and Profile for DPR-6 roads

Table 23 Plan and Profile for DPR-6 roads

SN	Drawing no	Drawing Title	No of Sheets
1	WTE_2292_06_R_2.01	PLAN AND PROFILE OF OLD KENT ROAD (ROAD NO. 02) AT OLD KENT ROAD TO MANGALADEVI ROAD JUNCTION	1
2	WTE_2292_06_R_2.02	PLAN AND PROFILE OF BOLAR FISHERIES COLLEGE ROAD (ROAD	1

		NO. 04) AT HOIGEBAZAR ROAD (KFDC Ltd) TO SEA FACE (MANGALURU OLD PORT)	
3	WTE_2292_06_R_2.03	PLAN AND PROFILE OF MULIHITHLU ROAD (ROAD NO. 05) AT MANGALADEVI TEMPLE TO MULIHITHLU ROAD	1
4	WTE_2292_06_R_2.04	PLAN AND PROFILE OF JEPPU MARKET ROAD (ROAD NO. 08) AT ABHAYA LIMBS CENTER TO JEPPU MARKET JUNCTION	1
5	WTE_2292_06_R_2.05	PLAN AND PROFILE OF GUJJARKERE ROAD (ROAD NO. 09) AT JEPPU MARKET JUNCTION TO JAPPINA MOGARU	1
6	WTE_2292_06_R_2.06	PLAN AND PROFILE OF PENDESHWARA NEW ROAD (ROAD NO. 03) ROSARIO CHURCH ROAD TO PENDESHWARA NEW ROAD	1
7	WTE_2292_06_R_2.07	PLAN AND PROFILE OF MANGALADEVI TEMPLE ROAD (ROAD NO. 06) MANGALADEVI TEMPLE TO MARNAMIKATTA CIRCLE	1
8	WTE_2292_06_R_2.08	PLAN AND PROFILE OF MONKEYSTAND NEW ROAD (ROAD NO. 07) MANGALADEVI ROAD (RAMKRISHNA MATH JN.) TO JAIHIND CIRCLE	1

2.5.1.2 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 for sub arterial roads & 30 km/h for distributor / Collector roads.

2.5.1.3 Cross Sections

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

1. Old kent Road from Old Kent Road to Mangaladevi Road Junction is being developed as "2 lane undivided carriageway with bi-directional traffic". Lane width has been considered as 3.1 m. Raised footpaths are proposed on both sides wherever width of 1.20m or more is available.
2. Pandeshwara New Road from Rosario Church Road to Pandeshwar New Road is being developed as "2 lane undivided carriageway with bi-directional traffic". Lane width has been considered as 3.1 m. Carriageway width is 5.50m from CH 0+240 to CH 0+290. No Raised footpath has been proposed due to minimal space availability.
3. Bolar Fisheries College Road from Hoigebazar Road (KFDC Ltd.) to Sea Face (Mangaluru Old Port) is being developed as “2 Lane two way single carriageway”. Lane width has been considered as 2.75 m. Raised footpath is proposed on one side of the carriageway.
4. Mulihithlu Road from Mangaladevi Temple to Mulihithlu Road is being developed as “2 Lane two way single carriageway”. Lane width has been considered as 3.10 m. Raised footpaths are proposed on both sides wherever width of 1.00m or more is available.
5. Mangaladevi Temple Road from Mangaladevi Temple to Marnamikatta Circle is being developed as "4 lane two directional undivided carriageway". Lane width has been considered as 3.5m. Raised footpath is proposed on both sides considering the space availability.

6. Monkey stand New Road from Mangaladevi Road (Ramakrishna Math Junction to Jaihind Circle) is being developed as “2 Lane two way single carriageway”. Lane width has been considered as 3.10 m. Raised footpaths are proposed on both sides wherever width of 1.00m or more is available.
7. Jeppur Market Road from Abhaya Limbs Center to Jeppu Market Junction is being "4 lane two directional undivided carriageway”. Lane width has been considered as 3.10 m.Lane width considered is 2.75m from CH 0+170 to CH 0+220. Raised footpaths are proposed on both sides wherever width of 1.00m or more is available.
8. Gujjarkara Road from Jeppu Market Junction to Jappina Mogaru is being developed as “2 Lane two way single carriageway”. Lane width has been considered as 3.10 m. Raised footpaths are proposed on both sides wherever width of 1.00m or more is available.

2.5.1.4 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.

2.5.1.5 Geometry / Alignment

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

2.5.2 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.

2.5.2.1 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.

2.5.2.2 *Classification of Intersections types*

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

- Un signalized intersection,
- Signalized Intersection and
- Roundabouts

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

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

B) Signalized Intersection:

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

C) Roundabouts:

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

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

Table 24 Pros and Cons of Signalized Intersection and Roundabout

Signalized Intersection	Roundabout
Pros	
Signalized intersection can handle high traffic volumes	Reduces number of conflicts
Safety is ensured by eliminating conflicts through signalization	Ensures safety through speed reduction by design
	Minimum delays for all road users

Cons	
Higher delays for all road users	Roundabouts are not very effective for more than two circulatory lanes
	Roundabouts have capacity limitations and may not be able to handle a very high volume of traffic.

2.5.2.3 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.

2.5.2.4 Consideration for Intersection Design

Design of a safe intersection depends on following major factors:

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

2.5.2.5 Design Traffic Volumes:

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

2.5.2.6 Capacity of Intersections:

Intersection capacity is the maximum hourly rate at which vehicles can reasonably be expected to pass through the intersection under prevailing traffic, roadway and signalized conditions. Capacity is influenced by traffic and roadway conditions. Traffic conditions includes volumes on each approach, the distribution of vehicles on each arm of intersection, the vehicle types distribution within each movement, pedestrian traffic flows and parking movements on approaches to the intersection.

Traffic control at intersections limits the capacity of the intersecting roadways, defined as the number of users that can be accommodated within a given time period. Capacity of an intersection depends on the following factors:

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

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

2.5.2.7 Traffic Calming Techniques

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

Trapezoidal Humps and Raised Pedestrian Crossing (Table Top)

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

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

2.5.3 Pavement Design

2.5.3.1 Old Kent Road

Design of Plain Jointed Rigid Pavement

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): 171 Commercial Vehicles per Day (CVPD)

CBR of Existing Soil: Samples collected and tested and are 8.0%

CBR (Considered) of Proposed Subgrade: 8%

CBR (Assumed) of Embankment below subgrade: 8%

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

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

Axle Load Spectrum (Assumed):

Table 25 Axial load Spectrum assumed – Old Kent Road

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 150mm thick Granular Sub-Base as drainage layer (Grading VI of Table 400-1 of MoRTH Specifications Fifth Revision)
- Provide a Dry Lean Concrete (DLC) sub-base of thickness 100mm with a minimum 7 day compressive strength of 10 MPa.
- Effective modulus of subgrade reaction of combined foundation of subgrade, granular sub-base and DLC sub-base is 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 %
- Total commercial vehicles during design period

  $C = 365 X A ((1 + r)^n – 1) / r$

  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

  $C = 365 X 461((1+0.05)^{30}-1)/0.05$

  C= 4146781

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

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

  = 4146781 X 2.35

  = 9744935

  No. of axles in predominant direction

  = 9744935X 0.5

  = 4872467

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

  = 4872467 X 0.25

  = 1218117

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

= 1218117 X 0.6

= 730870

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

= 1218117 X 0.4

=487247

- Day time six hour axle load repetitions

= 487247 X 0.5

= 243623

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

= **243623**

- Night time six hour axle load repetitions

= 730870 X 0.5

= 365435

% 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)

=365435X 0.55

= **200989**

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

Table 26 Fatigue Cracking Analysis

Axle Category	Proportion of the Axle Category	Category wise axle repetitions for Bottom-up cracking analysis	Category wise axle repetitions for Top-down cracking analysis
Front (Steering) single	0.45	109630	90445
Rear single	0.53	129120	106524
Tandem	0.02	4872	4020

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/m^3
- Design flexural strength of concrete – 4.95 MPa
- Max. day-time Temperature Differential in slab (for bottom-up cracking) – 19.0^{0}C
- Night-time Temperature Differential in slab (for top-down cracking) – day-time diff/2 + 5 = 14.50^{0}C
- Trial thickness of slab, h = 205 mm
- Radius of relative stiffness, l = $(Eh^3/(12k(1-\mu^2))^{0.25}$

  Where,

  l – radius of relative stiffness, m

  E – Elastic modulus of concrete, MPa

  h – concrete slab thickness, m

  k – modulus of subgrade reaction, MPa/m

  μ - Poisson's ratio of concrete

  = 0.574

- '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

Table 27 Fatigue Damage Analysis (Bottom-Up)

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	21926	2.838	0.573	64795	0.338	220 - 240	4385	2.298	0.464	8903108	0.000
105-115	10963	2.672	0.540	167797	0.065	200 - 220	487	2.148	0.434	Infinite	0.000
95-105	21926	2.505	0.506	574387	0.038						
< 85	54815	2.172	0.439	Infinite	0.000						
	576134	Fat Dam from Sing. Axles =			0.442		21741	Fat Dam from Tand Axles =			0.000

Table 28 Fatigue Cracking Analysis (Top-Down)

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	18089	2.575	0.520	323199	0.056	220 - 240	3618	2.518	0.509	512738	0.007
105-115	9045	2.461	0.497	877714	0.010	200 - 220	402	2.404	0.486	1670789	0.000
95-105	18089	2.346	0.474	3727461	0.005						
< 85	45223	2.118	0.428	Infinite	0.000						
	475310	Fat Dam from Sing. Axles =			0.071		21741	Fat Dam from Tand Axles =			0.007

It can be seen from the calculations given in the tables above that for the slab thickness of 205mmthe total fatigue damage for bottom-up cracking is 0.442 + 0.000 = 0.442. Total fatigue damage for top-down cracking is 0.071 + 0.007= 0.077 and total cumulative fatigue damage (CFD) = 0.449 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 Table5 '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 – 0.250 m
- Lane width, b – 3.1 m
- Coefficient of friction, f – 1.5
- Density of concrete, kN/m^3 – 24
- Allowable tensile stress in deformed bars, MPa -200(As per IRC:15-2017)
- Allowable bond stress for deformed tie bars, MPa – 2.46(As per IRC: 15-2017)

Design for Deformed Bars:

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

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

Where,

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

b – Lane width in meters

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

W – Weight of slab in kN/m^2 and

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

$$=3.1X1.5X0.250X24000/200$$

$$=140.45\ mm^2/m$$

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

$$= 113\ mm^2$$

- Perimeter of Tie Bar = πd = 37.7mm

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

  = 113/140.45X1000

  = 704 mm

  Say 810 mm

- Provide spacing of 730mm c/c

- **Length of tie bar**

  $L = 2S_{st}A_{cs} / BXP_{ptb}$

  Where,

  L –Length of tie bar, mm

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

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

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

  B – Permissible bond stress of concrete, 2.46 MPa

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

  = 487.80 mm

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

Pavement Composition:

Table 29 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

2.5.3.2 PANDESHWARA NEW ROAD

Design of Plain Jointed Rigid Pavement

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): 32 Commercial Vehicles per Day (CVPD)

CBR of Existing Soil: Samples collected and tested and are 10.0%

CBR (Considered) of Proposed Subgrade: 8%

CBR (Assumed) of Embankment below subgrade: 8%

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

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

Axle Load Spectrum (Assumed):

Table 30 Axial load Spectrum assumed – Pandeswar New Road

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 150mm thick Granular Sub-Base as drainage layer (Grading VI of Table 400-1 of MoRTH Specifications Fifth Revision)
- Provide a Dry Lean Concrete (DLC) sub-base of thickness 100mm with a minimum 7 day compressive strength of 10 MPa.
- Effective modulus of subgrade reaction of combined foundation of subgrade, granular sub-base and DLC sub-base is 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 %
- 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

  $C = 365 \times 32X ((1+0.05)^{30}-1)/0.05$

  C= 776006

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

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

  = 776006 X 2.35

  = 1823613

  No. of axles in predominant direction

  = 1823613X 0.5

  = 911807

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

  = 911807 X 0.25

  = 227952

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

= 227952 X 0.6

= 136771

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

= 227952 X 0.4

=91181

- Day time six hour axle load repetitions

= 91181 X 0.5

= 45590

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

= **45590**

- Night time six hour axle load repetitions

= 136771 X 0.5

= 68386

% 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)

=68386X 0.55

= **37612**

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

Table 31 Fatigue Cracking Analysis

Axle Category	Proportion of the Axle Category	Category wise axle repetitions for Bottom-up cracking analysis	Category wise axle repetitions for Top-down cracking analysis
Front (Steering) single	0.45	20516	16925
Rear single	0.53	24163	19934
Tandem	0.02	912	752

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/m^3
- Design flexural strength of concrete – 4.95 MPa
- Max. day-time Temperature Differential in slab (for bottom-up cracking) – 19.0^0C
- Night-time Temperature Differential in slab (for top-down cracking) – day-time diff/2 + 5 = 14.50^0C
- Trial thickness of slab, h = 195 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

  = 0.574

- '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

Table 32 Fatigue Damage Analysis (Bottom-Up)

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	4103	3.059	0.618	18733	0.219	220 - 240	821	2.489	0.503	667654	0.001
105-115	2052	2.874	0.581	52985	0.039	200 - 220	91	2.322	0.469	5636826	0.000
95-105	4103	2.689	0.543	151083	0.027						
< 85	10258	2.319	0.468	5959496	0.002						
	576134	Fat Dam from Sing. Axles =			0.287		21741	Fat Dam from Tand Axles =			0.001

Table 33 Fatigue Cracking Analysis (Top-Down)

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	3385	2.725	0.551	122170	0.028	220 - 240	677	2.662	0.538	178406	0.004
105-115	1693	2.598	0.525	272936	0.006	200 - 220	75	2.535	0.512	445022	0.000
95-105	3385	2.471	0.499	790950	0.004						
< 85	8463	2.217	0.448	Infinite	0.000						
	475310	Fat Dam from Sing. Axles =			0.038		21741	Fat Dam from Tand Axles =			0.004

It can be seen from the calculations given in the tables above that for the slab thickness of 195mmthe total fatigue damage for bottom-up cracking is 0.287 + 0.001 = 0.288. Total fatigue damage for top-down cracking is 0.038 + 0.004= 0.042 and total cumulative fatigue damage (CFD) = 0.330 which is less than 1.0.

Hence, the trial thickness of 195mm is adequate.30mm thickness is added considering two retexturing in 30 years and 15mm for rounding off and hence a thickness of 240mm is appropriate.

Design of Dowel Bars

As per Table5 '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 – 0.240 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

$$=3.1X1.5X0.260X24000/200$$

$$=134.76\ mm^2/m$$

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

$$= 113\ mm^2$$

- Perimeter of Tie Bar = πd = 37.7mm

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

  = 113/146.0X1000

  = 663 mm

  Say 670 mm

- Provide spacing of 670mm c/c

- **Length of tie bar**

  $L = 2S_{st}A_{cs} / BXP_{ptb}$

  Where,

  L –Length of tie bar, mm

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

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

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

  B – Permissible bond stress of concrete, 2.46 MPa

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

  = 487.80 mm

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

Pavement Composition:

Table 34 Pavement Composition

Sr. No.	Description	Thickness in mm
1	Pavement Quality Concrete (PQC)	240
2	Dry Lean Concrete (DLC)	100
3	Granular Sub-Base (GSB) (as Drainage Layer)	150
4	Selected Subgrade (CBR ≥ 8%)	500

2.5.3.3 MULIHITHLU ROAD

Design of Plain Jointed Rigid Pavement

Design of Slab Thickness

Input Data:

Road Type: Two lanesTwo 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): 370 Commercial Vehicles perDay (CVPD)

CBR of Existing Soil: Two Samples collected and tested and are 4.0% and 1.5%

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 98% and Tandem Axle 2%

Axle Load Spectrum (Assumed):

Table 35 Axial load Spectrum assumed – Mulihithulu Road

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 150mm thick Granular Sub-Base as drainage layer (Grading VI of Table 400-1 of MoRTH Specifications Fifth Revision)
- Provide a Dry Lean Concrete (DLC) sub-base of thickness 100mm with a minimum 7 day compressive strength of 10 MPa.
- Effective modulus of subgrade reaction of combined foundation of subgrade, granular sub-base and DLC sub-base is 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 %
- Total commercial vehicles during design period

$C = 365 X A ((1 + r)^n – 1) / r$

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

$C = 365 X 370((1+0.05)^{30}-1)/0.05$

C= 8972566

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

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

= 8972566 X 2.35

= 21085531

No. of axles in predominant direction

= 21085531X 0.5

= 10542765

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

= 10542765 X 0.25

= 2635691

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

  = 2635691 X 0.6

  = 1581415

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

  = 2635691 X 0.4

  =1054277

- Day time six hour axle load repetitions

  = 1054277 X 0.5

  = 527138

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

  = **527138**

- Night time six hour axle load repetitions

  = 1581415 X 0.5

  = 790707

  % 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)

  =790707X 0.55

  = **434889**

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

Table 36 Fatigue Cracking Analysis

Axle Category	Proportion of the Axle Category	Category wise axle repetitions for Bottom-up cracking analysis	Category wise axle repetitions for Top-down cracking analysis
Front (Steering) single	0.45	195700	237212
Rear single	0.53	230491	279383
Tandem	0.02	8698	10543

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/m^3
- Design flexural strength of concrete – 4.95 MPa
- Max. day-time Temperature Differential in slab (for bottom-up cracking) – 19.0^0C
- Night-time Temperature Differential in slab (for top-down cracking) – day-time diff/2 + 5 = 14.50^0C
- Trial thickness of slab, h = 205 mm
- Radius of relative stiffness, $l = (Eh^3/(12k(1- \mu^2))^{0.25}$

  Where,

  l – radius of relative stiffness, m

  E – Elastic modulus of concrete, MPa

  h – concrete slab thickness, m

  k – modulus of subgrade reaction, MPa/m

  μ - Poisson's ratio of concrete

  = 0.574

- '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

Table 37 Fatigue Damage Analysis (Bottom-Up)

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	39140	2.838	0.573	64795	0.604	220 - 240	7828	2.298	0.464	8903108	0.000
105-115	19570	2.672	0.540	167797	0.117	200 - 220	870	2.148	0.434	Infinite	0.000
95-105	39140	2.505	0.506	574387	0.068						
< 85	97850	2.172	0.439	Infinite	0.000						
	576134	Fat Dam from Sing. Axles =			0.789		21741	Fat Dam from Tand Axles =			0.000

Table 38 Fatigue Cracking Analysis (Top-Down)

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	47442	2.575	0.520	323199	0.147	220 - 240	9488	2.518	0.509	512738	0.018
105-115	23721	2.461	0.497	877714	0.027	200 - 220	1054	2.404	0.486	1670789	0.000
95-105	47442	2.346	0.474	3727461	0.013						
< 85	118606	2.118	0.428	Infinite	0.000						
	475310	Fat Dam from Sing. Axles =			0.187		21741	Fat Dam from Tand Axles =			0.018

It can be seen from the calculations given in the tables above that for the slab thickness of 205mmthe total fatigue damage for bottom-up cracking is 0.789 + 0.000 = 0.789. Total fatigue damage for top-down cracking is 0.187 + 0.018= 0.205 and total cumulative fatigue damage (CFD) = 0.994 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 Table5 '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 – 0.250 m
- Lane width, b – 3.1 m
- Coefficient of friction, f – 1.5
- Density of concrete, kN/m^3 – 24
- Allowable tensile stress in deformed bars, MPa - 200(As per IRC:15-2017)
- Allowable bond stress for deformed tie bars, MPa – 2.46(As per IRC: 15-2017)

Design for Deformed Bars:

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

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

Where,

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

b – Lane width in meters

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

W – Weight of slab in kN/m^2 and

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

$$=3.1X1.5X0.250X24000/200$$

$$=140.45 \text{ mm}^2/\text{m}$$

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

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

- Perimeter of Tie Bar = πd = 37.7mm

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

  = 113/140.45X1000

  = 704 mm

  Say 810 mm

- Provide spacing of 730mm c/c

- **Length of tie bar**

  $L = 2S_{st}A_{cs} / BXP_{ptb}$

  Where,

  L –Length of tie bar, mm

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

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

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

  B – Permissible bond stress of concrete, 2.46 MPa

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

  = 487.80 mm

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

Pavement Composition:

Table 39 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

2.5.3.4 MANGALADEVI TEMPLE ROAD

Design of Plain Jointed Rigid Pavement

Design of Slab Thickness

Input Data:

Road Type: Three lanesTwo 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): 3206 Commercial Vehicles perDay (CVPD)

CBR of Existing Soil: Two Samples collected and tested and are 2.5% and 1.5%

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 98% and Tandem Axle 2%

Axle Load Spectrum (Assumed):

Table 40 Axial load Spectrum assumed – Mangaladevi Temple Road

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 150mm thick Granular Sub-Base as drainage layer (Grading VI of Table 400-1 of MoRTH Specifications Fifth Revision)
- Provide a Dry Lean Concrete (DLC) sub-base of thickness 100mm with a minimum 7 day compressive strength of 10 MPa.
- Effective modulus of subgrade reaction of combined foundation of subgrade, granular sub-base and DLC sub-base is 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 %
- 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

$C = 365 \times 3206((1+0.05)^{30}-1)/0.05$

C= 77746075

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

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

= 77746075 X 2.35

=182703276

No. of axles in predominant direction

= 182703276X 0.5

= 91351638

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

= 91351638X 0.25

= 22837910

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

  = 22837910 X 0.6

  = 13702746

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

  = 22837910 X 0.4

  =9135164

- Day time six hour axle load repetitions

  = 9135164 X 0.5

  = 4567582

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

  = **4567582**

- Night time six hour axle load repetitions

  = 13702746 X 0.5

  = 6851373

  % 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)

  =6851373X 0.55

  = **3768255**

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

Table 41 Fatigue Cracking Analysis

Axle Category	Proportion of the Axle Category	Category wise axle repetitions for Bottom-up cracking analysis	Category wise axle repetitions for Top-down cracking analysis
Front (Steering) single	0.45	1695715	2255412
Rear single	0.53	1997175	2420818
Tandem	0.02	75365	91352

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/m^3
- Design flexural strength of concrete – 4.95 MPa
- Max. day-time Temperature Differential in slab (for bottom-up cracking) – 19.0^0C
- Night-time Temperature Differential in slab (for top-down cracking) – day-time diff/2 + 5 = 14.50^0C
- Trial thickness of slab, h = 225 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

  = 0.574

- '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

Table 42 Fatigue Damage Analysis (Bottom-Up)

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	339143	2.486	0.502	686965	0.494	220 - 240	67829	1.995	0.403	Infinite	0.000
105-115	169571	2.349	0.474	3593949	0.047	200 - 220	7537	1.871	0.378	Infinite	0.000
95-105	339143	2.212	0.447	Infinite	0.000						
< 85	847857	1.938	0.391	Infinite	0.000						
	576134	Fat Dam from Sing. Axles =			0.541		21741	Fat Dam from Tand Axles =			0.000

Table 43 Fatigue Cracking Analysis (Top-Down)

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	411082	2.336	0.472	4414178	0.093	220 - 240	82216	2.289	0.462	10874480	0.000
105-115	225541	2.242	0.453	37929175	0.005	200 - 220	9135	2.195	0.443	Infinite	0.000
95-105	411082	2.148	0.434	Infinite	0.000						
< 85	1027706	1.960	0.396	Infinite	0.000						
	475310	Fat Dam from Sing. Axles =			0.098		21741	Fat Dam from Tand Axles =			0.018

It can be seen from the calculations given in the tables above that for the slab thickness of 225mmthe total fatigue damage for bottom-up cracking is 0.541 + 0.000 = 0.541. Total fatigue damage for top-down cracking is 0.098 + 0.018= 0.116 and total cumulative fatigue damage (CFD) = 0.657 which is less than 1.0.

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

Design of Dowel Bars

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

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

Design of Tie Bars

Input Data:

- Slab Thickness – 0.270 m
- Lane width, b – 3.1 m
- Coefficient of friction, f – 1.5
- Density of concrete, kN/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

$$=3.1X1.5X0.270X24000/200$$

$$=151.69\ mm^2/m$$

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

$$= 113\ mm^2$$

- Perimeter of Tie Bar = πd = 37.7mm

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

  = 113/151.69X1000

  = 745 mm

  Say 750mm

- Provide spacing of 750mm c/c

- **Length of tie bar**

  $L = 2S_{st}A_{cs} / BXP_{ptb}$

  Where,

  L –Length of tie bar, mm

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

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

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

  B – Permissible bond stress of concrete, 2.46 MPa

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

  = 487.80 mm

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

Pavement Composition:

Table 44 Pavement Composition

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

2.5.3.5 MONKEYSTAND NEW ROAD

Design of Plain Jointed Rigid Pavement

Design of Slab Thickness

Input Data:

Road Type: Two lanesTwo 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): 568 Commercial Vehicles perDay (CVPD)

CBR of Existing Soil: Samples collected and tested and are 8.0% and 5.35%

CBR (Considered) of Proposed Subgrade: 8%

CBR (Assumed) of Embankment below subgrade: 8%

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

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

Axle Load Spectrum (Assumed):

Table 45 Axial load Spectrum assumed – Monkey Stand Road

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 150mm thick Granular Sub-Base as drainage layer (Grading VI of Table 400-1 of MoRTH Specifications Fifth Revision)
- Provide a Dry Lean Concrete (DLC) sub-base of thickness 100mm with a minimum 7 day compressive strength of 10 MPa.
- Effective modulus of subgrade reaction of combined foundation of subgrade, granular sub-base and DLC sub-base is 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 %
- 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

$C = 365 \times 568((1+0.05)^{30}-1)/0.05$

C= 13774102

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

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

= 13774102X 2.35

= 32369139

No. of axles in predominant direction

= 32369139X 0.5

= 16184570

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

= 16184570 X 0.25

= 4046142

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

  = 4046142 X 0.6

  = 2427685

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

  = 4046142 X 0.4

  =1618457

- Day time six hour axle load repetitions

  = 1618457 X 0.5

  = 809228

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

  = **809228**

- Night time six hour axle load repetitions

  = 2427685 X 0.5

  = 1213843

  % 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)

  =1213843X 0.55

  = **667613**

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

Table 46 Fatigue Cracking Analysis

Axle Category	Proportion of the Axle Category	Category wise axle repetitions for Bottom-up cracking analysis	Category wise axle repetitions for Top-down cracking analysis
Front (Steering) single	0.45	300426	364153
Rear single	0.53	353835	428891
Tandem	0.02	13352	16185

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/m^3
- Design flexural strength of concrete – 4.95 MPa
- Max. day-time Temperature Differential in slab (for bottom-up cracking) – 19.0^0C
- Night-time Temperature Differential in slab (for top-down cracking) – day-time diff/2 + 5 = 14.50^0C
- 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

  = 0.574

- '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

Table 47 Fatigue Damage Analysis (Bottom-Up)

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	60085	2.649	0.535	193504	0.311	220 - 240	12017	2.135	0.431	Infinite	0.000
105-115	30043	2.498	0.505	610885	0.049	200 - 220	1335	1.999	0.404	Infinite	0.000
95-105	60085	2.348	0.474	3655774	0.016						
< 85	150213	2.046	0.413	Infinite	0.000						
	576134	Fat Dam from Sing. Axles =			0.376		21741	Fat Dam from Tand Axles =			0.000

Table 48 Fatigue Cracking Analysis (Top-Down)

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	72831	2.447	0.494	1016550	0.072	220 - 240	14566	2.395	0.484	1863082	0.008
105-115	36415	2.343	0.473	3921636	0.009	200 - 220	1618	2.292	0.463	10297297	0.000
95-105	72831	2.240	0.452	40771703	0.002						
< 85	182076	2.033	0.411	Infinite	0.000						
	475310	Fat Dam from Sing. Axles =			0.083		21741	Fat Dam from Tand Axles =			0.008

It can be seen from the calculations given in the tables above that for the slab thickness of 215mmthe total fatigue damage for bottom-up cracking is 0.376 + 0.000 = 0.376. Total fatigue damage for top-down cracking is 0.083 + 0.008= 0.091 and total cumulative fatigue damage (CFD) = 0.467 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 15mm for rounding off and hence a thickness of 260mm is appropriate.

Design of Dowel Bars

As per Table5 '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 – 0.250 m
- Lane width, b – 3.1 m
- Coefficient of friction, f – 1.5
- Density of concrete, kN/m^3 – 24
- Allowable tensile stress in deformed bars, MPa -200(As per IRC:15-2017)
- Allowable bond stress for deformed tie bars, MPa – 2.46(As per IRC: 15-2017)

Design for Deformed Bars:

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

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

Where,

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

b – Lane width in meters

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

W – Weight of slab in kN/m^2 and

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

$$=3.1X1.5X0.260X24000/200$$

$$=146.07\ mm^2/m$$

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

$$= 113\ mm^2$$

- Perimeter of Tie Bar = πd = 37.7mm

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

  = 113/146.07X1000

  = 773 mm

  Say 780mm

- Provide spacing of 780mm c/c

- **Length of tie bar**

  $L = 2S_{st}A_{cs} / BXP_{ptb}$

  Where,

  L –Length of tie bar, mm

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

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

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

  B – Permissible bond stress of concrete, 2.46 MPa

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

  = 487.80 mm

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

Pavement Composition:

Table 49 Pavement Composition

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

2.5.3.6 JEPPU MARKET ROAD

Design of Plain Jointed Rigid Pavement

Design of Slab Thickness

Input Data:

Road Type: Two lanesTwo 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): 2,208 Commercial Vehicles perDay (CVPD)

CBR of Existing Soil: Samples collected and tested and are 8.4% and 4.4%

CBR (Considered) of Proposed Subgrade: 8%

CBR (Assumed) of Embankment below subgrade: 8%

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

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

Axle Load Spectrum (Assumed):

Table 50 Axial load Spectrum assumed – Jeppu Market Road

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 150mm thick Granular Sub-Base as drainage layer (Grading VI of Table 400-1 of MoRTH Specifications Fifth Revision)
- Provide a Dry Lean Concrete (DLC) sub-base of thickness 100mm with a minimum 7 day compressive strength of 10 MPa.
- Effective modulus of subgrade reaction of combined foundation of subgrade, granular sub-base and DLC sub-base is 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 %
- 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

$C = 365 \times 2208((1+0.05)^{30}-1)/0.05$

C= 53544396

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

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

= 53544396X 2.35

= 125829331

No. of axles in predominant direction

= 125829331X 0.5

= 62914665

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

= 62914665 X 0.25

= 15728666

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

  = 15728666 X 0.6

  = 9437200

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

  = 15728666 X 0.4

  =6291467

- Day time six-hour axle load repetitions

  = 6291467 X 0.5

  = 3145733

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

  = **3145733**

- Night time six hour axle load repetitions

  = 9437200 X 0.5

  = 4718600

  % 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)

  =4718600X 0.55

  = **2595230**

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

Table 51 Fatigue Cracking Analysis

Axle Category	Proportion of the Axle Category	Category wise axle repetitions for Bottom-up cracking analysis	Category wise axle repetitions for Top-down cracking analysis
Front (Steering) single	0.45	1167853	1415580
Rear single	0.53	1375472	1667239
Tandem	0.02	51905	62915

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/m^3
- Design flexural strength of concrete – 4.95 MPa
- Max. day-time Temperature Differential in slab (for bottom-up cracking) – 19.0^0C
- Night-time Temperature Differential in slab (for top-down cracking) – day-time diff/2 + 5 = 14.50^0C
- Trial thickness of slab, h = 225 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

  = 0.574

- '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

Table 52 Fatigue Damage Analysis (Bottom-Up)

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	233571	2.486	0.502	686965	0.340	220 - 240	46714	1.995	0.403	Infinite	0.000
105-115	116785	2.349	0.474	3593949	0.032	200 - 220	5190	1.871	0.378	Infinite	0.000
95-105	233571	2.212	0.447	Infinite	0.000						
< 85	583927	1.938	0.391	Infinite	0.000						
	576134	Fat Dam from Sing. Axles =			0.372		21741	Fat Dam from Tand Axles =			0.000

Table 53 Fatigue Cracking Analysis (Top-Down)

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	283116	2.336	0.472	4414178	0.064	220 - 240	56623	2.289	0.462	10874480	0.005
105-115	141558	2.242	0.453	37929175	0.004	200 - 220	6291	2.195	0.443	Infinite	0.000
95-105	283116	2.148	0.434	Infinite	0.000						
< 85	707790	1.960	0.396	Infinite	0.000						
	475310	Fat Dam from Sing. Axles =			0.068		21741	Fat Dam from Tand Axles =			0.005

It can be seen from the calculations given in the tables above that for the slab thickness of 225mmthe total fatigue damage for bottom-up cracking is 0.372 + 0.000 = 0.376. Total fatigue damage for top-down cracking is 0.068 + 0.005= 0.073 and total cumulative fatigue damage (CFD) = 0.449 which is less than 1.0.

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

Design of Dowel Bars

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

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

Design of Tie Bars

Input Data:

- Slab Thickness – 0.270 m
- Lane width, b – 3.1 m
- Coefficient of friction, f – 1.5
- Density of concrete, kN/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

$$=3.1X1.5X0.270X24000/200$$

$$=151.68\ mm^2/m$$

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

$$= 113\ mm^2$$

- Perimeter of Tie Bar = πd = 37.7mm

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

  = 113/151.68X1000

  = 744 mm

  Say 750mm

- Provide spacing of 750mm c/c

- **Length of tie bar**

  $L = 2S_{st}A_{cs} / BXP_{ptb}$

  Where,

  L –Length of tie bar, mm

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

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

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

  B – Permissible bond stress of concrete, 2.46 MPa

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

  = 487.80 mm

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

Pavement Composition:

Table 54 Pavement Composition

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

2.5.3.7 GUJJARKERE ROAD

Design of Plain Jointed Rigid Pavement

Design of Slab Thickness

Input Data:

Road Type: Two lanesTwo 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): 146 Commercial Vehicles perDay (CVPD)

CBR of Existing Soil: Samples collected and tested and are 8.4 and 4.4%

CBR (Considered) of Proposed Subgrade: 8%

CBR (Assumed) of Embankment below subgrade: 8%

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

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

Axle Load Spectrum (Assumed):

Table 55 Axial load Spectrum assumed – Gujjarekere Road

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 150mm thick Granular Sub-Base as drainage layer (Grading VI of Table 400-1 of MoRTH Specifications Fifth Revision)
- Provide a Dry Lean Concrete (DLC) sub-base of thickness 100mm with a minimum 7 day compressive strength of 10 MPa.
- Effective modulus of subgrade reaction of combined foundation of subgrade, granular sub-base and DLC sub-base is 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 %
- 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

$C = 365 \times 146*((1+0.05)^{30}-1)/0.05$

C= 3540526

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

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

= 3540526 X 2.35

= 8320237

No. of axles in predominant direction

= 8320237X 0.5

= 4160118

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

= 4160118X 0.25

= 1040030

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

  = 1040030 X 0.6

  = 624018

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

  = 1040030 X 0.4

  =416012

- Day time six hour axle load repetitions

  = 416012 X 0.5

  = 208005

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

  = **208005**

- Night time six hour axle load repetitions

  = 624018 X 0.5

  = 312009

  % 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)

  =312009X 0.55

  = **171604**

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

Table 56 Fatigue Cracking Analysis

Axle Category	Proportion of the Axle Category	Category wise axle repetitions for Bottom-up cracking analysis	Category wise axle repetitions for Top-down cracking analysis
Front (Steering) single	0.45	77222	93603
Rear single	0.53	90951	110243
Tandem	0.02	3432	4160

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/m^3
- Design flexural strength of concrete – 4.95 MPa
- Max. day-time Temperature Differential in slab (for bottom-up cracking) – 19.0^0C
- Night-time Temperature Differential in slab (for top-down cracking) – day-time diff/2 + 5 = 14.50^0C
- Trial thickness of slab, h = 205 mm
- Radius of relative stiffness, $l = (Eh^3/(12k(1- \mu^2))^{0.25}$

  Where,

  l – radius of relative stiffness, m

  E – Elastic modulus of concrete, MPa

  h – concrete slab thickness, m

  k – modulus of subgrade reaction, MPa/m

  μ - Poisson's ratio of concrete

  = 0.574

- '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

Table 57 Fatigue Damage Analysis (Bottom-Up)

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	15444	2.838	0.573	64795	0.238	220 - 240	3089	2.298	0.464	8903108	0.000
105-115	7722	2.672	0.540	167797	0.046	200 - 220	343	2.148	0.434	Infinite	0.000
95-105	15444	2.505	0.506	574387	0.027						
< 85	38611	2.172	0.439	Infinite	0.000						
	576134	Fat Dam from Sing. Axles =			0.311		3432	Fat Dam from Tand Axles =			0.000

Table 58 Fatigue Cracking Analysis (Top-Down)

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	18721	2.575	0.520	323199	0.058	220 - 240	3744	2.518	0.509	512738	0.007
105-115	9360	2.461	0.497	877714	0.011	200 - 220	416	2.404	0.486	1670789	0.000
95-105	18721	2.346	0.474	3727461	0.005						
< 85	46801	2.118	0.428	Infinite	0.000						
	93603	Fat Dam from Sing. Axles =			0.074		4160	Fat Dam from Tand Axles =			0.007

It can be seen from the calculations given in the tables above that for the slab thickness of 205mmthe total fatigue damage for bottom-up cracking is 0.311 + 0.000 = 0.311. Total fatigue damage for top-down cracking is 0.074 + 0.007= 0.081 and total cumulative fatigue damage (CFD) = 0.392 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 Table5 '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 – 0.250 m
- Lane width, b – 3.1 m
- Coefficient of friction, f – 1.5
- Density of concrete, kN/m^3 – 24
- Allowable tensile stress in deformed bars, MPa -200(As per IRC:15-2017)
- Allowable bond stress for deformed tie bars, MPa – 2.46(As per IRC: 15-2017)

Design for Deformed Bars:

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

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

Where,

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

b – Lane width in meters

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

W – Weight of slab in kN/m^2 and

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

$$=3.1X1.5X0.250X24000/200$$

$$=140.45\ mm^2/m$$

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

$$= 113\ mm^2$$

- Perimeter of Tie Bar = πd = 37.7mm

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

  = 113/140.45X1000

  = 704 mm

  Say 810 mm

- Provide spacing of 730mm c/c

- **Length of tie bar**

  $L = 2S_{st}A_{cs} / BXP_{ptb}$

  Where,

  L –Length of tie bar, mm

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

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

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

  B – Permissible bond stress of concrete, 2.46 MPa

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

  = 487.80 mm

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

Pavement Composition:

Table 59 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

2.5.3.8 BOLAR FISHERIES ROAD

Design of Plain Jointed Rigid Pavement

Design of Slab Thickness

Input Data:

Road Type: Two lanesTwo 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): 88 Commercial Vehicles perDay (CVPD)

CBR (Considered) of Proposed Subgrade: 8%

CBR (Assumed) of Embankment below subgrade: 8%

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

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

Axle Load Spectrum (Assumed):

Table 60 Axial load Spectrum assumed – Arya Samaj Road

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

Design:

E. Modulus of Subgrade Reaction:

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

  $C = 365 X A ((1 + r)^n – 1) / r$

  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

  $C = 365 X 88X ((1+0.05)^{30}-1)/0.05$

  C= 2134016

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

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

  = 2134016 X 2.35

  = 5014937

  No. of axles in predominant direction

  = 5014937X 0.5

  = 2507469

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

  = 2507469 X 0.25

  = 626867

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

  = 626867 X 0.6

= 376120

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

= 626867 X 0.4

=250747

- Day time six hour axle load repetitions

= 250747 X 0.5

= 125373

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

= **125373**

- Night time six hour axle load repetitions

= 376120 X 0.5

= 188060

% 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)

=188060X 0.55

= **103433**

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

Table 61 Fatigue Cracking Analysis

Axle Category	Proportion of the Axle Category	Category wise axle repetitions for Bottom-up cracking analysis	Category wise axle repetitions for Top-down cracking analysis
Front (Steering) single	0.45	46545	56418
Rear single	0.53	54820	66448
Tandem	0.02	2069	2507

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) – 19.0^0C
- Night-time Temperature Differential in slab (for top-down cracking) – day-time diff/2 + 5 = 14.50^0C
- Trial thickness of slab, h = 195 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

  = 0.574

- '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

Table 62 Fatigue Damage Analysis (Bottom-Up)

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	9309	3.059	0.618	18733	0.497	220 - 240	1862	2.489	0.503	667654	0.003
105-115	4654	2.874	0.581	52985	0.088	200 - 220	207	2.322	0.469	5636826	0.000
95-105	9309	2.689	0.543	151083	0.062						
< 85	23272	2.319	0.468	5959496	0.004						
	46544	Fat Dam from Sing. Axles =			0.650		21741	Fat Dam from Tand Axles =			0.003

Table 63 Fatigue Cracking Analysis (Top-Down)

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	11284	2.725	0.551	122170	0.092	220 - 240	2257	2.662	0.538	178406	0.013
105-115	5642	2.598	0.525	272936	0.021	200 - 220	251	2.535	0.512	445022	0.001
95-105	11284	2.471	0.499	790950	0.014						
< 85	28209	2.217	0.448	Infinite	0.000						
	475310	Fat Dam from Sing. Axles =			0.127		21741	Fat Dam from Tand Axles =			0.014

It can be seen from the calculations given in the tables above that for the slab thickness of 195mmthe total fatigue damage for bottom-up cracking is 0.650 + 0.003 = 0.653. Total fatigue damage for top-down cracking is 0.127 + 0.014= 0.141 and total cumulative fatigue damage (CFD) = 0.794 which is less than 1.0.

Hence, the trial thickness of 195mm is adequate.30mm thickness is added considering two retexturing in 30 years and 15mm for rounding off and hence a thickness of 240mm is appropriate.

Design of Dowel Bars

As per Table5 '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 – 0.240 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

$$=3.1X1.5X0.260X24000/200$$

$$=134.76\ mm^2/m$$

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

$$= 113\ mm^2$$

- Perimeter of Tie Bar = πd = 37.7mm

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

  = 113/146.0X1000

  = 663 mm

  Say 670 mm

- Provide spacing of 670mm c/c

- **Length of tie bar**

  $L = 2S_{st}A_{cs} / BXP_{ptb}$

  Where,

  L –Length of tie bar, mm

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

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

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

  B – Permissible bond stress of concrete, 2.46 MPa

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

  = 487.80 mm

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

Pavement Composition:

Table 64 Pavement Composition

Sr. No.	Description	Thickness in mm
1	Pavement Quality Concrete (PQC)	240
2	Dry Lean Concrete (DLC)	100
3	Granular Sub-Base (GSB) (as Drainage Layer)	150
4	Selected Subgrade (CBR ≥ 8%)	500

2.5 INFRASTRUCTURE AND UTILITIES PLANNING

2.5.1 Planned Utilities

Dedicated and planned utilities are one of the key features of smart roads. Various utilities planned under DPR-6 Smart Road include wet utilities include Water Supply, sewerage and storm water drainage system as well as dry utilities like Street Lights, Power Distribution and OFC.

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

Similarly; UGD (Underground sewerage network) and LED Street lighting are proposed as separate Project under Mangaluru Smart City. The proposal under UGD and LED project have been integrated while planning the utility corridor along DPR-6 Smart Road.

2.5.2 Electrical Infrastructure

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

Table 65 Existing Transformer locations

Road no.	Name of Road	Road		Length	Transformer Number	Rating in KVA	Location of Transformer	Pole No/MESCOM Identification
		From	TO					
1	OLD PORT ROAD	Hamilton circle	Bengre ferry-Old port Jn	465.00	TR-1	63kVA	STATE BANK OF INDIA STAFF QUARTERS	20030251317 DTC/HOTEL SWAGATH MPT 066 DTC027
					TR-2	63kVA	BADRIYA COMMERCIAL COMPLEX	2003025133D TC/ HOTEL GATEWAY MPT 058 DTC024
					TR-3	250kVA	OLD FORT JUNCTION	20030251307 DTC/ OLD PORT MPT046 DTC022

4	BOLAR FISHERIES COLLEGE RD	HOIGEBAZAR RD. (KFDC Ltd)	Sea Face (Mangalore old port	180.23	TR-1	250kVA	KFDC compound	200830270689 DTC/ KFDC 11016
3	**Pandeshwara New Road**	Rosario Church Road	Pandeshwar New Road	297.50	TR-1	63kVA	MAHALINGESHWARA	12263 M.I.D
					TR-2	100kVA	WEST GATE APT	12281 M.I.D
					TR-3	250kVA	JULIA BAGH	12152 M.I.D
					TR-4	63kVA	VIJAYALAKSHMI	12185 M.I.D
					TR-5	250kVA	IDEALS SWEET HOME	12061 M.I.D
2	Old Kent Road	Old Kent Road	Fire station	800.70	TR-1	63kVA	HOTEL CHAITANYA	HOTEL CHAITANYA - 12273
					TR-2	250kVA	Presidency vivo APTS	Presidency vivo APTS - 12325
					TR-3			20030260974 DTC
					TR-4			
					TR-5	63kVA	Minority office	Moulana azaad -12326
					TR-6	250kVA	Opp. Kerala samaj school	Sanjeeva castal building - 12136
					TR-7	100kVA	Kerala samaj school	20030260989 DTC
					TR-8	63kVA	Kent APTS	20030260995 DTC
2	BR Karkera Road	Fire Station	Mangaladevi road	385.00	TR-1	100kVA	LINGAMMA	12059 M.I.D
					TR-2	100kVA	ENTITY APT	12134 M.I.D
					TR-3	63kVA	SHIVARAMMA COMP .	12196 M.I.D
					TR-4	100kVA	MAYOR RESIDENC	12194 M.I.D

							Y	
					TR-5	100kV A	FATHIMA RESIDENC Y	12206 M.I.D
					TR-6	100kV A	DOOMAPP A COMP.	12047 M.I.D
7		Mangaladevi Rd.	JaiHind Circle	600.5 0	TR-1	100kV A	MARNAM IKATTE BRIDGE	20030270405 DTC
					TR-2	63kV A	MARNAM IKATTE DWARA	20030270398 DTC
					TR-3	100kV A	MARNAM IKATTE CIRCLE	20030271453 DTC
6		Mangaladevi Temple	JaiHind Circle	815.0 0	TR-1	250kV A	PRIMIER ARISTO BLDG - G+4	20030270794 DTC
					TR-2	25kV A	SRI DEVI KRIPA	20030270791 DTC
					TR-3	63kV A	SANGAM COMPLEX	20030270785 DTC
					TR-4	63kV A	VETERNA RY HOSPITAL	20030268739 DTC
					TR-5	250kV A	CASIA SCHOOL	20030270414 DTC
8 & 9	**Jeppu Market Road & Gujjarker e Road**	JaiHind Circle	Jappina mogaru	1178. 00	TR-1	100 KVA		
					TR-2	63 KVA	ST. RITA CHURCH	
					TR-3	100kV A	CASIA CHURCH	2003027499 DTC
					TR-4	250kV A	TUMBAY RESIDENC YG+5	20030271521 DTC
					TR-5	175kV A	DIAMON D BUILDING	20030271837 DTC
					TR-6	63 KVA		
					TR-7	100kV A	P L GATE	20030271628 DTC
					TR-8	250k VA	COMMO NWEALTH TILE FACTORY	2003027636 DTC

5	**Mulihithlu Road**	Mangaladevi Temple	Mulihithlu Road	409.30	TR-1	100k VA	P & T QUATERS	20030270621 DTC
					TR-2	63 KVA	BOLAR TOWER	20030270532 DTC
					TR-3	250kV A	MULIHITH LU CROSS	20030270528 DTC
					TR-4	250kV A	MANGALA SHUTHI BLG	2003027541 DTC
					TR-5	100kV A	PRIME HOME	2003027566 DTC
					TR-6	100kV A	TATHPI APT	2003027546 DTC
					TR-7	100kV A	MULIHITH LU KALUTI SANA	20030270563 DTC

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

Table 66 Existing Electric Cable/Pipes locations

Rd. no.	Name of Rd.	Road		No of Pipes with size (LEFT SIDE)		No of pipes with size (RIGHT SIDE)	
		From	To	415V	11kV	415V	11kV
1	**Old Port Road**	Hamilton Circle	Bendre Ferry - Old Fort Jn	**1**		**1**	**4**
2	**Old Kent Road**	Old Kent Rd.	Mangaladaevi Rd Jn.	**1**	**4**	**1**	**2**
3	**Pandeshwara New Road**	Rosario Church Rd.	Pandeshwar New Rd.	**1**	**4**	**1**	**4**
4	**Bolar Fisheries College Road**	Hoigebazar Rd. (KFDC Ltd)	Sea Face (Mangaluru Old Port)	**1**		**1**	**2**
5	**Mulihithlu Road**	Mangaladevi Temple	Mulihithlu Rd.	**1**	**4**	**1**	**4**
6	**Mangaladevi Temple Road**	Mangaladevi Temple	Marnamikatta Circle	**1**	**4**	**1**	**4**
7	**Monkeystand New Road**	Mangaladevi Rd (Ramakrishna Math Jn)	Jaihind Circle	**1**	**4**	**1**	**4**
8	**Jeppu Market Road**	Abhaya Limbs Center	Jeppu Market Jn.	**1**	**4**	**1**	**4**
9	**Gujjarkere Road**	Jeppu Market Jn.	JappinaMogaru				

2.5.3 Street Light

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

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

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

Table 67 Classification of lighting installation

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

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

2.5.4 Lighting Poles:

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

2.5.5 Centralized street lighting control

“Conversion of Conventional Street Lights into LED with

Smart Lighting Solutions" is one of the projects under MSC with an objective of reducing energy consumption as well as to reduce impact on environment by conventional lamps. The existing street lights are proposed to be converted into LED on PPP basis under a separate project. Smart LED street lighting system adopts centralized control system which will result in further saving of electrical energy. This system offers following Merits –

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

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

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

2.5.6 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. The budget has been extended to 49.5crores for UGD Package -5 and 46.1 crores for UGD Package-6.

The aim of the UGD DPR is to perform a detailed analysis and design of UGD network. The detailed Sewerage network design has been carried out for ABD area. The proposed sewerage system consist lateral and branch networks from Sewerage Zones draining into respective wetwells.

The sewerage system is designed using ***Bentley Sewer Gems V8i version software***.

The sewage from the individual properties will be collected and conveyed to the wet well by gravity sewers. In the proposed system, laterals are proposed along the roads to connect sewage from Individual property chambers and it is connected to branch sewers. Branch sewers are joined to main sewers and which is connected to existing Trunk sewer which is

connected to the Wetwell. The Sewage from the Wetwells in ABD Area are pumped to the 43.5MLD Sewage Treatment Plant at Kavoor. Proposed sewers are of UPVC pipes.

The UGD Network along Road 19, 20, 24 & 25 are proposed in Zone -5 under UGD Package-4. Road 22 is an earthen road leading to the Sea. There are no settlements along the road to be considered for municipal sewer. Hence this road is not taken up under UGD proposal. Road 23,26 & 27 is proposed in Zone-6 under UGD Package-4. New Sewer network is proposed along the roads 8, 10 , 19. 200mm diameter upvc pipe is provided for laterals and circular RCC manholes with SFRC cover and frame ranging from 1.2m to 1.5m in diameter has been provided in the proposed scheme

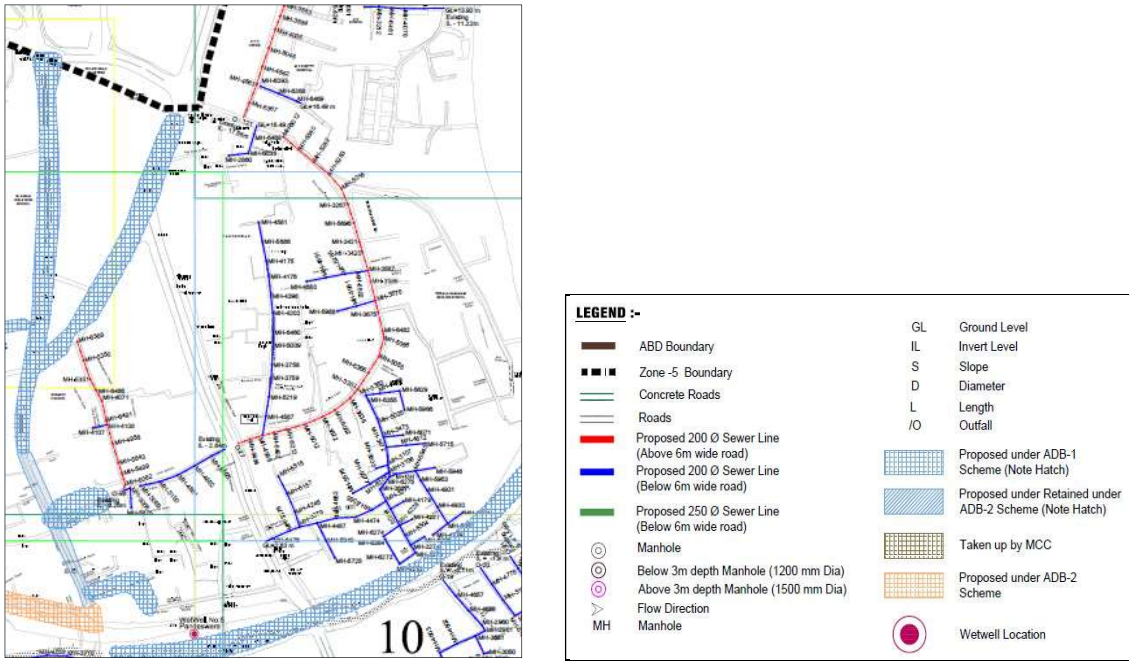


Figure 31 Mark-up showing the UGD lines proposed in Roads along Road 19 & 20

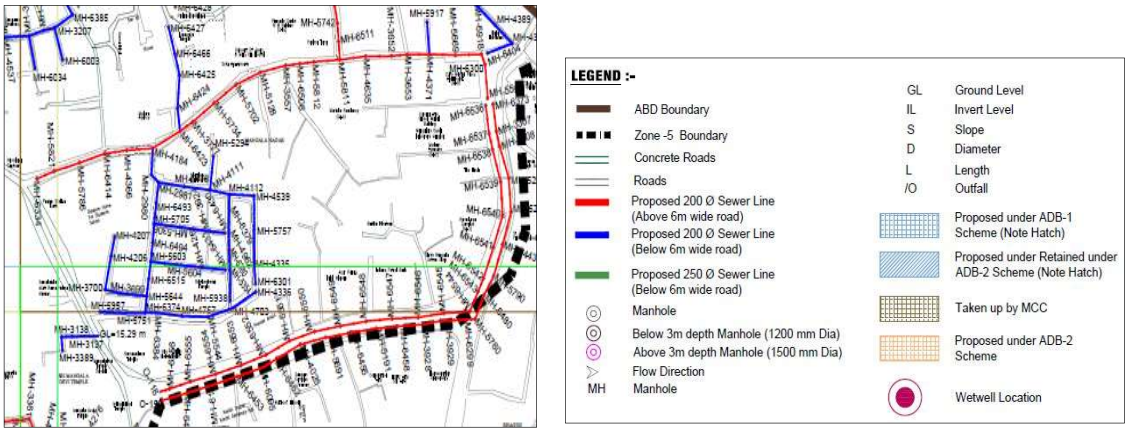


Figure 32 Mark-up showing the UGD lines proposed in Roads along Road 24 & 25

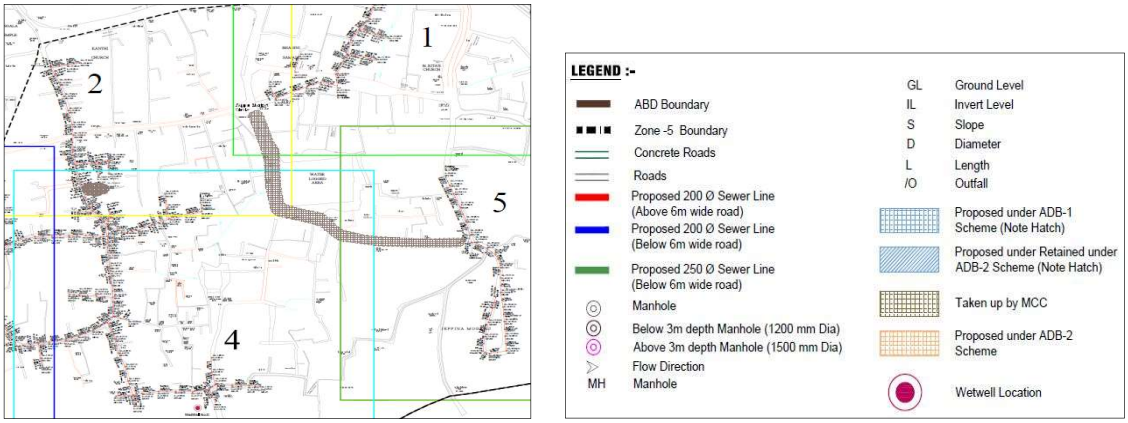


Figure 33 Mark-up showing the UGD lines proposed in Roads along Road 24 & 25

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

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

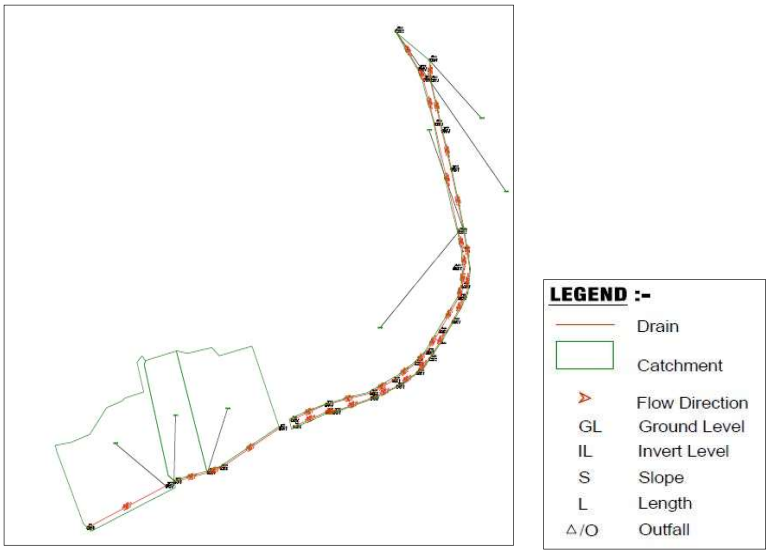


Figure 34: Storm water drainage on the considered road 19 & 20

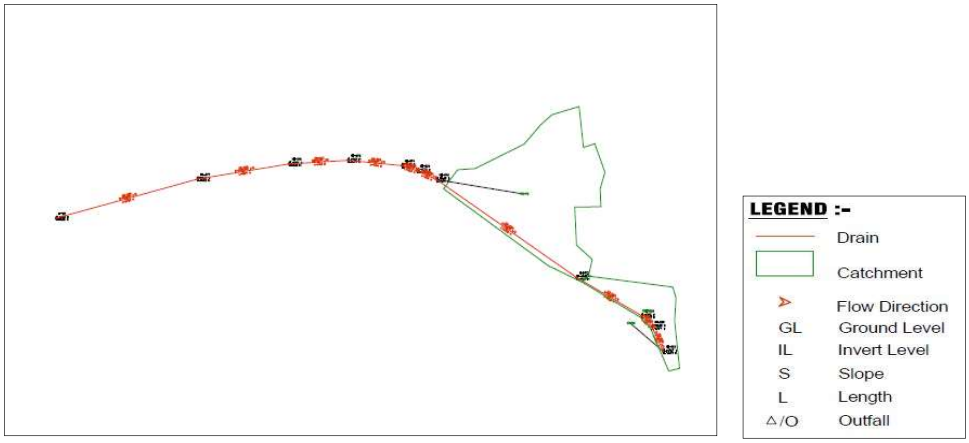


Figure 35: Storm water drainage on the considered road 22

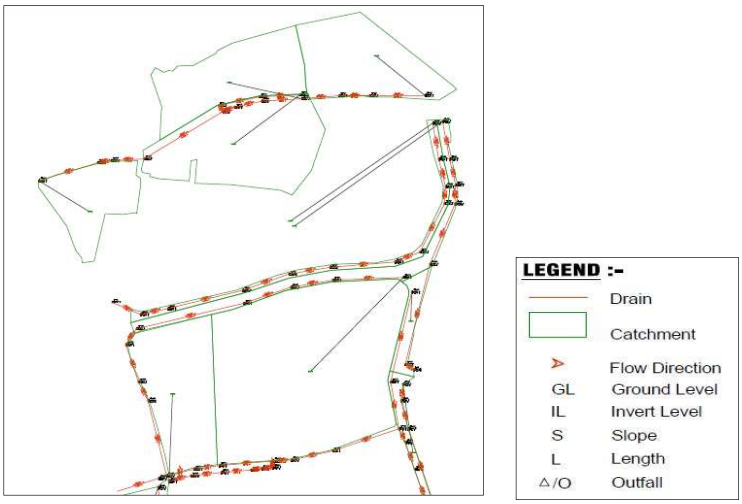


Figure 36: Storm water drainage on the considered road 22

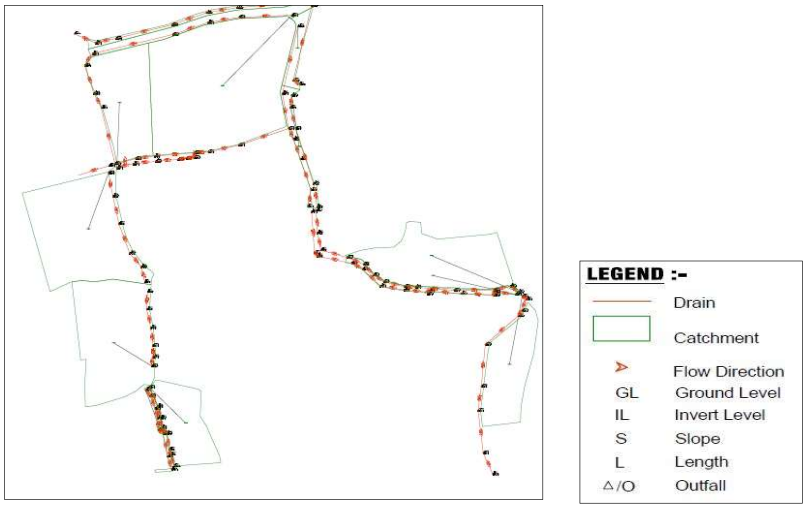


Figure 37: Storm water drainage on the considered road 23, 26 & 27

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 38 Existing drains along 19-BR Karkera Road

Figure 39 Drains in Pandeshwar New Road-20

Figure 40 Existing drain along Road 22 near KFDC

Figure 41 Existing drain along Road 23

Figure 42 Existing drains & newly Constructed drains along Road 24

Figure 43 Existing drains along Road 25

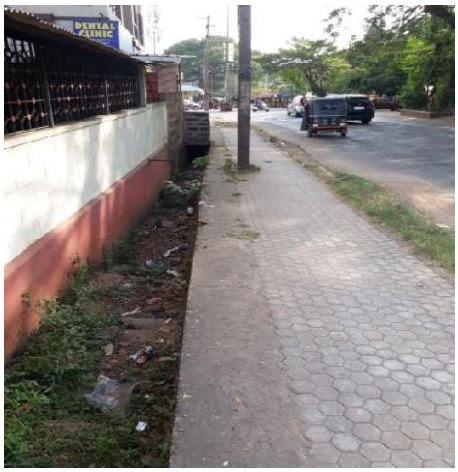


Figure 44 Existing drain along Road 26

Figure 45 Existing drains along 27

Table 68 Details of Utilities along DPR-6 Roads

S.NO	Road ID	Sewer				Water Supply			SWD		
		Length(m)	Diameter (mm)	Manhole Size(m)	Qty(Nos)	Dia(mm)	Qty(Nos)	Sluice Valve Qty (Nos)	Width(mm)	Orientation	Retain
1	19	647.7	200	1.2	20	63	1		600	both sides	
				1.5	6	160	1	4	900		
2	20	141.6	200	1.2	5	63	1		600	one side	
				1.5		110	1	3			
		Proposed under ADB-1 Scheme							750	one side	
3	22	Sewer Network not proposed along this road				90	1			one side	
4	23	601.8	200	1.2	23	110	1	2	600	both sides	
				1.5	1	160	1		900	both sides	
									1200	one side	
5	24	1128.2	200	1.2	43	63	1	2	600	both sides	Existing New drains to be retained
				1.5		110	2		900	both sides	
						250	1	1	1200	one side	
6	25	580.5	200	1.2	18	63	2		900	one side	
				1.5	2	200	1	4			
7	26	Existing Sewer Network to be retained				110	1		750	both sides	
						63	1		900	both sides	
8	27	Executed by MCC				63	1		900	both sides	
						110	1	3	1200	both sides	
						250	1				
						350	1	1			

Majority of the Sewer lines in the present DPR has been taken up under UGD Package -4 which includes Zone-5 & Zone-6 in ABD area. The Overall Summary of UGD Package -4 is mentioned in the following table

Table 69 Overall Summary of UGD Package-4

PACKAGE	ZONE	LENGTH (KM)	COST (CRORES)	WETWELL LOCATION	HOUSE SERVICE CONNECTIONS(Nos)
DPR-4	Zone-5(Road Width >6m)	7.01	8	Pandeshwar-WW-5	748
	Zone-5(Road Width <6m)	10.67	11.5		
	Zone-6	5.29	5.7	Mulihitlu-WW-6	
	Total	**22.9**	**24.5**		

The total cost of UGD Package -4 is 24.50 Crores. The cost abstract of this package is mentioned in following table

Table 70 Cost Abstract-UGD Package-4

Sr.No.	Description	Estimate cost in Rs.
A	**Underground Drainage**	
i	Zone 5 (Road width >6m)	6,20,68,395.00
ii	Zone 5 (Road width <6m)	9,01,22,989.00
iii	Zone 6 (Road width <6m)	3,95,69,171.00
B	**Utility Shifting – Compound Wall, Culvert and RCC Drain**	
i	Zone 5 (Road width >6m)	18,40,569.00
ii	Zone 5 (Road width <6m)	27,03,063.00
iii	Zone 6 (Road width <6m)	12,26,493.00
C	**Electrical Pole Shifting**	
i	Zone 5 (Road width >6m)	19,94,179.00
ii	Zone 5 (Road width <6m)	33,26,214.00
iii	Zone 6 (Road width <6m)	12,87,912.00
	Total Rs.	**20,41,38,986.00**
	Escalation	2,04,13,899.00
	Contingency at 3%	61,24,170.00
	Tax as applicable ,	2,44,96,678.00
	Administrative charges, Miscellaneous and rounding off (LS)	18,26,268.00
	Grand Total Rs.	**25,70,00,001.00**

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

Table 71 Components of UGD Package-4 DPR

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

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

2.6 STUDY FINDINGS AND OBSERVATIONS

2.6.1 Future Strategies as per Traffic Analysis

1. Pandeshwara new road, Mulihithlu road, Gujjarkere road can operate with their existing lane configuration without any capacity augmentation during the horizon period. Old Kent road requires capacity augmentation in the fag end which can be considered at a later date based on the ramp-up of the traffic. Even otherwise this road can function with little less LOS and hence can operate without capacity augmentation. Considering this Bolar fisheries college road, Monkey stand new road, Jeppu Market road require capacity augmentation. However, this being a developed town, space is a constraint.
2. However, this being already developed town, expansion of the width of the roads is not possible due to development on both sides of the road right now. Based on Master Plan proposals, Mangalore City Corporation has approved certain road widths. As and when the road widening is taken up, capacity augmentation of these roads can be taken up.
3. Moreover, the Design Service Volumes refer to Level of Service (LoS) C, which is, generally, at 0.7 of the Capacity. Further, traffic volume greater than capacity is often observed in Urban areas with lower Level of Service.
4. 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.
5. As per IRC 41, grade separation is warranted if the traffic on major road crosses more than 45,000 vehicles and minor road traffic crosses more than 12,000 vehicles per day. Mangaladevi Temple Junction and Mangaladevi Cross road Junction get qualified for grade separation. However, space is a constraint. Considering this grade separation is recommended as and when space is available at these locations and for the time being improvement of the junctions is suggested.
6. Mid block and at junction control measures are proposed for the pedestrians as the PV2 values are higher than 2x108 at many locations.

2.6.2 Summary of Findings

1. Mangalore Smart City Limited (MSCL) is implementing the Smart City Proposals with the help of the Project Management Consultants. Development of Smart Roads is one of important projects in the Smart City Proposal. Safe pedestrian movement along with smart features is key in the development of the Smart Roads.
2. This report deals with the DPR 6 for the Smart roads. Eight roads are considered under DPR 6 and are:Old Kent road, Pandeshwara New Road, Bolar Fisheries College Road, Mulihithlu Road, Mangaladevi Temple Road, Monkeystand New road, Jeppu Market road and Gujjarkere 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 workedout. Projections for future are made applying appropriate growth rates.
4. Pandeshwara new road, Mulihithlu road, Gujjarkere road can operate with their existing lane configuration without any capacity augmentation during the horizon

period. Old Kent road requires capacity augmentation in the fag end which can be considered at a later date based on the ramp-up of the traffic. Even otherwise this road can function with little less LOS and hence they can operate without capacity augmentation. Considering this Bolar fisheries college road, Monkey stand new road, Jeppu Market road require capacity augmentation. However, this being a developed town, space is a constraint

5. Based on Master Plan proposals, Mangalore City Corporation has approved certain road widths. As and when the road widening is taken up, capacity augmentation of these roads can be taken up.
6. Moreover, the Design Service Volumes refer to Level of Service (LOS) C, which is, generally, at 0.7 of the Capacity. Further, traffic volume greater than capacity is often observed in Urban areas with lower Level of Service.
7. Considering the above, it is suggested to deploy traffic management strategies, coupled with promotion of the Public Transport System to reduce the number of vehicles on the road.
8. Grade separation is warranted for Mangaladevi Temple Junction and Mangaladevi Cross road Junction. However, space is a constraint. Considering this grade separation is recommended as and when space is available at these locations and for the time being improvement of the junctions is suggested.
9. Mid block and at junction control measures are proposed for the pedestrians as the PV2 values are higher than 2x108 at few locations.

2.6.3 Trial Pit Reports

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DEPARTMENT OF CIVIL ENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY KARNATAKA, SURATHKAL
POST SRINIVASNAGAR, MANGALURU - 575 025 Date: 10.01.2019

SOIL TEST REPORT

This report is in response to the request made by Dr. Nitin Bhavsar, Team Leader, Wadia techno-Engineering Services Ltd., Bangalore. Vide his letter No. WTESL/2292/MSCL/267 dated 04th December 2018. It is requested to conduct laboratory modified Proctor compaction tests and California Bearing Ratio (CBR) tests on supplied soil samples. 36 soil samples were supplied. All these soil samples belong to road project of Mangalore Smart City Project in ABD area of Mangalore. This is the first report (of tests completed so far), and subsequent reports will follow as and when the other tests are done.

Following are the results

MSCL New Road No.	Rd. No.	Sample No. & type of soil	Name of Road	Road From	Road To	Modified compaction test results: Max. dry density (kN/m³)	Modified compaction test results: OMC (%)	Soaked CBR values of soils at max. dry density (%)
20	1c	1 Silty sand	Pandesh-wara New Rd.	Rosario Church Rd.	Pande-shwar New Rd.	20.7	7.0	10.0
20	1c	2 Silty sand				20.7	9.3	8.0
19	2	1 Gravelly silty sand	Old Kent Rd.	Old Kent Rd.	Keral Samaja Rd.	19.2	11.0	8.0
19	2	2 Gravelly silty sand				19.4	9.8	7.0
	20	1 Silty sand	Bendre Ferry Rd.	Jumma Masjid	BMS Ferry Lane	20.4	9.5	10.0
	20	2 Silty sand				20.6	9.7	10.0

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Date : 13.02.2019

SOIL TEST REPORT

This report is in response to the request made by Dr. Nitin Bhavvsar, Team Leader, Wadia techno-Engineering Services Ltd., Bangalore. Vide his letter No. WTESL/2292/MSCL/267 dated 04th December 2018. It is requested to conduct laboratory modified Proctor compaction tests and California Bearing Ratio (CBR) tests on supplied soil samples. 36 soil samples were supplied. All these soil samples belong to road project of Mangalore Smart City Project in ABD area of Mangalore. This is the second report (results of second set of tests conducted).

Following are the results

MSCL New No. Road	Rd. No.	Sample No. & type of soil	Name of Road	Road From	Road To	Modified compaction test results: Max. dry density (kN/m³)	Modified compaction test results: OMC (%)	Soaked CBR values of soils at max. dry density (%)
19	4c	1 Gravelly sand	BR Karkera Rd.	AB Shetty Circle	BR Karkera Rd.	20.4	9.1	10.95
19	4c	2 Gravelly sand				20.3	9.0	10.5
25	4d	1 Gravelly sand	Monkey Stand New Rd.	Mangala-devi	Jai Hind Circle	20.3	6.7	8.0
25	4d	2 Gravelly sand				19.2	10.5	5.35
	4e	1 Gravelly sand		BR Karkera Rd.	Railway Track	19.6	11.5	2.7
	4e	2 Gravelly sand				20.2	10.4	8.3

13/2/19
(R. Shivashankar)
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for (Varghese George)
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Date : 18.02.2019

SOIL TEST REPORT

This report is in response to the request made by Dr. Nitin Bhavvsar, Team Leader, Wadia techno-Engineering Services Ltd., Bangalore. Vide his letter No. WTESL/2292/MSCL/267 dated 04th December 2018. It is requested to conduct laboratory modified Proctor compaction tests and California Bearing Ratio (CBR) tests on supplied soil samples. 36 soil samples were supplied. All these soil samples belong to road project of Mangalore Smart City Project in ABD area of Mangalore. Earlier two reports were given as and when the test results were made available. This is the final report.

Following are the results

MSCL New Road No.	Rd. No.	Sample No. & type of soil	Name of Road	Road From	Road To	Modified compaction test results: Max. dry density (kN/m³)	Modified compaction test results: OMC (%)	Soaked CBR values of soils at max. dry density (%)
	4a	1 Gravelly sand	Mangaladevi Rd.	AB Shetty Circle	Marnami Katte Circle	18.6	13.0	3.5
	4a	2 Gravelly sand				19.3	10.7	6.8
	5a	1 Gravelly sand	Emmekere Rd.	Mangala-devi Rd.	Mangala-devi	20.3	12.0	1.7
	5a	2 Gravelly sand				20.1	10.3	1.8
24	5b	1 Gravelly sand	Mangaladevi Rd.	Mangala-devi	Abhaya Limbs Center	18.6	13.5	2.5
24	5b	2 Gravelly sand				19.4	11.0	1.5

18/2/19

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18/2/2019

MSCL New Road No.	Rd. No.	Sample No. & type of soil	Name of Road	Road		Modified compaction test results		Soaked CBR values of soils at max. dry density (%)
				From	To	Max. dry density (kN/m³)	OMC (%)	
26/27	5c	1 Gravelly sand	Near Gujjar Kere Rd.	Jai Hind Circle	Jappina Mogaru	19.7	10.1	8.4
26/27	5c	2 Gravelly sand				19.7	9.1	4.4
23	5d	1 Gravelly sand	Mulihithilu Rd.	Emmekere Rd.	Mulihithilu Rd.	19.0	11.5	4.0
23	5d	2 Gravelly sand				19.1	10.6	1.5
	5e	1 Gravelly sand	Bolar Rd. – Jeppu Market Rd.	Mangala-devi rd.	Bolar Main Rd.	20.1	10.4	6.6
	5e	2 Gravelly sand				20.4	10.5	2.7
	5f	1 Gravelly sand	Mulihithlu Rd. 1	P&T Colony	Bolar Sea face	19.6	9.3	7.0
	5f	2 Gravelly sand				19.1	12.8	2.4
	14d	1 Gravelly sand	Port Road	Bunder	Bendre Ferry Rd. Junction	20.0	9.2	10.0
	14d	2 Gravelly sand				20.2	11.9	9.5

18/2/2019

08/2/19

MSCL New Road No.

Rd. No.	Sample No. & type of soil	Name of Road	Road		Modified compaction test results		Soaked CBR values of soils at max. dry density (%)
			From	To	Max. dry density (kN/m³)	OMC (%)	
15b	1 Gravelly sand	Port rd.	Bunder Rd.	Badria School junction	20.8	9.9	5.5
15b	2 Gravelly sand				20.8	9.5	4.7
18a	1 Gravelly sand	Old Port – 1st Main Rd.	Railway gate bus stop	Bolar Main Rd.	19.3	11.0	9.0
18a	2 SAND - *poorly graded*				Maximum dry density = 15.6 kN/m³ Minimum dry density = 13.44 kN/m³		
18c	1 Gravelly sand		Emmekere rd.	Hoige-bazaar Rd.	19.3	12.7	6.2
18c	2 Gravelly sand				18.9	12.5	4.6
18d	1 Gravelly sand	Hoige-bazaar Rd.	Hoige-bazaar Rd.	Sea face	19.6	8.0	5.2
18d	2 Gravelly sand				19.6	12.0	4.5

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Chapter 3 PROPOSED DESIGN COMPONENTS

3.1 Smart Road Components – Urban Design, Landscape and ITMS

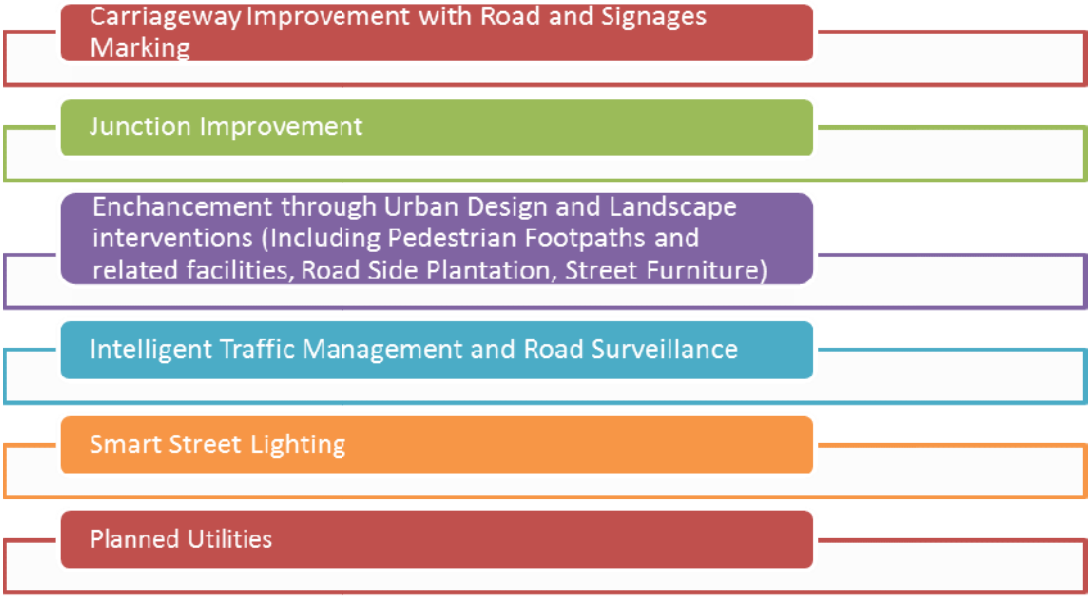
3.1.1 Urban Design and Landscape

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

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.

3.1.2 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-6.

3.1.3 Urban Design Features

Salient Features of Smart Roads for DPR-6 ROADS:

Road Cross Section:

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

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

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

Pedestrian Facilities and Smart Elements:

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

b. **Barrier free design:** Tactile paving is proposed at the centre of the footpath on all the DPR-6 Smart Roads. Curb ramps are present at the property entrances and parking bays for wheel chair access. Audio visual signals for blind people at the junctions.

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



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

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

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

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

Figure 46 Typical Proposed Model of Pedestrian Crossing and Smart Elements

Following are the list of drawings prepared for Urban Design elements of DPR-6 Smart Roads

Table 72 List of Cross Sections

No.	Drawing no	Drawing Title	No of Sheets
1	WTE_2292_06_R_5.01	OLD KENT ROAD (ROAD NO. 02) CROSS SECTIONS	16
2	WTE_2292_06_R_5.02	PANDESHWARA NEW ROAD (ROAD NO. 03) CROSS SECTIONS	6
3	WTE_2292_06_R_5.03	BOLARFISHERIES COLLAGE ROAD (ROAD NO. 04) CROSS SECTIONS	4
4	WTE_2292_06_R_5.04	MULIHITHLU ROAD (ROAD NO. 5) CROSS SECTIONS	16
5	WTE_2292_06_R_5.05	MANGLADEVI TEMPLE ROAD (ROAD NO. 06) CROSS SECTIONS	12
6	WTE_2292_06_R_5.06	MONKEYSTAND NEW ROAD (ROAD NO. 07) CROSS SECTIONS	11
7	WTE_2292_06_R_5.07	JEPPU MARKET ROAD (ROAD NO. 08) CROSS SECTIONS	4
8	WTE_2292_06_R_5.08	GUJJARKERE ROAD (ROAD NO. 09) CROSS SECTIONS	12
9	WTE_2292_06_R_5.01	OLD KENT ROAD (ROAD NO. 02) CROSS SECTIONS	16

Table 73 Proposed Urban Street Facilities

Road no	Road Name	Smart Features					Pedestrian Facilities						
		MUBs (trench)	Bus Shelter with E-Toilet	LED lights	Street furniture like signage, dustbins, benches, advt boards	Audi-visual signals	Road side plantation with tree grates	Pedestrian Crossing	Tactile paving and wheel chair access	Spaces for informal commercials	Subways or FOBs	Car Parking Lots	Parking for Auto rickshaws
1	OLD KENT ROAD	√	x	√	√	x	x	√	√	x	x	√	x
2	PANDESHWARA NEW ROAD	√	x	√	√	x	x	√	√	x	x	x	x
3	BOLAR FISHERIES COLLEGE RD	√	x	√	√	x	x	√	√	x	x	x	x
4	MULIHITHLU ROAD	√	x	√	√	x	x	√	√	x	x	√	x
5	MANGALADEVI TEMPLE ROAD	√	x	√	√	x	x	√	√	x	x	x	x
6	MONKEYSTAND NEW ROAD	√	x	√	√	x	x	√	√	x	x	x	x
7	JEPPU MARKET ROAD	√	x	√	√	x	x	√	√	x	x	x	x
8	GUJJARKERE ROAD	√	x	√	√	x	x	√	√	x	x	√	x

3.1.4 Landscaping

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

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

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

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

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

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

Further, following aspects should be considered while proposing landscape design

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

The roads considered under DPR-6 have very little open space to properly landscape. And many of the roads are having less RoW. In view of this only shrubs are proposed in the medians where possible.

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

3.1.5 Gujjerekere Road and Pond Landscape Designing

Traffic surveys were conducted on Gujjarkare road to collect the vehicle as well as pedestrian movement. The data is compiled and hourly distribution is presented below:

Time	Volume	PCU	Pedestrians
08:00	242	234	69
09:00	258	240	93
10:00	223	213	114
11:00	288	271	107
12:00	270	265	73
13:00	251	244	73
14:00	249	248	65
15:00	220	232	105
16:00	249	257	166
17:00	316	291	153
18:00	346	338	170
19:00	297	271	149
20:00	255	221	85
21:00	166	148	39
22:00	69	56	6
23:00	22	20	3
00:00	19	17	0
01:00	6	5	0
02:00	5	4	0
03:00	4	3	1
04:00	9	7	5
05:00	35	35	21
06:00	58	55	48
07:00	191	194	83
Total	**4,048**	**3,871**	**1628**
Peak, Vol	346	338	170
Peak, %	8.55%	8.73%	10.44%

The peak hour is happening for pedestrian movement is between 18:00 to 19:00 hours and peak hour pedestrian volume is 170 pedestrians.

IRC:93-1988 gives the capacity of the foot path and is reproduced below:

TABLE 1. CAPACITY OF SIDE-WALKS

Width of side-walk (metre)	Capacity in number of persons per hour	
	All in one direction	In both directions
1.50	1,200	800
2.00	2,400	1,600
2.50	3,600	2,400
3.00	4,800	3,200
4.00	6,000	4,000

Based on the pedestrian volume footpath width of 1.5 m is enough. However for comfort level it can be proposed to provide 2.0 m.

3.1.6 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 –

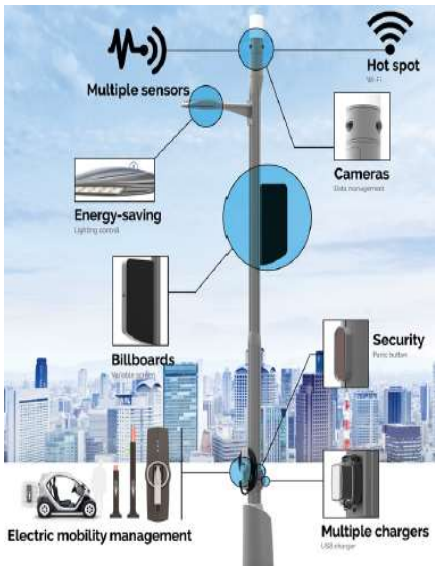
- Central control, fault detection
- Generation of burn hours reports
- Automatic operation with astronomical timers
- Manual operation from a central location through GPRS / GSM system
- Dimming operation
- Remote metering
- Voltage stabilization

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

3.1.7 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

3.2 Intelligent Traffic Management and Road Surveillance

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

3.2.1 Intelligent Transport System (ITS)

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

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

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

2. **Information on Bus Transport**

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

3. **Portable Ticketing**

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

4. Public Mobility App

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

5. Synchronized Signaling

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

3.2.2 Road Surveillance

1. Traffic Rule Violation Detection

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

The traffic violation detection by the Camera's to be analysed by the Video Analytics Software in the CCC and the ANPR to detect the vehicle number of the vehicles that violate the traffic rule. The identified vehicle number details then to be fetched from the RTO / Vahan -Sarathi systems and e-Challan to be sent to the contact details of the person against whose name the vehicle is registered.

2. Automatic Number Plate Recognition

3. Object Detection (for suspicious objects)

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

4. Road Disaster Alert

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

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

3.3 TRAFFIC MANAGEMENT PLAN

3.3.1 *Traffic Management during Construction and Upgradation Works*

The basic upgradation of roads are considered for development which are listed below

Table 74 Road Upgradation Features

Rd. No	Road	Type of Pavement	Quality of Pavement	Road Upgradation
1	OLD KENT ROAD	Rigid/Flexible	Poor	Rigid Pavement, Footpath, Utility Corridor, SWD
2	PANDESHWARA NEW ROAD	Flexible	Poor	Rigid Pavement, Footpath, Utility Corridor, SWD
3	BOLAR FISHERIES COLLEGE RD	Earthen	Poor	Rigid Pavement, Footpath, Utility Corridor, SWD
4	MULIHITHLU ROAD	Flexible	Poor	Rigid Pavement, Footpath, Utility Corridor, SWD
5	MANGALADEVI TEMPLE ROAD	Flexible	Poor	Rigid Pavement, Footpath, Utility Corridor, SWD
6	MONKEYSTAND NEW ROAD	Flexible	Poor	Rigid Pavement, Footpath, Utility Corridor, SWD
7	JEPPU MARKET ROAD	Flexible	Poor	Rigid Pavement, Footpath, Utility Corridor, SWD
8	GUJJARKERE ROAD	Flexible	Poor	Rigid Pavement, Footpath, Utility Corridor, SWD

3.3.2 *Old Kent Road*

At present, 7,723 vehicles (8,394 PCUs) ply on Old Kent Road. Eastward traffic can be diverted towards Mangaladevi Road from BR Karkera Road Jn.

Following table gives the composition of peak traffic of Old Kent Road.

Table 75 Modal Split of Old Kent Road

2 Wheeler	3 Wheeler	Car	LCV	Bus/Truck	Other (MT)	Other (NMT)	Total Vehicles	Total PCUs
3,915	1,566	2,061	88	83	0	10	7,723	8,394

3.3.3 *Pandeswara New Road*

At present, 1,171 vehicles (1,342 PCUs) ply on Pandeswara New Road. Westward traffic can be diverted towards Mangaladevi Road from BR Karkera Road Jn.

Following table gives the composition of peak traffic of Pandeswara New Road.

Table 76 Modal Split of New Pandeswara New Road

2 Wheeler	3 Wheeler	Car	LCV	Bus/Truck	Other (MT)	Other (NMT)	Total Vehicles	Total PCUs
519	283	334	19	13	0	3	1,171	1,342

3.3.4 Bolar Fisheries College Road

At present, 1962 vehicles (1741 PCUs) ply on DBS Road. Northward traffic can be diverted towards Azizuddin Road and Southward traffic can be diverted towards MPT Road or Bunder Road or the vice versa.

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

Table 77 Modal Split of Bolar Fisheries College Road

2 Wheeler	3 Wheeler	Car	LCV	Bus/Truck	Other (MT)	Other (NMT)	Total Vehicles	Total PCUs
1,302	367	139	125	24	0	5	1,962	1,741

3.3.5 Mulihithulu Road

At present, 478 vehicles (1440 PCUs) ply on Mulihithulu Road. Southward and Northward traffic can be diverted through P&T Colony Road. The alternative road is also very congested and a residential road, so it is recommended to initiate the constructions during night times.

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

Table 78 Modal Split of Mulihithulu Road

2 Wheeler	3 Wheeler	Car	LCV	Bus/Truck	Other (MT)	Other (NMT)	Total Vehicles	Total PCUs
8	22	77	9	361	0	1	478	1,440

3.3.6 Mangaladevi Temple Road

At present, 36,327 vehicles (35,998PCUs) ply on Mangaladevi Temple Road. Eastward traffic can be diverted towards Monkey stand Road and Westside traffic can be diverted towards Monkey stand road and Bolar Road.

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

Table 79 Modal Split of Mangaladevi Temple Road

2 Wheeler	3 Wheeler	Car	LCV	Bus/Truck	Other (MT)	Other (NMT)	Total Vehicles	Total PCUs
22,613	4,301	6,170	2499	707	1	36	36,327	35,998

3.3.7 Monkeystand Road

At present, 13,540 vehicles (13,519PCUs) ply on Monkey stand Road. Eastward and Westward traffic can be diverted towards Mangaladevi Temple Road. The junction of Shivanagar to be open during the phases to move the vehicles towards Shivanagar area.

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

Table 80 Modal Split of Monkeystand Road

2 Wheeler	3 Wheeler	Car	LCV	Bus/Truck	Other (MT)	Other (NMT)	Total Vehicles	Total PCUs
8,592	1,932	2,428	357	211	0	20	13,540	13,519

3.3.8 Jeppu Market Road

At present, 25,324 vehicles (24,852 PCUs) ply on Jeppu Market Road. Northward traffic can be diverted towards Bolar Road and Southward traffic can be diverted towards Mangaladevi Temple Road.

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

Table 81 Modal Split of Jeppu Market Road

2 Wheeler	3 Wheeler	Car	LCV	Bus/Truck	Other (MT)	Other (NMT)	Total Vehicles	Total PCUs
16,116	2,870	4,103	1723	485	1	26	25,324	24,852

3.3.9 Gujjarkere Road

At present, 4,048 vehicles (3,871PCUs) ply on Gujjarekere Road. Southward and Westward traffic can be diverted towards Morgans Gate Road.

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

Table 82 Modal Split of Gujjarkere Road

2 Wheeler	3 Wheeler	Car	LCV	Bus/Truck	Other (MT)	Other (NMT)	Total Vehicles	Total PCUs
2,810	498	549	94	52	0	45	4,048	3,871

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.

2.1.1 Safety Measure during Construction

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

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

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

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

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

For ensuring legibility and emphasis at night, the signs shall be retro-reflective of at least Grade Type III, i.e. high intensity grade conforming to 801 of Specifications for Roads & Bridges, Ministry of Road Transport and Highways. The material shall be smooth, sealed outer surface or illuminated to depict the same shape and similar color for both day and night. Sign illumination may be either internal or external and the signboards may be made of rigid or flexible material.

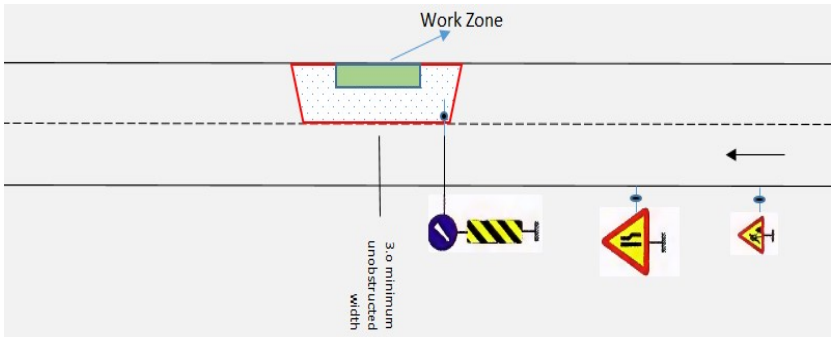


Figure 47 Traffic Control System along the road during Construction

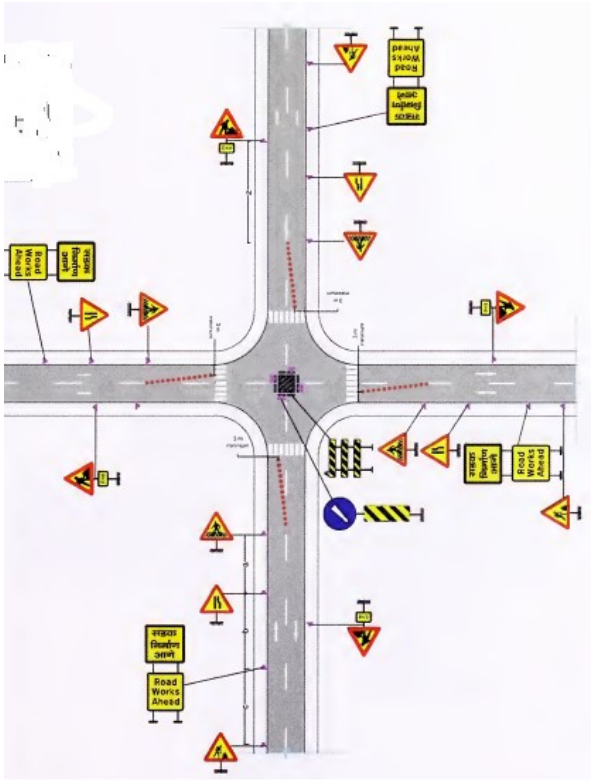


Figure 48 Traffic Control System along the road during Construction

2.1.2 Conclusion

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

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

Chapter 4 TIMELINE FOR EXECUTION

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

4.1 Construction Phase

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

4.2 Defect Liability

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

4.3 Maintenance Period

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

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

Chapter 5 MONITORING AND EVALUATION

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

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

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

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

Table 83 Risks Mitigation Strategies

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

			impact on the urban infrastructure sector is not envisaged. The present policies in force are expected to pave the way for Smart City development over the long term.
3	Force Majeure.		
	Act of God (Fire, earthquake, etc)	Low	Such risks shall be mitigated through insurance cover. The contractor would be mandated to keep in force insurance covering all project assets during the construction and contract liability phase for insurable events.

Chapter 6 COST ESTIMATES

The section of the report deals with the Cost Estimates for DPR-6 Smart Roads

6.1 Assumptions

- SOR rates as per Karnataka PWD SOR-Mangalore Circle (SOR 2018-19)
- 10% weightage has been added to SOR rates of Mangalore Circle PWD Circle
- Non SOR Items based on Rate Analysis OR on Vendor Quotations
- Landscaping rates as per Karnataka PWD and As per EOI.
- Water Supply Package are to be executed under ADB Project and as separate package, hence cost not to be considered in smart road tender cost
- UGD (sewer network) Package will be floated as separate tender, hence cost not to be considered in smart road tender cost
- LED Street Light Package will be floated as separate tender, hence cost not to be considered in smart road tender cost
- ICT Package will be floated as separate tender, hence not to be considered in smart road tender cost

6.2 Summary of Estimate

Summary of the estimate is as stated in table below:

Table 84 Smart Road Package- 5 – Summary of Estimate

Sr. No.	Description	Cost In INR
1	Road and Other Works	39,63,36,592
2	Street Lighting	64,45,368
3	Landscape Work	2,20,184
	Construction Cost Sub Total	**40,30,02,144**
	GST @ 12% on Civil Construction Cost (Refer 1.0 Abstract)	4,72,99,932
	Provision for Third Party Damages and Maintenance at 1 st Year(DLP-	39,63,351
	GST @12% on DLP Cost (Refer 5.1 Abstract)	2,76,713
	Maintenance Cost of 2nd,3rd and 4th Year	1,23,21,456
	GST @12% on Maintenance Cost	11,73,949
	Escalation and Tender Premium @10%	403,00,214
	Add 3 % Contingency	120,90,064
	Miscellaneous and Rounding off	72,177
	Grand Total	**52,05,00,000**

6.3 Detailed BOQ

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

ANNEXURES I – LIST OF DRAWINGS

No.	Drawing no	Drawing Title	No of Sheets
1	WTE_2292_06_R_1.01	EXISTING FEATURES OF OLD KENT RD. No. - 2 (OLD KENT RD. TO MANGALADAEVI RD JN. HOSPITAL ROAD)	4
2	WTE_2292_06_R_1.02	EXISTING FEATURES OF PANDESHWARA NEW Rd. No- 3 (ROSARIO CHURCH Rd. TO PANDESHWAR NEW Rd.)	2
3	WTE_2292_06_R_1.03	EXISTING FEATURES OF BOLAR FISHERIES COLLEGE Rd. No- 4 (HOIGEBAZAR Rd. (KFDC LTD). TO SEA FACE (MANGALURU OLD PORT)	1
4	WTE_2292_06_R_1.04	EXISTING FEATURES OF MULIHITHLU RD. No- 5 (MANGALADEVI TEMPLE ROAD TO MULIHITHLU ROAD)	3
5	WTE_2292_06_R_1.05	EXISTING FEATURES OF MANGALADEVI TEMPLE Rd. - NO- 6 (MANGALADEVI TEMPLE TO MARNAMIKATTA CIRCLE)	3
6	WTE_2292_06_R_1.06	EXISTING FEATURES OF MONKEYSTAND NEW Rd. No. - 7 (MANGALADEVI Rd. (RAMAKRISHNA MATH JN) TO JAIHIND CIRCLE)	3
7	WTE_2292_06_R_1.07	EXISTING FEATURES OF JEPPU MARKET Rd. No- 8 (ABHAYA LIMBS CENTER TO JEPPU MARKET Jn.)	1
8	WTE_2292_06_R_1.08	EXISTING FEATURES OF GUJJARKERE Rd. NO- 9 (JEPPU MARKET Jn. TO JAPPINA MOGARU)	3
9	WTE_2292_06_R_2.01	PLAN AND PROFILE OF OLD KENT ROAD (ROAD NO. 02) AT OLD KENT ROAD TO MANGALADEVI ROAD JUNCTION	1
10	WTE_2292_06_R_2.02	PLAN AND PROFILE OF BOLAR FISHERIES COLLEGE ROAD (ROAD NO. 04) AT HOIGEBAZAR ROAD (KFDC Ltd) TO SEA FACE (MANGALURU OLD PORT)	1
11	WTE_2292_06_R_2.03	PLAN AND PROFILE OF MULIHITHLU ROAD (ROAD NO. 05) AT MANGALADEVI TEMPLE TO MULIHITHLU ROAD	1
12	WTE_2292_06_R_2.04	PLAN AND PROFILE OF JEPPU MARKET ROAD (ROAD NO. 08) AT ABHAYA LIMBS CENTER TO JEPPU MARKET JUNCTION	1
13	WTE_2292_06_R_2.05	PLAN AND PROFILE OF GUJJARKERE ROAD (ROAD NO. 09) AT JEPPU MARKET JUNCTION TO JAPPINA MOGARU	1
14	WTE_2292_06_R_2.06	PLAN AND PROFILE OF PENDESHWARA NEW ROAD (ROAD NO. 03) ROSARIO CHURCH ROAD TO PENDESHWARA NEW ROAD	1
15	WTE_2292_06_R_2.07	PLAN AND PROFILE OF MANGALADEVI TEMPLE ROAD (ROAD NO. 06) MANGALADEVI TEMPLE TO MARNAMIKATTA CIRCLE	1
16	WTE_2292_06_R_2.08	PLAN AND PROFILE OF MONKEYSTAND NEW ROAD (ROAD NO. 07) MANGALADEVI ROAD (RAMKRISHNA MATH JN.) TO JAIHIND CIRCLE	1
17	WTE_2292_06_R_3.01	ROAD CARRIAGEWAY, FOOTPATH, SIGNAGES & ROAD MARKING PLAN OF OLD KENT ROAD-Road-2	4
18	WTE_2292_06_R_3.02	ROAD CARRIAGEWAY, FOOTPATH, SIGNAGES & ROAD MARKING PLAN OF PANDESHWARA NEW ROAD -3	2
19	WTE_2292_06_R_3.03	BOLAR FISHERIES CILLEGE ROAD -4	1
20	WTE_2292_06_R_3.04	ROAD CARRIAGEWAY, FOOTPATH, SIGNAGES & ROAD MARKING PLAN OF MULIHITHLU ROAD -5	3

21	WTE_2292_06_R_3.05	ROAD CARRIAGEWAY, FOOTPATH, SIGNAGES & ROAD MARKING PLAN OF MANGALADEVI TEMPLE ROAD-6	**3**
22	WTE_2292_06_R_3.06	ROAD CARRIAGEWAY, FOOTPATH, SIGNAGES & ROAD MARKING PLAN OF MONKEY STAND ROAD -7	**3**
23	WTE_2292_06_R_3.07	ROAD CARRIAGEWAY, FOOTPATH, SIGNAGES & ROAD MARKING PLAN OF JAPPU MARKET ROAD -8	**1**
24	WTE_2292_06_R_3.08	ROAD CARRIAGEWAY, FOOTPATH, SIGNAGES & ROAD MARKING PLAN OF GUJJAREKERE ROAD - 9	**3**
25	WTE_2292_06_R_4.01	ROAD SIGNAGES AND MARKING DETAILS	**1**
26	WTE_2292_06_R_5.01	OLD KENT ROAD (ROAD NO. 02) CROSS SECTIONS	**16**
27	WTE_2292_06_R_5.02	PANDESHWARA NEW ROAD (ROAD NO. 03) CROSS SECTIONS	**6**
28	WTE_2292_06_R_5.03	BOLARFISHERIES COLLAGE ROAD (ROAD NO. 04) CROSS SECTIONS	**4**
29	WTE_2292_06_R_5.04	MULIHITHLU ROAD (ROAD NO. 5) CROSS SECTIONS	**16**
30	WTE_2292_06_R_5.05	MANGLADEVI TEMPLE ROAD (ROAD NO. 06) CROSS SECTIONS	**12**
31	WTE_2292_06_R_5.06	MONKEYSTAND NEW ROAD (ROAD NO. 07) CROSS SECTIONS	**11**
32	WTE_2292_06_R_5.07	JEPPU MARKET ROAD (ROAD NO. 08) CROSS SECTIONS	**4**
33	WTE_2292_06_R_5.08	GUJJARKERE ROAD (ROAD NO. 09) CROSS SECTIONS	**12**

ANNEXURES II – SPECIFICATIONS

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

LANDSCAPE DETAILS AS PER SPECIFICATIONS MENTIONED IN DRWINGS FOR PLANTING DETAIL

SOME SPECIFIC SPECIFICATIONS CONSIDERED ARE AS MENTIONED BELOW

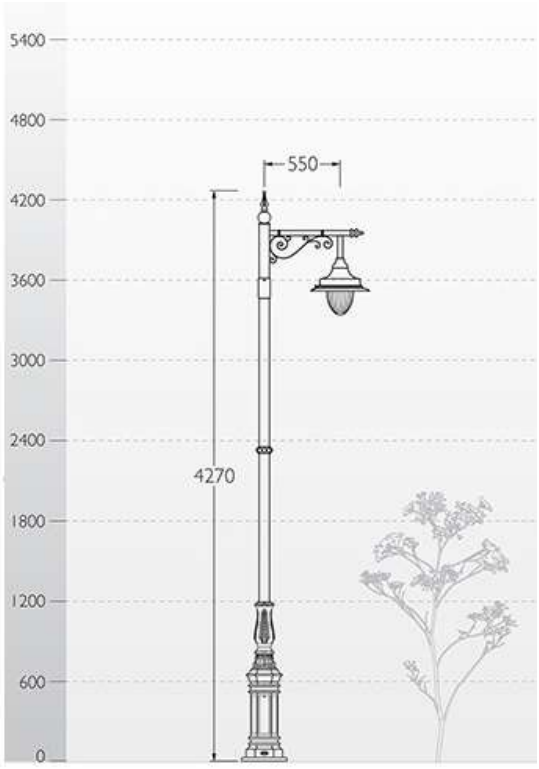
LIGHT FIXTURE FOR FOOTPATH

Make : K-LITE

MODEL : VICENT LIGHTING POLE

Code : KP-450

HT : 4270MM



PERMEABLE ECO-FRIENDLY PAVERS DETAILS

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

Description:

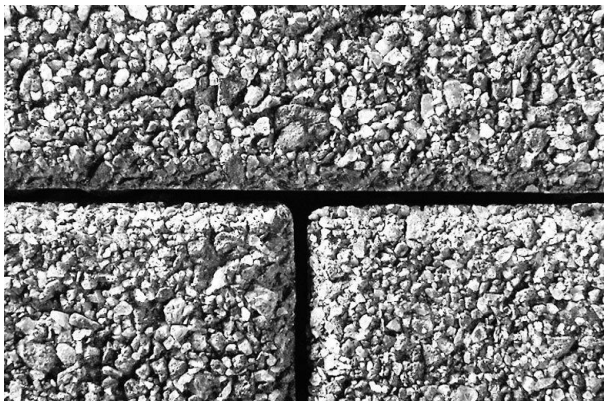


Figure 1 washed finish

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

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

Handling and Installation

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

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

Description:

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

- Maximizes ground water recharge enabling water harvesting for reuse.

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

Dimensions:

Thickness: 3 1/8 inches (80mm)

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

Inside Length : 4 ½ inches (112.5mm)

Pavers Per Sft: 2.41

Percentage of drainage "opening" area per sft : 12.18%

Figure 2 Terracotta 70%-grey 30%

PEDESTRIAN SIGNAL:

Salient features of Traffic Signal Heads

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

Pedestrian Traffic Light

ROADSIDE DUSTBIN:

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

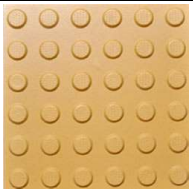
BOLLARDS:

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

Features

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

TACTILE PAVING

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

ANNEXURES III – DESIGN CALCULATIONS FOR STORM WATER DRAINAGE

OLD KENT ROAD (ROAD NO-1)																			
Start Node	Invert (Start) (m)	Stop Node	Invert (Stop) (m)	Length (Scaled) (m)	Slope (Calculated) (1/S)	Manning's n	Velocity (m/s)	Capacity (Full Flow) (L/s)	Flow / Capacity (Design) (%)	Width (m)	Elevation Ground (Start) (m)	Elevation Ground (Stop) (m)	Material	Depth (Average End) / Rise (%)	Flow (L/s)	Depth(Start)(m)	Depth(Stop)(m)	Orientation	Remarks
MH-542	15.63	MH-543	15	50.4	79.433	0.013	1.8	916.71	16.6	0.6	16.84	16.21	Concrete	26.5	151.9	1.21	1.21	Both Side	
MH-543	15	MH-544	14.75	13.1	52.517	0.013	2.06	1127.4	13.3	0.6	16.21	15.96	Concrete	30.6	150.26	1.21	1.21	Both Side	
MH-544	14.75	MH-545	14.5	49.4	200	0.013	1.3	577.72	25.9	0.6	15.96	16.06	Concrete	30.5	149.89	1.21	1.56	Both Side	
MH-545	14.5	MH-296	13.23	118.7	92.984	0.013	1.69	847.28	17.4	0.6	16.06	14.5	Concrete	26.6	147.73	1.56	1.27	Both Side	
MH-296	13.23	MH-297	12.52	21.1	30	0.013	2.25	1491.66	7.4	0.6	14.5	13.82	Concrete	18.9	111.03	1.27	1.3	Both Side	
MH-297	12.52	MH-298	12.04	19.2	40	0.013	2.04	1291.81	8.6	0.6	13.82	13.34	Concrete	19.6	110.87	1.3	1.3	Both Side	
MH-298	12.04	MH-299	11.57	18.8	40	0.013	2.04	1291.81	8.6	0.6	13.34	12.85	Concrete	19.6	110.7	1.3	1.28	Both Side	
MH-299	11.57	MH-300	11.25	12.9	40	0.013	2.04	1291.81	8.6	0.6	12.85	12.52	Concrete	19.5	110.54	1.28	1.27	Both Side	
MH-300	11.25	MH-301	9.5	43.7	25	0.013	2.38	1634.03	6.8	0.6	12.52	10.84	Concrete	18.5	110.43	1.27	1.34	Both Side	
MH-301	9.5	MH-302	8.57	27.9	30	0.013	2.24	1491.66	7.4	0.6	10.84	9.83	Concrete	18.8	110.11	1.34	1.26	Both Side	
MH-302	8.57	MH-303	8.04	18.8	35	0.013	2.13	1381.01	8	0.6	9.83	9.25	Concrete	19.2	109.9	1.26	1.21	Both Side	
MH-303	8.04	MH-304	6.63	35.3	25	0.013	2.38	1634.03	6.7	0.6	9.25	7.94	Concrete	18.4	109.75	1.21	1.31	Both Side	
MH-304	6.63	MH-305	5.34	32	25	0.013	2.37	1634.03	6.7	0.6	7.94	6.65	Concrete	18.4	109.49	1.31	1.31	Both Side	

MH-305	5.34	MH-306	4.25	59.9	55	0.013	1.83	1101.66	9.9	0.6	6.65	5.54	Concrete	20.2	109.26	1.31	1.29	Both Side	
MH-306	4.25	O-33	3.93	48	150	0.013	1.3	667.09	16.3	0.6	5.54	5.22	Concrete	23.3	108.71	1.29	1.29	Both Side	

MH-546	15.1	MH-547	14.74	21.5	60	0.013	2.49	1054.76	30.9	0.9	16.31	15.96	Concrete	59.8	326.21	1.21	1.22	Both Side	
MH-547	14.74	MH-549	14.6	55.8	400	0.013	1.22	408.51	79.6	0.9	15.96	16.02	Concrete	59.8	325.11	1.22	1.42	Both Side	
MH-549	14.6	MH-548	14.18	42.7	100	0.013	2.06	817.01	39.1	0.9	16.02	15.6	Concrete	45.7	319.45	1.42	1.42	Both Side	
MH-548	14.18	MH-531	13.06	66.9	60	0.013	2.47	1054.76	30	0.9	15.6	14.5	Concrete	42	316.95	1.42	1.44	Both Side	
MH-531	12.78	MH-532	11.59	41.6	35	0.013	2.16	1381.01	27.6	0.9	14.5	13.34	Concrete	44.2	381.66	1.72	1.75	Both Side	
MH-532	11.59	MH-533	10.86	25.7	35	0.013	2.16	1381.01	27.5	0.9	13.34	12.52	Concrete	44.2	379.79	1.75	1.66	Both Side	
MH-533	10.86	MH-534	9.81	36.6	35	0.013	2.16	1381.01	27.4	0.9	12.52	11.32	Concrete	44	378.65	1.66	1.51	Both Side	
MH-534	9.72	MH-535	8.29	50	35	0.013	2.16	1381.01	27.3	0.9	11.32	9.83	Concrete	43.9	377.02	1.6	1.54	Both Side	
MH-535	8.29	MH-536	7.74	22.2	40	0.013	2	1291.81	29	0.9	9.83	9.25	Concrete	44.7	374.83	1.54	1.51	Both Side	
MH-536	7.46	MH-537	5.98	29.7	20	0.013	2.83	1826.9	20.5	0.9	9.25	7.49	Concrete	40.8	373.81	1.79	1.51	Both Side	
MH-537	5.94	MH-538	5.14	36.2	45	0.013	2.87	1217.93	30.6	0.9	7.49	6.65	Concrete	45	372.75	1.55	1.51	Both Side	
MH-538	5.09	MH-539	4.15	51.6	55	0.013	2.67	1101.66	33.7	0.9	6.65	5.66	Concrete	46.2	371.05	1.56	1.51	Both Side	
MH-539	4.15	MH-540	4.03	9.5	80	0.013	2.32	913.45	40.3	0.9	5.66	5.54	Concrete	49.5	368.46	1.51	1.51	Both Side	
MH-540	4.03	O-59	3.67	45.3	125	0.013	1.97	730.76	50.3	0.9	5.54	5.18	Concrete	52.5	367.91	1.51	1.51	Both Side	

NEW PANDESWARA ROAD (ROAD NO-2)																		
Start Node	Invert (Start) (m)	Stop Node	Invert (Stop) (m)	Length (Scaled) (m)	Slope (Calculated) (1/S)	Manning's n	Velocity (m/s)	Capacity (Full Flow) (L/s)	Flow / Capacity (Design) (%)	Width (m)	Elevation Ground (Start) (m)	Elevation Ground (Stop) (m)	Material	Depth (Average End) / Rise (%)	Flow (L/s)	Depth(Start)(m)	Depth(Stop)(m)	Orientation
MH-572	6.15	O-61	2.39	112.8	30	0.013	2.44	1491.66	28.3	0.75	7.65	3.6	Concrete	46.4	421.63	1.5	1.21	one side
MH-527	5.95	MH-528	5.56	17.3	45	0.013	2.15	1217.93	43.1	0.6	7.22	6.8	Concrete	58.1	524.46	1.27	1.24	one side
MH-528	5.56	O-58	4.08	88.8	60	0.013	2.83	1054.76	49.6	0.6	6.8	5.29	Concrete	59.4	523.33	1.24	1.21	one side
MH-571	6.3	MH-527	5.95	44.9	125	0.013	1.64	730.76	25.9	0.6	7.58	7.22	Concrete	52.2	189.33	1.28	1.27	one side

BOLAR FISHERIES ROAD (ROAD NO-3)																			
Start Node	Invert (Start) (m)	Stop Node	Invert (Stop) (m)	Length (Scaled) (m)	Slope (Calculated) (1/S)	Manning's n	Velocity (m/s)	Capacity (Full Flow) (L/s)	Flow / Capacity (Design) (%)	Width (m)	Elevation Ground (Start) (m)	Elevation Ground (Stop) (m)	Material	Depth (Average End) / Rise (%)	Flow (L/s)	Depth(Start)(m)	Depth(Stop)(m)	Orientation	Remarks
MH-377	0.82	O-39	0.25	114.8	200	0.013	1.5	577.72	43.1	1.2	2.14	1.58	Concrete	43.5	249.18	1.3	1.9	one side	Existing Drain to be lined

MULIHITHULU ROAD (ROAD NO-4)																			
Start Node	Invert (Start) (m)	Stop Node	Invert (Stop) (m)	Length (Scaled) (m)	Slope (Calculated) (1/S)	Manning's n	Velocity (m/s)	Capacity (Full Flow) (L/s)	Flow / Capacity (Design) (%)	Width (m)	Elevation Ground (Start) (m)	Elevation Ground (Stop) (m)	Material	Depth (Average End) / Rise (%)	Flow (L/s)	Depth(Start)(m)	Depth(Stop)(m)	Orientation	Remarks
MH-551	11.59	MH-261	11.31	41	145	0.013	2.32	1141.32	78.7	0.9	12.91	12.63	Concrete	87.3	897.68	1.32	1.32	One Side	
MH-261	11.31	MH-262	9.88	49.9	35	0.013	2.95	1381.01	64.6	0.9	12.63	11.11	Concrete	79.7	891.54	1.32	1.23	One Side	
MH-262	9.88	MH-263	9.3	55.3	95	0.013	2.71	1410.04	62.9	0.9	11.11	10.52	Concrete	86.6	887.2	1.23	1.22	One Side	
MH-263	9.3	MH-615	8.88	31.4	75	0.013	2.92	943.41	93.3	0.9	10.52	10.09	Concrete	89.4	880.27	1.22	1.21	One Side	
MH-615	8.88	O-29	8.47	27.2	65	0.013	2.09	1013.38	86.5	0.9	10.09	9.68	Concrete	87.2	876.67	1.21	1.21	One Side	
MH-579	9.13	MH-578	8.98	16.4	-110	0.013	2.49	1310.38	60.4	0.9	10.38	10.23	Concrete	80.4	791.65	1.25	1.25	One Side	
MH-578	8.98	MH-577	8.42	19.7	-35	0.013	2.84	1381.01	57.2	0.9	10.23	9.66	Concrete	74.9	789.62	1.25	1.24	One Side	
MH-577	8.42	MH-576	7.84	31.8	-55	0.013	2.22	1101.66	71.5	0.9	9.66	9.06	Concrete	78.5	788.05	1.24	1.22	One Side	
MH-576	7.84	MH-575	7.33	33.2	-65	0.013	2.02	1013.38	77.5	0.9	9.06	8.54	Concrete	80.3	785.04	1.22	1.21	One Side	
MH-575	7.33	O-68	7.21	31.1	-250	0.013	1.83	869.21	89.9	0.9	8.54	8.86	Concrete	73.1	781.72	1.21	1.65	One Side	
MH-581	6.94	MH-582	3.99	36.3	20	0.013	2.7	1826.9	18.3	0.6	9.24	6.33	Concrete	37.8	334.64	2.3	2.34	Both Side	
MH-582	3.99	MH-583	2.94	20.9	20	0.013	2.7	1826.9	18.2	0.6	6.33	4.76	Concrete	37.9	333.36	2.34	1.82	Both Side	
MH-583	2.94	MH-584	2.07	17.4	20	0.013	2.69	1826.9	18.2	0.6	4.76	3.5	Concrete	38.1	332.63	1.82	1.43	Both Side	

MH-584	2.07	MH-585	1.77	13.8	45	0.013	2.78	1217.93	27.3	0.6	3.5	3.18	Concrete	42.4	332.03	1.43	1.41	Both Side	
MH-585	1.77	MH-586	0.63	28.4	25	0.013	2.41	1634.03	20.3	0.6	3.18	1.91	Concrete	38.5	331.39	1.41	1.28	Both Side	
MH-586	0.63	MH-587	0.27	9	25	0.013	2.41	1634.03	20.2	0.6	1.91	1.51	Concrete	40.1	330.33	1.28	1.24	Both Side	
MH-587	0.27	O-69	-0.34	21.6	35	0.013	2.03	1381.01	23.9	0.6	1.51	0.87	Concrete	40.3	329.99	1.24	1.21	Both Side	

MH-617	6.72	MH-618	5.41	12.9	20	0.013	1.71	1826.9	2	0.6	9.24	7.29	Concrete	8.7	36.58	2.52	1.88	Both Side	
MH-618	5.41	MH-619	4.21	24	20	0.013	1.71	1826.9	2	0.6	7.29	6.33	Concrete	8.7	36.48	1.88	2.12	Both Side	
MH-619	4.21	MH-620	3.36	16.9	20	0.013	1.71	1826.9	2	0.6	6.33	4.76	Concrete	8.7	36.28	2.12	1.4	Both Side	
MH-620	3.36	MH-621	2.29	21.4	20	0.013	1.71	1826.9	2	0.6	4.76	3.5	Concrete	8.7	36.14	1.4	1.21	Both Side	
MH-621	2.29	MH-622	1.78	10.1	20	0.013	1.7	1826.9	2	0.6	3.5	3.18	Concrete	8.6	35.97	1.21	1.4	Both Side	
MH-622	1.78	MH-623	-0.28	41.4	20	0.013	1.7	1826.9	2	0.6	3.18	1.51	Concrete	8.6	35.88	1.4	1.79	Both Side	
MH-623	-0.28	O-70	-0.96	23.8	35	0.013	1.42	1381.01	2.6	0.6	1.51	0.87	Concrete	9.1	35.55	1.79	1.83	Both Side	

MH-257	15.53	MH-366	15.43	24.8	250	0.013	2.19	2203.68	72.7	1.2	17.6	17.11	Concrete	63.7	1601.81	2.07	1.68	one Side	
MH-366	15.43	MH-258	14.95	52	110	0.013	2.96	3322.18	48	1.2	17.11	16.73	Concrete	55	1594.39	1.68	1.78	one Side	
MH-258	14.95	MH-259	14.33	28.1	45	0.013	2.05	5194.13	30.5	1.2	16.73	16.13	Concrete	49.4	1583.04	1.78	1.8	one Side	
MH-259	14.33	MH-260	11.43	101.5	35	0.013	2.42	5889.59	26.8	1.2	16.13	12.97	Concrete	46.6	1578.6	1.8	1.54	one Side	

MANGALADEVI TEMPLE ROAD (ROAD NO-5)																			
Start Node	Invert (Start) (m)	Stop Node	Invert (Stop) (m)	Length (Scaled) (m)	Slope (Calculated) (1/S)	Manning's n	Velocity (m/s)	Capacity (Full Flow) (L/s)	Flow / Capacity (Design) (%)	Width (m)	Elevation Ground (Start) (m)	Elevation Ground (Stop) (m)	Material	Depth (Average End) / Rise (%)	Flow (L/s)	Depth(Start)(m)	Depth(Stop)(m)	Orientation	Remarks
MH-223	17.68	MH-224	16.35	92.7	70	0.013	2.56	2365.94	73.2	1.2	19.19	17.88	Concrete	65.4	1732.16	1.51	1.53	Both Sides	Existing New drains to be retained
MH-224	16.35	MH-225	16.17	56	300	0.013	2.08	2011.68	85.2	1.2	17.88	17.69	Concrete	73.6	1713.18	1.53	1.52	Both Sides	Existing New drains to be retained
MH-225	16.17	MH-226	16.1	65.3	1000	0.013	1.32	1831.01	92.5	1.2	17.69	17.61	Concrete	72	1693.09	1.52	1.51	Both Sides	Existing New drains to be retained
MH-226	16.1	MH-257	15.95	145.2	1000	0.013	1.31	1831.01	90.5	1.2	17.61	17.6	Concrete	59.5	1657.3	1.51	1.65	Both Sides	Existing New drains to be retained

MH-207	21.79	MH-208	21.69	48	480	0.013	0.61	372.91	9.5	0.9	23.05	22.95	Concrete	15.8	35.46	1.26	1.26	Both Sides	Existing New drains to be retained
MH-208	21.69	MH-209	21.62	37.2	530	0.013	0.59	354.89	9.9	0.9	22.95	22.88	Concrete	13.8	35.24	1.26	1.26	Both Sides	Existing New drains to be retained
MH-209	21.62	MH-210	21.24	22.3	60	0.013	1.19	1054.76	3.3	0.9	22.88	22.52	Concrete	9.6	35.05	1.26	1.28	Both Sides	Existing New drains to be retained
MH-210	21.24	MH-211	19.65	71.7	45	0.013	1.31	1217.93	2.9	0.9	22.52	20.86	Concrete	9.3	35	1.28	1.21	Both Sides	Existing New drains to be retained
MH-211	19.65	MH-212	18.24	35.3	25	0.013	1.57	1634.03	2.1	0.9	20.86	19.49	Concrete	8.7	34.84	1.21	1.25	Both Sides	Existing New drains to be retained

MH-212	18.24	MH-213	16.81	85.6	60	0.013	1.19	1054.76	3.3	0.9	19.49	18.05	Concrete	9.6	34.78	1.25	1.24	Both Sides	Existing New drains to be retained
MH-213	16.81	MH-214	16.37	55.1	125	0.013	0.94	730.76	4.7	0.9	18.05	17.61	Concrete	15.3	34.58	1.24	1.24	Both Sides	Existing New drains to be retained
MH-214	16.37	MH-215	16.31	64.3	1000	0.013	0.47	258.36	13.3	0.9	17.61	17.57	Concrete	16	34.42	1.24	1.26	Both Sides	Existing New drains to be retained
MH-215	16.31	MH-216	15.95	101.3	280	0.013	0.72	488.26	7	0.9	17.57	17.21	Concrete	12	34.05	1.26	1.26	Both Sides	Existing New drains to be retained
MH-216	15.63	MH-256	15.48	36.8	250	0.013	0.74	516.73	6.5	0.9	17.21	17.57	Concrete	12.2	33.67	1.58	2.09	Both Sides	Existing New drains to be retained

MH-256	15.48	O-62	15.32	40.5	250	0.013	0.74	516.73	6.5	0.9	17.57	16.53	Concrete	11.6	33.54	2.09	1.21	Both Sides	Existing New drains to be retained
MH-218	21.51	MH-219	21.4	50.7	480	0.013	0.73	372.91	16.4	0.6	23.17	22.95	Concrete	22.8	61.24	1.66	1.55	Both Sides	Existing New drains to be retained
MH-219	21.4	MH-220	21.34	34.9	530	0.013	0.7	354.89	17.2	0.6	22.95	22.88	Concrete	19.8	60.89	1.55	1.54	Both Sides	Existing New drains to be retained
MH-220	21.34	MH-221	20.92	25.1	60	0.013	1.45	1054.76	5.7	0.6	22.88	22.52	Concrete	13.8	60.65	1.54	1.6	Both Sides	Existing New drains to be retained
MH-221	20.92	MH-222	19.01	85.8	45	0.013	1.59	1217.93	5	0.6	22.52	20.49	Concrete	13.3	60.56	1.6	1.48	Both Sides	Existing New drains to be retained

MONKEY STAND ROAD (ROAD NO-6)																			
Start Node	Invert (Start) (m)	Stop Node	Invert (Stop) (m)	Length (Scaled) (m)	Slope (Calculated) (1/S)	Manning's n	Velocity (m/s)	Capacity (Full Flow) (L/s)	Flow / Capacity (Design) (%)	Width (m)	Elevation Ground (Start) (m)	Elevation Ground (Stop) (m)	Material	Depth (Average End) / Rise (%)	Flow (L/s)	Depth(Start)(m)	Depth(Stop)(m)	Orientation	Remarks
MH-563	13.61	MH-564	12.26	80.8	60	0.013	1.95	1054.76	13.7	0.9	15.19	13.87	Concrete	24.6	144.24	1.58	1.61	One Side	
MH-564	12.26	MH-565	11.36	17.9	20	0.013	2.8	1826.9	7.8	0.9	13.87	12.92	Concrete	21.4	143.17	1.61	1.56	One Side	
MH-565	11.36	MH-566	9.2	43.3	20	0.013	2.8	1826.9	7.8	0.9	12.92	10.45	Concrete	21.4	143.01	1.56	1.25	One Side	
MH-566	9.2	MH-567	6.51	120.8	45	0.013	2.14	1217.93	11.7	0.9	10.45	7.72	Concrete	45.1	142.62	1.25	1.21	One Side	
MH-567	6.51	O-34	6.48	9.7	250	0.013	1.7	869.21	66.9	0.9	7.72	7.72	Concrete	59	581.34	1.21	1.24	One Side	
MH-612	20.68	MH-613	17.76	72.9	25	0.013	3.8	1634.03	29.3	0.9	22.69	19.43	Concrete	49.4	478.01	2.01	1.67	One Side	
MH-613	17.76	MH-614	15.09	40.1	15	0.013	4.55	2109.52	22.5	0.9	19.43	16.46	Concrete	46.4	474.43	1.67	1.37	One Side	
MH-614	15.09	MH-568	11.81	49.2	15	0.013	4.54	2109.52	22.4	0.9	16.46	13.47	Concrete	82.3	472.8	1.37	1.66	One Side	
MH-308	11.88	MH-309	9.21	53.2	20	0.013	4.19	1826.9	27.8	0.9	13.47	10.51	Concrete	50.1	507.35	1.59	1.3	One Side	
MH-309	9.21	O-34	6.48	54.8	20	0.013	4.19	1826.9	27.7	0.9	10.51	7.72	Concrete	50	505.45	1.3	1.24	One Side	
MH-568	11.81	MH-569	9.17	52.7	20	0.013	4.92	1826.9	50.5	0.9	13.47	10.51	Concrete	75.2	922.63	1.66	1.34	One Side	
MH-569	9.17	MH-570	7.37	36.1	20	0.013	4.92	1826.9	50.3	0.9	10.51	8.65	Concrete	75.6	918.82	1.34	1.28	One Side	
MH-570	7.37	MH-567	6.51	17.1	20	0.013	4.91	1826.9	50.2	0.9	8.65	7.72	Concrete	78.1	916.22	1.28	1.21	One Side	

JEPPU MARKET ROAD (ROAD NO-7)																			
Start Node	Invert (Start) (m)	Stop Node	Invert (Stop) (m)	Length (Scaled) (m)	Slope (Calculated) (1/S)	Manning's n	Velocity (m/s)	Capacity (Full Flow) (L/s)	Flow / Capacity (Design) (%)	Width (m)	Elevation Ground (Start) (m)	Elevation Ground (Stop) (m)	Material	Depth (Average End) / Rise (%)	Flow (L/s)	Depth(Start)(m)	Depth(Stop)(m)	Orientation	Remarks
MH-228	16.42	MH-229	11.57	121.2	25	0.013	2.2	1634.03	5.4	0.9	18.94	13.98	Concrete	15.9	87.75	2.52	2.41	Both Sides	
MH-229	11.57	MH-230	7.39	62.8	15	0.013	2.57	2109.52	4.1	0.9	13.98	9.95	Concrete	68.5	85.9	2.41	2.56	Both Sides	
MH-222	19.01	MH-605	13.58	136	25	0.013	1.92	1634.03	3.7	0.75	20.49	14.79	Concrete	12.4	60.3	1.48	1.21	Both Sides	
MH-605	13.58	O-66	13.49	12.8	160	0.013	1.05	645.91	9.3	0.75	14.79	14.71	Concrete	15.8	59.96	1.21	1.22	Both Sides	
MH-607	12.15	MH-608	11.08	21.6	20	0.013	2.36	1826.9	4.8	0.9	13.38	12.31	Concrete	15.5	87.76	1.23	1.23	Both Sides	
MH-608	11.08	MH-609	9.17	38.2	20	0.013	2.36	1826.9	4.8	0.9	12.31	10.38	Concrete	15.5	87.45	1.23	1.21	Both Sides	

GUJJAREKERE ROAD (ROAD NO-8)																			
Start Node	Invert (Start) (m)	Stop Node	Invert (Stop) (m)	Length (Scaled) (m)	Slope (Calculated) (1/S)	Manning's n	Velocity (m/s)	Capacity (Full Flow) (L/s)	Flow / Capacity (Design) (%)	Width (m)	Elevation Ground (Start) (m)	Elevation Ground (Stop) (m)	Material	Depth (Average End) / Rise (%)	Flow (L/s)	Depth(Start)(m)	Depth(Stop)(m)	Orientation	Remarks
MH-234	14.93	MH-235	14.91	16.9	1000	0.013	1.03	1101.84	58.1	1.2	16.58	16.8	Concrete	38.2	640.17	1.65	1.89	Both Sides	
MH-235	14.91	MH-236	13.44	29.4	20	0.013	2.92	7791.2	8.2	1.2	16.8	15.46	Concrete	23.9	636.07	1.89	2.02	Both Sides	

MH-236	13.44	MH-237	11.09	70.4	30	0.013	2.44	6361.48	10	1.2	15.46	12.99	Concrete	24.9	634.21	2.02	1.9	Both Sides	
MH-237	11.09	MH-238	8.36	68.4	25	0.013	2.64	6968.66	9	1.2	12.99	10.08	Concrete	24.3	629.18	1.9	1.72	Both Sides	
MH-238	8.36	MH-239	7.72	19.1	30	0.013	2.42	6361.48	9.8	1.2	10.08	9.45	Concrete	25	624.64	1.72	1.73	Both Sides	
MH-239	7.72	MH-240	6.78	37.7	40	0.013	2.11	5509.21	11.3	1.2	9.45	8.47	Concrete	25.4	623.3	1.73	1.69	Both Sides	
MH-240	6.78	MH-241	5.71	21.3	20	0.013	2.89	7791.2	8	1.2	8.47	7.27	Concrete	23.7	620.42	1.69	1.56	Both Sides	
MH-241	5.71	MH-242	4.85	25.9	30	0.013	2.41	6361.48	9.7	1.2	7.27	6.41	Concrete	24.6	619.13	1.56	1.56	Both Sides	
MH-242	4.85	MH-591	4.02	31.2	40	0.013	3.1	5509.21	11.2	1.2	6.41	5.58	Concrete	25.3	617.35	1.56	1.51	Both Sides	
MH-591	4.02	MH-246	3.83	48.3	250	0.013	1.67	2203.68	27.9	1.2	5.58	5.34	Concrete	33	615	1.56	1.51	Both Sides	
MH-246	3.83	MH-245	3.71	31	250	0.013	1.67	2203.68	27.6	1.2	5.34	5.31	Concrete	32.6	608.36	1.51	1.6	Both Sides	
MH-245	3.71	O-65	3.31	39.4	100	0.013	2.27	3484.33	17.3	1.2	5.31	5.46	Concrete	28	604.16	1.6	2.15	Both Sides	
MH-592	14.88	MH-593	13.81	37.3	35	0.013	2.03	1381.01	6.9	0.9	16.58	15.46	Concrete	23.2	95.31				
MH-593	13.81	MH-594	13.8	4.1	250	0.013	1.05	516.73	18.3	0.9	15.46	15.46	Concrete	23.1	94.63	1.65	1.66	Both Sides	
MH-594	13.8	MH-595	11.86	58.3	30	0.013	2.13	1491.66	6.3	0.9	15.46	13.26	Concrete	17	94.49	1.66	1.4	Both Sides	
MH-595	11.86	MH-596	9.59	56.8	25	0.013	2.24	1634.03	5.7	0.9	13.26	10.83	Concrete	22.8	93.5	1.4	1.24	Both Sides	
MH-596	9.59	MH-597	9.57	3.1	250	0.013	1.04	516.73	17.9	0.9	10.83	10.83	Concrete	22.7	92.6	1.24	1.26	Both Sides	
MH-597	9.57	MH-598	8.19	41.5	30	0.013	2.11	1491.66	6.2	0.9	10.83	9.46	Concrete	16.8	92.5	1.26	1.27	Both Sides	
MH-598	8.19	MH-599	7.25	42.3	45	0.013	1.84	1217.93	7.5	0.9	9.46	8.46	Concrete	17.5	91.82	1.27	1.21	Both Sides	
MH-599	7.25	MH-600	5.09	43.3	20	0.013	2.39	1826.9	5	0.9	8.46	6.41	Concrete	15.9	91.04	1.21	1.32	Both Sides	

MH-600	5.09	MH-601	4.47	21.7	35	0.013	1.99	1381.01	6.5	0.9	6.41	5.79	Concrete	16.8	90.43	1.32	1.32	Both Sides	
MH-601	4.47	MH-602	3.69	62.1	80	0.013	1.51	913.45	9.9	0.9	5.79	5	Concrete	22.3	90.07	1.32	1.31	Both Sides	
MH-602	3.69	MH-603	3.66	7.4	250	0.013	1.03	516.73	17.2	0.9	5	5	Concrete	23.2	88.73	1.31	1.34	Both Sides	
MH-603	3.66	O-64	3.37	72.7	250	0.013	1.02	516.73	17.1	0.9	5	5.46	Concrete	22.2	88.5	1.34	2.09	Both Sides	
MH-229	11.57	MH-230	7.39	62.8	15	0.013	2.57	2109.52	4.1	0.9	13.98	9.95	Concrete	68.5	85.9	1.7	1.65	Both Sides	
MH-230	7.39	MH-231	7.31	20.1	250	0.013	2.32	2203.68	92	0.9	9.95	9.61	Concrete	75	2026.64	1.65	1.66	Both Sides	
MH-231	7.31	MH-589	5.81	37.5	25	0.013	5.35	6968.66	29	0.9	9.61	7.77	Concrete	54	2020.16	1.66	1.4	Both Sides	
MH-589	5.81	MH-232	4.37	57.6	40	0.013	4.54	5509.21	36.6	0.9	7.77	6.27	Concrete	56.1	2014.95	1.4	1.24	Both Sides	
MH-232	4.37	O-63	3.54	29.2	35	0.013	4.75	5889.59	34.1	0.9	6.27	5.46	Concrete	56.5	2005.58	1.24	1.26	Both Sides	
MH-607	12.15	MH-608	11.08	21.6	20	0.013	2.36	1826.9	4.8	0.9	13.38	12.31	Concrete	15.5	87.76	1.27	1.21	Both Sides	
MH-608	11.08	MH-609	9.17	38.2	20	0.013	2.36	1826.9	4.8	0.9	12.31	10.38	Concrete	15.5	87.45	1.21	1.32	Both Sides	
MH-609	9.17	MH-610	5.1	101.6	25	0.013	2.19	1634.03	5.3	0.9	10.38	6.47	Concrete	15.8	86.9	1.32	1.32	Both Sides	
MH-610	5.1	O-67	4.27	41.6	50	0.013	1.74	1155.43	7.4	0.9	6.47	5.63	Concrete	16.9	85.37	1.32	1.31	Both Sides	

ANNEXURE IV: SUMMARY OF PAVEMENT THICKNESS – PACKAGE 6

Item	Pavement Quality Concrete (PQC)	Dry Lean Concrete (DLC)	Granular Sub-Base (GSB) (as Drainage Layer)	Selected Subgrade (CBR ≥ 8%)
Old Port Road	260	100	150	500
Old Kent Road	250	100	150	500
Pandeshwara New Road	250	100	150	500
Mulihithulu Road	250	100	150	500
Mangaladevi Temple Road	270	100	150	500
Monkey Stand New Road	260	100	150	500
Gujjarekere Road	250	100	150	500