CHAPTER 3
DESIGN

3.1 General

The design parameter as obtained from traffic survey indicate the widening of existing roads, the lane configuration has been decided and reproduced as given in **Table-3.1.** (Details given in separate volume).

3.1.1 Geometric Design

Lane configuration of road as per the traffic forecast of year 2026 and DP width available is proposed. The lane configuration is given in **Table 3.1**

Table 3.1 Proposed Lane Configuration

Road No.	Name of Road	Length (km)	Proposed Lane Configuration as per Traffic requirement							DP Width (m)	Land Use	Remarks
			Lane	Med-ian	On both sides of center line							
					Carri-age-way	Paver Block	Paved Shoul-der	Foot-path	Land scap-ing			
1	Railway Station to Vazirabad Police Station	0.750	4	0.6	7.5	0	0	1.2	0	18.00	Urban	-
2	Vazirabad Police Station Gurudwara Gate No.1	0.540	4	0.60	6.00	0.00	0.00	1.20	0.00	15.00	Urban	-
3	Gurudwara Gate No. 1 to Keli Market (upto Crusher road/Ambedkar Chowk)	0.762	4	0.60	7.50	0.00	0.00	1.20	0.00	18.00	Urban	-
4	Keli Market (Ambedkar Chowk) to Barki Chowk	0.307	4	0.60	7.50	0.00	0.00	1.20	0.00	18.00	Urban	-
5	Barki Chowk to Darbar Masjid Chowk to Navghat	0.769	4	0.60	6.00	0.00	0.00	1.20	0.00	15.00	Urban	Median by edge marking. No barrier.
6	Darbar Masjid Chowk to Fort	0.265	2	0.00	3.75	1.50	0.00	1.50	2.25	18.00	Urban	-

Road No.	Name of Road	Length (km)	Proposed Lane Configuration as per Traffic requirement							DP Width (m)	Land Use	Remarks
			Lane	Med-ian	On both sides of center line							
					Carri-age-way	Paver Block	Paved Shoul-der	Foot-path	Land scap-ing			
7	Regional Workshop to Mutha Chowk	3.351	6	1.2	7.5	2.4	0	1.5	0	24.00	Urban	-
8	Mutha Chowk to Mahaveer Chowk to Tower Barki Chowk to Degloor Naka	2.903	6	1.2	7.5	2.4	0	1.5	0	24.00	Urban	-
9	Degloor Naka (with a ROB Maltekdi Railway Station) to Hingoli Road	3.830	6	1.2	10.5	2.4	0	1.5	0	30.00	Urban	-
10	Mutha Chowk to Govardhanghat (with a bridge on Godavari) to Latur Road (thru Kautha)	2.736	6	1.20	7.50	2.40	0.00	1.50	0.00	24.00	Urban	-
11	Gurudwara Parikrama-II	0.278	2	0.00	3.75	1.25	0.00	2.50	0.00	15.00	Urban	Near Gurudar a
12	Baryam Singh Wine shop Gurudwara Gate No. 2 to Yatri Niwas	0.417	2	0.00	3.75	1.50	0.00	2.50	1.25	18.00	Urban	-
13	Chikhalwadi Road to Bhagat Singh Road	0.667	2	0.00	3.75	1.25	0.00	2.50	0.00	15.00	Urban	-
14	Chikalwadi Road to Bhagat Singh Road to Crusher Road	0.978	2	0.00	3.75	1.50	0.00	2.50	1.25	18.00	Rural	Existing Paveme nt to be replaced by new crust.
15	Gurudwara Gate No. 3/4 to Bhagat Singh Road	0.156	2	0.00	3.75	1.25	0.00	2.50	0.00	15.00	Urban	-
16	Gurudwara Gate No. 4 (Parikrama) to Gurudwara Road (Lohar Galli C.C. Road)	0.420	2	0.00	3.75	1.25	0.00	2.50	0.00	15.00	Urban	
17	Gurudwara Gate No. 1 to Dena Bank to Nagina Ghat (Partially pedestrian road)	0.719	2	0.00	3.75	1.50	0.00	2.50	4.25	24.00	Urban	5.25 is for Parking

Road No.	Name of Road	Length (km)	Proposed Lane Configuration as per Traffic requirement							DP Width (m)	Land Use	Remarks
			Lane	Median	On both sides of center line							
					Carriage-way	Paver Block	Paved Shoulder	Foot-path	Landscap-ing			
18	Gandhi Statue to Mahaveer Chowk	0.238	6	0.60	7.50	0.00	0.00	1.20	0.00	18.00	Urban	Refer Notes
19	Hingoli Gate (RUB) to Forest Office to Banda Ghat	1.833	6	0.60	7.50	0.00	0.00	1.20	0.00	18.00	Urban	Proposed ROB (Ch.0+200 to 0+560)
22	Nagina Ghat to Banda Ghat	0.380	2	0.00	3.75	1.50	0.00	2.50	2.25	20.00	Urban	-
23	Vazirabad Road to Banda Ghat	0.387	2	0.00	3.75	1.25	0.00	2.50	0.00	15.00	Urban	-
24	Degloor Road through C.R.C. to Gyanamata School (with an RUB or ROB Crossing Railway)	2.413	4	0.00	3.75	1.50	0.00	1.50	5.25	24.00	Urban	Refer Notes, Slope and open drain proposed in stead of landscaping
26	Mahadeo Dalmill to Gorakshan Chikalwadi Road	0.529	2	0.00	3.75	1.50	0.00	1.50	8.25	30.00	Urban	-
27	Dr Savrikar Building to Navghat	0.797	2	0.00	3.75	2.25	0.00	1.50	0.00	15.00	Urban	-
28	Bafna Petrol Pump to Old Mondha to New Bridge on Godawari	1.399	6	0.60	7.50	0.00	0.00	1.20	0.00	18.00	Urban	-
28A	Khalsa RUB Approaches	0.663	4	0.00	3.75	2.25	0.00	1.50	0.00	15.00	Urban	-
29	Crusher Road (from Degloor Road) to Keli Market (Ambedkar Chowk)	0.798	2	0.00	3.75	1.50	0.00	1.50	2.25	18.00	Urban	-
30	Latur Road to Milk Dairy	1.546	2	0.00	3.75	1.50	0.00	1.50	2.25	18.00	Rural	2.25m Is for open drain
31	Navghat Bridge to Milk Dairy (Latur Road)	0.975	2	0.00	3.75	0.00	1.50	1.50	8.25	30.00	Rural	8.25m Is for slope and open drain

Road No.	Name of Road	Length (km)	Proposed Lane Configuration as per Traffic requirement							DP Width (m)	Land Use	Remarks
			Lane	Med-ian	On both sides of center line							
					Carri-age-way	Paver Block	Paved Shoul-der	Foot-path	Land scap-ing			
32	Airport (Forest Naka) to Chhatrapati Nagar	3.954	4	1.20	7.50	1.50	0.00	1.50	3.90	30.00	Urban	-
34	Pawdewadi Naka to Rest House	1.062	2	0.00	3.75	1.50	0.00	1.50	2.25	18.00	Urban	-
35	Shivajinagar ROB to Nasratpur	2.569	2	0.00	3.75	2.25	0.00	1.50	0.00	15.00	Urban	-
37	Shivaji Statue (Thru Z.P. Girls School) to Degloor Road	0.520	4	0.00	6.30	0.00	0.00	1.20	0.00	15.00	Urban	-
38a	Part of Western bypass (Southern Part inclu. Bridge)	3.900	2	0.00	3.75	1.50	0.00	1.50	8.25	30.00	Rural	8.25m Is for slope and open drain
39	Anand Nagar Road	2.117	6	1.20	10.50	2.40	0.00	1.50	0.00	30.00	Urban	-
40	Bhagyanagar to Yashwant College to Railway Station	2.052	6	1.20	7.50	1.40	0.00	1.50	0.00	22.00	Urban	-
41	Gakul Dairy to Degloor Road Junction	1.878	4	1.20	7.50	1.50	0.00	1.50	3.90	30.00	Rural	3.9m Is for slope and open drain
42	Degloor Road Junction to Old Godawari river bridge	1.160	4	1.20	7.50	1.50	0.00	1.50	3.90	30.00	Rural	3.9m Is for slope and open drain
	Total Length	**51.018**										

Typical cross sections of project roads are given in **Fig.3.1** to **3.40.**
Paver Block has not been proposed on southern side of Nanded City on Road No. 10.

Based on standards discussed in chapter 2, geometric design of project roads has been carried out by using 'Softdesk R8' design software. Based on intersection point coordinates and basic curve data, the software is used to generate complete alignment designs and drawings on the topographical survey base plans. The details generated include centerline, road edge, footpath edge, chainage, horizontal curve data, super elevation data, etc. The vertical alignment is then designed in a similar manner using the software.

3.1.2 Horizontal Alignment

The proposed design alignment of the project roads generally follows alignment of the existing road, except where horizontal alignment improvements are necessary. Therefore all geometric elements have been designed to restrict the roadway within the available right of way (ROW) that meets the approved design parameters. The horizontal alignment has been designed based on the design criteria specified in Chapter 2. The horizontal circular curves with spiral transitions/curves attached on either side to attain the super elevation have been designed with respect to the centreline of the dual three/four-lane carriageway. The details of horizontal alignment for all project roads are given in **Annexure 3.1**.

Road Plans have been prepared showing the designed elements such as centreline, median, shoulders/paver block, footpaths, structure locations, at-grade intersections and existing ground features.

3.1.3 Vertical Alignment

The vertical alignment has been designed based on the design criteria given in the Chapter 2. The ground profile and the finished road profile have been developed along the centreline of road. Generally the vertical profile is dictated by obligatory levels of structures such as subways and existing C-D structures ,thickness of overlay and access to adjoining properties. Vertical profile of proposed Godavari Bridge on road no.10 and 34 was designed based on high flood level (HFL) of 355.75m observed up to previous year. It has been then revised considering the latest flood level of 356.8m observed in the month of August 2006. Vertical profile of ROB on road no.9 and 19 has been designed based on minimum vertical clearance on rail track, structural depth etc. The details of vertical curves are given in **Annexure 3.2.**

3.2 Design Data

Following survey & investigation have been carried out for determining various data required for the design.

1. Trial Pit Investigations
2. Traffic Survey
3. Axle Load Survey
4. Benkelman Beam Deflection (BBD) Survey

3.2.1 Design CBR

The assessment of the CBR has been carried out through two approaches.
In the first method, disturbed samples of the subgrade have been collected from the existing/proposed road site through trial pits. The samples were brought to the laboratory and subjected to soaked and unsoaked CBR tests, conducted as per IS: 2720 Part XVI. Soaking of sample was undertaken to simulate the worst subgrade conditions during monsoons. The samples were compacted at the maximum dry density determined as per IS:2720 Part VIII.

The second method is essentially empirical, which indirectly determines the field CBR of the in-situ subgrade, through the Dynamic Cone Penetration Tests. This method is widely adopted in practice, and the background of the approach is discussed briefly as below:

Dynamic Cone Penetration tests were conducted at pit locations to assess in situ CBR at sub-grade and below sub-grade level. The CBR value was calculated based on different soil layers encountered. The field DCP test yields the penetration per blow (mm/blow) information for each layer. The following TRRL equation is used to calculate the layer DCP-CBR value:

log10 (CBR) = 2.48 - 1.057 * log10 (mm/blow)

These layered CBR values have been converted to overall CBR value using Japanese formula for the purpose:

$$\text{Overall CBR} = \left[\frac{\sum(Layerthickness \times (DCP\,CBR)^{1/3})}{\sum(Layerthickness)}\right]^3$$

Table 3.2 presents the comparative CBR values from the laboratory and the field tests.

Table 3.2: Comparative Field and Laboratory CBR Values

Rd No.	Name of Road/Route	DP Width (m)	Length (km.)	Laboratory CBR (%)		Field CBR (DCPT Method)* (%)	Adopt-ed Design CBR	Present Condition of Road
				Unsoak-ed	Soak-ed			
1	Railway Station to Vazirabad Police Station	15	0.78	8.31	6.83	2.77	3	BT
2	Vazirabad Police Station Gurudwara Gate No.1	15	0.54	9.03	6.93	2.81	3	BT/CC

Rd No.	Name of Road/Route	DP Width (m)	Length (km.)	Laboratory CBR (%)		Field CBR (DCPT Method)* (%)	Adopt-ed Design CBR	Present Condition of Road
				Unsoak-ed	Soak-ed			
3	Gurudwara Gate No. 1 to Keli Market (upto Crusher road/Ambedkar Chowk)	18	0.72	11.4	8.24	5.08	5	CC Fair Condition
4	Keli Market (Ambedkar Chowk) to Barki Chowk	18	0.32	6	5.74	3.39	3	Metal/ BT
5	Barki Chowk to Darbar Masjid Chowk to Navghat	18	0.72	8.67	6.49	2.95	3	Narrow road, BT & CC
6	Darbar Masjid Chowk to Fort	18	0.50	-	-	-	3	Missing Link
7	Regional Workshop to Mutha Chowk	24	3.36	11.03	8.60	3.28	3	BT
8	Mutha Chowk to Mahaveer Chowk to Tower Barki Chowk to Degloor Naka	18	3.02	11.85	9.56	3.3	3	BT
9	Degloor Naka (with a ROB Maltekdi Railway Station) to Hingoli Road	30	4.80	11.71	8.89	3.18	3	Metal/ Earth
10	Mutha Chowk to Govardhanghat (with a bridge on Godavari) to Latur Road (thru Kautha)	24	3.00	10.02	7.96	2.89	3	BT/ Missing Link
11	Gurudwara Parikrama-II	15	1.01	-	-	-	4	CC. Narrow road, Missing Link
12	Baryam Singh Wine shop Gurudwara Gate No. 2 to Yatri Niwas	18	0.34	10.97	8.95	4.47	4	BT, CC
13	Chikhalwadi Road to Bhagat Singh Road	15	0.67	11.01	8.31	4.14	4	Metal/ BT
14	Chikalwadi Road to Bhagat Singh Road to Crusher Road	18	1.02	10.61	8.08	3.4	3	BT/Missing Link
15	Gurudwara Gate No. 3/4 to Bhagat Singh Road	15	0.15	11.56	8.83	4.13	4	BT

Rd No.	Name of Road/Route	DP Width (m)	Length (km.)	Laboratory CBR (%)		Field CBR (DCPT Method)* (%)	Adopt-ed Design CBR	Present Condition of Road
				Unsoak-ed	Soak-ed			
16	Gurudwara Gate No. 4 (Parikrama) to Gurudwara Road (Lohar Galli C.C. Road)	15	0.21	10.97	8.55	4.21	4	CC
17	Gurudwara Gate No. 1 to Dena Bank to Nagina Ghat (Partially pedestrian road)	24	0.72	10.47	8.47	4.22	4	CC/BT/Metal
18	Gandhi Statue to Mahaveer Chowk	18	0.23	11.72	9.03	2.71	3	BT
19	Hingoli Gate (RUB) to Forest Office to Banda Ghat	18	1.70	10.89	8.35	5.35	5	BT
22	Nagina Ghat to Banda Ghat	20	0.45	10.85	8.31	3.47	3	CC/ Earth
23	Vazirabad Road to Banda Ghat	15	0.35	11.36	9.066	2.97	3	Metal
24	Degloor Road through C.R.C. to Gyanamata School (with an RUB or ROB Crossing Railway)	24	2.50	10.93	8.47	3.17	3	Cart Track
26	Mahadeo Dalmill to Gorakshan Chikalwadi Road	30	0.80	10.85	8.4	3.43	3	Metal
27	Dr Savrikar Building to Navghat	15	0.74	10.85	8.31	2.94	3	CC/ BT
28	Bafna Petrol Pump to Old Mondha to New Bridge on Godawari	18	1.36	11.13	8.98	3.95	4	CC/BT
28A	Khalsa RUB Approaches	15	1.00	11.8	9.38	3.04	3	BT/CC/Metal
29	Crusher Road (from Degloor Road) to Keli Market (Ambedkar Chowk)	18	0.80	11.32	8.95	2.97	3	BT/Metal
30	Latur Road to Milk Dairy	18	1.40	10.49	8.43	3.14	3	BT/ Metal
31	Navghat Bridge to Milk Dairy (Latur Road)	30	1.20	11.05	8.948	2.72	3	BT/Metal
32	Airport (Forest Naka) to Chhatrapati Nagar	30	3.90	9.86	7.96	3.37	3	BT

Rd No.	Name of Road/Route	DP Width (m)	Length (km.)	Laboratory CBR (%)		Field CBR (DCPT Method)* (%)	Adopt-ed Design CBR	Present Condition of Road
				Unsoak-ed	Soak-ed			
34	Pawdewadi Naka to Rest House	18	0.90	10.73	8.28	3.34	3	BT/ Missing Link
35	Shivajinagar ROB to Nasratpur	15	5.00	10.85	8.35	3.59	3	BT/ Metal/ CC/ Missing Links
37	Shivaji Statue (Thru Z.P. Girls School) to Degloor Road	15	0.50	11.05	8.31	3.65	3	CC / Missing Links
38A	Part of Western bypass (Southern Part inclu. Bridge)	30	3.90	8.33	6.37	3.22	3	BT/Cart Track
39	Anand Nagar Road	30	2.06	10.68	8.39	5.27	5	BT
40	Bhagyanagar to Yashwant College to Railway Station	18-22	2.10	9.77	7.89	4.34	4	BT
41	Gakul Dairy to Degloor Road Junction	30	1.84	11.26	9.76	5.26	5	BT
42	Degloor Road Junction to Old Godawari river bridge	30	1.16	11.78	9.89	5.56	5	BT

The laboratory CBR values are determined on the subgrade samples compacted at the Modified Proctor Maximum Dry Density, which is higher than the field dry density encountered in site. The design of the crust is based either on the imported subgrade material (whose CBR is based on the laboratory results of samples compacted at MDD); or the natural sub-grade material (whose CBR is based on the in-situ observations).

In the present design approach, the crust thickness is based on the CBR of the natural sub-grade material and hence the field values are used to arrive at the design CBR.

The existing crust thickness as observed at trial pit locations were also recorded. In general the pavement courses observed comprise of bituminous Carpet, Bituminous Macadam 100-120 mm, Water Bound Macadam (200mm -250mm), and murum blanket 150 mm. The subgrade is not provided for the crust.

3.2.2 Design Traffic & Growth Factor

The expected (design) traffic volume on the project roads has been worked out based on the traffic studies conducted for these roads. The present traffic survey data and

traffic growth factor is given in the **Annexure 3.3** of this report. **Table 3.3** gives the summary of initial commercial traffic for project roads.

3.2.3 Distribution Factor

Distribution of commercial traffic by direction and by lane is necessary as it directly affects the total equivalent standard ale load application used in the design. Distribution factor for project roads have been determined depending upon the carriageway configuration.

Table 3.3 Initial Commercial Traffic & Distribution Factor

Road No.	Description Of Road	No. of Lanes	Commercial Traffic (Both Direction)	Lane Distribution Factor
1	Railway Station To Wazirabad Police Station	4	355	0.75
2	Wazirabad PolIce Station To Gurudwara Gate No. 1	4	82	0.75
3	Keli Market To Berki Chowk	4	232	0.75
4	Keli Market (Ambedkar Chowk) to Barki Chowk	4	4	0.75
5	Barki Chowk to Darbar Masjid Chowk to Navghat	4	5	0.75
6	Darbar Masjid Chowk to Fort	2	2	0.75
7	S.T Workshop Road To Mutho Chowk	6	267	0.6
8	Mutha- Mahavir -Berki Chowk	6	114	0.6
9	Deglur Naka to Hingoli Road	6	2489	0.6
10	Mutha Chowk to Govardhanghat (with a bridge on Godavari) to Latur Road (thru Kautha)	6	27	0.6
11	Gurudwara Parikrama-II	2	Missing Link	
12	Baryam Singh Wine shop Gurudwara Gate No. 2 to Yatri Niwas	2	58	0.75
13	Chikhalwadi Road to Bhagat Singh Road	2	307	0.75
14	Chikalwadi Road to Bhagat Singh Road to Crusher Road	2	350	0.75

Road No.	Description Of Road	No. of Lanes	Commercial Traffic (Both Direction)	Lane Distribution Factor
15	Gurudwara Gate No. 3/4 to Bhagat Singh Road	2	Missing Link	
16	Gurudwara Gate No. 4 (Parikrama) to Gurudwara Road (Lohar Galli C.C. Road)	2	Missing Link	
17	Gurudwara Gate No. 1 to Dena Bank to Nagina Ghat (Partially pedestrian road)	2	259	0.75
18	Gandhi Statue to Mahaveer Chowk	6	105	0.75
19	Hingoli Gate (RUB) to Forest Office to Banda Ghat	6	172	0.75
22	Nagina Ghat to Banda Ghat	2	155	0.75
23	Vazirabad Road to Banda Ghat	2	47	0.75
24	Degloor Road through C.R.C. to Gyanamata School (with an RUB or ROB Crossing Railway)	4	5472	0.75
26	Mahadeo Dalmill to Gorakshan Chikalwadi Road	2	-	
27	Dr Savrikar Building to Navghat	2	549	0.75
28	Bafna Petrol Pump to Old Mondha to New Bridge on Godawari	6	1079	0.75
28a	Khalsa RUB Approaches	4	1079	0.75
29	Crusher Road (from Degloor Road) to Keli Market (Ambedkar Chowk)	2	44	0.75
30	Latur Road to Milk Dairy	2	890	0.75
31	Navghat Bridge to Milk Dairy (Latur Road)	2	26	0.75
32	Airport (Forest Naka) to Chhatrapati Nagar	4	760	0.75
34	Pawdewadi Naka to Rest House	2	33	0.75
35	Shivajinagar ROB to Nasratpur	2	14	0.75

Road No.	Description Of Road	No. of Lanes	Commercial Traffic (Both Direction)	Lane Distribution Factor
37	Shivaji Statue (Thru Z.P. Girls School) to Degloor Road	4	1045	0.4
39	Anand Nagar Road	6	659	0.6
40	Bhagyanagar to Yashwant College to Railway Station	6	218	0.6
41	Gakul Dairy to Degloor Road Junction	4	2087	0.75
42	Degloor Road Junction to Old Godawari river bridge	4	4705	0.75

***** As road no. 9 is missing link, at present there is no existing traffic. Therefore, expected traffic in year 2006 has been considered for calculation of msa.

3.2.4 Vehicle Damage Factor

In order to estimate vehicle-loading pattern in the Project Area, and to determine vehicle damage factor for the commercial vehicles, the Consultants have carried out the axle load survey of the traffic plying on representative project road sections. The survey was carried out for 24 hours period.

The axle load survey was carried out on Road No.32 i.e. Airport to Chhatrapati Nagar, Road No.28, Bhagat Singh Road and Road no.42 i.e. Degloor Road ,as commercial traffic is not allowed on city inner roads. The axle load data obtained from the surveys have been analysed vehicle type-wise to obtain the gross vehicle weight and vehicle damage factor along the project road sections. Analysis of the data and calculation of 'esa' values are given in **Annexure 3.4**. The VDF values obtained from the analysis are presented in **Table 3.4**.

Table 3.4 Vehicle Damage Factor

Vehicle Type	VDF Values		
(Road No.)	**32**	**28**	**42**
Light Commercial Traffic (Minibuses, Goods Carrier)	0.03	0.108	0.142
Heavy Commercial Traffic (Trucks)	1.41	0.993	0.683
Buses	0.17	0.23	0.083
Multi Axle Traffic	0.86	1.35	1.125

Maximum value of VDF is observed as 1.4. As per IRC 37-2001, for initial commercial traffic volume per day of 150-1500, VDF for plain/rolling terrain is 3.5. Hence, for all project roads except road no.9, 24, 30,31,41 and 42 **VDF of 3.5 is suggested**. For **road no.9, 24,30,31,41 & 42**, as traffic is more than 1500, it is suggested to use **VDF of 4.5** in the design.

3.2.5 Characteristic Deflection

The rebound deflection measurements using Benkelman Beam method in accordance to CGRA procedure given in IRC- 81:1997 ("Guidelines for strengthening of Flexible Road Pavement using Benkelman Beam Deflection Technique") were observed all along the Project Road sections on both outer wheel paths for each lane about 50 m intervals. The values of mean corrected deflection, standard deviation and the characteristic deflection etc. were worked out for each project road section. Analysis is given in **Annexure 3.5**. Maximum & minimum values of characteristic deflection have been observed as 3.27 for road no.18 and 0.83 for road no.1.

3.2.6 Design Life

For flexible & rigid pavement design life has been considered as 20 years. Design life for overlay has been considered as 10 years.

3.3 Choice of Pavement

The choice of the appropriate economically advantageous pavement type, flexible or rigid has been made by carrying out Life Cycle Cost (LCC) analysis which takes in to account the initial investment cost and also the maintenance/ rehabilitation cost over the design life of the pavement structure. Life Cycle cost analysis has been described in Chapter 4 of this Report.

3.4 Design of Flexible Pavement

As per design methodology described in chapter 2 of this report, traffic in msa has been calculated and is given in **Annexure 3.6**. Also CBR has been taken in to consideration. As traffic ranges from 1 msa to 70 msa and CBR ranges from 3 to 5%, roads have been categorized as per both parameters and given in **Table 3.5**.

Table 3.5 Road Classification As Per Traffic & CBR

Sr. No.	Traffic Range (MSA)	Road Nos.		
		CBR 3 %	CBR 4%	CBR 5%
1	1-5	4, 22,23,29, 31,34,35	11, 40	-
2	5-10	14,26,37	12	39
3	10-20	27,28A,	-	
4	20-30	9,10,25	-	41
5	30-50	38A	-	
6	50-70	24,	-	42

The pavement layer composition as per IRC: 37-2001 corresponding to 3%, 4% and 5% CBR value and design traffic loading is as given in **Table No.3.6**:

Table No.3.6 Pavement Composition for Different MSA & CBR

CBR	**3%**					
Traffic	**BC**	**DBM**	**WMM**	**GSBI**	**GSBII**	**Total**
	(mm)	**(mm)**	**(mm)**	**(mm)**	**(mm)**	**(mm)**
1-5	40	60	250	175	175	700
5-10	40	90	250	200	200	780
10-20	40	120	250	200	200	810
20-30	40	140	250	200	200	830
30-50	40	160	250	200	200	850
50-70	50	180	250	200	200	880
CBR	**4%**					
Traffic	**BC**	**DBM**	**WMM**	**GSBI**	**GSBII**	**Total**
	(mm)	**(mm)**	**(mm)**	**(mm)**	**(mm)**	**(mm)**
1-5	40	60	250	150	150	650
5-10	40	80	250	175	175	720
10-20	40	110	250	175	175	750
20-30	40	130	250	175	175	770
30-50	40	160	250	175	175	800
50-70	50	170	250	175	175	820

CBR	5%					
Traffic	BC	DBM	WMM	GSBI	GSBII	Total
	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
1-5	40	60	250	150	150	650
5-10	40	70	250	150	150	660
10-20	40	100	250	150	150	690
20-30	40	120	250	150	150	710
30-50	40	140	250	150	150	730
50-70	50	150	250	150	150	750

From constructablity and uniformity point of view, sub base layers i.e. GSB I & GSB II have been kept same ie.200mm each for all category of traffic and CBR range. Thickness of BC and DBM have been proposed with respect to CBR of 4%. As DBM of 1cm thickness equals to 2cm of WMM, thickness of WMM has been varied as per CBR to minimize the cost. Following crust has been proposed for different msa & CBR range.

Table No.3.7 Recommended Pavement Composition

Traffic (msa)	BC (mm)	DBM (mm)	WMM (mm)			GSBI (mm)	GSBII (mm)
			3%	4%	5%		
1-5	40	60	275	250	225	200	200
5-10	40	80	275	250	225	200	200
10-20	40	110	275	250	225	200	200
20-30	40	130	275	250	225	200	200
30-50	40	160	275	250	225	200	200
50-70	50	170	275	250	225	200	200

A cushion layer of 200 mm thickness has been proposed under GSBII to take care of BC soil. Design calculation of road no.9, 27 and 42 are given in **Annexure 3.7.**

3.5 Design of Rigid Pavement

As per IRC 58-2002 Table 2, for soaked CBR of 3.0%, k value comes out to be 2.8 kg/cm2/cm. IRC 15:2002 suggests that cement concrete pavement can not be laid directly over the subgrade of k value less than 6kg/cm2/cm. Therefore, It has been proposed to provide dry lean concrete (DLC) of 150 mm thick as a base course for rigid pavement to increase 'k' value by 27.7 kg/cm2/cm. It has been observed that rigid pavement with permeable sub base course like drainage layer gave very good performance with no faulting, cracking or joint spalling. In view of this observation, it has been proposed to introduce drainage layer of granular sub base (GSBII) below DLC. In addition to this a cushion layer has been proposed to take care of BC Soil.

Hence, with constructability and durability point of view, consultants recommend following crust under rigid pavement.

Dry Lean Concrete (DLC)	150 mm
Granular Sub-base (GSB-I)	200 mm
Granular Sub-base (GSB-II), drainage Layer	200 mm
Cushion Layer	200 mm

Thickness of rigid pavement (PQC) has been derived from following parameters and design.

Table No. 3.8 Design Parameters for Rigid Pavement

Data	
Design Life	20 Years
Design Wheel Load	8000 Kg
Tyre Pressure	8.0 kg/sq.cm
K value of dry lean concrete base(CBR 3.0%)	13.8 kg/sq.cm
K value of dry lean concrete base(CBR 5.0%)	20.8 kg/sq.cm
Properties of Pavement Quality Concrete	
Compressive strength (field) at 28 days	350 kg/sq.cm
Flexural strength (field) at 28 days	41.4 kg/sq.cm
Modulus of elasticity, E	3x105 kg/sq.cm
Poisson's ratio	0.15
Coefficient of thermal expansion	10x10-6 /c0

Traffic in msa has been calculated for roads that are to be developed with rigid pavement. Design calculation of rigid pavement for road 1, 3 and 32 are given in **Annexure 3.8.**

3.5.1 Provision of Dowel Bar & Tie Bar

It will have doweled contraction joints at 4.5-m spacing. The longitudinal joints will have a spacing of 3.75 m and 3.50 m in order to accommodate 0.25 m wide edge strips. Expansion joints will be provided only at the junctions of structures like culverts, bridges etc. All contraction joints will be formed by saw-cutting.

At contraction joints, dowel bars of 3.2 cm diameter and 60 cm length are to be provided at 30 cm spacing. At longitudinal joints, deformed tie rods of 1.2 cm, diameter and 64 cm length are to be provided at 60 cm spacing

3.6 Design of Strengthening Overlays over the Existing Concrete Pavement Surface

Condition studies have been carried out to assess the condition of the existing pavement in order to find the structural and functional adequacy of the existing concrete pavement. Since the design life considered for the additional lanes of pavement (proposed widening) is 20 years, the existing pavement is expected to last for the same period. Hence, the existing pavement also needs to be strengthened to take care of the future traffic loading and to cover the deficiencies noted during field investigations. Pavement Condition Survey reveals that length of crack is bout 5.5 to 8.5m in 10 sqm area. As per IRC;SP 17, condition of pavement is under " moderately cracked" category. For slabs in "moderately" cracked condition, un-bonded overlay with 50 mm bituminous macadam as separation layer has been proposed.

Thickness of Overlay

Thickness of Monolithic Slab Hm	=	30 Cm
Thickness of existing concrete pavement	=	19 Cm
Pavement Condition Factor	=	0.55

Ho	=	SQRT (30^2-0.55x19^2)
	=	26.7 Cm
Say	=	27.5 cm.

Proposed Crust of unbonded overlay on rigid pavement:

PQC Overlay	-	275 mm
BM	-	50 mm

3.7 Design of Strengthening Overlays over the Existing Bituminous Pavement Surface

It is proposed to strengthen the existing carriageway of flexible roads by means of bituminous overlays. Overlay thickness of bituminous macadam has been determined referring to IRC: 81-1997.

Table 3.9 – Overlay Thickness on Flexible Pavement

Road No.	Name of Road	Traffic (msa)	Characteristic Deflection (mm)	Thickness of Bituminous Macadam
4	Keli Market (Ambedkar Chowk) to Barki Chowk	-	2.02	Not Applicable
10	Mutha Chowk to Govardhanghat (with a bridge on Godavari) to Latur Road (thru Kautha)	-	1.12	Not Applicable
23	Vazirabad Road to Banda Ghat	-	1.03	Not Applicable
30	Latur Road to Milk Dairy	13	1.93	120mm
34	Pawdewadi Naka to Rest House	0.5	1.86	-
35	Shivajinagar ROB to Nasratpur	-	1.02	Not Applicable
39	Anand Nagar Road	3	1.62	80mm
40	Bhagyanagar to Yashwant College to Railway Station	1	1.23	-
41	Gakul Dairy to Degloor Road Junction	15	1.05	-
42	Degloor Road Junction to Old Godawari river bridge	34	0.98	100mm

Thickness of bituminous macadam has then converted in to thickness of DBM/AC with following formula:

1 cm of Bituminous Macadam = 0.7 cm of DBM/AC/SDC

i.e., 100 mm of Bituminous Macadam = 70 mm of DBM/AC/SDC

In view of practical considerations such as constructability, durability and ability to serve the purpose, consultants recommend following crust for overlay.

Bituminous Concrete - 40 mm

Bituminous Macadam - 50 mm

Total Thickness of Overlay - 90 mm

Before implementing the overlay, existing surface shall be corrected and brought to proper profile by filling the cracks, pot holes, ruts and undulations.

3.8 Design of Paver Blocks

IRC:SP:63-2004 “Guidelines for the Use of Interlocking Concrete Block Pavement” has been used for design of Paver blocks in carriageway and footpath.

3.8.1 Paver Blocks for Carriageway

As per table 1 of IRC:SP:63-2004, for traffic 20-50 msa and CBR of 5-10 % following crust has been obtained for Paver block in carriageway.

Paver Block (M35 grade)	-	80 mm
Sand Bed	-	50 mm
Wet Mix Macadam (WMM)	-	250mm
Granular Sub Base	-	250 mm
Cushion Layer	-	200 mm

As Paver blocks will be laid beside the BT/CC carriageway, base & sub base layers of either of pavements and that of paver block should be matched in view of construct ability and functionality. Therefore, Consultants recommend following crust under paver block**.**

Table 3.10 – Pavement Crust under Paver Block

Crust under Paver Block	By the side of Flexible Pavement (mm)	By the side of Cement Concrete Pavement (mm)
Paver Block	80	80
Sand Bed	50	50
Wet Mix Macadam (WMM)	300	320
Granular Sub Base - i	200	200
Granular Sub Base – II	200	200
Cushion Layer	200	200

3.8.2 Paver Blocks for Footpath

As per table 1 of IRC:SP:63-2004, for pedestrian footpath and CBR of 5-10% following crust has been obtained.

Paver Block (M35 grade)	-	60 mm
Sand Bed	-	50 mm
Granular Sub Base	-	200 mm

GSB may be deleted if paver blocks are laid on drain concrete slab.

3.9 Junctions Improvement

Major and Minor Junctions have been designed based on the **IRC : SP-41-1994** Guidelines for the Design of At-Grade Intersections in Rural & Urban Areas. The Junction improvement drawings are presented in Drawing Volume-IX.

3.10 Parking

Two types of parking i.e. On-street parking and Off-street parking may be proposed depending upon the parking requirement, land availability etc. Due to limited DP width, on-street parking has not been proposed for the project roads except road no.17. As road no.17 is main road to Gurudwara , parking lane of 4.25m width has been proposed from Gurudwara Gate No.1 to Nagina Ghat. Off-street parking may be provided at reserved parking spaces proposed in development plan of Nanded City.

3.11 Bus Bays /Bus Stops

Bus bays may be proposed at the locations of bus stops. Due to non-availability of space because of limited DP width, bus bays have not been proposed for the project roads. However, bus stops have been kept same as existing.

3.12 Embankment Design

Vertical profile of project roads is governed by access to existing properties, overlay and strengthening requirement etc. As proposed profile of the road is following existing profile, high embankment is not required except for road no.10. New Godavari bridge has been proposed on Road No.10 to connect northern & southern part of Nanded. Vertical profile has been designed based on High Flood Level (HFL) because of which a substantial stretch at the southern side of the Godavari River needs to be constructed on embankment.

3.12.1 Slope Stability Analysis of Embankment

Stability analysis of the embankment has been carried out for the slope with maximum height, that is, 6.04m (chainage 1+980m). Method of slices have been used for the analysis, in which the failure surface has been assumed as an arc of circle. The critical analysis has been arrived for two cases as shown in **Fig.3.41.** The first surface is assumed to pass above the base, while the second case assumes base failure.

3.12.2 Basis of design parameters

Random variations of soil properties are likely along the alignment. In the absence of a lengthwise trend in the soil data, it will be appropriate to base design on typical values, with the effect of likely range of variations taken into consideration. Accordingly, the design soil parameter chosen for the base soil, that is Black Cotton soil, are as shown hereunder:

C=30kN/m2, γ=18kN/m3; phi = 0o

Fill material strengths for embankment, on expansive clayey base are generally to be assessed on the lower side to inhibit the formation of tension cracks in the fill. For murrum types available around Nanded, the following fill material strength parameters are appropriate:

Type of material	Unit weight (kN/m3)	C (kN/m2)	Ø (Deg)
Compacted fill	20.0	15.0	30.0o

Fig.3.41 shows the section of the embankment with height 6.035m. The load on the pavement is idealized as: Dead Load (Surcharge) =12kN/m2 and Live Load = 24 kN/m2. Factor of safety has been worked out by Swedish Circle method as follows:

For Failure Arc 1:

Table 3.11: Computation of FS for Failure Arc 1 by Swedish Circle Method (Refer Fig. 3.41)

Slice No.	W (kN/m)	Surcharge Load, Q (kN/m)	α (degrees)	N = (W+Q) Cosα (kN/m)	T = (W+Q) Sinα (kN/m)
1	26.8	0	5	26.69	2.335
2	70.90	0	10.5	69.71	12.91
3	100.16	0	20	94.12	34.24
4	113.12	0	27	100.79	51.33
5	107.02	0	35	87.67	61.36
6	47.82	78.84	41	95.59	83.1
Σ				474.65	245.24

Total length of failure arc, Larc = 16.0m.

F = (c. Larc + tan (phi). ΣN)/ ΣT

= (15 x 16.0 + Tan 30.0 x 474.65) / 245.24 = 594.04/245.24 = 2.1

Considering effects of submergence, F = 2.10/2 = 1.025.

Hence OK.

For Failure Arc 2:

Table 3.12.: Computation of FS for Failure Arc 2 by Swedish Circle Method (Refer Fig. 3.41)

Slice No.	W (kN/m)	Surcharge Load Q (kN/m)	α* (degrees)	N = (W+Q) Cosα (kN/m)	T = (W+Q) Sinα (kN/m)
1	64.28	0	-29	56.23	31.14*
2	171.66	0	-20.5	160.8	60.1*
3	253.34	0	-8	250.87	35.24*
4	312.93	0	7	310.60	38.12
5	350.62	0	24	320.34	142.542
6	394.38	81	40.5	299.98	256.02
7	324.72	81	54	190.99	262.61
8	193.26	81	67	72.30	179.144
Σ				1662.32	878.44 (only for slices 4 to 8)

* implies that its tangential component T, actually stabilizes the slope.

Stabilizing component of T (considering T value for slices 1 to 3), Tstab = 264.48 kN/m

Length of failure arc passing through Base soil, L = 15.953m. Length of failure arc passing slope material, L = 7.379 m.

F = (c. Larc +tan (phi). ΣN) +Tstab/ ΣT

= [(15 x 7.379 + 30 x 15.953)] + Tan 30.0 x 1662.32 +264.48 /878.44 = 1813.5/878.44

= 2.06

Considering effects of submergence, F = 2.06/2 = 1.03.

Hence OK.

3.12.3 Ground Improvement Scheme for Reinforced Earth (RE) Wall Portion

Pavements on level ground and low embankments are likely to be affected by alternate cycles of swelling and shrinking of expansive soils. For such embankments the preventive measure has been undertaken in form of cushion layer of soft murrum, 200mm thick, below the Granular Sub-base layer. The composite action of the cushion layer and the granular sub-base is effective in countering the detrimental effects of the virgin expansive soils.

However, in respect of high embankments / ramps supported by RE wall, swelling pressures are counter-acted due to its surcharge effect. For pavements on high embankments, it is the low bearing capacity of the base soil instead of swelling pressures, which is the cause of concern. The remedial measure shall be in form of partial removal of 1.5m layer of black soil by a more stable material like Murrum. Such a measure is effective in load transfer to a larger area through a layer of higher strength. The replacement shall be carried out for 1m additional width on either side of the RE as shown in the figure.

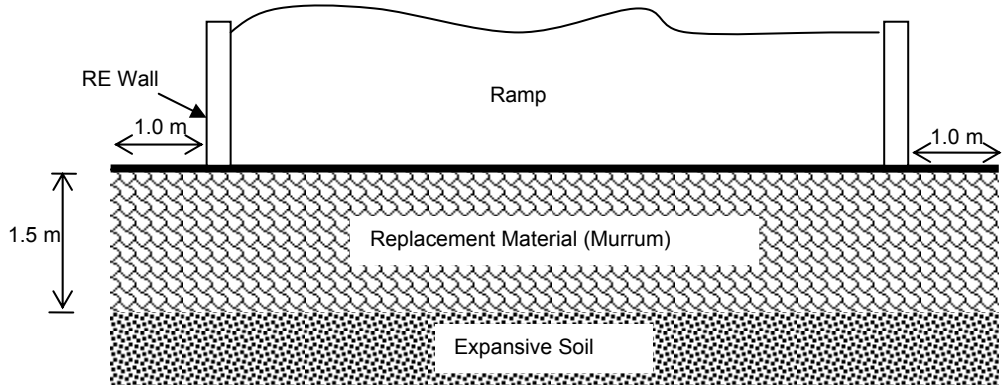

Fig. 3.42 Ground Improvement Scheme under Ramp Portion

3.13 Structural Design Elements

There are various elements and factors, which would govern the design and functioning of the ROBs and Bridges. These can be broadly grouped under the following:

- cross-sectional layout;
- alignment of main road and intersecting roads;
- alignment of loops and ramps;
- tapers for merging and diverging;
- pavement composition;
- river width;

- drainage;
- land-use;
- traffic control and safety measures; and
- aesthetics.

The basic design philosophy is based on the consideration of providing suitable alignment, cross-sectional layout, road geometric, safety and access control to cater to the fast and uninterrupted movement of through traffic.

3.14 Structural Design Philosophy

3.14.1 Prestressed Concrete Structures

Prestressed concrete design shall be based on IRC 18 (2000).

Primary and secondary stresses due to temperature difference effects shall be added to 50% of live load plus impact and dead loads at working stress condition.

Generally, the maximum possible cable eccentricities shall be used at points of maximum moments. For economy, maximum prestressing force shall be used. The tendons shall be jacked at both ends to maximum 0.765 UTS at anchorage. Low-relaxation strands shall be used. Friction and other tendon losses shall be in accordance with IRC 18. For all PSC Girders, corrugated HDPE sheathing of 'K' = 0.0020 & '□' = 0.17 shall be used to reduce frictional losses and hence to achieve economy.

Diameter of sheathing shall be as under -

Type	I.D. (mm)	O.D. (mm)
12T13	75	92
19T13	85	97

Minimum Residual Compressive Stress of 5 kg/cm2 is recommended to be maintained at final stress conditions. Ultimate flexural strengths shall be based on IRC 18 and strain compatibility as this usually results to lower capacities. Shear strength will be assessed at ultimate loads according to IRC: 18.

Future prestressing provision of 15% of total prestressing shall be made.

3.14.2 Reinforced Concrete

Reinforced concrete design shall be based on working stress method according to IRC:21-2000.

3.14.3 Crack Control

For crack control, main and temperature steel reinforcement shall be provided at maximum spacing of 150mm. Crack width limitation of 0.2 mm for severe exposure as per IRC 21 provision shall be strictly followed.

3.14.4 Bearings

POT - PTFE bearings of types viz. sliding free, sliding guided and fixed shall be proposed. The sliding surfaces shall be dimpled PTFE and sliding plates shall be of stainless steel. The disc base and plate will be cast steel, protected against corrosion. Bearing design shall be as per IRC 83 and BS 5400 Part 9.

3.14.5 Piers

The piers for the viaduct shall be of reinforced concrete. The top 2.0 m portion may be flared with vertical circular radius to give an aesthetically pleasing appearance. Few wide grooves may be provided on external face of pier from top of pile cap up to bottom of curved surface. These grooves proposed rendered with contrast colour gives pleasing appearance.

3.14.6 Abutments

The abutments shall be reinforced concrete cantilever wall-type with square return walls. Live load surcharge load of 1.2 m height shall be applied behind the abutment, wing walls and retaining wall as per IRC 78 - 2000.

3.14.7 Foundations for ROBs

ROB is proposed along road no. 19 at Hingoli gate. In general, Pile foundations shall be adopted for viaduct since competent stratum is available at larger depth. The pile shall be of 1000 mm diameter socketed into the basaltic rock. The geotechnical investigation report attached as Appendix 2, indicates the depth of the piles shall be 15m for ROB piers and abutments.

The foundations shall be designed for no tension condition.

Top of Pile Cap shall be kept 500 mm below G.L. minimum thickness of pile cap shall be 1.5 times pile diameter as per codal provisions or as per design whichever is greater. Embedment of pile inside pile cap shall be minimum 50 mm.

The piles shall be designed for the imposed lateral and vertical loads. Vertical piles are preferred as compared to raker piles.

3.14.8 Foundations for the River Bridge

River bridge is proposed at Govardhan ghat along the road no 10. Along the river, that is the central portion of the viaduct, good rock is available at relatively shallow depths. Hence Open foundations are proposed.

For the abutment and the approach viaduct at the northern side of the river, though competent stratum is available at 6-7m below ground, provision of open foundations would bring large area under excavation, and would hamper the traffic and adjoining structures. Hence in this area Pile foundations are proposed. These piles shall of 1.2m diameter and shall be socketed into rocks.

Presence of deep stretch of overburden soil at the southern side of the river along the bridge alignment stalls the provision of open foundation. Hence for the viaduct portion at the southern approach piles are proposed. These shall be 1.2m in diameter, socketed in basaltic rock.

Provision of pile at the southern abutment would require special considerations for earth pressures, and tension in the pile is inevitable. To avoid this problem, the southern abutment shall rest on Well foundation.

3.14.9 Reinforced Earth Retaining Walls

Reinforced Earth (RE) retaining walls shall be used for solid approaches of the viaduct. RE retaining walls have the following advantages over reinforced concrete retaining walls.

The space required for foundation is small which could be a great advantage in areas where wall toe projections of reinforced concrete construction may pose problems to the right-of-way.

They can be founded on low bearing capacity soils without base failure or damage as a result of differential settlement.

They are generally more economical for higher heights.

The time for construction is less compared to reinforced concrete walls and embankment.

The main concern of corrosion or durability of the tension strips in reinforced earth may be overcome by using galvanized mild steel strips with sacrificial thickness, or by the use of PVC coating to the galvanized mesh. Alternatively, geogrids are preferred as they eliminate any possibility of corrosion.

3.15 Cross Drainage Works

There are about 41 numbers of culverts present along the project road out of which 8 are slab culverts and 33 are HP culverts. Depending upon the existing condition of culverts, extension or new culverts have been proposed. **Table No.3.13** shows the list of CD structures and their improvement.

Table 3.13 – List of CD Structures

Sl No.	Road No.	Chainage	Type	Improvement	Size (m)
1	3	0+110	Slab	Nil	2*2.8x2.0
2	7	1+206	Slab	Widening	3.5x1.4
3	8	2+530	Pipe	Widening	2*0.9ϕ
4	9	0+250	Pipe	Widening	1.0 ϕ
5		0+720	Pipe	Widening	1.0 ϕ
6		1+200	Pipe	Widening	1.0 ϕ
7		1+660	Pipe	Widening	2x1.0 ϕ
8		2+900	Pipe	Widening	1.0 ϕ
9		3+180	Pipe	Widening	2x1.0 ϕ
10	10	1+815	Pipe	New Construction	1.2 ϕ
11		1+990	Pipe	New Construction	1.2 ϕ
12		2+250	Pipe	New Construction	1.2 ϕ
13		2+410	Pipe	New Construction	1.2 ϕ
14		2+520	Pipe	New Construction	1.2 ϕ
15	15	0+146	Pipe	New Construction	3x1.0 ϕ
16	16	0+078	Pipe	New Construction	3x1.0 ϕ
17	19	1+780	Slab	New Construction	4.0x4.0
18	22	0+080	Slab	New Construction	4.0x4.0
19	23	0+294	Slab	New Construction	4.0x4.0
20	24	1+460	Pipe	New Construction	1.2 ϕ
21		2+310	Pipe	New Construction	2x1.0 ϕ
22	28	0+700	Slab	New Construction	6.0 x 2.5
23	30	0+620	Slab	New Construction	6.0 x 4.0
24	31	0+020	Pipe	New Construction	1.2 ϕ
25		0+250	Pipe	New Construction	1.2 ϕ
26		0+660	Pipe	New Construction	1.2 ϕ
27		0+760	Pipe	New Construction	1.2 ϕ

Sl No.	Road No.	Chainage	Type	Improvement	Size (m)
28		0+800	Pipe	New Construction	1.2 ϕ
29	32	0+314	Pipe	New Construction	1.0 ϕ
30		1+200	Pipe	New Construction	2x1.0 ϕ
31		2+380	Pipe	New Construction	1.0 ϕ
32		2+590	Pipe	New Construction	2x1.0 ϕ
33		2+990	Pipe	New Construction	1.0 ϕ
34		3+190	Pipe	New Construction	1.0 ϕ
35	35	1+515	Pipe	New Construction	3x1.0 ϕ
36		1+900	Pipe	New Construction	1.2 ϕ
37		2+360	Pipe	New Construction	2x1.2 ϕ
38	38A	0+010	Pipe	New Construction	1.2 ϕ
39		0+460	Pipe	New Construction	1.2 ϕ
40		0+940	Pipe	New Construction	1.2 ϕ
41		2+880	Pipe	New Construction	1.2 ϕ
42	40	1+560	Slab	Widening	2*2.25x1.5
43	41	0+060	Pipe	New Construction	1.2 ϕ
44		1+260	Pipe	New Construction	4x1.2 ϕ
45	42	0+090	Pipe	New Construction	4x1.2 ϕ

3.16 Design of Lighting

3.16.1. Illumination

Light fixtures, pole heights and spacing between poles are selected keeping in view of the following:

- Visibility of roads and its details such as entry of side roads, traffic signs etc.
- Visual guidance on the alignment of the road.
- Clear visibility of the objects in time.
- Continuity and uniformity of lighting.

To achieve an average illumination level of 30 Lux, lighting has been designed for an illumination level of 35 to 40 lux with assumed maintenance factor of 80%. In due course of time this level will further reduce to 80% of design value because of aging and other factors.

3.16.2 Power Distribution

The existing power distribution system is through overhead lines, whereas the proposed distribution shall be through underground cables.
In addition to the road lighting, cables of other agencies like VSNL, MSEB etc will also run underground along the roads.
It as been decided that power supply to each Feeder Pillar shall be available from the nearest feeder pillar of MSEB.

Capacity of each Feeder Pillar shalll be limited to 100 Amps capacity.

3.16.3 Arrangement of poles

Depending on various factors like road width, provision of medians etc the different arrangements of poles like single sided, staggered, opposite etc have been considered based on guide lines stipulated in Code of Practices.

Annexure 3.9 Shows the Summary of Lighting Design.

3.17 Landscaping Design

Landscaping may be proposed in median, islands and along the roads depending upon the land availability. DP width of project roads is varying from 15m to 30m. Table 3.14 Shows the list of roads along which landscaping has been proposed.

Table No.3.14 – List of Roads Proposed for Landscaping

Sr No.	Road No.	Length (In Meters)	Width (In Meters)	Both Sides	Median	Total Landscape Area Median	Total Landscape Area Both Sides
1	1	750	0.6	1	1	450	-
2	2	540	0.6	1	1	324	-
3	3	762	0.6	1	1	457.2	-
7	7	3351	1.2	1	1	4021.2	-
8	8	2903	1.2	1	1	3483.6	-
11	12	417	1.25	2	1	-	1042.5
12	14	978	1.25	2	1	-	2445
13	17	719	4.25	2	1	-	6111.5
14	18	238	0.6	1	1	142.8	-
15	19	1833	0.6	1	1	1099.8	-
16	22	380	2.25	2	1		1710
19	28	1399	0.6	1	1	839.4	-
23	32						
	a	3954	1.2	1	1	4744.8	-
	b	3954	3.9	2	1		30841.2
				Total		**15563**	**42150**

3.18 Summary

The proposed improvements for project roads are summarized in **Annexure-3.10.**