# GOVERNMENT OF ORISSA
# WORKS DEPARTMENT

# ORISSA STATE ROAD PROJECT

## FEASIBILITY STUDY AND DETAILED PROJECT PREPARATION FOR PHASE-I ROADS

## FINAL DETAIL ENGINEERING REPORT
## BHAWANIPATNA - KHARIAR
## (2/00 to 70/00)

**(MAY-2007)**

# MAIN REPORT

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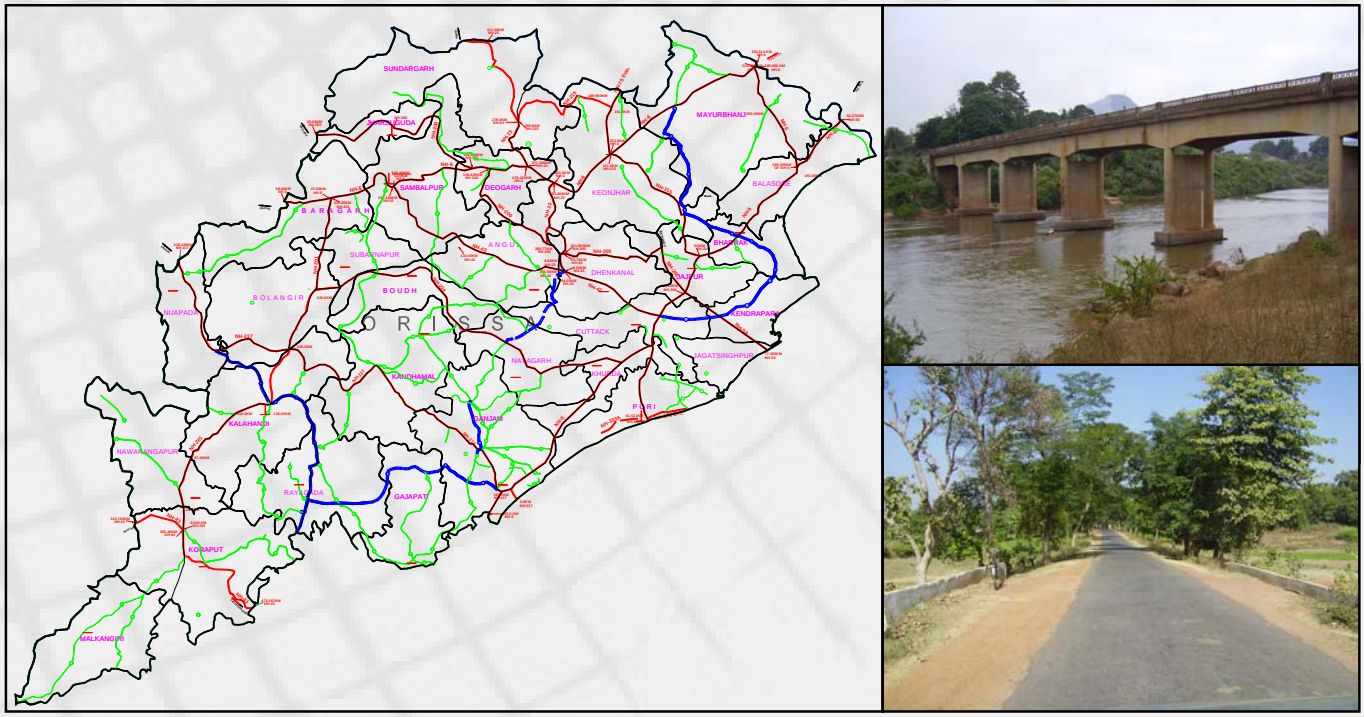

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# ABBREVATIONS

## ABBREVIATIONS

| | |
|---|---|
| AADT | Annual Average Daily Traffic |
| AASHTO | American Association of State Highway and Transportation Officials |
| ADT | Average Daily Traffic |
| BBD | Bankelman Beam Deflection |
| BC | Bituminious Concrete |
| BI | Bump Integrator-Roughness (mm/km) |
| BOQ | Bill of Quantities |
| CBR | California Bearing Ratio |
| CEG | Consulting Engineerws Group Ltd. |
| CV | Commercial Vechiles |
| CVD | Commercial Vehicles per Day |
| DBM | Dense Bituminous Macadam |
| DFS | Differential Free Swell Index |
| DLC | Dry Lean Concrete |
| DTM | Digital Terrain Model |
| EA | Environment Assessment |
| EIA | Environment Impact Assessment |
| EMP | Environment Management Plan |
| EIRR | Economic Internal Rate of Return |
| ESMF | Environment and Social Management Framework |
| ESAL | Equivalent Standard Axle Load |
| GDP | Gross Domestic Product |
| GNP | Gross National Product |
| GOO | Government of Orissa |
| GOI | Government of India |
| GSB | Granular Sub Base |
| HDM-4 | Highway Development and Management Model-4 |
| HFL | High Flood Level |
| HS | Hard Shoulder |
| IRC | Indian Roads Congress |
| IRI | International Roughness Index |
| LSF | Load Safety Factor |
| MDR | Major District Road |
| MoSRT&H | Ministry of Shipping, Road Transportation and Highways |
| MOU | Memoranda Of Understanding |
| MSA | Million Standard Axles |
| MTPA | Million Tonnes Per Annum |

| | |
|---|---|
| NGO | Non-Government Organization |
| NDT | Non-Destructive Test |
| NH | National Highway |
| NHAI | National Highway Authority of India |
| NMT | Non-Motorized Traffic |
| NNP | Net National Product |
| NPV | Net Present value |
| NSDP | Net State Domestic Product |
| O-D | Origin and Destination |
| OSRP | Orissa State Roads Project |
| OWD | Orissa Works Department |
| PCC | Project Coordinating Consultants |
| PCNSDP | Per Capita Net State Domestic Product |
| PCU | Passenger Car Unit |
| PIA | Project Influence Area |
| PIU | Project Implementation Unit |
| PMC | Pre Mix Carpet |
| SA | Social Assessment |
| SDBC | Semi Dense Bituminous Concrete |
| SF | Seasonal Factor |
| SH | State Highway |
| SOS | Strategic Option Study |
| TOR | Terms of Reference |
| TRRL | Transport and Road Research Laboratory (UK) |
| VDF | Vehicle Damage Factor |
| VOC | Vehicle Operating Costs |
| WB | World Bank |
| WBM | Water Bound Macadam |
| WMM | Wet Mix Macadam |

# EXECUTIVE SUMMARY

# EXECUTIVE SUMMARY

1. The Orissa Works Department (OWD) aims to upgrade and widen its vital arterial State roads to 2-lanes to accelerate the overall economic growth as the Orissa has untapped immense potential of development in mining, industry, tourism, ports sectors. The Orissa State has planned to arrange funds from World Bank for developing about 825 km of roads under Phase-I limiting to the amount of US $250million spread over 5 years.

2. The OWD has engaged M/s CEG Limited for providing the consultancy services for preparation of the Feasibility and Detail Project Report for 825km of roads under Phase-I. This Project also includes network analysis of 3700 km State Highways to arrive at selection of 1600 km for feasibility studies for subsequent Phases. The Consultancy services were commenced from 6th December 2005.

3. The present submission is the "Detailed Engineering Report for Bhawanipatna to Khariar Road (km 2/0 to km 70/0)" under Phase-I. This is a part of Khariar - Bhawanipatna - Muniguda – Kerada Corridor. The continuous interaction and joint field inspections of the consultant and PIU during the course of field surveys/ investigations and subsequent verification of actual designs of highway alignments and bridges in the field, has enabled to produce a practical Detailed Engineering Report.

4. The earlier submissions of Inception Report, Economic Viability Report, Social Screening and Environmental Screening Reports and Feasibility Report have already been accepted. The structure of this report is in accordance with reporting requirements as per agreement.

5. Detailed Survey and Investigations were carried out for the following:

    i. Topographical Survey
    ii. Geotechnical and Material Investigations
    iii. Hydraulic and Hydrological investigation
    iv. Investigation for Bridges and Structures
    v. Pavement Investigations
    vi. Road Safety Review
    vii. Surveying Utility Services

6. Topographic survey was conducted with the help of Total Station. Longitudinal section levels were taken at every 25 m interval along the centre line of the existing carriageway. Cross sections were taken at every 50 m interval covering full extent of survey corridor. Longitudinal and cross sections survey for major/minor streams was also carried out as per the requirements. Bench Mark Pillars were erected at an interval of 1 km along the route.

7. The sub-grade soil samples were collected from each km along the existing alignment. The detailed investigations for existing road include both field and laboratory testing. Test pits were excavated at the shoulder adjacent to pavement edge

at interval of 1km. Low to high expansive soils of CL-CI-CH group are found in various Sections of SH 16 i.e. Km 0/0, 8/0, 9/0, 10/0,18/0,21/0, 22/0, 24/0, 25/0, 26/0, 27/0, 29/0, 31/0, 32/0, 42/0, 54/0. In these stretches either replace the soil of high expansive properties by importing good soil from borrow area or treat the soil of low to medium expansive soils.

8. To identify potential sources of material for construction, the survey and investigation for different construction materials were carried out in respect of their likely sources and the availability and suitability of various materials. Relevant laboratory tests were conducted on representative samples as per requirement.

**Table 1: Sources of Construction Material**

| S.No. | Material | No. of Sources Identified |
|---|---|---|
| 1 | Granular Sub base | 6 |
| 2 | Coarse Aggregate/ Stone | 8 |
| 3 | Sand / Fine Aggregate | 2 |
| 4 | Morrum | 5 |
| 5 | Cement | 2 |
| 6 | Water | 2 |
| 7 | Stone | - |

9. Geotechnical investigation for bridges and other structures were carried out to determine the appropriate foundation type and its load carrying capacity.

**Table 2: Recommendations from Subsoil Investigations**

| Location | Chainage | Type of foundation | Minimum Depth of Foundation |
|---|---|---|---|
| 1 | 8/600 | Open | 1.5m from bed level |
| 2 | 10/500 | Open | 1.5m from bed level |
| 3 | 13/750 | Open | 3.5m from bed level |
| 4 | 17/120 | Open | 1.5m from Ground level |
| 5 | 21/000 | Open | 6.3m from bed level |
| 6 | 27/600 | Pile | 10m from bed level |
| 7 | 27/800 | Pile | 10m from Ground level |
| 8 | 27/850 | Pile | 12m from Ground level |
| 9 | 28/400 | Pile | 15m from Ground level |
| 10 | 28/900 | Pile | 15m from Ground level |
| 11 | 29/400 | Pile | 10m from Ground level |
| 12 | 45/700 | Open | 1.5m from Ground level |
| 13 | 54/600 | Open | 4.5m from Ground level |
| 14 | 58/900 | Open | 4m from Ground level |
| 15 | 59/400 | Pile | 12m from Ground level |
| 16 | 63/650 | Open | 1.5m from Ground level |
| 17 | 66/500 | Open | 1.5m from Ground level |
| 18 | 69/300 | Open | 1.5m from Ground level |

10. Hydrological investigations were carried out to determine hydraulic adequacy of the structures. All submersible bridges will be replaced with high-level bridges. Waterway and formation level for these bridges have been recommended on the basis of hydrological investigations.

11. A detailed inventory and condition survey was carried out for structures. There are total 21 bridges, 4 of them are major and remaining 17 are minor bridges. All bridges and culverts were inspected for their present condition and verified jointly with PIU Engineers. The NDT (Rebound hammer and Ultrasonic pulse velocity) tests were conducted for bridges at chainage 3/050,13/750,27/600,59/100, 59/400 and 69/300 to study the structural soundness of the structures. The recommendations are as follows.

**Table 3:Inventory and Condition of Existing Bridges**

| Sl. No. | Location/ Chainage | Existing Span Arrangement | Type of Superstructure | Type of foundation | Overall condition/ Recommendation |
|---|---|---|---|---|---|
| 1 | 3/050 | 3 x 8.8 | Solid Slab | Open foundation | Good, Rehabilitation required |
| 2 | 4/450 | 4 x 9.9 | Solid Slab | Open foundation | Good, Rehabilitation required |
| 3 | 8/600 | 1 x 7.3 | Solid Slab | Open foundation | Submersible bridge, to be replaced |
| 4 | 10/500 | 1 x 7.4 | Solid Slab | Open foundation | Submersible bridge, to be replaced |
| 5 | 13/750 | 2 x 7.2 | Solid Slab | Open foundation | Reconstruction due to poor condition |
| 6 | 17/120 | 1 x 7.55 | Iron Joist with Solid Slab | Open foundation | Reconstruction due to poor condition |
| 7 | 21/000 | (3 x 0.6)+(7 x 1.2) | Pipe Causeway | - | Submersible bridge, to be replaced |
| 8 | 27/600 | 7 x 9.2 | Solid Slab | Open foundation | Submersible bridge, to be replaced |
| 9 | 27/800 | 10 x 1.2 | Pipe causeway | - | Submersible bridge, to be replaced |
| 10 | 27/850 | 9 x 9.2 | Solid Slab | Open foundation | Pipe causeway, replaced by bridge |
| 11 | 28/400 | (2x9.9)+ (1x24.37)+ (1x34.9)+ (10x40.85) | RCC Box | Well foundation | Good, Nothing to do |
| 12 | 28/900 | 4 x 9.2 | Solid Slab | Open foundation | Submersible bridge, to be replaced |
| 13 | 29/400 | 2 x 9.2 | Solid Slab | Open foundation | Submersible bridge, to be replaced |
| 14 | 45/700 | 1 x 6.2 | Solid Slab | Open foundation | Reconstruction due to poor condition |
| 15 | 54/600 | 3 x 8.5 | Solid Slab | Open foundation | Reconstruction due to Realignment |
| 16 | 58/900 | 3 x 6.8 | Solid Slab | Open foundation | Reconstruction due to Realignment |
| 17 | 59/100 | (7 x 32.7)+(1 x 7.6) | PSC Girder | Well foundation | Minor Touchup repair |
| 18 | 59/400 | 5 x 4.0 | Box Cell | Raft foundation | Good, Rehabilitation required |
| 19 | 63/650 | 1 x 6.6 | Solid Slab | Open foundation | Reconstruction due to poor condition |
| 20 | 66/500 | 1 x 6.4 | Solid Slab | Open foundation | Reconstruction due to poor condition |
| 21 | 69/300 | 1 x 7.2 | Solid Slab | Open foundation | Reconstruction due to poor condition |

The total number of culverts is 112 in a road length of 68.00 km i.e. from km 2/0 to 70/0. Details of the culverts are available in Chapter 2. Following table gives the findings of culverts.

**Table 4: Summary of Existing Culverts**

| Type of Culvert | Nos. |
|---|---|
| Pipe | 49 |
| Slab | 45 |
| Stone Slab | 3 |
| Arch | 1 |
| Vented Causeway | 14 |
| **Total** | **112** |

12. Investigations were carried out on existing pavement condition to determine the most technically sound and economically feasible pavements design. The investigations include:

    i. Visual Inspection Survey
    ii. Pavement Composition.
    iii. Roughness Survey
    iv. Benkelman Beam Deflection Survey

13. The existing Project Roads has sharp horizontal curves and insufficient vertical design standard, which do not provide adequate overtaking sight and stopping distance even for 35 kmph thereby making the accidents more frequent. Existing road junctions are not properly designed. These deficiencies have been properly attended in the design report.

14. The traffic surveys were conducted to determine classified traffic volumes in terms of Annual Average Daily Traffic (AADT), directional split, hourly variation, trip length pattern, travel pattern of goods and passenger traffic, commodity flow and axle loads. Traffic Volume Count Survey was conducted at two locations; one VC-17 at km 18/700 near Pastipada and other VC-18 at 68/000 near Khariar. Axle load survey was carried out near Kharier, designated as AL-08 and conducted using Portable Load Pads, developed in Indian Institute Technology, Kharagpur, having platform size 550mm X 700mm X 30mm (weight 30 kg) with digital load indicator. Following tables gives the summary of traffic surveys carried out.

**Table 5: Summary of AADT and PCU**

| Count Stn. | Description | Total Motorised Vehicle | Total Comm. Vehicle | Total Non Motorised Vehicle | Total Vehicle |
|---|---|---|---|---|---|
| VC-17 | AADT | 1533 | 590 | 790 | 2323 |
| | PCU | 2482 | 1785 | 924 | 3406 |
| VC-18 | AADT | 1432 | 397 | 1166 | 2598 |
| | PCU | 1987 | 1305 | 691 | 2678 |

**Table 6: Design VDF**

| Station | Road Section | Recommended values of VDF for | | | | |
|---|---|---|---|---|---|---|
| | | LCV | 2-Axle Truck | | 3-Axle Truck | |
| | | | 2008-13 | 2013-28 | 2008-13 | 2013-28 |
| AL-08 | Bhawanipatna - Khariar | 0.15 | 4.57 | 3.5 | 4.39 | 3.5 |

**Table 7: Design MSA**

| Location | Design Year | Design MSA |
|---|---|---|
| VC-17 | 2028 | 20.51 |
| VC-18 | 2028 | 9.36 |

**Table 8: Projected Traffic**

| Year | AADT | | PCU | |
|---|---|---|---|---|
| | VC-17 | VC-18 | VC-17 | VC-18 |
| 2008 | 2753 | 3021 | 4119 | 3222 |
| 2013 | 3759 | 3881 | 5982 | 4590 |
| 2018 | 5325 | 5184 | 8988 | 6739 |
| 2023 | 7676 | 7082 | 13659 | 9995 |
| 2028 | 10933 | 9637 | 20334 | 14538 |

15. The existing road is a single lane carriageway road with horizontal and vertical geometric average to poor. Geometric Design Standards as per IRC: 73-1980 “Geometric Design Standards for Rural (Non-urban) Highway” has been generally followed. MX Road, AutoCAD and Autodesk Land Development Desktop softwares have been used for the designing and drafting. The Project road has been designed as a two-lane carriageway with hard shoulders. The width of two lanes has been taken as 7.0m with 2.5m wide hard shoulders on either side. Total roadway width has been taken as 12.00 m. In built up areas, paved shoulder of 1.5m widths shall be provided making total roadway width of 10m. Beyond this, covered drains shall be provided which will be used as walkway.

16. Plan and profile drawings has been prepared separately at scale of 1:2000 horizontal and 1:200 vertical. It shows all existing plan features, toe line of highway embankment, proposed right of way limits, drainage structure locations, existing ground profile, proposed finished profile, intersection layouts, typical cross sections

of the main alignment, etc. Bus-bays and Truck Lay-bays have been provided at appropriate locations and specified in schedule of drawings.

17. Designs for new pavement and overlays are worked out in accordance with Indian Standards. The CBR is taken at an interval of l Km along the stretch. If the CBR is less than 4%, then new construction is adopted. If the CBR is more than 4% but the deflection value is too high, reconstruction is adopted otherwise overlay is adopted. Crust details for new construction and reconstruction has been given in Chapter 4.

18. Unlined open trapezoidal drains for the rural sections and RCC Box covered drains for the Built-up Sections have been used.

19. Out of the existing 21 bridges, the bridges at location 27/600, 27/850, 28/400 and 59/100 are major and remaining 17 are minor. Tel River is the widest on this stretch. During recent flood on 2nd July 2006, the five bridges at chainage 27/600, 27/800, 27/850, 2228/900 and 28/400, which are in the approach of Tel River, overtopped. These bridges have been recommended for reconstruction to provide new waterway and raised deck levels. Bridges at location 8/600, 10/500 and 21/000 are also submersible and have been proposed for reconstruction with increased waterway and raised deck levels as per hydraulic requirements. Bridges at location 13/750, 17/120, 45/700, 63/650, 66/500 and 69/300 are in poor condition and being replaced. The bridges at location 54/600 and 58/900 are under realignment and will be constructed at new locations.

20. To increase the traffic safety and to reduce traffic accidents, every component of the highways and its users have been given equal importance. Road geometric components have been designed to meet the State Highway standards as specified in the IRC: 73-1980. The traffic control devices, which are used to reduce accidents and improve flow conditions, road markings and road signs have been used as per IRC standards.

21. In general, the specifications laid down in “Specifications for Road and Bridge Works – Fourth Revision - by MoRST&H” shall be followed. The detailed specifications have been given in Bidding Document prepared separately for each civil construction package. Construction scheme and traffic management system during construction have been described in Chapter 8. All necessary safety measures shall be adopted for safety of moving traffic and working persons engaged in the construction zone.

22. Estimated total cost of this package is Rs 1131.53 millions which includes engineering cost as Rs 946.82 millions. Estimated cost for provisional items, social, environmental and utility shifting costs as Rs 18.94 millions. The total cost also includes engineering supervision, PIU project office.

# CHAPTER - 1
# INTRODUCTION

# CHAPTER 1

# INTRODUCTION

## 1.1 GENERAL

The fast growing Orissa State is one of the major State of India with population 36.87 million persons and ranks 11th with population share 3.58% - Census 2001 and having geographical area 0.155 million Sq km with 9th rank in India. The 480 km coastline with ports also makes Orissa a distinguished State. The Orissa is not only very rich in minerals deposits but also has surplus power and water. The country's over 90% Chromites and Nickel deposits are in Orissa beside over 50% Bauxite, 30% of Manganese, Iron ore and coal. The Orissa is a favored destination of investment. The road transport is a dominant mode for movement of goods and passengers and need based upgrading of existing road network has been envisioned by the state.

This chapter describes the background of the project, present project roads with contract packages and composition of the Detailed Engineering Report of the contract package Bhawanipatna – Khariar (SH-16) (km 2/00 to km 70/00) section which is a part of Khariar - Bhawanipatna - Muniguda – Kerada 224 km project corridor. The report presents detailed design of road and bridges with cost for upgrading existing road to two lane. Proposals and further details for improving the existing road to two lanes are detailed in the succeeding chapters

## 1.2 PROJECT BACKGROUND

The Orissa Works Department (OWD) had conducted a Strategic Option Study of State Roads, in (1995-1997) which identified 2347 km of State Roads out of 4600km of State Highways and Major District Roads for improvement based on traffic volume, carriageway width, and pavement condition.

The Government of Orissa contracted a Project Coordinating Consultant (PCC) for feasibility study of 2347km to identify 700km in two phases for techno-economic appraisal with detailed project preparation to meet World Bank norms. The PCC had completed detailed engineering design for widening and strengthening for a length of 198km which was declared National Highway (NH-224) and as a result of techno-economic studies in this project, 1200km were prioritized for a four year periodic maintenance programme and but the project was not implemented.

The OWD intends to upgrade and widen its vital arterial State roads to 2-lanes to accelerate the overall economic growth of the State having immense untapped potential in mining, industry, tourism, and ports. The Orissa State has planned to avail loan from World Bank for developing about 825 km of roads under Phase-I limiting to the loan amount of US $250million spread over five years. This Project also includes network analysis of remaining 3700 km (3900 as per data collected) State Highways based techno-economic approach with an aim to arrive at selection of 1600 km of project routes for feasibility studies for subsequent Phases.

## 1.3 PRESENT ASSIGNMNET

The OWD has engaged M/s CEG Limited for providing the Consultancy Services for preparation of the Feasibility and Detail Project Report for 825 km of roads under Phase-I. The assignment also includes network analysis of 3700 km (3900 as per data collected) State Highways to arrive at selection of 1600 km for feasibility studies for subsequent Phases. The Consultancy services were commenced from 6th December 2005.

The Feasibility Study report for 825 km of roads has been completed and accepted by the OWD. The final Network Analysis report, Draft Detailed Engineering for year-1 roads and final Detailed Engineering Report for 0/00 (Behrampur) to 41/00 (Bangi Jn.), Bhadrak – Chandbali (0/00 to 45/00) and Bhadrak– Anandpur (0/00 to 50/00) has been submitted.

Present submission is Final Detailed Engineering Report of Bhawanipatna - Kariar (km 2/0 to km 70/0).

## 1.4 PROJECT ROADS UNDER PHASE-I

The Project, with total length 835 km, mostly existing State Highways, is comprising of five corridors which are passing through 14 districts (out of total 30 districts) having 51.7% area and 53.1% population of the State. These corridors provide vital connections with faster mobility within State and out side State for communication, mining, industry, tourism, ports etc. The list of the Project Road Corridors is given in Table 1.1 along with the road designation and total length in km. The Project Roads consist of existing State Highways and MDR. The Project Roads locations are shown in Map 1.1.

**Table 1.1: List of the project Road**

| Sl. No. | Name of Road | SH/MDR | Length (km) | District Crossed |
|---|---|---|---|---|
| 1 | **Jagatpur - Kendrapada - Chandbali Bhadrak** | | | 1.Bhadrak 2.Cuttack 3.Kendrapara |
| | a) Jagatpur - Kendrapada - Chadbali | SH-9A | 99 | |
| | b) Chandbali – Bhadrak | SH-9 | 53 | |
| 2 | **Bhadrak - Anandapur - Karanjia - Jashipur** | | | 1.Bhadrak 2.Keonjhar 3.Mayurbhanj |
| | a) Bhadrak – Anandapur | SH-53 | 57 | |
| | b) Anandapur - Karanjia | SH-53 | 65 | |
| | c) Karanjia - Jashipur | SH-49 | 15 | |
| 3 | **Berhampur - Raygada** | | | 1.Gajapati 2.Ganjam 3.Rayagada |
| | a) Berhampur - Bangi Jn. | SH-17 | 151 | |
| | b) Bangi Jn. - JK Pur | SH4 | 52 | |
| 4 | **Khariar - Bhawanipatna - Muniguda - Kerada** | | | 1.Bolangir 2.Kalahandi 3.Nuapada 4.Rayagada |
| | ***a)*** Khariar – Bhawanipatna | SH-16 | 70 | |
| | b) Bhawanipatna - Muniguda | SH-6 | 68 | |
| | c) Muniguda - J.K.Pur | SH-5 | 50 | |
| | d) Raygada - Kerada | MDR-48B | 24 | |
| 5 | **Banarpal – Daspalla and Bhanjanagar - Aska** | | | 1.Anugul 2.Cuttack 3.Dhenkanal 4.Nyagarh 5.Ganjam |
| | a) Banarpal - Daspalla | MDR-18,19 SH-65 | 89 | |
| | b) Bhanjanagar - Aska | SH-7 | 39 | |
| | | **TOTAL** | **832** | |

### 1.4.1 CONTRACT PACKAGES FOR THE PROJECT ROADS

In consultation with the OWD, the project roads have been divided into 11 (eleven) contract packages for construction and supervision, as shown in Table 1.2. The packaging is based on design, construction and administrative jurisdictions to facilitate effective construction and supervision. The packages with least environmental and social issues have been proposed in 'construction year-1' and remaining road sections in construction year-2 contracts.

**Table 1.2: List of Contract Packages for Construction of the Project Roads**

| **Construction Year-1 Packages** | | | | | | |
|---|---|---|---|---|---|---|
| **Package No.** | **Road Section** | **SH/MDR** | **From** | **To** | **Length (km)** | **Length of Package (km)** |
| 1 | Chandbali – Bhadrak | SH-9 | 0 | 45 | 45 | 96 |
| | Bhadrak – Anandpur | SH-53 | 0 | 51 | 51 | |
| 2 | Berhampur- Taptapani | SH-17 | 0 | 41 | 41 | 41 |
| **3** | **Khariar- Bhawanipatna** | **SH-16** | **2** | **70** | **68** | **68** |
| 4 | Taptapani-Raipanka | SH-17 | 41 | 109 | 68 | 68 |
| 5 | Raipanka-Bangi Jn | SH-17 | 109 | 151 | 42 | 84 |
| | Bangi Jn-JK Pur | SH-4 | 161 | 119 | 42 | |
| **Year-1 Total** | | | | | | **357** |
| **Construction Year-2 Packages** | | | | | | |
| **Package No.** | **Road Section** | **SH/MDR** | **From** | **To** | **Length (km)** | **Length of Package (km)** |
| 6 | Jagatpur-Kendrapada-Chandbali | SH-9A | 0 | 99 | 99 | 107 |
| | Chandbali – Bhadrak | SH-9 | 45 | 53 | 8 | |
| 7 | Bhadrak – Anandpur | SH-53 | 51 | 57 | 6 | 86 |
| | Anandpur – Karanjia | SH-53 | 0 | 65 | 65 | |
| | Karanjia – Jasipur | SH49 | 45 | 60 | 15 | |
| 8 | J K Pur – Rayagada | SH-4 | 119 | 109 | 10 | 84 |
| | Rayagada – Kereda | MDR-48B | 0 | 24 | 24 | |
| | J.K.Pur – Muniguda | SH-5 | 0 | 50 | 50 | |
| 9 | Muniguda-Bhawanipatna | SH-6 | 0 | 68 | 68 | 70 |
| | Bhawanipatna-Khariar | SH-16 | 0 | 2 | 2 | |
| 10 | Aska - Bhanjnagar | SH-7 | 0 | 39 | 39 | 39 |
| 11 | Banarpal - Dapalla | MDR-18&19 SH-65 | 0 | 89 | 89 | 89 |
| **Year-2 Total** | | | | | | **475** |

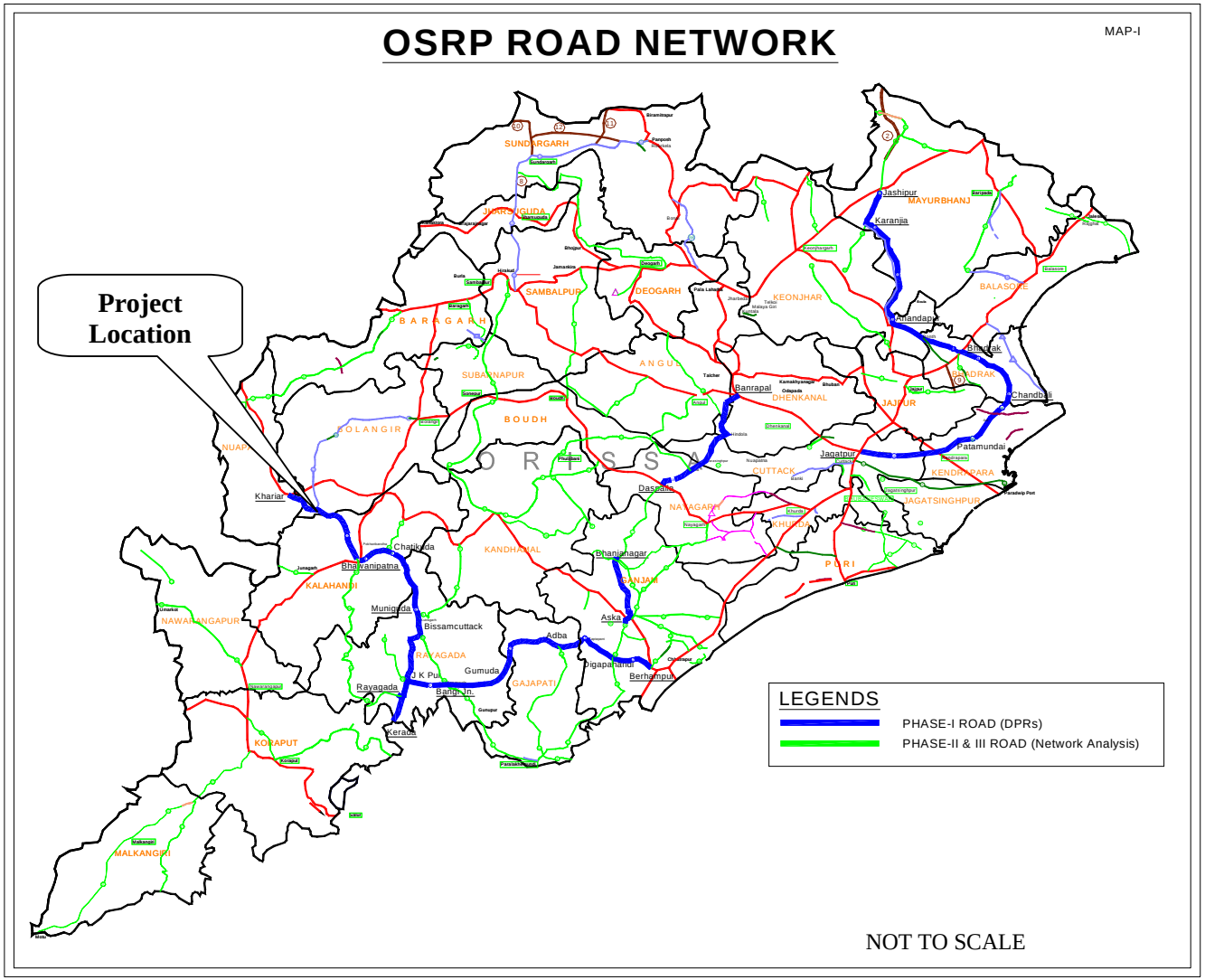
## 1.5 CONTRACT PACKAGE BHAWANIPATNA –KHARIAR (KM 2/0 TO KM 70/0)

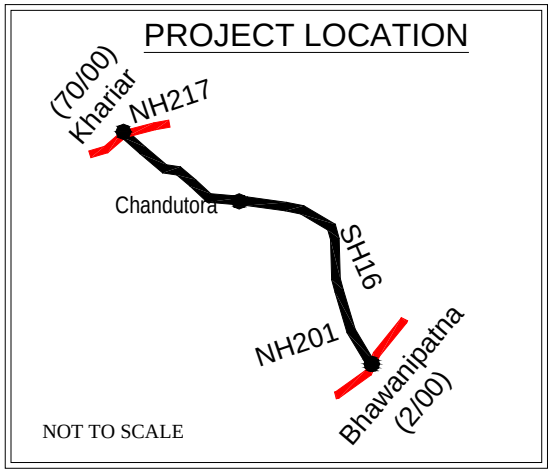
The present submission is the Final Detail project Report for Bhawanipatna-Khairar Road (2/00 to 70/00 of SH-16) which is a part of Khariar - Bhawanipatna - Muniguda – Kerada 224 km project corridor. The road starts from at Chainage 140 km of NH-201 and ends at Chainage 148 km of NH-217. However a bypass is proposed for Bhawanipatna town, which meets the project Road between km 2/0 to km 3/0, therefore the start point of road is considered as km 2/0. Bhawanipatna is the headquarter of Kalahandi Disrtict. This road caters the needs of nearest towns, this is plays an important role for movement of goods and passengers as it connects National Highways on both ends.

The roads traverse mostly through plain and rolling terrain and have mostly flat gradient with good geometry. Geometric of the road are generally mild; nevertheless improvement of the congested reaches is required. Roadside drains are rare, where provided in such areas, are generally choked or is non-functional resulting in water logging. Existing carriageway width varies from 3.6 m to 7.0 m with 1.0 m to 1.5m Earthen Shoulders on both sides. Riding quality all along the road is from Fair to Very Poor. There are total 20 existing bridges, one of them is major and remaining 4 are minor bridges and total number of existing culverts are 112. About 30% of the road length passes through built-up area.

The improvement works involves development of existing road to two lanes with 20 year design period.

**Map 1.1**


OSRP ROAD NETWORK
MAP-I
Project Location
SUNDARGARH
JHARSUGUDA
SAMBALPUR
DEOGARH
KEONJHAR
MAYURBHANJ
BALASORE
BARAGARH
SUBARNAPUR
ANGUL
BOUDH
BHADRAK
JAJPUR
DHENKANAL
CUTTACK
KENDRAPARA
JAGATSINGHPUR
NUAPADA
BOLANGIR
KHURDA
PURI
NAYAGARH
GANJAM
KANDHAMAL
KALAHANDI
NAWARANGAPUR
RAYAGADA
GAJAPATI
KORAPUT
MALKANGIRI
Jashipur
Karanjia
Anandapur
Bhadrak
Chandbali
Patamundai
Jagatpur
Banrapal
Dasapalla
Khariar
Chhatrapur
Bhawanipatna
Muniguda
Bissamcuttack
Aska
Adba
Digapahandi
Berhampur
Rayagada
Gumuda
G.K Pur
Bandhugan
Kerandi
LEGENDS
PHASE-I ROAD (DPRs)
PHASE-II & III ROAD (Network Analysis)
NOT TO SCALE


PROJECT LOCATION
(70/00)
Khariar
NH217
Chandutora
SH16
NH201
Bhawanipatna
(2/00)
NOT TO SCALE

## 1.6 COMPOSITION OF REPORT

The Detailing Engineering Report consists of total 7 volumes as follows:

- Main Report
- Highway Drawings: Plan, Profile and Schedules.
- Design Report of Bridge
- Design Report of Culverts
- Hydrology Report
- Drawings of Bridges and Culverts
- Detail Cost Estimates

The Draft Detailed Engineering Report for this project road has been submitted vide this office Letter No. CEG/OR/001/2006/302, dated 15th Decemeber 2006

The Geo-technical Investigation Report and Material Report for this project road have already been submitted vide this office letter no. CEG/OR/001/2006/243 dated 3rd Oct 2006 and CEG/OR/001/2006/207 dated 3rd Aug 2006 respectively.

The main report contains 9 Chapters as described below and is in accordance with the requirements of TOR for this project.

Reply to PIU comments are appended in Annexure – A.

**Chapter 1**: Introduces and provides the background to the OSRP. The study area is defined and the corridors selected for the Phase 1 are identified. The Brief description on chapterisation is also provided.

**Chapter 2**: Outlines the various field survey and investigation such as carried out their methodology adopted, findings etc. The various field survey includes, Topographical survey, Geotechnical and Material Investigations, Hydraulic and Hydrological investigation, Investigation for Bridges and Structures, Pavement Investigations, Surveying Utility Services, Road Safety Review, Traffic survey.

**Chapter 3**: Describes the detail design of road geometries, Standards adopted, Realignments, way side amenities etc

**Chapter 4**: Presents the various aspects of pavement design. The design methodology, calculation of MSA and CBR has been described. The detail designs of overlay and crust for new section has also been discussed in this chapter.

**Chapter 5**: Discuss the detail design of Drainage system and protection works, like longitudinal drains, Embankment Protection and River Training works.

**Chapter 6**: Presents the various aspects of Structures design. The design methodology, design standards adopted and details of structure design for the road.

**Chapter 7**: Outlines the Detail Design – Road Safety Measures, Traffic Control and Other Facilities, which includes, Road Intersections, Road Furniture, Pavement Marking, Road Lighting etc

**Chapter 8**: Describes the Specifications and Construction Plans specifications for all aspects of the works, based on current and acceptable international standards and work methods for projects of this type. Safety and traffic management plans as well as construction phasing / sequencing to be implemented during construction to ensure minimum hindrance / interruption to traffic flow and road safety.

**Chapter 9**: Social Assessment and Resettlement Action Plan (The report will be submitted in separately volume).

**Chapter 10**: Environmental Action and Environmental Management Plan. (The report will be submitted in separate volume).

**Chapter 11**: Discuss cost estimates for each of the items included in the scope of work. It covers cost of basic inputs - materials, equipment, labor, together with overheads, profit, etc. including rate analysis, quantities, and total estimated cost.

# CHAPTER - 2
# SURVEY AND INVESTIGATION

# CHAPTER – 2

# SURVEY AND INVESTIGATION

## 2.1 GENERAL

The primary objective of the survey and investigation is to collect the field data in the required format to use further for detail engineering designs. Following are the various components.

i. Topographical Survey
ii. Geotechnical and Material Investigations
iii. Hydraulic and Hydrological investigation
iv. Investigation for Bridges and Structures
v. Pavement Investigations
vi. Road Safety Review
vii. Surveying Utility Services

## 2.2 TOPOGRAPHICAL SURVEY

### 2.2.1 Reconnaissance Survey

The reconnaissance survey was conducted to study various features of the road. An initial assessment of the different features like geometric deficiencies, deficient curves, stretches requiring corrections in alignment/realignment identifications of junctions/intersections needing improved design, etc. were made.

### 2.2.2 Horizontal and Vertical Control

Efforts were made to get the GTS benchmarks along the survey route. Client has requested to Survey of India, Bhubneshwar to provide GTS benchmarks, as this information can be provided to Government officials only. But the values could not be obtained. In the absence of GTS benchmarks, the horizontal control was fixed by Total Station. The azimuth was determined from magnetic bearings using small sensitive magnetic needles assembled with Total Station. For vertical control, reference was used from the Benchmark located in Behrampur town near km 0/000.

### 2.2.3 Establishing Temporary Benchmarks

In order to establish temporary benchmarks (TBM) along the proposed route, reference pillars were erected at an interval of 1 km along the route. Leveling was carried out to connect all the reference pillars along the route. These temporary benchmarks were used for further detail survey. The details of these TBMs from km 2/0 to 70/0 are given in Table 2.1

**Table 2.1: List of TBM**

| BM Id | East | North | Elevation | BM Id | East | North | Elevation |
|---|---|---|---|---|---|---|---|
| BMP2 | 68000.192 | 2173328.375 | 273.659 | BMP38 | 39936.805 | 2189173.057 | 245.612 |
| BMP3 | 67086.739 | 2173728.712 | 267.472 | BMP39 | 39015.694 | 2188816.222 | 239.792 |
| BMP4 | 66329.832 | 2174354.337 | 264.705 | BMP40 | 38161.013 | 2188280.038 | 245.122 |
| BMP5 | 65501.457 | 2174915.043 | 264.614 | BMP41 | 37153.434 | 2188093.435 | 242.052 |
| BMP6 | 64876.637 | 2175668.645 | 258.264 | BMP42 | 36156.439 | 2187976.783 | 241.686 |
| BMP7 | 64017.572 | 2176236.631 | 253.061 | BMP43 | 35159.297 | 2187863.532 | 232.132 |
| BMP8 | 63225.809 | 2176821.467 | 253.548 | BMP44 | 34161.926 | 2187806.667 | 232.398 |
| BMP9 | 62452.146 | 2177463.229 | 250.091 | BMP45 | 33150.452 | 2187899.187 | 232.369 |
| BMP10 | 61667.591 | 2178075.705 | 243.568 | BMP46 | 32153.782 | 2187880.272 | 229.027 |
| BMP11 | 60896.186 | 2178703.487 | 242.404 | BMP47 | 31166.381 | 2187698.376 | 229.562 |
| BMP12 | 60126.468 | 2179333.067 | 254.439 | BMP48 | 30173.067 | 2187531.935 | 235.917 |
| BMP13 | 59290.248 | 2179915.689 | 243.764 | BMP49 | 29390.058 | 2186963.537 | 242.747 |
| BMP14 | 58510.265 | 2180521.832 | 234.248 | BMP50 | 28715.542 | 2186227.736 | 251.502 |
| BMP15 | 57744.760 | 2181109.616 | 234.421 | BMP51 | 27898.712 | 2185645.194 | 248.095 |
| BMP16 | 57006.597 | 2181783.747 | 236.822 | BMP52 | 27056.951 | 2185069.214 | 249.052 |
| BMP17 | 56628.977 | 2182717.044 | 226.168 | BMP53 | 26064.623 | 2185011.797 | 251.727 |
| BMP18 | 56079.313 | 2183494.515 | 228.752 | BMP54 | 25079.893 | 2185254.736 | 242.772 |
| BMP19 | 55427.051 | 2184254.003 | 223.999 | BMP55 | 24116.136 | 2185389.479 | 241.412 |
| BMP20 | 54657.570 | 2184873.101 | 219.368 | BMP56 | 23204.692 | 2185746.142 | 247.197 |
| BMP22 | 52967.973 | 2185931.877 | 221.534 | BMP57 | 22505.425 | 2186357.276 | 250.652 |
| BMP23 | 52062.785 | 2186363.501 | 223.619 | BMP58 | 22247.688 | 2187312.363 | 250.667 |
| BMP24 | 51427.788 | 2187108.299 | 228.281 | BMP59 | 21477.227 | 2187637.348 | 245.112 |
| BMP25 | 50892.187 | 2187950.688 | 229.135 | BMP60 | 20647.840 | 2188064.096 | 242.837 |
| BMP26 | 50355.106 | 2188793.672 | 222.902 | BMP61 | 19653.755 | 2187938.676 | 250.697 |
| BMP27 | 49813.243 | 2189637.887 | 217.326 | BMP62 | 18720.412 | 2187608.906 | 247.447 |
| BMP30 | 47314.867 | 2191187.806 | 220.007 | BMP63 | 17815.044 | 2187190.931 | 253.627 |
| BMP31 | 46342.602 | 2191233.344 | 222.457 | BMP64 | 16949.540 | 2186698.796 | 250.762 |
| BMP32 | 45346.036 | 2191127.961 | 221.942 | BMP65 | 16061.606 | 2186194.003 | 257.602 |
| BMP33 | 44355.793 | 2191031.284 | 222.522 | BMP66 | 15120.976 | 2186071.526 | 257.294 |
| BMP34 | 43366.626 | 2190921.867 | 225.797 | BMP67 | 14164.201 | 2186198.732 | 261.012 |
| BMP35 | 42363.932 | 2190803.182 | 233.282 | BMP68 | 13177.848 | 2186234.247 | 266.792 |
| BMP36 | 41485.934 | 2190389.185 | 242.507 | BMP69 | 12229.755 | 2186499.452 | 258.512 |
| BMP37 | 40622.380 | 2189824.584 | 244.987 | BMP70 | 11310.136 | 2186889.239 | 266.331 |

### 2.2.4 Total Station Traverse

Leveling was carried out from the known Benchmarks to the reference pillars along the route. All the coordinates i.e. x, y and z were fixed at the temporary benchmarks by close traversing. Leveling adjustments were also been made for horizontal as well as vertical co-ordinates with normal process for error distribution. These coordinates were used for further detail survey.

### 2.2.5 L-Section and X-Section Survey

Longitudinal section levels were taken at every 25 m interval along the centre line of the existing carriageway. Cross sections were taken at every 50 m interval covering full extent of survey corridor with nos. of spot levels on the ground to give existing

ground levels for widening purpose. Longitudinal section for cross roads was taken for a length of 100 m with adjacent spot levels of the ground on both sides to design intersections. Longitudinal and cross sections survey for major/minor streams was also carried out as per the requirements.

### 2.2.6 Detail Survey

The detailed field Surveys within road corridor was carried out using high precision and sophisticated instruments like Total Stations and Auto level. The output data from the topographical survey are in (x, y, z) format for use in a sophisticated digital terrain model (DTM). Road corridor was taken as 15m on either side of existing center line i.e. total width of 30m. Additional survey was carried out at the location of realignments and streams. Various features were recorded in x, y, z co-ordinates, along the existing road and also on both sides of the existing road within road corridor. The features include ROW, existing carriageway, Km stones, buildings, structures, monuments, places of worship, railway lines, streams, rivers, canals, culverts, trees, plantations, utility services such as electric power lines, electric poles, telephone posts and telephone lines and cross roads etc. The recorded survey data were later downloaded to computer and converted to text files as well as AutoCAD drawings using appropriate software.

## 2.3 GEOTECHNICAL AND MATERIAL INVESTIGATIONS

### 2.3.1 General

This Chapter covers the details of test and investigations carried out for evaluating the characteristics of the sub-grade along the project corridor Bhawanipatna to Khariar on SH-16 (Km 2.0/00 to 70.0/00) to establish the basis for the design of various elements of the highway including pavement and sub-grade, embankment and structures.

In order to widening and strengthening of the roads and bridges, various kinds of materials shall be required. To identify potential sources of material for construction, the survey of following materials have been carried out in the months of Jan 06– Feb 06 in respect of their likely sources and the availability and suitability of various materials. This chapter includes detailed investigation of materials and their potential sources with the relevant laboratory tests conducted on representative samples as per IRC: SP -19.

The main tasks carried out for soil and material investigations as carried out includes:

i. Investigation for road for sub-grade soil below existing pavement for strengthening, widening and reconstruction design.

ii. Investigation for construction materials including identification and inspection of potential sources of construction material and extraction sites, testing and evaluating of construction materials for suitability for project road construction.

iii. Geotechnical investigation for bridges and other structures.

### 2.3.2 Investigation for road

The detailed investigations include both field and laboratory testing. Test pits were excavated at the shoulder adjacent to pavement edge at interval of 1km. Fieldwork covered field density and in-situ moisture content test, sub-grade soil sampling, while laboratory tests included the determination of relevant engineering properties of the sub-grade soil.

The sub-grade soil samples were collected from each km along the existing alignment. For the roads along new alignments, the test pits for sub-grade soil have been excavated at every 1 km. The representative samples have been tested corresponding to each segment. The testing for sub-grade soil includes.

i. Gradation (IS: 2720 (Part 5) – 2001)

ii. Atterberg's Limits (IS: 2720, Part 5) - 2001

iii. Modified Proctor Test (IS: 2720 (Part 8) – 2001)

iv. California Bearing Ratio (CBR Soaked) (IS: 2720 (Part 16) – 2001)

v. Field density and In-situ moisture content (IS:2720, Part XXIX & Part II)

vi. Free Swell Index (IS: 2720, Part XXXX)

The results of the above field and laboratory investigations for various test pits are reported in Table 2.1 of Material Report – Part III, reproduced here also in Table 2.3.1.

## Table 2.2: Soil Investigation Data of Existing Subgrade

| Location (Km.) | Description of soil | Gradation: Percent by weight retained the Sieve (IS:2720-IV) | | | | Clay and silt content % | Atterberg Limits [ IS :2720-Pt-V] | | | Modified Proctor Test (IS:2720-VIII) | | Field dry density at subgrade level gm/cc | In-situ Moisture content % | CBR Soaked % | DFS | Group of soil (IS:1498) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 4.75 mm | 2.0 mm | 425 micron | 75 micron | | Liquid Limit (LL) % | Plastic Limit (PL) % | Plasticity Index (PI) | Max. dry density gm/cc. | OMC % | | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| 0/0 | Silty Clay with sand | 3.52 | 3.04 | 14.29 | 25.37 | 53.78 | 30 | 18 | 12 | 1.91 | 13.52 | 1.76 | 8.2 | 5.2 | 37 | CL |
| 1/0 | Silty sand with clay & gravel | 7.58 | 15.76 | 36.97 | 9.57 | 30.12 | 29 | 24 | 5 | - | - | 1.775 | 10.0 | - | 21.87 | SM-SC |
| 2/0 | Clayey sand with silt & gravel | 3.35 | 15.83 | 32.77 | 14.77 | 33.28 | 28 | 20 | 8 | 2.04 | 9.5 | 1.829 | 8.0 | 8.0 | 8.3 | SC |
| 3/0 | Silty sand with clay | 8.88 | 16.85 | 35.82 | 14.05 | 24.4 | 27 | 22 | 5 | - | - | 1.772 | 9.0 | - | 20.83 | SM-SC |
| 4/0 | Silty sand with clay | 0.87 | 2.1 | 18.05 | 31.37 | 47.61 | 27 | 21 | 6 | 1.97 | 13.4 | 1.782 | 4.5 | 9.5 | 18.2 | SM-SC |
| 5/0 | Silty sand with clay | 2.32 | 4.23 | 26.41 | 29.82 | 37.22 | 25 | 20 | 5 | - | - | 1.775 | 6.0 | - | - | SM-SC |
| 6/0 | Silty sand with clay | 0.5 | 0.5 | 16.17 | 34.1 | 48.73 | 37 | 25 | 12 | 1.98 | 11.05 | 1.789 | 7.0 | 8 | 22.61 | SC |
| 7/0 | Silty sand with gravel | 14.84 | 3.94 | 27.21 | 25.98 | 28.03 | 27 | NP | NIL | 1.89 | 12.9 | 1.89 | 8.5 | 13.6 | - | SM |
| 8/0 | Silty Clay with sand | 1.87 | 5.16 | 15.7 | 20.76 | 56.51 | 27 | 20 | 7 | 1.86 | 13.05 | 1.766 | 11.0 | 6.2 | 22.27 | ML-CL |
| 9/0 | Silty Clay with sand | 0.42 | 1.89 | 11.94 | 17.47 | 68.28 | 36 | 21 | 15 | 1.78 | 14.9 | 1.76 | 12.5 | 4.5 | 56 | CI |
| 10/0 | Silty clay | 4.29 | 1.26 | 7.2 | 23.56 | 63.69 | 38 | 18 | 20 | 1.79 | 17.02 | 1.769 | 12.0 | 2.7 | 78 | CI |
| 11/0 | Clayey sand with gravel | 15.61 | 3.86 | 11.27 | 19.49 | 49.77 | 32 | 18 | 14 | 2.08 | 11.4 | 1.72 | 10.5 | 6.2 | 25 | SC |
| 12/0 | Silty sand with gravel | 16.07 | 10.53 | 7.6 | 31.62 | 34.18 | 22 | NP | NIL | 1.98 | 10.2 | 1.788 | 9.5 | 15.8 | - | SM |
| 13/0 | Silty sand with clay & gravel | 16.4 | 4.06 | 15.16 | 18.9 | 45.48 | 28 | 22 | 6 | 1.92 | 12.8 | 1.776 | 10.2 | 12.0 | - | SM-SC |

## Table 2.3: Soil Investigation Data of Existing Subgrade (Contd …)

| Location (Km.) | Description of soil | Gradation: Percent by weight retained the Sieve (IS:2720-IV) | | | | Clay and silt content % | Atterberg Limits [ IS :2720-Pt-V] | | | Modified Proctor Test (IS:2720-VIII) | | Field dry density at subgrade level gm/cc | In-situ Moisture content % | CBR Soaked % | DFS | Group of soil (IS:1498) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 4.75 mm | 2.0 mm | 425 micron | 75 micron | | Liquid Limit (LL) % | Plastic Limit (PL) % | Plasticity Index (PI) | Max. dry density gm/cc. | OMC % | | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| 14/0 | Sandy gravel with silt & clay | 39.04 | 8.8 | 15.2 | 13.1 | 23.86 | 27 | 20 | 7 | - | - | 1.79 | 9.0 | - | - | SM-SC |
| 15/0 | Sandy gravel with silt & clay | 31.14 | 8.92 | 15.77 | 12.45 | 31.72 | 46 | 35 | 11 | - | - | 1.81 | 9.5 | - | - | SC |
| 16/0 | Sandy gravel with silt & clay | 23.08 | 11.57 | 16.63 | 14.89 | 33.83 | 39 | 28 | 11 | - | - | 1.79 | 10.5 | - | 25 | SC |
| 17/0 | Sandy gravel with silt & clay | 25.73 | 9.78 | 18.17 | 15.08 | 31.24 | 42 | 31 | 11 | 1.85 | 14.5 | 1.81 | 12.0 | 8.6 | 24 | SC |
| 18/0 | Silty clay | 1.77 | 0.7 | 4.57 | 20.97 | 71.99 | 37 | 20 | 17 | 1.78 | 16.82 | 1.764 | 12.0 | 2.5 | 55 | CI |
| 19/0 | Silty sand with clay | 5.64 | 12.5 | 19.68 | 28.5 | 33.68 | 23 | 19 | 4 | 1.94 | 10.65 | 1.773 | 12.5 | 12.5 | - | SM-SC |
| 20/0 | Clayey sand with silt | 0.32 | 1.21 | 15.33 | 37.86 | 45.28 | 35 | 25 | 10 | - | - | 1.771 | 10.0 | - | 23.92 | SC |
| 21/0 | Silty clay | 0.65 | 0.63 | 5.66 | 22.58 | 70.48 | 42 | 22 | 20 | 1.91 | 12.85 | 1.771 | 12.0 | 3 | 58 | CI |
| 22/0 | Silty clay | 3.85 | 0.87 | 4.58 | 21.47 | 69.23 | 39 | 20 | 19 | 1.81 | 15.9 | 1.774 | 11.3 | 3.5 | 49 | CI |
| 23/0 | Clayey sand | 18.42 | 5.35 | 12.73 | 29.76 | 33.74 | 24 | 12 | 12 | 2.13 | 10.4 | 1.703 | 7.0 | 7.00 | 22 | SC |
| 24/0 | Silty clay | 1.98 | 1.21 | 4.2 | 14.56 | 78.05 | 50 | 23 | 27 | 1.81 | 12.9 | 1.738 | 18.5 | 2.9 | 62.7 | CI-CH |
| 25/0 | Silty clay | 0.89 | 0.61 | 0.43 | 13.32 | 84.75 | 47 | 24 | 23 | 1.77 | 17.05 | 1.75 | 16.5 | 2.2 | 50.8 | CI |
| 26/0 | Silty clay (Inorganic/ fat clay) | 3.0 | 0.98 | 3.35 | 13.34 | 79.33 | 53 | 26 | 27 | 1.77 | 16.65 | 1.758 | 17.0 | 2.4 | 67 | CH |
| 27/0 | Silty clay | 5.37 | 2.76 | 5.7 | 14.18 | 71.99 | 50 | 22 | 28 | 1.88 | 16 | 1.674 | 10.0 | 2.8 | 57 | CI – CH |

## Table 2.3: Soil Investigation Data of Existing Subgrade (Contd …)

| Location (Km.) | Description of soil | Gradation: Percent by weight retained the Sieve (IS:2720-IV) | | | | Clay and silt content % | Atterberg Limits [ IS :2720-Pt-V] | | | Modified Proctor Test (IS:2720-VIII) | | Field dry density at subgrade level gm/cc | In-situ Moisture content % | CBR Soaked % | DFS | Group of soil (IS:1498) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 4.75 mm | 2.0 mm | 425 micron | 75 micron | | Liquid Limit (LL) % | Plastic Limit (PL) % | Plasticity Index (PI) | Max. dry density gm/cc. | OMC % | | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| 28/0 | **Tel River** | | | | | | | | | | | | | | | |
| 29/0 | Silty clay | 6.96 | 3.34 | 9.69 | 29.94 | 50.07 | 30 | 20 | 10 | 1.79 | 15.05 | 1.736 | 10.5 | 5 | 38 | CL |
| 30/0 | Silty sand with gravel | 6.17 | 4.42 | 11.87 | 40.49 | 37.05 | 25 | NP | NIL | - | - | 1.731 | 12.0 | - | - | SM |
| 31/0 | Silty clay with gravel | 6.34 | 2.22 | 8.13 | 30.11 | 53.2 | 41 | 20 | 21 | 1.79 | 15.05 | 1.779 | 12.5 | 3.5 | 52 | CI |
| 32/0 | Silty sand with clay & gravel | 6.38 | 2.03 | 7.92 | 31.6 | 52.07 | 39 | 18 | 21 | 1.84 | 16.8 | 1.704 | 11.0 | 4.5 | 47.4 | CI |
| 33/0 | Silty sand with clay & gravel | 9.86 | 3.22 | 9.57 | 36.86 | 40.49 | 24 | 20 | 4 | - | - | 1.731 | 9.5 | - | - | SM-SC |
| 34/0 | Silty sand with clay | 5.57 | 2.41 | 9.53 | 36.13 | 46.36 | 26 | 21 | 5 | 1.94 | 11.87 | 1.697 | 11.0 | 14.1 | 15.0 | SM-SC |
| 35/0 | Sandy gravel with silt | 24.48 | 5.93 | 16.44 | 27.3 | 25.85 | 26 | NP | NIL | - | - | 1.738 | 12.5 | - | - | SM |
| 36/0 | Sandy gravel with silt | 25.3 | 7.24 | 15.3 | 23.61 | 28.55 | 27 | NP | NIL | - | - | 1.725 | 10.0 | - | 21.59 | SM |
| 37/0 | Silty sand with clay & gravel | 7.88 | 3.94 | 20.13 | 39.46 | 28.59 | 25 | 21 | 4 | - | - | 1.747 | 10.5 | - | - | SM-SC |
| 38/0 | Silty Sand | 8.91 | 5.84 | 19.79 | 34.09 | 31.37 | 28 | NP | NIL | 2.06 | 13.9 | 1.774 | 11.0 | 15.5 | 6.06 | SM |
| 39/0 | Silty sand with gravel | 11.47 | 5.95 | 22.26 | 36.57 | 23.75 | 25 | 20 | 5 | 1.92 | 11.5 | 1.75 | 12.0 | 9.8 | - | SM-SC |
| 40/0 | Silty gravel with sand | 42.03 | 7.55 | 10.52 | 15.49 | 24.41 | 25 | 21 | 4 | - | - | 1.782 | 10.8 | - | - | SM-SC |
| 41/0 | Silty sand | 1.2 | 1.25 | 14.51 | 47.18 | 35.86 | 19 | NP | NIL | 1.97 | 11.35 | 1.949 | 10.0 | 12.8 | - | SM |

**Table 2.3: Soil Investigation Data of Existing Subgrade (Contd …)**

| Location (Km.) | Description of soil | Gradation: Percent by weight retained the Sieve (IS:2720-IV) | | | | Clay and silt content % | Atterberg Limits [ IS :2720-Pt-V] | | | Modified Proctor Test (IS:2720-VIII) | | Field dry density at subgrade level gm/cc | In-situ Moisture content % | CBR Soaked % | DFS | Group of soil (IS:1498) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 4.75 mm | 2.0 mm | 425 micron | 75 micron | | Liquid Limit (LL) % | Plastic Limit (PL) % | Plasticity Index (PI) | Max. dry density gm/cc. | OMC % | | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| 42/0 | Silty clay with sand | 3.64 | 3.01 | 11.55 | 24.97 | 56.83 | 27 | 14 | 13 | 2.01 | 10.2 | 1.659 | 12.0 | 5.5 | 31.76 | CL |
| 43/0 | Clayey sand with gravel | 8.55 | 5.08 | 15.43 | 27.02 | 43.92 | 28 | 22 | 6 | - | - | 1.647 | 10.0 | - | - | SM-SC |
| 44/0 | Clayey sand with gravel | 13.73 | 7.89 | 15.43 | 25.96 | 36.99 | 31 | 24 | 7 | 1.90 | 12.0 | 1.648 | 11.5 | 11.5 | - | SM-SC |
| 45/0 | Silty clay with gravel | 11.98 | 9.34 | 18.24 | 29.63 | 30.81 | 30 | 20 | 10 | 2.06 | 11.3 | 1.631 | 13.0 | - | 17.65 | SC |
| 46/0 | Clayey sand | 4.02 | 5.3 | 15.5 | 28.5 | 46.68 | 28 | 20 | 8 | 1.98 | 12.05 | 1.635 | 15.00 | 10.6 | 22.0 | SC |
| 47/0 | Silty sand | 0.7 | 2.15 | 15.41 | 38.72 | 43.02 | 22 | NP | NIL | - | - | 1.747 | 6.8 | - | - | SM |
| 48/0 | Silty sand | 3.85 | 2.05 | 15.63 | 38.2 | 40.27 | 22 | NP | NIL | - | - | 1.768 | 6.00 | - | - | SM |
| 49/0 | Silty sand | 22.71 | 7.25 | 27.54 | 22.35 | 20.15 | 25 | NP | NIL | 2.09 | 8.85 | 1.708 | 7.0 | 15.8 | 6.67 | SM |
| 50/0 | Clayey sand with gravel | 7.77 | 4.52 | 19.95 | 38.12 | 29.64 | 30 | 25 | 5 | - | - | 1.719 | 9.0 | - | - | SM-SC |
| 51/0 | Silty sand | 8.92 | 4.81 | 21.93 | 39.43 | 24.91 | 22 | NP | NIL | 1.98 | 12.05 | 1.839 | 6.00 | 13.0 | - | SM |
| 52/0 | Silty sand | 15.35 | 3.87 | 14.98 | 41.57 | 24.23 | 21 | NP | NIL | - | - | 1.76 | 10.50 | 12.20 | - | SM |
| 53/0 | Silty sand | 9.07 | 2.32 | 14.42 | 46.31 | 27.88 | 22 | NP | NIL | - | - | 1.789 | 9.00 | - | - | SM |
| 54/0 | Silty Clay | 1.82 | 1.11 | 10.37 | 29.3 | 57.4 | 26 | 18 | 8 | 2.04 | 10.05 | 1.771 | 13.00 | 6.5 | 36.25 | CL |
| 55/0 | Silty sand | 1.06 | 1 | 9.22 | 55.83 | 32.89 | 21 | NP | NIL | - | - | 1.746 | 9.00 | - | - | SM |
| 56/0 | Silty sand | 0 | 0.2 | 4.58 | 62.62 | 32.6 | 22 | NP | NIL | 1.96 | 12.8 | 1.748 | 11.00 | 12.5 | - | SM |

## Table 2.3: Soil Investigation Data of Existing Subgrade (Contd …)

| Location (Km.) | Description of soil | Gradation: Percent by weight retained the Sieve (IS:2720-IV) | | | | Clay and silt content % | Atterberg Limits [ IS :2720-Pt-V] | | | Modified Proctor Test (IS:2720-VIII) | | Field dry density at subgrade level gm/cc | In-situ Moisture content % | CBR Soaked % | DFS | Group of soil (IS:1498) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 4.75 mm | 2.0 mm | 425 micron | 75 micron | | Liquid Limit (LL) % | Plastic Limit (PL) % | Plasticity Index (PI) | Max. dry density gm/cc. | OMC % | | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| 57/0 | Silty sand | 0 | 0.4 | 4.6 | 63.65 | 31.35 | 23 | NP | NIL | - | - | 1.751 | 10.50 | - | - | SM |
| 58/0 | Silty sand with gravel | 10.2 | 6.82 | 30.6 | 26.28 | 26.1 | 20 | NP | NIL | 2.18 | 7.13 | 1.773 | 12.00 | 20.5 | - | SM |
| 59/0 | Silty sand with gravel | 7.33 | 5.17 | 22.78 | 36.5 | 28.22 | 21 | NP | NIL | - | - | 1.782 | 10.00 | - | - | SM |
| 60/0 | Silty sand with gravel | 7.77 | 5.92 | 26.9 | 30.01 | 29.4 | 22 | NP | NIL | 2.02 | 8.50 | 1.633 | 16.00 | 18.5 | - | SM |
| 61/0 | Silty sand with gravel | 6.54 | 9.7 | 22.53 | 31.55 | 29.68 | 22 | NP | NIL | 2.12 | 11.5 | 1.781 | 10.00 | - | 7.8 | SM |
| 62/0 | Silty sand with gravel | 9.05 | 6.33 | 22.67 | 37.21 | 24.74 | 22 | NP | NIL | - | - | 1.732 | 9.00 | - | - | SM |
| 63/0 | Silty sand | 2.3 | 6.12 | 24.42 | 41.75 | 25.41 | 21 | NP | NIL | - | - | 1.718 | 10.00 | - | - | SM |
| 64/0 | Silty sand | 3.2 | 1.87 | 12.22 | 32.95 | 49.76 | 32 | 20 | 12 | 1.98 | 12.05 | 1.721 | 9.00 | 8.5 | | SC |
| 65/0 | Clayey Sand with gravel | 13.94 | 2.43 | 12.57 | 26.18 | 44.88 | 29 | 14 | 15 | 2.03 | 11.25 | 1.702 | 12.00 | 6.2 | 26.47 | SC |
| 66/0 | Silty sand | 5.96 | 2.9 | 13.64 | 31.84 | 45.66 | 27 | 20 | 7 | 1.87 | 13.9 | 1.76 | 9.50 | 10.7 | | SM-SC |
| 67/0 | Silty sand | 6.34 | 3.75 | 25.53 | 36.17 | 28.21 | 22 | NP | NIL | 2.16 | 8.0 | 1.741 | 8.00 | 28.2 | 13.3 | SM |
| 68/0 | Silty sand | 0 | 0.26 | 12.35 | 54.35 | 33.04 | 18 | NP | NIL | - | - | 1.742 | 9.00 | - | - | SM |
| 69/0 | Silty sand | 1.9 | 3.05 | 21.35 | 37.05 | 36.65 | 26 | NP | NIL | 1.94 | 12.85 | 1.738 | 8.00 | 14.5 | - | SM |
| 70/0 | Silty sand | 2.07 | 2.9 | 22.38 | 36.47 | 36.18 | 27 | NP | NIL | - | - | 1.736 | 9.50 | - | - | SM |

**Discussion of Results**

The soils in this stretch mainly classify in the group of SM-SC / SC / SM /CL / CI /CH and it is described as Silty Sand with Clay /Silty Sand / Silty clay with Sand/ Silty Clay. CL/CI/CH soil is low to high plastic and cohesive having CBR values (Soaked) ranging from 2.2% to 6.5 %. The maximum dry density at O.M.C. of the existing subgrade soil of CL/CI/CH group varies between 1.77 gm/cm3 to 2.01 gm/cm3. In these sections PI value ranges from 5.0 to 28.0. The P.I. value is Nil in the case of Silty Sand soil of SM group. While the Clayey Sand with Silt (SC) soil is little plastic. In maximum kilometers (from 0.0/0.0 to 33/0.0), there are Expansive soils found with low to high degree of expansion. The treatments for such soils are discussed in the following Paragraph.

**Expansive Soils and their Treatment**

Low to high expansive soils of CL-CI-CH group are found in various Sections of SH 16 i.e. Km 0/0, 6/0, 8/0, 9/0, 10/0, 18/0, 21/0, 22/0, 23/0, 24/0, 25/0, 26/0, 27/0, 29/0, 31/0, 32/0, 42/0, 54/0. In such a long stretch of road section, it is always preferable either to replace the soil of high expansive properties by importing good soil from borrow area or to treat the soil of low to medium expansive soils.

To reduce the expansive properties of soil, first the expansive soil should be compacted slightly 1-2 % wet of the O.M.C and provide a buffer layer of non-expansive cohesive soil cushion of 0.6 – 1.0m thickness. It prevents the ingress of water in the underlying expansive soil layer, counteracts swelling. Even if the underlying expansive soil heaves, the movement will be more uniform and consequently more tolerable. However where provision of non-expansive buffer layer is not economically feasible, a blanket course of suitable material and thickness as discussed below must be provided.

A blanket course of at least 225 mm thickness composed of coarse/ medium sand or non-plastic moorum having PI less than 5 should be provided on expansive soil subgrade as a sub-base to serve as an effective intrusion barrier. The blanket course should extend over the entire formation width together with measures for efficient drainage of the pavement section. Improvement of drainage can significantly reduce the magnitude of seasonal heaves.

### 2.3.3 Investigation for Construction Material

Samples of borrow area soils, sand, gravel and crushed rocks for use in embankment, pavement structure and concrete mix were obtained from the existing and proposed borrow sources / quarries within reasonably short haulage distances of the project road. Test pits were also excavated wherever necessary to obtain samples for testing.

Appropriate laboratory tests were carried out on the representative samples of soil and materials obtained during field investigations to determine relevant engineering properties. Following table gives the details of different material sources identified.

**Table 2.4: Sources of Construction Material**

| S.No. | Material | No. of Sources Identified |
|---|---|---|
| 1 | Granular Sub base | 6 |
| 2 | Coarse Aggregate/ Stone | 8 |
| 3 | Sand / Fine Aggregate | 2 |
| 4 | Morrum | 5 |
| 5 | Cement | 2 |
| 6 | Water | 2 |
| 7 | Stone | - |

#### *2.3.3.1 Sub-grade*

In this stretch, there was no soil available in borrow areas .The materials which can be used in sub-grade from borrow areas are sand and Moorum only. The representative samples were collected from each of the quarries and the laboratory tests were conducted to determine the suitability for construction.

**Identified Location of Sand Quarries:**

i. Tel River @ km 28

ii. Sundar River @ km 59

**Identified Location of Moorum Quarries:**

i. Karlasoda @ Km 4/0

ii. Karlaguda @ Km 13/0

iii. Adhamunda @ Km 18/500

iv. Donguriguda @ Km 23/0

v. Debujhar @ Km 53/0

The Tests results are tabulated in Table. 2.2 and 6.1 of Material Report Part-III and their suitability for subgrade was found out on the basis of these results.

**Discussion of Test results**

Sand in this stretch mainly found in Kms 28/0(Tel River) , and 59/0(Sunder River) which classified in the group of SM described as Silty Sand. The Silty Sand ( SM) soil is non plastic and cohesion less .The maximum dry density at O.M.C. of the existing subgrade soil of SM group varies between 1.84 gm/cm3 to 2.07 gm/cm3. The sand from river borrow area is available in much quantity, also another alternative is either to use Moorrum mixed with sand, as subgrade material, which is abundantly available in this stretch. The various test results of samples collected from the Borrow areas are given in Table 2.2 & 6.1 (Refer Material Report – Part III).

#### *2.3.3.2 Granular Sub-base*

Along the Project corridor, six quarries were identified. The representative samples were collected from each of the quarries and the laboratory tests were conducted to determine the suitability for construction.

**Identified Location of Quarries:**

i. Karlasoda @ Km 4/0
ii. Karlaguda @ Km 13/0
iii. Pastipada @ Km 15/0
iv. Adhamunda @ Km 18/500
v. Donguriguda @ Km 23/0
vi. Debujhar @ Km 53/0

**Laboratory Tests Conducted:**

i. Gradation (MORT&H)
ii. Atterberg's Limits (IS: 2720, Pt V)
iii. Modified Proctor Test (IS: 2720, Pt VIII)
iv. California Bearing Ratio (CBR, Soaked) (IS : 2720, Pt XVI)

The Tests results are tabulated in Table. 4.1 and 4.2 of Material Report Part-III and their suitability for different type of works was found out on the basis of these results.

**Discussion of Test results**

The sub base material should have minimum CBR of 30 percent for traffic exceeding 2 msa and 20 percent for traffic up to 2 msa. From the tests results it is clearly evident that in Bhawani Patna - Kheriar section, only two GSB quarry's @ chainages KM18/5 & 23 are suitable which are having liquid limit and P.I. value within the prescribe limit as per MORT&H specifications. For rest of quarries in which liquid limit and Plasticity Index is more than 25 and 6.0 respectively, blending of coarse grained sandy soil is suggested to lower down their Liquid limit & P.I. within the prescribed limit. Quarries having CBR values less than 30% also need blending and for rest of quarries blending of sand in required proportion is to be done and their revised tests results have been tabulated in Table 4.2 (Refer Material Report Part-III)

Therefore it shall be ensured prior to actual execution that the material to be used in the sub-base satisfies the requirements of CBR and other physical requirements.

#### *2.3.3.3 Coarse Aggregate:*

Along the road section of SH-16, Bhawanipatna to Kheriar, eight quarries were found. The representative samples were collected from each of the quarries and the laboratory tests were conducted to determine the suitability for construction.

**Identified Location of Quarries:**

i. Adhamunda @ Km 0/0
ii. Kamathana Crusher @ Km 6/0
iii. @ Km 31/0
iv. Sindhigela @ Km 47/0
v. Dabujhar @ Km 53/0
vi. Risipeti @ Km 61/0
vii. Risigaon Quarry @ Km 64/0
viii. Singh Bhadi @ Km 70/0

**Laboratory Tests Conducted:**

i. Gradation (IS: 2386, Pt I& MoRST&H)
ii. Aggregate Impact Value (IS: 2386, Pt IV)
iii. Specific Gravity& Water Absorption (IS: 2386, Pt III)
iv. Combined Flakiness & Elongation Index (IS: 2386, Pt I)
v. Stripping Value (IS : 6241)

The Tests results are tabulated in Table 5.1 of Material Report Part-III and their suitability for different type of works is found out on the basis of these results.

**Discussion of Test Results**

The samples collected from various queries were tested in the laboratory. All the samples comply with the physical requirement of MORT&H specifications.

Their water absorption value ranges from 0.30% to 0.77% and the combined flakiness and elongation indices also comply with the physical requirements as per MORT&H specifications. The Impact values are in the range from 15% to 25% which is also well with in the prescribed limits as per MoRST&H. The aggregates from quarries do not conform exactly to the grading specified in the specification of MoRST&H.

Therefore, the blending as per the requirement should be done prior to mixing at plant. The stripping value of most of aggregate do not fulfill the requirements except some of the quarries like Kamathana (6/0), Adhamunda (18/0), For the aggregates whose stripping value do not fulfill the requirement then anti stripping agent should be used during execution as per the requirement, the MoRSTH (Appendix 1000-1). The test results are given in Table 3.1 (Refer Material Report – Part III).

In most of the quarries the aggregate is available in large quantities except in some of quarries named Singh Badi (70/0), Risipeti (Km 61/0), (KM 31/0), Kamathana (6.0) where material is available in small quantities.

Materials from quarries / crusher (aggregate) given in test results Table 5.1 (Refer Material Report – Part III) are suitable for WMM, Bituminous work and other construction works in accordance to MORT&H specifications.

#### *2.3.3.4 Sand / Fine Aggregate*

Sand/ Fine Aggregate will be required for concrete work. Along the road section of SH-16, Bhawanipatna to Kheriar, two quarries were found. The representative samples were collected from each of the quarries and the laboratory tests were conducted to determine the suitability for construction.

**Identified Location of Quarries:**

i. Tel River @ km 28
ii. Sundar River @ km 59

**Laboratory Tests Conducted:**

i. Gradation (IS: 383)
ii. Silt content and Fineness Modulus (IS: 383)
iii. Specific Gravity (IS: 2720, Pt III)
iv. Deleterious content (IS: 2386, Pt-I & IS: 383)

The Tests results are tabulated in Table 6.2 (Refer Material Report Part-III) and their suitability for different type of works is found out on the basis of these results.

**Discussion of Test results**

Sand sources are generally suitable for fine aggregate materials in Bituminous works and Concrete works but would require the removal of deleterious materials and Clay / Silt contents. From the test results it is evident that the Sand of Tel River and Sunder rivers are lying in zone III (at selected beds) it may vary at different bed levels. Test results shows that sand samples from both sources are also suitable for subgrade material as well as RCC / Masonry work.

### *2.3.3.5 Moorum*

**Identified Borrow areas for Moorum**

i. Karlasoda @ Km 4/0

ii. Karlaguda @ Km 13/0

iii. Adhamunda @ Km 18/5

iv. Donguriguda @ Km 23/0

v. Dabujhar @ Km 53 / 0

**Identified Borrow areas for Sand**

i. Tel River @ KM28

ii. Sunder River @ KM59

The soil samples were collected from borrow areas, which are located at some leads by the project corridor (SH-16). The borrow area locations with sufficient quantity of material is given in the borrow area lead chart in Fig 1.2(Refer Material Report – Part III) To assess their suitability as subgrade materials the following laboratory tests were conducted on the representative samples. The test results of borrow area soil and Moorum samples are tabulated in Table 2.2 & 6.1 respectively (Refer Material Report – Part III).

**Discussion of Results**

The soil in this stretch mainly found in Kms 28/0(Tel River), and 59/0(Sunder River), which classified in the group of SM described as Silty Sand. The Silty Sand (SM) soil is non-plastic and cohesion less .The maximum dry density at O.M.C. of the existing subgrade soil of SM group varies between 1.84 gm/cm3 to 2.07 gm/cm3. The various test results of soil samples collected from the road (Borrow area) are given in Table 2.2 & 6.1. (Refer Material Report – Part III). The sand from river borrow area is available in much quantity; also another alternative is either to use moorum as subgrade material, which is abundantly available in this stretch. The test results of Moorum available in different borrow areas are tabulated in Table 2.3 (Refer Material Report – Part III)

#### *2.3.3.6 Cement / Concrete*

**Cement**

Cement is made by branded manufacturers in the regions. In this region, Konark Slag Cement and Lafarge Cement are mainly in use for construction purpose. As cement is manufactured by branded companies and its testing is done on lot to lot basis regularly. Therefore, samples of these two types of cement were tested for the physical properties. The test results are tabulated in Table 7.1 and 7.2 (Refer Material Report-Part III).

**Concrete**

The concrete work shall consist of furnishing and placing structural concrete and incidental construction with these specifications and in conformity with the lines, grades and dimensions, as shown on the drawings or as directed by the Engineer. It is recommended that as the gradation and other physical properties of materials used in mix design vary site to site. Therefore fresh mix designs of the required grade should always be conducted before the construction starts and it should be checked at regular intervals during the phase of construction itself.

#### *2.3.3.7 Water*

Water used for mixing and curing shall be clean and free from injurious amounts of oils, acids, alkalis, organic materials or other substances that may be deleterious to concrete or steel. Potable water is generally considered satisfactory for mixing concrete. Mixing and curing with seawater shall not permit.

The samples were collected from Tel River and Sunder River and the laboratory tests were conducted to determine the suitability for use in construction as per IS: 456. For test results refer Material Report-Part III in Table 8.1 & 8.2.

From the given test results it is evident that these water samples are suitable for the construction purpose.

### 2.3.4 Investigation for Structures

The main function of a foundation is to distribute or transmit all the loads coming over it to the soil or ground upon which it rests. The knowledge of the characteristics of underlying soil is therefore very essential for safe & economical design of foundations. The performance of supporting stratum depends upon the physical properties of soil, type & shape of footing & structure, water table depth etc.

It is therefore necessary to have sufficient information about the arrangement & behavior of the underlying materials and their physical properties, for adopting and designing the structural foundation. Soil exploration through field investigation and relevant laboratory testing of the samples are essential to arrive at required parameter for designing of foundations.

#### *2.3.4.1 Sub soil exploration Test Locations*

The Sub Soil explorations were carried out at locations as indicated in following table.

**Table: 2.5: Sub Soil exploration Test Locations**

| Location | Chainage | Nallah |
|---|---|---|
| 1 | 8/600 | Sankharimal |
| 2 | 10/500 | Badakhermai |
| 3 | 13/750 | Badapolia |
| 4 | 17/120 | Manigah |
| 5 | 21/000 | Karla Pada |
| 6 | 27/600 | Sana Dubura Nallah Minor Bridge No-1 |
| 7 | 27/800 | Turkula Nallah |
| 8 | 27/850 | Minor Bridge No-2 (Tel Approach) |
| 9 | 28/400 | Tel Setu |
| 10 | 28/900 | Minor Bridge No-3 (Branch Of Udanti) |
| 11 | 29/400 | Minor Bridge No-4 (Branch Of Udanti) |
| 12 | 45/700 | Chand Tara |
| 13 | 54/600 | Kunda Nallah |
| 14 | 58/900 | Chandel |
| 15 | 59/400 | Tukula |
| 16 | 63/650 | Rasigaon Nallah |
| 17 | 66/500 | Lachhipur Nallah |
| 18 | 69/300 | Bichhi Nallah |

Detailed information about the sub soil exploration investigations, characteristics of site, field investigation, laboratory tests, analysis, test results, bore hole details and conclusions refer Geo-Technical report of Bhawanipatna to Khariar (SH-16).

### *2.3.4.2 Recommendations from Investigations:*

**Table 2.6: Recommendations from Subsoil Investigations**

| Location | Chainage | Type of foundation | Minimum Depth of Foundation |
|---|---|---|---|
| 1 | 8/600 | Open | 1.5m from bed level |
| 2 | 10/500 | Open | 1.5m from bed level |
| 3 | 13/750 | Open | 3.5m from bed level |
| 4 | 17/120 | Open | 1.5m from Ground level |
| 5 | 21/000 | Open | 6.3m from bed level |
| 6 | 27/600 | Pile | 10m from bed level |
| 7 | 27/800 | Pile | 10m from Ground level |
| 8 | 27/850 | Pile | 12m from Ground level |
| 9 | 28/400 | Pile | 15m from Ground level |
| 10 | 28/900 | Pile | 15m from Ground level |
| 11 | 29/400 | Pile | 10m from Ground level |
| 12 | 45/700 | Open | 1.5m from Ground level |
| 13 | 54/600 | Open | 4.5m from Ground level |
| 14 | 58/900 | Open | 4m from Ground level |
| 15 | 59/400 | Pile | 12m from Ground level |
| 16 | 63/650 | Open | 1.5m from Ground level |
| 17 | 66/500 | Open | 1.5m from Ground level |
| 18 | 69/300 | Open | 1.5m from Ground level |

## 2.4 HYDRAULIC AND HYDROLOGICAL INVESTIGATIONS

The Highway network in a project area crosses a number of rivers/ tributaries / streams / nallahs with small, medium or large catchment and therefore for design of bridges and other structures, hydrological parameters of these structures are essentially required. The design discharge has been calculated for a maximum 50-year return period as per IRC 5-1985, clause 103.

### 2.4.1 Design Discharge

For the calculation of discharge, following different methods have been used.

#### *2.4.1.1 Dicken's Formula*

This is an empirical formula and is used for small catchments upto 25 to 30 sqkm.

$Q = C * (M)^{3/4}$

Where, Q = Peak runoff in cumecs

M = Catchment area in Sq.km.

C= Dicken's constant

= 11-14 where the annual rainfall is 600 mm to 1200 mm

= 14- 19 where the annual rainfall is more than 1200 mm

=22 in Western Ghats

#### *2.4.1.2 Rational Formula*

The rational formula for assessment of peak discharge from project catchment takes into account rainfall, runoff under various circumstances, time of concentration and critical intensity of rainfall. The formulas used are as under.

One hour rainfall ($I_o$), $I_o = (F/T)*(T+1)/(1+1)$

Time of concentration (SP-13, page 12), $t_c = (0.87*L^3/H)^{0.385}$

Critical rainfall intensity $I_c = I_o*(2/(1+t_c)$

Discharge $Q=0.028 * P*f* A* I_c$

Where,

$t_c$ = Time of concentration i.e. time taken by runoff from farthest point on the periphery of catchment (hrs)

$I_o$ = One hour rainfall in cm.

$I_c$ = Critical intensity of rainfall in cm per hour

P = Coefficient of runoff for the catchment characteristics (Ref.Table-4.1, P-13, I.R.C. SP: 13-2004)

A = Catchment area in hectare

Q = Maximum discharge in cumecs

L = Distance from the critical point to the structure (Length of path) in Km

H = The difference in level from the critical point to the structure in metre

F = Maximum rain fall in mm

T = Duration of storm in hours

f = A fraction of maximum point intensity at the centre of he storm and related with the catchment area (Determined from Fig.4.2, Page-14, I.R.C.: SP: 13-2004.)

In the present study, storm rainfall and storm duration data of 50 –Year return period have been utilized from design flood hydrograph of near by project sites, developed on the basis of Hydro-meteorological studies as per Flood estimation reports of Mahanadi & Upper eastern coast sub-zones.

#### *2.4.1.3 Manning's Formula*

In this method cross sectional area and longitudinal slope of the stream is used to determine the velocity of flow and design discharge. Discharge has been calculated at three location i.e. one near the proposed bridge site, one at u/s and one at d/s of the proposed bridge site.

$V = (1/n) R^{2/3} S^{1/2}$

$Q = AV$

Where

V = Velocity of flow

n = Manning's constant

R = A/P = Hydraulic mean radius

A = Cross sectional area of flow

P = Wetted perimeter

S = Longitudinal slope of stream

Q = Discharge

#### *2.4.1.4 Unit Hydrograph Method*

This method is used for estimating design flood peak and design flood hydrograph of desired frequency, knowing the physical/ physiographic characteristics of the catchment and reasonable design storm rainfall.

The regional flood estimation reports under long-term plan of 26 Sub-Zones in India are available. These reports have been formulated as a joint venture by the Ministry of Water resources through Central Water Commission, Research, and Designs & Standards Organization (RDSO) of Ministry of Railways, Ministry of Shipping & Transport (MOST) and India Meteorological Department (IMD) of Government of India. The reports pertaining to Orrisa State are Sub-zone-III-d-Mahanadi basin and Sub-zone- IV-a- Upper Eastern coast.

In the absence of site-specific discharge data, which is generally the situation in case of small and medium catchments, the approach open is to evolve a regional frequency storm rainfall-loss-synthetic unit hydrograph model for a hydro-meteorological homogeneous region. The approach consists of working out regional Synthetic Unit hydrograph (SUG) parameters with pertinent physiographic characteristics from the recommended formulae in the particular Sub Zone flood estimation report, drawing and adjusting SUG, computation of design storm duration and point rainfall & areal rainfall, distribution of areal rainfall during design storm duration to obtain rainfall increments for unit duration intervals, assessment of effective rainfall units after subtraction of prescribed loss rate from rainfall increments, estimation of hourly rainfall excess, estimation of base flow and computation of 50-year peak flood and 50-year design flood hydrograph.

The step-by-step method has been described separately in Hydrology Report.

#### *2.4.1.5 Fixing Design Discharge*

Design discharge has been decided after comparing the discharge calculated from different methods as discussed above. Highest of these values has been adopted as design discharge, provided it does not the next highest discharge by more than 50%. If it exceeds, design discharge has been restricted to that limit.

### 2.4.2 Linear Waterway

Linear Waterway for a bridge structure is fixed from hydraulic and economic considerations with particular reference to:

i. Design flood

ii. Topography of the site

iii. Existing and proposed section

iv. Scour depth

v. Permissible afflux, and

vi. Construction and maintenance aspects

The linear water way/regime width (W) of a bridge across a purely alluvial stream in regime state as per IRC-SP-13,

$W = 4.8\ Q^{1/2}$

Where,

W= Liner waterway in metres

Q = Design flood discharge in cumecs.

### 2.4.3 Scour Depth

For the purpose of design of foundations, the design discharge as calculated above has been further increased as recommended in IRC:78-2000.

As per I.R.C.:78-2000, Clause: 703.1.1, normal scour depth is given by

$$d_{sf} = 1.34 * [ (D_b)^2 ] / (K_{sf})^{1/3}$$

$D_b$= Design discharge in cumecs/ metre

$K_{sf} = 1.76 (d_m)^{1/2}$ = silt factor

$d_m$ = Weighted mean diameter of the particles in mm

Maximum scour depth for individual foundations without any floor protection works is given as

For pier = $2 * d_{sf}$

For abutments = $1.27 * d_{sf}$

### 2.4.4 Vertical clearance

As per IRC-SP:13, following vertical clearances have been kept.

**Table 2.7: Vertical Clearance**

| Discharge in cumecs | Vertical clearance in m |
|---|---|
| Below 0.30 | 0.15 |
| 0.30 - 3.00 | 0.30 |
| 3.00 - 30.0 | 0.60 |
| 30.0 - 300.0 | 0.90 |
| 300.0 - 3,000.0 | 1.20 |
| Above 3,000.0 | 1.50 |

### 2.4.5 Summary of Hydraulic Parameters

Detailed hydrology has been carried out at each of the bridge locations and presented in separate report. The abstract of hydraulic parameters are as under.

**Table 2.8 : Hydraulic Parameters**

| S. N. | Location/ Chainage | Existing Span Arrange-ment (no.x span) | Design Discharge (Cumec) | Existing Waterway (m) | Proposed Waterway (m) | Remarks |
|---|---|---|---|---|---|---|
| 1 | 3/050 | 3 x 8.8 | 339.0 | 24.0 | - | Good, Rehabilitation required |
| 2 | 4/450 | 4 x 9.9 | 346.49 | 36.0 | - | Good, Rehabilitation required |
| 3 | 8/600 | 1 x 7.3 | 60.65 | 6.1 | 8.0 | Submersible bridge, to be replaced |
| 4 | 10/500 | 1 x 7.4 | 62.57 | 6.25 | 8.0 | Submersible bridge, to be replaced |
| 5 | 13/750 | 2 x 7.2 | 88.25 | 12.8 | 14.0 | Reconstruction due to poor condition |
| 6 | 17/120 | 1 x 7.55 | 48.62 | 6.75 | 8.0 | Reconstruction due to poor condition |
| 7 | 21/000 | (3 x 0.6)+ (7 x 1.2) | 48.62 | - | 12.0 | Submersible bridge, to be replaced |
| 8 | 27/600 | 7 x 9.2 | 2578.76 | 58.4 | - | Submersible bridge, to be raised |
| 9 | 27/800 | 10 x 1.2 | | 12.0 | 257.6 | Submersible bridge, to be replaced |
| 10 | 27/850 | 9 x 9.2 | | 75.2 | | Pipe Causeway, to be replaced by H.L. bridge |
| 11 | 28/400 | (2 x 9.9) + (1 x 24.37) + (1 x 34.9) + (10 x 40.85) | 15436.97 | 480.5 | - | Good, Nothing to do |
| 12 | 28/900 | 4 x 9.2 | 516.72 | 32.2 | - | Submersible bridge, to be raised |
| 13 | 29/400 | 2 x 9.2 | | 16.4 | 55.2 | Submersible bridge, to be raised and additional vent way required |
| 14 | 45/700 | 1 x 6.2 | 26.34 | 4.5 | 8.0 | Reconstruction due to poor condition |
| 15 | 54/600 | 3 x 8.5 | 340.35 | 22.2 | 28.8 | Reconstruction due to Realignment |
| 16 | 58/900 | 3 x 6.8 | 98.06 | 18.0 | 19.88 | Reconstruction due to Realignment |
| 17 | 59/100 | (7 x 32.7) + (1 x 7.6) | 5133.0 | 226.9 | - | Minor Touchup repair |
| 18 | 59/400 | 5 x 4.0 | 77.17 | 15.0 | - | Good, Rehabilitation required |
| 19 | 63/650 | 1 x 6.6 | 124.63 | 6.1 | 8.0 | Reconstruction due to poor condition |
| 20 | 66/500 | 1 x 7.2 | 66.18 | 6.1 | 8.0 | Reconstruction due to poor condition |
| 21 | 69/300 | 1 x 7.2 | 80.50 | 6.1 | - | Rehabilitation required |

## 2.5 INVESTIGATION FOR BRIDGES AND STRUCTURES

### 2.5.1 General

The total stretch of Bhawanipata to khariar is 68 Km on SH-16. The detailed study has been undertaken for the culverts & bridges. The details study consist of :

i. Inventory of culverts & bridges.

ii. Condition assessment of existing culverts & bridges.

iii. Additional cross drainage structures as per detailed site investigation.

iv. Construction of new bridge on same alignment because,

   a. Existing bridge is narrow and dilapidated.

   b. Hydrological study and local data indicates bridge getting overtopped frequently.

v. Possibility of widening the bridges to the required width if structural, hydrological considerations would so permit.

vi. Retaining the existing bridges with

   a. Touchup repairs if the prevailing structural and hydrological considerations are adequate.

   b. Touchup repair and scour protection measures, structural conditions are all right but hydraulic conditions are not met.

### 2.5.2 Inventory of Bridges and Culverts

The culvert and bridge inventory was undertaken by actual study, site visit, measurements and visual inspections. It was supplemented by survey and detailed investigations by the experienced team. After preparing draft inventory and condition survey report, joint verification was carried along with PIU Engineers. Necessary corrections as observed during site visit were incorporated. The final report after incorporating decisions taken during joint site visit was submitted to PIU. The detailed inventory and condition survey report along with recommendations has also been submitted in Feasibility Report.

Bridge Inventory broadly covers the following features.

i. Location of bridge

ii. Name of bridge or nallah

iii. Span arrangement

iv. Width of carriageway

v. Type of bridge

vi. Type of foundation

vii. Skew angle

viii. Type of superstructure & substructure

ix. Condition of superstructure & substructure

x. Condition of bearings, expansion joint, approach slab, drainage spout etc.

The format prescribed in SP-19 has been enhanced to accommodate additional features such as wearing coat, expansion joint & railing condition, floor protection and approach slab.

There are total 21 bridges, 4 of them are major and remaining 17 are minor bridges. The abstract of bridge inventory is presented in Table 2.9.

Culvert Inventory covers the following features.

i. Location of culvert

ii. Span arrangement

iii. Type of structure

iv. Width of carriageway

v. Material of abutment & headwall

vi. Condition of slab & pipe

vii. Condition of abutment & headwall

viii. Protection of bed

ix. Presence of scour

x. Hydrological adequacy

There are total 112 culverts, 49 of them are pipe culverts, 45 are RCC slab culverts, 3 are stone slab culverts, 1 is arch culvert and 14 are vented causeway. The abstract of culvert inventory is presented in Table 2.9

## 2.5.3 Condition surveys for bridges and culverts

### *2.5.3.1 Bridges*

Detailed visual inspections were carried out in addition to Non Destructive Tests (NDT). Special attention was paid to the Condition Survey of various features of bridges and hydraulic adequacy. The NDT (Rebound hammer and Ultrasonic pulse velocity) tests were conducted for bridges at chainage 3/050,13/750,27/600,59/100, 59/400 and 69/300 to study the structural soundness of the structures. Some of photographs showing NDT tests are presented in Plate 1.

There are total 21 bridges. Analytical study of the Condition Survey data has been carried out and following important conclusions are arrived:

i. Approach slab has not been provided in 12 no. of the bridges.

ii. Bed protection of 2 bridges at Ch 3/050 and 59/400 is in damaged condition and proposed to be redone.

iii. Splayed wing wall has been proposed on all four side for 2 bridges mentioned above.

iv. Mastic asphalt in case of bituminous concrete wearing coat has not been provided in any bridge.

v. The condition of the expansion joints in some of the bridges is poor.

vi. 6 numbers of bridges are in poor condition and have been proposed for reconstruction.

vii. Bridge at Ch 17/120 is narrow having 3.1m carriageway width, not in good condition, has been recommended for reconstruction.

viii. 8 numbers of submersible bridges have been replaced with high level bridge to have all weather road.

ix. Submersible bridge at Ch 4/450, which never overtopped has been retained.

x. 2 bridges at Ch 54/600 and 58/900 are realigned due to poor geometrics and have been recommended to be reconstructed along new alignment.

The abstract of inventory and condition of the existing bridge studies along with the recommendations is presented in Table 2.9.

The photographs showing NDT tests are shown in Plate 1. The Photographs of some of bridges to be dismantled is presented in Plate 2 and for rehabilitation in Plate 3.

**Table 2.9: Inventory and Condition of Existing Bridges**

| Sl. No. | Location/ Chainage | Existing Span Arrangement | Type of Superstructure | Type of foundation | Overall condition/ Recommendation |
|---|---|---|---|---|---|
| 1 | 3/050 | 3 x 8.8 | Solid Slab | Open foundation | Good, Rehabilitation required |
| 2 | 4/450 | 4 x 9.9 | Solid Slab | Open foundation | Good, Rehabilitation required |
| 3 | 8/600 | 1 x 7.3 | Solid Slab | Open foundation | Submersible bridge, to be replaced |
| 4 | 10/500 | 1 x 7.4 | Solid Slab | Open foundation | Submersible bridge, to be replaced |
| 5 | 13/750 | 2 x 7.2 | Solid Slab | Open foundation | Reconstruction due to poor condition |
| 6 | 17/120 | 1 x 7.55 | Iron Joist with Solid Slab | Open foundation | Reconstruction due to poor condition |
| 7 | 21/000 | (3 x 0.6) + (7 x 1.2) | Pipe Causeway | - | Pipe Causeway, to be replaced by H.L. bridge |
| 8 | 27/600 | 7 x 9.2 | Solid Slab | Open foundation | Submersible bridge, to be raised |
| 9 | 27/800 | 10 x 1.2 | Pipe causeway | - | Submersible bridge, to be raised |
| 10 | 27/850 | 9 x 9.2 | Solid Slab | Open foundation | Pipe Causeway, to be replaced by H.L. bridge |
| 11 | 28/400 | (2 x 9.9) + (1 x 24.37) + (1 x 34.9) + (10 x 40.85) | RCC Box Girder | Well foundation | Good, Nothing to do |
| 12 | 28/900 | 4 x 9.2 | Solid Slab | Open foundation | Submersible bridge, to be raised |
| 13 | 29/400 | 2 x 9.2 | Solid Slab | Open foundation | Submersible bridge, to be raised |
| 14 | 45/700 | 1 x 6.2 | Solid Slab | Open foundation | Reconstruction due to poor condition |
| 15 | 54/600 | 3 x 8.5 | Solid Slab | Open foundation | Good, Rehabilitation required |
| 16 | 58/900 | 3 x 6.8 | Solid Slab | Open foundation | Good, Rehabilitation required |
| 17 | 59/100 | (7 x 32.7)+(1 x 7.6) | PSC Girder | Well foundation | Minor Touchup repair |
| 18 | 59/400 | 5 x 4.0 | Box Cell | Raft foundation | Good, Rehabilitation required |
| 19 | 63/650 | 1 x 6.6 | Solid Slab | Open foundation | Reconstruction due to poor condition |
| 20 | 66/500 | 1 x 6.4 | Solid Slab | Open foundation | Reconstruction due to poor condition |
| 21 | 69/300 | 1 x 7.2 | Solid Slab | Open foundation | Rehabilitation required |

**Table 2.10: Summary of Existing Bridges**

| Type of Action Required | No. |
|---|---|
| Nothing to do cases | 1 |
| Rehabilitation cases | 11 |
| Replaced due to Poor condition | 5 |
| Replaced due to Submersible condition | 4 |

**Plate 1**

## Photographs of some of bridges showing NDT

**Rebound Hammer testing in Pier cap for bridge at Ch. 27/850**

**Pulse velocity Test in Pier cap for bridge at CH. 27/850**

**Rebound Hammer testing in Deck slab for bridge at Ch. 59/100**

**Plate 2**

## Photographs of some of bridges to be dismantled

**Bridge at Ch:13/750**

**Bridge at Ch:17/120**

**Bridge at Ch:45/700**

**Plate 3**

## Photographs of some of bridges to be rehabilitated

**Bridge at Ch:3/050**

**Bridge at Ch:4/450**

**Bridge at Ch:59/400**

### *2.5.3.2 Culverts*

Detailed visual inspection was made for each Culvert and their condition was assessed. The inventory and condition survey of the culverts along the project road were conducted.

Analytical study of the Condition Survey data has been carried out and following important conclusions are arrived:

i. The total number of culvert is 112 in a road length of from km 2/0 to 70/0 i.e. in a stretch of 68.00 km.

ii. Most of the culverts do not meet the considerations of maintenance of culverts (minimum vent size) as specified in IRC: SP-13: 2004, para 13.3.2.

iii. Most of the CD culverts are having overall width less than 12 m. These culverts have been widened if horizontal and vertical profile permit.

iv. Return walls, Head walls or parapet wall of most of the culverts are damaged and proposed to be reconstructed in case the culvert condition is good and alignment permits.

v. 40% of the culverts are RR stone masonry with RCC deck slab in poor condition and most of them have been proposed to be reconstructed.

vi. Most of the culverts have been provided without any protection works.

vii. 4 culverts with stone slab deck have been recommended for reconstruction.

viii. At certain locations ground levels and road levels are almost at same level due to which area becomes submerged. Additional culverts are provided at these locations after raising the road.

The following table presents abstract of inventory and condition of existing culverts along with the recommendation.

**Table 2.11: Inventory and Condition of Existing Culverts**

| Sl. No. | Location/ Chainage | Existing Span Arrangement | Type of Culvert | Recommendation |
|---|---|---|---|---|
| 1 | 3/450 | 1 x 1.0 | Slab | Reconstruction due to poor condition |
| 2 | 4/100 | 1 x 0.6 | Pipe | Nothing to do |
| 3 | 5/450 | 1 x 0.6 | Pipe | Nothing to do |
| 4 | 5/650 | 1 x 1.2 | Stone Slab | Stone slab culvert, to be replaced |
| 5 | 6/550 | 2 x 1.0 | Pipe | Nothing to do |
| 6 | 6/900 | 1 x 2.4 | Slab | To be widened |
| 7 | 7/015 | 1 x 0.6 | Pipe | Nothing to do |
| 8 | 7/800 | 1 x 0.3 | Stone Slab | Stone slab culvert, to be replaced |
| 9 | 9/450 | 1 x 0.9 | Slab | To be widened |
| 10 | 10/100 | 1 x 0.6 | Pipe | Nothing to do |
| 11 | 10/150 | 2 x 1.0 | Pipe | Replaced due to poor condition |
| 12 | 10/700 | 1 x 0.6 | Pipe | To be widened |
| 13 | 10/750 | 1 x 1.9 | Slab | Reconstruction due to poor condition |
| 14 | 12/600 | 1 x 0.6 | Pipe | Nothing to do |
| 15 | 12/700 | 1 x 1.8 | Slab | To be widened |
| 16 | 12/750 | 1 x 0.6 | Pipe | Nothing to do |
| 17 | 12/800 | 1 x 0.6 | Pipe | Nothing to do |
| 18 | 13/300 | 1 x 1.0 | Pipe | Nothing to do |
| 19 | 14/050 | 1 x 0.9 | Slab | To be widened |
| 20 | 14/400 | 2 x 0.9 | Vented Cause Way | Vented causeway, to be replaced |
| 21 | 14/800 | 3 x 1.0 | Pipe | Reconstruction due to poor condition |
| 22 | 15/005 | 1 x 0.6 | Pipe | Nothing to do |
| 23 | 15/250 | 1 x 0.9 | Vented Cause Way | Vented causeway, to be replaced |
| 24 | 15/600 | 1 x 0.6 | Pipe | To be widened |
| 25 | 15/850 | 2 x 0.9 | Vented Cause Way | Vented causeway, to be replaced |
| 26 | 16/050 | 1 x 0.6 | Pipe | To be widened |
| 27 | 17/500 | 3 x 0.9 | Vented Cause Way | Vented causeway, to be replaced |
| 28 | 18/100 | 2 x 0.9 | Vented Cause Way | Vented causeway to be replaced |
| 29 | 18/850 | 1 x 3.0 | Arch | Arch culvert to be replaced |
| 30 | 19/700 | 1 x 0.75 | Pipe | Nothing to do |
| 31 | 20/150 | 5 x 1.0 | Pipe | To be widened |
| 32 | 20/400 | 5 x 1.0 | Pipe | To be widened |
| 33 | 21/650 | 2 x 0.9 | Vented Cause Way | Vented causeway, to be replaced |
| 34 | 22/150 | 2 x 0.9 | Vented Cause Way | Vented causeway to be replaced |
| 35 | 22/350 | 2 x 0.9 | Vented Cause Way | Vented causeway to be replaced |
| 36 | 23/100 | 2 x 0.9 | Vented Cause Way | Vented causeway to be replaced |
| 37 | 23/250 | 1 x 1.0 | Pipe | Nothing to do |
| 38 | 23/350 | 2 x 0.9 | Vented Cause Way | Vented causeway to be replaced |
| 39 | 23/650 | 2 x 0.9 | Vented Cause Way | Vented causeway to be replaced |
| 40 | 24/100 | 1 x 0.6 | Pipe | Dismantled due to insufficient vent |
| 41 | 24/450 | 3 x 1.2 | Pipe | Nothing to do |
| 42 | 24/550 | 3 x 0.9 | Vented Cause Way | Vented causeway to be replaced |
| 43 | 25/750 | 2 x 0.9 | Vented Cause Way | Vented causeway to be replaced |
| 44 | 26/750 | 2 x 0.9 | Vented Cause Way | Vented causeway to be replaced |
| 45 | 27/100 | 1 x 0.6 | Pipe | Reconstruction due to poor condition |
| 46 | 27/250 | 1 x 0.6 | Pipe | Nothing to do |
| 47 | 30/850 | 1 x 1.5 | Slab | Reconstruction due to poor condition |
| 48 | 31/250 | 1 x 1.5 | Slab | Reconstruction due to poor condition |
| 49 | 32/050 | 1 x 1.5 | Slab | To be widened |
| 50 | 33/200 | 1 x 3.0 | Slab | To be widened |
| 51 | 34/700 | 1 x 1.5 | Slab | Dismantled due to Submergence |

| | | | | |
|---|---|---|---|---|
| 52 | 36/900 | 1 x 1.5 | Slab | Dismantled due to Submergence |
| 53 | 37/100 | 1 x 1.5 | Slab | Dismantled due to Submergence |
| 54 | 37/400 | 1 x 1.5 | Slab | Dismantled due to Submergence |
| 55 | 38/400 | 1 x 1.5 | Slab | Dismantled due to Submergence |
| 56 | 40/100 | 1 x 1.5 | Slab | Dismantled due to Submergence |
| 57 | 40/950 | 1 x 1.5 | Slab | To be widened |
| 58 | 41/300 | 1 x 1.5 | Slab | Reconstruction due to poor condition |
| 59 | 41/700 | 1 x 1.5 | Slab | To be widened |
| 60 | 42/200 | 1 x 1.5 | Slab | To be widened |
| 61 | 42/550 | 1 x 0.45 | Pipe | Reconstruction due to poor condition |
| 62 | 43/100 | 1 x 3.0 | Slab | Reconstruction due to poor condition |
| 63 | 44/150 | 1 x 1.5 | Slab | To be widened |
| 64 | 44/850 | 1 x 3.0 | Slab | Reconstruction due to poor condition |
| 65 | 45/150 | 1 x 0.6 | Pipe | To be widened |
| 66 | 45/600 | 1 x 0.6 | Pipe | Reconstruction due to poor condition |
| 67 | 45/850 | 1 x 4.5 | Slab | To be widened |
| 68 | 46/350 | 1 x 1.5 | Slab | To be widened |
| 69 | 47/050 | 1 x 1.5 | Slab | To be widened |
| 70 | 47/200 | 1 x 1.5 | Slab | Reconstruction due to poor condition |
| 71 | 49/600 | 1 x 1.5 | Slab | To be widened |
| 72 | 50/150 | 1 x 1.5 | Slab | To be widened |
| 73 | 50/300 | 1 x 1.5 | Slab | Reconstruction due to poor condition |
| 74 | 51/025 | 1 x 0.6 | Pipe | To be widened |
| 75 | 51/250 | 1 x 0.9 | Pipe | To be widened |
| 76 | 51/400 | 1 x 0.9 | Pipe | To be widened |
| 77 | 51/600 | 2 x 0.9 | Pipe | To be widened |
| 78 | 51/900 | 1 x 0.6 | Pipe | Reconstruction due to poor condition |
| 79 | 52/100 | 1 x 0.6 | Pipe | Reconstruction due to poor condition |
| 80 | 52/250 | 1 x 0.9 | Pipe | Reconstruction due to poor condition |
| 81 | 52/700 | 4 x 0.9 | Pipe | To be widened |
| 82 | 53/500 | 1 x 0.9 | Pipe | To be widened |
| 83 | 53/950 | 1 x 1.4 | Slab | To be widened |
| 84 | 54/350 | 1 x 1.3 | Slab | To be widened |
| 85 | 55/250 | 1 x 1.5 | Slab | Dismantled due to Submergence |
| 86 | 56/100 | 1 x 5.0 | Slab | Reconstruction due to poor condition |
| 87 | 56/400 | 1 x 0.9 | Pipe | To be widened |
| 88 | 57/150 | 1 x 0.9 | Pipe | Reconstruction due to poor condition |
| 89 | 57/500 | 1 x 0.6 | Pipe | To be widened |
| 90 | 57/900 | 1 x 0.45 | Skew Pipe | Reconstruction due to poor condition |
| 91 | 57/990 | 1 x 0.3 | Stone Slab | To be abandoned |
| 92 | 59/850 | 1 x 0.45 | Pipe | Reconstruction due to poor condition |
| 93 | 60/100 | 1 x 3.0 | Slab | To be widened |
| 94 | 60/750 | 1 x 1.5 | Slab | To be widened |
| 95 | 61/550 | 1 x 1.5 | Slab | Reconstruction due to poor condition |
| 96 | 62/250 | 1 x 3.0 | Slab | Reconstruction due to poor condition |
| 97 | 62/900 | 1 x 0.6 | Pipe | Nothing to do |
| 98 | 63/200 | 1 x 1.5 | Slab | To be widened |
| 99 | 63/550 | 1 x 6.2 | Slab | Reconstruction due to poor condition |
| 100 | 63/900 | 1 x 1.5 | Slab | To be widened |
| 101 | 64/600 | 1 x 0.6 | Pipe | Nothing to do |
| 102 | 64/825 | 1 x 0.6 | Pipe | Dismantled due to insufficient vent |
| 103 | 65/100 | 1 x 0.6 | Pipe | To be widened |
| 104 | 65/350 | 1 x 1.5 | Slab | To be widened |
| 105 | 65/675 | 1 x 1.5 | Slab | Reconstruction due to poor condition |
| 106 | 65/900 | 1 x 1.5 | Slab | Reconstruction due to poor condition |

| | | | | |
|---|---|---|---|---|
| 107 | 66/200 | 1 x 0.9 | Pipe | To be widened |
| 108 | 67/300 | 1 x 0.6 | Pipe | To be widened |
| 109 | 67/550 | 1 x 0.9 | Pipe | Nothing to do |
| 110 | 67/850 | 1 x 0.9 | Pipe | Nothing to do |
| 111 | 68/200 | 1 x 0.6 | Pipe | Nothing to do |
| 112 | 68/700 | 1 x 1.5 | Slab | To be widened |

**Table 2.12: Summary of Existing Culverts**

| Type of Culvert | Nos. |
|---|---|
| Arch | 49 |
| Pipe | 45 |
| Slab | 3 |
| Stone Slab | 1 |
| Vented Causeway | 14 |
| **Total** | **112** |

## 2.6 PAVEMENT INVESTIGATIONS

This section describes the studies and investigations carried out on existing pavement condition to determine the most technically sound and economically feasible pavements design. The investigations include:

i. Visual Inspection Survey
ii. Pavement Composition.
iii. Roughness Survey
iv. Benkelman Beam Deflection Survey

### 2.6.1 Visual Inspection Survey

The Visual Inspection Survey was carried out for the entire stretch under consideration. The parameters observed in this Survey were:

i. Type of surface
ii. Types of cracks (alligator/block/transverse/longitudinal) and its area.
iii. Pot holes, raveling and patching areas
iv. Shoulder condition
v. Rutting (measured with a 3 meter long straight edge).

The detailed field studies were carried out in respect of pavement condition. The data collected through pavement investigations are presented in Table 2.6.1, graphical representation of the same is presented in Figures2.6.1 to 2.6.5 shall be sufficient to meet the input requirements of HDM- IV.

**Table 2.13: Pavement condition**

| Chainage | | Riding Quality | | Pavement Condition | | | | | | | | | | | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| From (KM) | To (KM) | Speed (km/hr) | Quality G/F/P/ VP | Cracking (%) | Raveling (%) | Potholing (Nos. ) | Potholing (%) | Rut**** (None /Moderate/ Severe) | Patching (Nos. )** | Patching (%) | Pavement Edge Drop (mm) | Embank-ment Condition (G/ F/P) | Embank ment Height | Road side Drain (NE/ PF/ F)*** | |
| 0/0 | 1/0 | 30 | F | - | | - | - | None | 8 | 1 | 25 | F/P | 0.4 | F | City Hilly |
| 1/0 | 2/0 | 30 | G/F | - | | - | - | None | 12 | 1 | 20 | F/P | 1.6 | F | |
| 2/0 | 3/0 | 30 | VP | - | 40.0 | 33 | 4.0 | None | 36 | 4 | 10 | F/P | 1.5 | F | |
| 3/0 | 4/0 | 30 | VP | 10 | 40.0 | 42 | 5.0 | Moderate | 41 | 4 | 5 | F/P | 1.5 | PF | Edge Damage |
| 4/0 | 5/0 | 30 | VP | 5 | 40.0 | 31 | 4.0 | Moderate | 38 | 4 | 15 | F/P | 1.4 | PF | |
| 5/0 | 6/0 | 30 | VP | 2 | 40.0 | 54 | 6.0 | Moderate | 36 | 4 | 15 | F/P | 1.5 | PF | |
| 6/0 | 7/0 | 30 | VP | 2 | 35.0 | 31 | 3.0 | None | 22 | 2 | 15 | F/P | 1.9 | PF | |
| 7/0 | 8/0 | 30 | VP | 5 | 35.0 | 38 | 5.0 | None | 29 | 2 | 5 | F/P | 0.6 | PF | |
| 8/0 | 9/0 | 30 | VP | 5 | 44.0 | 35 | 5.0 | None | 41 | 4 | 5 | F/P | 1.6 | PF | Edge Damage |
| 9/0 | 10/0 | 30 | VP | 5 | 44.0 | 41 | 6.0 | Moderate | 43 | 4 | 10 | F/P | 1.5 | PF | |
| 10/0 | 11/0 | 30 | P/F | 5 | 20.0 | - | - | None | 41 | 4 | 5 | F/P | 1.5 | PF | |
| 11/0 | 12/0 | 30 | F | - | - | - | - | None | 45 | 5 | 10 | F | 1.5 | PF | |
| 12/0 | 13/0 | 30 | F | 2 | - | - | - | None | 42 | 4 | 15 | F/P | 0.8 | PF | |
| 13/0 | 14/0 | 30 | F | - | - | - | - | None | 36 | 3 | 5 | F/P | 0.8 | PF | |
| 14/0 | 15/0 | 30 | G/F | - | - | - | - | None | 27 | 3 | 5 | F/P | 0.8 | PF | |
| 15/0 | 16/0 | 30 | VP | 10 | 40.0 | 49 | 8.0 | None | 49 | 5 | 5 | | 1.1 | PF | |
| 16/0 | 17/0 | 30 | P | 2 | 35.0 | 36 | 5.0 | None | 45 | 4 | 20 | F | 0.8 | F | |
| 17/0 | 18/0 | 30 | VP | 4 | 35.0 | 42 | 5.0 | None | 64 | 6 | 15 | F/P | 0.9 | PF | |
| 18/0 | 19/0 | 30 | VP | 4 | 35.0 | 51 | 6.0 | None | 46 | 5 | 10 | F/P | 1.3 | PF | |
| 19/0 | 20/0 | 30 | F/P | - | - | 7 | 1.0 | Moderate | 26 | 3 | 10 | F/P | 1.3 | PF | |
| 20/0 | 21/0 | 30 | P | - | 7.0 | 20 | 2.0 | None | 13 | 1 | 10 | F/P | 1.5 | PF | |
| 21/0 | 22/0 | 30 | V/P | 5 | 20.0 | 34 | 4.0 | Moderate | 17 | 1 | 10 | F/P | 1.1 | PF | |
| 22/0 | 23/0 | 30 | P/F | - | 7.0 | 14 | 1.0 | None | 16 | 1 | 15 | F/P | 1.6 | PF | |
| 23/0 | 24/0 | 30 | F/P | - | - | 18 | 2.0 | None | 13 | 1 | 5 | F/P | 1.5 | PF | |

**Table 2.13 Pavement condition (Contd …)**

| Chainage | | Riding Quality | | Pavement Condition | | | | | | | | | | | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| From (KM) | To (KM) | Speed (km/hr) | Quality G/F/P/ VP | Cracking (%) | Raveling (%) | Potholing (Nos. ) | Potholing (%) | Rut**** (None /Moderate/ Severe) | Patching (Nos. )** | Patching (%) | Pavement Edge Drop (mm) | Embank-ment Condition (G/ F/P) | Embankment Height | Road side Drain (NE/ PF/ F)*** | |
| 24/0 | 25/0 | 30 | VP | 5 | 35.0 | 68 | 15.0 | None | 57 | 5 | 20 | F | 2.1 | PF | Black Cotton Soil |
| 25/0 | 26/0 | 30 | VP | 5 | 20.0 | 127 | 15.0 | None | 52 | 5 | 10 | F | 1.5 | PF | |
| 26/0 | 27/0 | 30 | VP | - | 28.0 | 74 | 10.0 | None | 43 | 4 | 10 | F | 1.5 | PF | |
| 27/0 | 28/0 | 30 | F/P | 5 | 7.0 | 60 | 5.0 | None | 25 | 3 | 5 | F | 8 | F | |
| 28/0 | 29/0 | 30 | P | 7 | 20.0 | 161 | 12.0 | None | 45 | 6 | 5 | F | 7.0 | PF | |
| 29/0 | 30/0 | 30 | P/F | 2 | 7.0 | 72 | 8.0 | None | 30 | 5 | 5 | F | 1.5 | PF | |
| 30/0 | 31/0 | 30 | V/P | 7 | 35.0 | 102 | 15.0 | None | 37 | 5 | 10 | F/P | 1.5 | PF | |
| 31/0 | 32/0 | 30 | V/P | 4 | 35.0 | 137 | 25.0 | None | 59 | 6 | 20 | F/P | 1.5 | PF | |
| 32/0 | 33/0 | 30 | VP | 10 | 35.0 | 104 | 15.0 | None | 61 | 6 | 10 | F/P | 1.1 | PF | |
| 33/0 | 34/0 | 30 | VP | 10 | 25.0 | 69 | 10.0 | None | 53 | 5 | 15 | F/P | 0.9 | PF | |
| 34/0 | 35/0 | 30 | VP | 15 | 7.0 | 113 | 20.0 | None | 72 | 8 | 10 | F/P | 0.9 | PF | |
| 35/0 | 36/0 | 30 | P/F | 7 | 7.0 | 63 | 10.0 | None | 68 | 8 | 20 | F/P | 1.5 | NE | |
| 36/0 | 37/0 | 30 | P | 2 | 15.0 | 41 | 3.0 | None | 79 | 10 | 10 | F/P | 1.1 | NE | |
| 37/0 | 38/0 | 30 | F | - | - | - | - | None | 32 | 3 | 5 | F/P | 0.5 | NE | |
| 38/0 | 39/0 | 30 | F | - | - | - | - | None | 53 | 5 | - | F/P | 0.4 | NE | |
| 39/0 | 40/0 | 30 | F | - | - | - | - | None | 27 | 3 | 10 | F/P | 0.4 | NE | |
| 40/0 | 41/0 | 30 | G/F | 2 | - | - | - | None | 15 | 1 | 15 | F | 0.5 | NE | |
| 41/0 | 42/0 | 30 | F | 5 | - | - | - | None | 18 | 1 | 10 | F | 0.4 | NE | Edge Damage |
| 42/0 | 43/0 | 30 | F | 2 | - | - | - | None | 16 | 1 | 15 | F | 0.6 | NE | Edge Damage |
| 43/0 | 44/0 | 30 | F | - | - | - | - | None | 38 | 4 | 25 | F | 0.4 | PF | |
| 44/0 | 45/0 | 30 | F/G | 5 | - | - | - | None | 19 | 2 | 15 | F | 1.4 | PF | |
| 45/0 | 46/0 | 30 | F/P | 5 | 25.0 | - | - | None | 23 | 2 | 20 | F/P | 1.4 | PF | |
| 46/0 | 47/0 | 30 | P/G | 2 | 12.0 | 12 | 1.0 | None | 18 | 2 | 10 | F/P | 0.6 | PF | |
| 47/0 | 48/0 | 30 | F | - | - | - | - | None | 10 | 1 | 12 | F/P | 0.7 | PF | |

**Table 2.13 Pavement condition (Contd …)**

| Chainage | | Riding Quality | | Pavement Condition | | | | | | | | | | | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| From (KM) | To (KM) | Speed (km/hr) | Quality G/F/P/ VP | Cracking (%) | Raveling (%) | Potholing (Nos. ) | Potholing (%) | Rut**** (None /Moderate/ Severe) | Patching (Nos. )** | Patching (%) | Pavement Edge Drop (mm) | Embank-ment Condition (G/ F/P) | Embankment Height | Road side Drain (NE/ PF/ F)*** | |
| 48/0 | 49/0 | 30 | VP | - | 40.0 | 116 | 15.0 | None | 39 | 3 | 15 | F/P | 0.7 | PF | Edge Damage |
| 49/0 | 50/0 | 30 | F/P | 5 | 35.0 | 12 | 1.0 | None | 30 | 3 | 15 | F/P | 1.2 | PF | |
| 50/0 | 51/0 | 30 | F | - | - | - | - | None | 18 | 1 | 10 | F/P | 1.5 | PF | |
| 51/0 | 52/0 | 30 | F | - | - | - | - | Moderate | 22 | 2 | 10 | F/P | 1.1 | PF | |
| 52/0 | 53/0 | 30 | P | 10 | 18.0 | 4 | 0.5 | None | 36 | 3 | 7 | F/P | 1.3 | PF | |
| 53/0 | 54/0 | 30 | F | - | - | - | - | None | 12 | 1 | 5 | F/P | 0.9 | PF | |
| 54/0 | 55/0 | 30 | FV/G | - | - | - | - | None | 15 | 1 | 5 | F/P | 0.9 | PF | |
| 55/0 | 56/0 | 30 | F/G | - | - | - | - | None | 8 | 1 | 5 | F/P | 0.8 | PF | |
| 56/0 | 57/0 | 30 | VP | - | 30.0 | 197 | 20.0 | None | 38 | 4 | 30 | F/P | 1.1 | NE | |
| 57/0 | 58/0 | 30 | F | - | - | - | - | None | 14 | 1 | 5 | F/P | 1.1 | NE | |
| 58/0 | 59/0 | 30 | F/P | 7 | 12.0 | 1 | - | None | 18 | 1 | 5 | F/P | 1.6 | PF | |
| 59/0 | 60/0 | 30 | P | 10 | 20.0 | 16 | 1.0 | None | 22 | 2 | 5 | F/P | 3.4 | PF | |
| 60/0 | 61/0 | 30 | P | 10 | 30.0 | 23 | 2.0 | None | 29 | 2 | 15 | F/P | 1.8 | PF | Edge Damage |
| 61/0 | 62/0 | 30 | F | - | - | 4 | 1.0 | None | 17 | 1 | 10 | F/P | 1.4 | PF | |
| 62/0 | 63/0 | 30 | F | 5 | - | 4 | 0.1 | None | 13 | 1 | 10 | F/P | 0.9 | PF | |
| 63/0 | 64/0 | 30 | F | 7 | - | - | - | None | 16 | 1 | 5 | F/P | 1.2 | PF | |
| 64/0 | 65/0 | 30 | F | 6 | - | - | - | None | 31 | 3 | 5 | F/P | 1.6 | PF | |
| 65/0 | 66/0 | 30 | F | 6 | 5.0 | - | - | None | 28 | 2 | 7 | F/P | 1.5 | PF | |
| 66/0 | 67/0 | 30 | F/P | 20 | 5.0 | - | - | None | 30 | 2 | 10 | F | 1.5 | PF | |
| 67/0 | 68/0 | 30 | F/P | 20 | 5.0 | - | - | None | 24 | 2 | 5 | F | 1.5 | PF | |
| 68/0 | 69/0 | 30 | F/P | 15 | 5.0 | - | - | None | 12 | 1 | 5 | F | 1.2 | PF | |
| 69/0 | 70/0 | 30 | F/P | 15 | - | - | - | None | 14 | 1 | 5 | F | 1.2 | PF | |

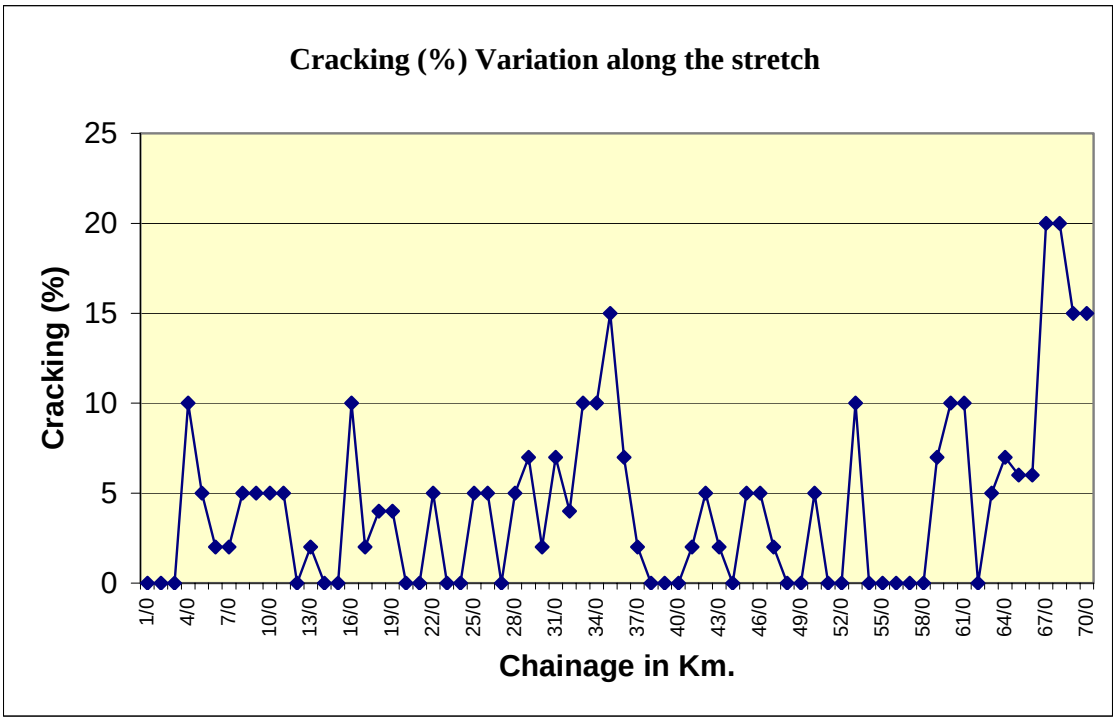



**Figure 2.6.1: Cracking (%) Variation along the stretch**

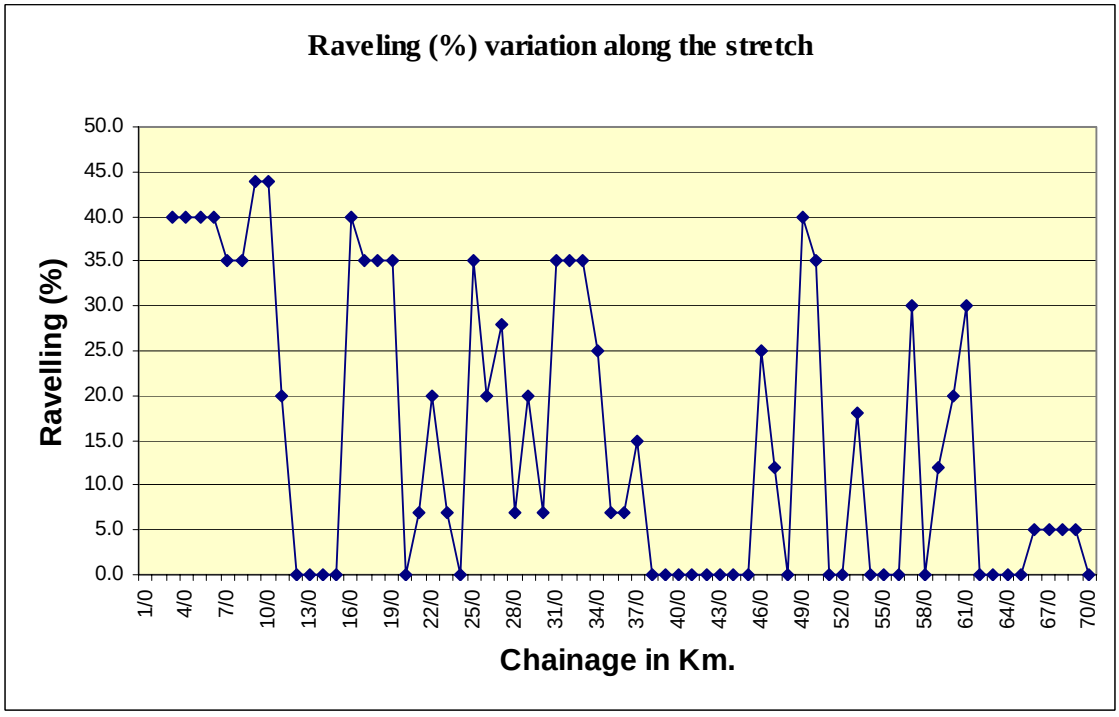



**Figure 2.6.2: Raveling (%) Variation along the stretch**

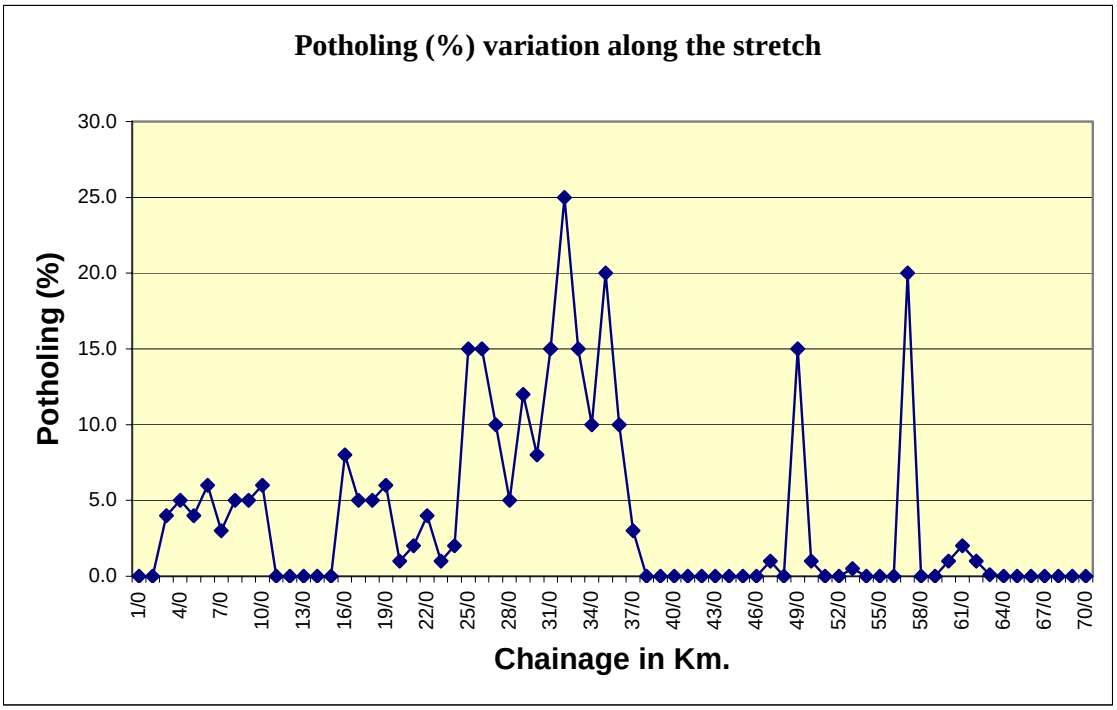



**Figure 2.6.3: Potholing (%) Variation along the stretch**

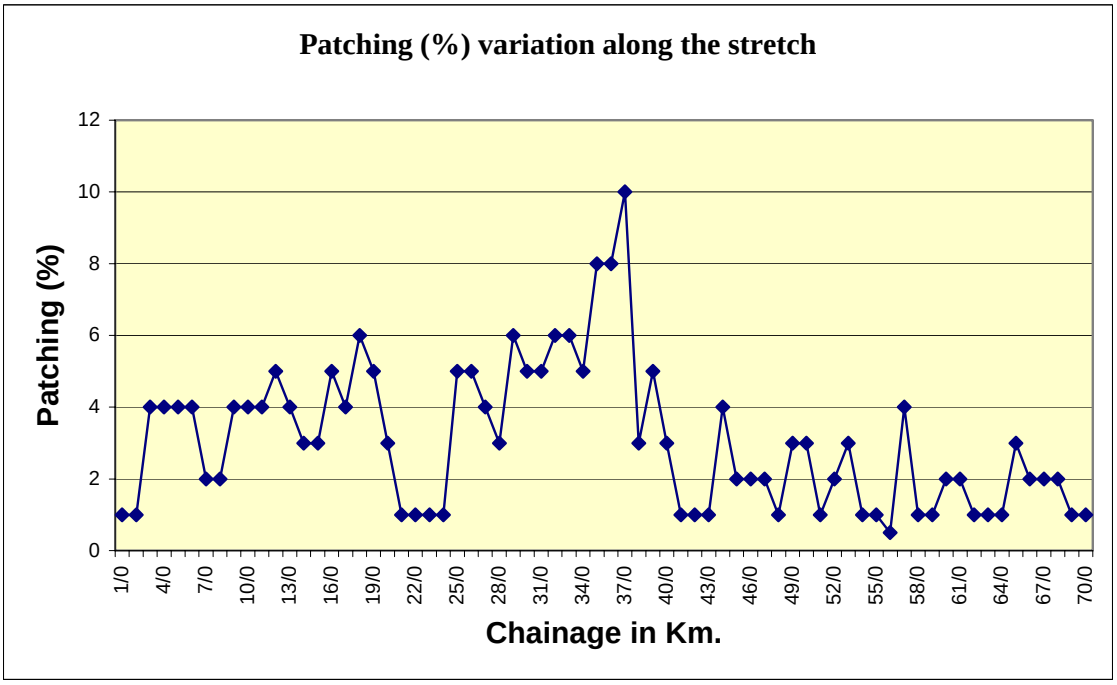



**Figure 2.6.4: Patching (%) Variation along the stretch**

## 2.6.2 Pavement Composition

The test pits were made to ascertain the pavement composition. The Test Pits measuring 1mx1m in plan were made at every 1 km interval (Staggered left/ Right) or at each major change in the pavement condition, whichever is less. The specification for making good the excavated pavement would be, by sand filling up to top level of sub grade followed by PCC in M-15 grade equal to road crust thickness.

For each test pit, the following information has been recorded:

i. Test pit reference (Identification number, location);
ii. Pavement composition (material type and thickness);
iii. Sub-grade type (textural classification) and condition (dry, wet)

The pavement composition has been shown in Table 2.14. Pavement sub-grade characteristics have already been discussed in section 2.3.2

**Table 2.14: Pavement composition**

| Chainage | | Wearing Course (mm) | Base course (mm) | Sub-base course (mm) | Total thickness (mm) | Chainage | | Wearing Course (mm | Base course (mm) | Sub-base course (mm | Total thickness (mm) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| From | To | | | | | From | To | | | | |
| 0 | 1 | 50 | 220 | 110 | 380 | 35 | 36 | 55 | 200 | 120 | 375 |
| 1 | 2 | 30 | 170 | 150 | 350 | 36 | 37 | 55 | 210 | 135 | 400 |
| 2 | 3 | 25 | 170 | 150 | 345 | 37 | 38 | 60 | 220 | 150 | 430 |
| 3 | 4 | 30 | 180 | 150 | 360 | 38 | 39 | 50 | 220 | 170 | 440 |
| 4 | 5 | 40 | 220 | 100 | 360 | 39 | 40 | 45 | 250 | 100 | 395 |
| 5 | 6 | 50 | 200 | 100 | 350 | 40 | 41 | 45 | 220 | 150 | 415 |
| 6 | 7 | 50 | 190 | 120 | 360 | 41 | 42 | 20 | 240 | 270 | 530 |
| 7 | 8 | 40 | 200 | 150 | 390 | 42 | 43 | 30 | 250 | 170 | 450 |
| 8 | 9 | 40 | 200 | 150 | 390 | 43 | 44 | 30 | 200 | 110 | 340 |
| 9 | 10 | 40 | 175 | 130 | 345 | 44 | 45 | 30 | 220 | 110 | 360 |
| 10 | 11 | 45 | 175 | 115 | 335 | 45 | 46 | 30 | 250 | 110 | 390 |
| 11 | 12 | 40 | 200 | 150 | 390 | 46 | 47 | 30 | 240 | 100 | 370 |
| 12 | 13 | 50 | 200 | 160 | 410 | 47 | 48 | 30 | 190 | 130 | 350 |
| 13 | 14 | 40 | 200 | 100 | 340 | 48 | 49 | 30 | 155 | 130 | 315 |
| 14 | 15 | 40 | 200 | 100 | 340 | 49 | 50 | 30 | 175 | 135 | 340 |
| 15 | 16 | 50 | 150 | 130 | 330 | 50 | 51 | 30 | 150 | 150 | 330 |
| 16 | 17 | 50 | 165 | 135 | 350 | 51 | 52 | 25 | 150 | 150 | 325 |
| 17 | 18 | 45 | 150 | 160 | 355 | 52 | 53 | 30 | 175 | 150 | 355 |
| 18 | 19 | 38 | 180 | 150 | 368 | 53 | 54 | 30 | 150 | 120 | 300 |
| 19 | 20 | 30 | 190 | 140 | 360 | 54 | 55 | 30 | 160 | 155 | 345 |
| 20 | 21 | 30 | 200 | 150 | 380 | 55 | 56 | 30 | 160 | 150 | 340 |
| 21 | 22 | 30 | 220 | 100 | 350 | 56 | 57 | 25 | 150 | 125 | 300 |
| 22 | 23 | 35 | 200 | 100 | 335 | 57 | 58 | 25 | 150 | 135 | 310 |
| 23 | 24 | 45 | 230 | 150 | 425 | 58 | 59 | 25 | 160 | 160 | 345 |
| 24 | 25 | 40 | 195 | 140 | 375 | 59 | 60 | 20 | 150 | 145 | 315 |
| 25 | 26 | 40 | 200 | 100 | 340 | 60 | 61 | 30 | 200 | 100 | 330 |
| 26 | 27 | 40 | 200 | 150 | 390 | 61 | 62 | 25 | 175 | 150 | 350 |
| 27 | 28 | 40 | 170 | 120 | 330 | 62 | 63 | 30 | 150 | 150 | 330 |
| 28 | 29 | - | - | - | - | 63 | 64 | 30 | 170 | 115 | 315 |
| 29 | 30 | 37 | 200 | 150 | 387 | 64 | 65 | 30 | 180 | 150 | 360 |
| 30 | 31 | 35 | 150 | 150 | 335 | 65 | 66 | 30 | 200 | 120 | 350 |
| 31 | 32 | 35 | 200 | 180 | 415 | 66 | 67 | 35 | 210 | 100 | 345 |
| 32 | 33 | 40 | 170 | 155 | 365 | 67 | 68 | 30 | 220 | 100 | 350 |
| 33 | 34 | 40 | 205 | 115 | 360 | 68 | 69 | 30 | 200 | 110 | 340 |
| 34 | 35 | 35 | 170 | 120 | 325 | 69 | 70 | 40 | 195 | 100 | 335 |

### 2.6.3 Roughness Survey

For assessment of roughness, reported in terms of unevenness index (UI), the locations identified on the carriageway were left and right wheel paths. Average of the values along left and right wheel paths were taken as the measure of unevenness index for the carriageway. Based on the IRC recommendations of roughness, the riding quality of the pavement has been determined in terms of Pavement Serviceability Rating (PSR) also.

The roughness surveys have been carried out using Bump Integrator. The calibration of the instrument has been done as per the procedure given in the World Bank's Technical Publications and duly got authenticated by CRRI. The surveys have been carried out along the left and right wheel paths. The surveys have covered a minimum of two runs along the wheel paths for each direction.

The results of the survey have been expressed in terms of UI and IRI and presented in Table 2.15. The processed data has analyzed using the cumulative difference approach to identify road segments homogenous with respect to surface roughness.

**Table 2.15: Roughness Value in IRI**

| Chainage | | Av. UI | IRI | Chainage | | Av. UI | IRI |
|---|---|---|---|---|---|---|---|
| From | To | mm/Km | m/Km | From | To | mm/Km | m/Km |
| 0 | 1 | 4250 | 3.84 | 35 | 36 | 8430 | 7.28 |
| 1 | 2 | 5460 | 4.83 | 36 | 37 | 7730 | 6.70 |
| 2 | 3 | 10240 | 8.76 | 37 | 38 | 7510 | 6.52 |
| 3 | 4 | 9390 | 8.06 | 38 | 39 | 7240 | 6.30 |
| 4 | 5 | 9730 | 8.34 | 39 | 40 | 6540 | 5.72 |
| 5 | 6 | 9830 | 8.43 | 40 | 41 | 6040 | 5.31 |
| 6 | 7 | 10330 | 8.84 | 41 | 42 | 6820 | 5.95 |
| 7 | 8 | 8020 | 6.94 | 42 | 43 | 6690 | 5.85 |
| 8 | 9 | 10800 | 9.22 | 43 | 44 | 7320 | 6.36 |
| 9 | 10 | 9010 | 7.75 | 44 | 45 | 6880 | 6.00 |
| 10 | 11 | 7720 | 6.69 | 45 | 46 | 7860 | 6.81 |
| 11 | 12 | 9070 | 7.80 | 46 | 47 | 7850 | 6.80 |
| 12 | 13 | 8010 | 6.93 | 47 | 48 | 6660 | 5.82 |
| 13 | 14 | 7020 | 6.12 | 48 | 49 | 10420 | 8.91 |
| 14 | 15 | 6980 | 6.08 | 49 | 50 | 6760 | 5.90 |
| 15 | 16 | 9780 | 8.38 | 50 | 51 | 5630 | 4.97 |
| 16 | 17 | 9370 | 8.05 | 51 | 52 | 5990 | 5.27 |
| 17 | 18 | 10030 | 8.59 | 52 | 53 | 6340 | 5.56 |
| 18 | 19 | 9860 | 8.45 | 53 | 54 | 6060 | 5.33 |
| 19 | 20 | 6350 | 5.57 | 54 | 55 | 6150 | 5.40 |
| 20 | 21 | 10100 | 8.65 | 55 | 56 | 15130 | 12.78 |
| 21 | 22 | 9950 | 8.52 | 56 | 57 | 7240 | 6.30 |
| 22 | 23 | 7960 | 6.89 | 57 | 58 | 6750 | 5.89 |
| 23 | 24 | 8200 | 7.09 | 58 | 59 | 7300 | 6.35 |
| 24 | 25 | 10950 | 9.35 | 59 | 60 | 7040 | 6.13 |
| 25 | 26 | 12020 | 10.23 | 60 | 61 | 6500 | 5.69 |
| 26 | 27 | 12070 | 10.27 | 61 | 62 | 6020 | 5.29 |
| 27 | 28 | 7880 | 6.82 | 62 | 63 | 5720 | 5.05 |
| 28 | 29 | 6710 | 5.86 | 63 | 64 | 5410 | 4.79 |
| 29 | 30 | 9200 | 7.91 | 64 | 65 | 5840 | 5.15 |
| 30 | 31 | 11740 | 9.99 | 65 | 66 | 6090 | 5.35 |
| 31 | 32 | 12680 | 10.77 | 66 | 67 | 6030 | 5.30 |
| 32 | 33 | 12130 | 10.32 | 67 | 68 | 5450 | 4.83 |
| 33 | 34 | 10970 | 9.36 | 68 | 69 | 6150 | 5.40 |
| 34 | 35 | 11010 | 9.40 | 69 | 70 | - | - |

### 2.6.4 Benkelman Beam Deflection Survey

The structural strength survey was carried out for existing pavements using Benkelman Beam Deflection technique in accordance with the CGRA procedure given in IRC: 81-1997 ("Guidelines for Strengthening of Flexible Road Pavements Using Benkelman Beam Deflection Technique"). During the course of the testing, checks of axle load and tyre pressure were made at frequent intervals. Deflection measurements were performed at 100 m interval for the total stretch covered under the study.

Details of BBD survey were presented in volume IV, Annexure to chapter 6 (6.5) of Appendices to Feasibility Report. The summary of BBD survey is presented in Table 2.16.

**Table 2.16: Characteristic Deflections**

| S. No. | Chainage | | Characteristic Deflection | S. No | Chainage | | Characteristic Deflection |
|---|---|---|---|---|---|---|---|
| | From | To | | | From | To | |
| 1 | 0 | 1 | 5.47 | 36 | 35 | 36 | 1.41 |
| 2 | 1 | 2 | 1.63 | 37 | 36 | 37 | 2.77 |
| 3 | 2 | 3 | 3.08 | 38 | 37 | 38 | 4.04 |
| 4 | 3 | 4 | 3.04 | 39 | 38 | 39 | 1.7 |
| 5 | 4 | 5 | 2.1 | 40 | 39 | 40 | 1.44 |
| 6 | 5 | 6 | 1.72 | 41 | 40 | 41 | 1.34 |
| 7 | 6 | 7 | 2.46 | 42 | 41 | 42 | 1.55 |
| 8 | 7 | 8 | 0.68 | 43 | 42 | 43 | 1.01 |
| 9 | 8 | 9 | 1.81 | 44 | 43 | 44 | 5 |
| 10 | 9 | 10 | 1.45 | 45 | 44 | 45 | 0.9 |
| 11 | 10 | 11 | 1.13 | 46 | 45 | 46 | 1.8 |
| 12 | 11 | 12 | 1.56 | 47 | 46 | 47 | 2.55 |
| 13 | 12 | 13 | 2.43 | 48 | 47 | 48 | 1.19 |
| 14 | 13 | 14 | 1.11 | 49 | 48 | 49 | 1.26 |
| 15 | 14 | 15 | 1.16 | 50 | 49 | 50 | 2.3 |
| 16 | 15 | 16 | 2.45 | 51 | 50 | 51 | 2.03 |
| 17 | 16 | 17 | 2.2 | 52 | 51 | 52 | 1.54 |
| 18 | 17 | 18 | 1.0 | 53 | 52 | 53 | 1.3 |
| 19 | 18 | 19 | 0.96 | 54 | 53 | 54 | 2.12 |
| 20 | 19 | 20 | 0.83 | 55 | 54 | 55 | 2.99 |
| 21 | 20 | 21 | 2.96 | 56 | 55 | 56 | 2.45 |
| 22 | 21 | 22 | 3.01 | 57 | 56 | 57 | 0.83 |
| 23 | 22 | 23 | 1.83 | 58 | 57 | 58 | 2.89 |
| 24 | 23 | 24 | 3.32 | 59 | 58 | 59 | 1.25 |
| 25 | 24 | 25 | 2.52 | 60 | 59 | 60 | 1.75 |
| 26 | 25 | 26 | 2.77 | 61 | 60 | 61 | 1.37 |
| 27 | 26 | 27 | 2.8 | 62 | 61 | 62 | 1.39 |
| 28 | 27 | 28 | 4.78 | 63 | 62 | 63 | 1.92 |
| 29 | 28 | 29 | NA | 64 | 63 | 64 | 1.19 |
| 30 | 29 | 30 | 2.55 | 65 | 64 | 65 | 1.19 |
| 31 | 30 | 31 | 1.58 | 66 | 65 | 66 | 1.83 |
| 32 | 31 | 32 | 4.55 | 67 | 66 | 67 | 1.23 |
| 33 | 32 | 33 | 1.62 | 68 | 67 | 68 | 1.6 |
| 34 | 33 | 34 | 2.08 | 69 | 68 | 69 | 2.19 |
| 35 | 34 | 35 | 1.24 | 70 | 69 | 70 | 2.4 |

## 2.7 ROAD SAFETY REVIEW

### 2.7.1 General

Traffic Safety is an important aspect of a road project. It is a matter of deep concern that in India, deaths in road accidents every year are more than all other types of accidental deaths taken together like drowning, industrial accidents, poisoning, fire, railway accidents and even natural calamities etc. India is a developing country and safety of roads is still in a premature stage. Not much importance is given to road safety in most of our roads.

The existing single lane to intermediate lanes has been proposed to be widened to two lanes to decongest and to provide a high-speed corridor for the movement of passenger and goods traffic. Considerations have been given to a safe design of the road components to reduce accident involving both human and vehicles. Some of the important design considerations are listed below,

i. Higher operating speed of the vehicles

ii. Road geometric components

iii. Partial access control

iv. High standards of traffic safety

v. Efficient and effective road signage schemes

vi. Appropriate road safety structures

Improved roads minimize the occurrence of accidents and reduce the accident cost. Thereby making the proposed facility more safe and user friendly to traffic.

Traffic on the Project Roads is mixed traffic comprising fast moving cars/ buses/ coaches to slow moving agricultural tractors, 3-wheelers and bi-cycles plus pedestrians and farm animals all moving along. The Project Roads have not pedestrian lane or cycle tracks to accommodate this traffic in the built up-sections.

The road geometric has been designed to provide and maintain harmony between the local community and better, faster and safer high speed State Highway.

The poor geometry of the road affects the risk and severity of the accidents. Hence appropriate design has been adopted so as to minimize the presence of sudden elements of surprise and to increase effective decision making of the road user traffic. This has been achieved by providing and improving the road safety features, road signage, partial access control, crash barriers etc.

The main causes observed for traffic accidents on the Project Road are:

i. Traffic on the road is far in excess of the capacity of a single lane road, and hence there is frustration among motor vehicle drivers about the low speeds achievable and the lack of over taking opportunities;

ii. Presence of slower vehicles incites overtaking by the faster moving vehicles and causes accidents;

iii. Undisciplined driving by the drivers in general, and the bus/coach, truck drivers in particular;

iv. Inadequate sight/stopping distances which results in accident during overtaking;

v. Present of large diameter trees next to the paved carriageway (within 1000-1500 mm) causes vehicles to hit the trees either to avoid an overtaking incoming vehicle or skidding while overtaking on curves or slippery carriageway / wet unpaved shoulder;

vi. The geometry of the existing road which has very poor sight distance;

vii. Frequent parking of breakdown vehicles within the carriageway thereby requiring overtaking and consequently accidents;

viii. Combination of horizontal and vertical curves for the two-way traffic carriageway;

ix. Lack of access control in the built up sections, resulting in traffic from connecting minor roads entering the main carriageway;

x. Non-availability of acceleration and deceleration lanes at junctions;

xi. Absence of guard beams at bridge approaches results in vehicles colliding with railings, and in some cases falling off bridges;

xii. Absence of guard beams at high embankments and sharper horizontal curves; and

xiii. Absence of proper road markings, and warning, cautionary and hazard signs.

The accident statistics of the state of Orissa, compiled by the consultant was presented in the Feasibility Report. The statistics and the results presented a gloomy picture in general and horrendous at several black spots identified by the Consultant along the project road.

### 2.7.2 Geometric Deficiencies

The overall geometry of the project road was found to be very poor. The existing Project Roads has sharp horizontal curves and insufficient vertical design standard, which do not provide adequate overtaking sight and stopping distance even for 35 kmph. Inadequate sight distance reduces the driver's perception to prepare himself for necessary maneuvers. It is therefore; very plausible that increase sight distance would reduce accidents, unless it results in increase speed. At some of the section it has an average speed of just over 20 kmph.

The existing geometric design did not have sufficient transition curves thereby making the accidents more frequent on the Project Road. The horizontal design speed did not match with vertical design speed that surprised the drivers and affected the decision making while choosing the right speed.

At Chainages 3/030, 3/700, 11/785, 14/500, 20/750, 20/900, 37/700, 54/630 and 58/275 the geometrics of the alignment are poor. All the existing bridges and culverts have insufficient carriageway width.

### 2.7.3 Road Intersections

During the road safety review, the existing poor condition of junctions was considered as one of the major contributing factor to the large prevailing numbers of accidents. Accordingly pilot surveys were conducted to assess the condition of the existing junctions.

As intersection areas normally carry heavier traffic than other highway sections as traffic approaches from both crossing roads, they become the potential black spot if not designed effectively. The conflict points at cross-junctions and T-junctions are shown in Fig 2.7.1.and Fig 2.7.2.

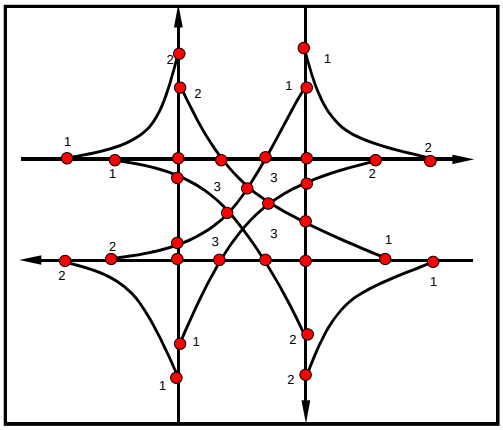


**Figure 2.7.1: Cross Junction**

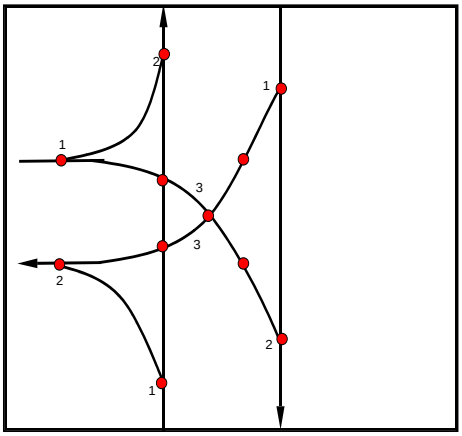


**Figure 2.7.2: T-Junction**

Though the present project road does not have any Major junctions, many minor junctions are present. The following points were observed with respect to the junctions,

i. None of the junctions along the project road had been designed as per the standards,

ii. Most of the junctions had no appropriate road markings to guide the merging as well as the main road traffic,

iii. Most of the intersections had no pedestrian crossing facility,

iv. The junction signage were absent,

v. Most of the junctions had insufficient sight distance, turning radius etc,.

vi. All the junctions are at grade junction,

The list of the minor junctions are presented below with the types of the junction,

**Table 2.17: List of Junctions**

| S. No. | Chainage | SIDE | Junction Type | Cross Road Type |
|---|---|---|---|---|
| 1 | 6/119 | RHS | T- Junction | BT Road |
| 2 | 7/428 | RHS | T- Junction | BT Road |
| 3 | 7/574 | LHS | T- Junction | BT Road |
| 4 | 8/837 | LHS | Y- Junction | BT Road |
| 5 | 12/958 | B/S | Y- Junction | BT Road |
| 6 | 18/353 | B/S | Y- Junction | BT Road |
| 7 | 18/523 | BS | Cross-Junction | BT Road |
| 8 | 21/194 | RHS | T- Junction | BT Road |
| 9 | 24/785 | RHS | Y- Junction | BT Road |
| 10 | 25/835 | B/S | Cross- Junction | BT Road |
| 11 | 26/274 | LHS | T- Junction | BT Road |
| 12 | 27/139 | RHS | T- Junction | BT Road |
| 13 | 30/600 | RHS | T- Junction | BT Road |
| 14 | 31/049 | LHS | T- Junction | BT Road |
| 15 | 36/200 | LHS | T- Junction | BT Road |
| 16 | 39/976 | LHS | Y- Junction | BT Road |
| 17 | 43/539 | LHS | T- Junction | BT Road |
| 18 | 46/854 | RHS | T- Junction | BT Road |
| 19 | 47/251 | RHS | T- Junction | BT Road |
| 20 | 50/109 | LHS | Y- Junction | BT Road |
| 21 | 53/142 | RHS | T- Junction | BT Road |
| 22 | 56/216 | LHS | T- Junction | BT Road |
| 23 | 57/068 | LHS | Y- Junction | BT Road |
| 24 | 57/160 | RHS | T- Junction | BT Road |
| 25 | 61/050 | RHS | T- Junction | BT Road |
| 26 | 61/240 | RHS | T- Junction | BT Road |
| 27 | 63/050 | RHS | Y- Junction | BT Road |
| 28 | 69/718 | LHS | T- Junction | BT Road |

### 2.7.4 Safety of Pedestrian

Due to the scattered / irregular settlements all along the proposed project road, due considerations have been given to safety of the local traffic and pedestrians in particular. The pedestrian movement in the built-up/settlements along the project road poses a major reason for the occurrence of the accidents. Access control is totally absent in the present project corridor. Some of the observations of the consultant are given below,

i. No Provision of footpath at the built up section on both sides of the Road.

ii. No road markings for the pedestrian crossing at congested intersections and market places.

iii. No signboard for speed reduction at built up sections.

iv. No access control facility.

### 2.7.5 Road Signs and Furniture

The road signs and furniture along the present project road is very poor not meeting the standards as outlined in the IRC guidelines. The Road Signs and Furniture are an important part to control and guide the flow of traffic on a road. These also reduce the occurrence of accidents as it increases the traffic safety by helping the drivers with more information for decision making.

**Road Markings**

The road markings are almost absent along the present section of the Project Road. This results in ineffective guiding of the traffic flow, hence tending to increase the road accidents. The junctions do not have any pavement markings and no traffic islands, which makes the junction a potential black spot along the corridor.

**Road Signs**

The road signs along the project road are grossly insufficient either to provide the drivers with information or to guide the drivers of the road features while driving. The drivers are often taken by surprise with sharp curves, congested built up, sudden change of speed, road humps, intersections etc.

**Road Delineators**

The presence of the road delineators is nil.

**Bus-Bays and Shelters**

The bus lay-bys along the existing project road are of very low standards. There are no proper and safe bus shelter structures provided for the passengers waiting for the bus. The bus shelter structure is not aesthetically pleasing and functional so as to protect the waiting passengers from sun, rain and wind. The current bus bays do not have any extra widening or extra lane dedicated for the buses. Thus the buses stop to drop and pick passengers on the main carriageway causing traffic disruptions and road mishaps.

**Truck Lay-Bys**

The project road does not have any truck lay byes at present. As a result the truck use the shoulder as well as the main carriageway to park their vehicles for refreshments or for washing the vehicle. In any case the carriageway capacity is reduced and affects the movement of the traffic on the road.

**Crash Barriers**

Crash barriers/high embankment protective works are almost absent along the whole of the project road. Thus making the accidents more severe and increasing the loss of life and property.

**Guard Post**

Guard Post or protective works of similar nature are mostly not provided to the bridge approaches. In such cases the accidents at such locations can be of serious nature.

### 2.7.6 Design Approach to Improve Traffic Safety Measures

The design approach followed as per the Indian Standards and with agreement with the OPWD for the two lane Project State Highways will eliminate the physical deficiencies stated here above and will significantly improve the safety of the users,

vehicles and pedestrians/ farm animals. Traffic safety measures have also been taken up extensively to improved safe passage of traffic and reduce the accident rates.

The salient features of the design approach to safety measures shall include:

i. Provision of two lane carriageway to increase the capacity of the road so as to allow more freedom to the drivers;

ii. Improvement of major and minor junction with the provision of extra lanes.

iii. Facilities to assure safe circulation of slow moving vehicles, pedestrians and farm animals:

iv. Provision of appropriate guard rails/crash barriers for high embankment;

v. To provide marker post and other safety signage at Bridge approaches;

vi. Proper road markings and traffic signage to warn the drivers as per the IRC norms;

vii. Adequate road side protective works like retaining walls, berms etc

viii. Delineators: will be provided at all bridges, high embankments, metal guard beams/ crash barriers on curves intersections and traffic islands as warranted.

ix. Bus and truck laybyes are provided along the Project Road sections;

The road safety measure has been fully inculcated in the detailed design and the various safety measures are discussed in detail in Chapter-7 “Detailed Design-Road Safety Measures, Traffic Control and Other Facilities”.

## 2.8 SURVEYING UTILITY SERVICES

Except for the vicinity of buildups and roadside establishments, the project road alignment runs through open country with predominantly agricultural land use. Hence, the project road is relatively free from the problems associated with utilities and services.

All the utility services such as electric power lines, electric poles, telephone posts and telephone lines etc. were recorded during survey.

Strip plan indicating the scheme for carriageway widening, location of all existing utility services (both over and underground) and the scheme for their relocation has been prepared separately.

## 2.9 TRAFFIC SURVEY

The traffic surveys were conducted to determine classified traffic volumes in terms of Annual Average Daily Traffic (AADT), directional split, hourly variation, trip length pattern, travel pattern of goods and passenger traffic, commodity flow and axle loads. The details of these have already been presented in Feasibility Report Chapter -7. Abstract of findings have been presented in following paragraphs.

### 2.9.1 Volume Count

Traffic Volume Count Survey was conducted at two locations; one VC-17 at km 18/700 (near Pastipada) and other VC-18 at 68/000 (near Khariar). Results are shown in Table 2.18 and Table 2.19. The table shows that Annual Average Daily Traffic (AADT) are 2323 and 2598, whereas the PCU are 3406 and 2678 respectively.

**Table 2.18: AADT and PCU**

| Count Stn. | Description | FAST MOVING VEHICLES | | | | | | | | | | | SLOW MOVING VEHICLES | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2 W | 3 W | Car/ Jeep/ Taxi | Bus | | LCV | TRUCK | | | Agri. Tractor | | Cycle | Rick-shaw | Animal DRAWN | |
| | | | | | Mini | Full | | 2-Axle | Multi-Axle | Articu-lated | With Trailer | No Trailer | | | Bullock Cart | Horse Drawn |
| VC-17 | AADT | 536 | 3 | 361 | 2 | 22 | 124 | 233 | 73 | 28 | 108 | 43 | 715 | 5 | 70 | 0 |
| | PCU | 268 | 3 | 361 | 4 | 65 | 187 | 699 | 218 | 127 | 485 | 65 | 357 | 9 | 558 | 0 |
| | % | 35.0% | 0.2% | 23.5% | 0.1% | 1.4% | 8.1% | 15.2% | 4.8% | 1.8% | 7.0% | 2.8% | 90.5% | 0.6% | 8.9% | 0.0% |
| VC-18 | AADT | 734 | 5 | 270 | 15 | 24 | 72 | 104 | 19 | 18 | 145 | 26 | 1129 | 29 | 8 | 0 |
| | PCU | 367 | 5 | 270 | 23 | 71 | 108 | 311 | 57 | 81 | 654 | 40 | 565 | 58 | 68 | 0 |
| | % | 51.3% | 0.3% | 18.9% | 1.0% | 1.7% | 5.0% | 7.3% | 1.3% | 1.3% | 10.1% | 1.8% | 96.8% | 2.5% | 0.7% | 0.0% |

**Table 2.19: Summary of AADT and PCU**

| Count Stn. | Description | Total Motorised Vehicle | Total Comm. Vehicle | Total Non Motorised Vehicle | Total Vehicle |
|---|---|---|---|---|---|
| VC-17 | AADT | 1533 | 590 | 790 | 2323 |
| | PCU | 2482 | 1785 | 924 | 3406 |
| VC-18 | AADT | 1432 | 397 | 1166 | 2598 |
| | PCU | 1987 | 1305 | 691 | 2678 |

### 2.9.2 Axle Load Survey

Axle load survey was carried out near Kharier, designated as AL-08. The axle load surveys were conducted using Portable Load Pads, developed in Indian Institute Technology, Kharagpur, having platform size 550mm X 700mm X 30mm (weight 30 kg) with digital load indicator.

The Vehicle Damage Factor (VDF) has been calculated direction wise and a higher value has been adopted for design. In light of the order passed by the Hon'ble Supreme Court of India on dated 9th November 2005 in Writ Petition (Civil) No. 136 of 2003 (Paramjit Bhasin and Others v/s Union of India), the over loading of the trucks beyond legal axle loads will be ceased in coming years. Therefore, the observed calculated values have been adopted for first five years only i.e. from 2008 to 2013. Beyond this period, the VDF values higher than 3.5 have been moderated to 3.5. Abstract of VDF is as presented in Table 2.21 and design year MSA in Table 2.22.

**Table 2.20: Design VDF**

| Station | Road Section | Recommended values of VDF for | | | | |
|---|---|---|---|---|---|---|
| | | LCV | 2-Axle Truck | | 3-Axle Truck | |
| | | | 2008-13 | 2013-28 | 2008-13 | 2013-28 |
| AL-08 | Bhawanipatna - Khariar | 0.15 | 4.57 | 3.5 | 4.39 | 3.5 |

**Table 2.21: Design MSA**

| Location | Design Year | Design MSA |
|---|---|---|
| VC-17 | 2028 | 20.51 |
| VC-18 | 2028 | 9.36 |

### 2.9.3 Projected Traffic

The traffic forecast has been made on the basis of elasticity of transport demand keeping in view present growth in registration of vehicles, economic indicators like Net State Domestic Product, Per Capita Income, Net National Domestic Product and growth in population. The projected traffic in different years is shown in Table 2.22.

**Table 2.22: Projected Traffic**

| Year | AADT | | PCU | |
|---|---|---|---|---|
| | VC-17 | VC-18 | VC-17 | VC-18 |
| 2006 | 2323 | 2598 | 3406 | 2678 |
| 2007 | 2426 | 2687 | 3592 | 2817 |
| 2008 | 2753 | 3021 | 4119 | 3222 |
| 2009 | 2920 | 3166 | 4424 | 3448 |
| 2010 | 3103 | 3324 | 4759 | 3696 |
| 2011 | 3303 | 3494 | 5128 | 3967 |
| 2012 | 3521 | 3680 | 5535 | 4264 |
| 2013 | 3759 | 3881 | 5982 | 4590 |
| 2014 | 4019 | 4101 | 6473 | 4945 |
| 2015 | 4303 | 4339 | 7014 | 5334 |
| 2016 | 4614 | 4597 | 7609 | 5760 |
| 2017 | 4953 | 4879 | 8265 | 6227 |
| 2018 | 5325 | 5184 | 8988 | 6739 |
| 2019 | 5717 | 5505 | 9755 | 7280 |
| 2020 | 6144 | 5852 | 10598 | 7871 |
| 2021 | 6611 | 6229 | 11524 | 8517 |
| 2022 | 7120 | 6638 | 12541 | 9223 |
| 2023 | 7676 | 7082 | 13659 | 9995 |
| 2024 | 8227 | 7519 | 14774 | 10761 |
| 2025 | 8824 | 7991 | 15989 | 11593 |
| 2026 | 9471 | 8499 | 17314 | 12495 |
| 2027 | 10173 | 9047 | 18759 | 13475 |
| 2028 | 10933 | 9637 | 20334 | 14538 |

# CHAPTER - 3
# DETAIL DESIGN – ROAD ALIGNMENT

# CHAPTER – 3

# DETAIL DESIGN – ROAD ALIGNMENT

## 3.1 GENERAL

The existing road is a single lane carriageway road with horizontal and vertical geometric average to poor. As detailed out in Final Feasibility, the road shall be upgraded to two lane carriageway facilities with hard shoulders on either side of the carriageway. The design philosophy that will be followed embodies the following.

i. Facility should be of State Highway standards.

ii. Facility must meet the needs for development activities in the region.

iii. Travel should be safe, with in-built engineering features.

iv. Facility should be aesthetically pleasing and should not be visually intrusive.

v. Facility should meet the environmental conditions.

While designing, improvement shall be done for widening to two lanes, horizontal and vertical geometry, road intersections, road signs, road markings, drainage system, bus bays and other road features as per requirements. Computer software have been used for plan and profile design.

## 3.2 DESIGN STANDARDS

Design Standards for the State Highway requirements have been framed for following items for providing the desirable level of service, safety and comfort to the vehicle using the facility. Design Standards given in IRC Codes, Guidelines and Special Publications besides MoSRT&H circulars and specifications as applicable to State Highways have been followed and also taking into consideration the inputs given by the OWD Officials on the local conditions. List of IRC publications referred for design is given in following Table.

**Table 3.1: List of IRC Publications**

| Ref. No. | Title of Standards |
|---|---|
| IRC:8-1980 | Type Designs for Highway Kilometre Stones (Second Revision) |
| IRC:25-1967 | Type Design for Boundary Stones |
| IRC:31-1969 | Route Marker Signs for State Routes |
| IRC:35-1997 | Code Of Practice for Road Markings (First Revision) |
| IRC:38-1988 | Guidelines for Design of Horizontal Curves for Highways and Design Tables (First Revision) |
| IRC:52-2001 | Recommendations About the Alignment Survey and Geometric Design of Hill Roads (First Revision) |
| IRC:54-1974 | Lateral and Vertical Clearance at Underpasses for Vehicular Traffic |
| IRC:64-1990 | Guidelines for Capacity of Roads in Rural Areas |
| IRC:66-1976 | Recommended Practice for Sight Distance on Rural Highways |
| IRC:67-1977 | Code Of Practice for Road Signs |
| IRC:73-1980 | Geometric Design Standard for Rural (Non-Urban) Highways |
| IRC:79-1981 | Recommended Practice for Road Delineators |
| IRC:80-1981 | Type Designs for Pick-Up Bus Stops on Rural (I.E., Non-Urban) Highways |
| IRC:99-1988 | Tentative Guidelines on the Provision of Speed Breakers for Control of Vehicles Speeds on Minor Roads |
| IRC SP:23-1983 | Vertical Curves for Highways |
| IRC SP:41-1994 | Guidelines on Design of At-Ggrade Intersections in Rural and Urban Areas |
| | Most Specifications for Roads & Bridge Works (2001) (Fourth Revision) |
| | Most Typical Designs for Intersections on National Highways |
| | Manual for Safety in Road Design |

## 3.3 GEOMETRIC DESIGN STANDARDS

For this Project Road, Geometric Design Standards as per IRC: 73-1980 “Geometric Design Standards for Rural (Non-urban) Highway” and IRC: SP-48 -1998 has been generally followed. Based on these documents, the requirements of Geometric Design Standards are given below.

The main design components are:

i. Geometric design: Alignment and Profile

ii. Cross-sectional elements

iii. Intersections

iv. Wayside amenities

v. Service Roads

To enable the design of above components, design standards adopted are given in the following paragraphs.

### 3.3.1 Terrain Classification

The classes of various terrains as IRC: 73-1980 is given below in Table 3.2. The Project Road has sections varying from Plain to rolling.

**Table 3.2: Terrain Classifications as per IRC**

| Sl no. | Terrain Classification | % Cross Slope of the Country |
|---|---|---|
| 1 | Plain | 0 to 10 |
| 2 | Rolling | 10 to 25 |
| 3 | Mountainous | 25 to 60 |
| 4 | Steep | 60 and above |

### 3.3.2 Design Speed

The Design Speed selected is the governing factor for all the geometric and road components. Based on, Table no 2 of IRC: 73-1980, Design Speed, Different sections of the Project Road have been designed with different design speed corresponding to the terrain classification.

The design speed as per Table 2 of IRC: 73-1980 for different terrain classes is given below in Table 3.3.

**Table 3.3: Design Speed for different Terrain Classes**

| Road Classification | Design Speed in kmph | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Plain Terrain | | Rolling Terrain | | Mountainous Terrain | | Steep Terrain | |
| | Ruling Design Speed | Minimum Design Speed | Ruling Design Speed | Minimum Design Speed | Ruling Design Speed | Minimum Design Speed | Ruling Design Speed | Minimum Design Speed |
| State/ National Highways | 100 | 80 | 80 | 65 | 50 | 40 | 40 | 30 |

The design speed of the project road has been adopted as per the design speeds given in Table 3.3 and the terrain classification of the project road section. But at certain sections, lower design speeds have been adopted as per record on instructions by the PIU officers. These changes have been agreed to and adopted to minimize the corridor impact of the proposed project on the social life and also to minimize the land acquisition. Attempts have been made to restrict the road design within the existing ROW in heavy built up sections.

### 3.3.3 Cross-Section Elements

The different components of cross-section adopted are as follows

**Right of Way (ROW)**

The recommended Road Land width (Right of Way) for different terrain classifications and for land use is given in Table 3.4 as per guidelines.

**Table 3.4: Recommended Road Land Width**

| Road Classification | Plain and Rolling Terrain | | | | Mountainous and steep terrain | |
|---|---|---|---|---|---|---|
| | Open areas | | Built-up areas | | Open areas | Built-up areas |
| | Normal | Range | Normal | Range | Normal | Normal |
| National & State Highways | 45 | 30-60 | 30 | 30-60 | 24 | 20 |

The existing ROW along the project road is not uniform and lesser then the IRC Recommendations. However, for improvement of junctions, relocation, realignment etc, design has been as per functional requirement. Additional land acquisition has been kept to the minimum for these areas.

Due to lesser/ limited existing ROW at certain sections and to minimize the Corridor of Impact (COI) and the land acquisition, the Consultant, World Bank Mission and the OWD together agreed upon to vary the limits set out in the IRC guidelines. Accordingly different ROW limits were adopted. With reference to the "Preparation Mission Aide Memo ire (July 4-13, 2006), Technical Aspects Para 23 – Design and Engineering Issues, for Bhawanipatna-Khariar road the ROW (absolute minimum corridor of impact, COI), in built-up areas has COI of 15m. If land needed to be acquired then such acquisition will be done up to 16m. In non built-up sections the minimum COI (Assuming an embankment height of 2m) has been taken about 22m.

**Cross-Slope**

For the project road each carriageway has a cross slope of 2.50 per cent. The paved/hard shoulder and earthen shoulder has a slope of 2.5 per cent and 3.5 per cent respectively.

**Roadway Details**

***i. Carriageway***

The Project road has been designed as a two-lane carriageway with hard shoulders. The width of two lanes has been taken as 7.0m.

***ii. Shoulder***

Hard Shoulders are provided as proposed in Final Feasibility Report and have a width of 2.5m on either side of carriageway.

***iii. Total Roadway Width***

Total roadway width has been taken as 12.00 m.

## 3.3.4 Sight Distance

Sufficient stopping distance is made available for drivers to stop their vehicles when faced with an unexpected obstruction in the carriageway. During the design of the project road, Intermediate Sight Distance that is twice the Stopping Sight Distance is taken into consideration to help the vehicles for taking over with reasonable caution. But Stopping Sight Distance has also been used at sections where the provision of the Intermediate Sight Distance does not fit in. At no section, standards lower than the safe minimum stopping sight distance has been adopted, which is given as per IRC:73-1980 as follows.

$$\text{Safe stopping minimum sight distance} = 0.278\ V.t + \frac{V^2}{254\ f}$$

Where,

V = Design speed in km/hr

t = Perception & break reaction time (taken as 2.5 sec.)

f = Co-efficient of longitudinal friction varying from 0.40 at 20 km/h
0.35 At 100 km/h

The safe stopping sight distance, overtaking sight distance as recommended in the IRC: 73-1980 is shown in Table 3.5

**Table 3.5: Minimum recommended Sight Distances**

| Speed (km/h) | Safe Stopping Sight Distance (m) | Overtaking Sight Distance (m) | Intermediate Sight Distance (m) |
|---|---|---|---|
| 100 | 180 | 640 | 360 |
| 80 | 120 | 370 | 240 |
| 65 | 90 | 340 | 180 |
| 60 | 80 | 300 | 160 |
| 50 | 60 | 235 | 120 |
| 40 | 45 | 165 | 90 |
| 30 | 30 | - | 60 |
| 20 | 20 | - | 40 |

### 3.3.5 Horizontal Alignment

Different parameters for horizontal alignment are as follows.

**Radius**

The radius of the project road section has been adopted as per the radius specified in IRC: 73-1980 Clause 9.4, for the design speed selected.

$$R = \frac{V^2}{127\,(e+f)}$$

Where,

V= vehicle speed in km/hr

e= super elevation (maximum 0.07) ratio in meter per meter.

f = co-efficient of side friction (taken as 0.15)

R= Radius in meters

Radius for some selected design speeds are given in Table 3.6.

**Table 3.6: Absolute Minimum Radius**

| Road Classification | Plain | | Rolling Terrain | | Mountainous and steep Terrain | |
|---|---|---|---|---|---|---|
| | | | Areas not affected by snow | Snow bound areas | Open areas | Built-up areas |
| | Ruling minimum | Absolute minimum | Ruling minimum | Absolute minimum | Ruling minimum | Absolute minimum |
| National & State Highways | 45 | 30-60 | 30 | 30-60 | 24 | 20 |

**Super Elevation**

As per Clause 9.3 of IRC: 7.3-1980, super elevation is given as follows.

$$e = \frac{V^2}{225\ R}$$

Where,

e = Super elevation in meter per meter

V = speed in km/h

R= radius in meters

The maximum super elevation has been kept as 7 % at plain to rolling and 10% for the mountainous sections. No super elevation has been proposed when its value obtained is less than the road camber. Radii beyond which super elevation is not proposed are given in Table 3.7, as per IRC: 73-1980.

**Table 3.7: Radius Beyond Which Super Elevation not Required**

| Design speed (km/h) | Radius (m) |
|---|---|
| 100 | 1800 |
| 80 | 1100 |
| 65 | 750 |
| 50 | 450 |
| 40 | 280 |
| 35 | 220 |
| 30 | 160 |
| 25 | 110 |
| 20 | 70 |

**Transition Curve**

Longer of the two values of minimum length of the transition curve derived from the following equations has been adopted. (Clause 9.5 of IRC: 73–1980).

$$\text{i) } Ls = \frac{0.0215\ V^3}{CR} \qquad \text{and} \qquad \text{ii) } Ls = \frac{2.7\ V^2}{R}$$

Where,

Ls = Length of transition in meters

V = speed in km/hr

R = Radius of Circular Curve in meter

C = 80 / (75+V), Subject to a maximum of 0.8 and minimum of 0.5

Minimum transition length for some radii is given in Table 17 of IRC: 73-1980.

**Extra Widening on Curves**

Extra widening on curves as per provision of IRC: 73 – 1980 section 9.8 are given in following table.

**Table 3.8: Extra Widening at Curve**

| Carriageway | Radius of Curve (m) | | | | |
|---|---|---|---|---|---|
| | Up to 20 | 21 to 40 | 41 to 60 | 61 to 100 | 101 to 300 |
| Two Lane | 1.5 | 1.5 | 1.2 | 0.9 | 0.6 |
| Single Lane | 0.9 | 0.6 | 0.6 | - | - |

Wherever the radius is less than that specified for minimum design speed, the transition curve, super elevation and pavement widening has been introduced. This will minimize the intrusion of vehicles on to adjacent lanes, tend to encourage uniformity of speed and increase vehicle speed at the curves.

## 3.3.6 Vertical Alignment

Different parameters for vertical alignment are as follows.

**Gradients**

Ruling gradient has been used as a matter of course in design. Limiting gradient has been used where the topography compels or where gentle grade would add enormously to the cost. Minimum gradient for drainage at embankment near level grades are not objectionable when the pavement has sufficient camber to drain the storm water laterally. However, in cut sections minimum gradient for drainage considerations is 0.5% if the side drains are lined and 1.0% if these are unlined.

The gradients to be maintained in the design are as per IRC: 73-1980, given in following table.

**Table 3.9: Gradients for Different Terrain**

| S.No | Terrain | Ruling gradient | Limited gradient | Exceptional gradient |
|---|---|---|---|---|
| 1 | Plain or rolling | 3.3 % (1 in 30) | 5 % (1 in 02) | 6.7 % (1 in 14.3) |
| 2 | Mountainous terrain, and steep terrain having elevation more than 3,000 m above the mean sea level | 5 % (1 in 20) | 6 % (1 in16.7) | 7 % (1 in 14.3) |
| 3 | Steep terrain up to 3,000 m height above mean sea level | 6 % (1 in16.7) | 7 % (1 in 14.3) | 8 % (1 in 12.5) |

**Vertical Curves**

Minimum length of vertical curves adopted in design are as given in following table. The actual length for the vertical curve shall however be provided as per IRC: 73–1980.

**Table 3.10: Minimum length of Vertical Curve**

| Design speed km/h | Maximum grade change not requiring a vertical curve (%) | Minimum Length of vertical curve (m) |
|---|---|---|
| 35 | 1.5 | 15 |
| 40 | 1.2 | 20 |
| 50 | 1.0 | 30 |
| 65 | 0.8 | 40 |
| 80 | 0.6 | 50 |
| 100 | 0.5 | 60 |

**Vertical Clearance**

IRC: 54 – 1978: Chapter 8: Vertical clearance at underpasses shall be at least 5 meters. However, in urban areas, this should be increased to 5.50 meters. so that double decker buses could be accommodated.

IRC: 73– 1980: 12.2.1 Vertical clearance at underpasses should be minimum 5 meters after making due allowance for any future raising/ strengthening of the underpass roadway.

### 3.3.7 Side Slopes

The side slopes of highway embankments shall be as flat as possible so that drivers accidentally leaving the roadway have better chances of survival. This has been also recommended in IRC-36, which provides a side slope of 1:4 for low embankment upto1.5m high.

For side slope of embankment, IRC: 36-1970 recommends the following slopes purely from the safety considerations.

**Table 3.11: Side Slope in Embankment**

| Embankment height | Side Slope |
|---|---|
| Up to 1.5 m | 1V : 4H |
| 1.5 m to 3.0 m | 1V : 3H |
| 3.0 m to 4.5 m | 1V: 2.5 H |
| 4.5 m to 6.0 m | 1V : 2 H |

The consultant feels that this will be very expensive and hence recommend providing a side slope of 1:2 with provisions for barriers in high embankments. The side slopes of cuttings depend on the soil type

## 3.4 DESIGN SOFTWARES

Following software have been used for the designing and drafting of road features, alignment, vertical profile etc.

- MX Road
- AutoCAD
- Autodesk Land Development Desktop

## 3.5 UTILITY SERVICES

Different types of existing utility services components e.g. Optical Fiber Cables (OFC), Electric poles, Telephone poles are to be shifted out of the proposed road way. For widening the Project Road to two-lane carriageway, all the utility service components coming in the way of the widening will require to be shifted/ relocated. Separate drawings have been prepared for utility shifting plans.

## 3.6 WAY SIDE AMENITIES

### 3.6.1 Bus-bays and Shelters

The lay out for bus bays and shelters will be in accordance with IRC: 80-1981. The bus shelter structure shall be structurally safe, aesthetically pleasing and functional so as to protect the waiting passengers from sun, rain and wind. These have been located suitably either start or end of small habitations and at both ends of large habitations. The location of bus-bays is given in drawings.

### 3.6.2 Truck Lay-bys

The provision of truck lay-bys shall be governed by site requirements and parking demand and as per the guidelines of MoSRT&H Technical Circular No. RW/34032/5/88-DO-II dated 22.8.88. Parking shall be designed in the form of a rectangular or trapezoidal area parallel and separated from the carriageway by a physical barrier. The parking lots shall have necessary facilities like repairing, eating and resting and shall be suitably landscaped. The location of truck lay-bys has been given in drawings.

## 3.7 DETAIL DRAWINGS

Plan and profile drawings has been prepared separately at scale of 1:2000 horizontal and 1:200 vertical. It shows all existing plan features, toe line of highway embankment, proposed right of way limits, drainage structure locations, existing ground profile, proposed finished profile, intersection layouts, typical cross sections of the main alignment, etc. Information has also been provided in the form of schedules for signposts, footpath barricade, signals, bus bays, truck lay bys, rumble strip location, road humps, etc. Typical layouts have been prepared for different type of road intersections.

## 3.8 CENTRE LINE MARKING

Proposed centre line has been marked on the ground at 200 m interval in straight portion and at 25m interval in curved portion. Where, proposed centre is shifting from existing centre line, the arrow showing the direction of shift and offset distance has been marked on existing centre line.

# CHAPTER 4
# PAVEMENT DESIGN

# CHAPTER 4

# PAVEMENT DESIGN

## 4.1 GENERAL

Designs for new pavement and overlays are worked out in accordance with Indian and International Practices. The design of new Flexible Pavement is carried out as per IRC: 37-2001, AASHTO Design Guide (1993), TRL Road Note-31 and Flexible overlays as per IRC: 81-1997. Generally the shoulder is structurally designed to carry 10 to 20% of the traffic load, the design lane is expected to carry. However the structural drainage system of the paved shoulder is required to be integrated with that of the carriageway pavement. The latter condition thus requires the thickness of pavement structure to be the same as that for the traffic lanes since the lower layer of the sub-base for the carriageway is extended to the full width of formation for the lateral drainage of any water percolating into the pavement. Therefore the drainage requirements demand that each carriageway pavement layer be extended to shoulder as this ensures constructional ease, quality and speed. Pavement design has been done by using all the three methods during Feasibility stage and compared all the three methods and concluded that IRC method of design is the best method of design and economical design for Indian conditions. In fact all the three methods cannot be compared as they are developed for different climatic conditions. So, it is recommended to use IRC method for Indian conditions.

## 4.2 IRC METHOD

The Flexible Pavement has been modeled as a three-layer structure. Pavement design has been based on CBR values of sub-grade soil, vehicle damage factor consequent to number of commercial vehicles on the road corridor and considering life of the project as 20 years.

## 4.3 DESIGN METHODOLOGY

For the new lane and widening, the sub grade strength has been considered for the design. Wherever the CBR was found below 4%, the CBR was considered low and the sub grade material is to be obtained from borrow areas identified. For pavement reconstruction, the reconstructed pavements were considered to be placed on existing sub grade fill. The top 250 mm of the existing sub grade is loosened and compacted and new layers are placed on the compacted sub grade. For pavement strengthening by overlay both the forecast traffic volume, the existing crusts details, surface condition of the road and rebound deflection will influence the thickness of the pavement design.

If the Differential free Swell Index (DFS) of the sub grade material is more than 50%, then sub grade and the top 500 mm of the embankment material is to be obtained from borrow areas identified (Clause 305.2.1.2 of MoRST&H). Such type of soils whose DFS is more than 50% were found in few kilometers i.e. in Km 9/0, 19/0, 37/0, 38/0, 39/0. So, it is recommended to replace the existing swelling fill material with borrow material from proposed chainage km 14/850 – 20/000 and 36/150 – 40/180.

The BBD test results are based on the elastic deflection of the pavement under the wheel loads. It again depends upon sub grade soil type, its moisture content and compaction, thickness of different pavement layers and pavement temperature. Existing pavement crust consists of thin BT surface (mostly distressed) and WBM over boulder soling.

By using simple input parameters of given sub-grade strength (CBR) and design traffic in terms of MSA, the appropriate designs could be chosen.

For the design of pavements to carry traffic in the range of 1 to 10 MSA and for traffic in the range of 10 to 150 MSA for the CBR values of sub grade ranging from 2% to 10%, the thickness design charts are given in IRC: 37-2001. The thickness deduced from the chart for the design CBR value and design traffic is the total pavement thickness to be provided and consists of granular sub base, granular base and bituminous surfacing.

### 4.3.1 Design Traffic

The intensity of repeated axle loading on a pavement over a given period of time is denoted by the cumulative number of million standard axles (MSA) during this period. As per IRC-37: 2001, the number of million standard axles for the design year is computed by the following equation.

$$N_s = \frac{365\left[(1+r)^n - 1\right]}{r} ADF$$

Where;

$N_s$ = Cumulative number of standard axles to be catered for in the design in terms of MSA.

A = Initial traffic for the design lane in terms of specified type of commercial vehicles per day;

D = Lane Distribution Factor

r = Annual growth rate of the specified types of commercial vehicles;

n = Design life in number of years;

F = Vehicle Damage Factor of the type of Commercial vehicle.

The traffic in the year of completion is estimated using the following formula.

$A = P\,(1+r)^x$

Where

P= Number of commercial vehicles as per last count.

x = Number of years between the last count and the year of completion of construction.

### 4.3.2 Design CBR

The CBR is taken at an interval of l Km along the stretch and the lower 10 percentile CBR is taken as Design CBR for the identified section. If the CBR is less than 4%, then new construction is adopted. If the CBR is more than 4% and if the deflection value is too high, reconstruction is adopted otherwise overlay is adopted.

From the field data analysis of the data collected through various surveys and investigations, the Consultant has designed the Bhawanipatna – Khariar (2/000 Km-70/000 Km) flexible pavement for new construction and Reconstruction by using IRC: 37-2001 and Overlay by using IRC: 81-1997. The designed overlay sections are converted into reconstruction and new construction due to submergence, undulations in the profile and realignment. The Flexible pavement thickness of the different sections for new construction is presented in Table 4.1; pavement thickness of the different sections for reconstruction is presented in Table 4.2.

**Table 4.1: Crust details for New Construction with borrow material for the Bhawanipatna – Khariar as per IRC method**

| KM | | Characteristic Deflection | Design Deflection | Existing Subgrade CBR | Design CBR | Design CBR adopted | Type of Construction | Remarks |
|---|---|---|---|---|---|---|---|---|
| From | To | | | | | | | |
| 2 | 3 | 3.08 | 3.06 | 8.00 | 8.00 | 6.00 | Overlay | **Overlay** |
| 3 | 4 | 3.04 | | - | | | | |
| 4 | 5 | 2.10 | | 9.50 | | | | |
| 5 | 6 | 1.72 | | - | | | | |
| 6 | 7 | 2.46 | | 8.00 | | | | |
| 7 | 8 | 0.68 | | 13.60 | | | | |
| 8 | 9 | 1.81 | | 6.2 | | | | |
| 9 | 10 | 1.45 | - | 4.50 | 3.50 | 6.00 | New Construction | **New construction is done due to DFS problem and poor CBR problem** |
| 10 | 11 | 1.13 | | 2.70 | | | | |
| 11 | 12 | 1.56 | 2.65 | 6.20 | 7.00 | 6.00 | Overlay | **Overlay** |
| 12 | 13 | 2.43 | | 15.80 | | | | |
| 13 | 14 | 1.11 | | 12.00 | | | | |
| 14 | 15 | 1.16 | | - | | | | |
| 15 | 16 | 2.45 | | - | | | | |
| 16 | 17 | 2.20 | | - | | | | |
| 17 | 18 | 1.00 | | 8.60 | | | | |
| 18 | 19 | 0.96 | - | 2.50 | 2.50 | 6.00 | New Construction | **New construction is done due to DFS problem and poor CBR problem** |
| 19 | 20 | 0.83 | 2.65 | 12.50 | 7.00 | 6.00 | Overlay | **Overlay** |
| 20 | 21 | 2.96 | | - | | | | |

| KM | | Characteristic Deflection | Design Deflection | Existing Subgrade CBR | Design CBR | Design CBR adopted | Type of Construction | Remarks |
|---|---|---|---|---|---|---|---|---|
| From | To | | | | | | | |
| 21 | 22 | 3.01 | - | 3.00 | 3.00 | 6.00 | New Construction | **New construction is done due to DFS problem and poor CBR problem** |
| 22 | 23 | 1.83 | | 3.50 | | | | |
| 23 | 24 | 3.32 | | 7.00 | | | | |
| 24 | 25 | 2.52 | | 2.90 | | | | |
| 25 | 26 | 2.77 | | 2.20 | | | | |
| 26 | 27 | 2.80 | | 2.40 | | | | |
| 27 | 28 | 4.78 | | 2.80 | | | | |
| 28 | 29 | NA | 2.45 | - | 5.00 | 6.00 | Overlay | **Overlay** |
| 29 | 30 | 2.55 | | 5.00 | | | | |
| 30 | 31 | 1.58 | | | | | | |
| 31 | 32 | 4.55 | - | 3.50 | 3.50 | 6.00 | New Construction | **New construction is done due to DFS problem and poor CBR problem** |
| 32 | 33 | 1.62 | | 4.50 | | | | |
| 33 | 34 | 2.08 | 2.49 | - | 10.00 | 6.00 | Overlay | **Overlay** |
| 34 | 35 | 1.24 | | 14.10 | | | | |
| 35 | 36 | 1.41 | | - | | | | |
| 36 | 37 | 2.77 | | - | | | | |
| 37 | 38 | 4.04 | 2.87 | 15.50 | 7.00 | 6.00 | Overlay | **Overlay** |
| 38 | 39 | 1.70 | | 9.80 | | | | |
| 39 | 40 | 1.44 | | - | | | | |
| 40 | 41 | 1.34 | | 12.80 | | | | |
| 41 | 42 | 1.55 | | 5.50 | | | | |
| 42 | 43 | 1.01 | | - | | | | |
| 43 | 44 | **5.00** | - | 11.50 | 10.00 | 6.00 | Reconstruction | |
| 44 | 45 | 0.90 | 2.52 | - | 8.00 | 6.00 | Overlay | **Overlay** |
| 45 | 46 | 1.80 | | 10.60 | | | | |
| 46 | 47 | 2.55 | | - | | | | |
| 47 | 48 | 1.19 | | - | | | | |
| 48 | 49 | 1.26 | | 15.80 | | | | |
| 49 | 50 | 2.30 | | - | | | | |
| 50 | 51 | 2.03 | | 13.00 | | | | |
| 51 | 52 | 1.54 | | 12.2 | | | | |
| 52 | 53 | 1.30 | | - | | | | |
| 53 | 54 | 2.12 | | 6.5 | | | | |
| 54 | 55 | 2.99 | | - | | | | |
| 55 | 56 | 2.45 | | 12.5 | | | | |
| 56 | 57 | 0.83 | | - | | | | |
| 57 | 58 | 2.89 | | 20.5 | | | | |
| 58 | 59 | 1.25 | | - | | | | |
| 59 | 60 | 1.75 | | 18.5 | | | | |
| 60 | 61 | 1.37 | | - | | | | |
| 61 | 62 | 1.39 | | - | | | | |
| 62 | 63 | 1.92 | | - | | | | |
| 63 | 64 | 1.19 | | 8.5 | | | | |
| 64 | 65 | 1.19 | | 6.2 | | | | |
| 65 | 66 | 1.83 | | 10.7 | | | | |
| 66 | 67 | 1.23 | | 28.2 | | | | |
| 67 | 68 | 1.60 | | - | | | | |
| 68 | 69 | 2.19 | | 14.5 | | | | |
| 69 | 70 | 2.40 | | - | | | | |

**Table 4.2: Crust details for New Construction with borrow material for the Bhawanipatna – Khariar as per IRC method**

| S.No | Chainage | | Length in Km | Thickness Design (IRC-37) Crust Details for new Construction | | | | | | | | | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Surface Course | | Base | | Sub Base | | Sub grade | Embank-ment | Total Thickness | |
| | From | To | | BC | DBM | WMM1 | WMM2 | GSB1 | GSB2 | | | | |
| 1 | 9.000 | 11.050 | 2.050 | 40 | 75 | 100 | 150 | 110 | 150 | 500 | 500 | **1625** | **DFS>50%** |
| 2 | 18.000 | 19.000 | 1.000 | 40 | 75 | 100 | 150 | 110 | 150 | 500 | 500 | **1625** | **DFS>50%** |
| 3 | 21.000 | 28.150 | 7.150 | 40 | 75 | 100 | 150 | 110 | 150 | 500 | 500 | **1625** | **DFS>50%** |
| 4 | 31.000 | 33.000 | 2.000 | 40 | 75 | 100 | 150 | 110 | 150 | 500 | 500 | **1625** | **DFS>50%** |

**Table 4.3: Crust details for New Construction with borrow CBR for the Bhawanipatna – Khariar as per IRC method**

| S.No | Chainage | | Length in Km | Thickness Design (IRC-37) Crust Details for new Construction | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Surface Course | | Base | | Sub Base | | Sub grade | Total Thickness |
| | From | To | | BC | DBM | WMM1 | WMM2 | GSB1 | GSB2 | | |
| 1 | 2.000 | 2.800 | 0.800 | 40 | 75 | 100 | 150 | 110 | 150 | 500 | **1125** |
| 2 | 3.500 | 4.200 | 0.700 | 40 | 75 | 100 | 150 | 110 | 150 | 500 | **1125** |
| 3 | 5.000 | 9.000 | 4.000 | 40 | 75 | 100 | 150 | 110 | 150 | 500 | **1125** |
| 4 | 11.600 | 13.900 | 2.300 | 40 | 75 | 100 | 150 | 110 | 150 | 500 | **1125** |
| 5 | 14.900 | 15.250 | 0.350 | 40 | 75 | 100 | 150 | 110 | 150 | 500 | **1125** |
| 6 | 15.650 | 16.100 | 0.450 | 40 | 75 | 100 | 150 | 110 | 150 | 500 | **1125** |
| 7 | 16.500 | 16.900 | 0.400 | 40 | 75 | 100 | 150 | 110 | 150 | 500 | **1125** |
| 8 | 17.350 | 18.000 | 0.650 | 40 | 75 | 100 | 150 | 110 | 150 | 500 | **1125** |
| | 19.000 | 21.000 | 2.000 | 40 | 75 | 100 | 150 | 110 | 150 | 500 | **1125** |
| 9 | 28.700 | 31.000 | 2.300 | 40 | 75 | 100 | 150 | 110 | 150 | 500 | **1125** |
| | 33.000 | 35.600 | 2.600 | 40 | 75 | 100 | 150 | 110 | 150 | 500 | **1125** |
| 10 | 36.200 | 36.400 | 0.200 | 40 | 75 | 100 | 150 | 110 | 150 | 500 | **1125** |

| S.No | Chainage | | Length in Km | Thickness Design (IRC-37) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Crust Details for new Construction | | | | | | | |
| | | | | Surface Course | | Base | | Sub Base | | Sub grade | Total Thickness |
| | From | To | | BC | DBM | WMM1 | WMM2 | GSB1 | GSB2 | | |
| 11 | 36.750 | 37.000 | 0.250 | 40 | 75 | 100 | 150 | 110 | 150 | 500 | **1125** |
| 12 | 37.450 | 39.600 | 2.150 | 40 | 50 | 100 | 150 | 110 | 150 | 500 | **1100** |
| 13 | 40.000 | 40.450 | 0.450 | 40 | 50 | 100 | 150 | 110 | 150 | 500 | **1100** |
| 14 | 40.750 | 41.000 | 0.250 | 40 | 50 | 100 | 150 | 110 | 150 | 500 | **1100** |
| 15 | 41.300 | 41.500 | 0.200 | 40 | 50 | 100 | 150 | 110 | 150 | 500 | **1100** |
| 16 | 41.700 | 43.500 | 1.800 | 40 | 50 | 100 | 150 | 110 | 150 | 500 | **1100** |
| 17 | 44.000 | 44.200 | 0.200 | 40 | 50 | 100 | 150 | 110 | 150 | 500 | **1100** |
| 18 | 44.700 | 46.500 | 1.800 | 40 | 50 | 100 | 150 | 110 | 150 | 500 | **1100** |
| 19 | 47.000 | 48.600 | 1.600 | 40 | 50 | 100 | 150 | 110 | 150 | 500 | **1100** |
| 20 | 49.200 | 49.900 | 0.700 | 40 | 50 | 100 | 150 | 110 | 150 | 500 | **1100** |
| 21 | 50.200 | 50.550 | 0.350 | 40 | 50 | 100 | 150 | 110 | 150 | 500 | **1100** |
| 22 | 50.950 | 51.950 | 1.000 | 40 | 50 | 100 | 150 | 110 | 150 | 500 | **1100** |
| 23 | 53.000 | 55.850 | 2.850 | 40 | 50 | 100 | 150 | 110 | 150 | 500 | **1100** |
| 24 | 56.100 | 57.550 | 1.450 | 40 | 50 | 100 | 150 | 110 | 150 | 500 | **1100** |
| 25 | 58.500 | 58.950 | 0.450 | 40 | 50 | 100 | 150 | 110 | 150 | 500 | **1100** |
| 26 | 59.600 | 60.700 | 1.100 | 40 | 50 | 100 | 150 | 110 | 150 | 500 | **1100** |
| 27 | 61.100 | 62.000 | 0.900 | 40 | 50 | 100 | 150 | 110 | 150 | 500 | **1100** |
| 29 | 62.250 | 64.950 | 2.700 | 40 | 50 | 100 | 150 | 110 | 150 | 500 | **1100** |
| 30 | 65.450 | 67.250 | 1.800 | 40 | 50 | 100 | 150 | 110 | 150 | 500 | **1100** |
| 31 | 67.450 | 70.000 | 2.550 | 40 | 50 | 100 | 150 | 110 | 150 | 500 | **1100** |

## Table 4.4: Crust details for Reconstruction / Widening for the Bhawanipatna – Khariar as per IRC method

| S.No | Chainage | | Length in Km | Thickness Design (IRC-37) | | | | | | | | | | | | | Total Thickness |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Crust Details for Reconstruction | | | | | | Crust Details for Widening | | | | | | | |
| | | | | Surface Course | | Base | | Sub Base | Total Thickness | Surface Course | | Base | | Sub Base | | Sub grade | |
| | From | To | | BC | DBM | WMM1 | WMM2 | GSB | | BC | DBM | WMM1 | WMM2 | GSB1 | GSB2 | | |
| 1 | 2.800 | 3.500 | 0.700 | 40 | 75 | 100 | 150 | 260 | **625** | 40 | 75 | 100 | 150 | 110 | 150 | 500 | **1125** |
| 2 | 4.200 | 5.000 | 0.800 | 40 | 75 | 100 | 150 | 260 | **625** | 40 | 75 | 100 | 150 | 110 | 150 | 500 | **1125** |
| 3 | 11.050 | 11.600 | 0.550 | 40 | 75 | 100 | 150 | 260 | **625** | 40 | 75 | 100 | 150 | 110 | 150 | 500 | **1125** |
| 4 | 13.900 | 14.900 | 1.000 | 40 | 75 | 100 | 150 | 260 | **625** | 40 | 75 | 100 | 150 | 110 | 150 | 500 | **1125** |
| 5 | 15.250 | 15.650 | 0.400 | 40 | 75 | 100 | 150 | 260 | **625** | 40 | 75 | 100 | 150 | 110 | 150 | 500 | **1125** |
| 6 | 16.100 | 16.500 | 0.400 | 40 | 75 | 100 | 150 | 260 | **625** | 40 | 75 | 100 | 150 | 110 | 150 | 500 | **1125** |
| 7 | 16.900 | 17.350 | 0.450 | 40 | 75 | 100 | 150 | 260 | **625** | 40 | 75 | 100 | 150 | 110 | 150 | 500 | **1125** |
| 8 | 28.150 | 28.700 | 0.550 | 40 | 75 | 100 | 150 | 260 | **625** | 40 | 75 | 100 | 150 | 110 | 150 | 500 | **1125** |
| 9 | 35.600 | 36.200 | 0.600 | 40 | 75 | 100 | 150 | 260 | **625** | 40 | 75 | 100 | 150 | 110 | 150 | 500 | **1125** |
| 10 | 36.400 | 36.750 | 0.350 | 40 | 75 | 100 | 150 | 260 | **625** | 40 | 75 | 100 | 150 | 110 | 150 | 500 | **1125** |
| 11 | 37.000 | 37.450 | 0.450 | 40 | 50 | 100 | 150 | 260 | **600** | 40 | 50 | 100 | 150 | 110 | 150 | 500 | **1100** |
| 12 | 39.600 | 40.000 | 0.400 | 40 | 50 | 100 | 150 | 260 | **600** | 40 | 50 | 100 | 150 | 110 | 150 | 500 | **1100** |
| 13 | 40.450 | 40.750 | 0.300 | 40 | 50 | 100 | 150 | 260 | **600** | 40 | 50 | 100 | 150 | 110 | 150 | 500 | **1100** |
| 14 | 41.000 | 41.300 | 0.300 | 40 | 50 | 100 | 150 | 260 | **600** | 40 | 50 | 100 | 150 | 110 | 150 | 500 | **1100** |
| 15 | 41.500 | 41.700 | 0.200 | 40 | 50 | 100 | 150 | 260 | **600** | 40 | 50 | 100 | 150 | 110 | 150 | 500 | **1100** |
| 16 | 43.500 | 44.000 | 0.500 | 40 | 50 | 100 | 150 | 260 | **600** | 40 | 50 | 100 | 150 | 110 | 150 | 500 | **1100** |
| 17 | 44.200 | 44.700 | 0.500 | 40 | 50 | 100 | 150 | 260 | **600** | 40 | 50 | 100 | 150 | 110 | 150 | 500 | **1100** |
| 18 | 46.500 | 47.000 | 0.500 | 40 | 50 | 100 | 150 | 260 | **600** | 40 | 50 | 100 | 150 | 110 | 150 | 500 | **1100** |
| 19 | 48.600 | 49.200 | 0.600 | 40 | 50 | 100 | 150 | 260 | **600** | 40 | 50 | 100 | 150 | 110 | 150 | 500 | **1100** |
| 20 | 49.900 | 50.200 | 0.300 | 40 | 50 | 100 | 150 | 260 | **600** | 40 | 50 | 100 | 150 | 110 | 150 | 500 | **1100** |
| 21 | 50.550 | 50.950 | 0.400 | 40 | 50 | 100 | 150 | 260 | **600** | 40 | 50 | 100 | 150 | 110 | 150 | 500 | **1100** |
| 22 | 51.950 | 53.000 | 1.050 | 40 | 50 | 100 | 150 | 260 | **600** | 40 | 50 | 100 | 150 | 110 | 150 | 500 | **1100** |
| 23 | 55.850 | 56.100 | 0.250 | 40 | 50 | 100 | 150 | 260 | **600** | 40 | 50 | 100 | 150 | 110 | 150 | 500 | **1100** |
| 24 | 57.550 | 58.500 | 0.950 | 40 | 50 | 100 | 150 | 260 | **600** | 40 | 50 | 100 | 150 | 110 | 150 | 500 | **1100** |
| 25 | 58.950 | 59.600 | 0.650 | 40 | 50 | 100 | 150 | 260 | **600** | 40 | 50 | 100 | 150 | 110 | 150 | 500 | **1100** |

| S.No | Chainage | | Length in Km | Thickness Design (IRC-37) | | | | | | | | | | | | | Total Thickness |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Crust Details for Reconstruction | | | | | | Crust Details for Widening | | | | | | | |
| | | | | Surface Course | | Base | | Sub Base | Total Thickness | Surface Course | | Base | | Sub Base | | Sub grade | |
| | From | To | | BC | DBM | WMM1 | WMM2 | GSB | | BC | DBM | WMM1 | WMM2 | GSB1 | GSB2 | | |
| 26 | 60.700 | 61.100 | 0.400 | 40 | 50 | 100 | 150 | 260 | **600** | 40 | 50 | 100 | 150 | 110 | 150 | 500 | **1100** |
| 27 | 62.000 | 62.250 | 0.250 | 40 | 50 | 100 | 150 | 260 | **600** | 40 | 50 | 100 | 150 | 110 | 150 | 500 | **1100** |
| 28 | 64.950 | 65.450 | 0.500 | 40 | 50 | 100 | 150 | 260 | **600** | 40 | 50 | 100 | 150 | 110 | 150 | 500 | **1100** |
| 29 | 67.250 | 67.450 | 0.200 | 40 | 50 | 100 | 150 | 260 | **600** | 40 | 50 | 100 | 150 | 110 | 150 | 500 | **1100** |

# CHAPTER – 5
# DRAINAGE SYSTEM AND PROTECTION WORKS

# CHAPTER – 5

# DRAINAGE SYSTEM AND PROTECTION WORKS

## 5.1 GENERAL

The road drainage is an important aspect for the durability and integrity of the structural strength of the pavement. An effective and an efficient drainage system is a primary requirement for a Road Project. A poor drainage system reduces the life and serviceability of the road. This aspect of road can be referred as the most neglected in the detailed design either due to the lack of engineering experience or due to lack of funds. The roadside drain can be divided in to types,

### 5.1.1 Surface Drainage

Surface water drain off is to remove the water from carriageway, shoulders or footpath by providing sufficient cross slope. The cross slope is fixed in order to achieve a balance between effective runoff without compromising the comfort and safety of the road users.

### 5.1.2 Sub-Surface Drainage

The sub-soil drainage represents the drainage of the water trapped in the subgrade, which may be due to percolation or infiltration of water from the pavement, shoulder, verges and also from the adjoining standing water through capillary action. It is important to drain off such water as it damages the road crust causing failure of the pavement by various reasons such as striping of bitumen, subgrade weakening etc.

The proper planning and provision of roadside drains and its effect on the overall cost of the project is minimal considering the overall benefits and pavement durability. Thus the roadside drainage schemes needs to be studied and provided as improve and capitalize the benefits of the Project under consideration.

## 5.2 EXISTING SCENARIO

The present project road section of SH-16 from Bhawanipatna (km 2.00) to Khariar (km 70.00) has no proper defined longitudinal drain. As Orissa receives an annual average rainfall of 1400-1500 mm, the drainage plan needs proper planning and maintenance. The built up sections (urban settlement section) is affected the most due to the water draining into the households. There is no functional roadside drain at any section of the Project Road. At present the surface water is being drained out directly to the adjoining land.

## 5.3 DETAILED DESIGN

During the detailed investigation and design of the road components, the Consultant assessed the requirement of the roadside drains. The design of the roadside longitudinal drains was done on the basis of the guidelines outlined in IRC SP: 42-1994 and IRC SP: 50-1999. The cross sectional requirements of the drains with respect to hydraulic sufficiency, bed slope, drain types and construction techniques.

The roadside drain shall be provided as per the following,

i. An effective drainage system for drainage of road shall be designed as per stipulations of IRC SP: 42-1994 and IRC SP: 50-1999.

ii. The road side channel will be trapezoidal/ rectangular of adequate capacity to carry 100% surface runoff of drainage area of highway ROW and will be drained to the nearest available natural water course.

iii. We propose to adopt trapezoidal section as it is more efficient and economical. This will be kuchha to drain out in the open field or to the defined outfall points. Lined rectangular drain will be adopted in urban areas.

iv. The superstructure shall be drained with suitable drainage spouts and by means of a combination of drainage spouts and longitudinal drain supported from the superstructure and discharging through vertical drainpipes at pier locations.

v. Suitable profiles of channels and pipe runs shall be provided at crossing with service needs and utilities to ensure that conflicts do not occur.

Accordingly to the requirements varying from location to location, two types of drains has been proposed for the present Project road. The two types of the drains are given below,

i. RCC Box covered drains for the Built-up Sections

ii. Unlined open trapezoidal drains for the rural sections.

### 5.3.1 RCC Box Covered Drains for Built-up Sections

The RCC box covered drains of 1.5 m width and 1.05 m depth shall be provided on both side of the road in the built up sections identified and presented in Table 5.1. The covered drains are to be used as footpath for the pedestrian movement.

**Table 5.1: List of Built-up Sections**

| Sl.No | Name of the Village | From | To | Length (m) | LHS/RHS |
|---|---|---|---|---|---|
| 1 | PASTIPADA | 14900 | 15200 | 300.00 | BOTH |
| 2 | KARLAPADA | 20350 | 21010 | 660.00 | BOTH |
| 3 | TURKEL | 27050 | 27200 | 150.00 | BOTH |
| 4 | KURUSUD | 43150 | 44000 | 850.00 | BOTH |
| 5 | KURUSUD | 44600 | 44900 | 300.00 | BOTH |
| 6 | GANDHARLA | 50000 | 50300 | 300.00 | BOTH |
| 7 | DOHELPADA | 56900 | 57300 | 400.00 | BOTH |
| 8 | TUKULA | 60700 | 61800 | 1100.00 | BOTH |
| 9 | LACHHIPUR | 65650 | 66000 | 350.00 | BOTH |
| | **Total Length = 4410 x 2 = 8820 m** | | | | |

The typical cross section is presented below in Fig. 5.1 and Fig. 5.2. The details of the cross-section have been presented in Standard Drawings volume.

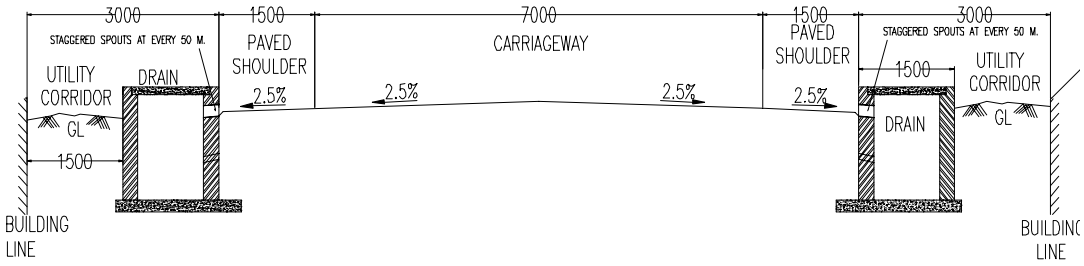



**Figure. 5.1: Road Section at Built-up location**

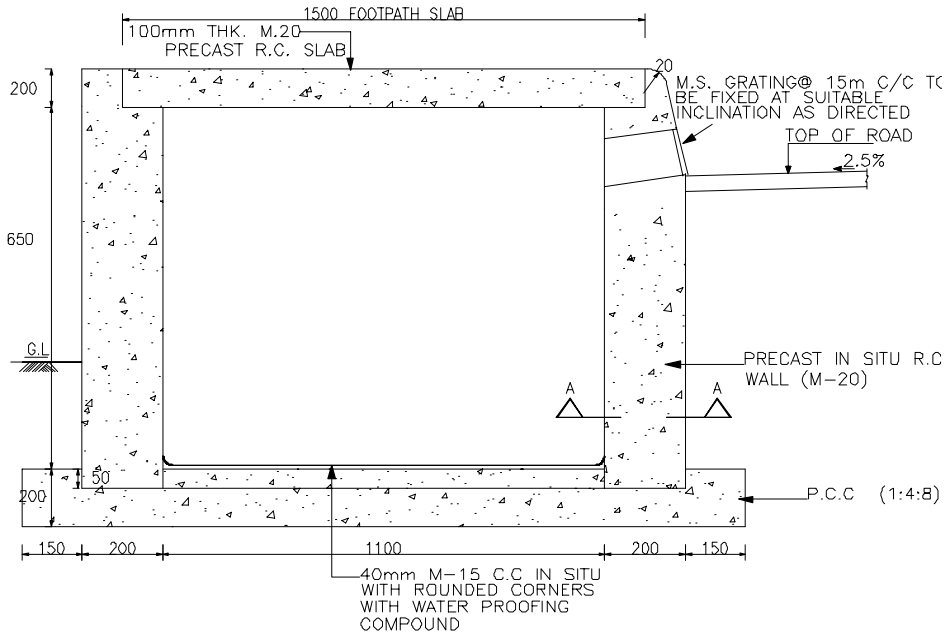



**Figure. 5.2: Detailed Urban Drain Section.**

## 5.3.2 Unlined Open Trapezoidal Drains for Rural Sections.

Open trapezoidal drains are proposed to be provided along both side of the highway to drain off the water to the nearest culvert locations or natural existing streams/nallas. The cross section details of the rural drain are presented in Fig. 5.3 and Fig 5.4 below.

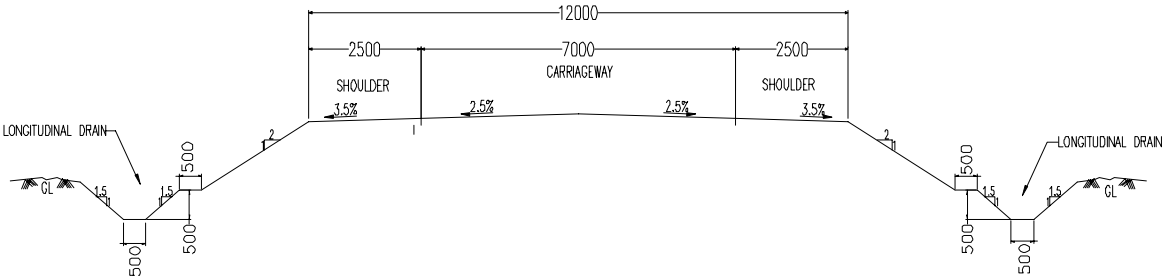



**Figure. 5.3: Road Section at Rural location**

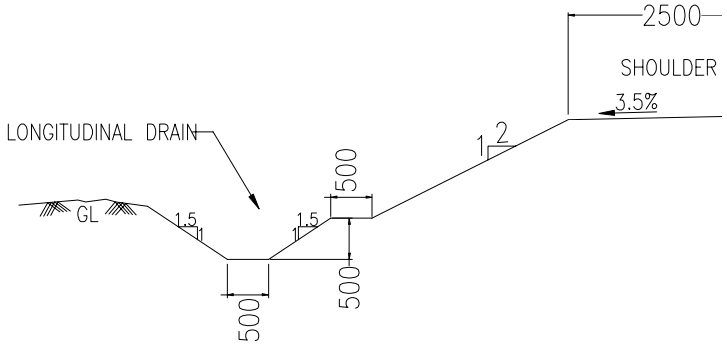



**Figure. 5.4: Detailed Rural Drain Section.**

## 5.4 DRAINAGE ON HIGH EMBANKMENT

Drainage on high embankment needs care and judicious considerations. The water from the carriageway and shoulder if let down directly on the high embankment slopes will damage the slopes severely with the formation of water cuts and will ultimately result in the failure of the slope. Chute drains and drain water collection piths shall be provided as per the guidelines detailed in IRC SP: 50-1999.

The surface runoff may be collected in collection piths and shall be drained through chute drains provided at suitable interval of 10m to 15m. The chute drains shall be lined with cement concrete.

The side slopes shall be protected with grass turfing in open areas for embankments more than 3m height. The slope protection on high embankments near approaches of bridges has been protected with stone pitching for a height upto HFL plus free board.

## 5.5 LONGITUDINAL GRADIENT

The type of the drain, construction material and the properties of the soil present in the section will govern the longitudinal gradient of the roadside drains. Taking into account these factors a minimum longitudinal gradient of 0.3% is considered satisfactory as per the IRC guidelines.

# CHAPTER – 6
# DETAIL DESIGN OF STRUCTURES

# CHAPTER – 6

# DETAIL DESIGN OF STRUCTURES

## 6.1 GENERAL

The different types of structures present are - Major Bridges, Minor Bridges and Culverts. Structures, which are structurally in poor condition or submersible, have been replaced with the new bridges. Detailed hydrological calculations have been done to determine the waterway of proposed new bridges. Details of Hydrology have been presented in separate report.

Geo-technical investigations were carried out for all the proposed bridges. The depth of foundation has been decided as per the results of the geo-technical investigations carried out and as per the hydrological investigations. Details of Geo-technical investigations are given in separate report.

The IRC codes given below have been referred for detail design of structures.

**Table 6.1: List of IRC Codes**

| | |
|---|---|
| IRC:5-1998 | Standard Specification & Code of practice for Road Bridges.<br>Section – I General Features of Design (Seventh Revision) |
| IRC: 6-2000 | Standard Specification & Code of practice for Road Bridges.<br>Section – II Loads & Stresses (Fourth Revision) |
| IRC: 18-2000 | Design Criteria for Prestressed Concrete Road Bridges (Post- Tensioned Concrete) (Third Revision ) |
| IRC: 21-2000 | Standard Specification & Code of practice for Road Bridges.<br>Section – III Cement Concrete Plain & Reinforced (Second Revision) |
| IRC: 22-1986 | Standard Specification & Code of practice for Road Bridges.<br>Section – VI Composite Construction (First Revision) |
| IRC: 24-2001 | Standard Specification & Code of practice for Road Bridges.<br>Section – V Steel Road Bridges (Second Revision) |
| IRC:45-1972 | Recommendations for Estimating the Resistance of soil below the maximum Scour Level in the Design of Well Foundations of Bridges. |
| IRC:73-1980 | Geometric Design standards for Rural (Non-Urban) Highways. |
| IRC:78-1983 | Standard Specification & Code of practice for Road Bridges.<br>Section – VII Foundation & Substructure (First Revision) |
| IRC: 83-1999 | Standard Specification & Code of practice for Road Bridges.<br>Section – IX Bearings, Part-I Metallic Bearings (First Revision) |
| IRC: 83-1987 | Standard Specification & Code of practice for Road Bridges.<br>Section – IX Bearings, Part-II Elastomeric Bearings |
| IRC: 83-2002 | Standard Specification & Code of practice for Road Bridges.<br>Section – IX Bearings, Part-III POT, POT-CUM-PTTE, PIN & Metallic guide bearings. |
| IRC: 89-1997 | Guidelines for Design & Construction of River training & control works for road bridges. |
| IRC:SP:13-2004 | Guidelines for the Design of small Bridges and Culverts |
| IRC: SP:33-1989 | Guidelines on supplemental Measures for Design, Detailing & Durability of Important Bridge Structures. |
| IRC: SP:35-1990 | Guidelines for inspection and maintenance of Bridges |
| IRC: SP:37-1991 | Guidelines for evaluation of load carrying capacity of Bridges. |
| IRC: SP:40-1993 | Guidelines on Techniques for strengthening and rehabilitation of Bridges. |

## 6.2 PROPOSED BRIDGES

Presently there are 21 bridges. Their location and existing span arrangements are as indicated in Table 6.1. The bridges at location 27/600, 27/850, 28/400 and 59/100 are major and remaining are minor bridges.

Tel River is the widest on this stretch. In addition to high-level major bridge on main stream, five bridges are also there in the approaches of Tel river, among which three are on Bhawanipatna side and two are on Khariar side. During recent flood on 2nd July 2006, the water level raised to upto 215.100m and all the five bridges overtopped. HFL data were provided by OWD. Detail hydraulic investigations have been carried out and presented in separate report. The revised waterway for these bridges has been provided as per hydraulic requirements. The deck level also has been raised to meet the requirements of recent flood. These bridges have been recommended for reconstruction to provide new waterway and raised deck levels.

Other submersible bridges at location 8/600, 10/500 and 21/000 have also been proposed for reconstruction with increased waterway and raised deck levels as per hydraulic requirements.

Bridges at location 13/750, 17/120, 45/700, 63/650 and 66/500 are in poor condition and being replaced. The bridges at location 54/600 and 58/900 are under realignment and will be constructed at new locations.

The details of proposed major and minor bridges are as follows.

**Table 6.2: Proposed Bridges**

| S. No. | Location/ Chainage | Design Chainage | Existing Span Arrangement | Proposed Span Arrangement | Carriageway Width (m) | Overall Width of Bridge (m) | Remarks |
|---|---|---|---|---|---|---|---|
| 1 | 3/050 | 3061.48 | 3 x 8.8 | - | - | - | Good, Rehabilitation required |
| 2 | 4/450 | 4418.87 | 4 x 9.9 | - | - | - | Good, Rehabilitation required |
| 3 | 8/600 | 8595.56 | 1 x 7.3 | 1 x 8.0 RCC Box | 11.0 | 12.0 | New bridge, existing submersible |
| 4 | 10/500 | 10532.99 | 1 x 7.4 | 1 x 8.0 RCC Box | 11.0 | 12.0 | New bridge, existing submersible |
| 5 | 13/750 | 13756.22 | 2 x 7.2 | 1 x 14.6 RCC T-beam | 11.0 | 12.0 | New bridge, existing in poor condition |
| 6 | 17/120 | 17042.05 | 1 x 7.55 | 1 x 8.0 RCC Box | 11.0 | 12.0 | New bridge, existing in poor condition |
| 7 | 21/000 | 20973.11 | (3 x 0.6)+ (7x1.2) | 1 x 12.6 RCC T-beam | 11.0 | 12.0 | New bridge, existing submersible |
| 8 | 27/600 | 27618.40 | 7 x 9.2 | - | - | - | Raising required, existing submersible |
| 9 | 27/800 | 27820.00 | 10 x 1.2 | 8 x 32.2 PSC Girder | 11.0 | 12.0 | New bridge, existing submersible |
| 10 | 27/850 | | 9 x 9.2 | | | | |
| 11 | 28/400 | 28193.00 | (2x9.9)+ (1x24.37)+ (1x34.9)+ (10x40.85) | - | - | - | Good, Nothing to do |
| 12 | 28/900 | 28910.00 | 4 x 9.2 | - | - | - | Raising required, existing submersible |
| 13 | 29/400 | 29211.50 | 2 x 9.2 | ( 2 x 9.2 ) + ( 2 x 9.2 ) solid slab (Additional spans on each side of the existing bridge ) | 7.5 | 12.0 | Raising with additional vent way required, existing submersible |
| 14 | 45/700 | 45988.71 | 1 x 6.2 | 1 x 8.0 RCC Box | 11.0 | 12.0 | New bridge, existing in poor condition |
| 15 | 54/600 | 54776.00 | 3 x 8.5 | 3 x 10.8 RCC Slab | 11.0 | 12.0 | New bridge, existing in realignment |
| 16 | 58/900 | 58750.00 | 3 x 6.8 | 1 x 21.6 RCC T-beam | 11.0 | 12.0 | New bridge, existing in realignment |
| 17 | 59/100 | 58954.51 | (7 x 32.7)+ (1x7.6) | - | - | - | Minor Touchup repair |
| 18 | 59/400 | 59508.50 | 5 x 4.0 | - | - | - | Good, Rehabilitation required |

| S. No. | Location/ Chainage | Design Chainage | Existing Span Arrangement | Proposed Span Arrangement | Carriageway Width (m) | Overall Width of Bridge (m) | Remarks |
|---|---|---|---|---|---|---|---|
| 19 | 63/650 | 63329.47 | 1 x 6.6 | 1 x 8.0 RCC Box | 11.0 | 12.0 | New bridge, existing in poor condition |
| 20 | 66/500 | 66133.94 | 1 x 6.4 | 1 x 8.0 RCC Box | 11.0 | 12.0 | New bridge, existing in poor condition |
| 21 | 69/300 | 69003.49 | 1 x 7.2 | - | - | - | Rehabilitation required |

## 6.3 WIDTH

In reference to clause 112 of IRC:5-1998, width of proposed minor bridges have been kept equal to the formation width which is 12.0m. In built-up areas, raised footpath of 1.5m widths shall be provided on both sides for minor bridges keeping total width as 12m. The carriageway for these bridges shall be 7.5m. All major bridges have been proposed for 2-lane carriageway with footpath making a total width of 12.0m.

## 6.4 DESIGN PHILOSOPHY

The superstructure for RCC T-beam and PSC-I girder bridges has been designed based on Grillage Analysis using STAAD.Pro-2006 Software. Moving live loads were applied to determine the critical load combinations. Output of the STAAD has been used for further detailed design using standard Excel Spreadsheets. End cross-girders have been designed for bearing replacement condition supported on Jacks. Slab bridges have been designed for unit width by taking dispersion of live loads as per IRC:21-2000. The different components of Substructure and foundation have been designed for the loads coming from super structure & other loads using Excel Spreadsheets.

## 6.5 DESIGN LOADS

Following loads has been considered for design.

### 6.5.1 Dead Loads

Unit weight of different construction materials shall be taken as per IRC:6-2000. The weights of basic materials are as follows:

| | |
|---|---|
| Cement Concrete – Plain | 2.2 t/m2 |
| Cement Concrete – Reinforced | 2.4 t/m2 |
| Cement Concrete – Prestressed | 2.5 t/m2 |
| Coursed Rubble Masonry | 2.6 t/m2 |
| Compacted Earth | 1.8 t/m2 |

### 6.5.2 Live Loads

The carriageway width of proposed minor bridges is 11.0m. Hence these have been designed for three lane loading. The carriageway width of proposed major bridges is 7.5m and has been designed for two lane loading. Design live loads for different class

of loadings and combination of live loads, impact factors, longitudinal forces, centrifugal forces for bridges on curves, etc. have been taken as per IRC:6-2000. The combination of different classes of live loads is as follows.

i. Minor Bridges:

- IRC class 70R tracked vehicle + IRC class-A one lane
- IRC class 70R wheeled vehicle + IRC class-A one lane
- IRC class-A three lanes

ii. Major Bridges:

- IRC class 70R tracked vehicle
- IRC class 70R wheeled vehicle
- IRC class-A two lanes

### 6.5.3 Water current forces

HFL, velocity of flow, scour depth has been taken as per past data received and hydraulic calculations. The water current forces on substructure and foundation have been calculated as per IRC:6-2000.

On piers parallel to the direction of water current, the intensity of pressure is given by following equation.

$p = 52 K V^2$

Where, p = intensity of pressure in kg/m2

K = a constant, value depends on shape of pier

V= velocity of current at point where pressure intensity is to be determined in m/s. (which is zero at the point of deepest scour and sqrt(2) times maximum mean velocity at the free surface).

### 6.5.4 Buoyancy forces

Full buoyancy (100%) has been considered for checking the stability of foundations. For checking stresses of the substructure components, 15% pore pressure uplift is considered in the design.

### 6.5.5 Earth pressure

Lateral forces due to earth pressure for the design of abutments and retaining walls have been calculated as per IRC:6-2000. Properties of backfill material are adopted as per IRC:78-2000, Appendix-6.

Live load surcharge equivalent height of 1.2m for abutments and 0.6m for return/wing walls has also been considered.

## 6.6 MATERIAL SPECIFICATIONS

Detail specifications for material shall be given separately in bidding document. However, general design requirements adopted in detail designs are as follows.

### 6.6.1 Concrete

In accordance with IRC: 21-2000 Table -5, following minimum grade of concrete has been used for moderate and severe conditions of exposure for different components:

| Member | PSC/ Major Bridges | Other Minor Bridges & Culverts |
|---|---|---|
| **Moderate Conditions of Exposure** | | |
| PCC Members | M 25 | M 15 |
| RCC Members | M 30 | M 20 |
| PSC Members | M 35 | - |
| **Severe Conditions of Exposure** | | |
| PCC Members | M 30 | M 20 |
| RCC Members | M 35 | M 25 |
| PSC Members | M 40 | - |

### 6.6.2 Reinforcement Steel

The grade of steel reinforcement Fe 415 for HYSD bars and Fe 240 for Mild Steel bars used in design.

### 6.6.3 Pre-stressing Cables

The pre-stressing cables shall be 12T13 or 19K13 type. Strands of 12.7 mm nominal dia 7 ply low relaxation confirming to IS:14268-95 shall be used. Multipull strand system of “Freyssinet” or “ISMAL CCL” or equivalent shall be used.

### 6.6.4 Bearings

Tarpaper bearing has been provided for RCC solid slab superstructure of minor bridges upto 11m span. Elastomeric bearings have been provided for other type of simply supported superstructures and slab super structures exceeding 11 m span. These bearings have been designed as per IRC: 83 (Part-II)-1987.

POT fixed / POT PTFE sliding bearing has been proposed for long span simply supported super structures. Design loads’ coming on the bearings has been provided to enable the manufacturer to design and supply.

### 6.6.5 Expansion joints

In accordance MORTH specification for road and bridge works – clause No. 2600 for solid slab super structures up to 10 m span, the “Filler Type Expansion Joints” (20mm. thick joint filler) has been provided.

“Single Strip Seal Expansion Joints” has been provided for superstructures with movement upto 80 mm (+/- 40 mm)

“Modular Strip Seal Expansion Joints” has been provided for superstructures with movement exceeding 80 mm (+/- 40 mm)

### 6.6.6 Wearing Course

Wearing course shall consist of 50 mm thick asphaltic concrete (two layers of 25 mm each) over a coat of mastic asphalt, 6 mm thick.

## 6.7 DETAIL DESIGN

Detailed structural analysis and designs for the new structures have been presented in the Detailed Project Report (DPR) in separate volume.

## 6.8 PROPOSED CULVERTS

There exist slab culverts, pipe culverts and vented causeway. A detailed inventory and condition survey was made and the results have been presented in Chapter-02. Culverts in good condition and adequate size, which meets the requirements of plan and profile in respect of highway geometry and levels have been retained. These have been widened to make full formation width if narrow. The culverts, which need replacement due to poor condition or inadequate size, have already been indicated in Chapter-02. The culverts, which cannot be used due to change in horizontal alignment or change in vertical alignment, also need replacement along new alignment. A list of proposed culverts is given below.

## Table 6.3: Proposed Culverts

| S. No. | Location/ Chainage | Design Chainage | Existing Span Arrangement | Type of Existing Culvert | Proposed Span Arrangement | Type of Proposed Culvert | Remarks |
|---|---|---|---|---|---|---|---|
| 1 | 3/450 | 3683 | 1 x 1.0 | Slab | 2 x 1.0 | Pipe | Reconstruction due to poor condition |
| 2 | 4/100 | 4112 | 1 x 0.6 | Pipe | 1 x 1.0 | Pipe | **Replaced due to insufficient vent, to be used for Environmental purpose** |
| 3 | 5/450 | 5494 | 1 x 0.6 | Pipe | 1 x 1.0 | Pipe | Replaced due to insufficient vent |
| 4 | 5/650 | 5691 | 1 x 1.2 | Stone Slab | 1/34/0 | RCC Box | Stone slab culvert, to be replaced |
| **5** | **5/800** | **5800** | - | - | **1/22/0** | **RCC Box** | **Additional structure** |
| 6 | 6/550 | 6533 | 2 x 1.0 | Pipe | 1/34/0 | RCC Box | Replaced due to poor conditon |
| 7 | 6/900 | 6935 | 1 x 2.4 | Slab | 1/45/0 | RCC Box | Replaced due to raise in road level |
| 8 | 7/015 | 7030 | 1 x 0.6 | Pipe | 1 x 1.0 | Pipe | Replaced due to insufficient vent |
| 9 | 7/800 | 7815 | 1 x 0.3 | Stone Slab | 1/22/0 | RCC Box | Stone slab culvert, to be replaced |
| 10 | 9/450 | 9474 | 1 x 0.9 | Slab | 1/34/0 | RCC Box | Replaced due to poor condition |
| 11 | 10/100 | 10109 | 1 x 0.6 | Pipe | 1/23/0 | RCC Box | Replaced due to insufficient vent |
| 12 | 10/150 | 10147 | 2 x 1.0 | Pipe | 1/23/0 | RCC Box | Replaced due to poor condition |
| 13 | 10/700 | 10698 | 1 x 0.6 | Pipe | 1 x 1.0 | Pipe | Replaced due to insufficient vent |
| 14 | 10/750 | 10744 | 1 x 1.9 | Slab | 1/34/0 | RCC Box | Reconstruction due to poor condition |
| **15** | **11/650** | **11700** | - | - | **1 x 1.0** | **Pipe** | **Additional structure** |
| 16 | 12/600 | 12599 | 1 x 0.6 | Pipe | 1 x 1.0 | Pipe | Replaced due to insufficient vent |
| 17 | 12/700 | 12687 | 1 x 1.8 | Slab | 1/23/0 | RCC Box | Replaced due to raise in road level |
| 18 | 12/750 | 12746 | 1 x 0.6 | Pipe | 1 x 1.0 | Pipe | Replaced due to insufficient vent |
| 19 | 12/800 | 12826 | 1 x 0.6 | Pipe | 1 x 1.0 | Pipe | Replaced due to insufficient vent |
| 20 | 13/300 | 13341 | 1 x 1.0 | Pipe | - | - | To be widened |
| 21 | 14/050 | 14055 | 1 x 0.9 | Slab | 1/22/0 | RCC Box | Replaced due to raise in road level |
| 22 | 14/400 | 14372 | 2 x 0.9 | Vented Causeway | 1/23/0 | RCC Box | Vented causeway, to be replaced |
| 23 | 14/800 | 14799 | 3 x 1.0 | Pipe | 1/22/0 | RCC Box | Reconstruction due to poor condition |
| 24 | 15/005 | 14990 | 1 x 0.6 | Pipe | 1 x 1.0 | Pipe | Replaced due to insufficient vent |
| 25 | 15/250 | 15191 | 1 x 0.9 | Vented Causeway | 1 x 1.0 | Pipe | Vented causeway, to be replaced |
| 26 | 15/600 | 15574 | 1 x 0.6 | Pipe | 1/22/0 | RCC Box | Replaced due to insufficient vent |

| S. No. | Location/ Chainage | Design Chainage | Existing Span Arrangement | Type of Existing Culvert | Proposed Span Arrangement | Type of Proposed Culvert | Remarks |
|---|---|---|---|---|---|---|---|
| 27 | 15/850 | 15830 | 2 x 0.9 | Vented Causeway | 1/45/0 | RCC Box | Vented causeway, to be replaced |
| 28 | 16/050 | 16002 | 1 x 0.6 | Pipe | 2 x 1.0 | Pipe | Replaced due to insufficient vent |
| 29 | 17/500 | 17509 | 3 x 0.9 | Vented Causeway | 1/45/0 | RCC Box | Vented causeway, to be replaced |
| 30 | 18/100 | 18047 | 2 x 0.9 | Vented Causeway | 2 x 1.0 | Pipe | Vented causeway to be replaced |
| 31 | 18/850 | 18831 | 1 x 3.0 | Arch | 1/34/0 | RCC Box | **Arch culvert to be replaced, to be used for Environmental purpose** |
| 32 | 19/700 | 19661 | 1 x 0.75 | Pipe | 1 x 1.0 | Pipe | Replaced due to insufficient vent |
| 33 | 20/150 | 20112 | 5 x 1.0 | Pipe | 1/43/0 | RCC Box | Replaced due to insufficient vent |
| 34 | 20/400 | 20337 | 5 x 1.0 | Pipe | 1/43/0 | RCC Box | Replaced due to insufficient vent |
| 35 | 21/650 | 21607 | 2 x 0.9 | Vented Causeway | 2 x 1.0 | Pipe | Vented causeway, to be replaced |
| 36 | 22/150 | 22135 | 2 x 0.9 | Vented Causeway | 1/23/0 | RCC Box | **Vented causeway to be replaced, to be used for Environmental purpose** |
| 37 | 22/350 | 22380 | 2 x 0.9 | Vented Causeway | 2 x 1.0 | Pipe | Vented causeway to be replaced |
| 38 | 23/100 | 23061 | 2 x 0.9 | Vented Causeway | 1/23/0 | RCC Box | Vented causeway to be replaced |
| 39 | 23/250 | 23200 | 1 x 1.0 | Pipe | 1 x 1.0 | Pipe | Replaced due to raise in road level |
| 40 | 23/350 | 23321 | 2 x 0.9 | Vented Causeway | 1/34/0 | RCC Box | Vented causeway to be replaced |
| 41 | 23/650 | 23538 | 2 x 0.9 | Vented Causeway | 2 x 1.0 | Pipe | Vented causeway to be replaced |
| 42 | 24/100 | 24062 | 1 x 0.6 | Pipe | 1 x 1.0 | Pipe | Replaced due to insufficient vent |
| 43 | 24/450 | 24402 | 3 x 1.2 | Pipe | - | - | To be widened |
| 44 | 24/550 | 24513 | 3 x 0.9 | Vented Causeway | 2 x 1.0 | Pipe | Vented causeway to be replaced |
| 45 | 25/750 | 25723 | 2 x 0.9 | Vented Causeway | 2 x 1.0 | Pipe | Vented causeway to be replaced |
| 46 | 26/750 | 26695 | 2 x 0.9 | Vented Causeway | 2 x 1.0 | Pipe | Vented causeway to be replaced |
| 47 | 27/100 | 27045 | 1 x 0.6 | Pipe | 1 x 1.0 | Pipe | Reconstruction due to poor condition |
| 48 | 27/250 | 27175 | 1 x 0.6 | Pipe | 1 x 1.0 | Pipe | Replaced due to insufficient vent |
| 49 | 30/850 | 30830 | 1 x 1.5 | Slab | 1/23/0 | RCC Box | Reconstruction due to poor condition |
| 50 | 31/250 | 31300 | 1 x 1.5 | Slab | 1/23/0 | RCC Box | Reconstruction due to poor condition |
| 51 | 32/050 | 32044 | 1 x 1.5 | Slab | 1/23/0 | RCC Box | Replaced due to raise in road level |
| 52 | 33/200 | 33238 | 1 x 3.0 | Slab | 1/23/0 | RCC Box | Replaced due to raise in road level |
| **53** | **33/800** | **33800** | - | - | **1/23/0** | **RCC Box** | **Additional structure** |

| S. No. | Location/ Chainage | Design Chainage | Existing Span Arrangement | Type of Existing Culvert | Proposed Span Arrangement | Type of Proposed Culvert | Remarks |
|---|---|---|---|---|---|---|---|
| 54 | 34/700 | 34732 | 1 x 1.5 | Slab | 2 x 1.0 | Pipe | Replaced due to Submergence |
| **55** | **35/985** | **36050** | - | - | **1/22/0** | **RCC Box** | **Additional structure** |
| 56 | 36/900 | 36961 | 1 x 1.5 | Slab | 1/33/0 | RCC Box | Replaced due to Submergence |
| 57 | 37/100 | 37214 | 1 x 1.5 | Slab | 1/34/0 | RCC Box | Replaced due to Submergence |
| 58 | 37/400 | 37563 | 1 x 1.5 | Slab | 1/23/0 | RCC Box | Replaced due to Submergence |
| 59 | 38/400 | 38383 | 1 x 1.5 | Slab | 1/23/0 | RCC Box | Replaced due to Submergence |
| **60** | **39/100** | **39150** | - | - | **2 x 1.0** | **Pipe** | **Additional structure** |
| 61 | 40/100 | 40089 | 1 x 1.5 | Slab | 1/23/0 | RCC Box | Replaced due to Submergence |
| 62 | 40/950 | 41037 | 1 x 1.5 | Slab | 1/22/0 | RCC Box | Replaced due to raise in road level |
| 63 | 41/300 | 41409 | 1 x 1.5 | Slab | 1/23/0 | RCC Box | Reconstruction due to poor condition |
| 64 | 41/700 | 41789 | 1 x 1.5 | Slab | 1/45/0 | RCC Box | Replaced due to raise in road level |
| 65 | 42/200 | 42320 | 1 x 1.5 | Slab | 1/34/0 | RCC Box | Replaced due to raise in road level |
| 66 | 42/550 | 42635 | 1 x 0.45 | Pipe | 1 x 1.0 | Pipe | Reconstruction due to poor condition |
| 67 | 43/100 | 43159 | 1 x 3.0 | Slab | 1/33/0 | RCC Box | Reconstruction due to poor condition |
| 68 | 44/150 | 44261 | 1 x 1.5 | Slab | 1/22/0 | RCC Box | Replaced due to raise in road level |
| 69 | 44/850 | 44954 | 1 x 3.0 | Slab | 1/34/0 | RCC Box | Reconstruction due to poor condition |
| 70 | 45/150 | 45296 | 1 x 0.6 | Pipe | 1 x 1.0 | Pipe | Replaced due to insufficient vent |
| 71 | 45/600 | 45711 | 1 x 0.6 | Pipe | 1/23/0 | RCC Box | Reconstruction due to poor condition |
| 72 | 45/850 | 46047 | 1 x 4.5 | Slab | 1/63/0 | RCC Box | Replaced due to raise in road level |
| **73** | **46/200** | **46325** | - | - | **2 x 1.0** | **Pipe** | **Additional structure** |
| 74 | 46/350 | 46514 | 1 x 1.5 | Slab | 1/22/0 | RCC Box | Replaced due to raise in road level |
| 75 | 47/050 | 47165 | 1 x 1.5 | Slab | 1/22/0 | RCC Box | Replaced due to raise in road level |
| 76 | 47/200 | 47322 | 1 x 1.5 | Slab | 1 x 1.0 | Pipe | Reconstruction due to poor condition |
| 77 | 49/600 | 49726 | 1 x 1.5 | Slab | 1/23/0 | RCC Box | Replaced due to raise in road level |
| 78 | 50/150 | 50287 | 1 x 1.5 | Slab | 1/44/0 | RCC Box | Replaced due to raise in road level |
| 79 | 50/300 | 50499 | 1 x 1.5 | Slab | 1/23/0 | RCC Box | Reconstruction due to poor condition |
| 80 | 51/025 | 51174 | 1 x 0.6 | Pipe | 1 x 1.0 | Pipe | Replaced due to insufficient vent |
| 81 | 51/250 | 51409 | 1 x 0.9 | Pipe | 2 x 1.0 | Pipe | Replaced due to |

| S. No. | Location/ Chainage | Design Chainage | Existing Span Arrangement | Type of Existing Culvert | Proposed Span Arrangement | Type of Proposed Culvert | Remarks |
|---|---|---|---|---|---|---|---|
| | | | | | | | insufficient vent |
| 82 | 51/400 | 51580 | 1 x 0.9 | Pipe | 2 x 1.0 | Pipe | Replaced due to insufficient vent |
| 83 | 51/600 | 51760 | 2 x 0.9 | Pipe | 1/34/0 | RCC Box | Replaced due to raise in road level |
| 84 | 51/900 | 52068 | 1 x 0.6 | Pipe | 1 x 1.0 | Pipe | Reconstruction due to poor condition |
| 85 | 52/100 | 52296 | 1 x 0.6 | Pipe | 2 x 1.0 | Pipe | Reconstruction due to poor condition |
| 86 | 52/250 | 52424 | 1 x 0.9 | Pipe | 1 x 1.0 | Pipe | Reconstruction due to poor condition |
| 87 | 52/700 | 52844 | 4 x 0.9 | Pipe | - | - | To be widened |
| 88 | 53/500 | 53679 | 1 x 0.9 | Pipe | 1 x 1.0 | Pipe | Replaced due to insufficient vent |
| 89 | 53/950 | 54148 | 1 x 1.4 | Slab | 1/23/0 | RCC Box | Replaced due to raise in road level |
| 90 | 54/350 | 54606 | 1 x 1.3 | Slab | 1/44/0 | RCC Box | **Replaced due to raise in road level, to be used for Environmental purpose** |
| 91 | 55/250 | 55420 | 1 x 1.5 | Slab | 1 x 1.0 | Pipe | Replaced due to Submergence |
| 92 | 56/100 | 56270 | 1 x 5.0 | Slab | 1/64/0 | RCC Box | Reconstruction due to poor condition |
| **93** | **56/200** | **56390** | - | - | **1/22/0** | **RCC Box** | **Additional structure** |
| 94 | 56/400 | 56587 | 1 x 0.9 | Pipe | - | - | To be widened |
| **95** | **56/950** | **57150** | - | - | **2 x 1.0** | **Pipe** | **Additional structure** |
| 96 | 57/150 | 57321 | 1 x 0.9 | Pipe | 1 x 1.0 | Pipe | Reconstruction due to poor condition |
| 97 | 57/500 | 57360 | 1 x 0.6 | Pipe | 1 x 1.0 | Pipe | Replaced due to insufficient vent |
| 98 | 57/900 | 57664 | 1 x 0.45 | Skew Pipe | 1 x 1.0 | Pipe | Reconstruction due to poor condition |
| 99 | 59/850 | 59625 | 1 x 0.45 | Pipe | 1 x 1.0 | Pipe | Reconstruction due to poor condition |
| 100 | 60/100 | 59915 | 1 x 3.0 | Slab | 1/33/0 | RCC Box | Replaced due to raise in road level |
| 101 | 60/750 | 60567 | 1 x 1.5 | Slab | 1/34/0 | RCC Box | Replaced due to raise in road level |
| 102 | 61/550 | 61373 | 1 x 1.5 | Slab | 1/23/0 | RCC Box | Reconstruction due to poor condition |
| 103 | 62/250 | 62100 | 1 x 3.0 | Slab | 1/33/0 | RCC Box | Reconstruction due to poor condition |
| 104 | 62/900 | 62962 | 1 x 0.6 | Pipe | 1 x 1.0 | Pipe | Replaced due to insufficient vent |
| 105 | 63/200 | 63300 | 1 x 1.5 | Slab | 1/23/0 | RCC Box | Replaced due to raise in road level |
| 106 | 63/550 | 63298 | 1 x 6.2 | Slab | 1/63/0 | RCC Box | Reconstruction due to poor condition |
| 107 | 63/900 | 63700 | 1 x 1.5 | Slab | 1 x 1.0 | Pipe | Replaced due to raise in road level |

| S. No. | Location/ Chainage | Design Chainage | Existing Span Arrangement | Type of Existing Culvert | Proposed Span Arrangement | Type of Proposed Culvert | Remarks |
|---|---|---|---|---|---|---|---|
| 108 | 64/600 | 64622 | 1 x 0.6 | Pipe | 1 x 1.0 | Pipe | Replaced due to insufficient vent |
| 109 | 64/825 | 64891 | 1 x 0.6 | Pipe | 1 x 1.0 | Pipe | **Replaced due to insufficient vent, to be used for Environmental purpose** |
| 110 | 65/100 | 65122 | 1 x 0.6 | Pipe | 1 x 1.0 | Pipe | Replaced due to insufficient vent |
| 111 | 65/350 | 65430 | 1 x 1.5 | Slab | 1 x 1.0 | Pipe | Replaced due to raise in road level |
| 112 | 65/675 | 65624 | 1 x 1.5 | Slab | 1/23/0 | RCC Box | Reconstruction due to poor condition |
| 113 | 65/900 | 66027 | 1 x 1.5 | Slab | 1/22/0 | RCC Box | Reconstruction due to poor condition |
| 114 | 66/200 | 66161 | 1 x 0.9 | Pipe | 1/23/0 | RCC Box | Replaced due to insufficient vent |
| **115** | **66/430** | **66500** | - | - | **1/23/0** | **RCC Box** | **Additional structure** |
| 116 | 67/300 | 67100 | 1 x 0.6 | Pipe | 1/22/0 | RCC Box | Replaced due to raise in road level |
| 117 | 67/550 | 67325 | 1 x 0.9 | Pipe | 1 x 1.0 | Pipe | Replaced due to insufficient vent |
| 118 | 67/850 | 67620 | 1 x 0.9 | Pipe | 1/23/0 | RCC Box | **Replaced due to raise in road level, to be used for Environmental purpose** |
| 119 | 68/200 | 68010 | 1 x 0.6 | Pipe | 1/23/0 | RCC Box | Replaced due to insufficient vent |
| 120 | 68/700 | 68445 | 1 x 1.5 | Slab | 1/22/0 | RCC Box | Replaced due to raise in road level |

**Table 6.4: Summary of Existing Culverts**

| Type of Culvert | Nos. |
|---|---|
| Culverts Retained | |
| Culverts Widened | |
| Pipe extension | 4 |
| Slab widening | |
| Culverts Replaced | |
| New Single Pipe | 33 |
| New Double Pipe | 13 |
| New Single Box of 1/22/0 | 11 |
| New Single Box of 1/23/0 | 24 |
| New Single Box of 1/33/0 | 4 |
| New Single Box of 1/34/0 | 11 |
| New Single Box of 1/43/0 | 2 |
| New Single Box of 1/44/0 | 2 |
| New Single Box of 1/45/0 | 4 |
| New Single Box of 1/63/0 | 2 |
| New Single Box of 1/64/0 | 1 |
| Additional Culverts proposed | |

| Type of Culvert | Nos. |
|---|---|
| Single Pipe | 1 |
| Double Pipe | 3 |
| Single Cell Box of 1/22/0 | 3 |
| Single Cell Box of 1/23/0 | 2 |
| **Total** | **120** |

## 6.9 REHABILITATION OF STRUCTURES

A detailed inspection was made for repair and rehabilitation measures including replacement / retaining of existing bridges. The structures that are in distressed condition (reinforcement exposed & rusted, cracks in the structure, concrete falls by light hammering) have been suggested for Non destructive testing. NDT has been conducted at 6 Nos of bridges in the stretch and NDT report along with recommendations has been submitted to PIU. The rehabilitation proposals for the different structures are as detailed under.

**Table 6.4: Rehabilitation of Minor Bridges**

| S.No. | Location Km | Span Arrangement | General Condition | Recommendation |
|---|---|---|---|---|
| 1 | 3+050 | 3 x 8.8 | Good | i. Bed Protection to be redone, old abutment to be dismantled causing obstruction in flow, toe wall to be reconstructed<br>ii. Filler type expansion joint to be provided<br>iii. Both edges of deck slab to be gunited by 25 mm thick<br>iv. Touch up repair in cement concrete wearing coat. |
| 2 | 4+450 | 4 x 9.9 | Good | i. Existing expansion joint to be replaced by filler type<br>ii. Wearing coat to be replaced completely<br>iii. Guard posts to be replaced by crash barrier |
| 3 | 59+100 | (7 x 32.7) + (1 x 7.6) | Good | i. Single strip seal expansion joint to be provided at one location of pier<br>ii. RCC wearing coat of size 8 x 3.5 m shall be reconstructed |
| 4 | 59+400 | 5 x 4.0 (Box Cell) | Good | i. Bed protection shall be provided<br>ii. Minor repair to be done in railings<br>iii. Edge of kerb shall be gunited by |

| | | | | |
|---|---|---|---|---|
| | | | | 40 mm thick<br>iv. Grouting of all faces of walls of five cell box shall be done<br>v. Wing walls shall be constructed on all four sides<br>vi. Approach slab to be provided on both sides. |
| 5 | 69+300 | 1 x 7.2 | Good | i. Grouting to be done for entire slab with polymer modified cementious material<br>ii. Guniting followed by 40 mm th CC to be done for slab<br>iii. Pitching and toe walls shall be provided on all sides of the existing bridge |

# CHAPTER 7
# ROAD SAFETY MEASURES

# CHAPTER 7

# ROAD SAFETY MEASURES

## 7.1 GENERAL

Highways form an important lifeline for the movement of goods and passengers from one place to another, from a place of raw material to production and to the distribution end. Provision of traffic safety measures on highways gains significance with each year as the number of vehicles and traffic volume increases, hence the accident rates also increases. The road accident data reveals that one person is killed after every third road accident and one person is injured after every accident. Although pedestrians and cyclists are most vulnerable to road accidents but data are silent on these groups. Generally the findings on the basis of available accident data indicate that it is driver's behavior, which is mainly responsible for most of accidents, but it is not fair to ignore the technical aspects of road and traffic regulatory measures.

For higher traffic safety it is highly important to incorporate practical safety standards into the highway facilities at the design stage or during improvement and maintenance activities. The design and the safety measures should meet the expectations of the driver and guarantee from unexpected changes in the road conditions which might lead to a traffic accident.

Keeping into account the traffic safety drawbacks on the existing facility during the "Road Safety Review", traffic safety measures has been taken as a major criterion for the detailed design of the Project Highway and its features to provide a safe and a speedy road.

## 7.2 ROAD SAFETY MEASURES

To increase the traffic safety and to reduce traffic accidents, every component of the Highways and its users has been given equal importance. The road safety measures have been incorporated for the headers detailed below,

i. The Road Geometric Components
ii. Road Pavement Condition
iii. Road Junctions
iv. Road Furniture
v. Highway Policing and Emergency Response

### 7.2.1 The Road Geometric Components

The road geometric components have been designed to meet the State Highway standards as specified in the IRC: 73-1980 "Geometric Design Standard for Rural (Non-urban) Highways" guidelines. The design has been done to match horizontal alignment and vertical grades as to eliminate elements of surprise to the drivers as discussed. Overtaking sight distances have been provided to increase safe overtaking opportunities and to reduce accidents. At heavy built up / village sections speed limits have been reduced to 50 kmph to 65 kmph considering the heavy pedestrian and local

traffic movement by posting appropriate signs. In open uninhabited areas where the existing alignment is safe enough to maintain a speed of 80 Kph, the design speed of 100 Kph has been adopted with minor changes to the alignment.

Superelevation is applied according to IRC guidelines with respect to the proposed centreline and the rate of introduction is kept more than the minimum of 1 in 150 as specified by IRC. For a curve without transition, two thirds of the Superelevation is achieved before the start of the circular curve in the straight part, 1/3rd of the Superelevation is achieved in the circular curve portion.

The provision of paved shoulders provides additional space for overtaking, slow moving and non-motorised traffic and for parking in the built up section. A wide cross-section (7.0 m carriageway + 1.5 m paved shoulder) has been used in to increase safety, by allowing separation of slower traffic, which can travel on the relatively wide paved shoulder, rather than completely in the main carriageway, which is now the case. This manner further helps to reduce accidents and increase road capacity.

All the narrow bridges (less than 7.5m carriageway) are proposed for development to minimum of 7.5m carriageway.

All the narrow culverts are proposed for development to full formation width i.e, 12.0 m.

### 7.2.2 Road Pavement Condition

The road pavement condition that influences the traffic safety includes evenness and grittiness of pavement surfaces, as these qualities influence the friction and skid resistance, which the pavement can offer in contact with the tire. This is a very important aspect for the braking distance. Poor antiskid performances increase the number of accidents. Therefore pavement condition shall be maintained so as to achieve acceptable serviceability indicators Level-2 of the road in accordance with the "Guidelines for Maintenance Management of Primary, Secondary and Urban Roads" of MoRST&H, 2004.

**Table 7.1: Serviceability Criteria**

| Sl No | Serviceability Index | Level-2 (Average) |
|---|---|---|
| 1 | Roughness by Bump Integrator (Max Permissible) | 3000 mm/km |
| 2 | Potholes/km (Max Numbers) | 2-3. |
| 3 | Cracking and Patch Repair (Max Permissible) | 10 per cent |
| 4 | Rutting (20 mm) ((Max Permissible) | 1.5 per cent |
| 5 | Skid Resistance | 40 SN |
| 6 | Defective bridge deck area and bump at Approaches (Max Permissible) | 10 per cent |
| 7 | User Information | Only major road signs, km stones, Some road markings in good condition |

### 7.2.3 Road Junctions

As discussed in para 2.7.3 Chapter-2, Traffic Safety Review, junctions if not improved to meet the design standards can become potential accident zones along the present project road. The Consultant has identified 28 minor junctions along the

project road, as shown in Table 7.2, which are required to be improved. The entire crossroads are BT roads. The junctions shall be developed as per the IRC guidelines and standard junction drawing presented in Drawing Volume separately.

**Table 7.2: List of Junctions**

| S. No. | Chainage | SIDE | Junction Type | Cross Road Type |
|---|---|---|---|---|
| 1 | 6/120 | RHS | T- Junction | BT Road |
| 2 | 7/428 | RHS | Y- Junction | BT Road |
| 3 | 7/574 | LHS | T- Junction | BT Road |
| 4 | 8/837 | LHS | Y- Junction | BT Road |
| 5 | 12/958 | BOTH | X- Junction | BT Road |
| 6 | 18/353 | BOTH | X- Junction | BT Road |
| 7 | 18/523 | BOTH | X-Junction | BT Road |
| 8 | 21/194 | RHS | T- Junction | BT Road |
| 9 | 24/785 | BOTH | X- Junction | BT Road |
| 10 | 25/835 | BOTH | X- Junction | BT Road |
| 11 | 26/275 | LHS | T- Junction | BT Road |
| 12 | 27/139 | RHS | T- Junction | BT Road |
| 13 | 30/600 | BOTH | X- Junction | BT Road |
| 14 | 31/050 | BOTH | X- Junction | BT Road |
| 15 | 36/200 | BOTH | X- Junction | BT Road |
| 16 | 39/976 | LHS | Y- Junction | BT Road |
| 17 | 43/539 | BOTH | X- Junction | BT Road |
| 18 | 46/854 | BOTH | X- Junction | BT Road |
| 19 | 47/252 | BOTH | X- Junction | BT Road |
| 20 | 50/110 | LHS | Y- Junction | BT Road |
| 21 | 53/142 | RHS | T- Junction | BT Road |
| 22 | 56/217 | LHS | T- Junction | BT Road |
| 23 | 57/068 | LHS | Y- Junction | BT Road |
| 24 | 57/161 | BOTH | X- Junction | BT Road |
| 25 | 60/918 | BOTH | X- Junction | BT Road |
| 26 | 69/419 | LHS | T- Junctions | BT Road |

**Safety at Junction**

The safety of a particular intersection design is best assured by studying the frequency with which types of accidents occur at particular type of intersection and its correlation with volume and types of traffic. Intersection improvement can be prioritised based on a simple equation as per IRC: SP-41 1994. The equation relates the accident frequency with traffic volume. The equation is given below,

$$C = \frac{A}{(Qq)^{0.5}}$$

A=No of accidents a year, Q=Traffic volume on Project road

q=Traffic volume on intersecting road (1000 veh per day)

The improved junctions shall be provided with standard road pavement markings, acceleration and deceleration lanes, adequate signboards etc.

**Widths of Median Island**

A minimum width of 1.2m has been adopted where median islands are introduced in the absence of a continuous median. Minimum lengths of median islands are 20 m and maximum lengths are based on site requirements.

**Channelising Islands**

Channelising islands have been provided depending on the volume of turning traffic and the importance of the road. The minimum area of these islands is 4.5 sq.m. At all intersections a minimum 0.3 to 0.6m island offset from normal vehicle paths is provided. The island shapes have been designed to ensure wheel path turning diagrams of design vehicles can negotiate the curves safely and clear of the islands.

**Kerbs**

Kerbs at central and channelling islands are of the semi-barrier type in all project designed intersections.

**Cross slope at Intersection**

Maximum cross slope of 0.5% is maintained to drain off surface water effectively from carriageway. The longitudinal gradient of not more than 0.5% at intersection and not steeper than 1.0% (1in100) shall be achieved beyond intersection for a distance of 100m on cross road or minor arm intersecting with project road at major or minor intersections.

**Traffic Control Devices**

For both major and minor road intersections, the use of traffic control devices and other road furniture has been considered. The common types of traffic control devices, which are used to reduce accidents and improve flow conditions at junctions, are road markings, road signs and safety railings. These are as per IRC standards and specifications mentioned below:

i. IRC: 35-1997 (Code of Practice for Road Markings)
ii. IRC: 67-1977 (Code of Practice for Road Signs)
iii. IRC: 79-1981 (Recommended Practice for Road Delineators)
iv. IRC: 103-1988 (Guidelines for Pedestrian Facilities)

### 7.2.4 Road Furniture

Road Furniture details includes:

i. Road Markings
ii. Traffic Sign (Cautionary, Mandatory and Informatory)
iii. Kilometer Stones
iv. 200m Stones and Boundary Stones
v. Delineators and Object Markers

vi. Bus Bays
vii. Truck Lay Byes
viii. Guard Posts
ix. Crash Barriers
x. Road Humps & Rumble Strips
xi. Footpath Barriers
xii. Reflective Pavement Markers (RPM)
xiii. Chevron Signs Boards

The Standard Drawing and location schedule of different road furniture are presented in drawing volumes separately.

**Road Markings**

Road markings perform the important function of guiding and controlling traffic on a highway. The markings serve as psychological barriers and signify the delineation of traffic paths and their lateral clearance from traffic hazards for safe movement of traffic. Road markings are therefore essential to ensure smooth and orderly flow of traffic and to promote road safety. The Code of Practice for Road Markings, IRC: 35-1997 has been used in the study as the design basis. Schedules of Road Markings are included in contract drawings.

The following road markings are provided:

| | |
|---|---|
| **Longitudinal markings** | : Center Line |
| | : Edge Lines |
| | : Traffic Lines |
| | : Width Transition |
| | : Obstructions Ahead |
| **Intersections** | : Stop Lines |
| | : Word “STOP” |
| | : Pedestrian Crossing |
| | : Approach to Intersection |
| | : Direction Arrows |
| | : Continuity Lines |
| | : Traffic island |
| **Parking** | : Bus Stop |
| | : Emergency Parking |

The road marking material will be hot applied thermoplastic reflective as per Clause 803 of MoSRTH Specifications.

**Traffic Sign (Cautionary, Mandatory and Informatory)**

Cautionary, mandatory and informatory signs are provided depending on the situation and function they perform in accordance with the IRC: 67-1997 guidelines for Road Signs. The different types of road signs are categorized and provided are:

i. Mandatory / Regulatory
ii. Cautionary / Warning
iii. Directional
iv. Hazard Markers
v. Informatory

The Code of Practice for Road Signs, IRC: 67-1997, is followed for sizes, configuration, colour and location of all road signs and the Clause 801 of MoSRTH Specifications for their construction. Retro-reflectorised type, which is made of high intensity, encapsulated lens types reflective sheeting fixed over aluminium sheeting for a better visibility at night and road users safety.

The signs should be placed at right angles to the line of travel of the approaching traffic. Signs relating to parking of vehicles during specified periods must, however, be fixed parallel to the carriageway. These signposts must be installed at an offset distance of 2m from the edge of the carriageway. The cautionary/warning signs are located at distances of 120m in plain and rolling terrain and 60m in hilly terrain in advance of hazard warnings in rural sections of State Highways, 50m in advance of hazard warnings in urban areas. Informatory signs such as advance direction sign boards, etc. are located at specified distances usually at major intersections on appropriate directions of travel.

Where light reflection from the sign face is encountered to such an extent as to reduce legibility, the sign should be turned slightly away from the road. On Horizontal curves, the sign should not be fixed normal to the carriageway but the angle of placement should be determined to the course of the approaching traffic.

The retro reflective sheeting used on the sign shall consist of white or coloured sheeting having a smooth outer surface, which has the property of retro-reflection over its entire surface. It shall be weather resistant and show colourfastness. It shall be new and unused and shall no evidence of cracking, scaling, pitting, blistering, edge lifting or curling and shall have negligible shrinkage or expansion. A certificate of having tested the sheeting for these properties in an unprotected outdoor exposure facing the sun for two years and its having passed these tests shall be obtained from a reputed test laboratory.

The colour of the sheeting in case of wide-angle prismatic lens shall confirm to the colour requirements determined by instrumental method in accordance with ASTM E-1164 on sheeting applied to aluminium test panels. Computation shall be done in accordance with E-308 for 2-degree observer. In case of Encapsulated lens type-sheeting specification shall confirm with MoSRTH, ASTM E-810.

**Kilometer Stones**

The details of kilometre stones are in accordance with IRC: 8-1980 guidelines. Both ordinary and fifth kilometre stones are provided as per the schedule given in tender

drawings. Kilometre stones are located on the left-hand side of the road as one proceeds from the station from which the Kilometre count starts. Kilometre stones shall be fixed at right angles to the centre line of the carriageway.

**200m Stones and Boundary Stones**

The details of 200m stones and boundary stones conform to IRC: 26-1967 and IRC: 25-1967. 200m stones are located on the same side of the road as the kilometre stones. The inscription on the stones shall be the numerals 2,4,6 and 8 marked in an ascending order in the direction of increasing kilometerage away from the starting station. The numerals shall be 80mm high. The colour of the numerals shall be black on a white background. Boundary stones shall be located on either side of the road opposite every 200m stone and kilometre stone. In addition these shall be fixed at all angular points of the boundary. Where the boundary is on a curve or the land is of significant value and likely to be encroached upon, the boundary stones, as required, shall be installed at closer intervals.

The letter RB, indicating road boundary, shall be inscribed on each stone and below it the name of the authority in which the road rests i.e., PWD, C&B etc.

**Delineators and Object Markers**

Reflective Delineators and Hazard Markers: Delineators and Hazard Markers are provided to guide the road users for the delineation of carriageway or particular topographical features like traffic island at intersection and junctions, sharp horizontal curves and steep gradients higher than 5%. Object markers are used to indicate hazards and obstructions within the vehicle flow path, for example, channelising islands close to the intersections.

The design, materials and locations of the road delineators are conforming to the Recommended Practice for Road Delineators - IRC: 79 and relevant drawings.

They are basically driving aids and should not be regarded as substitutes for warning signs, road markings or barriers. Delineators are provided for all curves of radius less than 600m. They are not provided at locations where Chevron signboards are provided. Delineators and object markers are provided as per the details given in the drawings and are provided in accordance with the provisions of IRC: 79-1989.

**Bus Bays**

Bus bays are proposed as per the recommendations of IRC: 80-1981. The following data was gathered during field visits.

i. All though there were considerable through bus traffic movements, the number of buses stopping at existing bus stops was few.

ii. People travelling from villages to nearby towns make use of taxicabs, jeeps and other light commercial vehicles including goods vehicles in preference to buses.

iii. The number of trips made by other carriers was greater than those made by buses.

iv. Local consultations were held to study the need for bus bays in specific villages by collecting details pertaining to the number of buses, frequency of buses stopping to pick up passengers, duration of bus stops, etc.

v. The need for bus bays at religious places, educational institutions, public buildings, intersections of minor roads leading to interior villages, which are not connected to the bus route network, were studied.

With due consideration to the above data, bus bay locations are provided in all the upgradation links as required. The typical bus bay consists of deceleration and acceleration lanes of 45m length with stopping lane of 3.5m wide, 15m long. Adequate arrangements have also been made to drain off surface water. Typical bus bay layout and schedule of locations are included in the Drawings Volume. The chainage locations of the bus bays are given in Table 7.3.

**Table 7.3: Schedule of Bus Bays**

| LEFT | | RIGHT | |
|---|---|---|---|
| **Start** | **End** | **Start** | **End** |
| 5925 | 6030 | 5850 | 5955 |
| 7150 | 7255 | 7180 | 7285 |
| 7850 | 7955 | 7875 | 7980 |
| 8880 | 8985 | 9050 | 9155 |
| 20525 | 20630 | 20850 | 20955 |
| 30050 | 30155 | 30070 | 30175 |
| 39990 | 40095 | 39800 | 39905 |
| 43620 | 43725 | 43400 | 43505 |
| 49920 | 50025 | 50250 | 50355 |
| 50600 | 50705 | 50770 | 50875 |
| 53000 | 53105 | 53170 | 53275 |
| 5600 | 5705 | 57170 | 57275 |
| 57620 | 57725 | 57580 | 57685 |
| 60160 | 60265 | 61000 | 61105 |
| 61420 | 61525 | 61630 | 61735 |
| 62860 | 62965 | 62550 | 62655 |
| 65900 | 66005 | 66005 | 66110 |

### Truck Lay-byes

Truck lay bye is provided at location as specified in drawing. The following procedure was adopted in locating the Truck lay-bye:

i. Surveys were carried out to identify the places where the trucks are regularly parked along the project roads. These places are usually near check posts, petrol bunks, town approaches, and restaurants/ dhabas and at locations where truck repair facilities were available. Rural sections of highway merely have any such locations.

ii. There were no specific parking places for trucks along the project roads. This situation makes the truck drivers park vehicles at various locations in disorder that causes congestion for smooth flow of traffic particularly at town approaches.

iii. Local consultations were held at the places of petty repair shops, restaurants/ dhaba etc. and subjective opinion of the drivers regarding necessity of truck lay bye was gathered.

iv. Following information was collected during the inventory survey of truck lay-byes:

- Location, chainage.
- Timings of opening of shop – split hour/continuous.
- Number of trucks parked during different hours a day (including peak hours)
- Repair facilities available – vulcanising, minor repairs, major repairs
- Other facilities available – rest rooms, dormitory facilities etc.

v. The scenario of existing truck traffic on State Highways is entirely different from that on National Highways as only limited number of vehicles ply on the project roads from time to time and this trend changes during different seasons.

vi. The facilities of vulcanising and minor repairs are generally not available at most of the repair shops.

vii. Keeping in view all the above considerations, typical truck lay-bye design is proposed. It consists of deceleration and acceleration lane of length 25.0m with central parking area of 50m length and 14m wide with 1.2m wide raised Kerb Island separating the carriageway & lay-bye. This can accommodate parking space (4.0m x 8.0m) for 13 trucks at an angular parking of 45 degrees. Sufficient working area and space for roadside establishments such as repair shops, vulcanising shops, service centre, spare parts shops, telephone booth and light refreshments with first aid facilities can be provided.

viii. Cement concrete pavement is proposed to prevent damage caused by frequent application of brakes and parking of loaded trucks for minor repair works.

**Guard posts**

Guard posts are proposed on embankments of height more than 1.5m, bridge approaches and horizontal curves of radius greater than 170m. The spacing of guard post shall be 1.0m c/c. Typical Guard post consists of pre-cast (M20) CC post of size 150mm diametre and height of 1000mm. They are encased in M15 cement concrete to a depth of 300mm below ground level. Guard posts are painted with alternate black and white reflective paint of 150mm wide bands. Typical details of guard post are provided in standard highway drawings provided.

**Table 7.4: Location of Guard Posts**

| Start | End | Length (m) | Start | End | Length (m) |
|---|---|---|---|---|---|
| 3011 | 3061 | 50 | 37500 | 37710 | 210 |
| 3088 | 3138 | 50 | 40060 | 40120 | 60 |
| 4369 | 4509 | 140 | 4169 | 41890 | 37721 |
| 4600 | 4630 | 30 | 42250 | 42360 | 110 |
| 4670 | 4770 | 100 | 43100 | 43130 | 30 |
| 6490 | 6570 | 80 | 44740 | 44870 | 130 |
| 6600 | 6800 | 200 | 44960 | 45040 | 80 |
| 6830 | 7080 | 250 | 45300 | 45330 | 30 |
| 9430 | 9530 | 100 | 45870 | 46150 | 280 |
| 10400 | 10450 | 50 | 49720 | 49760 | 40 |
| 10470 | 10520 | 50 | 50230 | 50340 | 110 |
| 10541 | 10680 | 139 | 51130 | 51180 | 50 |
| 15700 | 15950 | 250 | 51735 | 51770 | 35 |
| 17380 | 17580 | 200 | 53340 | 53380 | 40 |
| 18770 | 18970 | 200 | 54410 | 54680 | 270 |
| 20060 | 20360 | 300 | 54760 | 54840 | 80 |
| 20830 | 21230 | 400 | 56140 | 56240 | 100 |
| 21490 | 21690 | 200 | 56830 | 56910 | 80 |
| 23290 | 23350 | 60 | 57240 | 57360 | 120 |
| 24300 | 24380 | 80 | 58690 | 59300 | 610 |
| 27280 | 28193 | 913 | 59458 | 59580 | 122 |
| 28210 | 28760 | 550 | 63200 | 63240 | 40 |
| 28785 | 29550 | 765 | 64620 | 64650 | 30 |
| 30690 | 30750 | 60 | 66200 | 66250 | 50 |
| 31160 | 31200 | 40 | 67970 | 68000 | 30 |
| 37180 | 37270 | 90 | 68953 | 69060 | 107 |

### Road Humps and Rumble Strips

**Road Humps** are formed by providing a rounded hump of 3.7m width (17m radius) and 0.10m height for the preferred advisory crossing speed of 25Kph for general traffic as per the IRC: 99–1988 guidelines. The basic material for construction is bituminous concrete formed to required shape. Road humps are located at T-intersections (and cross road intersections) on minor roads or perpendicular arms about 25m away from the inner edge of the carriageway. Proper signboards and markings are provided to advise the drivers in advance of the situation. Road humps are extended across carriageway up to the edge of paved shoulder. The locations of the road humps are given in Schedule are given in Table 7.5.

**Table 7.5: Schedule of Road Humps**

| SL.NO. | CHAINAGE | DESCRIPTION |
|---|---|---|
| 1 | 6120 | T-JUNCTION |
| 2 | 7428 | Y-JUNCTION |
| 3 | 7574 | T-JUNCTION |
| 4 | 8837 | Y-JUNCTION |
| 5 | 12958 | X-JUNCTION |
| 6 | 18353 | X-JUNCTION |
| 7 | 18523 | X-JUNCTION |
| 8 | 21194 | T-JUNCTION |
| 9 | 24785 | X-JUNCTION |
| 10 | 25835 | X-JUNCTION |
| 11 | 26275 | T-JUNCTION |
| 12 | 27139 | T-JUNCTION |
| 13 | 30600 | X-JUNCTION |
| 14 | 31050 | X-JUNCTION |
| 15 | 36200 | X-JUNCTION |
| 16 | 39976 | Y-JUNCTION |
| 17 | 43539 | X-JUNCTION |
| 18 | 46854 | T-JUNCTION |
| 19 | 47252 | X-JUNCTION |
| 20 | 50110 | Y-JUNCTION |
| 21 | 53142 | T-JUNCTION |
| 22 | 56217 | T-JUNCTION |
| 23 | 57068 | Y-JUNCTION |
| 24 | 57161 | X-JUNCTION |
| 25 | 60918 | X-JUNCTION |
| 26 | 69419 | T-JUNCTION |
| 27 | 5800 | SCHOOL ZONE |
| 28 | 7260 | SCHOOL ZONE & HOSPITAL ZONE |
| 29 | 7470 | HOSPITAL ZONE |
| 30 | 20700 | SCHOOL ZONE |
| 31 | 26030 | SCHOOL ZONE |
| 32 | 26670 | HOSPITAL ZONE |
| 33 | 32940 | SCHOOL ZONE |
| 34 | 33050 | SCHOOL ZONE |

**Rumble Strips** are formed by a sequence of transverse strips laid across a carriageway. Maximum permitted height of 20mm. These rumble devices produce audible and vibratory effects to alert drivers to take greater care and do not normally reduce traffic speeds in themselves. The typical design details of rumble strips proposed are transverse strips of Pre-mix bituminous concrete 500mm wide and overall thickness 20mm laid across a carriageway up to the end of paved shoulder. There will be 6 such transverse strips spaced at 2.0m c/c. Rumble strips are proposed at:

i. Sharp curves with radius less than 170m.

ii. Transition zones (speed limit zones).

iii. Village/urban approaches.

Proper signboards and marking are proposed to advise the drivers in advance of the situation. The locations of the road humps are given in Schedule of Drawings separately.

**Footpath Barriers**

Barriers can be used to alter patterns of pedestrian movements as part of any road safety measures. They are used in short lengths in front of school entrances, recreation grounds, and footpaths to prevent haphazard movement of pedestrians.

Covered drains of 1.5m wide have been provided at built-up section for the pedestrian movement.

Footpath barriers are formed of tubular steel sections (of designated weight in kilograms per running metre) in conformance with IS 1239. These barriers will have overall height of 1.0m above the kerb and length of 2.0m. They are difficult to climb, as there are no horizontal rails more than 100mm above the footway. These barriers are located at an offset of 150mm from the face of the kerb. The standard drawings are presented in Drawing Volume. The location and exact Chainages shall be determined at the stage of construction. The schedule of Pedestrian crossing is presented in Table 7.6.

**Table 7.6: Schedule of Pedestrian Crossing**

| SCHOOL ZONE | HOSPITAL ZONE | BUS BAYS | |
|---|---|---|---|
| CHAINAGE | | | |
| 5800 | 7260 | 5970 | 5910 |
| 20700 | 7470 | 7195 | 7240 |
| 26030 | 26670 | 7895 | 7935 |
| 32940 | - | 8925 | 9110 |
| 33050 | - | 20570 | 20910 |
| - | - | 30095 | 30130 |
| - | - | 40035 | 39860 |
| - | - | 43665 | 43460 |
| - | - | 49965 | 50310 |
| - | - | 50645 | 50830 |
| - | - | 53045 | 53230 |
| - | - | 5645 | 57230 |
| - | - | 57665 | 57640 |
| - | - | 60655 | 61060 |
| - | - | 61465 | 61690 |
| - | - | 62905 | 62610 |
| - | - | 65945 | 66065 |

**Reflective Pavement Markers (RPM)**

i. Reflective Pavement Marker (RPM) or road stud is a device, which is bonded to or anchored within the road surface for lane marking and delineation for night time visibility. It reflects incident light in directions close to the direction from which it came.

ii. Plastic body of RPM/road stud shall be moulded from ASA (Acrylic Strene Acrylonitrite) or HIPS - (High Impact Polystyrene) or ABS or any other

suitable material approved by the Engineer-in-Charge. The markers shall support a load of 13635 Kg tested in accordance with ASTM D4280.

iii. Reflective panels shall consist of number of lens containing single or dual prismatic cubes capable of providing total internal reflection of light entering the lens face. Lenses shall be moulded of methyl methecrylate conforming to ASTM D788 or equivalent.

iv. Design details, Optical performance details and details of fixing and placement shall be in-accordance with **Ministry's letter No.RW/NH-33023 /10/ 97-DO III dated, the 11th June, 1997 on 'Technical Specifications for Reflective Pavement Markers (Road Studs)**'.

**Chevron Sign Boards**

i. The size of "Chevron" Signboard has to be 400mm x 550mm.
ii. The signboard should be wide-angle micro-prismatic lens.
iii. The retro – reflective surface after cleaning with soap and water in dry condition shall have the minimum co-efficient of retro–reflection (MOST wide 801.3.2 clause) as indicated below for encapsulated lens.

| Observation Angle (in deg) | Entrance Angle (in deg) | White | Yellow | Green/Red | Blue |
|---|---|---|---|---|---|
| 0.2 | -4 | 250 (430) | 170 (325) | 45 (325) | 20 (20) |
| 0.2 | +30 | 150 (235) | 100 (205) | 25 (205) | 11 (11) |
| 0.5 | -4 | 95 (250) | 62 (240) | 15 (240) | 7.5 (10) |
| 0.5 | +30 | 65 (170) | 45 (110) | 10 (110) | 5.0 (7) |

*Note: Figure in brackets indicates co-efficient of retro-reflection (Cd/Lux/$m^2$) for wide-angle micro prismatic lens type sheeting as per ASTM E-810 test method.*

- *When totally wet, the sheeting shall not show less than 90% of the value of retro – reflective indicated in the table above. At the end of 7 years, the sheeting shall retain at least 75% of its original retro – reflectance.*
- *Chevron sign boards shall be installed at 10m c/c as shown in the drawings at all curves of radius less than 200 m along the outer edge facing the traffic of nearby lane.*

### 7.2.5 Highway Policing and Emergency Response

The most important of all the traffic safety measures and which the enforcing officers often neglect are the Highway Policing and adequate facility for emergency response during accidents. Special training sessions for driver behavior orientation should be organized from time to time. The road users should be made aware of the traffic signs, road pavement markings, hazards of rash driving etc. Driving during the effect of alcohol and other drugs should be fined and punished by the law.

The responsibilities of the State Highway Patrol will be,

i. Quick response to move injured persons & disabled vehicles from state highway.

ii. Record and maintain accident database.

iii. Impose fine on spot for traffic rule violation.

# CHAPTER – 8
# SPECIFICATIONS AND CONSTRUCTION PLANS

# CHAPTER – 8

# SPECIFICATIONS AND CONSTRUCTION PLANS

## 8.1 SPECIFICATIONS

In general, the specifications laid down in "Specifications for Road and Bridge Works – Fourth Revision - by MoSRT&H" shall be followed. The detailed specifications have been given in Bidding Document prepared separately for each civil construction package.

## 8.2 CONSTRUCTION PLANS

The different steps involved in construction are as under.

i. The first operation in road construction involves site clearance and preparation of ground surface. The construction of structures is independent activity. New constructions/ Extensions of cross-drainage structures can be taken up simultaneously with clearance operations.

ii. After clearances the next step is the preparation of the road shoulder on one side so that traffic can continue on this side while work on the other side proceeds. Specification Cl. 112 of MoSRTH gives the requirements.

iii. Start construction activities on other side of half width. Speed restrictions will be imposed on traffic in the stretch in which construction is going on.

iv. For approved construction lengths of more than 500m, passing bays are specified (Cl. 112 of MoSRTH specifications). Additional width shall be provided for passing bays. Passing bays are also useful for temporary parking of broken-down vehicles.

v. Alternatively, the working lengths should be limited to about 1km stretches with minimum 0.5km spacing in between. This non-working zone will be used for overtaking and temporary stopping of vehicles.

vi. In stretches where it is not possible to pass the traffic on part width of the carrigeway, a temporary diversion shall be constructed.

vii. The traffic should not be allowed to move on the space occupied for construction. Proper barriers should be provided between the working side and the traffic side. Necessary safety measures shall be adopted.

viii. If the local conditions are such that two-way traffic cannot be maintained, one-way traffic movement should be operated with suitable controls at either end. In such cases working lengths should preferably not exceed 500m.

### 8.2.1 Setting out of Work

i. Establish working benchmarks at 250m intervals on the road in question with the help of Reference Bench Marks in the area.

ii. Establish centre line of the carriageway and have it referenced by marker pegs and chainage boards set near the road land boundary at 50m intervals. (In hills and on curves in plains, the intervals of reference pegs should be 20m).

iii. Prepare a schedule of reference dimensions and maintain the markers until the works reach finished formation level and are accepted by the Engineer.

iv. Verify the dimensions and levels, shown on the drawings or mentioned in contract documents, on the site and inform the Engineer of any apparent errors or discrepancies.

v. Prepare a profile along the centre line and cross-sections at intervals as specified in the drawings, otherwise as prescribed by the Engineer.

vi. Obtain approval of the Engineer to the profile and cross-sections as these form the basis for measurements and payments for various items of work. The work can commence thereafter.

vii. The lines and levels of formation, side slopes, drainage works, carriageway and shoulders should be carefully set out and frequently checked, care being taken to ensure that correct gradients and cross-sections are obtained everywhere.

### 8.2.2 Site Clearance

i. The road land should be cleared of all materials unsuitable for the work by cutting, removing and disposing of all materials, such as trees, bushes, shrubs, stumps, roots, grass, weeds, top organic soil not exceeding 150mm in thickness, rubbish, etc. This should be in advance of earthwork operations.

ii. Excavation below the ground level arising out of removal of trees, stumps, etc be filled in layers with suitable material and compacted thoroughly.

iii. All trees, stumps, etc falling within the excavation and embankment lines should be cut to such depth below ground level that in no case these fall within 500mm of the subgrade. Beyond these limits, they need to be cut down to 1m below ground level.

### 8.2.3 Excavation

i. The limits of excavation should be set out true to lines, curves, slopes, grades and sections as shown on the drawings. The work of excavation should be carried out in conformity with the drawings.

ii. Undertake stripping of topsoil before excavation if so required under the contract and stack it suitably for reuse.

iii. Keep the excavation dry.

iv. After excavation, the sides of excavated area should be trimmed and the area contoured to minimize erosion and ponding, allowing natural drainage to take place.

v. In case in-situ soil is to be used for subgrade, loosen the soil and compact to a thickness of 500mm with a suitable roller to 97 per cent modified proctor compaction density.

### 8.2.4 Embankment / Subgrade Construction

The material to be used in embankment/ subgrade and its compaction shall meet the requirements as laid down in specifications. The maximum particle size shall not be more than two-thirds of the compacted layer thickness.

It shall be ensured that the subgrade material when compacted to the density requirements as per specifications shall yield the design CBR value of the subgrade.

**Widening of Existing Road Embankment**

When an existing embankment and/ or subgrade is to be widened and its slopes are steeper than 1 vertical on 4 horizontal, continuous horizontal benches, each at least 300mm wide, shall be cut into the old slope for ensuring adequate bond with the fresh embankment/ subgrade material to be added. The material obtained from cutting of benches could be utilized in the widening of the embankment/ subgrade. However, when the existing slope against which the fresh material is to be placed is flatter than 1 vertical on 4 horizontal, the slope surface may only be ploughed or scarified instead of resorting to benching.

**Embankment and Subgrade to be Placed Against Sloping Ground**

Where an embankment/ subgrade is to be placed against sloping ground, the latter shall be appropriately benched or ploughed/ scarified before placing the embankment/ subgrade material. Extra earthwork involved in benching or due to ploughing/ scarifying etc. shall be considered incidental to the work.

**Earthwork over Existing Road Surface**

Where the embankment is to be placed over an existing road surface, the work shall be carried out as indicated below:

i. If the existing road surface is of granular or bituminous type and lies within 1m of the new subgrade level, the same scarified to a depth of 50mm or more if specified, so as to provide ample bond between the old and new material ensuring that at least 500mm portion below the top of new subgrade level is compacted to the desired density.

ii. If the existing road surface is of cement concrete type and lies within 1m of the new subgrade level the same shall be removed completely.

If the level difference between the existing road surface and the new formation level is more than 1m, the existing surface shall be permitted to stay in place without any modification.

**Earthwork for high embankment**

In the case of high embankment, the contractor shall normally use the material from the specified borrow area. In case he desires to use different material for his own convenience, he shall have to carry out necessary soil investigations and redesign the high embankment at his own cost. The contractor shall then furnish the soil test data and design of high embankment for approval of the Engineer, who reserves the right to accept or reject it.

## 8.3 TRAFFIC MANAGEMENT

All necessary safety measures shall be adopted for safety of moving traffic. The traffic moving on the road should face least disturbances due to construction activities. The safety measures should provide:

i. Clear advance warning to road users;

ii. Clear demarcated path for movement of vehicles in construction zone;

iii. Proper devices to guide road users through Construction and Maintenance Zones.

### 8.3.1 Construction and Maintenance Zones

The Construction and Maintenance Zones require special attention, as these are the zones where conflict can occur between the road users and the contractor. The basic components of Construction and Maintenance Zones are as under.

i. **Warning Zone:** It warns in advance and prepares road users for an up-coming hazard. It is an essential part of any traffic control system. The warning system should prepare the road users well in advance by providing information regarding distance, extent and type of hazard so that they can gradually reduce their speed. The information in the zone is conveyed mostly through a series of traffic signs along the length of the zone;

ii. **Transition Zones:** These are the areas in which the traffic is guided into and out of the diverted path around the work zone. They are the most crucial zones from the safety point of view, since most of the movements are turning movements. The traffic in this zone is diverted mostly with the help of barricades and channelisers.

iii. **Working Zone:** This is the actual area where construction or maintenance activity is taking place and the main concern, therefore, is the safety of the workers at the site. The path of the traffic must, therefore, be clearly delineated to avoid intrusion of vehicles into the work area. Necessary buffer space shall be maintained between the workspace and moving traffic.

The distance between two work zones should be such that the flow of traffic can return to normal by permitting fast moving traffic to overtake slow moving vehicles for easy dissipation of queuing vehicles.

### 8.3.2 Traffic Control Devices

Traffic control devices in the Construction and Maintenance Zones are required to warn, inform and guide the road users so that they as well as the workers are protected, and safe passage of traffic is possible. The primary traffic control devices used are signs, delineators, barricades, cones, pylons, pavement markings, flashing lights etc. They should be easily understood without any confusion, be clearly visible during both day and night, conform to the prevailing speeds in the immediate vicinity, be stable against sudden adverse weather conditions and be easy to install, remove and maintain. It is important that they are maintained in good visible and working condition.

### 8.3.3 Traffic Signs

Traffic signs will consist of:

i. Ahead of the Roadwork (for both directions of traffic), on the shoulder on the side of the approaching traffic:

- Men at Work/ Go Slow;
- Road Narrows;
- No Overtaking;
- Keep Right (at merging end);
- Diversion Ahead (for bridgework);
- Road Closed (for bridgework);
- Compulsory Keep Left/Right (for bridgework).

ii. On the half-width of road where work is taking place, at each end of the Works:

- 1 permanent barrier;
- 1 flag man controlling successive flows of traffic in alternate directions, if one way trafficking is in operation;
- Keep Left (at diverging end);
- Delineators such as Chevron sign boards, traffic cones etc.

iii. Along the length of the roadwork:

- Continuous concrete barriers, permanent barricades, traffic cones and reflective tapes.

  (On long works sections, intermediate traffic controllers may also be required to transfer "Stop/Go" instructions. Alternatively portable traffic lights or hand radio sets could be used).

iv. At the end of the roadwork (for both directions of traffic):

- On the shoulder on the side of the traffic leaving the diversion, "Restriction Ends" signs should be placed approximately 200 meters beyond the traffic barrier.

### 8.3.4 Safety and Management Practices

Typical measures for providing safe movement of traffic in some of the most commonly occurring work zones on the roads are as follows:

i. **Temporary Diversion:** In the cases of temporary off-road diversions running parallel to the highway, barricading may be required to prevent construction material falling on the diversion.

The warning for the construction ahead should be provided by the sign "Men at Work Ahead". A supplementary plate indicating "Diversion" should also be provided. In addition to the sign for "Compulsory Turn Right/Left Sign",

the "Detour" and "Sharp Deviation" signs should be used to guide the traffic into the diversion. Hazard markers should be placed at the point where the railing for the cross drainage structures on the diversion starts.

ii. **Partial Closure for Work on a single Carriageway:** Care has to be taken to ensure that traffic is guided from the closed lane in to the operating lane without conflicting with traffic from the opposite direction.

## 8.4 CONSTRUCTION METHODOLOGY

The traffic management needs to be closely coordinated with the sequence of the construction operations. The ideal condition is that traffic should be diverted to a detour or to separate diversion but when it is not possible then the sequence of construction should be as under for concentric as well as eccentric widening.

### 8.4.1 Widening of Existing Road

Stage 1: Treated shoulder shall be provided on the side on which work is not in progress. The treatment to shoulder shall consist of providing at least 150mm thick granular base course with bituminous surface dressing with a width of minimum 2.0m.

Stage 2: Widening work on the other side of the carriageway is to be done right from sub-base level. While constructing sub base the shoulder need to be constructed simultaneously in layers matching the thickness of the sub base.

Stage 3: Similarly base course layers are also be constructed in layers along with the shoulder matching the thickness of the base course layers.

Stage 4: After completion of the compaction of base course the one layer of bituminous course is laid. The continuous length in which such work shall be carried out would be limited to 500m at a place, however, for longer stretches, passing places at least 20m long with additional paved width of 2.5m shall be provided at every 0.5km interval. The traffic arrangement shall be as per **Figure 8.1**.

Stage 5: After completing one side in above steps the other side is taken up as per steps 2 to 4.

Stage 6: The bituminous layers are laid in such a way that it overlaps the joint of widened portion. The work is taken up in half the carriageway whereas the other half is open to traffic. Diversion of traffic shall be as per **Figure 8.2**.

### 8.4.2 Raising of Existing Road

Stage 1: Treated shoulder shall be provided on the side on which work is not in progress. The treatment to shoulder shall consist of providing at least 150mm thick granular base course with bituminous surface dressing with a width of minimum 2.0m

Stage 2: Raising half the carriageway by doing earthwork for embankment and subgrade as per para 8.2.4.

Stage 3: Execution of granular sub base, sub base and bituminous work along with the shoulders. Refer traffic management drawing in **Figure 8.1**.

Stage 4: Diverting traffic on the newly constructed road. Refer **Figure 8.2** for diversion of traffic.

Stage 5: Construction of remaining half as per Stage 2 & 3 above.

### 8.4.3 Strengthening of Existing Road

The sequence of construction should be as under:

Stage 1: The shoulder adjacent to half the carriageway that is going to be used as diversion should be suitably strengthened to cater to the diverted traffic volume.

Stage 2: Strengthening work shall be carried out in other half of the carriageway.

Stage 3: Having completed operation in Stage 2 above, the strengthened pavement along with the hard shoulder shall be used as diversion while strengthening the other half. Diversion of traffic as per **Figure 8.2**.

### 8.4.4 Spur Road Development

All the Spur Roads connecting to Project Road shall be developed (upto 50.00m or 1 in 30 slope which ever is applicable) as given below.

| Existing | Proposed Improvement |
|---|---|
| Earthern Road | Earthern Road |
| WBM Road | WMM + MSS |
| BT Road | GSB + WMM + PMC |
| Concrete Road | WMM + MSS |

### 8.4.5 Passage of Traffic along a Temporary Diversion

In stretches where it is not possible to pass the traffic on part width of the carriageway, temporary diversion shall be constructed with 3.5 m carriageway and 1.0m earthern shoulders on each side (Total width of roadway 5.5m) with the following provision for road cruse in the 3.5 m width:

(i) 100 mm WMM;
(ii) 150 mm (compacted) GSB and
(iii) Premix carpet.

### 8.4.6 Temporary Diversion of CD Works

Where the construction zone would close the road completely the remaining carriageway space would be insufficient for the traffic and create large delays, and there is no suitable alternative route, it will be necessary to construct a temporary carriageway for all or part of the traffic. This is most common situation in the case of

any major repair or reconstruction of cross drainage works. The diversion can be as given in **Figure 8.3**. The diversion shall be 3.5m carriageway with 1.0m earthern shoulders on each side with following provisions of road crust 100mm WMM, 150mm (compacted) GSB, and premix carpeting.

The temporary carriageway must satisfy the following requirements:

i. It should have smooth horizontal and vertical profile with smooth vertical and horizontal curves;

ii. It should not get overtopped by flood or drainage discharges under any conditions;

iii. It should have adequate capacity to cater to the expected traffic;

iv. It should be dust free and should ensure clear visibility at all times of day and night; and

v. Barricading should be provided to prevent construction material falling on the diversion.

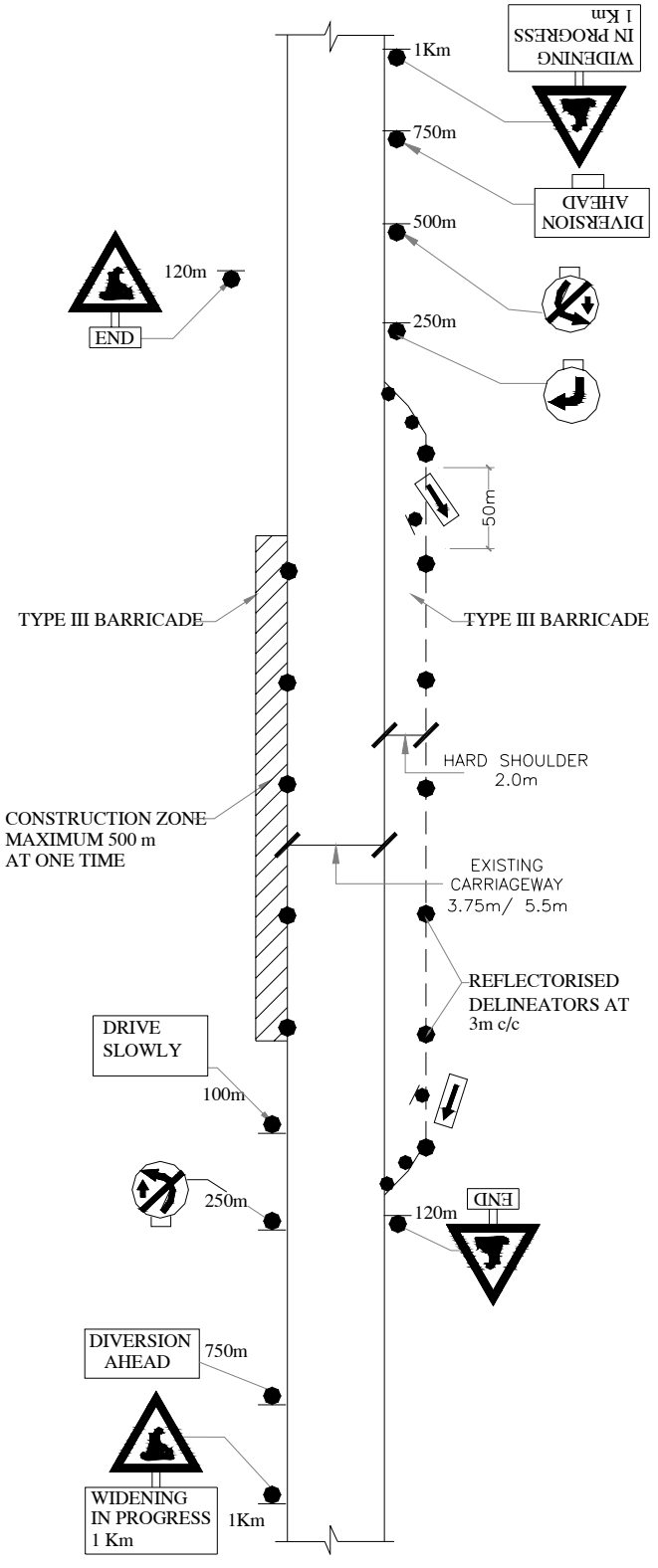



FIGURE 8.1: TRAFFIC CONTROL WITH DIVERSION

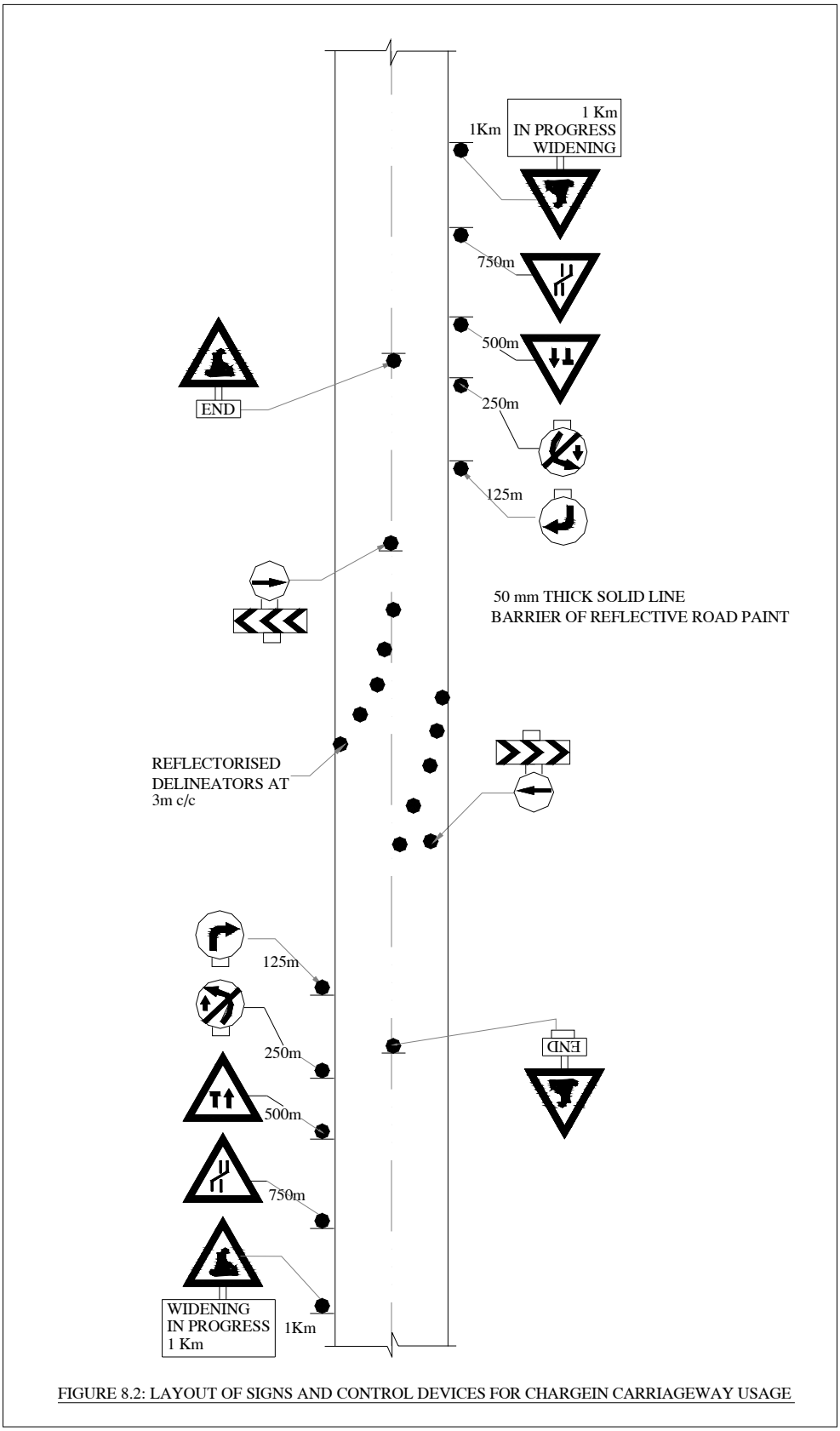



FIGURE 8.2: LAYOUT OF SIGNS AND CONTROL DEVICES FOR CHARGEIN CARRIAGEWAY USAGE

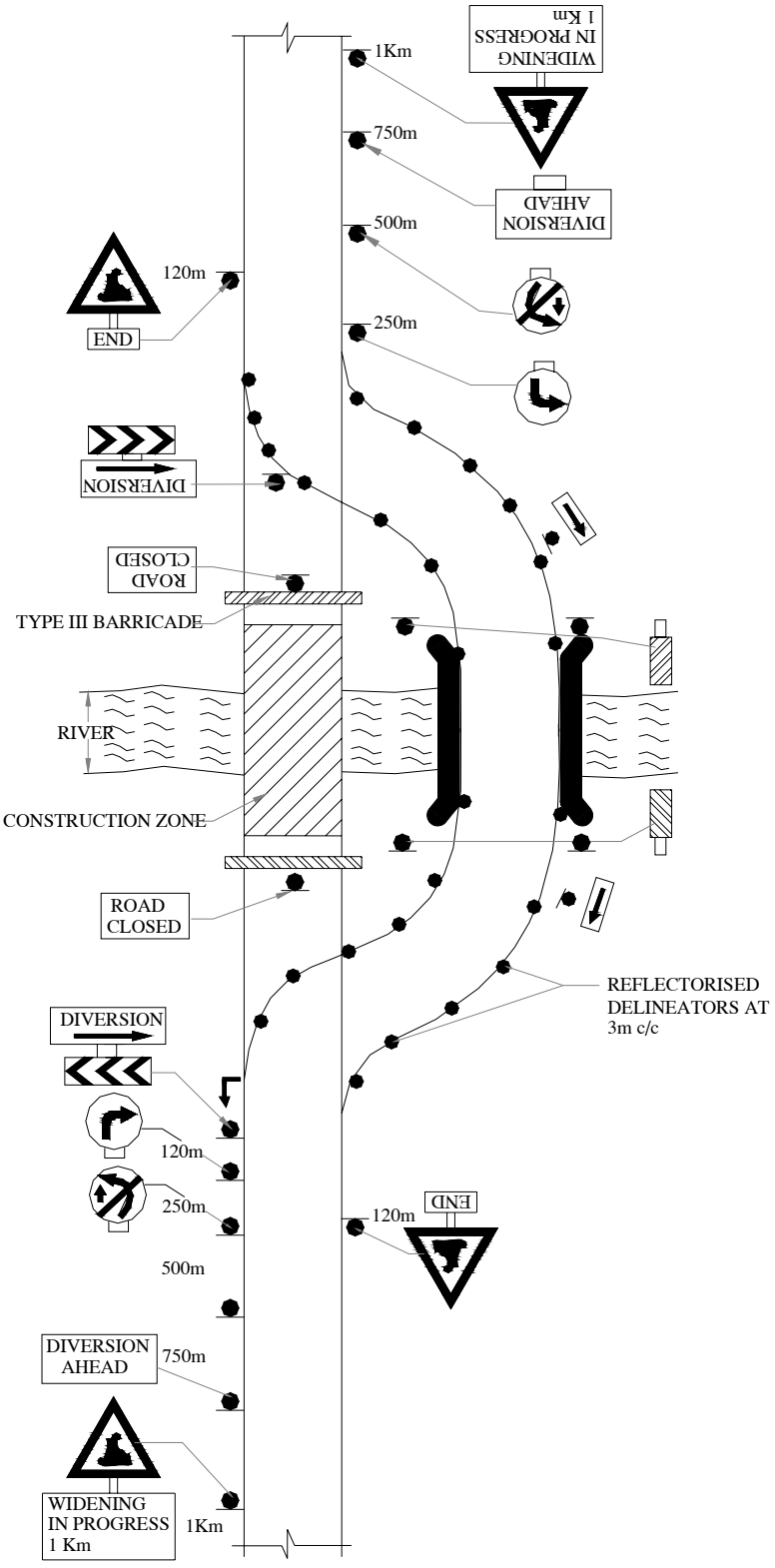



FIGURE 8.3: LAYOUT OF SIGNS AND CONTROL DEVICES FOR ROAD CLOSED WITH A DIVERSION

# CHAPTER - 9
# SOCIAL ASSESSMENT AND RESETTLEMENT ACTION PLAN

# CHAPTER – 9

# SOCIAL ASSESSMENT AND RESETTLEMENT PLAN

## 9.1 GENERAL

The social Report (Social Assessment and Resettlement Action plan) will be submitted in separate volume. However the cost for social component has been incorporated in this report.

# General Abstract of Cost of Bhawanipatna - Khariar

| Bill No. | Description | Amount in Rupees |
|---|---|---|
| 1 | Site clearance and Dismantling | 9,294,096.00 |
| 2 | Earth Work | 149,130,049.00 |
| 3 | Sub-base and base courses | 186,238,152.00 |
| 4 | Bituminous courses | 224,932,061.00 |
| 5 | Culverts & Underpasses | 114,565,638.00 |
| 6 | Bridges | 135,001,850.00 |
| 7 | Drainage & Protective works | 80,889,107.00 |
| 8 | Miscellaneous items | 33,150,024.00 |
| 9 | Maintenance, Repair and Rehabilitation works | 13,622,941.00 |
| | **SubTotal (A)** | **946,823,918.00** |
| 10 | Provisional Item | 34,604,324.00 |
| | Add for<br>( i) Social Cost(LAQ+R&R) | 31,792,664.00 |
| | (ii) Utility relocation, 2% of A | 18,936,478.00 |
| | (iii) Cost of Environmental Implementation Plan, 2% of A | 25,344,150.00 |
| | **Total (B)** | **1,057,501,534.00** |
| | (i) Engineering Supervision, 3% of B | 31725046.02 |
| | (ii) PIU - Project office , 1% of B | 10,575,015.34 |
| | (iii) Contigencies , 3% of B | 31725046.02 |
| | **Total Civil Construction Cost** | **1,131,526,641.38** |

# CHAPTER - 10
# ENVIRONMENTAL ACTION AND ENVIRONMENTAL MANAGEMENT PLAN

**CHAPTER – 10**

# ENVIRONMENTAL ACTION AND MANAGEMENT PLAN

## 9.1 GENERAL

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| | (iii) Contigencies , 3% of B | 31725046.02 |
| | **Total Civil Construction Cost** | **1,131,526,641.38** |

# CHAPTER – 11
# COST ESTIMATIES

# CHAPTER – 11

# COST ESTIMATES

## 11.1 GENERAL

The cost estimate for detail engineering report has been framed on the basis of current rate analysis on labour rate and material rate schedule-2006 issued by the OWD. The approximate leads for different construction materials for respective sections were calculated by the field team. The production cost for various materials i.e. GSB, WMM and DBM at site are also calculated. The rate analysis is done using standard data book of MoSRTH.

## 11.2 METHODOLOGY

Estimation of the detailed quantity of each item of works is the important input required for the Cost Estimate. The quantities of the items under Site Clearance, Earth Works, Sub-base and Base Courses, Bituminous/Cement Concrete Courses, Road Junctions, Drainage and Protective Works, Bridges, Culverts and Rehabilitation etc. have been computed based on the design and drawings.

After the quantities are computed for each of the work items the amount of each item is evaluated by multiplying the respective quantities with the relevant unit rates and finally the total estimated cost is arrived accordingly.

## 11.3 BILL OF QUANTITIES

The Bill of Quantities for the Item Rate contract was prepared under different Bills. The quantities and unit of the different work items under each bill were calculated based on the estimated quantities.

Besides the other relevant information like rate analysis, lead for various materials from different quarry locations were collected, which serves the basic guide for preparation of the tentative cost for all sections.

## 11.4 UNIT RATES

The Unit Rate Analysis has been framed on the basis of the latest MoSRT&H Data Book.

### 11.4.1 Basic Rates of Material

Market Rates of material have been considered invariably. The stone aggregate has been evaluated by way of installing crusher plant and manufacturing the required quantities of the different sizes of aggregate exclusively for use in the project work.

This would ensure considerable overall economy when compared with direct purchase of the finished products from the private crusher owners of the area.

For HYSD Bar, information on rates has been collected from the stockyard of SAIL/ TISCO located at Bhubaneswar. Likewise the rates for High Tensile steel strands have also been adopted after market inquiry for pre-stressed work.

With regard to Bitumen, 60/70 grade is proposed and its rate is collected from the offices of the HPC/ IOC at Bhubaneswar.

Bitumen emulsion shall be used for primer coat and tack coat. The rate was also collected by inquiry from the offices of the Petroleum Companies at Bhubaneswar.

### 11.4.2 Lead of Material

Shortest average leads have been adopted in respect of stone aggregate, Moorum, sand etc from the quarries/ sources up to the proposed location of the Hot Mix plant, Pug Mill, Concrete Batching Plant as the Case may be. For HYSD bar, Bitumen and Bitumen Emulsion the leads are from Bhubaneswar, Visakhapatnam, Haldia are taken.

Extra lead for the mixed materials from the Hot Mix Plant/ Pug Mill/ Concrete Batching Plant as the case may be to work site is allowed as per MoSRTH Data Book.

### 11.4.3 Provision of Royalty

Royalty has been added to the basic rates of the materials in the Rate Analysis as per prevailing Government Norms.

### 11.4.4 Carriage Rates of finished Materials

The carriage rates of materials, as stipulated in the State Schedule of Rates have been allowed in the analysis. However, in case of the mixed materials from the concerned plants to the workplace overall rate has been considered. The labour rates are taken from SSR-2006 of Orissa state with increase of Rs 15 as discussed with PIU. The machinery cost is taken from the MoSRT&H data book and SSR-2006.

## 11.5 COST ESTIMATES

Detail costs have been worked out for the different items of road works and structures. Estimated total cost of this package is Rs 1131.53 millions which includes engineering cost as Rs 946.82 millions. Estimated cost for provisional items, social, environmental and utility shifting costs as Rs 18.94 millions. The total cost also includes engineering supervision, PIU project office. The General Abstract of cost is appended here with.

# ABSTRACT OF COST

# General Abstract of Cost of Bhawanipatna - Khariar

| Bill No. | Description | Amount in Rupees |
|---|---|---|
| 1 | Site clearance and Dismantling | 9,294,096.00 |
| 2 | Earth Work | 149,130,049.00 |
| 3 | Sub-base and base courses | 186,238,152.00 |
| 4 | Bituminous courses | 224,932,061.00 |
| 5 | Culverts & Underpasses | 114,565,638.00 |
| 6 | Bridges | 135,001,850.00 |
| 7 | Drainage & Protective works | 80,889,107.00 |
| 8 | Miscellaneous items | 33,150,024.00 |
| 9 | Maintenance, Repair and Rehabilitation works | 13,622,941.00 |
| | **SubTotal (A)** | **946,823,918.00** |
| 10 | Provisional Item | 34,604,324.00 |
| | Add for<br>( i) Social Cost(LAQ+R&R) | 31,792,664.00 |
| | (ii) Utility relocation, 2% of A | 18,936,478.00 |
| | (iii) Cost of Environmental Implementation Plan, 2% of A | 25,344,150.00 |
| | **Total (B)** | **1,057,501,534.00** |
| | (i) Engineering Supervision, 3% of B | 31725046.02 |
| | (ii) PIU - Project office , 1% of B | 10,575,015.34 |
| | (iii) Contigencies , 3% of B | 31725046.02 |
| | **Total Civil Construction Cost** | **1,131,526,641.38** |

## B. Work Items

| Item No. | Description | Unit | Quantity | Rate | Amount |
|---|---|---|---|---|---|
| | **BILL NO.1 : SITE CLEARANCE** | | | | |
| 1.01 | Cleaning and Grubbing for road land complete as per Technical Specification Clause 201 and as per the direction of Engineer-in-charge. | Hectare | 124.00 | 26639.50 | 3303298 |
| 1.02 | Dismantling structures and pavement including disposal of resulting material and/or salvaging useful materials complete as per Technical Specification Clause 202, 2809 and as per the direction of Engineer in-charge. | | | | |
| | a) Brick/ Stone Structures of dry or in lime/cement mortar | Cum | 444.00 | 111.50 | 49506 |
| | b) Concrete/Reinforced concrete/ Prestressed concrete structures including cleaning straightening & cutting of bars and separating them out from RCC/PSC. | | | | |
| | For Slab Culverts & Box Culverts and Bridges | | | | |
| | i)P.C.C. | Cum | 827.00 | 230.00 | 190210 |
| | ii)R.C.C. | Cum | 790.00 | 355.70 | 281003 |
| | c) Dismantling of all type of Pavement course | Cum | 41714.00 | 135.20 | 5639733 |
| | d) Hume pipe | Lm | 768.00 | 45.10 | 34637 |
| | e) Kerb | Lm | 14.00 | 6.80 | 95 |
| | f) Dry stone pitching | Cum | 60.00 | 87.10 | 5226 |
| | g) RCC railing | Lm | 253.00 | 26.80 | 6780 |
| | h) Expansion joint | Lm | 208.00 | 1647.60 | 342701 |
| | i) Wearing coat | | | | |
| | a) Bituminous concrete | Sqm | 265.00 | 43.20 | 11448 |
| | b) Cement concrete | Sqm | 1573.00 | 56.70 | 89189 |
| 1.03 | Rebate towards salvage value of scarified/dismantled material for each type of item | | | | |
| | a) Steel | MT | 15.00 | 29662.00 | -444930 |
| | b) Aggregate | Cum | 100.00 | 148.00 | -14800 |
| | c) Concrete | Cum | 100.00 | 2000.00 | -200000 |
| | **Total for Bill No. 1** | | | | ***9294096*** |
| | **BILL NO.2 : EARTH WORKS** | | | | |
| 2.01 | Roadway excavation including removal of unsuitable soil necessary for construction of roadway complete as per Technical Specification Clause 301 and as per the direction of Engineer-in-charge. | | | | |
| | a) All kinds of soil | Cum | 427482.00 | 43.80 | 18723712 |
| | b) softrock (blasting not required) (LS) | Cum | 1000.00 | 53.20 | 53200 |
| | c) Hard rock (blasting required) (LS) | Cum | 1000.00 | 133.00 | 133000 |
| | d) Hard rock (blasting not required) (LS) | Cum | 1000.00 | 211.00 | 211000 |
| 2.02 | Construction of embankment with approved material from approved borrow areas complete as per drawing and Technical Specification Clause 305 and as per the direction of Engineer-in-charge. | Cum | 203885.00 | 120.40 | 24547754 |

| Item No. | Description | Unit | Quantity | Rate | Amount |
|---|---|---|---|---|---|
| 2.03 | Construction of subgrade and earthen shoulder with approved material as per drawing complete and Technical Specification Clause 305 and as per the direction of Engineer-in-charge. | Cum | 603207.00 | 143.70 | 86680846 |
| 2.04 | Construction of granular/gravel shoulders with approved material as per drawing complete and Technical Specification Clause 305 with all leads an lifts and as per the direction of Engineer-in-charge. | Cum | | 473.32 | |
| 2.05 | Construction of embankment and subgrade with suitable material deposited at site from roadway and drainage excavation all complete as per drawing and Technical Specification Clause 305 and as per the direction of Engineer-in-charge. | Cum | 256490.00 | 70.50 | 18082545 |
| 2.06 | Loosening and recompacting the existing subgrade in all kinds of soil upto a depth of 300mm/500mm to meet the requirement of table 300-2 complete as per Technical Specification Clause 305 and as per the direction of Engineer-in-charge. | Cum | 5675.00 | 42.50 | 241188 |
| 2.07 | Earthwork with agriculture soil for filling of median/island complete as per Technical Specification Clause 407 and as per the direction of Engineer-in-charge. | Cum | 2700.00 | 139.00 | 375300 |
| 2.08 | Scarifying the existing bituminous surface layers without disturbing the base including carrying , processing , laying and disposal of waste material complete as per Technical Specification Clause 501 and as per the direction of Engineer-in-charge. | Sqm | 26292.00 | 3.10 | 81505 |
| | **Total for Bill No. 2** | | | | **149130049** |
| | **(Carried forward to Summary, p. ____)** | | | | |
| | **BILL NO.3 : SUB-BASE AND BASE COURSES** | | | | |
| 3.01 | Construction of Granular Sub-base course by providing the materials i.e. naturally occurring morrum , gravel , sand or combination thereof conforming to Gr-I of Table 400-2 complete as per Technical Specification clause 401 and as per the direction of Engineer-in-charge. | Cum | 201749.00 | 412.30 | 83181113 |
| 3.02 | Construction of wet mix macadam complete as per Technical Specification clause 406 and as per the direction of Engineer-in-charge. | | | | |
| | a) for Base | Cum | 134119.00 | 768.40 | 103057040 |
| | b) for Profile Corrective Course | Cum | | | |
| | **Total for Bill No. 3** | | | | **186238152** |
| | **BILL NO.4 : BITUMINOUS COURSES** | | | | |
| 4.01 | Providing bituminous Primer coat over granular surface complete all as per Technical specification clause 502 and as per the direction of Engineer-in-charge. | Sqm | 505567.00 | 12.00 | 6066804 |
| 4.02 | Providing Tack coat complete as per Technical Specification clause 503 and as per the direction of Engineer-in-charge. | | | | |

| Item No. | Description | Unit | Quantity | Rate | Amount |
|---|---|---|---|---|---|
| | a) Granular surface treated with primer | Sqm | 505567.00 | 4.60 | 2325608 |
| | b) over normal bituminous surface | Sqm | 505567.00 | 4.60 | 2325608 |
| 4.03 | Providing dense bituminous macadam course complete as per Technical Specification Clause 507 and as per the direction of Engineer-in-charge. | Cum | 31896.00 | 3868.10 | 123376918 |
| 4.04 | Providing bituminous concrete wearing course using CRMB-55 complete as per Technical Specification Clause 509 & 521 and as per the direction of Engineer-in-charge. | Cum | 20432.00 | **4441.60** | 90750771 |
| 4.05 | Providing, laying mixed seal surfacing in spur roads complete as per technical specification clause 512 and as per the direction of Engineer-in-charge. | Sqm | 1028.00 | **84.00** | 86352 |
| | **Total for Bill No. 4** | | | | **224932061** |
| | | | | | |
| | **BILL NO.5 : CULVERTS AND UNDERPASSES** | | | | |
| 5.01 | Earthwork in excavation of foundation for structures complete as per drawing and technical specifications clause 304 including all leads and lifts and as per the direction of Engineer-in-charge. | Cum | 14150.00 | 30.90 | 437235 |
| 5.02 | Earth fill below pitching in quadrant portion with approved material complete as per drawing and Technical Specification Clause 305 with all leads and lifts and as per the direction of Engineer-in-charge. | Cum | 5073.00 | 120.40 | 610789 |
| 5.03 | Providing and filling behind abutment, wing wall and return wall with granular material etc. and below pipe bed in layers not exceeding 150mm thick including All leads and lifts complete as per drawings, direction of the Engineer and Technical specification clause 304 and as per the direction of Engineer-in-charge. | Cum | 7379.00 | 333.70 | 2462372 |
| 5.04 | Providing filter media behind abutment, wing wall and return wall complete as per drawing and Technical Specification clause 2504, 2509, 2510 and as per the direction of Engineer-in-charge. | Cum | 2880.00 | 1049.90 | 3023712 |
| 5.05 | Cement Concrete M-15 grade in leveling course etc. including centering and shuttering all complete as per Drawings and Technical Specification Sections 1500 and 1700 and as per the direction of Engineer-in-charge. | Cum | 2898.00 | 2715.70 | 7870099 |
| 5.06 | Cement Concrete M-15 grade in substructure & headwall including centering and shuttering all complete as per Drawings and Technical Specification Sections 1500, 1700, 2200 and as per the direction of Engineer-in-charge. | Cum | 1511.00 | 2873.50 | 4341859 |
| 5.07 | Reinforced cement concrete in all types of culverts as per drawing and technical specification Section 1500, 1700 & 2200 and as per the direction of Engineer-in-charge. | | | | |
| | a) M-20 grade | Cum | 9567.00 | 3581.00 | 34259427 |
| | b) M-25 grade | Cum | | 3813.00 | |

| Item No. | Description | Unit | Quantity | Rate | Amount |
|---|---|---|---|---|---|
| 5.08 | Reinforced cement concrete M-30 grade in approach slabs including cost of reinforcement all complete as per Drawing and Technical Specification Clause 2704 and as per the direction of Engineer-in-charge. | Cum | 1580.00 | 5780.80 | 9133664 |
| 5.09 | HYSD(TMT) bar reinforcement complete as per drawing and technical specifications clause 1600 and as per the direction of Engineer-in-charge. | MT | 574.00 | 44104.70 | 25316098 |
| 5.10 | Providing laying and joining NP-4(I.S 458) hume pipes for culverts complete as per drawing Tech. Specification section2900 and IRC special publication no.13 and as per the direction of Engineer-in-charge. | | | | |
| | a) 1m dia. hume pipe in single row | Lm | 634.00 | 3447.90 | 2185969 |
| | b) 1m dia. hume pipe in double row | Lm | 1098.00 | 6944.00 | 7624512 |
| 5.11 | Providing and laying filter material underneath stone pitching in slopes complete as per drawings and technical specification section 2504, 2509, 2510 and as per the direction of Engineer-in-charge. | Cum | 1684.00 | 1049.90 | 1768032 |
| 5.12 | Providing and laying stone Pitching on embankment slopes complete as per drawing and technical specification Clause 2504 and as per the direction of Engineer-in-charge | Cum | 3369.00 | 577.50 | 1945598 |
| 5.13 | Providing rubble stone flooring in Cement mortar (1 Cement:3 Sand) and joints complete as per Drawing and Technical Specification Section 1400, 2504 and as per the direction of Engineer-in-charge. | Cum | 1797.00 | 2413.20 | 4336520 |
| 5.14 | Providing weep holes in box portion, return wall, wing wall etc. all complete as per drawing and technical specification clause . 2706 and as per the direction of Engineer-in-charge. | Nos | 8974.00 | 99.60 | 893810 |
| 5.15 | Supplying, fitting and fixing in position true to line and level tar paper bearings confirming to IRC-83 (para-II) section IX complete with all accessories as per drawings and technical specification clause 2011, IS 1398 and as per the direction of Engineer-in-charge. | | | | |
| a) | Tar paper bearing | Sqm | | 50.00 | |
| 5.16 | Supplying and fixing Asphaltic Plug expansion joints complete as per Drawing and as per IRC: SP : 69-2005 and as per the direction of Engineer-in-charge. | Lm | 1584.00 | 803.00 | 1271952 |
| 5.17 | Reinforced cement concrete railing complete as per Drawing and Technical Specification Section 2700 (Including cost of Reinforcement) and as per the direction of Engineer-in-charge. | Lm | 1381.00 | 1169.60 | 1615218 |
| 5.18 | Bituminous wearing course 56mm thick comprising 50mm thick asphaltic concrete in a single layer over Bituminous mastic course 6mm thick with a prime coat complete as per Drawing and Technical Specification Section 2700, Clause 512 and as per the direction of Engineer-in-charge. | Sqm | 7874.00 | 693.00 | 5456682 |
| 5.19 | Synthetic enamel painting of culvert no. and span arrangement as per IRC - 7 - 1971 and as per the direction of Engineer-in-charge. | No. | 264 | 45.80 | 12091 |
| | **Total for Bill No. 5**<br>**(Carried forward to Summary, p. ____)** | | | | **114565638** |

| Item No. | Description | Unit | Quantity | Rate | Amount |
|---|---|---|---|---|---|
| | **BILL NO.6 : BRIDGES** | | | | |
| 6.01 | Earthwork in excavation of foundation for structures complete as per drawing and technical specification clause 304 including all leads & lift and as per the direction of Engineer-in-charge. | Cum | 19254.00 | 30.90 | 594949 |
| 6.02 | Providing and filling foundation and at the back of abutment, wing wall and return wall etc. and below pipe bed in layers not exceeding 150mm thick with granular material including all leads & lifts as per Technical specification Clause 304 and as per the direction of Engineer-in-charge. | Cum | 9145.00 | 333.70 | 3051687 |
| 6.03 | Providing Filter media behind abutment, wing wall and return wall complete as per drawing and technical Specification clause 2504 and as per the direction of Engineer-in-charge. | Cum | 669.00 | 1049.90 | 702383 |
| 6.04 | Cement concrete M-15 grade in leveling course etc including centering and shuttering all complete as per drawing and Technical specification Section 1500 and 1700 and as per the direction of Engineer-in-charge. | Cum | 730.00 | 2715.70 | 1982461 |
| 6.05 | Cement concrete in foundation and substructure etc including centering and shuttering all complete as per drawing and Technical specification Section 1500, 1700, 2100, 2200 and as per the direction of Engineer-in-charge. | | | | |
| | a) M-15 Grade | Cum | 3326.00 | 2873.50 | 9557261 |
| | b) M-20 Grade | Cum | 1764.00 | 3344.00 | 5898816 |
| 6.06 | Reinforced cement concrete in foundation complete as per drawing & Technical specification sections 1500, 1700, 2100, 2200 and as per the direction of Engineer-in-charge. | | | | |
| | a) M-20 Grade | Cum | | 3266.60 | |
| | b) M-25 Grade | Cum | 691.00 | 3596.20 | 2484974 |
| | c) M-30 Grade | Cum | | 3608.60 | |
| | d) M-35 Grade | Cum | 1080.00 | 3733.60 | 4032288 |
| 6.07 | Reinforced cement concrete in substructure complete as per drawing & Technical specification sections 1500, 1700, 2200 and as per the direction of Engineer-in-charge. | | | | |
| | a) M-20 Grade | Cum | 2242.00 | 3455.20 | 7746558 |
| | b) M-25 Grade | Cum | 1011.00 | 3813.00 | 3854943 |
| | c) M-30 Grade | Cum | 310.00 | 3835.00 | 1188850 |
| | c) M-35 Grade | Cum | 357.00 | 4031.30 | 1439174 |
| 6.08 | Reinforced cement concrete in super structure complete as per drawing and Technical specification section 1500, 1700, 2300 and as per the direction of Engineer-in-charge. | | | | |
| | a) M-25 grade | Cum | 211.00 | 4307.20 | 908819 |
| | b) M-30 grade | Cum | 891.00 | 4359.80 | 3884582 |
| | b) M-35 grade | Cum | 350.00 | 4199.00 | 1469650 |
| 6.09 | Prestressed cement concrete of M-40 grade in super structure complete as per drawing and Technical specification section 1500, 1700, 1800, 2300 and as per the direction of Engineer-in-charge. | Cum | 2184.00 | 4569.50 | 9979788 |

| Item No. | Description | Unit | Quantity | Rate | Amount |
|---|---|---|---|---|---|
| 6.10 | Reinforced cement concrete railing complete as per drawing and Technical specification section 2703 and as per the direction of Engineer-in-charge. | Lm | 203.00 | 1169.60 | 237429 |
| 6.11 | Bored cast-in-situ M-35 grade RCC Pile etc. complete as per drawing and technical specification clause 1100, 1700 and as per the direction of Engineer-in-charge. | Lm | 698.00 | 7650.50 | 5340049 |
| 6.12 | HYSD(TMT)bar reinforcement complete as per drawing and technical specifications clause 1600 and as per the direction of Engineer-in-charge. | | | | |
| | a) in foundation | MT | 278.00 | 44064.80 | 12250014 |
| | b) in substructure | MT | 291.00 | 44104.70 | 12834468 |
| | c) in superstructure | MT | 487.00 | 44488.80 | 21666046 |
| 6.13 | High tensile steel strand complete as per drawing and technical specifications section 1800 and as per the direction of Engineer-in-charge. | MT | 60.00 | 69481.20 | 4168872 |
| 6.14 | Providing and fixing specified bearings complete as per Drawing and technical specification 2000 and as per the direction of Engineer-in-charge. | | | | |
| | a) Elastomeric bearing | Cucm | 150000.00 | 1.60 | 240000 |
| | b) Tar paper bearing | Sqm | 187.00 | 50.00 | 9350 |
| | c) POT-PTFE Bearing | | | | |
| | i) fixed (3000KN Capacity) | No. | 32.00 | 208.80 | 6682 |
| | i) sliding (3000KN Capacity) | No. | 32.00 | 208.80 | 6682 |
| 6.15 | Reinforced cement concrete M-30 grade for in approach slabs complete as per Drawing and Technical specification section 1500, 1600, 1700, 2700 and as per the direction of Engineer-in-charge. | Cum | 343.00 | 5780.80 | 1982814 |
| 6.16 | Bituminous wearing course 56mm thick comprising 50mm thick asphaltic Concrete in a single layer over Bituminous mastic course 6 mm thick with a prime Coat Complete as per drawing and Technical Specification Section 509 & 2700 and as per the direction of Engineer-in-charge. | Sqm | 5765.00 | 693.00 | 3995145 |
| 6.17 | Cement concrete wearing course 75mm thick Complete as per drawing and Technical Specification Section 2700 and as per the direction of Engineer-in-charge. | Sqm | 290.00 | 512.90 | 148741 |
| 6.18 | Providing and fixing Drainage Spouts Complete as per drawing and Technical Specification Clause 2705 and as per the direction of Engineer-in-charge. | No | 213 | 739.60 | 157535 |

| Item No. | Description | Unit | Quantity | Rate | Amount |
|---|---|---|---|---|---|
| 6.19 | Providing and laying Stone pitching in slopes complete as per drawing and Technical Specification Section 2500 and as per the direction of Engineer-in-charge. | Cum | 3551.00 | 577.50 | 2050703 |
| 6.20 | Providing as laying fitter material underneath Stone pitching in slopes Complete as per drawing and Technical Specification clause 2504 and as per the direction of Engineer-in-charge. | Cum | 1776.00 | 1095.30 | 1945253 |
| 6.21 | Providing weep holes in abutments, wing walls and return walls etc. as per drawing and Technical Specification clause 2706 and as per the direction of Engineer-in-charge. | Nos | 1822.00 | 99.60 | 181471 |
| 6.22 | Providing rubble Stone flooring in Cement mortar (1Cement:3 sand) and joints Complete as per drawing and Technical Specification Section 1400 and 2500 and as per the direction of Engineer-in-charge. | Cum | 3644.00 | 577.50 | 2104410 |
| 6.23 | Supplying as fixing the following types of expansion joints Complete as per Drawing and as per IRC: SP : 69-2005 and as per the direction of Engineer-in-charge. | | | | |
| | a) Asphaltic plug | Lm | 494.00 | 803.00 | 396682 |
| | b) Compression seal type of expansion joint. | Lm | 108.00 | | |
| 6.24 | Synthetic enamel painting of culvert no. and span arrangement as per IRC - 7 - 1971 and as per the direction of Engineer-in-charge. | No. | 56 | 45.80 | 2565 |
| 6.25 | Carrying and Confirmatory bores up to required depth at locations of bridges as directed be Engineer complete in all respects, conducting all the tests required as directed by the Engineer and as per Technical Specification Section 2400 and interpretation of the bore data and presentation of the results and as per the direction of Engineer-in-charge. | | | | |
| | a) In all types of soil (except rock) | | | | |
| | i) depth from 0m to 10m | Lm | 200.00 | 400.00 | 80000 |
| 6.26 | Providing and painting of flood gauge on substructure is fall height and 500mm width and as per the direction of Engineer-in-charge. | Lm | 120.00 | 827.90 | 99348 |
| 6.27 | Providing and laying 150mm dia. HDPE Service pipe as per drawing and as per the direction of Engineer-in-charge. | Lm | 3290.00 | 300.00 | 987000 |
| 6.28 | Earth fill below pitching in quadrant portion with approved material complete as per drawing and Technical Specification Clause 305 with all leads and lifts and as per the direction of Engineer-in-charge. | Cum | 7298.00 | 120.40 | 878679 |
| 6.29 | Sand Filling in Foundation Trenches as per Drawing & Technical Specification Clause 304, 305 and as per the direction of Engineer-in-charge. | Cum | | 258.50 | |
| 6.30 | PCC in flooring as per Drawing & Technical Specification section 1700, 2500 and as per the direction of Engineer-in-charge. | | | | |
| | a) M-15 | Cum | 352.00 | 2715.70 | 955926 |
| | b) M-20 | Cum | 117.00 | 3161.30 | 369872 |

| Item No. | Description | Unit | Quantity | Rate | Amount |
|---|---|---|---|---|---|
| 6.31 | Reinforced cement concrete crash barrier including cost of steel and its fabrication to bridge structures as per the approved drawing and Technical Specification clause 809, and section 1500, 1600, 1700 and as per the direction of Engineer-in-charge . | Lm | 1381.00 | 2265.70 | 3128932 |
| | **Total for Bill No. 6**<br>**(Carried forward to Summary, p. ____)** | | | | **135001850** |
| | | | | | |
| | **BILL NO.7 : RETAINING WALL, DRAINAGE AND PROTECTIVE WORKS** | | | | |
| 7.01 | Retaining Wall | | | | |
| (a) | Earthwork in excavation for foundation complete as per drawing and Technical Specification Clause 304 in Retaining wall for high embankment stretches as per the direction of Engineer-in-charge. | Cum | 4275.00 | 30.90 | 132098 |
| (b) | Providing and filling foundation and at the back of abutment, wing wall and return wall etc. and below pipe bed in layers not exceeding 150mm thick including all leads & lifts as per Technical specification Clause 305 and as per the direction of Engineer-in-charge. | Cum | | 334.30 | |
| ( c) | Filter media behind wall complete as per drawing and Technical Specification Clauses 2504 and as per the direction of Engineer-in-charge. | Cum | 2700.00 | 1049.90 | 2834730 |
| (d) | Plain cement concrete M -15 in foundation leveling course etc. including centering and shuttering all complete as per drawing and Technical Clauses 1500, 1700 and as per the direction of Engineer-in-charge. | Cum | 713.00 | 2873.50 | 2048806 |
| (e) | Cement concrete M -20 for reinforced concrete in foundation and substructure including centering and shuttering all complete as per drawing and Technical Clauses 1500, 1700, 2100 and as per the direction of Engineer-in-charge. | Cum | 4785.00 | 3455.20 | 16533132 |
| (f) | Providing steel reinforcement HYSD(TMT) for retaining wall complete as per drawing and Technical Specification Clause 1600 and as per the direction of Engineer-in-charge. | MT | 383.00 | 44104.70 | 16892100 |
| (g) | Providing guard post complete as per drawings and Technical specifications section 806 and as per the direction of Engineer-in-charge. | No. | 1000 | 321.90 | 321900 |
| (h) | Providing weep holes in retaining wall complete as per drawing and Technical Specification Clause 2706 and as per the direction of Engineer-in-charge. | No. | 3000 | 99.60 | 298800 |
| 7.02 | Providing and laying stone pitching on embankment slopes as per drawing and Technical Specification Clause 2504 and as per the direction of Engineer-in-charge. | Cum | 1409.00 | 577.50 | 813698 |

| Item No. | Description | Unit | Quantity | Rate | Amount |
|---|---|---|---|---|---|
| 7.03 | Providing and laying filter material underneath stone pitching on embankment slopes as per drawing and Technical Specification Clause 2504 and as per the direction of Engineer-in-charge. | Cum | 705.00 | 1095.30 | 772187 |
| 7.04 | Turfing side slopes of main road and service road with grass sods complete as per Technical Specification Clause 307 and as per the direction of Engineer-in-charge. | Sqm | 346620.00 | 18.90 | 6551118 |
| 7.05 | Constructing lined surface drains/ sub surface drains to the required lines and grades as per drawing and Technical Specification section 1500,1600, 1700, 2100 and as per the direction of Engineer-in-charge. | Lm | 8820.00 | 3709.00 | 32713380 |
| 7.06 | Constructing box type drains to the required lines and grades including cost of steel and its fabrication as per drawing and technical specification section 1500, 1600, 1700, 2100 and as per the direction of Engineer-in-charge. | Lm | 120.00 | 8143.00 | 977160 |
| | **Total for Bill No. 7** | | | | **80889107** |
| | **(Carried forward to Summary, p. ____)** | | | | |
| | | | | | |
| | **BILL NO-8 : MISCELLANEOUS ITEMS.** | | | | |
| 8.01 | Providing and laying plain cement concrete kerb as per drawing and Technical Specifications Clauses 408, section 1500,1700 and as per the direction of Engineer-in-charge. | Lm | 480.00 | 155.80 | 74784 |
| 8.02 | Providing service ducts with 150mm dia GI pipes over concrete base of M-15 under existing and proposed carriageways including cutting of trenches through existing roadway and reinstatement of the same as per design and specification and as per the direction of Engineer-in-charge. | Lm | | 1687.70 | |
| 8.03 | Providing and fixing RCC boundary posts complete as per drawing and Technical Specification Clause 806 and as per the direction of Engineer-in-charge. | No | 743 | 246.70 | 183298 |
| 8.04 | Providing and fixing RCC/PCC hectometer, Kilometer and 5th kilometer stones complete as per Technical Specification Clause 804 and as per the direction of Engineer-in-charge. | | | | |
| | a) No of (200) Hectometer Stone | No | 271 | 276.80 | 75013 |
| | b) No of Kilometer stone | No | 54 | 1023.20 | 55253 |
| | c) No. of 5th Kilometer Stone | No | 14 | 1683.10 | 23563 |
| 8.05 | Constructing footpath/ paved separator at toll plaza, passenger platform / paved part of medians and islands complete as per drawing and Technical Specifications Clause 409 and 407 and as per the direction of Engineer-in-charge. | Sqm | 863.00 | 2000.00 | 1726000 |
| 8.06 | Providing passenger shelters for Bus Bays as per drawing and Technical Specifications Section 1500, 1600, 1700, 2100, 2200, 2300 and as per the direction of Engineer-in-charge. | No | 34 | 80000.00 | 2720000 |
| 8.07 | Construction of temporary diversion including Cross drainage works where necessary and maintenance thereof including traffic control and safety complete as per Technical Specification Clause 112 and as per the direction of Engineer-in-charge. | Lm | 7875.00 | 1517.60 | 11951100 |

| Item No. | Description | Unit | Quantity | Rate | Amount |
|---|---|---|---|---|---|
| | a) Lane line / Edge marking | sqm | 17394.00 | 557.80 | 9702373 |
| | b) Directional arrows and lettering etc. | No | 192 | 39.30 | 7546 |
| 8.08 | Supplying and fixing sign boards complete as per Technical Specifications Clause 801. Including the cost of Posts, Fitting & fixing. Sheeting will be retro reflective type of high intensively grade and messages / boarders and as per the direction of Engineer-in-charge. | | | | |
| (a) | Informatory Signs | | | | |
| | (i) Facility Information (800 x 600)mm | No | 2 | 2880.00 | 5760 |
| | (ii) Direction Signs (1200 x 700 mm) | No | 4 | 8472.00 | 33888 |
| | (iii) Advance Direction (size 1800 x 1200mm) , | No | 1 | 8702.30 | 8702 |
| | (iv) Re-Assurance Sign (1800 X 1200 mm) , | No | 1 | 8702.30 | 8702 |
| | (v) Destination Sign (1500 X 900 mm) , | No | 2 | 6702.30 | 13405 |
| | (vi) Place Identification (1500 X 900 mm) , | No | 1 | 6702.30 | 6702 |
| | (vii) Route Marker Sign (450mm x 600mm) | No | 4 | 2993.40 | 11974 |
| | (viii) Other Informatory Signs (2100mm x 1500mm) | No | 4 | 8702.30 | 34809 |
| (b) | CAUTIONARY SIGNS triangular 900mm side | No | 130 | 3563.60 | 463268 |
| (c) | Mandatory signs | | | | |
| | (i) Circular 600mm dia | No | 30 | 3086.10 | 92583 |
| | (ii) Octagaon 900 mm height | No | 20 | 5858.80 | 117176 |
| | (iii) Triangular 900 mm side | No | 30 | 3563.60 | 106908 |
| 8.09 | Providing & fixing retro - reflectorised road delineators complete as per drawing , Technical specifications clause 805 and as per the direction of Engineer-in-charge. | | | | |
| | ( I ) Roadway delineator | No | 452 | 787.00 | 355724 |
| | ( ii ) Hazard Marker | No | 168 | 787.00 | 132216 |
| | ( iii ) Object Marker | No | 52 | 787.00 | 40924 |
| 8.10 | Providing and fixing RCC Guard post with reflective paint marking on the top 25mm width band complete including end anchorage as per drawing and Technical Specifications Clause 806 and as per the direction of Engineer-in-charge. | No. | 3357 | 321.90 | 1080618 |
| 8.11 | Supply of colour recorded photographs negative and two colour prints there-from mounted in album and also in digital form in CD as per Technical Specifications Clause 125 As per requirements and as per the direction of Engineer-in-charge. | No | 700 | 5.00 | 3500 |
| 8.12 | Supply of additional prints of coloured photographs referred to above as per Technical Specifications Clause 125 As per requirements and as per the direction of Engineer-in-charge. | No | 1400 | 5.00 | 7000 |
| 8.13 | Supply of colour video coverage in CD form during construction as per Technical Specifications Clause 126 As per requirement and as per the direction of Engineer-in-charge. | set | 3.00 | 200.00 | 600 |
| 8.14 | Providing rumble strips for complete carriageway width at required places as per drawing and as per the direction of Engineer-in-charge. | No. | 26 | 5253.00 | 136578 |
| 8.15 | Providing road hump complete at required places as per drawing and as per the direction of Engineer-in-charge. | No. | 42 | 13418.00 | 563556 |
| 8.16 | Providing toll plaza as per drawing and technical specification and as per the direction of Engineer-in-charge. | No. | 1 | 1170506.00 | 1170506 |
| 8.17 | Providing utility duct across the road in specified locations as per the schedule mentioned in drawing and as per the direction of Engineer-in-charge. | Lm. | 18.00 | 124221.90 | 2235994 |
| | **Total for Bill No. 8** | | | | **33150024** |
| | **(Carried forward to Summary, p. ____)** | | | | |

| Item No. | Description | Unit | Quantity | Rate | Amount |
|---|---|---|---|---|---|
| | **BILL NO.9 MAINTENANCE, REPAIR AND REHABILITATION** | | | | |
| 9.01 | Carrying out all such as pothole repairs, shoulders making up, jungle clearance, crack sealing etc. routine maintenance of Highway as per Technical Specifications Section 3000 and as per direction of the Engineer-in-charge. | Km-month | 955.00 | 1500.00 | 1432500 |
| 9.02 | Carrying out surface treatment and any necessary patching to the existing bituminous carriageway surfacing with 2 coat surface dressing as per Technical Specification Section 3000 & Clause 510 and as per direction of the Engineer-in-charge. | Sqm | 85000.00 | 41.90 | 3561500 |
| 9.03 | Guniting by 25mm thick complete as per Technical specification clause 2807 and as per direction of the Engineer-in-charge. | Sqm | 134.00 | 588.20 | 78819 |
| 9.04 | Grouting with polymer modified cementious material complete as per Technical specification clause 2806and as per direction of the Engineer-in-charge. | Sqm | 495.00 | 9093.70 | 4501382 |
| 9.05 | Jacketing to the existing structure in M-20 grade concrete as per technical specification section 1500, 1700, 2200 and as per direction of the Engineer-in-charge. | Cum | | 3455.20 | |
| 9.06 | Providing and laying Cement concrete wearing coat M 30 grade complete as per technical specification section 2700 and as per direction of the Engineer-in-charge. | Cum | 290.00 | 512.90 | 148741 |
| 9.07 | Lifting of deck slab by jacking, shifting the entire deck slab to the side of the existing bridge and holding the same till the completion of the raising of the substructure and replacing the decks slab complete as per direction of the Engineer-in-charge. | No. | 13 | 300000.00 | 3900000 |
| | **Total for Bill No. 9**<br>**(Carried forward to Summary, p. ____)** | | | | **13622941** |

| | | | | | |
|---|---|---|---|---|---|
| | **BILL NO.10 ENVIRONMENTAL MITIGATION MEASURES** | | | | |
| 10.01 | **Earthwork** in excavation of foundation for structures complete as per drawing no. OSRP/CEG/SH/ENV/1-A,B,C,D,03,04-A,B,05,05-A,07,09,10,12and technical specifications clause 304 including all leads and lifts and as per the direction of Engineer-in-charge. | cum | 2045.00 | 30.90 | 63191 |
| 10.02 | **Sand filling** below foundation of wing wall and return wall, pipe bed in layers not exceeding 150mm thick including All leads and lifts complete as per drawing no. OSRP/CEG/SH/ENV/1-A,B,C,D,03,04-A,B,05,05-A,07,09,10,12 direction of the Engineer and Technical specification clause 304 and as per the direction of Engineer-in-charge. | cum | 388.00 | 120.40 | 46715 |

| Item No. | Description | Unit | Quantity | Rate | Amount |
|---|---|---|---|---|---|
| 10.03 | Providing & making **K.B. Brick masonry** work in 1:3 cement mortar in sub-structure complete as per the drawing as per drawing no.OSRP/CEG/SH/ENV/06,07 and Technical Specifications 1300 and as per the direction of Engineer-in-charge. | cum | 461.00 | 2304.40 | 1062328 |
| 10.04 | Providing & laying in position **Cement Concrete M-15 grade** in foundation, levelling course etc. including centering and shuttering all complete as per drawing no. OSRP/CEG/SH/ENV/1-A,B,C,D,03,04-A,05-A,07,09,10,12 and Technical Specification Sections 1500 and 1700 and as per the direction of Engineer-in-charge. | cum | 326.00 | 2715.70 | 885318 |
| 10.05 | Providing & laying in position plain cement **concrete M 20 grade (in kerbs)** as per drawing no. OSRP/CEG/SH/ENV/01-A.01-B,01-C and Technical Specifications Clause 408 and section 1700 and as per the direction of Engineer-in-charge. | cum | 2880.00 | 155.80 | 448704 |
| 10.06 | Providing & laying in position **Cement Concrete M-20 grade** over stone masonary, levelling course etc. including centering and shuttering all complete as per Drawing no. OSRP/CEG/SH/ENV/03/09/10 and Technical Specification Sections 1500 and 1700 and as per the direction of Engineer-in-charge. | cum | 1379.00 | 3161.30 | 4359433 |
| 10.07 | Providing **weep holes** in PCC toe wall with 100mm dia AC pipe at 1mtrs horizontal interval all complete as per Drawing no. OSRP/CEG/SH/ENV/03 and Technical Specification section. 2700& 2200 and as per the direction of Engineer-in-charge. | Nos | 1235.00 | 99.60 | 123006 |
| 10.08 | Providing & laying in position **Reinforced cement concrete of M-20 Grade i**n **foundation** complete as per drawing no.OSRP/CEG/SH/ENV/04-A,B,C,05,05-A,06,07,10 & Technical specification sections 1700, 2100 & 2200 and as per the direction of Engineer-in-charge. | cum | 428.00 | 3455.20 | 1478826 |
| 10.09 | Providing & laying in position **Reinforced cement concrete in superstructure** complete as per drawing no.OSRP/CEG/SH/ENV/04-A,B,05 & Technical specification sections 1500, 1700 & 2300 and as per the direction of Engineer-in-charge. | cum | 106.00 | 3726.20 | 394977 |
| 10.10 | **HYSD(TMT) bar reinforcement** with anti-corrosive treatment coating complete as per drawing no.OSRP/CEG/SH/ENV/04-A,B,C,D,05,06,07,10 and technical specifications clause 1600 and as per the direction of Engineer-in-charge. | **MT** | 22.00 | 44064.80 | 969426 |
| 10.11 | **Painting** two coats with synthetic enamel paint on new concrete surface as per drawing no.OSRP/CEG/SH/ENV/01-A,B,C and technical specification on building items and as per the direction of Engineer-in-charge. | **Sqm** | 576.00 | 31.90 | 18374 |
| 10.12 | **Supplying and fixing of M.S.GRILL** at junctions including cost of painting as per drawing no.OSRP/CEG/SH/ENV/01-B as per technical specifications on building items and as per the direction of Engineer-in-charge. | **kg** | 11088.00 | 45.00 | 498960 |

| Item No. | Description | Unit | Quantity | Rate | Amount |
|---|---|---|---|---|---|
| 10.13 | Supplying and fixing of **M.S grill gate** for sensitive receptors complete as per Drawing no.OSRP/CEG/SH/ENV/05-A as per technical specifications for building items and as per the direction of Engineer-in-charge. | kg | 3875.00 | 35.00 | 135625 |
| 10.14 | Supplying and fixing of 50X50X6 mm angle post, split 70 mm at the bottom end and galvanised, to be fixed vertically in position in concrete (cost of concrete to be paid separately) and holes drilled in it, at a spacing of 1500mm c/c as per drawing OSRP/CEG/SH/ENV/04-B,C,D and 05 and as per the direction of Engineer-in-charge. | kg | 1828.00 | 35.00 | 63980 |
| 10.15 | Providing and fixing pedestrian guard rail (Footpath barrier) for interception as per drawing no. OSRP/CEG/FB technical specification cl no. 808 and as per the direction of Engineer-in-charge.. | rm | 110.00 | 2753.00 | 302830 |
| 10.16 | Providing and fixing of G.I wire of 4mm dia @ 100 gms/m including cost of material , labour all complete as per drawing no. OSRP/CEG/SH/ENV/04-B,C and 05 and as per the direction of Engineer-in-charge. | kg | 3600.00 | 55.00 | 198000 |
| 10.17 | Providing and fixing in position **'Tree Guard',** including cost of all materials, labbour, fabrication & painting with approved synthetic enamel paint using 25mm X50mmX13 G welded mesh, as per drawing no.OSRP/CEG/SH/ENV/08 and as per the direction of Engineer-in-charge. | **Nos** | 8811.00 | **55.00** | 484605 |
| 10.18 | Providing & planting tree species as per the schedule attached and maintaining the same upto 3 years and as per the direction of Engineer-in-charge.. | Nos | 8681.00 | 111.88 | 971230 |
| 10.19 | Supplying and laying in position 600mm dia **NP3 Hume pipes** complete as per drawing no.OSRP/CEG/SH/ENV/12, at the location of trap drains and technical specification Cl no.2900 and as per the direction of Engineer-in-charge. | Lm | | 1126.70 | |
| 10.20 | Providing 100mm dia PVC pipe for soak pit as per Drawing no. OSRP/CEG/SH/ENV/07 and as per the direction of Engineer-in-charge. | Lm | 650.00 | 40.00 | 26000 |
| 10.21 | Laying of 20mtrs long 20mm PVC pipe with all fittings and tap point in position for stand post including digging of pipe line and connecting the mains supply with ferrule.as per Drawing no. OSRP/CEG/SH/ENV/07 and as per the direction of Engineer-in-charge. | Lm | 60.00 | 1500.00 | 90000 |
| 10.22 | Providing & laying in position of **PCC M15** for fixing of PVC pipe from platform to soak pit below G.L with a base and cover as per Technical specification cl. 1500, 1700, 2100 as per Drawing no. OSRP/CEG/SH/ENV/07 and as per the direction of Engineer-in-charge. | Cum | 38.00 | 2715.70 | 103197 |
| 10.23 | Providing and laying of **boulder appron** with HG Boulders at spilling locations as per technical specification Cl.2506 and as per Drawing no. OSRP/CEG/SH/ENV/10 and as per the direction of Engineer-in-charge. | Cum | 103.00 | 675.10 | 69535 |
| 10.24 | Constructing **course rubble hard granite stone masonry** in CM1:3 (at bathing ghat) as per technical specification cl. No.1400,2200 as per Drawing No.OSRP/CEG/SH/ENV/09 and as per the direction of Engineer-in-charge. | Cum | 218.00 | 2792.90 | 608852 |
| 10.25 | Providing and laying **filter material** underneath pitching in slopes at water bodies and ponds as per technical specification Section 2500 and as per Drawing No.OSRP/CEG/SH/ENV/03 and as per the direction of Engineer-in-charge. | Cum | 500.00 | 1095.30 | 547650 |

| Item No. | Description | Unit | Quantity | Rate | Amount |
|---|---|---|---|---|---|
| 10.26 | Providing and laying **pitching** on slopes over filter media as per technical specification Section 2500 and as per Drawing No.OSRP/CEG/SH/ENV/03 and as per the direction of Engineer-in-charge. | Cum | 1000.00 | 577.50 | 577500 |
| 10.27 | Providing **Cement plastering** 12mm with punning 1:3 for platform as per technical specification cl.1300& 2200 & as per Drawing No.OSRP/CEG/SH/ENV/01-A,B,C,04-A,B,C,D,05,05-A,06,07 and as per the direction of Engineer-in-charge. | Sqm | 2490.00 | 5.90 | 14691 |
| 10.28 | Providing and making site enhancement by planting of two trees at tube well and water stand post as per Drawing no. OSRP/CEG/SH/ENV/07 and as per the direction of Engineer-in-charge. | No | 130 | 50.00 | 6500 |
| 10.29 | Planting at junction as per drawing no. OSRP/CEG/SH/ENV/01-A,01-B,01-C and as per the direction of Engineer-in-charge. | No | 25200 | 15.00 | 378000 |
| 10.30 | Providing and fixing fixed flower vase as per drawing no. OSRP/CEG/SH/ENV/04-A and as per the direction of Engineer-in-charge. | No | 105 | 100.00 | 10500 |
| 10.31 | Planting of shrubs & trees at 2.5m spacing including digging of pits manure as per drawing no. OSRP/CEG/SH/ENV/04-A, B, C, D, 05 and as per the direction of Engineer-in-charge. | No | 1520 | 50.00 | 76000 |
| 10.32 | Planting of shrubs on both sides of approach road at 30cm interval with digging of pits,30/30/30cm manuring insecticides and pesticides as per drawing no. OSRP/CEG/SH/ENV/04-A,B,C,D,05 and as per the direction of Engineer-in-charge. | No | 2660 | 20.00 | 53200 |
| 10.33 | Planting of **climbers** at 50cm interval from plant to plant inside the compound near boundary wall and interception wall with digging of pits 30/30/30cm manuring, watering etc for 1yr as per drawing no. OSRP/CEG/SH/ENV/04-A,B,C,D,05 and as per the direction of Engineer-in-charge. | No | 1330 | 20.00 | 26600 |
| 10.34 | Construction of approach road with **GSB** and murrom topping well mixed and compacted as hard shoulder as per technical specification Cl.400-2 drawing no. OSRP/CEG/SH/ENV/04-A,B,C,D,05 and as per the direction of Engineer-in-charge. | Lm | 365.00 | 412.30 | 150490 |
| 10.35 | Providing **Cement paint** two coats to the walls as per drawing no. OSRP/CEG/SH/ENV/04-A,B,C,D,05 and as per the direction of Engineer-in-charge. | Sqm | 998.00 | 8.00 | 7984 |
| 10.36 | Maintenance of **haulage road** for 4 occurrences through out the construction period as per technical specification cl.no.3002 and as per the direction of Engineer-in-charge. | Lm | 11440.00 | 55.00 | 629200 |
| 10.37 | Providing and making site enhancement Plantation including maintenance with specified enclosed in schedule and as per the direction of Engineer-in-charge. | No | 2400 | 9.94 | 23850 |
| | **Total for Bill No. 10** | | | | **15905277** |
| | **(Carried forward to Summary, p. ____)** | | | | |

| Item No. | Description | Unit | Quantity | Rate | Amount |
|---|---|---|---|---|---|
| | **BILL NO. - 11 : PROVISIONAL ITEMS** | | | | |
| 11.01 | Cutting of trees including cutting of trunks, branches and removal of stumps including stacking of serviceable material within a lead of 1000 metres and earthfilling in the depression/pit | | | | |
| | a) Girth From 300mm to 600mm | No | 82 | 79.20 | 6494 |
| | b) Girth From 600mm to 900mm | No | 175 | 161.00 | 28175 |
| | c) Girth From 900mm to 1800mm | No | 1935 | 283.70 | 548960 |
| | d) Girth From 1800mm to Above | No | 98 | 512.50 | 50225 |
| 11.02 | A) Plantation of trees | No | 9150 | 10.00 | 91500 |
| | B) Planting of plants & shrubs in median/ verges | Lm | 25000.00 | 20.00 | 500000 |
| 11.03 | Boring for soil investigation including conducting necessary tests and preparation of report, as per direction of the Engineer and Technical Specification Clause 2400. | Lm | 300.00 | 400.00 | 120000 |
| 11.04 | Co-ordination for Shifting of Utilities as per Technical Specification Clause 110. | Km | 68.00 | 2000.00 | 136000 |
| 11.05 | Construction of building (plinth area 9 sq m.) and installation of weigh bridge including arrangement for electric supply, all electrical items like lights, exhaust fans, sockets, receptacles and complete wiring with necessary earthing etc. complete as directed by Engineer. | No | 2 | 40500.00 | 81000 |
| 11.06 | Providing and fixing Pedestrian guard rails in 2m and 1m modules including painting with approved paint complete as per drawing and Technical Specification Clause 803,1008,1300 & 1700 | Lm | 10000.00 | 3000.00 | 30000000 |
| 11.07 | Conducting drilling a perfectly vertical bore hole of specified dia and depth through consolidated & unconsolidated rock with down the hole with own hammer drilling rigs or combination drilling rigs as required to suit the site condition as per Eng-in-Charge and including tools, plants and consumables etc., for lowering of 125mm dia PVC/CI pipes for housing fitted with socket and with or without well screen as per the necessity for soft, medium, hard and boulder formation (CI/PVC) casing pipes if prevent to collapse of over burden is to be provide by the contraactor including lowering and withdrawing after completion of the tube well 125/100mm dia bore.as per drawing no.OSRP/CEG/SH/ENV/07, | | | | |
| | 0 to 30mtr. | Mtr | 1860.00 | 345.00 | 641700 |
| | 31Mtr to 60mtr. | Mtr | 1860.00 | 342.00 | 636120 |
| | 60mtr. To 75mtr | Mtr | 930.00 | 279.00 | 259470 |
| 11.08 | Providing labour for lowering the following size of PVC or GI pipes or without strainers as per necessity and fitted and fixed including cutting and threading the pipe as may be necessity and supplying all jointing materials extra socket (Gi or PVC of heavy quality) T&P etc, complete and keeping the top of the casing pipe threaded including plugging the tube well to prevent the entry of foreign matter from above.90 to 60mtr and above.as per drawing no.OSRP/CEG/SH/ENV/07and labour as per direction of Eng-in-Charge. | Mtr | 1860.00 | 36.00 | 66960 |

| Item No. | Description | Unit | Quantity | Rate | Amount |
|---|---|---|---|---|---|
| 11.09 | Cleaning & developing the tube wells with Compressor supplied by the contractor continuously worked till clear and the quota discharge is obtained from the tubewells including supply and use of necessary equipment and labour as per direction of Eng-in-Charge. | Each | 62.00 | 200.00 | 12400 |
| | Providing labour for fixing of 1m II hand pump | Each | 62.00 | 100.00 | 6200 |
| | Supplying 125mm PVC pipe | RM | 1860.00 | 500.00 | 930000 |
| | Supplying 1m II hand pump | Each | 62.00 | 5000.00 | 310000 |
| | Supplying 32mm GI riser pipe | Each | 496.00 | 350.00 | 173600 |
| 11.10 | Conducting enumeration of trees jointly by forest,revenue,private individual,PIU and contractors representaives with blazing15/15cm removal of blazed bark,encircling the cut end with approved paint digit hammering of the property hammer and marking hammer impression | Nos | 69.00 | 80.00 | 5520 |
| | **Total for Bill No. 11**<br>**(Carried forward to Summary, p. ____)** | | | | **34604324** |