GOVERNMENT OF ORISSA
WORKS DEPARTMENT

ORISSA STATE ROAD PROJECT

FEASIBILITY STUDY AND DETAILED PROJECT PREPARATION FOR PHASE-I ROADS

FINAL DETAIL ENGINEERING REPORT
BHADRAK - CHANDBALI (0/00 TO 45/00)
BHADRAK – ANANDPUR (0/00 TO 50/00)

(MAY - 2007)

MAIN REPORT

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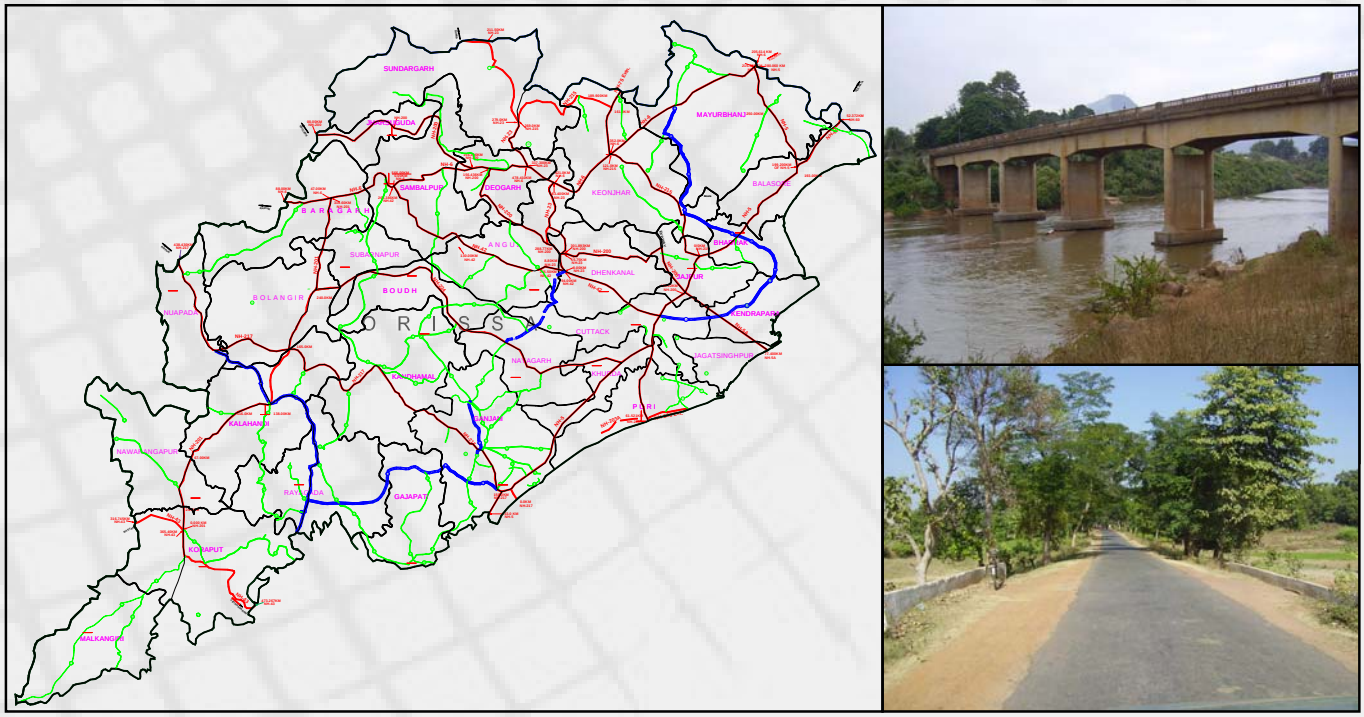

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ABBREVATIONS

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 Bhadrak to Chandbali (km 0/0 to km 45/0 of SH-9) and Bhadrak – Anandpur (km 0/0 to 50/0 of SH-53) under Phase-I. This is a part of Bhadrak - Anandapur - Karanjia - Jashipur 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-9 i.e. km 1/0, 2/0, 3/0, 5/0, 6/0, 7/0, 8/0, 9/0, 10/0, 11/0, 12/0, 13/0,14/0,15/0,16/0,17/0,18/0,19/0,20/0,21/0,22/0,23/0,24/0,25/0,26/0,27/0,28/0,29/0, 30/0,32/0,33/0,34/035/0,36/0,37/0,38/0,39/0,44/0 and Low to high expansive soils of CL- CI-CH group are found in various Sections of SH-53i.e. km 1/0, 2/0, 3/0, 4/0, 5/0,7/0,8/0,9/0,10/0,11/0,12/0,13/0,14/0,15/0,16/0,17/0,18/0,19/0,20/0,21/0,22/0,23/0, 24/0,25/0,26/0,30/0,32/0,33/0,34/035/0,37/0,39/0,40/0,42/0,43/0,46/0,47/0,48/0,49/0, 50/0,51/0,52/0,53/0,54/0,55/0,56/0,57/0. 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 for Bhadrak – Chandbali Stretch

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

Table 2: Sources of Construction Material for Bhadrak – Anandpur Stretch

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

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

Table 3: Recommendations from Subsoil Investigations for Bhadrak-Chandbali Road

Location	Chainage	Type of foundation	Minimum Depth of Foundation
1	1/005	Open	1.5m from bed level
2	1/800	Open	1.5m from bed level
3	3/200	Pile	15m from ground level
4	3/900	Pile	15m from ground level

Location	Chainage	Type of foundation	Minimum Depth of Foundation
5	13/600	Open	2.0m from bed level
6	28/100	Open	2.0m from bed level
7	30/050	Open	1.5m from bed level
8	31/600	Open	1.5m from bed level
9	31/950	Open	1.5m from bed level
10	36/005	Open	1.5m from bed level
11	42/400	Open	2.0m from bed level
12	43/500	Open	2.0m from bed level
13	46/700	Open	1.5m from bed level

Table 4: Recommendations from Subsoil Investigations for Bhadrak-Anandpur Road

Location	Chainage	Type of foundation	Minimum Depth of Foundation
1	11/600	Open (Isolated/Raft)	2.5m from bed level
2	17/700	Open (Isolated/Raft)	2.5m from bed level
3	37/600	Open (Isolated/Raft)	2.5m from bed level

10. Hydrological investigations were carried out to determine hydraulic adequacy of the structures. None of the Bridge found inadequate.

11. A detailed inventory and condition survey was carried out for structures. There are total 32 bridges all of them are minor bridges. All bridges and culverts were inspected for their present condition and verified jointly with PIU Engineers. NDT test were conducted for bridges at Chainage 6/050,9/300 and 38/100 on Bhadrak – Chandbali stretch and at chainage 19/300,37/600,37/850,38/010 and 38/200 on Bhadrak – Anandpur stretch to study the structural soundness of the structures. The recommendations are as follows.

Table 5: Inventory and Condition of Existing Bridges (Bhadrak – Chandbali)

Sl. No.	Location/ Chainage	Existing Span Arrangement	Type of Superstructure	Type of foundation	Overall condition/ Recommendation
1	0/00	2 x 6.5	Solid Slab	Open foundation	Good, Rehabilitation required
2	1/005	2 x 3.45	Solid Slab	Open foundation	Reconstruction due to poor condition
3	1/800	2 x 3.4	Solid Slab	Open foundation	Reconstruction due to poor condition
4	3/200	5 x 3.7	Solid Slab	Open foundation	Reconstruction due to poor condition
5	3/900	3 x 7.6	Solid Slab	Open foundation	Reconstruction due to poor condition
6	6/050	4 x 6.7	Solid Slab	Open foundation	Rehabilitation required
7	9/200	5 x 2.7	Solid Slab & Arch	Open foundation	Reconstruction due to poor condition
8	9/300	3 x 7.0	Solid Slab	Open foundation	Rehabilitation required

Sl. No.	Location/ Chainage	Existing Span Arrangement	Type of Superstructure	Type of foundation	Overall condition/ Recommendation
9	13/600	2 x 4.5	Solid Slab	Open foundation	Reconstruction due to poor condition
10	28/100	3 x 4.35	Solid Slab	Open foundation	Reconstruction due to poor condition
11	28/800	6 x 2.5	Solid Slab	Open foundation	Reconstruction due to submergence and poor condition
12	30/050	10 x 2.0	Solid Slab	Open foundation	Reconstruction due to submergence and poor condition
13	30/200	2 x 6.7	RCC Cell Box	Raft foundation	Good, Rehabilitation required
14	32/100	4 x 1.75	Solid Slab	Open foundation	Reconstruction due to submergence and poor condition
15	33/500	5 x 2.0	Solid Slab	Open foundation	Reconstruction due to submergence and poor condition
16	33/900	5 x 1.9	Solid Slab	Open foundation	Reconstruction due to submergence and poor condition
17	34/700	1 x 10.3	RCC girder with slab	Open foundation	Good, Rehabilitation required
18	36/005	10 x 2.1	Solid Slab	Open foundation	Reconstruction due to submergence and poor condition
19	38/100	5 x 10.45	RCC girder with slab	Pile foundation	Good, Rehabilitation required
20	42/400	2 x 3.65	Solid Slab & Arch	Open foundation	Reconstruction due to poor condition
21	43/500	2 x 3.2	Solid Slab	Open foundation	Reconstruction due to poor condition

Table 6: Inventory and Condition of Existing Bridges (Bhadrak – Anandpur)

Sl. No.	Location/ Chainage	Existing Span Arrangement	Type of Superstructure	Type of foundation	Overall condition/ Recommendation
1	9/800	(1 x 3.55) + (1 x 3.95)	Solid slab	Open foundation	Reconstruction due to poor condition
2	11/600	2 x 7.0	Rolled steel girder with RCC slab	Open foundation	Reconstruction due to poor condition
3	17/700	2 x 7.0	Solid slab	Open foundation	Reconstruction due to poor condition
4	18/400	1 x 6.9	Solid slab	Open foundation	Reconstruction due to submersible and poor condition
5	19/300	2 x 6.3	Solid slab	Open foundation	Good, Rehabilitation required
6	30/950	1 x 5.5	Solid slab	Open foundation	Good, Rehabilitation required
7	37/600	1 x 8.6	Solid slab	Open foundation	Good, Rehabilitation required

Sl. No.	Location/ Chainage	Existing Span Arrangement	Type of Superstructure	Type of foundation	Overall condition/ Recommendation
8	37/700	1 x 8.6	Solid slab	Open foundation	Good, Rehabilitation required
9	37/850	1 x 8.6	Solid slab	Open foundation	Good, Rehabilitation required
10	38/010	1 x 8.3	Solid slab	Open foundation	Good, Rehabilitation required
11	38/200	2 x 5.1	Solid slab	Well foundation	Good, Rehabilitation required

The total numbers of culverts are 151 in a road length of 95 Kms i.e from km 0/0 to 45/0 of SH-9 and 0-50 of SH-53. Details of the Existing and proposed culverts are available in Chapter 2. Following table gives the details of existing culverts.

Table 7: Summary of Existing Culverts (Bhadrak – Chandbali)

Type of Culvert	Nos.
Pipe	27
Slab	19
Arch	5
Choked	1
Total	**52**

Table 8: Summary of Existing Culverts (Bhadrak – Anandpur)

Type of Culvert	Nos.
Pipe	51
Slab	36
Arch	4
Choked	8
Total	**99**

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 Road has sharp horizontal curves and insufficient vertical design standard, which do not provide adequate overtaking sight and stopping distance even for 50 kmph thereby making the accidents more frequent. Existing road junctions are not properly designed. These deficiencies have been properly attended in the design.

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-03 at km

5/500 of SH-9 (near Barik Chhak) and other VC-04 at 4/600 of SH-53 (near FACOR Factory). Axle load survey was carried out at two locations near Bhadrak (Km 3 of SH-9), and Near Karanjia (before junction of SH-53 & SH-49) designated as AL-02 and AL-04, 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 9: Summary of AADT and PCU

Count Stn.	Description	Total Motorised Vehicle	Total Comm. Vehicle	Total Non Motorised Vehicle	Total Vehicle
VC-03	AADT	3543	454	2056	5599
	PCU	3054	1030	1184	4238
VC-04	AADT	4142	1069	1939	6081
	PCU	4895	2929	1060	5955

Table 10: 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-02	Bhadrak - Chandbali	0.44	6.72	3.5	3.50	3.5
AL-04	Bhadrak - Anandpur	0.34	4.38	3.5	3.50	3.5

Table 11: Design MSA

Location	Design Year	Design MSA
VC-03	2028	15.15
VC-04	2025	37.93

Table 12: Projected Traffic

Year	AADT		PCU	
	VC-03	VC-04	VC-03	VC-04
2008	6704	7282	5242	7356
2013	8557	10018	7007	11104
2018	11289	14562	9689	17600
2023	14867	21472	13353	28014
2028	19385	31128	18160	43292

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. All the existing bridges are minor bridges. 6 numbers of bridges are recorded as submerged and also in poor condition and have been proposed for reconstruction to have all weather road, it is recommended for re-construction on Bhadrak –Chandbali stretch.. The bridge at Ch. 18/400 is recorded as submerged and also in poor condition and have been proposed for reconstruction on Bhadrak – Anandpur stretch.

20. 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 summary of retained, widening and new culverts are given in table below.

Table 6.13: Summary of proposed Culverts (Bhadrak - Chandbali)

Type of Culvert	**Nos.**
Culverts Widened	
Slab widening	3
Culverts Replaced	
New Single Box of 1/22/0	33
New Single Box of 1/23/0	8
New Single Box of 1/33/0	1
New Single Box of 1/34/0	1
New Single Box of 1/43/0	3
New Single Box of 1/63/0	1
New Single Box of 1/64/0	1
Additional Culverts Proposed	

Type of Culvert	Nos.
Single Cell Box of 1/23/0	1
New Single Box of 1/43/0	14
New Single Box of 1/44/0	5
Total	**71**

Table 6.14: Summary of proposed Culverts (Bhadrak - Anandpur)

Type of Culvert	Nos.
Culverts Widened	
Pipe extension	12
Culverts Replaced	
New Single Pipe	13
New Double Pipe	22
New Single Box of 1/22/0	15
New Single Box of 1/23/0	10
New Single Box of 1/33/0	10
New Single Box of 1/34/0	7
New Single Box of 1/43/0	3
New Single Box of 1/44/0	2
New Single Box of 1/63/0	1
Additional Culverts Proposed	
Single Cell Box of 1/22/0	1
Single Cell Box of 1/23/0	3
Single Cell Box of 1/34/0	3
Total	**102**

21. To increase the traffic safety and to reduce traffic accidents, every component of the highways and its users has 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.

22. 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. 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.

23. Estimated total cost of this package is Rs 2157.52 millions which includes engineering cost as Rs 1809.20 millions. Estimated cost for provisional items, social, environmental and utility shifting costs as Rs 207.18 millions. The total cost also includes engineering supervision, PIU project office and contingencies.

CHAPTER - 1
INTRODUCTION

CHAPTER 1

INTRODUCTION

1.1 GENERAL

The fast growing Orissa State is one of the major state of India with population 36.8 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 Bhadrak – Chandbali (SH-9) (km 0/0 to km 45/0) and Bhadrak – Anandpur (SH-53) (km 0/00 – 50/00). The report presents detailed design of road and bridges with cost for upgrading existing single lane road to two-lane road. 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 4600 km 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 2347 km to identify 700 km 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 198 km which was later declared National Highway (NH-224) and as a result of techno-economic studies in this project, 1200 km 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.) has been submitted.

Present submission is Final Detailed Engineering Report of Bhadrak - Chandbali (km 0/0 to km 45/0) and Bhadrak – Anandpur (0/00 to 50/00).

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

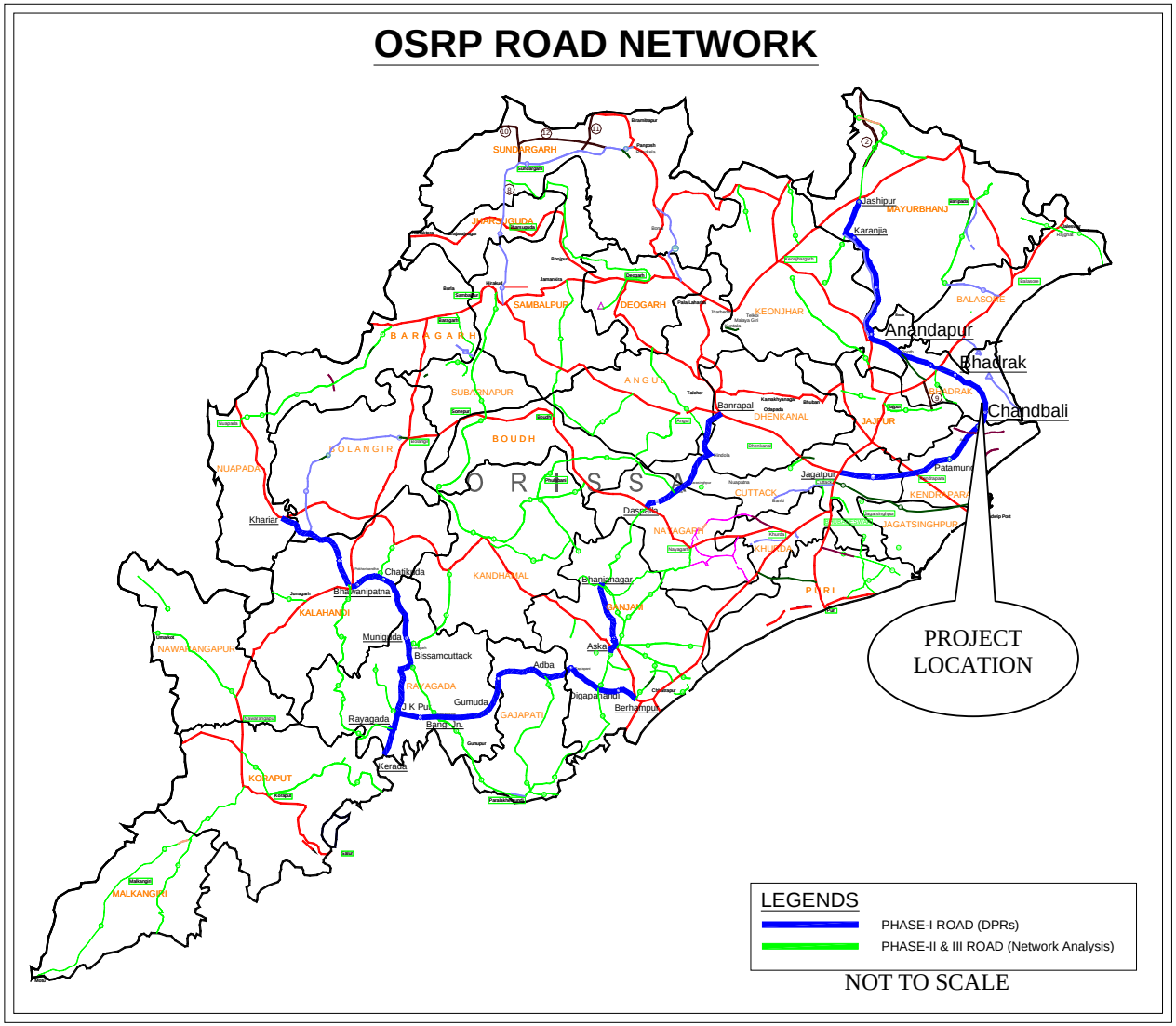
Construction Year-1 Packages						
Package No.	**Road Section**	**SH/MDR**	**From**	**To**	**Length (km)**	**Length of Package (km)**
1	**Chandbali – Bhadrak**	**SH-9**	**0**	**45**	**45**	**95**
	Bhadrak – Anandpur	**SH-53**	**0**	**50**	**50**	
2	Berhampur- Taptapani	SH-17	0	41	41	41
3	Khariar- Bhawanipatna	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						**356**
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	50	57	7	87
	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 with Bhawanipatna bypass (length?)	SH-16 ???	0	2 (check? ?	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						**476**

1.5 CONTRACT PACKAGE- BHADRAK – CHANDBALI (KM 0/0 TO KM 45/0) & BHADRAK – ANANDPUR (0/0 TO 50)

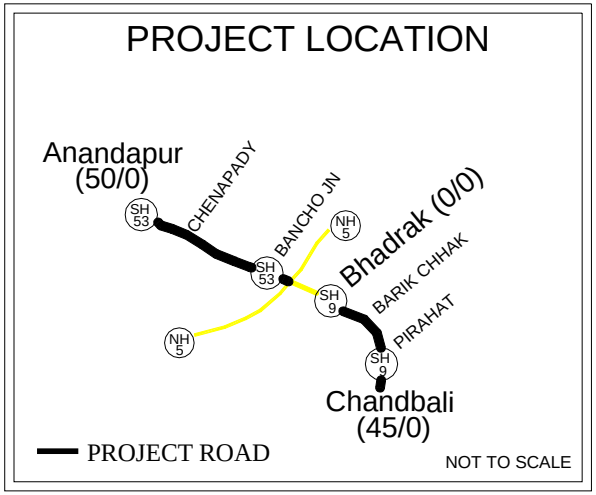
The present submission is the final Detailed Engineering Report for Bhadrak to Chandbali (km 0/0 to km 45/0 of SH-9) and Bhadrak – Anandpur (km 0/0 to km 50/0) which is a part of the project corridor Bhadrak - Anandapur - Karanjia – Jashipur -137 km. The road stretch Bhadrak – Chandbali – SH-9 (0/0 to 45/0) starts at Bhadrak (0/0) and ends at Chandbali (45/0), Bhadrak – Anandpur stretch starts from Kolkata - Chennai 4 - lane highway (NH-5) Chainage 155/00. The Bhadrak is a district headquarters of Bhadrak, Chandbali is major town and a business hub in the Bhadrak District, Anandpur is a town in Keonjhar District.

The Chandbali – Bhadrak and Bhadrak – Anandpur stretch traverses through plain terrain and has mostly flat gradients 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 5.5 m with 1.0 m to 1.5m earthen shoulders on both sides. Riding quality all along the road is from good to poor. There are total 32 existing bridges, all are minor bridges including vented causeway more than 6m, total number of existing culverts are 151. About 32% of the road length passes through built-up area.

The improvement works involves development of existing road to two lanes with 20 years design period for Chandbali - Bhadrak stretch and 16 years design period for Bhadrak –Anandpur stretch.


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

Map 1.1


PROJECT LOCATION
Anandapur
(50/0)
CHENAPADY
SH 53
BANCHO JN
NH 5
SH 53
Bhadrak (0/0)
SH 9
BARIK CHHAK
PIRAHAT
NH 5
SH 9
Chandbali
(45/0)
PROJECT ROAD
NOT TO SCALE

1.6 COMPOSITION OF REPORT

The Detailing Engineering Report consists of Eleven ten 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
- Electrical Utility Shifting Plan (Chandbali – Bhadrak)
- Electrical Utility Shifting Plan (Bhadrak - Anandpur)
- Utility Shifting Plan (Telephone, OFC and Hand Pump) (Chandbali – Bhadrak)
- Utility Shifting Plan (Telephone, OFC and Hand Pump) (Chandbali – Bhadrak)

Electrical utility shifting plan, utility shifting plan of Telephone, OFC and Hand Pump, Standard Drawings for Highway for both stretches i.e., Bhadrak – Chandbali and Bhadrak - Anandpur already been submitted, same shall apply.

The Draft Detailed Engineering Report for this project road has already been submitted vide this office Letter No. CEG/OR/001/2007/322, dated January 25th 2007.

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 Nine 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 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 separate volume).

Chapter 10: Environment 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 Survey of India, Bhubaneswar 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 Bhadrak 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 0/0 to 45 /0 of SH-9 and km 0/0 to 50/0 of SH-53 are given in Table 2.1 and 2.2 respectively

Table 2.1 List of TBM (Bhadrak – Chandbali)

BM Id	East	North	Elevation	BM Id	East	North	Elevation
BMP51	471447.809	2296744.808	7.072	BMP23	465911.105	2318232.399	7.178
BMP48	473779.358	2298441.795	8.278	BMP22	464952.805	2318523.704	6.773
BMP47	474375.876	2299239.827	5.386	BMP21	463996.683	2318840.007	7.451
BMP46	474544.945	2300232.104	7.515	BMP20	463036.822	2319134.469	7.938
BMP45	474654.713	2301237.042	7.012	BMP19	462101.042	2319503.565	7.852
BMP44	474659.566	2302233.839	7.204	BMP18	461196.85	2319933.285	6.866
BMP43	474628.349	2303235.202	6.638	BMP17	460310.733	2320401.713	8.401
BMP42	474406.119	2304205.545	5.274	BMP16	459596.953	2321105.876	7.072
BMP41	474704.777	2305139.044	7.076	BMP15	458903.577	2321824.872	6.862
BMP40	474909.471	2306126.025	8.789	BMP14	458172.42	2322517.535	7.466
BMP39	475079.998	2307115.815	7.363	BMP13	457385.708	2323134.972	7.605
BMP38	474745.645	2308072.244	6.1	BMP12	456423.493	2323346.95	9.402
BMP37	474227.578	2308892.896	5.027	BMP11	455646.988	2323851.585	8.624
BMP36	473430.38	2309620.526	5.185	BMP10	454704.964	2324191.933	11.237
BMP35	473237.91	2310299.542	5.021	BMP9	454316.851	2325092.528	10.236
BMP34	472899.129	2311401.904	5.338	BMP8	453439.865	2325570.746	11.592
BMP33	472629.474	2312324.555	7.524	BMP7	452529.773	2325986.76	12.271
BMP32	472430.467	2313248.446	5.188	BMP6	451609.252	2325977.803	12.18
BMP31	472328.298	2314263.165	6.331	BMP5	450662.467	2326092.092	13.504
BMP30	472116.966	2315142.434	5.419	BMP4	449695.466	2326350.551	14.601
BMP27	469293.639	2316100.154	6.205	BMP3	449127.059	2327074.174	15.561
BMP25	467658.353	2317250.176	5.963	BMP2	448425.08	2327799.056	16.109
BMP24	466814.558	2317802.132	6.652	BMP1	447557.341	2328310.277	17.127

Table 2.2 List of TBM (Bhadrak – Anandpur)

BM Id	East	North	Elevation	BM Id	East	North	Elevation
BMP0	445357.574	2327334.897	19.359	BMP30	418897.339	2337888.588	39.298
BMP1	444455.329	2327151.407	19.209	BMP31	418057.209	2338417.691	39.905
BMP2	443486.926	2327326.829	19.889	BMP32	417167.977	2338927.692	41.908
BMP3	442763.473	2327918.368	20.221	BMP33	416413.493	2339359.784	41.1
BMP4	441840.475	2328298.979	20.836	BMP34	415592.25	2339851.427	42.057
BMP5	440923.393	2328693.978	21.461	BMP35	414740.596	2340319.562	42.95
BMP6	439970.048	2329093.981	21.855	BMP36	413895.851	2340719.994	42.208
BMP7	439098.794	2329526.968	22.749	BMP37	412947.018	2340776.583	40.399
BMP8	438223.1	2329981.666	23.497	BMP37/ 600	412426.565	2340855.499	38.43
BMP9	437676.233	2330256.493	24.438	BMP39	411129.964	2341103.763	37.388
BMP10	436711.658	2330527.577	24.08	BMP40	410153.739	2341217.679	37.628
BMP11	435775.818	2330875.085	24.852	BMP41	409216.203	2341326.446	38.562
BMP12	434962.532	2331255.987	23.933	BMP42	408252.47	2341444.46	40.062
BMP13	433975.195	2331397.362	25.999	BMP43	407347.045	2341710.056	40.273
BMP14	433095.341	2331818.21	25.77	BMP44	406402.87	2341784.799	44.897
BMP15	432130.614	2332078.875	27.122	BMP45	405538.315	2342140.232	43.997
BMP16	431165.275	2332353.727	28.541	BMP46	405602.993	2343075.085	46.588
BMP17	430223.953	2332681.518	29.701	BMP47	406097.847	2343940.332	49.99
BMP18	429353.03	2332700.735	30.744	BMP48	406051.872	2344946.791	44.954
BMP19	428408.435	2332657.819	31.016	BMP49	406023.721	2345976.633	48.359

BM Id	East	North	Elevation	BM Id	East	North	Elevation
BMP20	427457.987	2332890.233	33.156	BMP50	406035.378	2346959.076	53.256
BMP21/230	426297.608	2333303.414	32.365	BMP51	405715.887	2347835.405	49.75
BMP22/300	425404.072	2333644.962	32.547	BMP52	404821.211	2348310.432	52.423
BMP24	423791.273	2334394.481	34.292	BMP53	403975.596	2348785.399	54.103
BMP25	422955.34	2334988.057	35.334	BMP54	403039.217	2349274.686	58.817
BMP26	422101.427	2335506.594	37.063	BMP55	402374.649	2349944.677	58.794
BMP27	421300.094	2336104.562	37.391	BMP56	402350.406	2350954.881	59.318
BMP28	420505.114	2336710.805	37.497	BMP57	402626.298	2351911.348	60.606
BMP29	419703.447	2337306.609	38.312				

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 section covers the details of tests and investigations carried out for evaluating the characteristics of the sub-grade along the project road Bhadrak – Chandbali (SH-9) (Km 0/00 to Km 45) and Bhadrak - Anandpur (SH-53) (Km 0/00 to Km 50/00) 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, strengthening and reconstruction 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: 19-2001.

The main tasks carried out for soil and material investigations include:

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 for stretch Chandbali – Bhadrak are reported in Table 2.1 of Material Report – Part II, reproduced here also in Table 2.3.

The results of the above field and laboratory investigations for various test pits for stretch Bhadrak - Anandpur are reported in Table 2.1 of Material Report – Part IV, reproduced here also in Table 2.4.

Table 2.3 Soil Investigation Data of Existing Subgrade (Bhadrak – Chandbali) (0/00 to 45/00)

Sl. No.	Location (Km.)	Description of soil	Gradation: Percent by weight retained the Sieve (IS:2720-IV)				Clay and silt content %	Atterberg Limits			Modified Proctor Test (IS:2720-Pt-VIII)		Field dry density at subgrade level gm/cc	In-situ Moisture content %	CBR Soaked %	DFS	Group of soil
			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	18
1	0/0	Silty Clay (Inorganic)	2.05	1.07	6.77	7.0	83.11	53	25	28	1.74	20.5	1.714	12.3	3.2	54	CH
2	1/0	Silty Clay with sand	2.14	0.89	6.36	11.04	79.57	47	21	26	-	-	1.675	14.50	-	56.67	CI
3	2/0	Silty Clay (Inorganic)	1.55	2.42	4.92	6.66	84.45	54	21	33	1.77	19.85	1.723	14.00	3	63	CH
4	3/0	Silty Clay with sand	2.06	0.51	16.47	15.92	65.04	35	20	15	1.878	14.68	1.709	14.00	5.2	58	CL
5	4/0	Silty Sand with Clay	0.16	0.42	21.28	32.52	45.62	29	22	7	1.84	12.05	1.655	13.50	9.2	16	SM-SC
6	5/0	Silty Clay with sand	0.37	0.62	14.05	24.4	60.56	34	20	14	-	-	1.674	13.00	-	-	CL

Sl. No.	Location (Km.)	Description of soil	Gradation: Percent by weight retained the Sieve (IS:2720-IV)				Clay and silt content %	Atterberg Limits			Modified Proctor Test (IS:2720-Pt-VIII)		Field dry density at subgrade level gm/cc	In-situ Moisture content %	CBR Soaked %	DFS	Group of soil
			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	18
7	6/0	Silty Clay with sand	0.85	0.7	13.9	23.1	61.45	36	20	16	1.84	15.02	1.681	14.00	6.5	41	CL
8	7/0	Silty Clay with sand	0.98	0.65	14.05	22.5	61.82	35	19	16	-	-	1.717	15.50	-	-	CL
9	8/0	Silty Clay with sand	5.07	2.27	12.7	12.62	67.34	35	20	15	-	-	1.77	15.00	-		CL
10	9/0	Silty Clay with sand	6.05	1.95	11.05	11.15	69.8	39	20	19	1.79	17.01	1.712	16.00	5.9	52	CI
11	10/0	Silty Clay with sand	0.0	0.21	4.32	32.07	63.4	34	22	12	-	-	1.717	18.00	-		CL
12	11/0	Silty Clay with sand	0.23	0.64	2.62	7.02	89.49	46	22	24	1.79	15.02	1.713	13.50	3.0	58	CI
13	12/0	Silty Clay with sand and Gravel	0.95	0.84	2.42	7.35	88.44	47	21	26	-	-	1.724	15.50	-	-	CI

Sl. No.	Location (Km.)	Description of soil	Gradation: Percent by weight retained the Sieve (IS:2720-IV)				Clay and silt content %	Atterberg Limits			Modified Proctor Test (IS:2720-Pt-VIII)		Field dry density at subgrade level gm/cc	In-situ Moisture content %	CBR Soaked %	DFS	Group of soil
			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	18
14	13/0	Silty Clay with sand	0.135	0.16	3.97	12.57	83.165	45	21	24	1.85	16.4	1.712	12.10	3.8	60	CI
15	14/0	Silty Clay with sand	1.9	0.95	3.45	12.65	81.05	46	21	25	-	-	1.741	13.20	-	-	CI
16	15/0	Silty Clay with sand	0.86	1.65	9.22	12.27	76.02	40	20	20	1.73	14.05	1.739	17.50	4.8	50.45	CI
17	16/0	Silty Clay with sand and Gravel	7.05	0.65	7.05	11.35	73.9	42	20	22	-	-	1.705	14.00	-	-	CI
18	17/0	Silty Clay with Sand	0.23	0.25	1.95	18.13	79.44	43	21	22	-	-	1.697	14.50	-	-	CI
19	18/0	Silty Clay with Sand	5.05	1.05	1.85	17.25	74.8	39	20	19	-	-	1.687	16.00	3.5	-	CI
20	19/0	Silty Clay with Sand	3.02	1.15	2.05	16.02	77.76	38	19	19	-	-	1.708	15.50	-	-	CI

Sl. No.	Location (Km.)	Description of soil	Gradation: Percent by weight retained the Sieve (IS:2720-IV)				Clay and silt content %	Atterberg Limits			Modified Proctor Test (IS:2720-Pt-VIII)		Field dry density at subgrade level gm/cc	In-situ Moisture content %	CBR Soaked %	DFS	Group of soil
			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	18
21	20/0	Silty Clay with Sand	2.16	1.19	3.49	6.23	86.93	45	22	23	1.72	18.02	1.764	14.60	3.6	59.58	CI
22	21/0	Silty Clay with Sand	0.29	0.83	1.48	3.07	94.33	48	23	25	-	-	1.70	14.20	-	37.5	CI
23	22/0	Silty Clay (Inorganic)	0.0	0.0	0.87	5.08	94.05	52	24	28	1.76	15.9	1.733	13.40	2.5	61.25	CH
24	23/0	Silty Clay with Sand	1.27	0.87	2.09	3.58	92.19	47	23	24	-	-	1.712	13.40	-	-	CI
25	24/0	Silty Clay with Sand	0.45	0.39	1.42	13.68	84.06	42	20	22	-	-	1.70	16.50	-	-	CI
26	25/0	Silty Clay (Inorganic)	0.0	0.31	1.05	3.61	95.03	54	23	31	1.79	16.64	1.75	14.50	2.2	60	CH
27	26/0	Silty Clay with Sand with Gravel	6.08	1.15	3.02	34.65	55.1	32	20	12	1.81	14.05	1.725	12.20	6.8	-	CL

Sl. No.	Location (Km.)	Description of soil	Gradation: Percent by weight retained the Sieve (IS:2720-IV)				Clay and silt content %	Atterberg Limits			Modified Proctor Test (IS:2720-Pt-VIII)		Field dry density at subgrade level gm/cc	In-situ Moisture content %	CBR Soaked %	DFS	Group of soil
			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	18
28	27/0	Silty Clay with Sand	0.0	1.31	6.7	14.6	77.39	38	20	18	-	-	1.684	13.93	-	-	CI
29	28/0	Silty Clay with Sand	1.14	0.94	1.69	3.34	92.89	46	22	24	1.78	15.92	1.766	14.00	2.6	55	CI
30	29/0	Silty Clay with Sand	0.0	0.39	3.47	4.81	91.33	45	22	23	-	-	1.712	13.20	-	-	CI
31	30/0	Silty Clay (Inorganic)	0.20	0.65	0.57	1.94	97.14	55	24	31	1.76	18.01	1.69	16.10	2.8	60	CH
32	31/0	Silty Clay with Sand	0.85	0.6	1	31.85	65.7	34	20	14	1.78	14.65	1.741	15.20	6.5	28	CL
33	32/0	Silty Clay with Sand	1.9	0.82	7.05	21.4	68.83	39	19	20	-	-	1.741	16.00	-	-	CI
34	33/0	Silty Clay with Sand	0.0	0.9	1.32	2.98	94.82	48	23	25	-	-	1.779	16.00	-	-	CI

Sl. No.	Location (Km.)	Description of soil	Gradation: Percent by weight retained the Sieve (IS:2720-IV)				Clay and silt content %	Atterberg Limits			Modified Proctor Test (IS:2720-Pt-VIII)		Field dry density at subgrade level gm/cc	In-situ Moisture content %	CBR Soaked %	DFS	Group of soil
			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	18
35	34/0	Silty Clay (Inorganic)	0.0	0.46	0.92	0.52	98.1	57	23	34	1.82	18.05	1.724	16.00	2.3	56.25	CH
36	35/0	Silty Clay (Inorganic)	5.37	0.93	2.48	2.07	89.15	52	24	28	-	-	1.702	18.10	-	59.3	CH
37	36/0	Silty Clay (Inorganic)	0.0	0.0	0.31	0.79	98.9	57	25	32	1.79	18.05	1.800	13.20	2.1	69.62	CH
38	37/0	Silty Clay with Sand	6.1	0.35	0.32	18.86	74.37	39	20	19	-	-	1.791	18.10	-	-	CI
39	38/0	Silty Clay (Inorganic)	0.0	0.24	1.06	3.09	95.61	55	24	31	1.84	16.35	1.774	14.67	3.2	59.15	CH
40	39/0	Silty Clay with Sand	6.1	1.02	1.15	23.8	67.93	39	20	19	-	-	1.712	18.00	-	-	CI
41	40/0	Clayey sand with Silt	2.1	0.76	2.27	52.35	42.52	31	23	8	-	-	1.715	13.50	9	18	SC

Sl. No.	Location (Km.)	Description of soil	Gradation: Percent by weight retained the Sieve (IS:2720-IV)				Clay and silt content %	Atterberg Limits			Modified Proctor Test (IS:2720-Pt-VIII)		Field dry density at subgrade level gm/cc	In-situ Moisture content %	CBR Soaked %	DFS	Group of soil
			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	18
42	41/0	Silty Sand with Clay	7.05	2.05	3.05	48.6	39.25	30	23	7	-	-	1.711	13.50	10.2	-	SM-SC
43	42/0	Clayey sand with Silt	1.0	3.26	5.72	42.76	47.26	32	23	9	-	-	1.729	15.50	-	-	SC
44	43/0	Silty asnd	0.0	0.08	0.56	69.94	29.42	23	NP	NIL	1.89	11.45	1.747	14.00	12.2	-	SM
45	44/0	Silty Clay with Sand	1.48	1.43	5.73	14.27	77.09	45	23	22	-	-	1.738	14.20	-	43.75	CI
46	45/0	Silty Sand	3.2	0.45	0.51	78.11	17.73	20	NP	NIL	1.94	10.84	1.719	15.50	13.5	-	SM

Discussion of Results

The soil in this stretch mainly classifies in the group of CI/CH and it is described as Silty Clay respectively. The Silty clay (CI/CH) soil is High plastic and cohesive oil having CBR values (Soaked) ranging from 2.2% to 5.9 %. While the soil Silty sand with clay (SM-SC) is little plastic. In these sections PI value ranges from 7.0 to 9.0. The CBR value (Soaked) of the soil ranges from 9.2% to 10.2%. The maximum dry density at O.M.C. of the existing subgrade soil of CI/CH group varies between 1.74 gm/cm^3 to 1.83 gm/cm^3 .In maximum kilometers, there are Expansive soils found with medium to high degree of expansion.

Expansive Soils and their Treatment

Low to high expansive soils of CL- CI-CH group are found in various Sections of SH-9i.e.km1/0,2/0,3/0,5/0,6/0,7/0,8/0,9/0,10/0,11/0,12/0,13/0,14/0,15/0,16/0,17/0,18/0,19/0,20/0,21/0,22/0,23/0,24/0,25/0,26/0,27/0,28/0,29/0,30/0,32/0,33/0,34/035/0,36/0,37/0,38/0,39/0,44/0. Though, there are maximum kilometers in such a long stretch of road section are expansive nature, it is always preferable either to replace the soil of high expansive properties or to treat the soil of low to medium expansive soils as below.

Thus to reduce the expansive properties of soil, firstly 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 and secondly even if the underlying expansive soil heaves, the movement will be more uniform and consequently more tolerable or it is recommended to either replace the soil by importing good soil from borrow area in the case of high ly expansive soils. 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 and composed of coarse/ medium sand or non-plastic moorum having PI less than five 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.

Table 2.4: Soil Investigation Data of Existing Subgrade (Bhadrak – Anandpur) (0/00 to 50/00)

Sl. No.	Location (Km.)	Description of soil	Gradation: Percent by weight retained the Sieve (IS:2720-IV)				Clay and silt content %	Atterberg Limits [IS:2720-V]			Modified Proctor Test (IS:2720-Pt-VIII)		Field dry density at subgrade level gm/cc	In-situ Moisture content %	CBR Soaked % [IS:2720-16]	DFS in % [IS:2720-40]	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	18
1	1/0	Silty clay with sand	1.11	0.74	8.03	10.11	80.01	52	21	31	1.77	15.07	1.735	13.5	3.3	40	CI
2	2/0	Silty clay with sand	3.8	1.0	9.05	14.02	72.1	37	20	17	-	-	1.705	12.0	-	-	CI
3	3/200	Silty clay with sand	4.78	3.695	15.61	22.815	53.105	34	21	13	1.923	10.8	1.684	11.5	6.5	25	CL
4	4/0	Silty clay with sand	2.45	1.05	15.01	19.08	62.4	35	20	15	-	-	1.691	14.2	-	-	CL-CI
5	5/0	Silty clay with sand	1.04	1.24	17.23	28.11	52.38	31	22	9	-	-	1.718	10.5	-	30.22	CL
6	6/0	Clayey Sand with Silt	2.05	1.84	21.8	39.05	35.26	30	22	8	2.03	9.8	1.724	9.8	8.5	21	SC

Sl. No.	Location (Km.)	Description of soil	Gradation: Percent by weight retained the Sieve (IS:2720-IV)				Clay and silt content %	Atterberg Limits [IS:2720-V]			Modified Proctor Test (IS:2720-Pt-VIII)		Field dry density at subgrade level gm/cc	In-situ Moisture content %	CBR Soaked % [IS:2720-16]	DFS in % [IS:2720-40]	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	18
7	7/0	Silty clay with sand	0.0	0.66	15.19	21.03	63.12	35	21	14	1.893	11.7	1.742	12.5	5.8	20	CL
8	8/0	Silty clay with sand	0.95	1.9	15.05	14.35	67.75	39	20	19	-	-	1.698	13.7	-	-	CI
9	9/0	Silty clay with sand	1.05	1.65	11.6	19.05	66.65	39	21	17	-	-	1.706	14.5	-	-	CI
10	10/0	Silty clay(Inorganic clay)	0	0.34	2.59	4.44	92.63	56	24	32	1.786	20.3	1.687	13.3	2.8	55	CH
11	11/0	Silty clay with sand	1.35	0.68	2.65	17.59	77.73	44	20	24	-	-	1.735	14.7	-	-	CI
12	12/0	Silty clay with sand	6.26	1.68	8.32	15.35	68.39	42	24	18	1.875	12.65	1.705	10.8	5.2	40	CI
13	13/0	Silty clay with sand	2.09	1.79	7.05	16.35	72.72	41	19	22	-	-	1.687	13.4	-	-	CI

Sl. No.	Location (Km.)	Description of soil	Gradation: Percent by weight retained the Sieve (IS:2720-IV)				Clay and silt content %	Atterberg Limits [IS:2720-V]			Modified Proctor Test (IS:2720-Pt-VIII)		Field dry density at subgrade level gm/cc	In-situ Moisture content %	CBR Soaked % [IS:2720-16]	DFS in % [IS:2720-40]	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	18
14	14/0	Silty clay(Inorganic clay)	0.14	0.15	0.69	1.83	97.19	56	26	30	1.78	19.05	1.742	14.8	2.6	58	CH
15	15/0	Silty clay with sand	0.0	4.15	7.83	10.52	77.5	37.0	17.0	20.0	1.86	14	1.717	12.3	4.7	40	CI
16	16/0	Silty clay with sand	0.9	3.05	6.9	19.45	69.7	39	18	21	-	-	1.767	12.8			CI
17	17/0	Silty clay with sand	0.17	0.62	13.88	21.44	63.89	37	22	15	-	-	1.695	13.5			CI
18	18/0	Silty clay	0.92	1.05	9.15	17.3	71.58	46	21	25	1.79	17.02	1.687	14.0	3.2	45	CI
19	19/0	Silty clay with sand	1.28	1.59	8.73	11.32	77.08	47	20	27	-	-	1.696	14.0			CI
20	20/0	Silty clay with sand	2.01	1.38	8.16	8.63	79.82	48	21	27	-	-	1.758	13.3			CI

Sl. No.	Location (Km.)	Description of soil	Gradation: Percent by weight retained the Sieve (IS:2720-IV)				Clay and silt content %	Atterberg Limits [IS:2720-V]			Modified Proctor Test (IS:2720-Pt-VIII)		Field dry density at subgrade level gm/cc	In-situ Moisture content %	CBR Soaked % [IS:2720-16]	DFS in % [IS:2720-40]	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	18
21	21/0	Silty clay with sand	1.95	0.92	7.3	8.35	81.48	47	22	25	-	-	1.686	14.5			CI
22	22/0	Silty clay(Inorganic clay)	0.34	0.79	2.17	4.77	91.93	57	25	32	1.68	22.3	1.657	15.0	2.5	60	CH
23	23/0	Silty clay with sand	2.05	1.09	2.45	17.35	77.06	43	21	22	-	-	1.785	14.6			CI
24	24/0	Silty clay with sand	3.19	2.3	5.55	19.05	69.91	38	20	18	-	-	1.708	13.2		25	CI
25	25/0	Silty clay with sand	1.12	0.69	5.23	7.72	85.24	46	22	24	1.79	14.05	1.694	12.3	2.5	45.0	CI
26	26/0	Silty clay with sand	1.9	0.85	6.25	29.15	61.85	35	22	13	-	-	1.728	14.2		35	CL-CI
27	27/0	Silty clay(Inorganic clay)	0.18	0.18	2.47	11.76	85.41	55	23	32	1.76	19.2	1.715	13.4	3.2	65	CH

Sl. No.	Location (Km.)	Description of soil	Gradation: Percent by weight retained the Sieve (IS:2720-IV)				Clay and silt content %	Atterberg Limits [IS:2720-V]			Modified Proctor Test (IS:2720-Pt-VIII)		Field dry density at subgrade level gm/cc	In-situ Moisture content %	CBR Soaked % [IS:2720-16]	DFS in % [IS:2720-40]	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	18
28	28/0	Silty sand	0	0.6	32.43	35.59	31.38	24	NP	NIL	2.03	8.9	1.821	10.4	9.7	-	SM
29	29/0	Clayey Sand	3.05	1.4	17.45	39.05	39.05	30	22	8	-	-	1.807	11.4	-	-	SC
30	30/0	Silty clay with sand	0.17	0.39	5.26	5.55	88.63	46	22	24	1.81	15.05	1.724	14.2	3	40	CI
31	31/0	Clayey Sand	3.31	1.9	11.05	39.1	44.64	30	22	8	-	-	1.804	9.5	-	-	SC
32	32/0	Silty clay with sand	0.21	0.475	6.615	17.37	75.33	42	21	21	1.853	14.2	1.698	12.8	4.7	35	CI
33	33/0	Silty clay with sand	0.97	0.8	5.39	37.25	55.59	34	22	12	-	-	1.734	11.4	-	-	CL
34	34/0	Silty clay with sand	1.09	0.7	6.05	19.4	72.76	44	21	23	-	-	1.723	13.2	-	-	CI

Sl. No.	Location (Km.)	Description of soil	Gradation: Percent by weight retained the Sieve (IS:2720-IV)				Clay and silt content %	Atterberg Limits [IS:2720-V]			Modified Proctor Test (IS:2720-Pt-VIII)		Field dry density at subgrade level gm/cc	In-situ Moisture content %	CBR Soaked % [IS:2720-16]	DFS in % [IS:2720-40]	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	18
35	35/0	Silty clay(Inorganic clay)	0.12	0.405	3.66	6.695	89.12	53	22	31	1.73	18.5	1.708	12.5	2.8	45	CH
36	36/0	Clayey Sand	3.05	1.09	10.5	39.05	46.31	32	23	9	-	-	1.815	10.4	-	-	SC
37	37/0	Silty clay with sand	0	0.11	7.64	27.73	64.52	35	21	14	-	-	1.728	11.5	-	-	CL-CI
38	38/0	Clayey Sand	2.3	1.05	6.5	41.05	49.1	32	23	9	1.957	10.8	1.827	10.5	9	22	SC
39	39/0	Silty clay with sand	1.9	0.9	5.25	37.75	54.2	33	22	11	-	-	1.806	11.2	-	-	CL
40	40/0	Silty clay with sand	0.38	0.21	7.26	10.18	81.97	43	22	21	1.77	14.05	1.698	12.8	3.5	35	CI
41	41/0	Clayey Sand	0.0	0.0	28.8	31.2	40.0	31.0	21.0	10.0	1.94	10.5	1.713	13.5	8.5	30	SC

Sl. No.	Location (Km.)	Description of soil	Gradation: Percent by weight retained the Sieve (IS:2720-IV)				Clay and silt content %	Atterberg Limits [IS:2720-V]			Modified Proctor Test (IS:2720-Pt-VIII)		Field dry density at subgrade level gm/cc	In-situ Moisture content %	CBR Soaked % [IS:2720-16]	DFS in % [IS:2720-40]	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	18
42	42/0	Silty clay with sand	0.36	0.62	7.24	29.45	62.33	35	21	14	-	-	1.759	12	-	-	CL-CI
43	43/0	Silty Clay with Sand	0	0.37	5.39	25.49	68.75	37	20	17	-	-	1.751	13	-	-	CI
44	44/0	Silty sand	0	0	4.5	72.5	23	20	NP	NIL	1.8	8.5	1.842	9.8	10.5	0	SM
45	45/0	Silty sand	0.38	0.19	3.57	64.26	31.6	24	NP	NIL	-	-	1.814	10.5	-	-	SM
46	46/0	Silty clay with sand	4.67	1.76	6.94	16.39	70.24	41	20	21	-	-	1.734	12.3	-	-	CI
47	47/0	Silty clay with sand	0.27	0.77	5.2	10.55	83.21	43	21	22	-	-	1.726	11.7	-	-	CI
48	48/0	Silty clay(Inorganic clay)	0	0.21	3.22	8.59	87.98	62	26	36	1.72	19.05	1.687	13.4	2.5	62	CH

Sl. No.	Location (Km.)	Description of soil	Gradation: Percent by weight retained the Sieve (IS:2720-IV)				Clay and silt content %	Atterberg Limits [IS:2720-V]			Modified Proctor Test (IS:2720-Pt-VIII)		Field dry density at subgrade level gm/cc	In-situ Moisture content %	CBR Soaked % [IS:2720-16]	DFS in % [IS:2720-40]	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	18
49	49/0	Clayey Sand	0	0.45	13.89	41.88	43.78	31	23	8	-	-	1.826	9.5	-	-	SC
50	50/0	Silty clay with sand	0.27	0.4	6.61	11.7	81.02	43	21	22	-	-	1.809	10.6	-	-	CI
51	51/0	Silty clay with sand	0.86	0.98	6.79	17.86	73.5	39	20	19	-	-	1.735	11.4	-	-	CI
52	52/0	Silty clay(Inorganic clay)	0.77	1.37	2.77	7.83	87.26	56	23	33	1.75	18.7	1.728	12.2	2.8	65	CH
53	53/0	Silty clay with sand	1.8	1.05	5.5	14.05	77.6	44	21	23	-	-	1.694	13.5	-	-	CI
54	54/0	Silty clay with sand	2.9	1.42	7.34	15.01	73.33	46	21	25	-	-	1.708	11.4	-	-	CI
55	55/0	Silty clay with sand	1.09	0.65	5.19	21.4	71.67	41	20	21	-	-	1.697	10.6	-	-	CI

Sl. No.	Location (Km.)	Description of soil	Gradation: Percent by weight retained the Sieve (IS:2720-IV)				Clay and silt content %	Atterberg Limits [IS:2720-V]			Modified Proctor Test (IS:2720-Pt-VIII)		Field dry density at subgrade level gm/cc	In-situ Moisture content %	CBR Soaked % [IS:2720-16]	DFS in % [IS:2720-40]	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	18
56	56/0	Silty clay with sand	0.95	1.35	6.9	19.1	71.7	43	20	23	-	-	1.705	12.5	-	-	CI
57	57/0	Silty clay with sand	1.75	0.9	5.5	17.05	74.8	45	21	24	1.78	16.02	1.724	11.4	3	40	CI

Discussion of Results

The soil in this stretch mainly classifies in the group of CI/CH and it is described as Silty Clay respectively. The Silty clay (CI/CH soil is High plastic and cohesive oil having CBR values (Soaked) ranging from 2.5% to 4.7 %. While the soil Silty sand with clay (SC) is little plastic. In these sections PI value ranges from 8.0 to 11.0. The CBR value (Soaked) of the soil ranges from 8.5% to 12%. The maximum dry density at O.M.C. of the existing subgrade soil of CI/CH group varies between 1.68 gm/cm^3 to 1.79gm/cm^3 .In maximum kilometers, there are Expansive soils found with medium to high degree of expansion.

Expansive Soils and their Treatment

Low to high expansive soils of CL- CI-CH group are found in various Sections of SH-53i.e.km1/0,2/0,3/0,4/0,5/0,7/0,8/0,9/0,10/0,11/0,12/0,13/0,14/0,15/0,16/0,17/0,18/0,19/0,20/0,21/0,22/0,23/0,24/0,25/0,26/0,30/0,32/0,33/0,34/035/0,37/0,39/0,40/0,42/0,43/0,46/0,47/0,48/0,49/0,50/0,51/0,52/0,53/0,54/0,55/0,56/0,57/0,. Though, there are maximum kilometers in such a long stretch of road section are expansive nature, it is always preferable either to replace the soil of high expansive properties or to treat the soil of low to medium expansive soils as below.

Thus to reduce the expansive properties of soil, firstly 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 and secondly even if the underlying expansive soil heaves, the movement will be more uniform and consequently more tolerable or it is recommended to either replace the soil by importing good soil from borrow area in the case of highly expansive soils. 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. Treatment of weak soil are given in Annexure-I (Garware –wall Ropes Limited) Geosynthetics Division

A blanket course of at least 225 mm thickness and composed of coarse/ medium sand or non-plastic moorum having PI less than five 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 2.5: Sources of Construction Material for Bhadrak – Chandbali Stretch

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

Table 2.6: Sources of Construction Material for Bhadrak – Anandpur Stretch

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

2.3.3.1 Sub-grade

In Bhadrak – Chandbali 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. Sathipur Baitarni River KM 0/0

ii. Baitarni River KM 50/0

Identified Location of Moorum Quarries:

i. Bhaghudi (Km 4/0)

ii. Kupari Hill (Km 0/0)

The Tests results are tabulated in Table. 2.3 and 6.2 of Material Report Part-II 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 0/0 (Sathipur Baitarini River), and 50/0 (Baitarini 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 sand varies between 1.89 gm/cm3 to 1.90 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 2.3 & 6.2 (Refer Material Report – Part II).

In Bhadrak – Anandpur 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. Sathipur Baitarni River KM 0/0

ii. Baitarni River KM 50/0

Identified Location of Moorum Quarries:

i. Baghudi @ Km 0/0

ii. Kupari Hill @ Km 8/0

iii. @Km 30/0

iv. @Km 34/0

v. Chenapadi @ Km 40/0

vi. Sada @ Km 45/0

vii. Maigram @ Km 45/0

The Tests results are tabulated in Table. 2.3 and 6.2 of Material Report Part-IV 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 Kms0/0 (Sathipur Baitarni River), and 45/0 (Baitarini 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 sand varies between 1.88 gm/cm3 to 1.90 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 2.3 & 6.2 (Refer Material Report – Part IV).

2.3.3.2 Granular Sub-base

Along the Chandbali-Bhadrak Road Section, two quarries were identified and Bhadrak - Anandpur Section seven 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:

Bhadrak - Chandbali

i. Kupari Hill @ Km 0/0

ii. Baghudi @ 4/0

Bhadrak-Anandpur

i. Baghudi @ Km 0/0

ii. Kupari Hill @ Km 8/0

iii. @Km 30/0

iv. @Km 34/0

v. Chenapadi @ Km 40/0

vi. Sada @ Km 45/0

vii. Maigram @ Km 45/0

Laboratory Tests Conducted:

i. Gradation (MoSRT&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-II and IV 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 upto 2 msa. The samples of granular sub base materials were collected from various quarries along the Chandbali to Anandpur From the tests results it is clearly evident that in Chandbali to Bhadrak road section, only one number of quarry named Baghudi Hill (Km 0/0), in Bhadrak to Anandpur road section, only two number of quarries named baghudi hill, chenapadi have suitable GSB material having liquid limit and P.I. value within the prescribe limit of MoSRT&H. For rest of quarries in which liquid limit and Plasticity Index is more than 25 and 6.0 respectively, in 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 Reports Part II and IV)

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. Coarse Aggregate:

2.3.3.3 Coarse Aggregate/Stone

Along the road section of SH-9, Chandbali to Bhadrak only one quarry was found and in the road section and on SH-53, Bhadrak- Anandpur road section three 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:

Bhadrak-Chandbali

i. Bhaghudi @ Km 0 / 0

Bhadrak-Anandpur

i. Baghudi @ Km 0/0
ii. Kupari quarry @ Km 8 / 0
iii. Gohiri quarry @ Km 45 / 0

Laboratory Tests Conducted:

i. Gradation (IS: 2386, Pt I& MoSRT&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-II and IV 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 MoSRT&H specifications.

Their water absorption value ranges from 0.3 % to 0.52% 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 19% which is also well within the prescribed limits as per MoSRTH. The aggregates from quarries do not conform exactly to the grading specified in the specification of MoSRT&H. Therefore the blending as per the requirement should be done prior to mixing at plant. The stripping values of most of aggregate do not fulfill the requirements. For the aggregates whose stripping values do not fulfill the requirement then anti stripping agent should be used during execution as per the requirement. The tests results are given in Table 5.1. Refer Material Report – Part II and IV)

Materials from quarries / crusher (aggregate) given in test results Table 5.1 (Refer Material Report – Part II and IV) are suitable for W.M.M., 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-9 and 53, Chandbali to Bhadrak and Bhadrak to Anandpur, 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.

Bhadrak-Chandbali

i. Sathipur Baitarani River @Km 0/0
ii. Baitarani River sand Quarry @ Km 50/0

Bhadrak-Anandpur

i. Sathipur Baitarani River @Km 0/0

ii. Baitarani River sand Quarry @ Km 45/0

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 6.1 (Refer Material Report Part-II and IV) 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 Table 6.1 and Table 6.2, of Material Report Part-II and IV it is evident that the Sand of Sathipur Baitarni River(km 0/0) and Baitarni River Sand (Km 50/0 of Sh-9 and Km 45/0 of Sh-53) are laying in zone II and III, though that sample are suitable for RCC/Masonry work..

2.3.3.5 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 II and IV).

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.

2.3.3.6 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.

Two samples of water from each road sections of Sathipur-Baitarni river (km 0/0 lead 34 km from SH-9 and 53 were collected and tested for the suitability for use in

construction as per IS: 456. For test results refer Material Report-Part II and IV 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 Sub Soil explorations were carried out at locations as indicated in following tables 2.7 and 2.8.

Table: 2.7 Sub Soil exploration Test Locations for Bhadrak-Chandbali Road

Location	Chainage	Name of River Crossing
1	1/005	2 no polo salandi bypass
2	1/800	3 no Polo
3	3/200	6 no Bridge Near Mirzapur
4	3/900	Haladiha Bypass Bridge
5	13/600	Nandapur Polo
6	28/100	Luhadarbada
7	30/050	Gadi Ghushura
8	31/600	Baharpal Ghusura
9	31/950	Kheranga Teraturia Canal
10	36/005	Nalagandha Ghusura
11	42/400	-
12	43/500	Chandanpur Polo

Table: 2.8 Sub Soil exploration Test Locations for Bhadrak-Anandpur Road

Location	Chainage	Name of River Crossing
1	11/600	Ganijanga
2	17/700	Tillo Polo
3	37/600	Charnalia nala no 1

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 Chandbali-Bhadrak Road (SH-9) and Bhadrak-Anandpur Road (SH-53).

2.3.4.1 Recommendations from Investigations:

Table 2.9 Recommendations from Subsoil Investigations for Bhadrak-Chandbali Road

Location	Chainage	Type of foundation	Minimum Depth of Foundation
1	1/005	Open	1.5m from bed level
2	1/800	Open	1.5m from bed level
3	3/200	Pile	15m from ground level
4	3/900	Pile	15m from ground level
5	13/600	Open	2.0m from bed level
6	28/100	Open	2.0m from bed level
7	30/050	Open	1.5m from bed level

Location	Chainage	Type of foundation	Minimum Depth of Foundation
8	31/600	Open	1.5m from bed level
9	31/950	Open	1.5m from bed level
10	36/005	Open	1.5m from bed level
11	42/400	Open	2.0m from bed level
12	43/500	Open	2.0m from bed level
13	46/700	Open	1.5m from bed level

Table 2.10 Recommendations from Subsoil Investigations for Bhadrak-Anandpur Road

Location	Chainage	Type of foundation	Minimum Depth of Foundation
1	11/600	Open (Isolated/Raft)	2.5m from bed level
2	17/700	Open (Isolated/Raft)	2.5m from bed level
3	37/600	Open (Isolated/Raft)	2.5m from bed 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), $I_o = \frac{F}{T}\left(\frac{T+1}{1+1}\right)$

Time of concentration (SP-13, page 12), $t_c = \left(0.87\frac{L^3}{H}\right)^{0.385}$

Critical rainfall intensity $I_c = I_C = I_O\left(\frac{2}{t_c + 1}\right)$

Discharge $Q = 0.028PAI_C$

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.

$$V = \frac{1}{n}R^{2/3}S^{\frac{1}{2}}$$

$$Q = AV$$

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 (MoRST&H) 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,

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

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

$$d_{sf} = d_{sm} = 1.34\left(\frac{D_b^{\,2}}{K_{sf}}\right)^{1/3}$$

D_b= Design discharge in cumecs/ metre

$K_{sf} = K_{sf} = 1.76(d_m)^{1/2}$ = 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 2.11 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 for Bhadrak – Chandbali and Bhadrak – Anandpur are presented in Table 2.12 and Table 2.13.

Table 2.12 Hydraulic Parameters (Bhadrak – Chandbali)

S. N.	Location/ Chainage	Existing Span Arrange-ment (no.x span)	Design Discharge (Cumec)	Existing Waterway (m)	Proposed Waterway (m)	Remarks
1	0/00	2 x 6.5	-	11.0	-	Good, Rehabilitation required
2	1/005	2 x 3.45	6.17	4.9	9.0	Reconstruction due to poor condition
3	1/800	2 x 3.4	6.03	5.3	9.0	Reconstruction due to poor condition
4	3/200	5 x 3.7	43.1	14.8	16.0	Reconstruction due to poor condition
5	3/900	3 x 7.6	32.53	17.9	16.0	Reconstruction due to poor condition
6	6/050	4 x 6.7	-	23.0	24.0	Reconstruction due to poor condition
7	9/200	5 x 2.7	20.06	9.0	9.0	Reconstruction due to poor condition
8	9/300	3 x 7.0	53.74	17.9	-	Rehabilitation required
9	13/600	2 x 4.5	21.69	7.4	9.0	Reconstruction due to poor condition
10	28/100	3 x 4.35	15.73	9.5	12.0	Reconstruction due to poor condition
11	28/800	6 x 2.5	19.14	13.2	9.0	Reconstruction due to submergence and poor condition
12	30/050	10 x 2.0	36.64	20.0	9.0	Reconstruction due to submergence and poor condition
13	30/200	2 x 6.7	15.84	11.4	-	Good, Rehabilitation required
14	32/100	4 x 1.75	3.26	7.0	6.0	Reconstruction due to submergence and poor condition
15	33/500	5 x 2.0	5.22	7.5	9.0	Reconstruction due to submergence and poor condition
16	33/900	5 x 1.9	4.83	7.0	9.0	Reconstruction due to submergence and poor condition
17	34/700	1 x 10.3	-	9.3	-	Good, Rehabilitation required
18	36/005	10 x 2.1	14.33	15.8	9.0	Reconstruction due to submergence and poor condition to poor condition

S. N.	Location/ Chainage	Existing Span Arrange-ment (no.x span)	Design Discharge (Cumec)	Existing Waterway (m)	Proposed Waterway (m)	Remarks
19	38/100	5 x 10.45	-	45.3	-	Good, Rehabilitation required
20	42/400	2 x 3.65	3.29	5.5	6.0	Reconstruction due to poor condition
21	43/500	2 x 3.2	2.35	4.3	6.0	Reconstruction due to poor condition

Table 2.13 Hydraulic Parameters (Bhadrak – Anandpur)

S. N.	Location/ Chainage	Existing Span Arrange-ment (no.x span)	Design Discharge (Cumec)	Existing Waterway (m)	Proposed Waterway (m)	Remarks
1	9/800	(1 x 3.55) + (1 x 3.95)	-	5.6	8.0	Reconstruction due to poor condition
2	11/600	2 x 7.0	67.44	11.6	16.0	Reconstruction due to Realignment
3	17/700	2 x 7.0	89.43	11.6	27.0	Reconstruction due to Realignment
4	18/400	1 x 6.9	10.44	6.1	6.0	Reconstruction due to submersible and poor condition
5	19/300	2 x 6.3	-	10.7	-	Good, Rehabilitation required
6	30/950	1 x 5.5	-	-	-	Good, Rehabilitation required
7	37/600	1 x 8.6	265.37	7.6	-	Good, Rehabilitation required
8	37/700	1 x 8.6		7.6	-	Good, Rehabilitation required
9	37/850	1 x 8.6		7.6	-	Good, Rehabilitation required
10	38/010	1 x 8.3		7.3	-	Good, Rehabilitation required
11	38/200	2 x 5.1		8.6	10.0	Reconstruction due to poor condition

2.5 INVESTIGATION FOR BRIDGES AND STRUCTURES

2.5.1 General

The stretch of Bhadrak – Chandbali (SH-9) is 45 Km and Bhadrak – Anandpur (SH-53) Km 50. The detailed study has been undertaken for the culverts & bridges. The detailed study consists 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 including vented causeway of than 6.0 m length, all of them are minor bridges on Bhadrak – Chandbali stretch and 11 number of minor bridges on Bhadrak – Anandpur stretch. The abstract of bridge inventory is presented in Table 2.14 and Table 2.15.

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 52 culverts, 27 of them are pipe culverts, 19 are RCC slab culverts, 5 are arch culvert, 1 are in choked condition on Bhadrak – Chandbali stretch and on Bhandrak – Anandpur stretch total 99 culverts are present 51 of them are pipe culverts, 36 are RCC slab culverts, 4 arch culvert and 8 nos in choked condition. . The abstract of culvert inventory is presented in Table 2.18 and Table 2.19.

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 and corrosion test by half cell potential meter) tests were conducted for bridges at Chainage 6/050,9/300 and 38/100 on Bhadrak – Chandbali stretch and at chainage 19/300,37/600,37/850,38/010 and 38/200 on Bhadrak – Anandpur stretch to study the structural soundness of the structures. Some of photographs showing NDT tests are presented in Plate 1.

There are total 32 bridges (21 nos on Bhadrak – Chandbali and 11 nos on Bharak – Anandpur). Analytical study of the Condition Survey data has been carried out and following important conclusions are arrived:

Bhadrak – Chandbali:

i. Mastic asphalt in case of bituminous concrete wearing coat has not been provided in any bridge.
ii. The expansion joint has not been provided in most of the bridges, their construction date back to sixties.
iii. 6 numbers of bridges are recorded as submerged and also in poor condition and have been proposed for reconstruction to have all weather road.

iv. 9 numbers of old & poor bridges are recommended to be reconstructed.

v. Bridge at Ch. 3/900 has been proposed to be reconstructed by shifting 20.0 mt towards Chandbali side as per site condition.

vi. Bridge at Ch 6/050 is narrow having 6.8m carriageway width, is of Brick masonry Abutment and PCC Pier with poor workmanship has been suggested for NDT tests.

vii. Bridge at Ch 30/200, which is situated near Gadi village, has been suggested to provide footpath.

viii. Approach slab has not been provided in any of the bridges.

ix. Brick masonry bridge at Ch 9/300 has been suggested for NDT tests for deck slab and dewatering of the bridge has been suggested to ascertain the foundation of the structure.

x. Bridge at Ch 38/200 has been constructed by Irrigation Department in the year 2005. No bearing has been provided for RCC girder type of superstructure. Neoprene bearing has been suggested by lifting the superstructure from support at bed level.

xi. Submergence zone from Ch. 5/500-5/900,15//000-16/000,25/300-25/650,27/700-28/100,29/750-30/350,31/900-32/500 and 33/800-36/100 has been identified as per site condition.

Bhadrak – Anandpur:

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

ii. The expansion joints has not been provided in most of the bridges

iii. The bridge at Ch. 18/400 is recorded as submerged and also in poor condition and have been proposed for reconstruction.

iv. 3 numbers of bridges at Ch. 9/800,11/600 and 17/700 are in poor condition and have been proposed for reconstruction.

v. NDT test has been suggested for bridge at Ch. 38/200.The bridge appears to be extended to two lane carriageway from single lane. A cushion of around 2 feet has been observed over the deck slab.

vi. The condition of bridge at Ch. 30/950 could not be assessed as that is a syphon aqueduct and shall be taken care during execution .

vii. Bridges at Ch. 37/600,37/700,37/850 and at Ch. 38/010 named as Charnallah are of Single span having stone masonry Abutment in good condition has been recommended for NDT tests of deck slab.

The abstract of inventory and condition of the existing bridge studies along with the recommendations is presented in Table 2.14 and Table 2.15 and summary at a glance has been presented in Table 2.16 and Table 2.17.

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 2.14: Inventory and Condition of Existing Bridges (Bhadrak – Chandbali)

Sl. No.	Location/ Chainage	Existing Span Arrangement	Type of Superstructure	Type of foundation	Overall condition/ Recommendation
1	0/00	2 x 6.5	Solid Slab	Open foundation	Good, Rehabilitation required
2	1/005	2 x 3.45	Solid Slab	Open foundation	Reconstruction due to poor condition
3	1/800	2 x 3.4	Solid Slab	Open foundation	Reconstruction due to poor condition
4	3/200	5 x 3.7	Solid Slab	Open foundation	Reconstruction due to poor condition
5	3/900	3 x 7.6	Solid Slab	Open foundation	Reconstruction due to poor condition
6	6/050	4 x 6.7	Solid Slab	Open foundation	Rehabilitation required
7	9/200	5 x 2.7	Solid Slab & Arch	Open foundation	Reconstruction due to poor condition
8	9/300	3 x 7.0	Solid Slab	Open foundation	Rehabilitation required
9	13/600	2 x 4.5	Solid Slab	Open foundation	Reconstruction due to poor condition
10	28/100	3 x 4.35	Solid Slab	Open foundation	Reconstruction due to poor condition
11	28/800	6 x 2.5	Solid Slab	Open foundation	Reconstruction due to submergence and poor condition
12	30/050	10 x 2.0	Solid Slab	Open foundation	Reconstruction due to submergence and poor condition
13	30/200	2 x 6.7	RCC Cell Box	Raft foundation	Good, Rehabilitation required
14	32/100	4 x 1.75	Solid Slab	Open foundation	Reconstruction due to submergence and poor condition
15	33/500	5 x 2.0	Solid Slab	Open foundation	Reconstruction due to submergence and poor condition
16	33/900	5 x 1.9	Solid Slab	Open foundation	Reconstruction due to submergence and poor condition
17	34/700	1 x 10.3	RCC girder with slab	Open foundation	Good, Rehabilitation required
18	36/005	10 x 2.1	Solid Slab	Open foundation	Reconstruction due to submergence and poor condition
19	38/100	5 x 10.45	RCC girder with slab	Pile foundation	Good, Rehabilitation required
20	42/400	2 x 3.65	Solid Slab & Arch	Open foundation	Reconstruction due to poor condition
21	43/500	2 x 3.2	Solid Slab	Open foundation	Reconstruction due to poor condition

Table 2.15: Inventory and Condition of Existing Bridges (Bhadrak – Anandpur)

Sl. No.	Location/ Chainage	Existing Span Arrangement	Type of Superstructure	Type of foundation	Overall condition/ Recommendation
1	9/800	(1 x 3.55) + (1 x 3.95)	Solid slab	Open foundation	Reconstruction due to poor condition
2	11/600	2 x 7.0	Rolled steel girder with RCC slab	Open foundation	Reconstruction due to poor condition
3	17/700	2 x 7.0	Solid slab	Open foundation	Reconstruction due to poor condition
4	18/400	1 x 6.9	Solid slab	Open foundation	Reconstruction due to submersible and poor condition
5	19/300	2 x 6.3	Solid slab	Open foundation	Good, Rehabilitation required
6	30/950	1 x 5.5	Solid slab	Open foundation	Good, Rehabilitation required
7	37/600	1 x 8.6	Solid slab	Open foundation	Good, Rehabilitation required
8	37/700	1 x 8.6	Solid slab	Open foundation	Good, Rehabilitation required
9	37/850	1 x 8.6	Solid slab	Open foundation	Good, Rehabilitation required
10	38/010	1 x 8.3	Solid slab	Open foundation	Good, Rehabilitation required
11	38/200	2 x 5.1	Solid slab	Open foundation	Good, Rehabilitation required

Table 2.16: Summary of Existing Bridges (Bhadrak – Chandbali)

Type of Action Required	No.
Nothing to do cases	Nil
Rehabilitation cases	5
Replaced due to Poor condition	9
Replaced due to Submergence and Poor condition	7

Table 2.17: Summary of Existing Bridges (Bhadrak – Anandpur)

Type of Action Required	No.
Nothing to do cases	Nil
Rehabilitation cases	6
Replaced due to Poor condition	4
Replaced due to Submergence and Poor condition	1

Plate 1

Photographs of some of bridges showing NDT (Bhadrak-Chandbali)

Rebound Hammer testing in Deck slab for bridge at Ch.6/050

Pulse velocity Test in Deck Slab for bridge at Ch.9/300

Pulse Velocity testing in RCC Girder for bridge at Ch.38/100

Plate 2

Photographs of some of bridges to be dismantled (Bhadrak -Chandbali)

Bridge at Ch: 1/005

Bridge at Ch: 6/050

Bridge at Ch: 30/050

Plate 3

Photographs of some of bridges to be rehabilitated (Bhadrak – Chandbali)

Bridge at Ch: 9/300

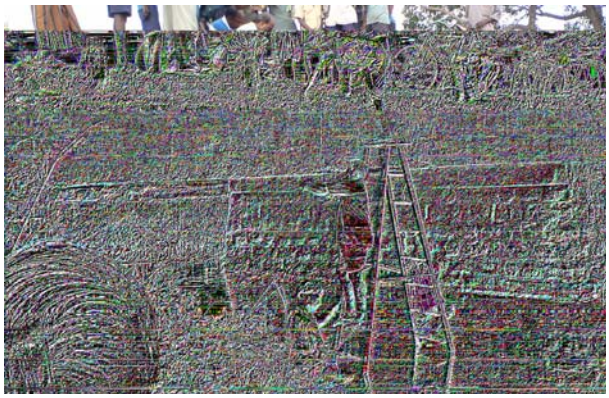
Bridge at Ch: 30/200

Bridge at Ch: 38/200

Plate 4

Photographs of some of bridges showing NDT (Bhadrak – Anandpur)

Rebound Hammer testing in deck slab for bridge at Ch. 19/300



Pulse Velocity Test in deck slab for bridge at Ch. 37/600

Pulse velocity testing in Deck slab for bridge at Ch. 38/200

Plate 5

Photographs of some of bridges to be dismantled (Bhadrak – Anandpur)

Bridge at Ch: 9/800

Bridge at Ch: 17/700

Bridge at Ch: 18/400

Plate 6

Photographs of some of bridges to be rehabilitated (Bhadrak – Anandpur)

Bridge at Ch: 30/950

Bridge at Ch: 37/700

Bridge at Ch: 37/850

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:

Bhadrak – Chandbali:

i. The total number of culvert is 52 in a road length of from km 0/0 to 45/0.

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. The culverts in good condition have been widened provided horizontal and vertical profile permits.

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. 7 Nos of culverts are RR stone masonry with RCC deck slab and 13 Nos are Brick masonry with RCC deck slab out of 20 slab culverts and most of them have been proposed to be reconstructed.

vi. At certain stretches the area get submerged as the level difference between existing road level and ground level is too less. Some new culverts has been suggested for such stretches.

vii. Pipe culverts not meeting the requirement of modern days loading has been suggested to be reconstructed based on site condition with large vent preferably box type structures.

viii. Culvert at Ch. 31/600 has been proposed to abandoned as per site condition

Bhadrak – Anandpur:

i. The total number of culvert is 99 in a road length of from km 0/0 to 50/0 i.e. in a stretch of 50.00 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 permits.

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. 17 Nos of culverts are RR stone masonry with RCC deck slab and 8 Nos are Brick masonry with RCC deck slab out of 36 slab culverts 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. 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 Tables 2.18 and 2.19 presents abstract of inventory and condition of existing culverts along with the recommendation.

Table 2.18: Inventory and Condition of Existing Culverts (Bhadrak – Chandbali)

Sl. No.	Location/ Chainage	Existing Span Arrangement	Type of Culvert	Recommendation
1	2/500	1 x 3.0	Slab	To be widened
2	2/800	1 x 3.0	Slab	To be widened
3	4/300	2 x 1.0	Pipe	Replaced due to poor condition
4	4/900	1 x 2.0	Arch	Replaced due to poor condition
5	6/990	1 x 0.9	Pipe	Replaced due to poor condition
6	7/900	1 x 0.9	Pipe	Replaced due to poor condition
7	8/900	1 x 4.5	Slab	Replaced due to poor condition
8	9/500	1 x 2.0	Slab	Replaced due to poor condition
9	9/900	1 x 4.5	Slab	Replaced due to poor condition
10	10/250	1 x 1.4	Slab	Replaced due to poor condition
11	11/100	1 x 1.4	Slab	Replaced due to poor condition
12	11/650	2 x 0.3	Pipe	Replaced due to poor condition
13	12/600	1 x 0.3	Pipe	Replaced due to poor condition
14	12/900	1 x 0.9	Pipe	Replaced due to poor condition
15	13/150	1 x 1.4	Slab	Replaced due to poor condition
16	14/800	1 x 0.3	Pipe	Replaced due to poor condition
17	15/600	1 x 0.3	Pipe	Replaced due to poor condition
18	15/700	1 x 3.2	Slab	Replaced due to poor condition
19	16/500	1 x 0.6	Pipe	Replaced due to poor condition
20	16/700	1 x 0.6	Pipe	Replaced due to poor condition
21	17/100	1 x 1.5	Slab	Replaced due to poor condition
22	17/700	1 x 0.9	Pipe	Replaced due to poor condition
23	17/900	1 x 1.0	Pipe	Replaced due to poor condition
24	18/200	1 x 1.0	Pipe	Replaced due to poor condition
25	18/600	1 x 1.0	Pipe	Replaced due to poor condition
26	19/100	1 x 1.0	Pipe	Replaced due to poor condition
27	19/400	2 x 1.5	Slab	Replaced due to poor condition
28	19/900	2 x 2.3	Slab	To be widened
29	20/100	1 x 1.4	Slab	Replaced due to poor condition
30	20/200	1 x 0.6	Pipe	Replaced due to poor condition
31	20/700	1 x 0.6	Pipe	Replaced due to poor condition
32	21/050	1 x 0.45	Pipe	Replaced due to poor condition
33	21/150	1 x 0.45	Pipe	Replaced due to poor condition
34	21/400	1 x 0.6	Pipe	Replaced due to poor condition
35	21/700	1 x 1.5	Slab	Replaced due to poor condition
36	22/700	1 x 0.9	Pipe	Replaced due to poor condition
37	23/150	1 x 3.2	Slab	Replaced due to poor condition
38	24/050	1 x 0.9	Arch	Replaced due to poor condition
39	24/350	1 x 0.8	Pipe	Replaced due to poor condition
40	24/500	1 x 1.2	Slab	Replaced due to poor condition

Sl. No.	Location/ Chainage	Existing Span Arrangement	Type of Culvert	Recommendation
41	25/200	1 x 1.0	Pipe	Replaced due to poor condition
42	26/400	-	Choked	Replaced due to insufficient vent
43	30/600	1 x 0.5	Arch	Replaced due to poor condition
44	31/600	1 x 0.5	Arch	To be abandoned
45	39/300	2 x 0.45	Pipe	Replaced due to poor condition
46	39/800	1 x 0.8	Pipe	Replaced due to poor condition
47	40/350	1 x 0.6	Pipe	Replaced due to poor condition
48	40/950	1 x 0.9	Pipe	Replaced due to poor condition
49	41/990	2 x 1.5	Slab	Replaced due to poor condition
50	43/050	1 x 0.6	Arch	Replaced due to poor condition
51	43/600	1 x 4.8	Slab	Replaced due to poor condition
52	44/400	1 x 1.8	Slab	To be widened

Table 2.19: Inventory and Condition of Existing Culverts (Bhadrak – Anandpur)

Sl. No.	Location / Chainage	Existing Span Arrangement	Type of Culvert	Recommendation
1	1/010	1 x 0.9	Pipe	Replaced due to poor condition
2	1/275	-	Choked	Replaced due to insufficient vent
3	1/900	1 x 0.9	Pipe	Replaced due to insufficient vent
4	2/150	3 x 1.5	Slab	Replaced due to poor condition
5	2/400	3 x 0.9	Pipe	Replaced due to poor condition
6	2/600	1 x 1.8	Slab	Replaced due to poor condition
7	2/800	-	-	To be abandoned
8	3/500	-	-	To be abandoned
9	3/700	1 x 1.5	Slab	Replaced due to poor condition
10	3/900	-	Choked	Replaced due to insufficient vent
11	4/500	1 x 3.0	Slab	Replaced due to poor condition
12	5/010	1 x 3.0	Slab	To be widened
13	6/800	1 x 1.5	Slab	Replaced due to poor condition
14	7/880	1 x 3.0	Slab	To be widened
15	8/300	1 x 2.7	Slab	Replaced due to poor condition
16	8/750	1 x 0.6	Pipe	Replaced due to poor condition
17	8/850	2 x 0.9	Pipe	To be extended
18	10/600	1 x 3.0	Slab	To be widened
19	11/150	1 x 1.5	Slab	Replaced due to poor condition
20	12/200	1 x 0.6	Pipe	Replaced due to poor condition
21	13/110	1 x 0.6	Pipe	To be extended
22	13/800	1 x 0.6	Pipe	Replaced due to poor condition
23	14/200	1 x 0.9	Pipe	To be extended
24	14/400	1 x 1.8	Slab	Replaced due to poor condition
25	14/600	1 x 2.4	Slab	To be widened
26	15/500	2 x 0.9	Pipe	To be extended
27	17/200	1 x 1.5	Slab	Replaced due to poor condition
28	17/300	2 x 0.9	Pipe	Replaced due to poor condition
29	18/500	2 x 0.9	Pipe	To be extended
30	18/700	-	Choked	Replaced due to insufficient vent
31	18/800	1 x 0.6	Pipe	Replaced due to poor condition
32	18/850	1 x 0.6	Pipe	Replaced due to poor condition
33	19/250	1 x 0.3	Pipe	Replaced due to poor condition
34	20/100	1 x 0.6	Pipe	Replaced due to poor condition
35	20/800	4 x 0.45	Pipe	To be extended

Sl. No.	Location / Chainage	Existing Span Arrangement	Type of Culvert	Recommendation
36	20/825	1 x 1.3	Slab	Replaced due to poor condition
37	21/050	1 x 4.6	Slab	Replaced due to poor condition
38	21/750	1 x 0.8	Pipe	Replaced due to insufficient vent
39	22/800	2 x 0.6	Pipe	Replaced due to insufficient vent
40	23/600	1 x 0.6	Pipe	Replaced due to insufficient vent
41	24/150	1 x 0.3	Pipe	Replaced due to insufficient vent
42	24/700	1 x 0.6	Pipe	Replaced due to insufficient vent
43	24/750	1 x 0.6	Pipe	Replaced due to insufficient vent
44	25/700	1 x 1.5	Slab	To be widened
45	25/710	1 x 0.9	Pipe	Replaced due to insufficient vent
46	25/990	-	Choked	Replaced due to insufficient vent
47	26/450	-	Choked	Replaced due to insufficient vent
48	26/700	1 x 0.6	Pipe	Replaced due to poor condition
49	27/050	1 x 0.45	Pipe	Replaced due to poor condition
50	27/100	2 x 0.9	Pipe	Replaced due to poor condition
51	27/800	2 x 0.9	Pipe	To be extended
52	28/200	1 x 0.6	Pipe	Replaced due to poor condition
53	28/950	2 x 0.9	Pipe	Replaced due to poor condition
54	29/100	2 x 0.9	Pipe	Replaced due to poor condition
55	29/650	1 x 0.6	Pipe	Replaced due to poor condition
56	29/700	1 x 0.45	Pipe	Replaced due to poor condition
57	29/800	2 x 0.9	Pipe	To be extended
58	30/150	2 x 0.9	Pipe	To be extended
59	30/500	2 x 0.9	Pipe	To be extended
60	30/900	2 x 0.9	Pipe	To be extended
61	31/100	2 x 0.9	Pipe	Replaced due to poor condition
62	31/500	1 x 1.5	Slab	Nothing to do
63	31/800	-	Choked	Replaced due to insufficient vent
64	31/900	2 x 0.6	Pipe	Replaced due to poor condition
65	32/200	4 x 0.9	Pipe	To be extended
66	32/400	2 x 0.9	Pipe	To be extended
67	33/050	2 x 0.9	Pipe	To be extended
68	33/450	1 x 3.0	Slab	Replaced due to poor condition
69	33/500	2 x 0.9	Pipe	To be extended
70	34/400	1 x 0.9	Pipe	To be extended
71	34/750	2 x 1.0	Pipe	To be extended
72	35/300	2 x 1.1	Pipe	To be extended
73	35/700	1 x 0.6	Pipe	Nothing to do
74	35/900	1 x 1.0	Slab	Replaced due to insufficient vent
75	36/100	1 x 1.0	Slab	Replaced due to poor condition
76	36/250	1 x 1.0	Slab	Replaced due to poor condition
77	36/600	2 x 1.0	Slab	Replaced due to poor condition
78	37/150	1 x 0.6	Pipe	Replaced due to poor condition
79	37/200	1 x 0.6	Pipe	Replaced due to poor condition
80	37/300	1 x 3.15	Slab	To be widened
81	38/900	1 x 3.0	Slab	To be widened
82	39/450	2 x 2.5	Arch	Replaced due to poor condition
83	40/500	1 x 0.9	Arch	Replaced due to poor condition
84	40/850	1 x 0.9	Arch	Replaced due to poor condition
85	41/100	2 x 1.8	Arch	Replaced due to poor condition

Sl. No.	Location / Chainage	Existing Span Arrangement	Type of Culvert	Recommendation
86	41/700	2 x 1.2	Slab	Replaced due to poor condition
87	43/200	1 x 0.9	Pipe	Nothing to do
88	44/700	1 x 0.75	Slab	Lies in bypass
89	45/300	1 x 0.25	Pipe	Lies in bypass
90	45/500	1 x 1.5	Slab	Replaced due to poor condition
91	45/700	1 x 1.5	Slab	To be widened
92	45/900	1 x 1.6	Slab	To be widened
93	45/990	1 x 1.5	Slab	To be widened
94	46/600	1 x 1.5	Slab	To be widened
95	46/900	1 x 1.6	Slab	To be widened
96	47/300	1 x 1.6	Slab	To be widened
97	47/800	1 x 3.0	Slab	To be widened
98	48/550	1 x 1.5	Slab	To be widened
99	49/100	1 x 3.0	Slab	To be widened

Table 2.20: Summary of Existing Culverts (Bhadrak – Chandbali)

Type of Culvert	Nos.
Pipe	27
Slab	19
Arch	5
Choked	1
Total	**52**

Table 2.21: Summary of Existing Culverts (Bhadrak – Anandpur)

Type of Culvert	Nos.
Pipe	51
Slab	36
Arch	4
Choked	8
Total	**99**

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 for Bhadrak-Chandbali and Bhadrak-Anandpur roads are presented in Table 2.22 and Table 2.23; graphical representation of the same is presented in Figures 2.1 to 2.5 shall be sufficient to meet the input requirements of HDM- IV.

Table 2.22 Pavement condition for Bhadrak-Chandbali Stretch

CHAINAGE		Riding Quality		Pavement Condition											Remarks
From (KM)	To (KM)	Speed (km/hr)	Quality G/F/P/VP	Crac-king (%)	Rave-lling (%)	Poth-ole (Nos)	Pothol-ing (%)	Rut**** (None / Moderate / Severe)	Patchin-g (Nos)**	Patch-ing (%)	Pave-ment Edge drop (mm)	Emba-nkment Condition (G/F/P)	Emba-nkment Height	Road side Drain (NE/PF/F)***	
45/0	44/0	30	F/P	-	-	-	-	NONE	156	15.0	25	F	3.0	F	
44/0	43/0	30	F/P	4	-	-	-	M	115	12.0	30	F/P	3.5	F	
43/0	42/0	30	F/P	1	-	11	0.2	NONE	101	10.0	10	F/P	0.5	F	
42/0	41/0	30	F/P	-	-	7	0.1	NONE	131	13.0	20	F/P	1.0	F	
41/0	40/0	30	P	2	35.00	18	0.5	NONE	67	7.0	15	F/P	1.0	F	
40/0	39/0	30	F/P	2	-	20	1.0	NONE	72	8.0	30	F/P	3.0	F	
39/0	38/0	30	P	3	-	53	2.0	NONE	197	10.0	35	F/P	3.5	F	
38/0	37/0	30	P	10	-	51	2.0	NONE	131	12.0	30	F/P	2.0	F	CROCODILE CRACK
37/0	36/0	30	P	8	-	15	0.5	NONE	112	11.0	35	F/P	1.0	F	SUB MERGEN
36/0	35/0	30	P	12	-	28	1.0	NONE	97	10.0	30	F/P	1.5	F	
35/0	34/0	30	F	5	-	12	0.2	NONE	138	13.0	35	F/P	0.8	F	
34/0	33/0	30	P	7	10.00	18	0.3	NONE	126	12.0	20	F/P	0.6	F	
33/0	32/0	30	F/P	5	-	13	0.2	NONE	115	11.0	10	F/P	0.6	F	
32/0	31/0	30	F	-	-	-	-	NONE	142	15.0	10	F/P	0.5	F	
31/0	30/0	30	F	1	-	-	-	NONE	87	8.0	15	F	1.0	PF	
30/0	29/0	30	F/P	3	2.00	22	1.0	M	76	7.0	10	F	1.0	PF	
29/0	28/0	30	F	-	-	-	-	NONE	59	6.5	15	F	1.2	PF	OIL PIPE LINE CROSSING
28/0	27/0	30	F	3	2.00	22	1.0	NONE	63	5.0	15	F	1.5	PF	
27/0	26/0	30	F/P	2	-	13	0.5	NONE	79	8.0	10	F	0.8	PF	
26/0	25/0	30	F/P	-	-	-	-	NONE	163	16.0	20	F	0.8	PF	
25/0	24/0	30	F/P	3	-	-	-	NONE	95	10.0	20	F	0.8	PF	
24/0	23/0	30	F/P	3	-	-	-	NONE	159	16.0	10	F	0.5	PF	
23/0	22/0	30	F/P	5	-	-	-	NONE	265	25.0	10	F	0.6	PF	
22/0	21/0	30	F/P	5	-	-	-	NONE	178	20.0	5	F	0.6		
21/0	20/0	30	F	2	-	-	-	NONE	151	18.0	15	F	0.4	PF	EDGE DAMAGE

Table 2.22 Pavement condition for Bhadrak-Chandbali Stretch (Contd…)

CHAINAGE		Riding Quality		Pavement Condition											Remarks
From (KM)	To (KM)	Speed (km/hr)	Quality G/F/P/VP	Crac-king (%)	Rave-lling (%)	Poth-ole (Nos)	Pothol-ing (%)	Rut**** (None / Moderate / Severe)	Patchin-g (Nos)**	Patch-ing (%)	Pave-ment Edge drop (mm)	Emba-nkment Condition (G/F/P)	Emba-nkment Height	Road side Drain (NE/PF/F)***	
20/0	19/0	30	F/P	5	-	8	0.1	NONE	212	22.0	10	F/P	0.4	PF	EDGE DAMAGE
19/0	18/0	30	P	3	10.00	10	0.2	NONE	183	20.0	10	F/P	0.4	PF	
18/0	17/0	30	F	7	8.00	14	0.3	NONE	139	15.0	15	F/P	0.3	PF	MARKET AREA
17/0	16/0	30	F	3	3.00	-	-	NONE	131	14.0	5	F/P	0.5	PF	
16/0	15/0	30	F	3	2.00	-	-	NONE	148	15.0	10	F/P	0.4	PF	
15/0	14/0	30	F	1	-	-	-	NONE	239	25.0	10	F/P	0.6	PF	
14/0	13/0	30	P/F	1	4.00	-	-	NONE	253	25.0	8	F/P	1.0	PF	
13/0	12/0	30	F	3	-	-	-	NONE	180	20.0	5	F/P	0.4	PF	
12/0	11/0	30	F/P	3	5.00	-	-	NONE	165	18.0	15	F/P	0.5	PF	
11/0	10/0	30	F/P	2	2.00	14	0.3	NONE	280	30.0	15	F/P	0.5	PF	EDGE BROKEN
10/0	9/0	30	F/P	2	-	17	0.5	NONE	234	25.0	15	F/P	1.8	PF	EDGE BROKEN
9/0	8/0	30	P	2	-	26	1.0	NONE	246	25.0	15	F/P	1.2	PF	EDGE BROKEN
8/0	7/0	30	P	3	-	20	1.0	NONE	289	32.0	20	F/P	1.0	PF	
7/0	6/0	30	F/P	5	-	23	1.0	NONE	142	13.0	20	F/P	1.6	PF	
6/0	5/0	30	F	1	-	-	-	NONE	131	13.0	10	P	1.0	PF	
5/0	4/0	30	F	1	-	-	-	NONE	114	12.0	15	F/P	0.8	PF	
4/0	3/0	30	F	-	-	-	-	NONE	108	10.0	15	F/P	0.8	PF	
3/0	2/0	30	F	-	-	-	-	NONE	131	14.0	30	F/P	0.5	PF	
2/0	1/0	30	F	-	-	-	-	NONE	115	12.0	15	F/P	1.2	PF	
1/0	0/0	30	F	-	-	-	-	NONE	131	14.0	10	F/P	1.2	PF	

Table 2.23 Pavement condition for Bhadrak-Anandpur Stretch

CHAINAGE		Riding Quality		Pavement Condition											Remarks
From (KM)	To (KM)	Speed (km/hr)	Quality G/F/P/VP	Crac-king (%)	Rave-lling (%)	Poth-ole (Nos)	Pothol-ing (%)	Rut**** (None / Moderate / Severe)	Patchin-g (Nos)**	Patch-ing (%)	Pave-ment Edge drop (mm)	Emba-nkment Condition (G/F/P)	Emba-nkment Height	Road side Drain (NE/PF/F)***	
0/0	1/0	30	F	-	-	17	0.5	NONE	18	1.0	10	F	1.5	PF	200MT POOR CONDITION BDK TO ON SHIP
1/0	2/0	30	F	-	1	-	-	NONE	20	1.0	15	F	1.0	F	
2/0	3/0	30	P	-	3	46	2.0	NONE	35	2.0	10	P	1.0	PF	LEVEL CROSSING 100MT WBM ROAD
3/0	4/0	30	VP	2	4	51	2.5	NONE	78	3.0	10	P	1.0	PF	
4/0	5/0	30	F/P	-	-	-	-	NONE	183	20.0	30	F	1.0	F	
5/0	6/0	30	F	-	-	-	-	NONE	64	3.0	30	F	1.2	F	
6/0	7/0	30	F	-	-	-	-	NONE	71	3.0	30	F	-	F	
7/0	8/0	30	F/P	-	-	13	0.5	NONE	172	17.0	30	F	1.0	F	
8/0	9/0	30	F/P	-	-	16	0.6	NONE	92	10.0	20	F		PF	B.S.E.T.COLLEGE
9/0	10/0	30	F	-	-	-	-	NONE	78	5.0	10	P	1.5	F	
10/0	11/0	30	F	-	-	-	-	NONE	82	7.0	10	F	1.2	F	EDGE BROKEN
11/0	12/0	30	F	-	2	-	-	NONE	45	3.0	15	F	1.5	F	
12/0	13/0	30	F	-	-	7	0.1	NONE	32	2.0	20	F	1.5	PF	
13/0	14/0	30	VP	-	-	72	2.5	NONE	83	7.0	20	P	1.2	PF	EDGE BROKEN
14/0	15/0	30	F	-	-	12	0.5	NONE	73	6.0	35	F	1.5	F	
15/0	16/0	30	P/F	-	-	8	0.2	NONE	115	11.0	10	F	1.2	PF	
16/0	17/0	30	P/F	-	-	8	0.2	NONE	128	13.0	5	F	1.2	F	
17/0	18/0	30	P/F	-	-	-	-	NONE	103	10.0	10	F	1.2	PF	EDGE BROKEN
18/0	19/0	30	P/F	-	-	-	-	NONE	81	8.0	8	F	1.2	PF	EDGE BROKEN
19/0	20/0	30	P/F	2	-	8	0.2	NONE	62	6.0	8	F/P	1.0	PF	EDGE BROKEN
20/0	21/0	30	F/P	2	-	18	1.0	NONE	72	7.0	10	F/P	1.2	PF	
21/0	22/0	30	F	-	-	8	0.3	NONE	31	2.0	10	F/P	1.5	F	
22/0	23/0	30	F	2	-	-	-	NONE	46	2.0	15	F/P	1.5	F	

Table 2.23 Pavement condition for Bhadrak-Anandpur Stretch (Contd…)

CHAINAGE		Riding Quality		Pavement Condition											Remarks
From (KM)	To (KM)	Speed (km/hr)	Quality G/F/P/VP	Crac-king (%)	Rave-lling (%)	Poth-ole (Nos)	Pothol-ing (%)	Rut**** (None / Moderate / Severe)	Patchin-g (Nos)**	Patch-ing (%)	Pave-ment Edge drop (mm)	Emba-nkment Condition (G/F/P)	Emba-nkment Height	Road side Drain (NE/PF/F)***	
23/0	24/0	30	F	-	-	6	0.1	NONE	27	1.0	10	F/P	1.5	F	
24/0	25/0	30	F/P	-	-	10	0.5	NONE	30	1.5	10	F/P	1.5	PF	
25/0	26/0	30	F/P	-	-	23	1.0	NONE	40	2.0	10	F/P	1.2	PF	
26/0	27/0	30	F/P	3	-	30	1.5	NONE	47	2.0	8	F/P	1.0	PF	
27/0	28/0	30	F/P	3	1	76	2.5	NONE	86	8.0	8	F/P	1.0	PF	
28/0	29/0	30	F/P	5	2	63	2.0	NONE	32	2.0	8	F/P	1.0	PF	
29/0	30/0	30	F/P	5	2	76	3.0	NONE	51	4.0	8	F/P	1.0	PF	
30/0	31/0	30	G	-	-	-	-	NONE	32	2.0	5	F	1.0	PF	
31/0	32/0	30	G	-	-	-	-	NONE	24	1.0	5	F	1.0	PF	
32/0	33/0	30	G	-	-	-	-	NONE	23	1.0	5	F	1.0	PF	
33/0	34/0	30	G	-	-	-	-	NONE	52	4.0	5	F	1.0	PF	
34/0	35/0	30	G	-	-	-	-	NONE	46	3.0	5	F	1.0	PF	
35/0	36/0	30	G	-	-	-	-	NONE	41	2.5	5	F	1.2	PF	
36/0	37/0	30	G	-	-	-	-	NONE	46	2.5	5	F	1.5	PF	
37/0	38/0	30	G	-	-	-	-	NONE	58	3.0	5	F	1.5	PF	
38/0	39/0	30	G	-	-	-	-	NONE	28	1.0	5	F	1.5	PF	
39/0	40/0	30	G	-	-	-	-	NONE	18	1.0	5	F	1.5	PF	
40/0	41/0	30	G	-	-	-	-	NONE	23	1.0	8	F	1.0	PF	
41/0	42/0	30	G	-	-	-	-	NONE	17	1.0	5	F	1.0	PF	
42/0	43/0	30	G	-	-	-	-	NONE	38	2.5	5	F	0.8	PF	
43/0	44/0	30	G	-	-	-	-	NONE	18	1.0	5	F	0.2	PF	ANANDAPUR TOWN SHIP
44/0	45/0	30	G	-	-	-	-	NONE	27	1.0	8	F	0.2	PF	
45/0	46/0	30	F/P	-	-	51	2.0	M	68	4.0	10	F/P	0.5	PF	100MT STARTING V.P.

Table 2.23 Pavement condition for Bhadrak-Anandpur Stretch (Contd…)

CHAINAGE		Riding Quality		Pavement Condition											Remarks
From (KM)	To (KM)	Speed (km/hr)	Quality G/F/P/VP	Crac-king (%)	Rave-lling (%)	Poth-ole (Nos)	Pothol-ing (%)	Rut**** (None / Moderate / Severe)	Patchin-g (Nos)**	Patch-ing (%)	Pave-ment Edge drop (mm)	Emba-nkment Conditio n (G/F/P)	Emba-nkment Height	Road side Drain (NE/PF/F)***	
46/0	47/0	30	F/P	2	2	30	1.5	NONE	18	1.0	20	F/P	0.4	PF	EDGE DAMAGE
47/0	48/0	30	F/P	2	2	18	1.0	NONE	10	0.5	20	F/P	0.4	PF	EDGE DAMAGE
48/0	49/0	30	F/P	-	-	-	-	NONE	13	0.5	10	F/P	0.3	PF	EDGE DAMAGE
49/0	50/0	30	F/P	-	-	28	1.0	NONE	12	0.5	25	F/P	0.4	PF	EDGE DAMAGE
50/0	51/0	30	F/P	2	5	77	3.5	NONE	95	9.0	10	F	0.5	PF	
46/0	47/0	30	F/P	2	2	30	1.5	NONE	18	1.0	20	F/P	0.4	PF	EDGE DAMAGE
47/0	48/0	30	F/P	2	2	18	1.0	NONE	10	0.5	20	F/P	0.4	PF	EDGE DAMAGE
48/0	49/0	30	F/P	-	-	-	-	NONE	13	0.5	10	F/P	0.3	PF	EDGE DAMAGE

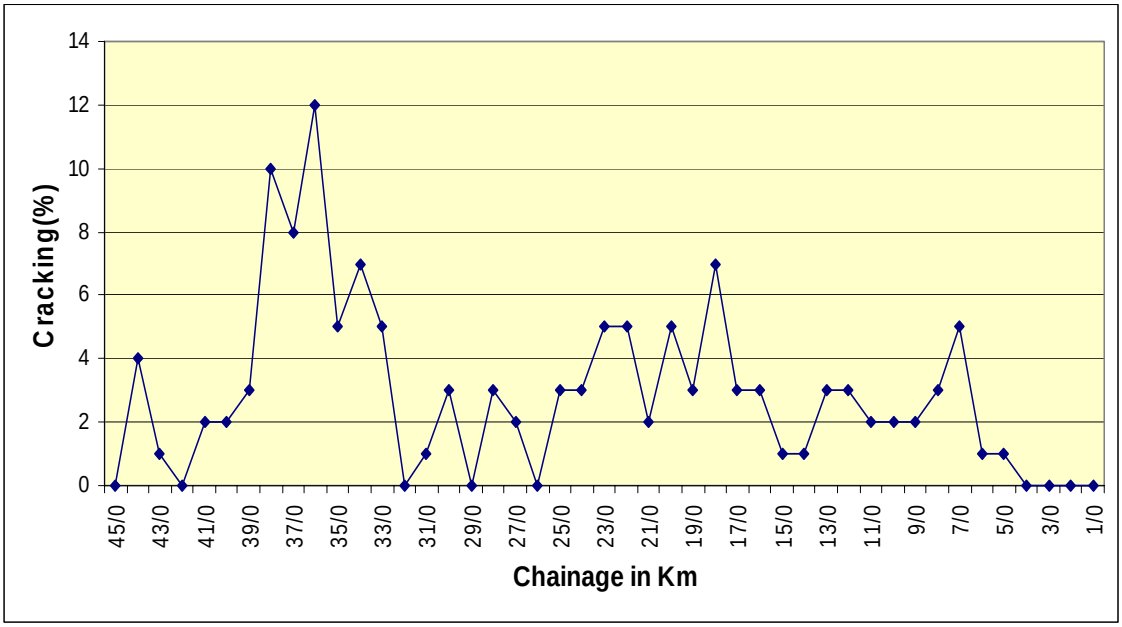


Figure 2.1 Cracking (%) Variation along the Bhadrak-Chandbali stretch

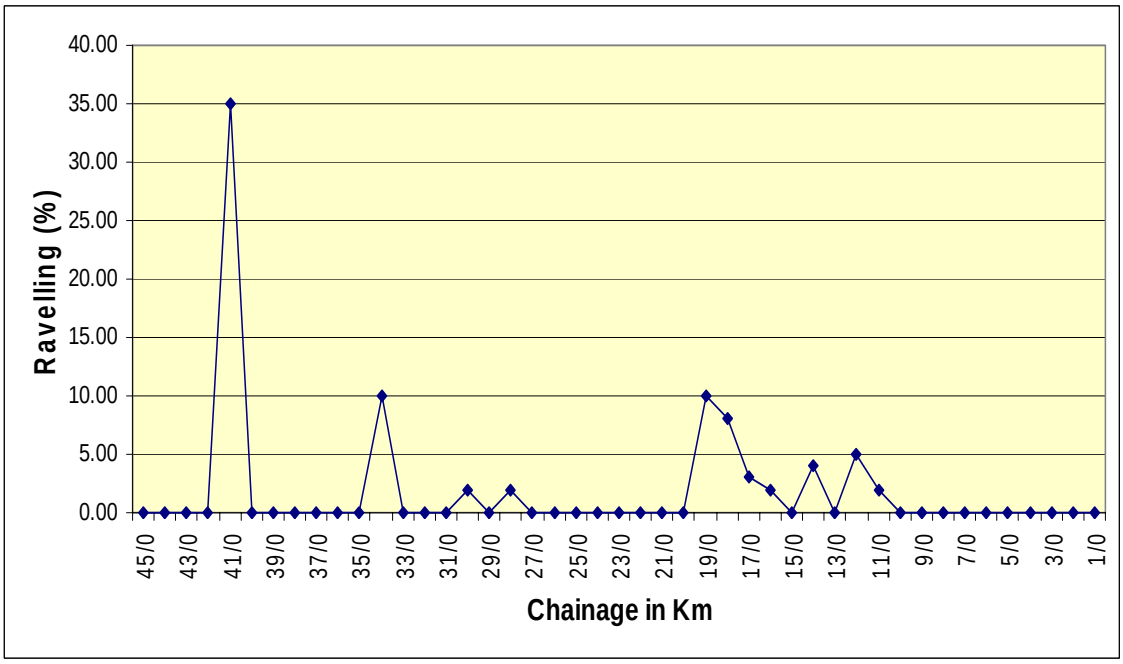


Figure 2.2 Raveling (%) Variation along the Bhadrak-Chandbali stretch

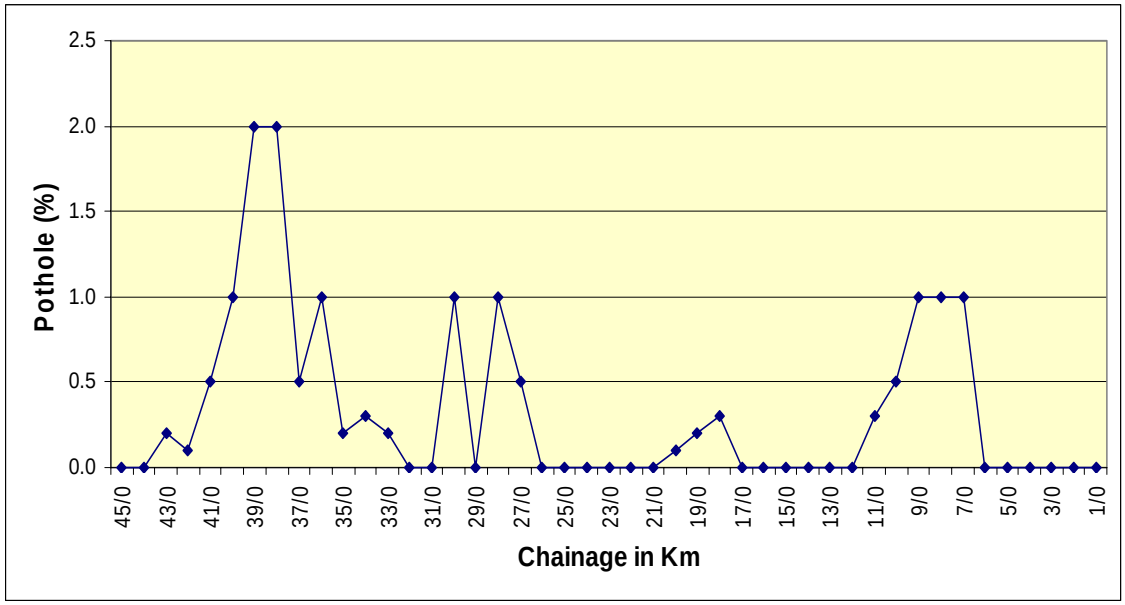


Figure 2.3 Potholing (%) Variation along the Bhadrak-Chandbali stretch

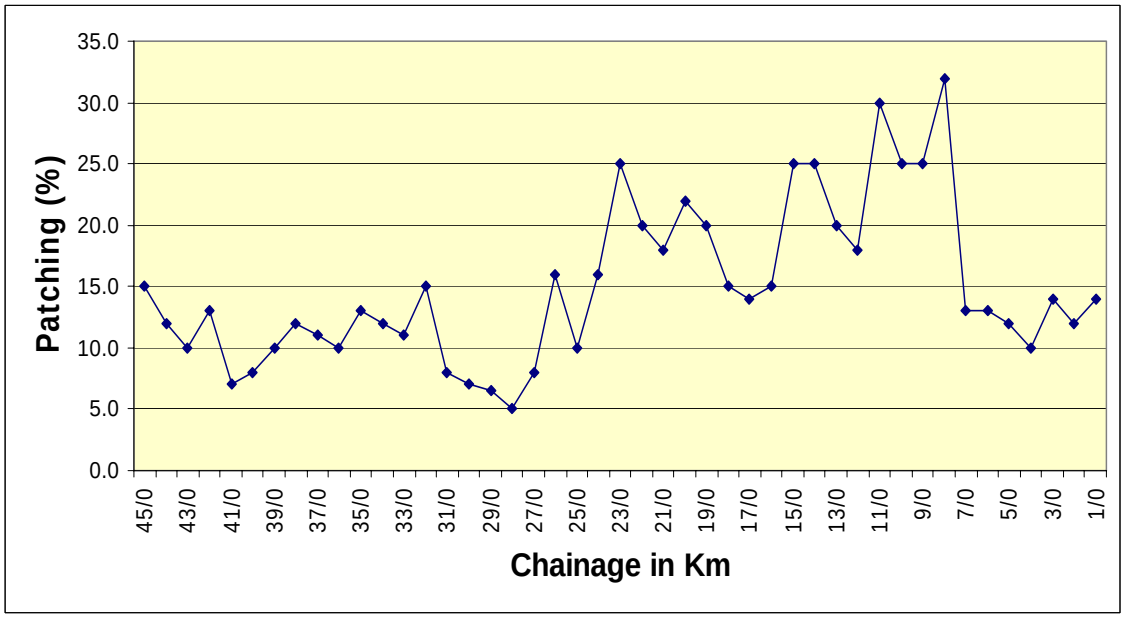


Figure 2.4 Patching (%) Variation along the Bhadrak-Chandbali stretch

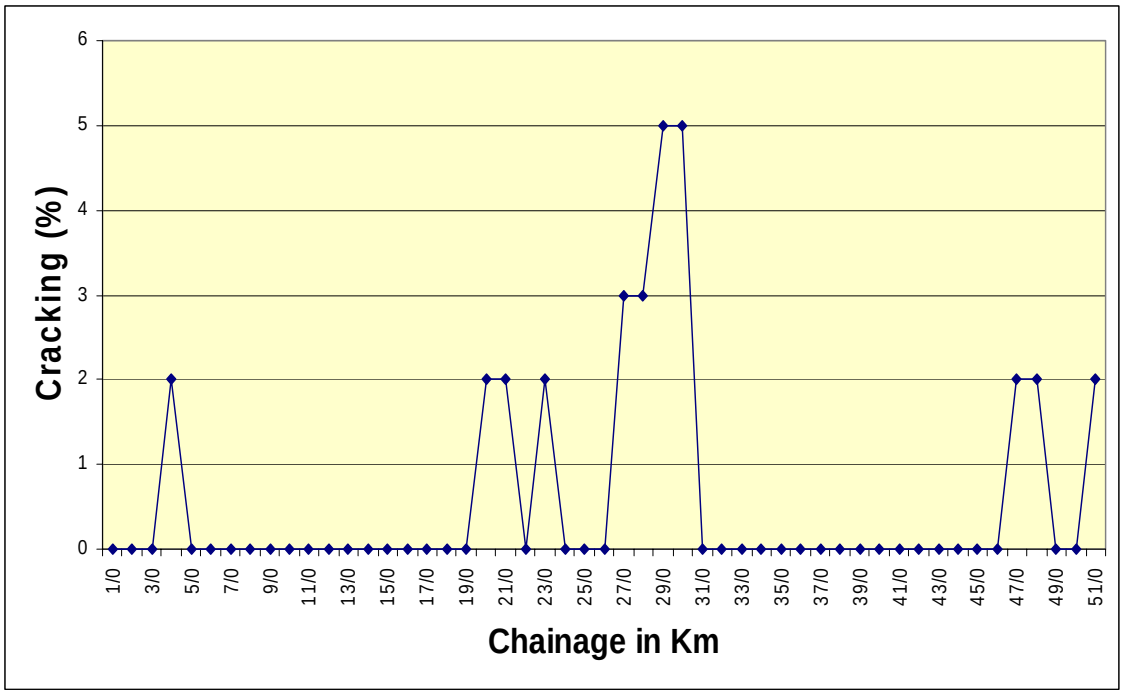


Figure 2.5Cracking (%) Variation along the Bhadrak-Anandpur stretch

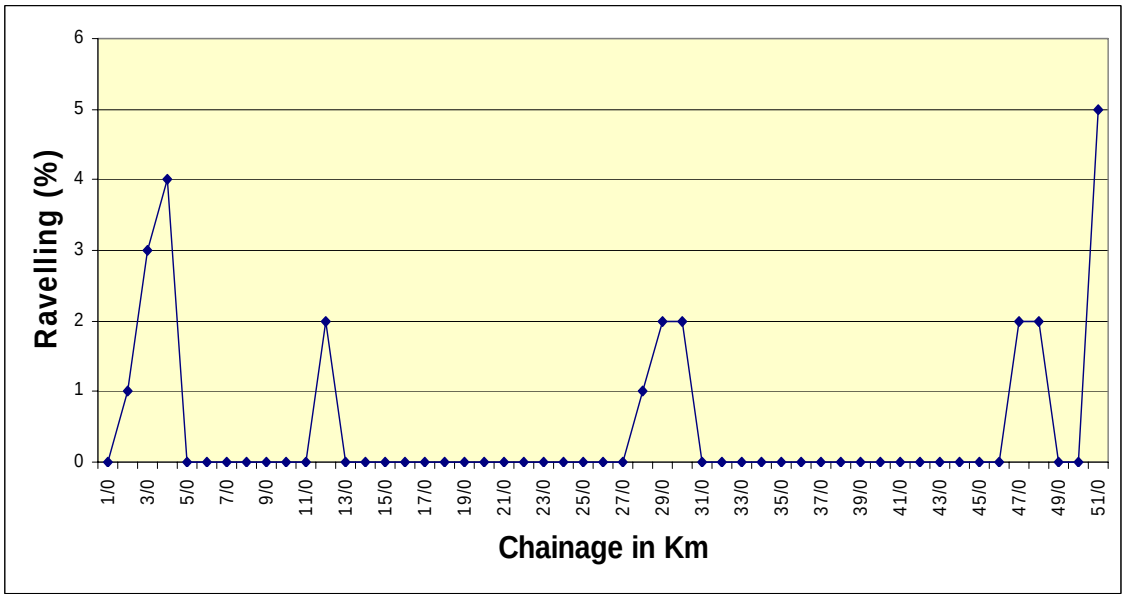


Figure 2.6 Raveling (%) Variation along the Bhadrak-Chandbali stretch

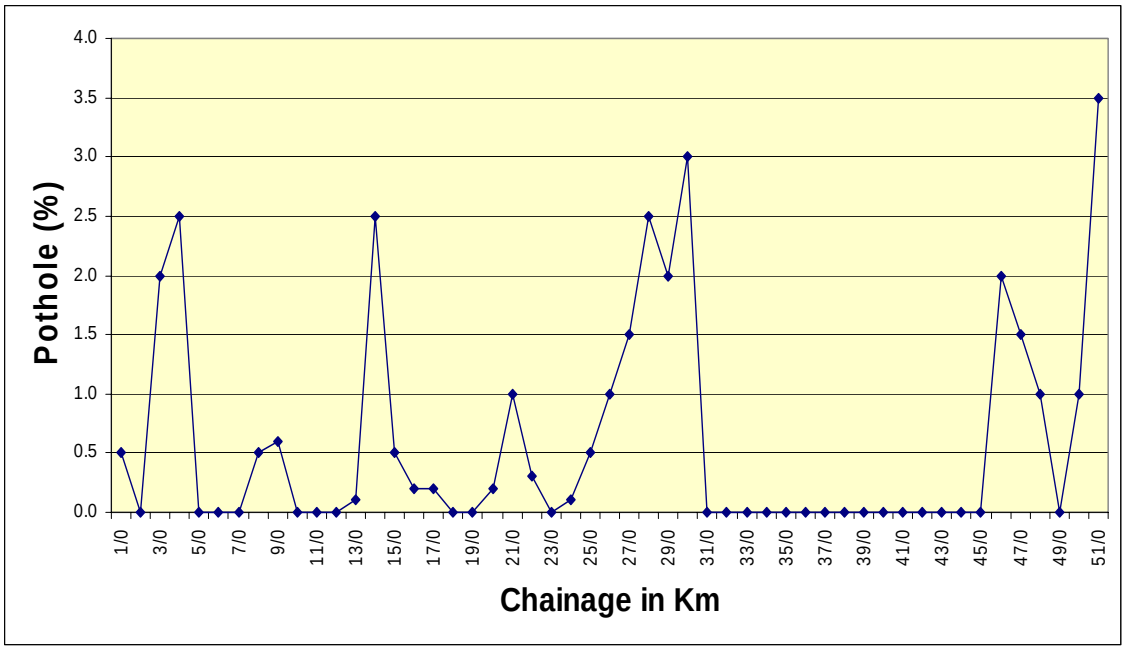


Figure 2.7 Potholing (%) Variation along the Bhadrak-Chandbali stretch

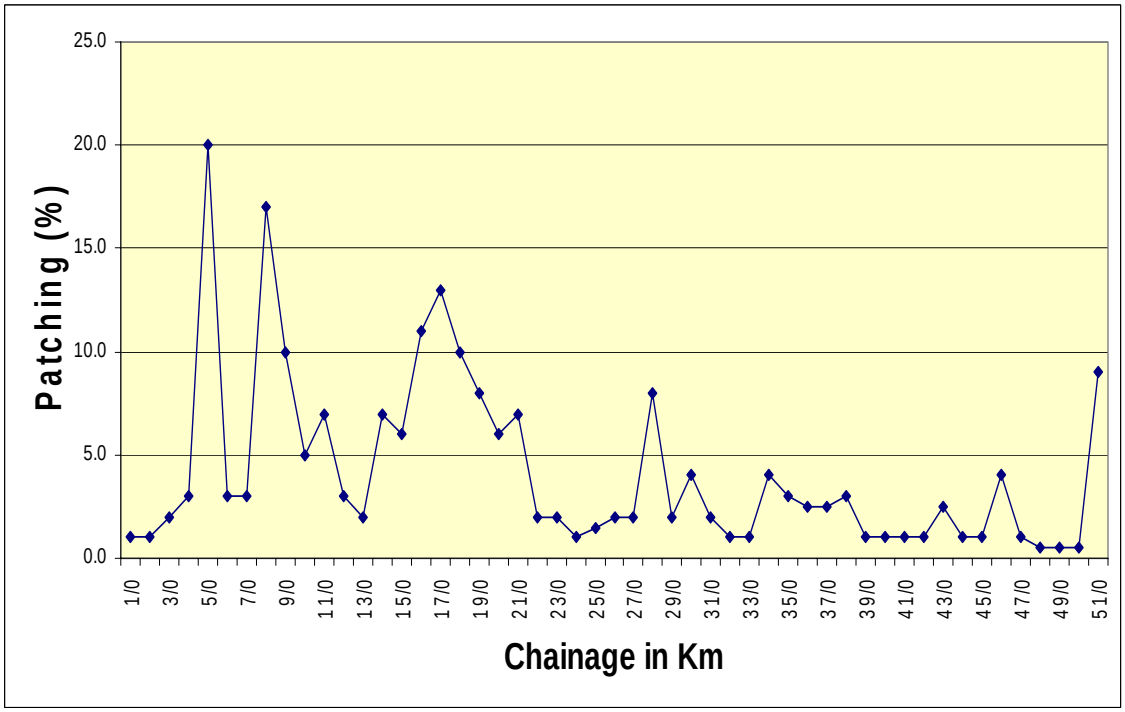


Figure 2.8 Patching (%) Variation along the Bhadrak-Chandbali stretch

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 compositions for Bhadrak-Chandbali and Bhadrak-Anandpur roads have been shown in Tables 2.24 and 2.25. Pavement sub-grade characteristics have already been discussed in section 2.3.2

Table 2.24 Pavement composition for Bhadrak-Chandbali Road

Chainage		Wear-ing Course (mm)	Base Course (mm)	Sub-base course (mm)	Total Thickness (mm)	Chainage		Wear-ing Course (mm)	Base Course (mm)	Sub-base course (mm)	Total Thickness (mm)
From	To					From	To				
0	1	30	150	150	**330**	23	24	25	150	140	**315**
1	2	40	170	140	**350**	24	25	25	140	130	**295**
2	3	20	150	160	**330**	25	26	15	130	150	**295**
3	4	15	200	120	**335**	26	27	15	185	140	**340**
4	5	30	155	160	**345**	27	28	15	150	140	**305**
5	6	15	170	140	**325**	28	29	70	160	140	**370**
6	7	15	145	165	**325**	29	30	70	160	140	**370**
7	8	20	185	160	**365**	30	31	70	130	150	**350**
8	9	30	180	170	**380**	31	32	15	115	200	**330**
9	10	30	210	140	**380**	32	33	20	150	165	**335**
10	11	30	140	180	**350**	33	34	20	150	140	**310**
11	12	35	165	160	**360**	34	35	20	150	160	**330**
12	13	20	170	155	**345**	35	36	75	170	130	**375**
13	14	18	185	160	**363**	36	37	90	170	140	**400**
14	15	20	185	140	**345**	37	38	25	165	150	**340**
15	16	20	240	120	**380**	38	39	20	165	160	**345**
16	17	20	190	110	**320**	39	40	45	160	150	**355**
17	18	25	170	190	**385**	40	41	20	200	125	**345**
18	19	20	220	130	**370**	41	42	20	200	125	**345**
19	20	20	210	130	**360**	42	43	20	170	130	**320**
20	21	20	180	100	**300**	43	44	20	140	170	**330**
21	22	15	140	150	**305**	44	45	60	165	150	**375**
22	23	40	180	150	**370**						

Table 2.25 Pavement composition for Bhadrak-Anandpur Road

Chainage		Wear-ing Course (mm)	Base Course (mm)	Sub-base course (mm)	Total Thickness (mm)	Chainage		Wear-ing Course (mm)	Base Course (mm)	Sub-base course (mm)	Total Thickness (mm)
From	To					From	To				
1	2	30	175	150	**355**	26	27	25	200	170	**395**
2	3	25	160	150	**335**	27	28	20	150	140	**310**
3	4	15	160	135	**310**	28	29	20	190	170	**380**
4	5	60	190	120	**370**	29	30	25	180	160	**365**
5	6	70	175	140	**385**	30	31	25	195	175	**395**
6	7	30	165	150	**345**	31	32	30	180	165	**375**
7	8	30	160	135	**325**	32	33	25	190	130	**345**

Chainage		Wear-ing Course (mm)	Base Course (mm)	Sub-base course (mm)	Total Thickness (mm)	Chainage		Wear-ing Course (mm)	Base Course (mm)	Sub-base course (mm)	Total Thickness (mm)
From	To					From	To				
8	9	30	170	150	**350**	33	34	35	170	170	**375**
9	10	25	160	140	**325**	34	35	25	160	150	**335**
10	11	25	170	170	**365**	35	36	25	200	130	**355**
11	12	45	190	100	**335**	36	37	25	190	170	**385**
12	13	50	190	100	**340**	37	38	30	165	150	**345**
13	14	30	160	150	**340**	38	39	30	210	140	**380**
14	15	20	190	130	**340**	39	40	30	190	175	**395**
15	16	25	170	150	**345**	40	41	30	195	180	**405**
16	17	25	180	130	**335**	41	42	25	170	150	**345**
17	18	20	160	170	**350**	42	43	20	185	170	**375**
18	19	20	200	130	**350**	43	44	20	150	200	**370**
19	20	20	170	150	**340**	44	45	25	160	140	**325**
20	21	20	165	150	**335**	45	46	25	170	180	**375**
21	22	20	150	150	**320**	46	47	25	150	130	**305**
22	23	20	200	145	**365**	47	48	25	140	120	**285**
23	24	20	220	140	**380**	48	49	25	140	140	**305**
24	25	20	200	160	**380**	49	50	20	150	130	**300**
25	26	25	190	160	**375**	50	51	20	160	150	**330**

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 for Bhadrak-Chandbali and Bhadrak-Anandpur roads are presented in Tables 2.26 and 2.27.

Table 2.26 Roughness Value in IRI for Bhadrak-Chandbali road

Chainage		Avg.UI (mm/Km)	IRI Value (m/Km)	Chainage		Avg.UI (mm/Km)	IRI Value (m/Km)
From	To			From	To		
0	1	6090	7.58	23	24	8230	9.92
1	2	6450	7.98	24	25	8620	10.34
2	3	6880	8.45	25	26	10360	12.18
3	4	3140	4.20	26	27	7520	9.15
4	5	5610	7.04	27	28	8110	9.79
5	6	5910	7.38	28	29	8560	10.27
6	7	4070	5.29	29	30	7390	9.01

Chainage		Avg.UI (mm/Km)	IRI Value (m/Km)	Chainage		Avg.UI (mm/Km)	IRI Value (m/Km)
From	To			From	To		
7	8	3830	5.01	30	31	6980	8.56
8	9	2750	3.73	31	32	7620	9.26
9	10	3990	5.20	32	33	5720	7.17
10	11	3690	4.85	33	34	6200	7.70
11	12	2890	3.90	34	35	6190	7.69
12	13	5830	7.29	35	36	6230	7.74
13	14	5490	6.91	36	37	6670	8.22
14	15	6580	8.12	37	38	6160	7.66
15	16	8290	9.98	38	39	6830	8.40
16	17	9110	10.86	39	40	6410	7.94
17	18	8300	9.99	40	41	5320	6.72
18	19	7490	9.12	41	42	6340	7.86
19	20	7620	9.26	42	43	6270	7.78
20	21	7960	9.63	43	44	6450	7.98
21	22	5800	7.26	44	45	6890	8.46
22	23	5040	6.40				

Table 2.27 Roughness Value in IRI for Bhadrak-Anandpur road

Chainage		Avg.UI (mm/Km)	IRI Value (m/Km)	Chainage		Avg.UI (mm/Km)	IRI Value (m/Km)
From	To			From	To		
0	1	6460	7.99	25	26	5080	6.45
1	2	6060	7.55	26	27	6920	8.50
2	3	8920	10.66	27	28	6540	8.08
3	4	9730	11.52	28	29	6940	8.52
4	5	6250	7.76	29	30	7020	8.61
5	6	6650	8.20	30	31	4040	5.25
6	7	6440	7.97	31	32	3180	4.24
7	8	7060	8.65	32	33	3040	4.08
8	9	6810	8.38	33	34	3330	4.42
9	10	5300	6.70	34	35	2980	4.00
10	11	5670	7.11	35	36	2890	3.90
11	12	7470	9.10	36	37	3010	4.04
12	13	6850	8.42	37	38	2730	3.70
13	14	8340	10.04	38	39	2760	3.74
14	15	5880	7.35	39	40	2560	3.50
15	16	10730	12.57	40	41	2840	3.84
16	17	5420	6.83	41	42	2690	3.65
17	18	5940	7.41	42	43	3070	4.11
18	19	5690	7.13	43	44	3070	4.11
19	20	5340	6.74	44	45	2960	3.98
20	21	6500	8.03	45	46	7140	8.74
21	22	6130	7.63	46	47	6440	7.97
22	23	5640	7.08	47	48	6050	7.54
23	24	5060	6.42	48	49	6060	7.55
24	25	5800	7.26	49	50	5770	7.22

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 Tables 2.28 and 2.29.

Table 2.28 Characteristic Deflections for Bhadrak-Chandbali Road

Chainage		Characteristic Deflection	Chainage		Characteristic Deflection
From	To		From	To	
0	1	3.03	23	24	4.61
1	2	3.03	24	25	2.61
2	3	1.59	25	26	4.69
3	4	1.38	26	27	4.07
4	5	2.33	27	28	4.06
5	6	2.95	28	29	4.20
6	7	2.54	29	30	4.33
7	8	3.10	30	31	4.13
8	9	2.66	31	32	3.66
9	10	4.56	32	33	3.53
10	11	2.80	33	34	3.46
11	12	4.80	34	35	5.02
12	13	5.05	35	36	4.95
13	14	2.70	36	37	5.50
14	15	3.76	37	38	5.70
15	16	2.50	38	39	4.46
16	17	3.35	39	40	5.31
17	18	3.61	40	41	3.54
18	19	4.67	41	42	3.46
19	20	4.97	42	43	3.58
20	21	5.07	43	44	3.20
21	22	4.78	44	45	2.73
22	23	4.50			

Table 2.29 Characteristic Deflections for Bhadrak-Anandpur Road

Chainage		Characteristic Deflection	Chainage		Characteristic Deflection
From	To		From	To	
0	1	0.55	25	26	0.85
1	2	1.48	26	27	1.54
2	3	1.74	27	28	1.45
3	4	0.44	28	29	1.26
4	5	1.36	29	30	1.23
5	6	2.01	30	31	2.07
6	7	1.00	31	32	1.37

Chainage		Characteristic Deflection	Chainage		Characteristic Deflection
From	To		From	To	
7	8	0.75	32	33	2.52
8	9	1.66	33	34	4.86
9	10	0.88	34	35	0.76
10	11	6.00	35	36	2.34
11	12	1.53	36	37	1.06
12	13	5.80	37	38	1.64
13	14	1.27	38	39	1.03
14	15	1.03	39	40	1.88
15	16	1.13	40	41	0.95
16	17	1.16	41	42	2.17
17	18	1.34	42	43	1.49
18	19	1.86	43	44	2.90
19	20	1.62	44	45	2.25
20	21	2.12	45	46	3.75
21	22	1.28	46	47	2.01
22	23	1.45	47	48	2.35
23	24	1.56	48	49	1.74
24	25	1.35	49	50	1.22

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 that too without reflectors on the rear side, incites overtaking by the faster moving vehicles and causes accidents and also parked vehicles along the road without reflectors/back light;

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. Unpainted/damaged parapet walls, absence of reflectors;

xi. Frequent occurrence of bridges and culverts having in adequate width

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

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

xiv. 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 fair. 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 50 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 40 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.

Existing bridges have insufficient carriageway width at Chainages Km 1/970, 11/270 and 29/500.

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 2.5.and Fig 2.6.

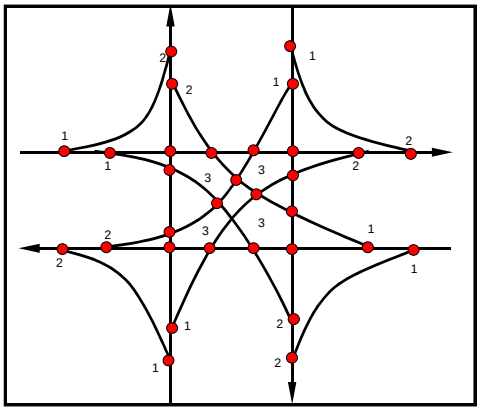


Figure 2.5 Cross Junction

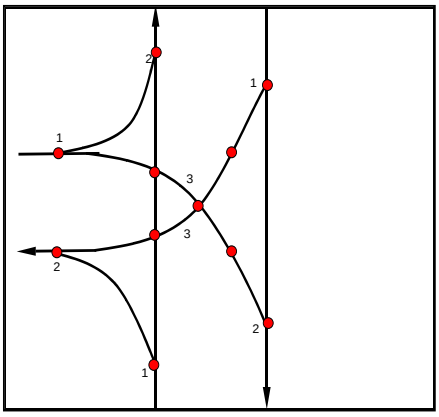


Figure 2.6 T-Junction

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 major and minor junctions are presented below with the types of the junction,

Table 2.30 List of Junctions Bhadrak-Chandbali Road

Sl no	Chainage	Type of Junction	LHS/RHS	Name of the Village
1	3950	Y-Type	RHS	-
2	6500	Y-Type	LHS	Basudevpur
3	12235	T-Type	LHS	To College
4	16417	Y-Type	RHS	Baulapala
5	17668	T-Type	RHS	Gangpada
6	18425	T-Type	RHS	-
7	19376	T-Type	RHS	Pathepur
8	21420	T-Type	LHS	Mangalpur
9	21990	T-Type	LHS	Patana
10	23252	T-Type	LHS	Indina
11	24600	Cross Jn	Both	Kankmara
12	33126	T-Type	RHS	Gahatpur
13	36195	T-Type	RHS	Nalgunda
14	37255	T-Type	LHS	Bansgada
15	40000	T-Type	RHS	-
16	50020	Y-Type	LHS	-
17	50448	T-Type	RHS	-

Table 2.31 List of Junctions Bhadrak-Anandpur Road

Sl no	Chainage	Type of Junction	LHS/RHS	Name of the Village
1	1356	Cross	Both	Pathasai & Janbath
2	1795	T-Type	RHS	Dhankabat
3	3359	T-Type	LHS	Randia
4	3595	T-Type	RHS	College
5	4427	Cross	Both	Ramkrishnapur & Odher
6	5984	T-Type	RHS	Barpada
7	8459	Y - Type	RHS	Agrapoda
8	8576	T-Type	LHS	School
9	8737	T - Type	LHS	College
10	10024	Y - Type	LHS	Asindpur
11	11798	T - Type	LHS	Ganijanga
12	13463	T - Type	LHS	Sandathida
13	14528	T - Type	LHS	Brahmapur
14	17018	T - Type	RHS	
15	18866	Cross	Both	Bathanpada & Bithathapur
16	19402	Y - Type	LHS	Barikpur
17	19453	T - Type	LHS	
18	24252	T - Type	LHS	Manjiro

Sl no	Chainage	Type of Junction	LHS/RHS	Name of the Village
19	29851	Y - Type	RHS	Ponnada
20	30339	T - Type	LHS	Somaha
21	31478	T - Type	LHS	Sullona
22	31588	Y - Type	RHS	Hadragada
23	33952	T - Type	LHS	Boncha
24	35809	T - Type	RHS	Otharak
25	36571	T - Type	LHS	Rakio
26	38543	Y - Type	RHS	Muchindha
27	39977	T - Type	RHS	Chalavanthi
28	40048	T - Type	LHS	Fakirpur
29	40567	Y - Type	LHS	Fakirpur
30	44031	T - Type	RHS	Anandpur main road
31	47013	T - Type	RHS	Padmapur
32	48340	T - Type	RHS	Sadavoni

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

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

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

viii. 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 built-up 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-03 at km 5/500 of SH-9 (near Barik Chhak) and other VC-04 at 4/600 of SH-53(near FACOR Factory). Results are shown in Table 2.32. The table shows that Annual Average Daily Traffic (AADT) are 8152 and 6647, whereas the PCU are 1190 and 687 respectively.

Table 2.32 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-03	AADT	2141	143	795	128	71	102	146	2	3	2	10	1952	104	0	0
	PCU	1071	143	795	192	213	153	439	7	15	11	15	976	208	0	0
	%	60.4%	4.0%	22.4%	3.6%	2.0%	2.9%	4.1%	0.1%	0.1%	0.1%	0.3%	94.9%	5.1%	0.0%	0.0%
VC-04	AADT	2219	108	742	80	100	133	621	109	8	18	4	1894	41	4	0
	PCU	1110	108	742	121	300	200	1864	328	35	81	6	947	83	30	0
	%	53.6%	2.6%	17.9%	1.9%	2.4%	3.2%	15.0%	2.6%	0.2%	0.4%	0.1%	97.7%	2.1%	0.2%	0.0%

Table 2.33 Summary of AADT and PCU

Count Stn.	Description	Total Motorised Vehicle	Total Comm. Vehicle	Total Non Motorised Vehicle	Total Vehicle
VC-03	AADT	3543	454	2056	5599
	PCU	3054	1030	1184	4238
VC-04	AADT	4142	1069	1939	6081
	PCU	4895	2929	1060	5955

2.9.2 Axle Load Survey

Axle load survey was carried out at two locations near Bhadrak (Km 3 of SH-9), and Near Karanjia (before junction of SH-53 & SH-49) designated as AL-02 and AL-04. 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 2.34 and design year MSA in Table 2.35

Table 2.34 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-02	Bhadrak - Chandbali	0.44	6.72	3.5	3.50	3.5
AL-04	Bhadrak - Anandpur	0.34	4.38	3.5	3.50	3.5

Table 2.35 Design MSA

Location	Design Year	Design MSA
VC-03	2028	15.15
VC-04	2025	37.93

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 2.36.

Table 2.36 Projected Traffic

Year	AADT		PCU	
	VC-03	VC-04	VC-03	VC-04
2006	5599	6081	4238	5955
2007	5816	6362	4433	6327
2008	6704	7282	5242	7356
2009	7023	7738	5542	7965
2010	7366	8235	5866	8637
2011	7735	8778	6217	9379
2012	8131	9371	6596	10199
2013	8557	10018	7007	11104
2014	9025	10765	7460	12147
2015	9530	11585	7951	13305
2016	10074	12486	8484	14590
2017	10659	13475	9062	16016
2018	11289	14562	9689	17600
2019	11910	15704	10314	19284
2020	12575	16955	10989	21146
2021	13287	18325	11717	23207
2022	14050	19827	12503	25489
2023	14867	21472	13353	28014
2024	15660	23095	14183	30531
2025	16505	24859	15074	33292
2026	17405	26776	16030	36321
2027	18363	28861	17057	39644
2028	19385	31128	18160	43292

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 Kilometer 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-Grade Intersections in Rural and Urban Areas
	Most Specifications for Roads & Bridge Works (2001) (Fourth Revision)
	Most Type 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 per 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 (or Right of Way) for different terrain classifications and for land use is given in Table 3.4 as per IRC 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 Memoire (July 4-13, 2006), Technical Aspects Para 23 – Design and Engineering Issues, for Bhadrak – Chandbali and Bhadark - Anandpur road the ROW (absolute minimum corridor of impact, COI), in built-up areas has COI of 17m. If land needed to be acquired then such acquisition will be done up to 18m. (Please check) In non built-up sections the minimum COI (Assuming an embankment height of 2m) has been taken about 25 m.

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.

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. Following table gives the location of bus-bays and Shelters. 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 have 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 paved shoulder is structurally designed to carry 10 to 20% of the traffic loads, 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 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 methods 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 (FLEXIBLE PAVEMENT)

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 embankment fill is to be obtained from borrow areas identified. For pavement reconstruction, the reconstructed pavements were considered to be placed on existing embankment 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 500mm of the embankment material is to obtained from borrow areas identified (Clause 305.2.1.2 of MoRST&H). Soils whose DFS is more than 50% were found on this road. Chainages where DFS more than 50% are presented in Table 4.3 and 4.4. So it is recommended to replace existing swelling fill material with borrow material from Chainage 0/00 (Sathipur River) and 44/00 (Baitarni River) for Bhadrak – Anandpur stretch, from Baitarni River for Chandbali – Bhadrak stretch.

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 identified section; details of CBR at each km and Design for the identified section are presented in Table 4.1 & 4.2. 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 Bhadrak - Chandbali (0/000 km - 41/000 km) and Bhadrak – Anandpur (0/000 to 50/000) flexible pavement for new construction, Reconstruction by using

IRC: 37-2001 and Overlay using IRC: 81-1997. As specified by PIU Rigid Pavement is proposed in Chandbali – Bhadrak stretch (0/00 to 0/200, 9/600 to 10/250, 16/00 to 17/00, 21/250 to 21/500 and 25/800 to 27/100) for length of 3.300 km. The Flexible pavement thickness of the different sections for new construction is presented in Table 4.1and 4.2, and pavement thickness of the different sections for Overlay is presented in Table 4.3 and 4.4.

Table 4.l: Design CBR for Bhadrak - Chandbali corridor

KM		Characte-ristic Deflection	Design Deflec-tion	Existing Subgrade CBR	Design CBR	Design CBR adopted	Type of Constru-ction	Remarks
From	To							
0	1	3.03	-	3.2	3.06	6.00	New Constructi on	**New construction is done due to DFS problem and poor CBR problem**
1	2	3.03		-				
2	3	1.59		3				
3	4	1.38		5.2				
4	5	2.33	3.04	9.2	6.50	6.00	Overlay	**Overlay**
5	6	2.95		-				
6	7	2.54		6.5				
7	8	3.10		-				
8	9	2.66		-				
9	10	4.56	-	5.9	3.08	6.00	New Constructi on	**New construction is done due to DFS problem and poor CBR problem**
10	11	2.80		-				
11	12	4.80		3				
12	13	5.05		-				
13	14	6.00		3.8				
14	15	3.76		-				
15	16	2.50		4.8				
16	17	3.35		-				
17	18	3.61		-				
18	19	4.67		3.5				
19	20	4.97		-				
20	21	5.07		3.6				
21	22	4.78		-				
22	23	4.50		2.5				
23	24	4.61		-				
24	25	2.61		-				
25	26	4.69		2.2				
26	27	4.07		6.8				
27	28	4.06		-				
28	29	4.20		2.6				
29	30	4.33		-				
30	31	4.13		2.8				
31	32	3.66	3.65	6.5	6.50	6.00	Overlay	**Overlay**
32	33	3.53		-				
33	34	3.46	-	-	2.14	6.00	New Constructi on	**New construction is done due to DFS problem and poor CBR problem**
34	35	5.02		2.3				
35	36	4.95		-				
36	37	5.50		2.1				
37	38	5.70		-				
38	39	4.46		3.2				
39	40	5.31		-				
40	41	3.54	3.56	9	7	6	Overlay	**Overlay**
41	42	3.46		10.2				
42	43	3.58		-				
43	44	3.20		12.2				
44	45	2.73		-				

Table 4.2: Design CBR for Bhadrak - Anandpur corridor

KM		Character-istic Deflection	Design Deflect-ion	Existing Subgrade CBR	Design CBR	Design CBR adopted	Type of Construc-tion	Remarks
From	To							
0	1	0.87	-	3.30	3.3	6.00	New Construction	**New construction is done due to poor CBR problem**
1	2	1.53		-				
2	3	1.63	1.80	6.50	6.00	6.00	Overlay	**Overlay**
3	4	0.54		-				
4	5	1.30		-				
5	6	1.80		8.50				
6	7	0.84		5.80				
7	8	0.65		-				
8	9	1.75		-				
9	**10**	0.85	-	2.80	2.80	6.00	New Construction	**New construction (DFS)**
10	11	6.00	-	-	5.00	5.00	Reconstruction	Reconstruction with Design CBR(Deflection values are high)
11	12	1.70		5.20				
12	13	5.59		-				
13	**14**	1.45	-	2.60	2.60	6.00	New Construction	**New construction (DFS)**
14	15	1.85	1.85	4.70	5.00	5.00	Overlay	**Overlay**
15	16	1.25		-				
16	17	1.21		-				
17	18	1.74	-	3.20	3.20	6.00	New Construction	**New construction is done due to poor CBR problem**
18	19	2.21		-				
19	20	2.39		-				
20	21	3.35		-				
21	**22**	3.65		2.50	2.50	6.00	New Construction	**New construction (DFS)**
22	23	2.50	-	-	2.50	6.00	New Construction	**New construction is done due to poor CBR problem**
23	24	2.54		-				
24	**25**	2.18		2.50	2.50	6.00	New Construction	**New construction (DFS)**
25	26	1.34	-	-	2.50	6.00	New Construction	**New construction (Poor CBR)**
26	**27**	2.48		3.20	3.20	6.00	New Construction	**New construction (DFS)**
27	28	2.10	2.10	9.70	9.70	6.00	Overlay	**Overlay**
28	29	1.10		-				
29	30	1.23	-	3.00	3.00	6.00	New Construction	**New construction (Poor CBR)**
30	31	2.07	2.50	-	4.70	5.00	Overlay	**Overlay**
31	32	1.37		4.70				
32	33	2.52		-				
33	34	4.86	-	-	4.70	6.00	New Construction	**New construction (Poor CBR)**
34	**35**	0.76	-	2.80	2.80	6.00	New Construction	**New construction (DFS)**

KM		Character-istic Deflection	Design Deflect-ion	Existing Subgrade CBR	Design CBR	Design CBR adopted	Type of Construc-tion	Remarks
From	To							
35	36	2.34	2.30	-	9.00	6.00	Overlay	**Overlay**
36	37	1.06		-				
37	38	1.64		9.00				
38	39	1.03	-	-	3.50	6.00	New Construction	**New construction (Poor CBR)**
39	40	1.88		3.50				
40	41	0.95	2.20	8.50	8.50	6.00	Overlay	**Overlay**
41	42	2.17		-				
42	43	1.49		-				
43	44	2.90		10.50				
44	45	2.25		-				
45	46	3.75	-	-	2.5	6.00	New Construction	**New construction (Poor CBR)**
46	**47**	2.01	-	-	2.50	6.00	New Construction	**New construction (DFS)**
47	**48**	2.35		2.50				
48	49	1.74	-	-	2.50	6.00	New Construction	**New construction (Poor CBR)**
49	50	1.22		-				

Table 4.3: Crust details for New Construction with borrow material for the Chandbali - Bhadrak as per IRC method

S. No	Chainage		Length in Km	Thickness Design (IRC-37)									Remarks
				Crust Details for new Construction									
				Surface Course		Base		Sub Base		Sub grade	Emban-kment	Total Thick-ness	
	From	To		BC	DBM	WMM1	WMM2	GSB1	GSB2				
1	0.000	4.000	4.000	40	75	100	150	110	150	500	500	**1625**	**DFS>50%**
2	9.000	9.600	0.600	40	75	100	150	110	150	500	500	**1625**	**DFS>50%**
3	10.250	16.100	5.850	40	75	100	150	110	150	500	500	**1625**	**DFS>50%**
4	18.500	21.250	2.750	40	75	100	150	110	150	500	500	**1625**	**DFS>50%**
5	21.600	25.800	4.200	40	75	100	150	110	150	500	500	**1625**	**DFS>50%**
6	27.100	31.000	3.900	40	75	100	150	110	150	500	500	**1625**	**DFS>50%**
7	33.000	39.100	6.100	40	75	100	150	110	150	500	500	**1625**	**DFS>50%**

Table 4.4(a): Crust details for New Construction with borrow material, DFS Problem for the Bhadrak - Anandpur as per IRC method

S. No	Chainage		Length in Km	Thickness Design (IRC-37)									Remarks
				Crust Details for new Construction									
				Surface Course		Base		Sub Base		Sub grade	Emban-kment	Total Thick-ness	
	From	To		BC	DBM	WMM1	WMM2	GSB1	GSB2				
1	8.500	10.000	1.500	40	100	100	150	110	150	500	500	**1650**	**DFS>50%**
2	13.000	14.000	1.000	40	50	100	150	110	150	500	500	**1600**	**DFS>50%**
3	21.000	22.000	1.000	40	50	100	150	110	150	500	500	**1600**	**DFS>50%**
4	24.000	25.000	1.000	40	50	100	150	110	150	500	500	**1600**	**DFS>50%**
5	26.000	27.000	1.000	40	50	100	150	110	150	500	500	**1600**	**DFS>50%**
6	34.000	35.000	1.000	40	50	100	150	110	150	500	500	**1600**	**DFS>50%**
7	46.000	48.000	2.000	40	50	100	150	110	150	500	500	**1600**	**DFS>50%**

Table 4.4(b): Crust details for New Construction with borrow material for the Bhadrak - Anandpur 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	0.000	2.000	2.000	40	100	100	150	110	150	500	**1150**
2	17.000	21.000	4.000	40	50	100	150	110	150	500	**1100**
3	22.000	24.000	2.000	40	50	100	150	110	150	500	**1100**
4	25.000	26.000	1.000	40	50	100	150	110	150	500	**1100**
5	29.000	30.000	1.000	40	50	100	150	110	150	500	**1100**
6	33.000	34.000	1.000	40	50	100	150	110	150	500	**1100**
7	38.000	40.000	2.000	40	50	100	150	110	150	500	**1100**
8	45.000	46.000	1.000	40	50	100	150	110	150	500	**1100**
9	48.000	50.000	2.000	40	50	100	150	110	150	500	**1100**

Table 4.5: Crust details for Reconstruction / widening for the Bhadrak – Chandbali as per IRC method

S. No	Chainage		Length in Km	Thickness Design (IRC-37)													
				Crust Details for Reconstruction						Crust Details for Widening							
				Surface Course		Base		Sub Base	Total Thickness	Surface Course		Base		Sub Base		Sub grade	Total Thickness
	From	To		BC	DBM	WMM1	WMM2	GSB		BC	DBM	WMM1	WMM2	GSB1	GSB2		
1	4.000	9.000	5.000	40	75	100	150	260	**625**	40	75	100	150	110	150	500	**1125**
2	31.000	33.000	2.000	40	75	100	150	260	**625**	40	75	100	150	110	150	500	**1125**
3	40.300	44.600	4.300	40	75	100	150	260	**625**	40	75	100	150	110	150	500	**1125**

Table 4.6: Crust details for Reconstruction / widening for the Bhadrak – Anandpur as per IRC method

S.No	Chainage		Length in Km	Thickness Design (IRC-37)													
				Crust Details for Reconstruction						Crust Details for Widening							
				Surface Course		Base		Sub Base	Total Thickness	Surface Course		Base		Sub Base		Sub grade	Total Thickness
	From	To		BC	DBM	WMM1	WMM2	GSB		BC	DBM	WMM1	WMM2	GSB1	GSB2		
1	10.000	13.000	3.000	40	50	100	150	260	**600**	40	50	100	150	110	150	500	**1100**

4.3.3 Overlay Design:

Overlay thickness design has been based on characteristic deflection determined for each relevant section of road and the design chart given in IRC: 81-1997. The following points describe the methodology adopted in arriving at the overlay thickness.

- Benkelman Beam Deflection test data was analyzed as per IRC guidelines and characteristic deflection was calculated for each Km of the road.
- Characteristic deflection is estimated as mean rebound deflection plus twice the standard deviation as per IRC guidelines.
- Correction for temperature is done as per IRC: 81-1997.
- After de-marking the homogenous sections, characteristic deflection was calculated for each section as mean rebound deflection plus twice the standard deviation.
- Depending on the traffic loading, overlay thickness in terms of BM (Bituminous Macadam) layer was established as per design chart given in IRC: 81-1997 for each section.
- Equivalency factors given in IRC: 81-1997 was used to find out the layer thickness of BC (Bituminous Concrete), DBM (Dense Bituminous Concrete) and WMM (Wet Mix Macadam) layers. WMM layer was proposed as a granular overlay below the bituminous layer. Keeping in view all the constraints, this proposal is both cost effective and efficient.
- Profile corrective course with WMM layer was proposed in place of BM layer, to correct the existing camber as well as undulations in the existing surface.

Table 4.7: Crust details for Overlay for the Bhadrak - Anandpur as per IRC method (IRC: 81-1997)

S.No	Chainage		Length in Km	Thickness Deisgn (IRC-81)				Thickness Design (IRC-37)							
				Crust Details for Overlay				Crust Details for Widening							
				Surface Course		PCC	Total Thickness	Surface Course		Base		Sub Base		Sub grade	Total Thickness
	From	To		BC	DBM	WMM1		BC	DBM	WMM1	WMM2	GSB1	GSB2		
1	2.000	8.500	6.500	40	100	100	**240**	40	100	100	150	110	150	500	**1150**
2	14.000	17.000	3.000	40	50	100	**190**	40	50	100	150	110	150	500	**1100**
3	27.000	29.000	2.000	40	50	100	**190**	40	50	100	150	110	150	500	**1100**
4	30.000	33.000	3.000	40	50	100	**190**	40	50	100	150	110	150	500	**1100**
5	35.000	38.000	3.000	40	50	100	**190**	41	50	100	150	110	150	500	**1101**
6	40.000	45.000	5.000	40	50	100	**190**	42	50	100	150	110	150	500	**1102**

4.4 DESIGN OF RIGID PAVEMENT

Design of Rigid Pavement is carried out in accordance with IRC: 58-2002. The paved shoulders (Rigid) of 1.5m width is provided on either side. The composition of the paved shoulder is same as with carriageway. The design has been done for the chainages specified by PIU in Chandbali-Bhadrak (km 0/000 to km 45/000) section.

4.5 IRC METHOD

4.6 DESIGN METHODOLOGY (RIGID PAVEMENT)

Cement concrete pavements are subjected to stresses due to a variety of factors acting simultaneously. The severest combination of different factors that induce the maximum stress in the pavement will give the critical stress condition. The factors commonly considered for the design of pavement thickness are Flexural Stresses due to Traffic loads and Temperature differentials between the top and bottom fibers of the concrete slab, as the two are assumed to be additive under critical condition.

The maximum combined tensile stress in three regions of the slab will thus be caused when effects of temperature differential are such as to be additive to the load effects. This would occur during the day in case of interior and edge regions at the time of maximum temperature differential in the slab. In the corner region temperature stress is negligible but the load stress is maximum at night when the slab corners have a tendency to lift up due to warping and loose partly the foundation support. Considering the total combined stress for the three regions i.e. corner, edge and interior, for which the load stresses decreases in that order while the temperature stress increases. The critical stress condition is reached in the edge region.

The effective modulus of Subgrade reaction (k) is obtained based on the Subgrade CBR. The axle loads are divided into axle load spectrum and pavement is checked for the Fatigue and Edge temperatures stresses.

4.7 FACTORS GOVERNING DESIGN

4.7.1 Wheel Load

The legal axle load limits in India have been fixed as 10.2, 19 and 24 tones for single axle, tandem axle and tridem axle.

4.7.2 Tyre Pressure

Tyre pressures and shape of contact areas of the CV also govern load stresses. For most of the CVs, it ranges from 0.7 to 1 MPA, but it is found that stresses in concrete pavements having thickness of 20cm or more are not affected significantly by the variation of tyre pressure. A tyre pressure of 0.8 MPa has been adopted for design.

4.7.3 Load Safety Factor (LSF)

LSF varies from 1.0 to 1.2. For heavy traffic, for Expressways, NH, and other roads where there will be uninterrupted traffic flow and high volumes of truck traffic LSF of 1.2 has been adopted.

4.7.4 Design Period

The design period is taken as 30 years.

4.7.5 Design Traffic

Design traffic shall be 25% of total two-lane two way CV's may be considered for two lane two way road. Design traffic shall be 25% of total traffic in the direction of predominant traffic shall be considered for four-lane and multilane divided highways. 25% of total two-lane two way CV's has been considered for design of pavement.

The cumulative number of axles during the period shall be computed using the below equation.

$$C = \frac{365\,x\left[(1+r)^n - 1\right]}{r} xA$$

C= Cumulative number of axles during the design period
A= Initial number of axles per day in the year when the road is operations.
r = Annual rate of growth of commercial vehicles traffic.
n = Design period in years.

Expected number of applications of different axle load groups during the design period is estimated from the axle load spectrum.

4.7.6 Temperature Differential

Temperature differential between the top and bottom of concrete pavements causes the concrete slab to warp, giving rise to stresses. For the assumed thickness the temperature differential is adopted from Table 1 of IRC: 58-2002.

4.7.8 Characteristics of Sub grade and Sub base

The strength of Subgrade is expressed in terms of modulus of Subgrade reaction (k). It is obtained from Table 2 of IRC: 58-2002 for the design CBR.

A Dry Lean Concrete (DLC) sub base is generally recommended for modern concrete pavements particularly those with high intensity of traffic. The effective modulus of sub grade reaction over DLC is obtained from Table 4 of IRC: 58-2002.

4.7.9 Characteristics of Concrete

Since the Concrete Pavements fail due to bending stresses, it is necessary that their design is based on the Flexural strength of the concrete. The Flexural Strength of the Concrete is adopted as 45 Kg/cm^2.

4.7.10 Modulus of Elasticity and Poisson's ratio

The Modulus of Elasticity, E, and Poisson's Ratio, μ of Cement Concrete varies with concrete materials and strength. E is adopted as $3x10^5$ Kg/cm^2, μ is adopted as 0.15.

4.7.11 Coefficient of Thermal Expansion (α)

The Coefficient of Thermal Expansion varies with type of aggregate. However, for the design purposes α value is taken as $10x10^{-6}$ per ^{0}C.

4.7.12 Fatigue behavior of Cement Concrete

Due to repeated application of Flexural stresses by the traffic loads, progressive fatigue damage takes place in the cement concrete slab in the form of gradual development of micro cracks especially when the applied stress in terms of Flexural strength of concrete is high. The ratio between the Flexural stress due to the load and Flexural strength of the concrete is termed as Stress Ratio (SR). This can be expressed in terms of Stress Ratio (SR). If the SR is less than 0.45 the concrete is expected to sustain infinite number of repetitions. As the SR increases the number of load repetitions (N) required to cause cracking decreases.

N = Infinite for SR< 0.45

$$N = \left[\frac{4.2577}{SR - 0.4325}\right]^{3.268} \quad \text{When } 0.45 <= SR <= 0.55$$

$$Log_{10} N = \frac{0.9718 - SR}{0.0828} \quad \text{For SR} > 0.55$$

<u>Stress Calculation:</u>

a) Due to Load

Stress can be calculated by using computer programme IITRIGID developed at IIT, Kharagpur or by using stress charts shown in *Appendix - 1* of IRC: 58-2002.

b) Due to Temperature

The temperature stress at the critical edge region may be obtained by using the equation presented below.

$$S_{te} = \frac{E \alpha t C}{2}$$

S_{te} = Temperature stress in the edge region, Kg/cm^2
E = Modulus of concrete, kg/cm^2
t = Maximum temperature differential during day between top and bottom of slab
α = Coefficient of thermal expansion of cement concrete per ^{0}C

C = Bradbury's coefficient which can be ascertained directly from Bradbury's chart against values of L/l and B/l presented in Fig 2 of IRC: 58-2002.
W = Slab width or spacing between consecutive contraction joints, cm
l = Radius of relative stiffness, cm

$$= 4\sqrt{\frac{Eh^3}{12(1-\mu^2)k}}$$

μ = Poisson's ratio
h = Thickness of the concrete slab, cm
k = Modulus of Sub grade reaction Kg/cm^2

c) Corner Stress

The load stress in the corner region may be obtained as per equation presented below.

$$S_c = \frac{3P}{h^2}\left[1-\left(\frac{a\sqrt{2}}{l}\right)^{1.2}\right]$$

Where;

S_c = Load stress in the corner region, other notations remaining the same as in the case of edge load stress formula
P = Wheel load, kg
a = Radius of equivalent circular contact area, cm

4.8 DESIGN OF JOINTS

Cement Concrete Pavements have transverse and longitudinal joints. Longitudinal joints are required in pavement of widths greater than 4.5m to allow for transverse contraction and warping.

4.8.1 Load Transfer at Transverse Joints

Transverse joints shall be provided with dowels as explained in clause 8.3.6 of IRC 15-2002. Load transfer to relive part of the load stresses in edge and corner regions of pavement slab at transverse joints is provided by means of mild steel.

4.8.2 Design of dowel bars

Maximum bearing stress between the concrete and dowel bar is obtained from the equation as:

$$\sigma_{max} = \frac{KP_t}{4\beta^3 EI}(2+\beta z)$$

Where;

$$\beta = 4\sqrt{\frac{kb}{4EI}}$$

β = Relative stiffness of the bar embedded in concrete.
K = Modulus of dowel/concrete interaction (dowel support, kg/cm^2/cm)
b = Diameter of the dowel,
z = Joint width, cm
E = Modulus of the elasticity of the dowel, kg/cm^2
I = Moment of inertia of the dowel, cm^4
P_t= Load transferred by a dowel bar.

Each dowel bar should transfer load that is less than design load for the maximum bearing pressure. The allowable bearing stress is calculated by using the equation presented below.

$$F_b = \frac{(10.16 - b) f_{ck}}{9.525}$$

Where;

F_b = Allowable bearing stress, kg/cm^2
b = Dowel diameter, cm
f_{ck} = Ultimate compressive strength (characteristic strength of the concrete, kg/cm^2 (400 kg/cm^2 for M40 concrete)

4.8.3 Design of tie bars

Tie bars are used across the joints of concrete pavements wherever it is necessary or desirable to ensure firm contact between slab faces or to abutting slabs from separating.

The area of steel required per meter length is computed by using the following formula:

$$A = \frac{bfW}{S}$$

Where;

A = Area if steel in cm^2 required for per meter length of joint
b = Distance between the joint in question and nearest free joint or edge in m
f = Co-efficient of friction between pavement and Sub grade (usually taken at 1.5)
W = Weight of pavement slab per sq meter in kg, i.e., 24kg/sqm per cm thickness and
S = Allowable working stress of steel in kg/sqm

The length of any tie bar should be at least twice that required to develop bond strength equal to the working stress of the steel. It is calculated by using the equation shown below.

$$L = \frac{2SA}{BP}$$

Where;

L = Length of tie bar, cm
S = Allowable working stress in steel, kg/cm^2
A = Cross-sectional area of one tie bar cm^2
B = Maximum permissible bond stress, kg/cm^2

To permit warping at the joint, the maximum diameter of tie bars may be limited to 20mm and to avoid concentration of tensile stresses they should not be spaced more than 75cm apart.

Design of Slab thickness

The Design parameters are:

Flexural strength of cement concrete	= 45 kg/cm2
Effective modulus of sub grade reaction of the DLC sub-base	= 13.8 kg/cm^3
Elastic modulus of concrete, E	= 300000 kg/cm^2
Poisson's ratio, μ	= 0.15
Coefficient of thermal expansion of concrete, ∝	= 0.00001 / ^{0} C
Tyre pressure, p	= 8 kg/cm^2
Spacing of contraction joints	= 4.0 m
Width of slab	= 2.5 m
Total commercial traffic per day, A	= 454
Load safety factor (LSF)	= 1.2
98th percentile axle load (From Axle Load Spectrum)	= 18.0 Ton
Total design life, n	= 30 Yrs
Assumed Slab Thickness	= 30 cm

Growth rate adopted for different vehicles is given in the following table

Table 4.8: Growth rate adopted for different vehicles

Year	Buses	LCV	2-Axle	3-Axle	Tractor & Trailer
Up to 2008	3.93%	9.17%	6.00%	6.00%	7.64%
2008-13	4.59%	10.77%	7.00%	7.00%	8.98%
2013-18	4.72%	10.82%	7.20%	7.20%	9.02%
2018-23	4.30%	10.04%	6.56%	6.56%	8.37%
2023-28	3.89%	9.07%	5.94%	5.94%	7.56%
2028-33	3.89%	9.07%	5.94%	5.94%	7.56%
2033-38	3.89%	9.07%	5.94%	5.94%	7.56%

The Axle load spectrum obtained from Axle load survey is given in the following table

Table 4.9: Development of Axle load spectrum

Single Axle Loads							Tandem Axle Loads					
Axle Load class, tons		Axle Load (mid value)	Total Single Axle Loads (f)	% of Total Axle loads	% of Single Axle loads	Cumulative %	Axle Load class, tons		Axle Load (mid value)	Total Tandem Axle Loads	% of Axle loads	Cumulative %
>0	<=9	8	263	78.27	79.94	79.94	>0	<=14	14	6	1.79	1.79
>9	<=11	10	10	2.98	3.04	82.98	>14	<=18	16	0	0.00	1.79
>11	<=13	12	28	8.33	8.51	91.49	>18	<=22	20	1	0.30	2.08
>13	<=15	14	11	3.27	3.34	94.83	>22	<=26	24	0	0.00	2.08
>15	<=17	16	7	2.08	2.13	96.96	>26	<=30	28	0	0.00	2.08
>17	<=19	18	2	0.60	0.61	97.57	>30	<=34	32	0	0.00	2.08
>19	<=21	20	5	1.49	1.52	99.09	>34	<=38	36	0	0.00	2.08
>21	<=23	22	2	0.60	0.61	99.70	>38	<=41	40	0	0.00	2.08
>23	<=25	24	0	0.00	0.00	99.70	>41	<=43	42	0	0.00	2.08
>25	<=27	26	1	0.30	0.30	100.00	>43	<=45	44	0	0.00	2.08
Total			**329**	**97.92**	**100**					**7**	**2.08**	

Design traffic: The cumulative number of axles during the period shall be computed using the following table.

Table 4.10: Cumulative number of Commercial vehicles

Year	Bus		LCV	Truck			Agri Tractor	Total Comm Vehicles	Cumulative Comm Veh
	Mini	Full		2-Axle	Multi Axle	Articulated	With Trailer		
2006	128	71	102	146	2	3	2		
2007	133	74	111	155	2	3	2	480	
2008	**152**	**84**	**134**	**219**	**7**	**9**	**3**	**608**	**608**
2009	159	88	148	234	8	9	3	650	1258
2010	167	92	164	250	9	10	3	695	1953
2011	174	97	182	268	9	11	3	744	2697
2012	182	101	202	287	10	11	4	796	3493
2013	**191**	**106**	**223**	**307**	**10**	**12**	**4**	**853**	**4346**
2014	200	111	247	329	11	13	4	915	5261
2015	209	116	274	352	12	14	5	982	6244
2016	219	121	304	378	13	15	5	1,055	7299
2017	229	127	337	405	14	16	6	1,134	8432
2018	**240**	**133**	**373**	**434**	**15**	**17**	**6**	**1,219**	**9651**
2019	250	139	411	463	16	18	7	1,303	10954
2020	261	145	452	493	17	20	7	1,394	12348
2021	272	151	497	525	18	21	8	1,493	13841
2022	284	157	547	560	19	22	8	1,598	15439
2023	**296**	**164**	**602**	**597**	**20**	**24**	**9**	**1,712**	**17152**
2024	308	171	657	632	22	25	10	1,824	18976
2025	320	177	717	670	23	27	10	1,943	20919
2026	332	184	782	709	24	28	11	2,071	22990
2027	345	191	853	752	26	30	12	2,208	25198
2028	**358**	**199**	**930**	**796**	**27**	**32**	**13**	**2,355**	**27553**
2029	372	207	1,014	843	29	34	14	2,513	30066
2030	387	215	1,106	894	31	36	15	2,682	32748
2031	402	223	1,207	947	32	38	16	2,864	35613
2032	417	232	1,316	1,003	34	40	17	3,060	38673
2033	**434**	**241**	**1,436**	**1,063**	**36**	**42**	**19**	**3,270**	**41943**
2034	451	250	1,566	1,126	38	45	20	3,496	45438
2035	468	260	1,708	1,193	41	48	22	3,738	49177
2036	486	270	1,863	1,263	43	50	23	3,999	53176
2037	505	280	2,032	1,338	46	53	25	4,280	57457
2038	**505**	**280**	**2,032**	**1,338**	**46**	**53**	**25**	**4,280**	**61737**

Design Traffic = 25 percent of the total repetitions of commercial vehicles
= 0.25*61737 = 15,434 commercial vehicles

Stress due to loads: Stress due to loads (Single and Tandem) is calculated based on the following table

Table 4.11: Stress Calculation

Single Axle Load

Axle Load, Ton		Percentage of axles	Mid Value, T	Load Safety factor	Actual Load, T	Stress, Kg/cm2	Stress Ratio	Expected repetitions	Allowable Repetitions (Fatigue Life, N)	Fatigue Life Consumed
			(1)	(2)	(1)*(2)	(3)	(4)	(5)	(6)	(5)/(6)
<	9	78.27	9	1.2	10.8	13.08	0.29	12080		0
9	11	2.98	10	1.2	12	14.14	0.31	459		0
11	13	8.33	12	1.2	14.4	16.64	0.37	1286		0
13	15	3.27	14	1.2	16.8	19.40	0.43	505		0.00
15	17	2.08	16	1.2	19.2	21.80	0.48	321	2402754	0.00
17	19	0.60	18	1.2	21.6	23.64	0.53	91	229127	0.00
19	21	1.49	20	1.2	24	25.30	0.56	229	94065	0.003
21	23	0.60	22	1.2	26.4		0	91		0.00
23	25	0.00	24	1.2	28.8		0	0		0
25	27	0.30	26	1.2	31.2		0	45		0

Tandem Axle load

Axle Load, Ton		Percentage of axles	Mid Value, T	Load Safety factor	Actual Load, T	Stress, Kg/cm2	Stress Ratio	Expected repetitions	Allowable Repetitions (Fatigue Life, N)	Fatigue Life Consumed
			(1)	(2)	(1)*(2)	(3)	(4)	(5)	(6)	(5)/(6)
<	14	1.79	14	1.2	16.8	7.80	0.17	275		0
14	18	0.00	16	1.2	19.2	9.94	0.22	0		0
18	22	0.30	20	1.2	24	12.14	0.27	45		0
22	26	0.00	24	1.2	28.8	13.98	0.31	0		0
26	30	0.00	28	1.2	33.6		0.00	0		0
30	34	0.00	32	1.2	38.4		0.00	0		0
34	38	0.00	36	1.2	43.2		0.00	0		0
38	41	0.00	40	1.2	48		0.00	0		0
41	43	0.00	42	1.2	50.4		0.00	0		0
43	45	0.00	44	1.2	52.8		0	0		0

Cumulative fatigue life consumed = 0.0030 <1.0; so, safe from fatigue considerations.

Check for Temperature Stresses: The temperature stress at the critical edge region may be obtained by using the equation presented below.

$$S_{te} = \frac{E \alpha t C}{2}$$

Radius of relative stiffness, l = $\sqrt[4]{\frac{Eh^3}{12(1-\mu^2)k}}$

= 84.11 cm

C value depends on L/l ratio

L/l = 400/84.11 = 4.76

C = 0.67

t = 16.8^0 C

Temperature differential (t) is taken as 16.8^0 C for Eastern Orissa region for 30 cm thickness

S_{te} = 16.884 kg/cm^2

Check:

Total stress = Stress due to max load + Temperature stress

= 25.30 + 16.88

= 42.18 < 45 kg/cm^2

So, the pavement thickness is safe under the combined action of wheel load and temperature

Check for Corner Stresses:

The load stress in the corner region may be obtained as per equation presented below.

$$S_c = \frac{3P}{h^2}\left[1-\left(\frac{a\sqrt{2}}{1}\right)^{1.2}\right]$$

P = 9000 Kg

h = 30 cm

l = 84.11 cm

a = 27.62 cm

S_c = 18.05 kg/cm2 < 45 kg/cm^2

The corner stress is less than the flexural strength of the concrete, i.e., 45 kg/cm^2 and the pavement thickness of 30 cm assumed is safe.

DESIGN OF DOWEL BAR

98th percentile axle load	= 18000 Kg
So, Wheel load, W	= 9000 Kg
Percentage of load transfer	= 40
Slab thickness	= 30 cm
Joint width, z	= 2 cm
Radius of relative stiffness, l	= 84.11 cm
Char Compressive strength of concrete cube, f_{ck}	= 400 kg/cm^2 (M-40 Grade)
Diameter of dowel bar, b	= 3.2 cm
Assumed spacing between dowels	= 24 cm

Permissible bearing stress in concrete is calculated as follows

$$F_b = \frac{(10.16 - b) f_{ck}}{9.525}$$

$F_b = 292$ kg/cm^2

Length of dowel bar	= 50 cm
No of dowel bars participating in load transfer	= 5 (1+l/spacing)
Modulus Elasticity of Steel, E	= 2000000 kg/cm^2
k, Kg/cm3	= 41500
Total load transferred by the dowel bar system	= 2.288 Pt
Load carried by outer dowel bar, Pt	= 1573 kg

Check for bearing stress:

Moment of Inertia of dowel	= 5.147 cm^4
Relative stiffness of dowel bar embedded in concrete (β)	= 0.238 cm
Bearing stress in dowel bar	= 290.12 kg/cm^2 < 292 kg/cm^2

Hence the assumed spacing and dia of dowel bar are safe.

DESIGN OF TIE BAR:

Slab Thickness	= 30 cm
Lane width, b	= 2.5 m
Coefficient of friction, f	= 0.15
Density of concrete	= 2400 Kg/m^3
Allowable tensile stress in deformed bar, S	= 2000 kg/cm^2
Allowable bond stress in deformed tie bar, B	= 24.6 kg/cm^2
Assume dia of tie bar, d	= 12 mm

Spacing and length of the Deformed Tie bar:

Area of steel bar per meter width of joint $A = \frac{bfW}{S}$

= 1.35 Cm^2/m

Area of Tie bar, A	= 1.1304 Cm^2
Perimeter of Tie bar, P	= 3.768 Cm
Spacing of Tie bars	= 60 Cm

So, provide at a spacing of 84 cm c/c

Length of Tie bar $L = \frac{2SA}{BP}$

= 49 cm

Note: Increase length by 10 cm for loss of bond due to painting and another 5 cm for tolerance in placement.

So, total length of tie bar = 64 cm

Summary:

Effective Modulus of sub grade Reaction of the DLC sub-base	= 13.8 Kg/cm^3
Spacing of contraction joints	= 4.0 m
Width of slab	= 2.5 m
Total design life, n	= 30 yrs
Slab Thickness (M-40 grade)	= 30 cm
Dry Lean Concrete sub base (DLC of M - 10 grade) thickness	= 15 cm
Separation layer between DLC and Slab (Polythene membrane)	= 125 Micron

Design of Dowel bar:

Joint width, z	= 2.0 cm
Diameter of dowel bar, b	= 3.2 cm
Spacing between dowels	= 24 cm
Length of dowel bar	= 50 cm

Design of Tie bar(Deformed Tie bar):

Dia of tie bar, d	= 12 mm
Spacing of Tie bars	= 60 cm
Length of Tie bar, L	= 65 cm

Table 4.12: Crust details for Rigid Pavement

S No	Chainage		Length	Thickness Design (IRC: 58-2002)					
	From	To		PQC Slab, mm	Seperartion layer, Micron	Subbase (DLC), mm	Subbase GSB, mm	Subgrade, mm	Embankment, mm
1	9.600	10.250	0.650	300	125	150	150	500	500
2	16.100	18.500	2.400	300	125	150	150	500	500
3	21.250	21.600	0.350	300	125	150	150	500	500
4	25.800	27.100	1.300	300	125	150	150	500	500
5	39.100	40.300	1.200	300	125	150	150	500	500
6	44.600	45.000	0.400	300	125	150	150	500	-

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 into two types i.e., Surface Drainage and Sub-Surface Drainage.

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 from Jagatpur – Kendrapara - Chandbali (km 0/0 to km 99/00) and Chandbali - Bhadrak (45/00 to 53/00), has no proper defined longitudinal drains except at certain built up areas. 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 designs of the roadside longitudinal drains were 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 and Table 5.2. The covered drains are to be used as footpath for the pedestrian movement.

Table 5.1: List of some of the Built-up Sections in Jagatpur – Kendrapara - Chandbali Stretch

Sl.No.	Name of Village	Proposed Chainage		Length (m)	Side
		From	To		
1	BHADRAK	0/00	1200	1016	BOTH SIDE
2	BARIK CHHAK	5/600	5/880	280	BOTH SIDE
3	ICHHAPUR	6/300	6/650	350	BOTH SIDE
4	DOLOSAHI	9/600	10/250	650	BOTH SIDE
5		11/500	12/900	1400	BOTH SIDE
6	NANDAPUR	14/000	14/300	300	BOTH SIDE
7	TIHIDI	16/100	18/500	2400	BOTH SIDE
8	KOLHA	20/200	20/600	400	BOTH SIDE
9	PIRAHAT	25/800	27/100	1300	BOTH SIDE
10	GADDI	30/300	30/500	200	BOTH SIDE
11	KHANANG	32/900	33/200	300	BOTH SIDE
12	DIGACHNIA	37/100	37/400	300	BOTH SIDE
13	MOTTO	39/100	40/300	1200	BOTH SIDE
14	MAHULEYA	44/600	45/000	400	BOTH SIDE

Table 5.2: List of some of the Built-up Sections in Chandbali - Bhadark Stretch

Sl.No.	Name of Village	Proposed Chainage		Length (m)	Side
		From	To		
1	BAGURAI	1/800	2/670	870	BOTH SIDE
2	RANDIA	3/330	4/230	900	BOTH SIDE
3	BARPADA	7/600	8/850	1250	BOTH SIDE
4	GANIJANGA	11/600	11/900	300	BOTH SIDE
5	PALASA	13/320	13/850	530	BOTH SIDE
6	TILLO	16/670	17/100	430	BOTH SIDE
7	BONTH	17/520	20/700	3180	BOTH SIDE
8	ORALI CHHAKA	24/000	24/300	325	BOTH SIDE
9	BASANTIA	25/450	26/100	650	BOTH SIDE
10	MAREIGAON	27/100	27/950	850	BOTH SIDE
11	HATADHI	27/950	30/500	2550	BOTH SIDE
12	CHHENAPADY	30/920	32/400	1475	BOTH SIDE
13	CHORAKODIYA	32/750	33/100	350	BOTH SIDE
14	BONCHA Jn	33/650	34/100	450	BOTH SIDE
15	AMBAGADIA	35/050	35/500	450	BOTH SIDE
16	CHALAVANTHI	39/900	40/100	200	BOTH SIDE
17	FAKIRPUR & ANANDPUR	40/400	42/300	1900	BOTH SIDE
18	ANANDPUR & PIRISON	44/600	45/550	950	BOTH SIDE
19	PADMAPUR	46/800	47/100	300	BOTH SIDE
20	SADAVONI	48/150	48/450	300	BOTH SIDE

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

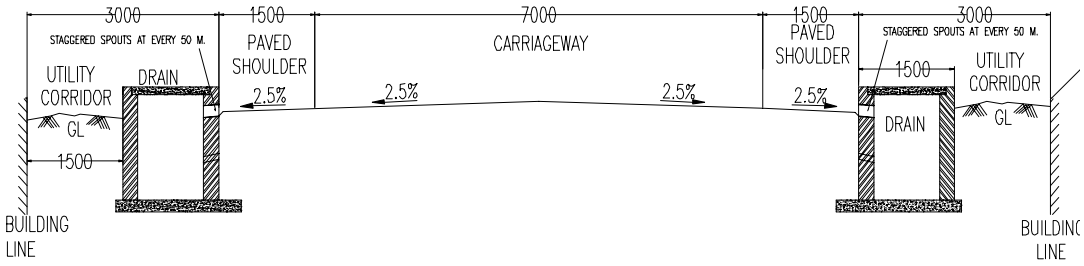


Figure 5.1: Road Section at Built-up location

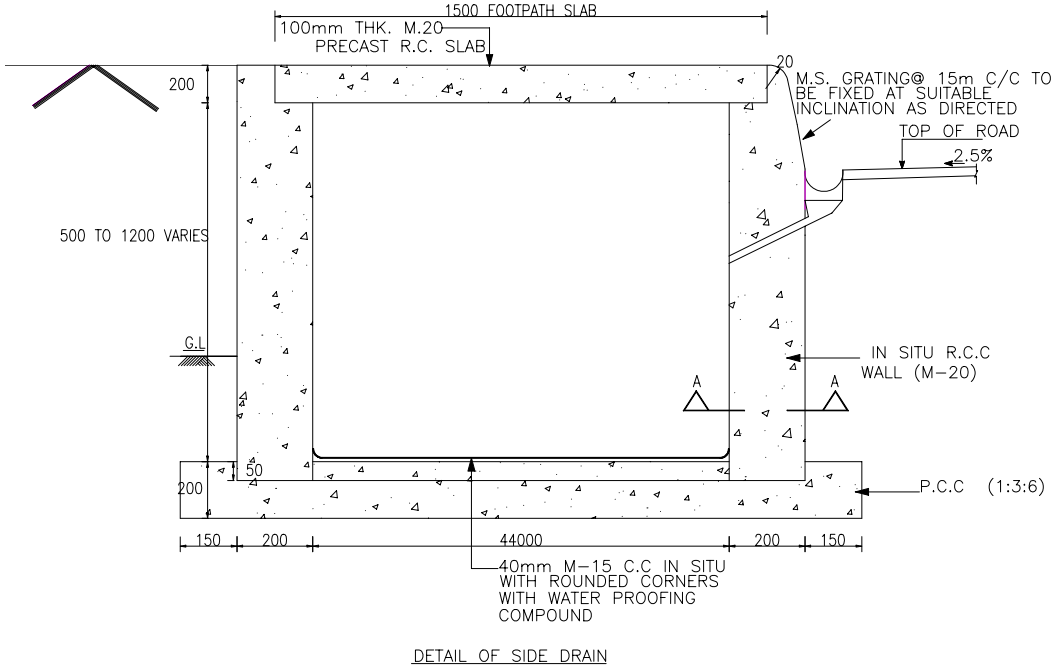


Figure 5.2: Detailed Urban Drain Section.

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 Figure. 5.3 and Figure 5.4 below.

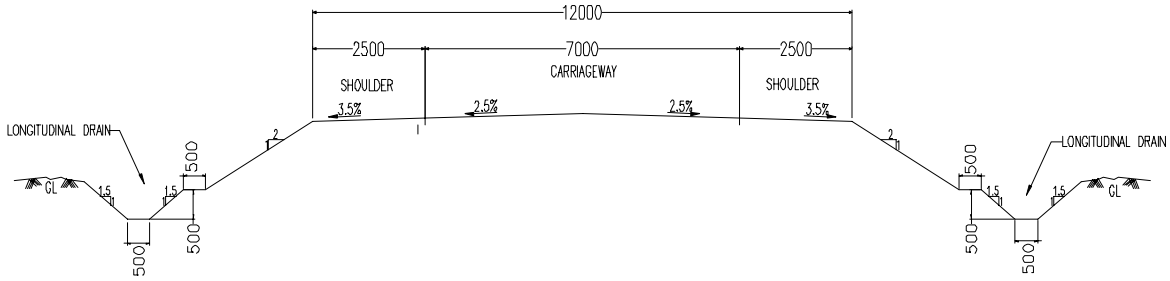


Figure 5.3: Road Section at Rural location

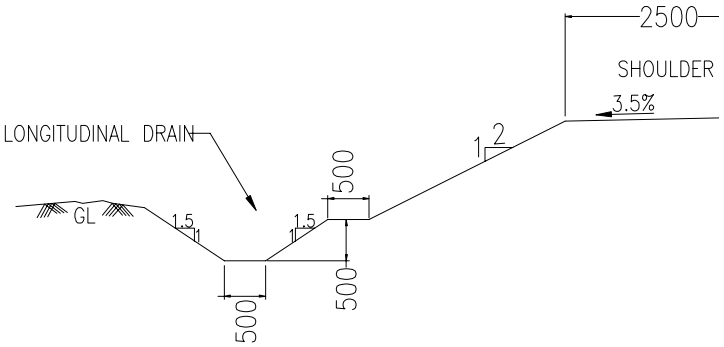


Figure 5.4: Detailed Rural Drain Section.

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 - Minor Bridges and Culverts. Structures, which are structurally in poor condition or realigned, 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. Section – I General Features of Design (Seventh Revision)
IRC: 6-2000	Standard Specification & Code of practice for Road Bridges. 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. Section – III Cement Concrete Plain & Reinforced (Second Revision)
IRC: 22-1986	Standard Specification & Code of practice for Road Bridges. Section – VI Composite Construction (First Revision)
IRC: 24-2001	Standard Specification & Code of practice for Road Bridges. 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. Section – VII Foundation & Substructure (First Revision)
IRC: 83-1999	Standard Specification & Code of practice for Road Bridges. Section – IX Bearings, Part-I Metallic Bearings (First Revision)
IRC: 83-1987	Standard Specification & Code of practice for Road Bridges. Section – IX Bearings, Part-II Elastomeric Bearings
IRC: 83-2002	Standard Specification & Code of practice for Road Bridges. 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

There are 32 bridges present on project road. Their location and existing span arrangements are as indicated in Table 6.2 and 6.3. The bridge at location 29/230 is major and remaining are minor bridges.

Bhadrak – Chandbali (SH-9, 0/0 to 45/0):

Submersible bridges with poor condition at location 28/800, 30/050, 32/100, 33/500, 33/900 and 36/005 have also been proposed for reconstruction with increased waterway and raised deck levels as per hydraulic requirements on.

Bridges at location 1/005, 1/800, 3/200, 3/900, 6/050, 9/200, 13/600, 28/100,42/400, and 43/500 are in poor condition and being replaced.

Bridge at Ch. 0/000 lies in the market area of main town and a major junction at this location has been proposed. Hydrologically there is no requirement of that bridge as per site condition. A Box type culvert has been proposed at this location.

Bhadrak – Anandpur (SH-53, 0/0 to 50/0):

Bridges at location 9/800 is in poor condition, bridge at Ch.18/400 is submerged and also in poor condition and bridge at Ch. 38/200 is recommended to reconstruct from NDT result and being replaced. The bridges at location 11/600 and 17/700 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 (Bhadrak – Chandbali)

Sl. No	Existing Chainage	Proposed Chainage	Existing Span Arrangement	Proposed Span Arrangement	Carriageway Width (m)	Overall Width of Bridge (m)	Remarks
1	**0/00**	**0/00**	**2 x 6.5**	-	-	-	**One Major junction has been proposed**
2	1/005	1/015	2 x 3.45	3 x 3 Triple Cell Box	11.0	12.0	Reconstruction due to poor condition
3	1/800	1/755	2 x 3.4	3 x 3 Triple Cell Box	11.0	12.0	Reconstruction due to poor condition
4	3/200	3/241	5 x 3.7	2 x 8.0 m	11.0	12.0	Reconstruction due to poor condition
5	3/900	3/862	3 x 7.6	2 x 8.0 m	11.0	12.0	Reconstruction due to poor condition
6	6/050	6/096	4 x 6.7	3 x 8.0 m	11.0	12.0	Reconstruction due to poor condition
7	9/200	9/159	5 x 2.7	3 x 3 Triple Cell Box	11.0	12.0	Reconstruction due to poor condition
8	9/300	9/245	3 x 7.0	-	-	-	Good, Rehabilitation required
9	13/600	13/646	2 x 4.5	3 x 3 Triple Cell Box	11.0	12.0	Reconstruction due to poor condition

Sl. No	Existing Chainage	Proposed Chainage	Existing Span Arrangement	Proposed Span Arrangement	Carriageway Width (m)	Overall Width of Bridge (m)	Remarks
10	-	**25/425**	-	**3 x 3 Triple Cell Box**	**11.0**	**12.0**	**Additional Bridge**
11	-	**25/550**	-	**10 x 1.0 m dia pipe**	**11.0**	**12.0**	**Additional Bridge**
12	-	**27/800**	-	**10 x 1.0 m dia pipe**	**11.0**	**12.0**	**Additional Bridge**
13	-	**27/925**	-	**3 x 3 Triple Cell Box**	**11.0**	**12.0**	**Additional Bridge**
14	28/100	28/168	3 x 4.35	2 x 6.0 Double Cell Box	11.0	12.0	Reconstruction due to poor condition
15	-	**28/500**	-	**3 x 8.0 Box**	**11.0**	**12.0**	**Additional Bridge**
16	28/800	28/837	6 x 2.5	3 x 3 Triple Cell Box	11.0	12.0	Reconstruction due to submergence and poor condition
17	-	**28/900**	-	**3 x 3 Triple Cell Box**	**11.0**	**12.0**	**Additional Bridge**
18	-	**29/850**	-	**10 x 1.0 m dia pipe**	**11.0**	**12.0**	**Additional Bridge**
19	-	**29/950**	-	**10 x 1.0 m dia pipe**	**11.0**	**12.0**	**Additional Bridge**
20	30/050	30/154	10 x 2.0	3 x 3 Triple Cell Box	11.0	12.0	Reconstruction due to submergence and poor condition
21	30/200	30/335	2 x 6.7	-	-	-	Good, Rehabilitation required
22	-	**31/050**	-	**3 x 3 Triple Cell Box**	**11.0**	**12.0**	**Additional Bridge**
23	-	**31/150**	-	**3 x 3 Triple Cell Box**	**11.0**	**12.0**	**Additional Bridge**
24	-	**31/900**	-	**10 x 1.0 m dia pipe**	**11.0**	**12.0**	**Additional Bridge**
25	32/100	32/100	4 x 1.75	1 x 6.0 Single Cell Box	11.0	12.0	Reconstruction due to submergence and poor condition
26	-	**32/380**	-	**3 x 3 Triple Cell Box**	**11.0**	**12.0**	**Additional Bridge**
27	33/500	33/543	5 x 2.0	3 x 3 Triple Cell Box	11.0	12.0	Reconstruction due to submergence and poor condition
28	33/900	33/907	5 x 1.9	3 x 3 Triple Cell Box	11.0	12.0	Reconstruction due to submergence and poor condition
29	-	**34/025**	-	**3 x 3 Triple Cell Box**	**11.0**	**12.0**	**Additional Bridge**

Sl. No	Existing Chainage	Proposed Chainage	Existing Span Arrangement	Proposed Span Arrangement	Carriageway Width (m)	Overall Width of Bridge (m)	Remarks
30	-	**34/375**	-	**3 x 3 Triple Cell Box**	**11.0**	**12.0**	**Additional Bridge**
31	34/700	34/803	1 x 10.3	-	-	-	Good, Rehabilitation required
32	-	**35/000**	-	**3 x 3 Triple Cell Box**	**11.0**	**12.0**	**Additional Bridge**
33	-	**35/090**	-	**3 x 3 Triple Cell Box**	**11.0**	**12.0**	**Additional Bridge**
34	-	**35/280**	-	**3 x 3 Triple Cell Box**	**11.0**	**12.0**	**Additional Bridge**
35	-	**35/340**	-	**3 x 8.0 Box**	**11.0**	**12.0**	**Additional Bridge**
36	-	**35/425**	-	**3 x 8.0 Box**	**11.0**	**12.0**	**Additional Bridge**
37	-	**35/510**	-	**3 x 8.0 Box**	**11.0**	**12.0**	**Additional Bridge**
38	-	**35/600**	-	**3 x 8.0 Box**	**11.0**	**12.0**	**Additional Bridge**
39	-	**35/680**	-	**3 x 8.0 Box**	**11.0**	**12.0**	**Additional Bridge**
40	36/005	35/825	10 x 2.1	3 x 3 Triple Cell Box	11.0	12.0	Reconstruction due to submergence and poor condition
41	-	**35/900**	-	**3 x 8.0 Box**	**11.0**	**12.0**	**Additional Bridge**
42	-	**35/975**	-	**3 x 8.0 Box**	**11.0**	**12.0**	**Additional Bridge**
43	-	**36/040**	-	**3 x 8.0 Box**	**11.0**	**12.0**	**Additional Bridge**
44	-	**37/000**	-	**3 x 3 Triple Cell Box**	**11.0**	**12.0**	**Additional Bridge**
45	-	**37/075**	-	**3 x 3 Triple Cell Box**	**11.0**	**12.0**	**Additional Bridge**
46	38/100	38/005	5 x 10.45	-	-	-	Good, Rehabilitation required
47	-	**41/750**	-	**3 x 3 Triple Cell Box**	**11.0**	**12.0**	**Additional Bridge**
48	42/400	42/487	2 x 3.65	1 x 6.0 Single Cell Box	11.0	12.0	Reconstruction due to poor condition
49	43/500	43/558	2 x 3.2	1 x 6.0 Single Cell Box	11.0	12.0	Reconstruction due to poor condition

Table 6.3: Proposed Bridges (Bhadrak – Anandpur)

Sl. No.	Existing Chainage	Proposed Chainage	Existing Span Arrangement	Proposed Span Arrangement	Carriageway Width (m)	Overall Width of Bridge (m)	Remarks
1	9/800	10/016	(1 x 3.55) / (1 x 3.95)	1 x 8.0 RCC Box	11.0	12.0	Reconstruction due to poor condition
2	11/600	11/407	2 x 7.0	2 x 8.0 RCC Box	11.0	12.0	Reconstruction due to Realignment
3	17/700	17/275	2 x 7.0	3 x 9.0 RCC Box	11.0	12.0	Reconstruction due to Realignment
4	18/400	17/830	1 x 6.9	3 x 3 m Double cell	11.0	12.0	Reconstruction due to submerged and poor condition
5	19/300	18/879	2 x 6.3	-	-	-	Rehabilitation required
6	30/950	30/638	1 x 5.5	-	-	-	Good, Rehabilitation required
7	37/600	36/892	1 x 8.6	-	-	-	Rehabilitation required
8	37/700	36/989	1 x 8.6	-	-	-	Rehabilitation required
9	37/850	37/120	1 x 8.6	-	-	-	Rehabilitation required
10	38/010	37/276	1 x 8.3	-	-	-	Rehabilitation required
11	38/200	37/573	2 x 5.1	1 x 10.8 Solid slab	11.0	12.0	Reconstruction due to poor condition

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.

6.4 DESIGN PHILOSOPHY

In this stretch as per geotechnical investigation, type of soil is poor and bearing capacity is too less. In such type of soil properties all new construction has been proposed to be box type Single, Double or Triple cell to meet out the bearing capacity requirement.

On Bhadrak – Anandpur stretch, out of five bridges four bridges have been recommended for box type structure based on geo-technical investigation. One bridge is proposed for slab type superstructure.

The superstructure for RCC T-beam and Solid slab bridges has been taken from MoSRTH standard drawings. 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.

RCC Non spill through type abutment has been designed for slab type bridge at Ch. 38/200 on Bhadrak - Anandpur using STAAD_PRO for live load for various load combination and using standard Excel spread sheets for following cases.

- Dry Case (Normal and span dislodged condition)
- HFL case (Normal and span dislodged condition)

Solid slab type superstructure has been taken from MoSRTH standard drawings without skew reprinted in October 2005.

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/m^2
Cement Concrete – Reinforced	2.4 t/m^2
Cement Concrete – Prestressed	2.5 t/m^2
Coursed Rubble Masonry	2.6 t/m^2
Compacted Earth	1.8 t/m^2

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.

$$p = 52KV^2$$

Where, p = intensity of pressure in kg/m^2

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 √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 (as per clause 216.5 of IRC: 6-2000).

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	-

Member	Box Type structures	Other Minor Bridges & Culverts
Moderate Conditions of Exposure		
RCC Members	M 20	M 20
Severe Conditions of Exposure		
RCC Members	M 25	M 25

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 Bearings

Tarpaper bearing has been provided for RCC solid slab superstructure of minor bridges upto 10 m span. In box type of structure no such bearing is required.

6.6.4 Expansion joints

Asphaltic Plug type expansion joint with a movement upto 25 mm has been provided in all box type structures.

In accordance MoSRTH 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.

6.6.5 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 arch culverts. 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 culverts along with remarks are given below in Table 6.4 and 6.6.

Table 6.4: Proposed Culverts (Bhadrak – Chandbali)

S. No.	Existing Chainage	Proposed Chainage	Existing Span Arrangement	Type of Existing Culvert	Proposed Span Arrangement	Type of Proposed Culvert	Remarks
1	-	**0/0**	-	-	**1/23/0**	**RCC Box**	**Additional structure**
2	2/500	2/507	1 x 3.0	Slab	-	-	To be widened
3	2/800	2/865	1 x 3.0	Slab	-	-	To be widened
4	4/300	4/350	2 x 1.0	Pipe	1/23/0	RCC Box	Replaced due to poor condition
5	4/900	4/935	1 x 2.0	Arch	1/23/0	RCC Box	Replaced due to poor condition
6	-	**5/705**	-	-	**1/43/0**	**RCC Box**	**Additional structure**
7	-	**5/740**	-	-	**1/44/0**	**RCC Box**	**Additional structure**
8	6/990	7/001	1 x 0.9	Pipe	1/22/0	RCC Box	Replaced due to poor condition
9	7/900	7/927	1 x 0.9	Pipe	1/22/0	RCC Box	Replaced due to poor condition
10	8/900	8/939	1 x 4.5	Slab	1/64/0	RCC Box	Replaced due to poor condition
11	9/500	9/602	1 x 2.0	Slab	1/23/0	RCC Box	Replaced due to poor condition
12	9/900	9/902	1 x 4.5	Slab	1/63/0	RCC Box	Replaced due to poor condition
13	10/250	10/260	1 x 1.4	Slab	1/22/0	RCC Box	Replaced due to poor condition
14	11/100	11/142	1 x 1.4	Slab	1/23/0	RCC Box	Replaced due to poor condition
15	11/650	11/535	2 x 0.3	Pipe	1/22/0	RCC Box	Replaced due to poor condition
16	12/600	12/397	1 x 0.3	Pipe	1/22/0	RCC Box	Replaced due to poor condition
17	12/900	12/923	1 x 0.9	Pipe	1/22/0	RCC Box	Replaced due to poor condition
18	13/150	13/132	1 x 1.4	Slab	1/23/0	RCC Box	Replaced due to poor condition
19	14/800	14/791	1 x 0.3	Pipe	1/22/0	RCC Box	Replaced due to poor condition
20	-	**15/125**	-	-	**1/43/0**	**RCC Box**	**Additional structure**
21	15/600	15/360	1 x 0.3	Pipe	1/22/0	RCC Box	Replaced due to poor condition
22	-	**15/425**			**1/43/0**	**RCC Box**	**Additional structure**
23	15/700	15/714	1 x 3.2	Slab	1/43/0	RCC Box	Replaced due to poor condition
24	-	**15/750**	-	-	**1/43/0**	**RCC Box**	**Additional structure**
25	-	**15/850**	-	-	**1/43/0**	**RCC Box**	**Additional structure**
26	16/500	16/509	1 x 0.6	Pipe	1/23/0	RCC Box	Replaced due to poor condition
27	16/700	16/733	1 x 0.6	Pipe	1/22/0	RCC Box	Replaced due to poor condition
28	17/100	17/078	1 x 1.5	Slab	1/22/0	RCC Box	Replaced due to poor condition

S. No.	Existing Chainage	Proposed Chainage	Existing Span Arrangement	Type of Existing Culvert	Proposed Span Arrangement	Type of Proposed Culvert	Remarks
29	17/700	17/666	1 x 0.9	Pipe	1/22/0	RCC Box	Replaced due to poor condition
30	17/900	17/928	1 x 1.0	Pipe	1/22/0	RCC Box	Replaced due to poor condition
31	18/200	18/195	1 x 1.0	Pipe	1/22/0	RCC Box	Replaced due to poor condition
32	18/600	18/627	1 x 1.0	Pipe	1/22/0	RCC Box	Replaced due to poor condition
33	19/100	19/096	1 x 1.0	Pipe	1/22/0	RCC Box	Replaced due to poor condition
34	19/400	19/367	2 x 1.5	Slab	1/33/0	RCC Box	Replaced due to poor condition
35	19/900	19/888	2 x 2.3	Slab	-	-	To be widened
36	20/100	20/144	1 x 1.4	Slab	1/22/0	RCC Box	Replaced due to poor condition
37	20/200	20/365	1 x 0.6	Pipe	1/22/0	RCC Box	Replaced due to poor condition
38	20/700	20/691	1 x 0.6	Pipe	1/22/0	RCC Box	Replaced due to poor condition
39	21/050	21/074	1 x 0.45	Pipe	1/22/0	RCC Box	Replaced due to poor condition
40	21/150	21/235	1 x 0.45	Pipe	1/22/0	RCC Box	Replaced due to poor condition
41	21/400	21/490	1 x 0.6	Pipe	1/22/0	RCC Box	Replaced due to poor condition
42	21/700	21/829	1 x 1.5	Slab	1/22/0	RCC Box	Replaced due to poor condition
43	22/700	22/570	1 x 0.9	Pipe	1/22/0	RCC Box	Replaced due to poor condition
44	23/150	23/240	1 x 3.2	Slab	1/43/0	RCC Box	Replaced due to poor condition
45	24/050	24/096	1 x 0.9	Arch	1/22/0	RCC Box	Replaced due to poor condition
46	24/350	24/478	1 x 0.8	Pipe	1/22/0	RCC Box	Replaced due to poor condition
47	24/500	24/770	1 x 1.2	Slab	1/22/0	RCC Box	Replaced due to poor condition
48	25/200	25/249	1 x 1.0	Pipe	1/22/0	RCC Box	Replaced due to poor condition
49	26/400	26/430	-	Choked	1/22/0	RCC Box	**Replaced due to insufficient vent, to be used for Environmental purpose**
50	-	**28/225**	-	-	**1/43/0**	**RCC Box**	**Additional structure**
51	-	**30/075**	-	-	**1/44/0**	**RCC Box**	**Additional structure**
52	30/600	30/821	1 x 0.5	Arch	1/22/0	RCC Box	Replaced due to poor condition
53	-	**31/400**	-	-	**1/43/0**	**RCC Box**	**Additional structure**
54	-	**31/700**	-	-	**1/43/0**	**RCC Box**	**Additional structure**
55	-	**36/775**	-	-	**1/43/0**	**RCC Box**	**Additional structure**

S. No.	Existing Chainage	Proposed Chainage	Existing Span Arrangement	Type of Existing Culvert	Proposed Span Arrangement	Type of Proposed Culvert	Remarks
56	-	**36/850**	-	-	**1/44/0**	**RCC Box**	**Additional structure**
57	-	**37/850**	-	-	**1/43/0**	**RCC Box**	**Additional structure**
58	39/300	39/387	2 x 0.45	Pipe	1/22/0	RCC Box	Replaced due to poor condition
59	39/800	39/837	1 x 0.8	Pipe	1/22/0	RCC Box	Replaced due to poor condition
60	40/350	40/310	1 x 0.6	Pipe	1/22/0	RCC Box	Replaced due to poor condition
61	40/950	40/974	1 x 0.9	Pipe	1/23/0	RCC Box	**Replaced due to insufficient vent, to be used for Environmental purpose**
62	-	**41/125**	-	-	**1/43/0**	**RCC Box**	**Additional structure**
63	-	**41/275**	-	-	**1/43/0**	**RCC Box**	**Additional structure**
64	-	**41/375**	-	-	**1/43/0**	**RCC Box**	**Additional structure**
65	-	**41/550**	-	-	**1/43/0**	**RCC Box**	**Additional structure**
66	41/990	41/996	2 x 1.5	Slab	1/34/0	RCC Box	Replaced due to poor condition
67	-	**42/225**	-	-	**1/44/0**	**RCC Box**	**Additional structure**
68	-	**42/400**	-	-	**1/44/0**	**RCC Box**	**Additional structure**
69	43/050	43/061	1 x 0.6	Arch	1/22/0	RCC Box	Replaced due to poor condition
70	43/600	43/771	1 x 4.8	Slab	1/43/0	RCC Box	Replaced due to poor condition
71	44/400	44/315	1 x 1.8	Slab	1/23/0	RCC Box	Replaced due to raising of road level

Table 6.5: Summary of proposed Culverts (Bhadrak - Chandbali)

Type of Culvert	Nos.
Culverts Widened	
Slab widening	3
Culverts Replaced	
New Single Box of 1/22/0	33
New Single Box of 1/23/0	8
New Single Box of 1/33/0	1
New Single Box of 1/34/0	1
New Single Box of 1/43/0	3
New Single Box of 1/63/0	1
New Single Box of 1/64/0	1
Additional Culverts Proposed	
Single Cell Box of 1/23/0	1
New Single Box of 1/43/0	14
New Single Box of 1/44/0	5
Total	**71**

Table 6.6: Proposed Culverts (Bhadrak – Anandpur)

Sl. No.	Existing Chainage	Proposed Chainage	Existing Span Arrangement	Type of Existing Culvert	Proposed Span Arrangement	Type of Proposed Culvert	Remarks
1	1/010	1165	1 x 0.9	Pipe	1/23/0	Box Cell	Replaced due to poor condition
2	1/275	1328	-	Choked	1/23/0	Box Cell	Replaced due to insufficient vent
3	1/900	2010	1 x 0.9	Pipe	1/34/0	Box Cell	Replaced due to insufficient vent
4	2/150	2201	3 x 1.5	Slab	1/44/0	Box Cell	Replaced due to poor condition
5	2/400	2354	3 x 0.9	Pipe	1/23/0	Box Cell	Replaced due to poor condition
6	2/600	2668	1 x 1.8	Slab	1/34/0	Box Cell	Replaced due to poor condition
7	3/700	3604	1 x 1.5	Slab	1/22/0	Box Cell	Replaced due to poor condition
8	3/900	3979	-	Choked	1/22/0	Box Cell	Replaced due to insufficient vent
9	4/500	4411	1 x 3.0	Slab	1/33/0	Box Cell	Replaced due to poor condition
10	5/010	5122	1 x 3.0	Slab	1/33/0	Box Cell	Replaced due to raise in road level
11	6/800	6675	1 x 1.5	Slab	2 x 1.0	Pipe	Replaced due to poor condition
12	7/880	7785	1 x 3.0	Slab	1/33/0	Box Cell	Replaced due to less carriage way width
13	8/300	8498	1 x 2.7	Slab	2 x 1.0	Pipe	Replaced due to poor condition
14	8/750	8958	1 x 0.6	Pipe	1/23/0	Box Cell	Replaced due to poor condition
15	8/850	9027	2 x 0.9	Pipe	2 x 0.9	-	To be extended

Sl. No.	Existing Chainage	Proposed Chainage	Existing Span Arrangement	Type of Existing Culvert	Proposed Span Arrangement	Type of Proposed Culvert	Remarks
16	10/600	10699	1 x 3.0	Slab	1/33/0	Box Cell	Replaced due to less carriage way width
17	11/150	10975	1 x 1.5	Slab	1/22/0	Box Cell	Replaced due to poor condition
18	-	**11249**	-	-	**1/22/0**	**Box Cell**	**Additional structure**
19	-	**11500**	-	-	**1/23/0**	**Box Cell**	**Additional structure**
20	12/200	11869	1 x 0.6	Pipe	1 x 1.0	Pipe	**Replaced due to poor condition, to be used for Environmental purpose**
21	13/110	12809	1 x 0.6	Pipe	1 x 1.0	Pipe	Replaced due to insufficient vent
22	13/800	13507	1 x 0.6	Pipe	1 x 1.0	Pipe	**Replaced due to poor condition, to be used for Environmental purpose**
23	14/200	13909	1 x 0.9	Pipe	1 x 0.9	-	To be extended
24	14/400	14166	1 x 1.8	Slab	1/22/0	Box Cell	Replaced due to poor condition
25	14/600	14300	1 x 2.4	Slab	1/33/0	Box Cell	Replaced due to raise in road level
26	15/500	15110	2 x 0.9	Pipe	2 x 0.9	-	To be extended
27	17/200	17002	1 x 1.5	Slab	1/22/0	Box Cell	**Replaced due to poor condition, to be used for Environmental purpose**
28	17/300	17123	2 x 0.9	Pipe	1/22/0	Box Cell	Replaced due to poor condition
29	-	**17500**	-	-	**1/34/0**	**Box Cell**	**Additional structure**
30	18/500	17954	2 x 0.9	Pipe	2 x 0.9	-	To be extended
31	18/700	18261	-	Choked	2 x 1.0	Pipe	Replaced due to insufficient vent
32	18/800	18444	1 x 0.6	Pipe	1 x 1.0	Pipe	Replaced due to poor condition
33	18/850	18486	1 x 0.6	Pipe	1 x 1.0	Pipe	Replaced due to poor condition
34	19/250	18902	1 x 0.3	Pipe	2 x 1.0	Pipe	Replaced due to poor condition
35	20/100	19695	1 x 0.6	Pipe	1 x 1.0	Pipe	Replaced due to poor condition
36	20/800	20426	4 x 0.45	Pipe	2 x 1.0	Pipe	Replaced due to insufficient vent
37	20/825	20450	1 x 1.3	Slab	1/22/0	Box Cell	Replaced due to poor condition
38	21/050	20648	1 x 4.6	Slab	1/43/0	Box Cell	Replaced due to poor condition
39	21/750	21024	1 x 0.8	Pipe	2 x 1.0	Pipe	**Replaced due to insufficient vent, to be used for Environmental purpose**

Sl. No.	Existing Chainage	Proposed Chainage	Existing Span Arrangement	Type of Existing Culvert	Proposed Span Arrangement	Type of Proposed Culvert	Remarks
40	22/800	22225	2 x 0.6	Pipe	1/34/0	Box Cell	Replaced due to insufficient vent
41	23/600	22794	1 x 0.6	Pipe	2 x 1.0	Pipe	Replaced due to insufficient vent
42	24/150	23700	1 x 0.3	Pipe	2 x 1.0	Pipe	Replaced due to insufficient vent
43	24/700	24205	1 x 0.6	Pipe	2 x 1.0	Pipe	Replaced due to insufficient vent
44	24/750	24375	1 x 0.6	Pipe	2 x 1.0	Pipe	Replaced due to insufficient vent
45	25/700	25253	1 x 1.5	Slab	1/22/0	Box Cell	Replaced due to raise in road level
46	25/710	25265	1 x 0.9	Pipe	2 x 1.0	Pipe	Replaced due to insufficient vent
47	25/990	25571	-	Choked	2 x 1.0	Pipe	Replaced due to insufficient vent
48	26/450	26025	-	Choked	2 x 1.0	Pipe	Replaced due to insufficient vent
49	26/700	26351	1 x 0.6	Pipe	1 x 1.0	Pipe	Replaced due to poor condition
50	27/050	26645	1 x 0.45	Pipe	1 x 1.0	Pipe	Replaced due to poor condition
51	27/100	26699	2 x 0.9	Pipe	2 x 1.0	Pipe	Replaced due to poor condition
52	27/800	27440	2 x 0.9	Pipe	2 x 0.9	-	To be extended
53	28/200	27733	1 x 0.6	Pipe	1 x 1.0	Pipe	Replaced due to poor condition
54	28/950	28531	2 x 0.9	Pipe	2 x 1.0	Pipe	Replaced due to poor condition
55	29/100	28684	2 x 0.9	Pipe	2 x 1.0	Pipe	Replaced due to poor condition
56	29/650	29159	1 x 0.6	Pipe	1 x 1.0	Pipe	Replaced due to poor condition
57	29/700	29250	1 x 0.45	Pipe	1 x 1.0	Pipe	Replaced due to poor condition
58	29/800	29374	2 x 0.9	Pipe	2 x 0.9	-	To be extended
59	30/150	29601	2 x 0.9	Pipe	2 x 0.9	-	To be extended
60	30/500	29984	2 x 0.9	Pipe	2 x 0.9	-	To be extended
61	30/900	30501	2 x 0.9	Pipe	2 x 0.9	-	To be extended
62	31/100	30684	2 x 0.9	Pipe	2 x 1.0	Pipe	Replaced due to poor condition
63	31/500	31097	1 x 1.5	Slab	1/22/0	Box Cell	Replaced due to raise in road level
64	31/800	31353	-	Choked	2 x 1.0	Pipe	Replaced due to insufficient vent
65	31/900	31484	2 x 0.6	Pipe	1 x 1.0	Pipe	Replaced due to poor condition
66	32/200	31776	4 x 0.9	Pipe	2 x 1.0	Pipe	Replaced due to change in alignment
67	32/400	32108	2 x 0.9	Pipe	2 x 1.0	Pipe	Replaced due to change in alignment

Sl. No.	Existing Chainage	Proposed Chainage	Existing Span Arrangement	Type of Existing Culvert	Proposed Span Arrangement	Type of Proposed Culvert	Remarks
68	33/050	32528	2 x 0.9	Pipe	2 x 1.0	Pipe	Replaced due to change in alignment
69	33/450	32964	1 x 3.0	Slab	2 x 1.0	Pipe	Replaced due to poor condition
70	33/500	33013	2 x 0.9	Pipe	1/22/0	Box Cell	Replaced due to change in alignment
71	34/400	33760	1 x 0.9	Pipe	1 x 0.9	-	To be extended
72	34/750	34204	2 x 1.0	Pipe	2 x 1.0	-	To be extended
73	35/300	34662	2 x 1.1	Pipe	2 x 1.0	-	To be extended
74	35/700	34935	1 x 0.6	Pipe	1 x 1.0	Pipe	Replaced due to insufficient vent
75	35/900	35281	1 x 1.0	Slab	1/63/0	Box Cell	Replaced due to insufficient vent
76	36/100	35444	1 x 1.0	Slab	1/23/0	Box Cell	Replaced due to poor condition
77	36/250	35595	1 x 1.0	Slab	1/34/0	Box Cell	Replaced due to poor condition
78	36/600	35998	2 x 1.0	Slab	1/34/0	Box Cell	Replaced due to poor condition
79	37/150	36430	1 x 0.6	Pipe	1/23/0	Box Cell	Replaced due to poor condition
80	37/200	36510	1 x 0.6	Pipe	1/34/0	Box Cell	Replaced due to poor condition
81	37/300	36624	1 x 3.15	Slab	1/44/0	Box Cell	Replaced due to raise in road level
82	-	**38300**	-	-	**1/34/0**	**Box Cell**	**Additional structure**
83	38/900	38088	1 x 3.0	Slab	1/33/0	Box Cell	Replaced due to change in alignment
84	39/450	38665	2 x 2.5	Arch	1/43/0	Box Cell	Replaced due to poor condition
85	40/500	39657	1 x 0.9	Arch	1/22/0	Box Cell	Replaced due to poor condition
86	40/850	40017	1 x 0.9	Arch	1/22/0	Box Cell	Replaced due to poor condition
87	41/100	40242	2 x 1.8	Arch	1/43/0	Box Cell	**Replaced due to poor condition, to be used for Environmental purpose**
88	41/700	40808	2 x 1.2	Slab	1/33/0	Box Cell	Replaced due to poor condition
89	-	**42425**	-	-	**1/23/0**	**Box Cell**	**Additional structure**
90	43/200	42191	1 x 0.9	Pipe	1/33/0	Box Cell	Replaced due to change in alignment
91	-	**43500**	-	-	**1/34/0**	**Box Cell**	**Additional structure**
92	-	**44400**	-	-	**1/23/0**	**Box Cell**	**Additional structure**
93	45/500	44680	1 x 1.5	Slab	1/22/0	Box Cell	Replaced due to poor condition
94	45/700	45094	1 x 1.5	Slab	1/23/0	Box Cell	Replaced due to raise in road level

Sl. No.	Existing Chainage	Proposed Chainage	Existing Span Arrangement	Type of Existing Culvert	Proposed Span Arrangement	Type of Proposed Culvert	Remarks
95	45/900	45275	1 x 1.6	Slab	1/22/0	Box Cell	Replaced due to raise in road level
96	45/990	45395	1 x 1.5	Slab	1/22/0	Box Cell	Replaced due to raise in road level
97	46/600	45720	1 x 1.5	Slab	1/23/0	Box Cell	Replaced due to raise in road level
98	46/900	46032	1 x 1.6	Slab	1/23/0	Box Cell	Replaced due to raise in road level
99	47/300	46311	1 x 1.6	Slab	1/23/0	Box Cell	Replaced due to change in alignment
100	47/800	47246	1 x 3.0	Slab	1/33/0	Box Cell	Replaced due to raise in road level
101	48/550	47931	1 x 1.5	Slab	1/34/0	Box Cell	Replaced due to raise in road level
102	49/100	48530	1 x 3.0	Slab	1/33/0	Box Cell	Replaced due to raise in road level

Table 6.7: Summary of Proposed Culverts (Bhadrak –Anandpur)

Type of Culvert	Nos.
Culverts Widened	
Pipe extension	12
Culverts Replaced	
New Single Pipe	13
New Double Pipe	22
New Single Box of 1/22/0	15
New Single Box of 1/23/0	10
New Single Box of 1/33/0	10
New Single Box of 1/34/0	7
New Single Box of 1/43/0	3
New Single Box of 1/44/0	2
New Single Box of 1/63/0	1
Additional Culverts Proposed	
Single Cell Box of 1/22/0	1
Single Cell Box of 1/23/0	3
Single Cell Box of 1/34/0	3
Total	**102**

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 (Rebound Hammer, Pulse velocity and Half cell potential meter tests) has been conducted at 8 Nos of bridges (5 Nos on Bhardark – Chandbali and 3 Nos Bhadrak – Anandpur) in these stretches, NDT report along with recommendations has been submitted to PIU.

The rehabilitation proposals for the different structures are as detailed under in Table 6.8 and 6.9.

Table 6.8: Rehabilitation of Minor Bridges (Bhadrak – Chandbali)

Sl.No.	Location Km	Span Arrangement	General Condition	Recommendation
1	9/300	3 x 7.0	Overall Good	i. Jacketing with dowels is suggested in piers and abutments ii. Touch up repair to be done in the edge of slab (1.0 sq.mt) iii. Expansion joint buried due to overlay of BT and shall be replaced by filler type iv. Existing Bituminous over lay shall be removed v. Approach slab to be constructed vi. Bed protection and curtain wall shall be provided vii. Vegetations to be removed from the structure
2	30/200	2 x 6.7	Good	i. Expansion joint shall be replaced by asphalt plug type with approach slab ii. Existing railings to be dismantled and Foot path shall be provided iii. Bed protection shall be provided iv. Vegetations to be removed from the structure
3	34/700	1 x 10.3	Good	i. Bed protection shall be provided ii. Existing Railings shall be dismantled and crash barier shall be provided iii. Filler type expansion joint shall be provided iv. Approach slab to be done by chipping out top 300 mm concrete from wall across trffic direction. v. Return walls shall be repaired by surface treatment with polymer modified mortar
4	38/100	5 x 10.45	Good	i. Expansion joints shall be replaced by filler type ii. The superstructure shall be lifted from the support at bed level and Neoprene bearing (Size 400 x 250 x 48 mm)shall be placed iii. Honeycombing observed on diaphragms and girders,shall be take care by polymer modified concrete iv. Bed protection to be done newly v. Approach revetment to be repacked vi. Approach slab to be constructed

Table 6.9: Rehabilitation of Minor Bridges (Bhadrak – Anandpur)

Sl.No.	Location Km	Span Arrangement	General Condition	Recommendation
1	19/300	2 x 6.3	Overal Good	i. As per NDT result the slab to be dismantled and new slab shall be constructed ii. Crash barrier shall be cast iii. Filler type expansion joints shall be provided iv. 50mm BC laid over 6mm thick mastic asphalt v. Drainage spouts shall be provided (6 nos) vi. Tar paper bearing shall be provided vii. Approach slab to be constructed
2	30/950	1 x 5.5	Good	i. Railing to be reconstructed (40.0 mt) ii. Existing wearing coat shall be dismantled and 50mm BC laid over 6mm thick mastic asphalt shall be laid newly iii. Filler type expansion joint shall be provided iv. Vegetation to be removed from the structure
3	37/600	1 x 8.6	Overal Good	i. As per NDT result the slab to be dismantled and new slab shall be constructed ii. Abutments shall be plastered with 25 mm thick cement mortar (1:3) iii. Crash barrier shall be cast iv. Filler type expansion joints shall be provided v. 50mm BC laid over 6mm thick mastic asphalt vi. Drainage spouts shall be provided (4 nos) vii. Approach slab to be constructed viii. Side Pitching (revetment) shall be done ix. Bed protection to be done and curtain walls shall be provided x. Vegetation to be removed from the structure
4	37/700	1 x 8.6	Overal Good	i. As per NDT result the slab to be dismantled and new slab shall be constructed ii. Abutments shall be plastered with 25 mm thick cement mortar (1:3) iii. Crash barier shall be cast iv. Filler type expansion joints shall be provided v. 50mm BC laid over 6mm thick mastic asphalt vi. Drainage spouts shall be provided (4 nos) vii. Approach slab to be constructed

				viii. Side Pitching (revetment) shall be done ix. Bed protection to be done and curtain walls shall be provided x. Vegetation to be removed from the structure
5	37/850	1 x 8.6	Overal Good	i. As per NDT result the slab to be dismantled and new slab shall be constructed ii. Abutments shall be plastered with 25 mm thick cement mortar (1:3) iii. Crash barier shall be cast iv. Filler type expansion joints shall be provided v. 50mm BC laid over 6mm thick mastic asphalt vi. Drainage spouts shall be provided (4 nos) vii. Approach slab to be constructed viii. Bed protection to be done and curtain walls shall be provided ix. Vegetation to be removed from the structure
6	38/010	1 x 8.3	Overal Good	i. As per NDT result the slab to be dismantled and new slab shall be constructed ii. Abutments shall be plastered with 25 mm thick cement mortar (1:3) iii. Crash barier shall be cast iv. Filler type expansion joints shall be provided v. 50mm BC laid over 6mm thick mastic asphalt vi. Drainage spouts shall be provided (4 nos) vii. Approach slab to be constructed viii. Bed protection to be done and curtain walls shall be provided ix. Vegetation to be removed from the structure

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 increase traffic volume; 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 centerline 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 12.0m

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 MoSRTH, 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 project road. The Consultant has identified 49 major junctions along the project road,

out of which 17 are on Jagatpur – Kendrapara – Chandbali (SH-9A) stretch and remaining 32 are on Chandbali - Bhadrak (SH-9) stretch. The lists of the junctions to be improved along the project road are shown in Table 7.2 and Table 7.3. The entire crossroads are BT roads. The minor junctions shall be developed as per the IRC guidelines and standard junction drawing presented in Drawings Volume separately. The major junctions shall be developed as per the drawings provided in Drawings Volume.

Table 7.2: List of Junctions (Chandbali – Bhadrak)

SL NO	CHAINAGE	SIDE	TYPE OF JUNCTION	CROSS ROAD TYPE
1	3/950	RHS	Y-Type	BT Road
2	6/500	LHS	Y-Type	BT Road
3	12/235	LHS	T-Type	BT Road
4	16/417	RHS	Y-Type	BT Road
5	17/668	RHS	T-Type	BT Road
6	18/425	RHS	T-Type	BT Road
7	19/376	RHS	T-Type	BT Road
8	21/420	LHS	T-Type	BT Road
9	21/990	LHS	T-Type	BT Road
10	23/252	LHS	T-Type	BT Road
11	24/600	Both	Cross Junction	BT Road
12	33/126	RHS	T-Type	BT Road
13	36/195	RHS	T-Type	BT Road
14	37/255	LHS	T-Type	BT Road
15	40/000	RHS	T-Type	BT Road
16	50/020	LHS	Y-Type	BT Road
17	50/448	RHS	T-Type	BT Road

Table 7.3: List of Junctions (Bhadrak - Anandpur)

SL NO	CHAINAGE	SIDE	TYPE OF JUNCTION	CROSS ROAD TYPE
1	1/356	Both	Cross	BT-Road
2	1/795	RHS	T – Type	BT-Road
3	3/359	LHS	T – Type	BT-Road
4	3/595	RHS	T – Type	BT-Road
5	4/427	Both	Cross-Junction	BT-Road
6	5/984	RHS	T – Type	BT-Road
7	8/459	RHS	Y – Type	BT-Road
8	8/576	LHS	T – Type	BT-Road
9	8/737	LHS	T – Type	BT-Road
10	10/024	LHS	Y – Type	BT-Road
11	11/798	LHS	T – Type	BT-Road
12	13/463	LHS	T – Type	BT-Road
13	14/528	LHS	T – Type	BT-Road
14	17/018	RHS	T – Type	BT-Road
15	18/866	Both	Cross-Junction	BT-Road
16	19/402	LHS	Y – Type	BT-Road
17	19/453	LHS	T – Type	BT-Road
18	24/252	LHS	T – Type	BT-Road

SL NO	CHAINAGE	SIDE	TYPE OF JUNCTION	CROSS ROAD TYPE
19	29/851	RHS	Y – Type	BT-Road
20	30/339	LHS	T – Type	BT-Road
21	31/478	LHS	T – Type	BT-Road
22	31/588	RHS	Y – Type	BT-Road
23	33/952	LHS	T – Type	BT-Road
24	35/809	RHS	T – Type	BT-Road
25	36/571	LHS	T – Type	BT-Road
26	38/543	RHS	Y – Type	BT-Road
27	39/977	RHS	T – Type	BT-Road
28	40/048	LHS	T – Type	BT-Road
29	40/567	LHS	Y – Type	BT-Road
30	44/031	RHS	T – Type	BT-Road
31	47/013	RHS	T – Type	BT-Road
32	48/340	RHS	T – Type	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 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 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 include:

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 type reflective sheeting fixed over aluminium sheeting for a better visibility at night and road users safety.

The signs must 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 kilometrage 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. Typical details design of 200m stones are provided in standard highway drawings.

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: 79-1989 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 7.4 and 7.5.

Table 7.4: Schedule of Bus Bays in Jagatpur – Kendrapara - Chandbali Stretch

SCHEDULE OF BUS BAYS			
LOCTIONS			
LEFT		RIGHT	
START	END	START	END
1300	1405	1015	1120
3/600	3/705	3/595	3/700
5/400	5/505	6/545	6/650
6/400	6/505	10/095	10/200
9/800	9/905	12/295	12/400
11/400	11/505	14/195	14/300
13/800	13/905	17/895	18/000
16/500	16/605	21/395	21/500
20/200	20/305	24/545	24/650
24/250	24/355	26/245	26/350
25/700	25/805	27/095	27/200
26/600	26/705	31/195	31/300
30/500	30/605	33/095	33/200
32/750	32/855	36/295	36/400
39/500	39/605	37/195	37/300
41/900	42/005	40/195	40/300
43/100	43/205	42/595	42/700
44/500	44/605	43/295	43/400
48/900	49/005	46/175	46/280

Table 7.5: Schedule of Bus Bays in Chandbali - Bhadrak Stretch

SCHEDULE OF BUSBAY DETAILS			
LOCTIONS			
LEFT		RIGHT	
FROM	TO	FROM	TO
8/000	8/105	8/255	8/360
11/425	11/530	11/900	12/005
13/300	13/405	13/555	13/660
14/375	14/480	14/630	14/735
17/400	17/505	17/720	17/825
18/445	18/550	19/400	19/505
20/020	20/125	24/345	24/450
24/095	24/200	26/095	26/200
25/345	25/450	27/545	27/650
27/045	27/150	30/020	30/125
29/270	29/375	31/825	31/930
30/845	30/950	33/695	33/800
34/050	34/155	35/400	35/505
34/970	35/075	35/825	35/930
39/750	39/855	40/020	40/125
40/945	41/050	41/175	41/280
42/345	42/450	44/245	44/350
45/100	45/205	45/595	45/700
46/845	46/950	47/025	47/130
48/600	48/705	48/150	48/255

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 7.6: Location of Guard Posts (Jagatpur – Kendrapara - Chandbali)

Chainage		Length (m)	Side
From	To		
4213	4233	20	BOTH
4243	4263	20	BOTH
3834	3854	20	BOTH
3864	3884	20	BOTH
6064	6084	20	BOTH
6094	6114	20	BOTH
28812	28832	20	BOTH
28842	28862	20	BOTH
34975	34995	20	BOTH
35005	35025	20	BOTH
35025	35085	60	BOTH
35095	35275	180	BOTH
35285	35328	43	BOTH
35352	35413	61	BOTH
35437	35498	61	BOTH
35522	35588	66	BOTH
35612	35668	56	BOTH
35692	35820	128	BOTH
35830	35888	58	BOTH
37959	37979	20	BOTH
38021	38041	20	BOTH

Table 7.7: Location of Guard Posts (Chandbali - Bhadrak)

Sl.No	Chainage		Length (m)	Side
	From	To		
1	17806	17826	20	Both
2	18853	18873	20	Both
3	30615	30635	20	Both
4	36868	36888	20	Both
5	36965	36985	20	Both
6	37096	37116	20	Both
7	17839	17859	20	Both
8	18883	18903	20	Both
9	30645	30665	20	Both
10	36898	36918	20	Both
11	36995	37015	20	Both
12	37126	37146	20	Both

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 of Drawings separately. The schedule of road humps in Jagatpur – Kendrapara – Chandbali and Chandbali - Bhadrak stretch are presented in Table 7.8 and Table 7.9 respectively.

Table 7.8: Schedule of Road Humps (Jagatpur – Kendrapara – Chandbali)

SL.NO	CHAINAGE	DESCRIPTION	LHS / RHS
1	3950	Y-Type	RHS
2	6500	Y-Type	LHS
3	12235	T-Type	LHS
4	16417	Y-Type	RHS
5	17668	T-Type	RHS
6	18425	T-Type	RHS
7	19376	T-Type	RHS
8	21420	T-Type	LHS
9	21990	T-Type	LHS
10	23252	T-Type	LHS
11	24600	Cross Junction	Both
12	33126	T-Type	RHS
13	36195	T-Type	RHS
14	37255	T-Type	LHS
15	40000	T-Type	RHS
16	50020	Y-Type	LHS
17	50448	T-Type	RHS
18	480	School zone	
19	510	School zone	
20	16800	School zone	
21	16900	School zone	
22	25200	School zone	
23	25260	School zone	
24	27770	School zone	
25	27830	School zone	
26	36175	School zone	
27	36260	School zone	
28	47770	School zone	
29	47900	School zone	
30	13270	Hospital zone	
31	13330	Hospital zone	

Table 7.9: Schedule of Road Humps (Chandbali - Bhadrak)

SL.NO	CHAINAGE	DESCRIPTION	LHS/RHS
1	1356	Cross-Type	BOTH
2	1795	T -Type	RHS
3	3359	T - Type	LHS
4	3595	T - Type	RHS
5	4427	Cross-Type	Both
6	5984	T - Type	RHS
7	8459	Y - Type	RHS
8	8576	T - Type	LHS
9	8737	T - Type	LHS
10	10024	Y - Type	LHS
11	11798	T - Type	LHS
12	13463	T - Type	LHS
13	14528	T - Type	LHS
14	17018	T - Type	RHS
15	18866	Cross -Type	Both
16	19402	Y - Type	LHS
17	19453	T - Type	LHS
18	24252	T - Type	LHS
19	29851	Y - Type	RHS
20	30339	T - Type	LHS
21	31478	T - Type	LHS
22	31588	Y - Type	RHS
23	33952	T - Type	LHS
24	35809	T - Type	RHS
25	36571	T - Type	LHS
26	38543	Y - Type	RHS
27	39977	T - Type	RHS
28	40048	T - Type	LHS
29	40567	Y - Type	LHS
30	42300	T - Type	RHS
31	42520	Y - Type	LHS
32	44031	T - Type	RHS
33	44031	T - Type	RHS
34	44625	Y - Type	RHS
35	47013	T - Type	RHS
36	47013	T - Type	RHS
37	48340	T - Type	RHS
38	48340	T - Type	RHS
39	17588	School Zone	

SL.NO	CHAINAGE	DESCRIPTION	LHS/RHS
40	20246	School Zone	
41	20364	School Zone	
42	20479	School Zone	
43	33991	School Zone	
44	35165	School Zone	
45	44623	School Zone	
46	45044	School Zone	
47	45382	School Zone	
48	48783	School Zone	
49	6414	Hospital Zone	
50	40888	Hospital 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 are presented in Table 7.10 and 7.11.

Table 7.10: Schedule of Pedestrian Crossing (Jagatpur – Kendrapara - Chandbali)

SCHEDULE OF PEDESTRIAN CROSSING		
SCHOOL ZOZE	**HOSPITAL ZONE**	**BUS BAYS**
CHAINAGE		
510	13/270	1342
6/460	-	1078
12/830	-	9842
16/900	-	10158
25/260	-	11442
27/830	-	12358
40/930	-	16542
-	-	17958
-	-	20424
-	-	21458
-	-	24292
	-	24608
-	-	26642
-	-	26308
-	-	34542
	-	31258
-	-	41942
-	-	40258
-	-	44542
	-	46238
-	-	48942
-	-	49718

Table 7.X: Schedule of Pedestrian Crossing (Chandbali - Bhadrak)

SHEDULE OF PEDESTRIAN CROSSING		
SCHOOL ZOZE	**HOSPITAL ZONE**	**BUS BAYS**
CHAINAGE		
17588	6413	8045
20245	40887	8315
20364	-	11470
20479	-	11960
33991	-	13345
35165	-	13615
44623	-	14420
45044	-	14690
45381	-	17445
48783	-	17805
-	-	18490
-	-	19460
-	-	20065
-	-	24140
-	-	24405
-	-	25390
-	-	26155
-	-	27090
-	-	27605
-	-	29315
-	-	30080
-	-	30890
-	-	31885
-	-	33755
-	-	34095
-	-	35015
-	-	35460
-	-	35885
-	-	39795
-	-	40080
-	-	40990
-	-	41235
-	-	42390
-	-	44305
-	-	45145
-	-	45655
-	-	46890
-	-	47085
-	-	48210
-	-	48645

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 (MoSRTH wide 801.3.2 clause) as indicated below for encapsulated lens.
iv.

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 carriageway, 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 sub grade. 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 sub grade, 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/ sub grade 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 sub grade material when compacted to the density requirements as per specifications shall yield the design CBR value of the sub grade.

Widening of Existing Road Embankment

When an existing embankment and/ or sub grade 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/ sub grade material to be added. The material obtained from cutting of benches could be utilized in the widening of the embankment/ sub grade. 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/ sub grade is to be placed against sloping ground, the latter shall be appropriately benched or ploughed/ scarified before placing the embankment/ sub grade 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 sub grade 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 sub grade 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 sub grade 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 sub grade 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**.

8.5 SPUR ROAD DEVELOPMENT

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

Existing	Proposed Improvement
Earthen Road	Earthen Road
WBM Road	WMM + MSS
BT Road	GSB + WMM + PMC
Concrete Road	WMM + MSS

8.5.1 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 7 m carriageway and 2.5 m earthen shoulders on each side (Total width of roadway 12m) with the following provision for road cruse in the 7 m width:

(i) 200 mm (compacted) granular sub base;
(ii) 225 mm (compacted) granular base course; and
(iii) Mix Seal Surfacing (MSS).

8.5.2 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 7m carriageway with 2.5m earthen shoulders on each side with following provisions of road crust 200mm (compacted) granular sub base, 225mm (compacted) granular base, premix carpet with seal coat in 7m width.

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.

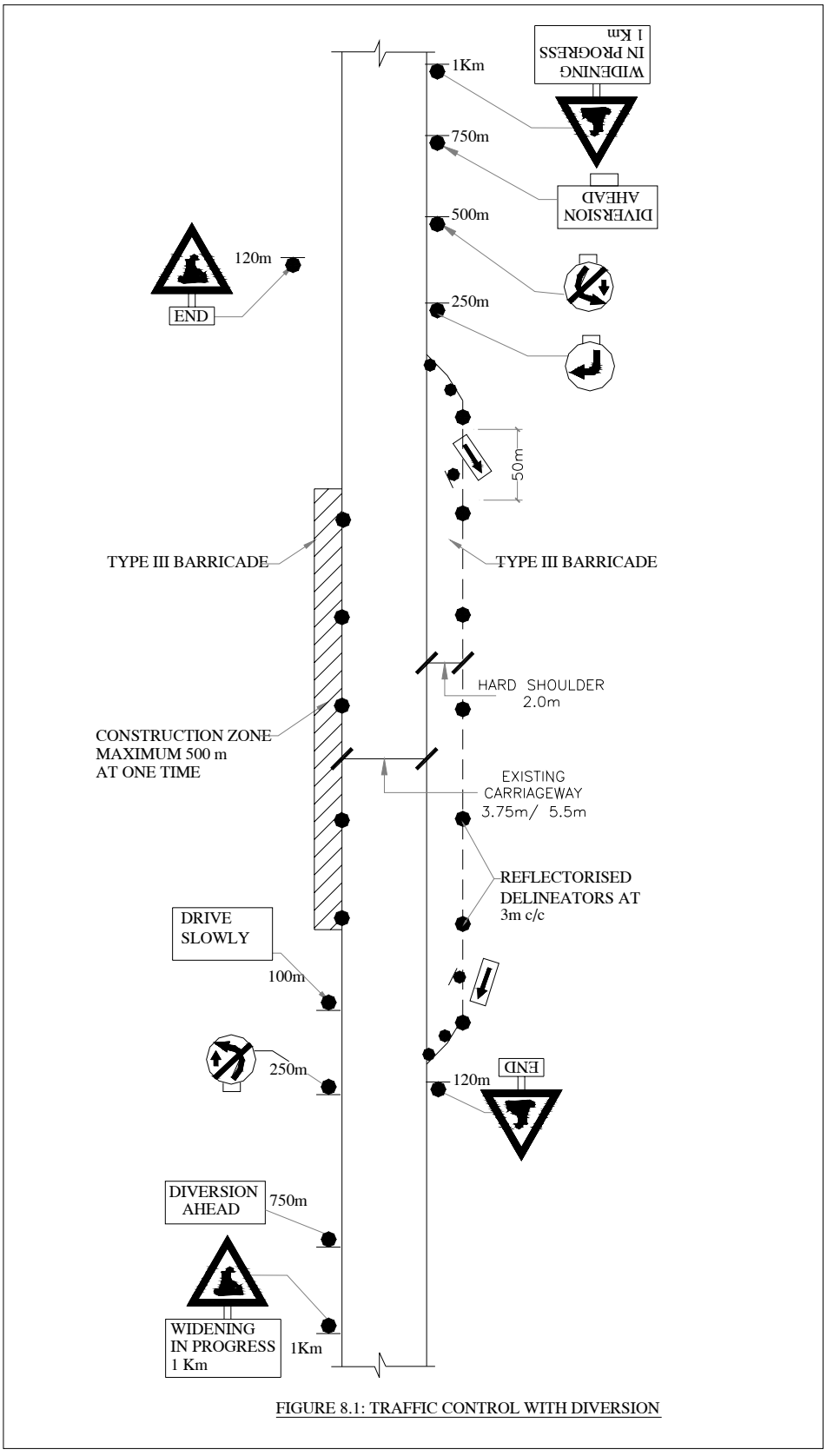


FIGURE 8.1: TRAFFIC CONTROL WITH DIVERSION

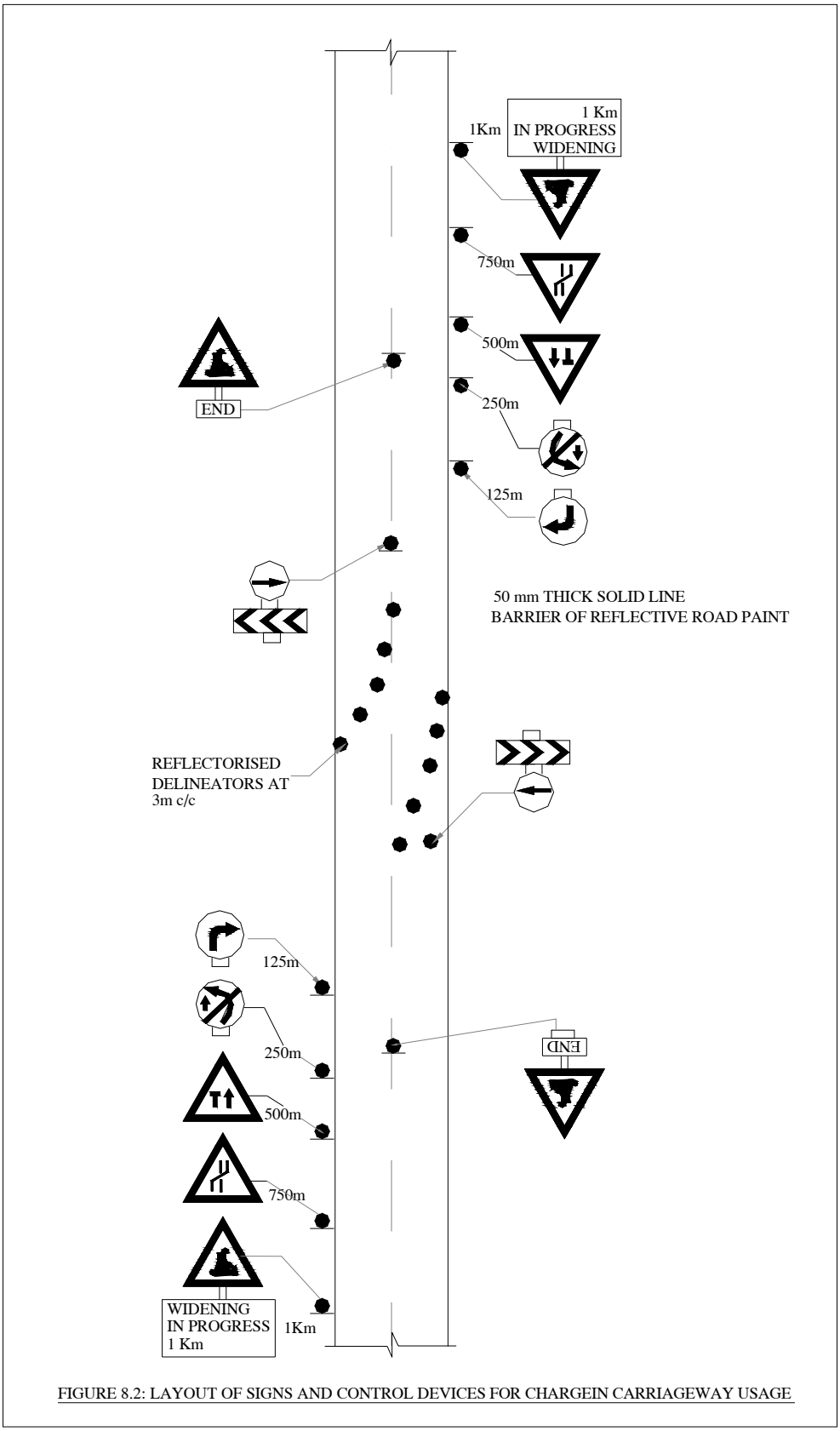


FIGURE 8.2: LAYOUT OF SIGNS AND CONTROL DEVICES FOR CHARGEIN CARRIAGEWAY USAGE

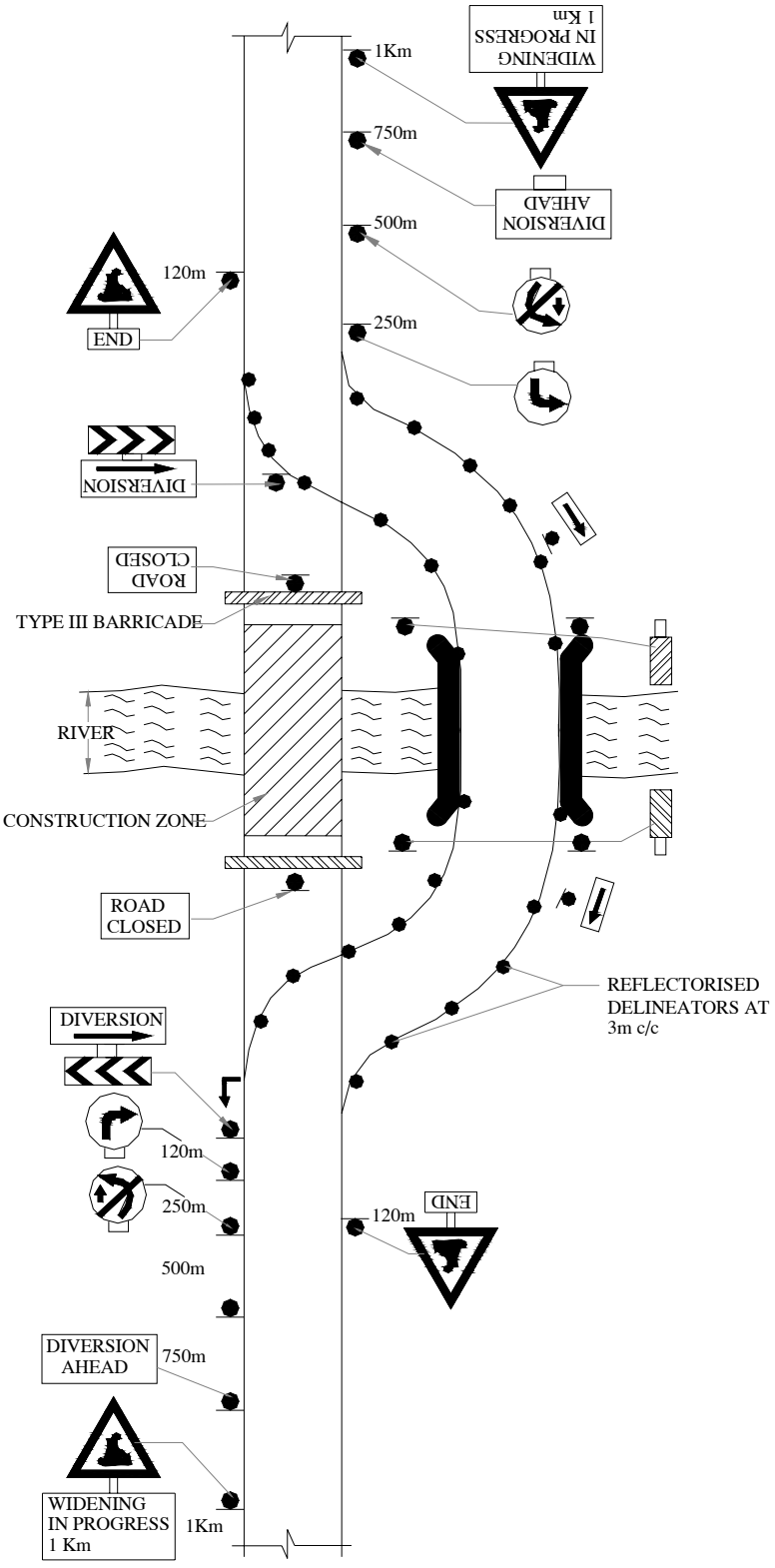


FIGURE 8.3: LAYOUT OF SIGNS AND CONTROL DEVICES FOR ROAD CLOSED WITH A DIVERSION

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.

Abstract of Cost of Package (Chandballi - Bhadrak - Anandpur)

Bill No.	Description	Amount in Rupees
1	Site clearance and Dismantling	14,912,730.00
2	Earth Work	188,230,420.00
3	Sub-base and base courses	375,113,220.00
4	Bituminous courses	490,736,333.00
5	Culverts & Underpasses	276,077,120.00
6	Bridges	205,516,332.00
7	Drainage & Protective works	165,550,622.00
8	Miscellaneous items	73,551,810.00
9	Maintenance, Repair and Rehabilitation works	19,510,023.00
	Sub total (A)	**1,809,198,610.00**
10	Provisional Item	**5,306,174.00**
	Add for **(i) Social Cost(LAQ+R&R)**	108,541,840.00
	(ii) Utility relocation, 2% of A	36,183,972.00
	(iii) Cost of Environmental Implementation Plan	57,144,011.00
	Total (B)	**2,016,374,607.00**
	(i) Engineering Supervision, 3% of B	60,491,238.00
	(ii) PIU - Project office , 1% of B	20,163,746.00
	(iii) Contigencies , 3% of B	60,491,238.00
	Grand Total	**2,157,520,829.00**

CHAPTER - 10
ENVIRONMENTAL ACTION AND ENVIRONMENTAL MANAGEMENT PLAN

CHAPTER – 10

ENVIRONMENTAL ACTION AND MANAGEMENT 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.

Abstract of Cost of Package (Chandballi - Bhadrak - Anandpur)

Bill No.	Description	Amount in Rupees
1	Site clearance and Dismantling	14,912,730.00
2	Earth Work	188,230,420.00
3	Sub-base and base courses	375,113,220.00
4	Bituminous courses	490,736,333.00
5	Culverts & Underpasses	276,077,120.00
6	Bridges	205,516,332.00
7	Drainage & Protective works	165,550,622.00
8	Miscellaneous items	73,551,810.00
9	Maintenance, Repair and Rehabilitation works	19,510,023.00
	Sub total (A)	**1,809,198,610.00**
10	Provisional Item	**5,306,174.00**
	Add for (i) Social Cost(LAQ+R&R)	108,541,840.00
	(ii) Utility relocation, 2% of A	36,183,972.00
	(iii) Cost of Environmental Implementation Plan	57,144,011.00
	Total (B)	**2,016,374,607.00**
	(i) Engineering Supervision, 3% of B	60,491,238.00
	(ii) PIU - Project office , 1% of B	20,163,746.00
	(iii) Contigencies , 3% of B	60,491,238.00
	Grand Total	**2,157,520,829.00**

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 MoSRTH 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 MoSRTH data book and SSR-2006.

11.5 COST ESTIMATES

Estimated total cost of this package is Rs 2157.52 millions which includes engineering cost as Rs 1809.20 millions. Estimated cost for provisional items, social, environmental and utility shifting costs as Rs 207.18 millions. The total cost also includes engineering supervision, PIU project office and contingencies.

ABSTRACT OF COST

Abstract of Cost of Package (Chandballi - Bhadrak - Anandpur)

Bill No.	Description	Amount in Rupees
1	Site clearance and Dismantling	14,912,730.00
2	Earth Work	188,230,420.00
3	Sub-base and base courses	375,113,220.00
4	Bituminous courses	490,736,333.00
5	Culverts & Underpasses	276,077,120.00
6	Bridges	205,516,332.00
7	Drainage & Protective works	165,550,622.00
8	Miscellaneous items	73,551,810.00
9	Maintenance, Repair and Rehabilitation works	19,510,023.00
	Sub total (A)	**1,809,198,610.00**
10	Provisional Item	**5,306,174.00**
	Add for (i) Social Cost(LAQ+R&R)	108,541,840.00
	(ii) Utility relocation, 2% of A	36,183,972.00
	(iii) Cost of Environmental Implementation Plan	57,144,011.00
	Total (B)	**2,016,374,607.00**
	(i) Engineering Supervision, 3% of B	60,491,238.00
	(ii) PIU - Project office , 1% of B	20,163,746.00
	(iii) Contigencies , 3% of B	60,491,238.00
	Grand Total	**2,157,520,829.00**

Detail Quantities

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.The abstract area calculated from MX software is mentioned below and the detailed quantity is annexed herewith.	Hectare	66.00	26639.00	1758174.00
1.02	Dismantling structures and pavement including disposal of resulting material and/or salvaging useful materials complete as per Technical Specifiction Clause 202				
	a) Brick/ Stone Structures	Cum	444.19	111.00	49305.00
	b) Concrete/Reinforced concrete/ Prestressed concrete structures including cleaning straghtening & cutting of bars and separating them out from RCC/PSC.				
	For Slab Culverts & Box Culverts and Bridges				
	i)P.C.C.	Cum	627.38	230.00	144296.00
	ii)R.C.C.	Cum	444.87	356.00	158372.00
	c) Dismantalling of Pavement course	Cum	35385.00	135.00	4776975.00
	d) Pipe, guard rail, edging kerbs, masonry parapet, gutters & fencing				
	Hume pipe	Lm	767.80	45.00	34551.00
	e) Kerb	Lm	13.80	7.00	97.00
	f) stone pitching	Cum	59.70	87.00	5194.00
	g) concrete railing	Lm	13.80	27.00	373.00
	SUB TOTAL				**6,927,337.00**
	BILL NO.2 : EARTH WORKS				
2.01	Roadway excavation necessary for construction of roadway complete as per Technical Specification Clause 301 calculated from Mx software and is annexed herewith.				
	a) Soil	Cum	332983.00	44.00	14651252.00
	b) softrock (blasting not required) (LS)	Cum	1000.00	53.00	53000.00
	c) Hard rock (blasting required) (LS)	Cum	1000.00	133.00	133000.00
2.02	Construction of embankment with approved material complete as per drawing and Technical Specification Clause 305 with all leads and lifts , calculated from MX software and annexed herewith.	Cum	76667.00	110.00	8433370.00
2.03	Construction of subgrade and earthen shoulder with approved material as per drawing complete and Technical Specification Clause 305 with all leads and lifts calculated from MX Software and annexed herewith.	Cum	365525.00	134.00	48980350.00

Item No.	Description	Unit	Quantity	Rate	Amount
2.04	Construction of granular/gravel shoulders with approved material as per drawing complete and Technical Specification Clause 305 with all leads and lifts	Cum	0.00	473.32	0.00
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 with all leads and lifts.	Cum	199790.00	56.00	11188240.00
2.06	Loosening and recompacting subgrade in all kinds of soil complete as per Technical Specification Clause 305	Cum	10438.00	40.00	417520.00
2.07	Filling of median/island complete as per Technical Specitication Clause 407	Cum	2700.00	128.00	345600.00
2.09	Scarifying the existing bituminous surface layers complete as per Technical Specification Clause 305 calculated from MX Software and annexed herewith.	Sqm	8981.00	3.00	26943.00
2.10	Lime Stabilisation for Improving embankment (Laying and spreading available soil/excavated soil in the embankment on a prepared surface, pulverising, mixing the spread soil in place with rotavator with 3 % slaked lime having minimum content of 70% of CaO, grading with motor grader and compacting with the road roller at OMC to the desired density to form a layer of improved sub grade)	Sqm	5000.00	141.00	705000.00
2.11	Providing Geotextiles for improvement of sub-soil strength as per drawing and technical specification.	Sqm	5000.00	71.00	355000.00
	SUB TOTAL				**85,289,275.00**

Item No.	Description	Unit	Quantity	Rate	Amount
	BILL NO.3 : SUB-BASE AND BASE COURSES				
3.01	Construction of Coarse graded Granular Sub-base course complete as per Technical Specification clause 401 , calculated from MX software and annexed herewith.	Cum	154000.00	584.00	89936000.00
3.02	Construction of wet mix macadam complete as per Technical Specification clause 406 , calculated from MX software and annexed herewith.	Cum	122557.00	1276.00	156382732.00
	SUB TOTAL				**246,318,732.00**
	BILL NO.4 : BITUMINOUS COURSES				
4.01	Providing Primer coat over granular surface complete all as per Technical specification clause 502, calculated from MX software and annexed herewith.	Sqm	468975.00	11.00	5158725.00
4.02	Providing Tack coat complete as per Technical Specification clause 503 as calculated from MX software	Sqm	468975.00	4.00	1875900.00
4.03	Providing dense bituminous macadamcourse complete as per Technical Specification Clause 507, calculated from MX software and annexed herewith.	Cum	27704.00	4199.00	116329096.00
4.04	Providing bituminous concrete wearing course using CRMB-55 complete as per Technical Specification Clause 512, calculated from MX software and annexed herewith.	Cum	18735.00	4763.00	89234805.00
4.05	Providing, laying mixed seal surfacing in spur roads complete as per technical specification clause 512.	Sqm	7555.00	95.00	717725.00
	SUB TOTAL				**213,316,251.00**
	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.	Cum	7687.16	31.00	238302.00
5.02	Earth fill below pitching in quadrant portion	Cum	2840.11	110.00	312413.00

Item No.	Description	Unit	Quantity	Rate	Amount
5.03	Providing and filling behind abutment, wing wall and return wall 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.	Cum	4308.32	332.00	1430362.00
5.04	Providing filtter media behind abutment, wing wall and return wall complete as per drawing and Technical Specification clause 305.	Cum	2096.22	1453.00	3045807.00
5.05	Cement Concrete M-15 grade in levelling course etc. including centering and shuttering all complete as per Drawings and Technical Specification Sections 1500 and 1700.	Cum	2221.11	2991.00	6643335.00
5.06	Cement Concrete M-15 grade in substructure & headwall including centering and shuttering all complete as per Drawings and Technical Specification Sections 1500 and 1700.	Cum	1353.91	3164.00	4283757.00
5.07	Reinforced cement concrete M-25 in all types of culverts as per drawing and technical specification Clause No.1700 & 2300.	Cum	6518.90	4160.00	27118604.00
5.08	Reinforced cement concrete M-30 grade in approach slabs including cost of reinforcement all complete as per Drawing and Technical Specification Section 2700.	Cum	1316.70	6019	7925217.00
5.09	HYSD bar reinforcement complete as per drawing and technical specifications clause 1600	MT	391.13	42446.00	16602062.00
5.10	Providing laying and joining NP-4(I.S 458) hume pipes with culvert complete as per drawing Tech. Specification section2900 and IRC special publication no.13				
	a) 1m dia. hume pipe in single row	Rm	338.750	3277.00	1110084.00
	b) 1m dia. hume pipe in double row	Rm	1412.500	6602.00	9325325.00
5.11	Providing and laying filter material underneath stone pitching in slopes complete as per drawings and technical specification section 2500.	Cum	26788.61	1453.00	38923853.00
5.12	Providing and laying stone Pitching on embankment slopes complete as per drawing and technical specification	Cum	2184.07	847.00	1849909.00

Item No.	Description	Unit	Quantity	Rate	Amount
5.13	Providing rubble stone flooring in Cement mortar (a Cement:3 Sand) and joints complete as per Drawing and Technical Specification Section 1400 and 2500.	Cum	1501.67	2778	4171643.00
5.14	Providing weep holes in box portion, return wall, wing wall etc. all complete as per drawing ans technical specification clause . 2706.	Nos	6162.00	100.00	616200.00
5.15	Supplying, fitting and fixing in position true to line and level bearings confirming to IRC-83 (para-II) section IX complete with all accessories as oer drawings and technical specification clause 2605	Sqm	0.00		
5.16	Supplying as fixing the following types of expansion joints complete as per Drawing and Technical Specification Section 2600.	Rmt	1320.00	34.00	44880.00
5.17	Reinforced cement concrete railing complete as per Drawing and Technical Specification Section 2700 (Including cost of Reinforcement)	Rmt	1143.88	1168.00	1336052.00
5.18	Bituminous wearing course 56mm thick comprasing 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 and Clause 512.	Sqm	6520.12	640.45	4175808.00
5.19	Synthetic enamel painting of culvert no. and span arrangement as per IRC - 7 - 1971 and as directed by the Engineer.	No.	220.00	47.00	10340.00
	SUB TOTAL				**129,163,953.00**
	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	Cum	10068.65	31.00	312128.00

Item No.	Description	Unit	Quantity	Rate	Amount
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 including including all leads & lifts as per Technical specification Clause 304 and 305.	Cum	1277.17	332.00	424022.00
6.03	Providing Filter media behind abutment, wing wall and return wall complete as per drawing and technical Specification clause 305 and 2504	Cum	168.08	1453.00	244227.00
6.04	Cement concrete M-15 grade in levelling course etc including centering and shuttering all complete as per drwaing and Technical specification Section 1500 and 1700.	Cum	321.69	2991.00	962185.00
6.05	Cement concrete M-15 grade in foundation and substructure etc including centering and shuttering all complete as per drwaing and Technical specification Section 1500 and 1700.	Cum	909.30	3164.00	2877015.00
6.06	Reinforced cement concrete in foundation complete as per drawing & Technical specification sections 1700, 2100 & 2200				
	a) M-20 Grade			3605	0.00
	b) M-25 Grade			3923	0.00
	c) M-30 Grade	Cum	145.92	3933	573903.00
6.07	Reinforced cement concrete in substructure complete as per drawing & Technical specification sections 1700, 2100 & 2200				
	a) M-20 Grade	Cum	0.00	3814.00	0.00
	b) M-25 Grade	Cum	638.35	4160.00	2655542.00
	c) M-30 Grade	Cum	515.89	4182.00	2157465.00
	c) M-35 Grade	Cum	905.09	4373.00	3957947.00
	c) M-40 Grade	Cum	336.867	4749.00	1599780.00
6.08	Rainforced cement concrete in super structure complete as per drwaing and Technical specification section 1700 & 2200.				
	a) M-25 grade	Cum	0.00	4702.00	0.00
	b) M-30 grade	Cum	119.99	4753.00	570303.00

Item No.	Description	Unit	Quantity	Rate	Amount
6.09	Prestressed cement concrete in super structure complete as per drawing and Technical Specification Section 1800 and Clause 2305.				
	M-40 grade	Cum	0.00		
6.10	Reinforced cement concrete railing complete as per drwaing and Technical specification section 2700 (Including cost of Rainforcement)				
	Hand Railing	Rmt	81.38	1168.00	95054.00
6.11	Bored cast-in-situ M-35 grade RCC Pile excluding reinforcement complete as per drawing and technical specification cl.1100 , 1600 , 1700 and removal of excavated earth with all leads and lifts.	Rmt	0.00		
6.12	A)HYSD bar reinforcement with Anti-corrosive treatment coating complete as per drawing and technical specifications clause 1600				
	a) in foundation	Tonne	8.76	42406.00	371273.00
	b) in substructure		129.36	42446.00	5490779.00
	c) in superstructure		8.13	42830.00	348126.00
	B)Providing and supplying High Tensile steel strands including all accessories for stressing, stressing operation and grouting complete as per Drawing and Technical Specification Section 1800.	Tonne	0.00		
6.13	Providing and fixing elastomeric bearings complete as per Drawing and technical specification 2000.				
	a) Elastomeric bearing	Cucm		1.61	0.00
	b) POT PTFE bearing	Tonne			
	c) Tar paper bearing	Sqm	2.621	50.00	131.00
6.14	Reinforced cement concrete M-30 grade for in approach slabs including cost of reinforcement all complete as per Drawing and Technical specification section 2700.	Cum	218.03	6019.00	1312300.00
6.15	Bituminous wearing course 56mm thick comprasing 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 2700 and Clause 512.	Sqm	1799.97	640.45	1152793.00

Item No.	Description	Unit	Quantity	Rate	Amount
6.16	Providing and fixing Drainage Spouts Complete as per drawing and Technical Specification Clause 2705	No	58.00	733.00	42514.00
6.17	Providing and laying Stone pitching in slopes complete as per drawing and Technical Specification Section 2500	Cum	397.84	847.00	336970.00
6.18	Providing as laying fitter material underneath Stone pitching in slopes Complete as per drawing and Technical Specification Section 2500.	Cum	622.67	1501.00	934633.00
6.19	Providing weep holes in abutments, wing walls and return walls etc. as per drawing and Technical Specification Section 2700	Nos	463.60	100.00	46360.00
6.20	Providing rubble Stone flooring in Cement mortar (1Cement:3 sand) and joints Complete as per drawing and Technical Specification Section 1400 and 2500	Cum	1075.57	847.00	911005.00
6.21	Supplying as fixing the following types of expansion joints Complete as per drawing and Technical Specification Section 2600 a)Filler type	Rm	241.54	34.00	8212.00
	b) Strip seal type of expansion joint including acceptance testing as Specified, to be installed under Supervision of the specialist manufacturer	Rm	0.00	11931.00	0.00
6.22	Synthetic enamel painting of Bridge No and Span arrangements as per IRC-1971 and as directed by Engineer	No	20.00	47.00	940.00
6.23	Carrying and Confirmatory bores up to required depth as locations of bridges as directed be Engineer complete in all respects handling testing as per Technical Specification Section 2400 and interpretation of the bore data and presentation of the results				

Item No.	Description	Unit	Quantity	Rate	Amount
	a) In all types of soil (except rock)				
	I) depth from 0m to 10m	Lm	20.00	400.00	8000.00
	ii) depth from 10m to 20m	Lm	20.00	450.00	9000.00
	iii) depth from 20m to 30m	Lm	10.00	500.00	5000.00
	b) In soft rock				
	I) depth from 0m to 5m	Lm	10.00	600.00	6000.00
	ii) depth from 5m to 10m	Lm	10.00	650.00	6500.00
6.24	Providing and painting of flood gauge on substructure is fall height and 500mm width as per direction as the Engineer	Rm	135.00	830.00	112050.00
6.25	Providing HDPE Service pipe as approved quality in footpath as per drawing and direction of the Engineer	Rm	355.94	300.00	106782.00
6.25	Plastering	Sqm	259.65	2326	603937.00
6.26	Earth fill below pitching in quadrant portion	Cum	711.84	110	78302.00
6.27	Sand filling below foundation	Cum	1248.96	472	589510.00
6.28	PCC in flooring				
	a) M-15	Cum	313.95	2991	939027.00
	b) M-20	Cum	104.65	3436	359578.00
	SUB TOTAL				**30,209,293.00**
	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	Cum	4275.00	31.00	132525.00
(b)	Back filling behind wing wall with selected imported granular material of apporved quality complete as per drawing and Technical	Cum	0.00	546.00	0.00
(c)	Filter medium behind wing wall complete as per drawing and Technical Specification Clauses 305 & 2504	Cum	1620.00	1453.00	2353860.00
(d)	Plain cement concrete M -15 in foundation levelling course etc. including centering and shuttering all complete as per drawing and Technical Clauses 1500 & 1700	Cum	285.00	3164.00	901740.00

Item No.	Description	Unit	Quantity	Rate	Amount
(e)	Cement concrete M -25 for reinfoced concrete in foundation including centering and shuttering all complete as per drawing and Technical Clauses 1500 &1700	Cum	795	3923.00	3118785.00
(f)	Cement concrete M -25 for reinfoced concrete in substructure including centering and shuttering all complete as per drawing and Technical Clauses 1500 &1700	Cum	810	4160.00	3369600.00
(f)	providing steel reinforcement (HYSD) for retaining wall complete as per drawing and Technical Specification Clause 1600	Cum	128.4	42446.00	5450066.00
(g)	Reinforced cement concrete railing of grade M-30 complete as per drawings and Technical specifications section 2700 (including cost of reinforcement)	Lm	1000	1168.00	1168000.00
(I)	Providing weep holes in retaining wall complete as per drawing and Technical Specification Clause 2700	No.	200	100.00	20000.00
7.02	Providing and laying stone pitching on embankment slopes as per drawing and Technical Specification Clause 2504 Near Bridge approaches where separate embankment exists	Cum	738.000	847.00	625086.00
7.03	Providing and laying filter material underneath stone pitching on embankment slopes as per drawing and Technical Specification Clause 2504	Cum	369.000	1501.00	553869.00
7.04	Turfing side slopes of main road and service road with grass sods complete as per Technical Specification Clause 307	Sqm	205093.000	12.00	2461116.00
7.05	Constructing lined surface drains/ sub surface drains to the required lines and grades as per drawing and Technical Specification Clause 309	Lm	13650.000	3966.00	54135900.00
7.06	Constructing box type drains to the required lines and grades as per drawing and technical specification	Lm	1480.000	8539.00	12637720.00
	SUB TOTAL				**86,928,267.00**

Item No.	Description	Unit	Quantity	Rate	Amount
	BILL NO-8 : MISCELLANEOUS ITEMS.				
8.01	Providing and laying plain cement concrete kerb as per drawing and Technical Specifications Clauses 408 and section 1700.	Lm	336.483	168.00	56529.00
8.02	Providing service ducts with 150mm dia GI pipes over concrete base under existing and proposed carrigeways including cutting of trenches through existing roadway and reinstatement of the same as per design and specification of new construction (but exclud	Lm	378.000	1666.00	629748.00
8.03	Providing and fixing RCC boundry posts complete as per drawing and Technical Specification Clause 806 (including cost of reinforcement)	No	540.000	294.00	158760.00
8.04	Providing and fixing RCC/PCC hectometre, Kilometre and 5th kilometre stones complete as per Technical Specification Clause 804 (including cost of reinforcement)				
	a) No of (200) Hectometre Stone	No	196.900	288.00	56707.00
	b) No of Kilometre stone	No	39.225	1095.00	42951.00
	c) No. of 5th Kilometre Stone	No	10.000	1787.00	17870.00
8.05	Constructing footpath/ paved separator / passenger platform / paved part of medians and islands complete a spe drawing and Technical Specifications Clause 409 and 407 For Toll Plaza	sqm	3693.000	2000.00	7386000.00
8.06	Providing passenger shelters for Bus Bays as per drawing and Technical Specifications Section 1700.	No	40.000	80000.00	3200000.00
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.	Lm	4827.000	1796.00	8669292.00
8.08	(I) Pavement marking with hot applies thermoplastic paints confirming to ASTMD86 / BS 3262-Part as per drawing and Technical specifications Clause 803.				
	a) Lane line / Edge marking	sqm	12788.000	595.00	7608860.00
	b) Directional arrows and lettering etc.	No	189.000	39.00	7371.00

Item No.	Description	Unit	Quantity	Rate	Amount
8.09	Supplying and fixing sign boards complete as per Technical Specifications Clause 801 and as directed by Engineer. Including the cost of Posts,Fitting & fixing. Sheeting will be retro reflective type of high intensively grade and messages / boarders wil				
(a)	Informatory Signs				
	(i) Facility Information (800 x 600)mm	No	6.000	2880.00	17280.00
	(ii) Direction Signs (1200 x 700 mm)	No	2.000	8355.00	16710.00
	(iii) Advance Direction (size 1800 x 1200mm) ,	No	1.000	14316.00	14316.00
	Re-Assurance Sign (1800 X 1200 mm) ,	No	1.000	14316.00	14316.00
	Destination Sign (1500 X 900 mm) ,	No	2.000	12316.00	24632.00
	Place Identification (1500 X 900 mm) ,	No	1.000	12316.00	12316.00
	(iv) Route Marker Sign (450mm x 600mm)	No	2.000	3031.00	6062.00
	(v) Other Informatory Signs (2100mm x 1500mm)	No	2.000	14316.00	28632.00
(b)	CAUTIONARY SIGNS triangular 900mm side	No	35.000	3601.00	126035.00
(c)	MANDATORY SIGNS				
	Circular 600mm dia	No	8.000	3123.00	24984.00
	Octagaon 900 mm height	No	12.000	5896.00	70752.00
	Triangular 900 mm side	No	12.000	3601.00	43212.00
8.10	Providing & fixing retro - reflectorised road delinators complete as per drawing , Technical specifications clause 805 and as directed by Engineer				
	(I) Roadway delinator	No	549.000	787.00	432063.00
	(ii) Hazard Marker	No	16.000	787.00	12592.00
	(iii) Object Marker	No	24.000	787.00	18888.00
8.11	Providing and fixing RCC Guard post complete including end anchorage as per drawing and Technical Specifications Clause 810	No.	176.000	328.00	57728.00
8.12	Supply of colour record photographs negative and two colour prints therefrom mounted in album as per Technical Specifications Clause 125 As per requirements	No	600.000	5.00	3000.00
8.13	Supply of additional prints of coloured photographs referred to above as per Technical Specifications Clause 125 As per requirements	No	800.000	5.00	4000.00

Item No.	Description	Unit	Quantity	Rate	Amount
8.14	Supply of colour video cassette records during construction as per Technical Specifications Clause 126 As per requirement	set	2.000	200.00	400.00
8.15	Providing rumble strips complete as per drawing and technical specification.	No.	12.000	5656.00	67872.00
8.16	Providing road hump complete as per drawing and technical specification.	No.	47.000	14640.00	688080.00
8.17	Providing toll plaza as per drawing and technical specification.	No.	1.000	1170506.00	1170506.00
8.18	providing utility duct across the road in specified locations as per the schedule mentioned in drawing	No.	25.000	130220.49	3255512.00
	SUB TOTAL				**33,943,976.00**
	BILL NO.9 MAINTENANCE, REPAIR AND REHABILITATION				
9.01	Carrying out routine maintenance of Highway as per Technical Specifications Clause 3002 and as per direction of the Engineer (excluding bituminous work)	Km-month	245.000	1500.00	367500.00
9.02	Carrying out treatment and repairs to pot-holes and any necessary patching to the existing bituminous carraigeway surfacing as per Technical Specification Clause 3004 as per direction of the Engineer	Sqm	9000.000	81.00	729000.00
9.03	Providing and laying reinforced Cement Concrete of grade M- 30 in railings including dismentalling of damaged railings, straightening and cleaning of the existing reinforcement as required Complete as per drawing and Specification Sections 1500,1600,1700,2200 & 2800.	Cum	0.000	42531.00	0.00
9.04	Plain Cement Concrete M- 20 grade for extension of masonary/ P.C.C. Abutment/Pile, foundation including cleaning of dismetalled face of existing structure and applying a coat of Cement slurry, costin fresh Concrete against the old Concrete face including cost of all materials, form work, centering , staging during all complete as per Technical Specification Sections 2100,2200 and 2300	Cum	0.000	3634.00	0.00

Item No.	Description	Unit	Quantity	Rate	Amount
9.05	Removal of damaged expansion joint Complete and replacement with steel plate sliding expansion joint as per drawing as Technical Specification Sections 2600 & 2800	Lm	0.000	1770.00	0.00
9.06	Replacement of existing wearing coat by Bituminous wearing course56mm thick comprasing 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 2700 and Clause 512.	Sqm	93.000	697.45	64863.00
9.07	Reinforced Cement Concrete M- 30 grade approach slabs including cost of reinforcements Complete as per drawing and Technical Specification Section 2700	Cum	600.000	847.00	508200.00
	SUB TOTAL				**1,669,563.00**
	BILL NO. - 10 : PROVISIONAL ITEMS				
10.01	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	82.000	79.00	6478.00
	b) Girth From 600mm to 900mm	No	101.000	161.00	16261.00
	c) Girth From 900mm to 1800mm	No	1945.000	284.00	552380.00
	d) Girth From 1800mm to Above	No	158.000	513.00	81054.00
10.04	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	120000.00
10.05	Co-ordination for Shifting of Utilities as per Technical Specification Clause 110 Total project length	Km	49.00	2000.00	98000.00
10.06	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	2.00	40500.00	81000.00

Item No.	Description	Unit	Quantity	Rate	Amount
10.07	Providing and fixing Pedestrian guard rails in 2m and 1m modules including painting wrth approved paint complete as per drawing and Technical Specification Clause 803,1008,1300 & 1700	Lm	100.00	3000.00	300000.00
10.08	Providing and fixing Ornamental grill fencing with MS flats complete with gate, painting, brickwork base and foundation complete as per drawing and Technical Specification Clause 1008,1300 & 1700	Lm	100.00	1000.00	100000.00
	SUB TOTAL				**1,355,173.00**

REPLY TO PIU COMMENTS
ANNEXURE - A

Reply to PIU comments

Comments received from PIU vide letter no: PIU (WB)/36/05/Part/7226, dated: 22/2/2007

S.No	Comments	Reply
1	There are some stretches (for a length of 35 km) where CI, CL, and CH type of soil are present in the Embankment / subgrade with DFS value more than 50%. The design should cover the aspect of provision of suitable or improved / treated soil layer of 500mm below the bottom of subgrade (Refer 2.3.2 of main report)	Stretches where DFS value more than 50%, suitable treatment is provided (Refer 4.3 of main report).
2	For Bhadrak Chandbali road, longitudinal drain shall not function as the terrain here is very flat and minimum gradient requirement for the longitudinal drain can not be provided in most of the stretches. Clear height must be maintained between FRL and the HWL so as to cater to the thicknesses of crust, subgrade and minimum clearance between subgrade and HWL.	Necessary provisions for clear height for drainage have been made. Submersible sections have been raised. Additional CD structures has also been provided as per requirement.
3	For Bhadrak – Chandbali Road, the section between Bhadrak and NH-5 may be included in the corridor.	The section between Bhadrak and NH-5 is included in Bhadrak – Chandbali stretch.
4	In the Bhadrak – Anandpur section, the following stretches may be realigned as discussed with the World Bank team during site visit in order to save trees. • 0-2/00 km • 12/500 – 13/000 km • 21/600 – 22/000 km	Modifications have been made as per subsequent discussions with PIU.
6	Coherence in list of culverts in the drawing, report and schedule of culverts must be maintained with the actual requirement in the field, with proper design Chainages.	The list of culverts as been reconciled and presented in report, drawings and schedule.
7	Cross reference to Environmental features to appear with reference of their detail drawings.	Environmental features have been incorporated.
8	Name of the villages are to be corrected at certain locations.	The name of the villages has been corrected.
9	Estimate may be recast considering the bitumen rate already transmitted to you and other parameters as stated above.	The estimate has been revised as per bitumen rates transmitted and other parameter stated above.

Other modifications incorporated for the comments raised during time to time discussion with PIU.

- In Bhadrak to Chandbali section, the carriageway in Open area has been modified from 7m+2x2.5 Hard Shoulder to 7m+2x2.5 Earthen Shoulder in 2 – 45 km and 7.0m+2x1.5m Paved Shoulder +2 x1.0m earthen shoulder 0- 2 km. In Built Up area the carriageway is modified from 7.0m+2x1.5m Paved Shoulder to 7.0m+2x1.5m Paved Shoulder + 2x0.25m Concrete Saucer drain.

- In Bhadrak to Anandpur section, the carriageway in Open area has been modified from 7m+2x2.5 Hard Shoulder to 7m+2x2.5 Earthen Shoulder in 8/200 – 50 km and 7.0m+2x1.5m Paved Shoulder +2 X1.0m earthen shoulder upto 8/200 km. In Built Up area the carriage is modified from 7.0m+2x1.5m Paved Shoulder to 7.0m+2x1.5m Paved Shoulder + 2X0.25m Concrete Saucer drain.

- The Crash Barriers are replaced by Guard Posts.

- Floor protection works for bridges have been reviewed and necessary modifications have been made.

- Where DFS is more than 50%, it is suggested that sub grade and the top 500 mm of the embankment material is to be obtained from borrow areas identified.