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1. DESIGN STANDARDS

1.1 GEOMETRIC DESIGNS

1.1.1 *General*

The project highway passes through mountainous and steep terrain. The cross slope of the country is greater than 25%. Geometric design has been carried out based on IRC SP 73 2015. In certain cases the criteria given in IRC SP 73 2015 cannot be fulfilled, in that case IRC SP 48 has been adopted and the specific locations are provided separately. The design has been done keeping in view the least provision of protection work which enable less environmental and cost impact to the project. The horizontal alignment is shifted more towards hill sides so as to have less retaining wall. Hair pin bends and S-curves are designed with IRC SP 48 with design speed less than 40KMPH.

1.1.2 *Classification of Design Standards for Geometrics of Highway*

The project highway shall follow the design standards mentioned below:

1.1.2.1 Design Speed

The design speed given in table below have been adopted for various terrain classifications.

Table 1-1: Design Speed

Nature of Terrain	Cross Slope of Ground	Design Speed (Kmph)	
		Ruling	Minimum
Mountainous and steep terrain	more 25%	60	40

The project highway passes through mountainous to steep terrain hence the speed varies from 60 kmph to 40 kmph as per table 2.1 of IRCC SP 73. The locations where the minimum design speed cannot be achieved are given separately in the table. These curves are designed based on Hill Road Manual.

1.1.2.2 Design of Horizontal/Vertical Alignment

The following latest code of standards & technical specifications has been used for the alignment design:

Table 1-2: Summary of Code of Standards & Technical Specifications

Publication	Description
IRC:38	Guidelines for Design of Horizontal Curves
IRC:SP:23	Vertical Curves for Highway
IRC: SP:73	Manual of specifications and standards for two laning of highways with paved shoulder
IRC:SP:48	Hill Road Manual

The Project highway is designed based on IRC SP 73 and IRC SP 48.

1.1.2.3 Horizontal Alignment

Alignment is fluent and is blended with the topography. The horizontal curves have been designed as per IRC 38 requirement.

Radii of horizontal Curves

The desirable minimum radii of horizontal curves are given in table below:

Table 1-3: Minimum Radii of horizontal Curves

Design Parameters	Radii (m)	Remarks
Desired Radius (m)	150 m	IRC SP 73 2015
Absolute Minimum Radius (m)	75 m	
Desired Radius (m) Mountainous terrain	80	IRC SP 48 1998
Absolute Minimum Radius (m) Mountainous Terrain	50	
Desired Radius (m) Steep Terrain	50	
Absolute Minimum Radius (m)Steep Terrain	30	

Transition Curves

Properly designed transition curves are provided at both ends of the circular curve. The minimum length of transition curves shall be provided as per IRC: 38 (latest). At locations where transition curve cannot be provided the change is crossfall shall be provided with 1/3rd on curve portion and 2/3rd on transition.

1.1.2.4 Vertical Alignment

The vertical alignment should provide for a smooth longitudinal profile. Grade changes are not too frequent to cause kinks and visual discontinuities in the profile.

Gradients

The gradient for mountainous to hilly terrain are as follows:

Ruling Gradient – 5%
Limiting gradient- 6%
Exceptional gradient -7%

1.1.3 *Coordination of Horizontal and Vertical alignment*

The overall appearance of project road is enhanced considerably by judicious combination of the horizontal and vertical alignments. Plan and profile of the road shall not be designed independently but in unison, so as to produce an appropriate three-dimensional effect. Proper co-ordination in this respect will ensure safety, avoid visual discontinuities and contribute to overall aesthetics.

Vertical curvature superimposed upon horizontal curvature gives a pleasing effect. As such the vertical and horizontal curves shall coincide as far as possible and horizontal curve length shall be somewhat longer than the vertical curve. Short vertical curve superimposed on long horizontal curves have been avoided at or near the apex.

1.1.3.1 Crossfall and Super Elevation

The crossfall on straight sections of project road carriageway shall be as given in below table. Each carriageway shall have unidirectional crossfall.

Table 1-4: Crossfall on different Surfaces

Cross-sectional Element	Annual Rainfall
	1000 mm or more
Carriageway, Paved Shoulders, Edge Strip	2.5%

The crossfall for earthen/granular shoulders on straight portions is at least 0.5 percent steeper than the values given in above table

1.1.3.2 Lane Width of Carriageway

The standard lane width of the Project Corridor is 3.50m.

1.1.3.3 Shoulders

The shoulders on the outer side (left side of carriageway) shall be 0.9 m wide hard plus 1 m wide earthen on valley side(at locations where retaining walls are not provided). The shoulder composition shall be as below:

- The composition and specification of the hard shoulder shall of CT granular layer.

1.1.3.4 Barriers

W-Beam crash barrier shall be provided at locations where embankment height is greater than 3m as per clause 9.7.3 of IRC SP:73 latest revision.

1.1.3.5 Widening of curves

Widening of curve shall be designed as per clause 6.8.5.2 of IRC SP 48

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1.1.3.6 Super Elevation

The super elevation is limited to 7%. Super elevation shall not be less than the minimum specified crossfall.

1.1.3.7 Right of Way

The RoW in rural area varies from 24m to 18m in open areas and 20m to 18m in urban areas as per clause 6.5.1 of IRC SP 48.

1.1.4 *Drainage:*

The IRC: SP 42 will generally be followed for design of highway drainage. The planning of highway and drainage is intricately linked with the terrain, alignment of the highway and the proposed cross drainage works. The planning and designing of adequate drainage system is a primary requirement for maintaining a structural soundness and functional efficiency of a road. Pavement structure including sub-grade must be protected from any ingress of water; otherwise over a period of time it may weaken the sub-grade by saturating it and cause distress in the pavement structure. Hence disposal of water from the pavement and sub-grade is a basic consideration in road design. Over and above quick drainage takes away the water from pavement surface and reduces chances of skidding of vehicles. In order to guard the pavement from the poorly drained conditions, planning, designing, construction and maintenance of longitudinal drains on hill side of the roads is very much essential. The surface water from the pavement and shoulders will be made to flow in to the drains by providing suitable cross Slopes / Camber.

All drains are connected to cross drainage structure.

1.1.5 *Embankment and Cut Sections*

The design and construction of the road in embankment and in cutting shall be carried out in accordance with Section 300 of MORT&H Specifications and the requirements, and standards and specifications given in IRC: SP-99 latest version.

1.1.6 *Traffic Control Devices, Road Safety Devices and Road Side Furniture*

Traffic Control Devices, Road Safety Devices and Road Side Furniture shall comprise of road signs, road markings, object markers, hazard markers, studs, delineators, attenuators, safety barriers, boundary fences, boundary stones, kilometer stones, etc. Relevant IRC Guidelines (IRC 2, IRC:8, IRC:35, IRC:67, IRC SP 48, etc).

1.2 PAVEMENT DESIGN STANDARDS

1.2.1 *General*

The design of pavement shall take into account all relevant factors for assuring reliable performance, surface characteristics and shall satisfy the specified minimum performance requirements. The guidelines followed for the Pavement design are IRC: 37, IRC 58, IRC: SP-73 and MoRT&H Specifications, V Revision.

1.2.2 *Type of Pavement*

The type and thickness of Pavement for Main Carriageway and paved shoulders have been finalized considering the site condition, locally available materials and project viability.

1.2.3 *Design Methodology*

Pavement Design methodology for project highway is as given below:

- Assessment of Sub-grade strength of the project highway
- Identification of traffic homogeneous sections
- Assessment of vehicle damaging factors (VDFs) for commercial vehicles

- Assessment of number of cumulative commercial vehicles as per the traffic (ADT/AADT)
- Assessment of Traffic Growth Rates for the future projections
- Traffic Loading on the proposed pavement (MSA)
- Assessment of the construction materials for the highway

1.2.4 *Design of Flexible Pavement*

The pavement shall be designed to ensure the specified performance for the projected traffic needs, climate and type of soils in the given area. Design procedure that is appropriate to produce a cost-effective structure meeting the performance requirements and long term durability shall be taken into account. IRC: 37 "Tentative Guidelines for the Design of Flexible Pavements" shall be used as basis for design.

Design life considered for flexible pavement is 15 years.

1.2.5 *Design of Plain Jointed Rigid Pavement*

Plain jointed rigid pavement shall be designed in accordance with the method prescribed in IRC: 58-2015 "Guidelines for the Design of Plain Jointed Rigid Pavements for Highways". Design life considered for Rigid Pavement is 30 years.

1.2.6 *Materials*

All materials to be used in works shall be in conformity with the requirements laid down for relevant item in MORT&H Specifications, V Revision. If any material, which is not covered in MORT&H Specifications, is used, shall conform to IRC or relevant Indian or International Standards, provisions.

2. DESIGN PROPOSALS

2.1 HIGHWAY PROPOSALS

2.1.1 General

This chapter is intended to give brief descriptions concerning the various design proposals for the Project Highway. These design proposals are based on the findings from various engineering studies carried out on the project road. These studies are discussed in detail in the previous chapters.

The improvement proposals for the proposed highway include the provisions for the following major items:

- Geometric design
- Cross-section
- Location wise TCS Application
- Protection work details
- Road Junctions
- Pavement
- Bridges and Cross-Drainages
- Safety and Special Problems

Design proposals for a highway essentially consist of two components, geometric of road and structural composition. Geometric improvement deals with visible dimensions of roadway and is dictated by the traffic and economic considerations. Geometric design involves several design elements such as horizontal and vertical alignments, sight distance considerations, cross sectional elements, lateral and vertical clearances, intersection treatment etc. The structural component deals with the pavement and embankment design aspects, i.e., the ability of the highway to adequately carry and support the vehicle/ wheel loads over the design period.

2.1.2 Geometric Design Proposals

The proposals for the geometric elements of the any highway generally include:

- Cross sectional elements,
- Horizontal Alignment Design
- Vertical alignment design

2.1.3 Cross Sectional Elements

2 lanes Section: Cross-section has been developed on the basis of IRC-73: 2015. 7 / 7.5 m carriageway having lane width of 3.5m has been provided. The hard shoulder width of 0.9 m on both sides is provided. The earthen shoulder of 1m on valley side has been provided at locations where normal embankments slope are provided. Drain has been provided on hill side and parapet wall/ W- beam crash barrier are provided on valley side along with retaining wall.

Keeping these basic requirements various typical cross sections are developed to meet the need of land use along the project road. The details of the TCS chainage wise are mentioned below.

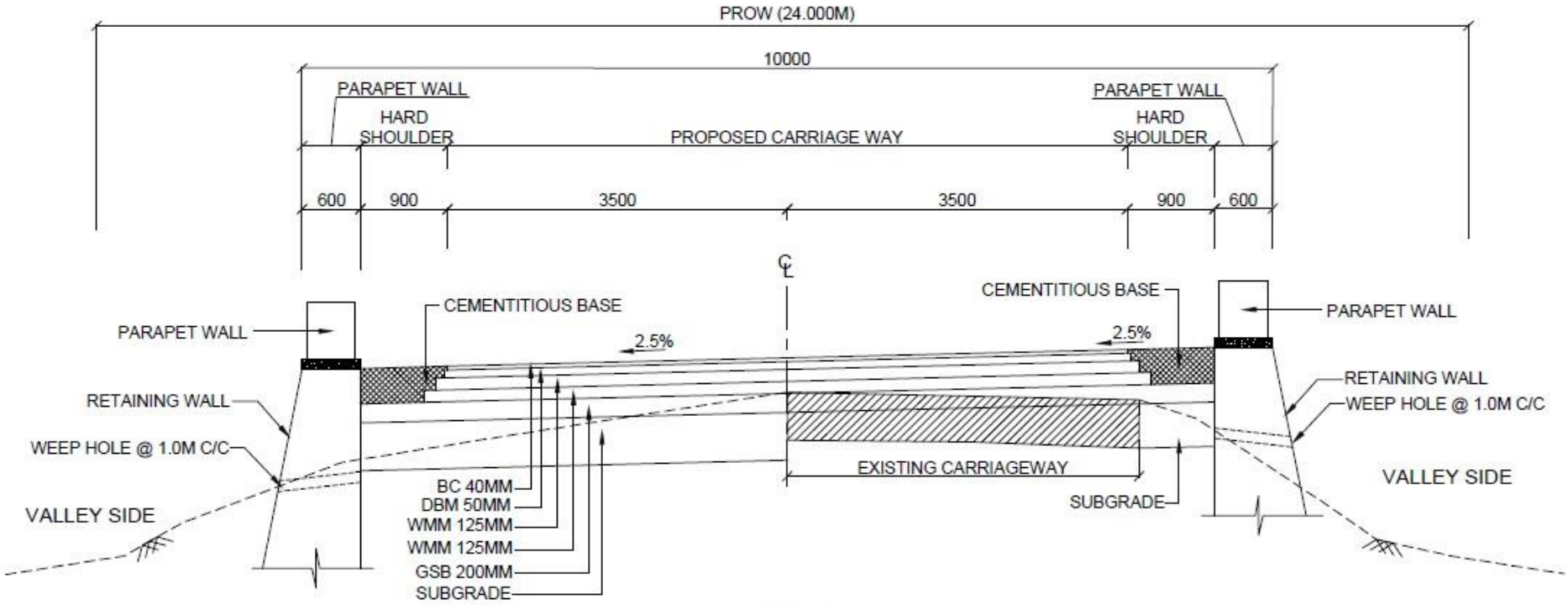
Table 2-1 : TCS Schedule

From (m)	To (m)	Length (m)	Descriptions	TCS Type
29500	31500	2000	Typical Cross Section of 2- lane Widening in Built-up area	4
31500	36920	5420	Typical Cross Section in Reconstruction of 2 lane with hardshoulder in rural areas	3
36920	36970	50	Typical Cross section of new construction of 2 lane with hard shoulder in box cutting	5
36970	37001	31	Typical cross section in rural area with retaining wall both side	1
37001	37054	53	Typical cross section of Minor Bridge Retained	6
37054	37090	37	Typical Cross Section in Reconstruction of 2 lane with hardshoulder in rural areas with breast wall on hill side and retaining wall on valley side.	2
37090	38144	1054	Typical Cross Section in Reconstruction of 2 lane with hardshoulder in rural areas	3
38144	38187	43	Typical cross section of Minor Bridge Retained	6

From (m)	To (m)	Length (m)	Descriptions	TCS Type
38187	38200	14	Typical cross section in rural area with retaining wall both side	1
38200	39660	1460	Typical Cross Section in Reconstruction of 2 lane with hardshoulder in rural areas	3
39660	39700	40	Typical Cross Section in Reconstruction of 2 lane with hardshoulder in rural areas with breast wall on hill side and retaining wall on valley side.	2
39700	40350	650	Typical Cross Section in Reconstruction of 2 lane with hardshoulder in rural areas	3
40350	40440	90	Typical Cross Section in Reconstruction of 2 lane with hardshoulder in rural areas with breast wall on hill side and retaining wall on valley side.	2
40440	40500	60	Typical Cross Section in Reconstruction of 2 lane with hardshoulder in rural areas	3
40500	40600	100	Typical Cross Section in Reconstruction of 2 lane with hardshoulder in rural areas with breast wall on hill side and retaining wall on valley side.	2
40600	40720	120	Typical Cross Section in Reconstruction of 2 lane with hardshoulder in rural areas	3
40720	40790	70	Typical Cross Section in Reconstruction of 2 lane with hardshoulder in rural areas with breast wall on hill side and retaining wall on valley side.	2
40790	41210	420	Typical Cross Section in Reconstruction of 2 lane with hardshoulder in rural areas	3
41210	41250	40	Typical Cross Section in Reconstruction of 2 lane with hardshoulder in rural areas with breast wall on hill side and retaining wall on valley side.	2
41250	42480	1230	Typical Cross Section in Reconstruction of 2 lane with hardshoulder in rural areas	3
42480	42520	40	Typical Cross Section in Reconstruction of 2 lane with hardshoulder in rural areas with breast wall on hill side and retaining wall on valley side.	2
42520	43270	750	Typical Cross Section in Reconstruction of 2 lane with hardshoulder in rural areas	3
43270	43350	80	Typical Cross section of new construction of 2 lane with hard shoulder in box cutting	5
43350	43390	40	Typical Cross Section in Reconstruction of 2 lane with hardshoulder in rural areas	3
43390	43430	40	Typical Cross Section in Reconstruction of 2 lane with hardshoulder in rural areas with breast wall on hill side and retaining wall on valley side.	2
43430	44400	970	Typical Cross Section in Reconstruction of 2 lane with hardshoulder in rural areas	3

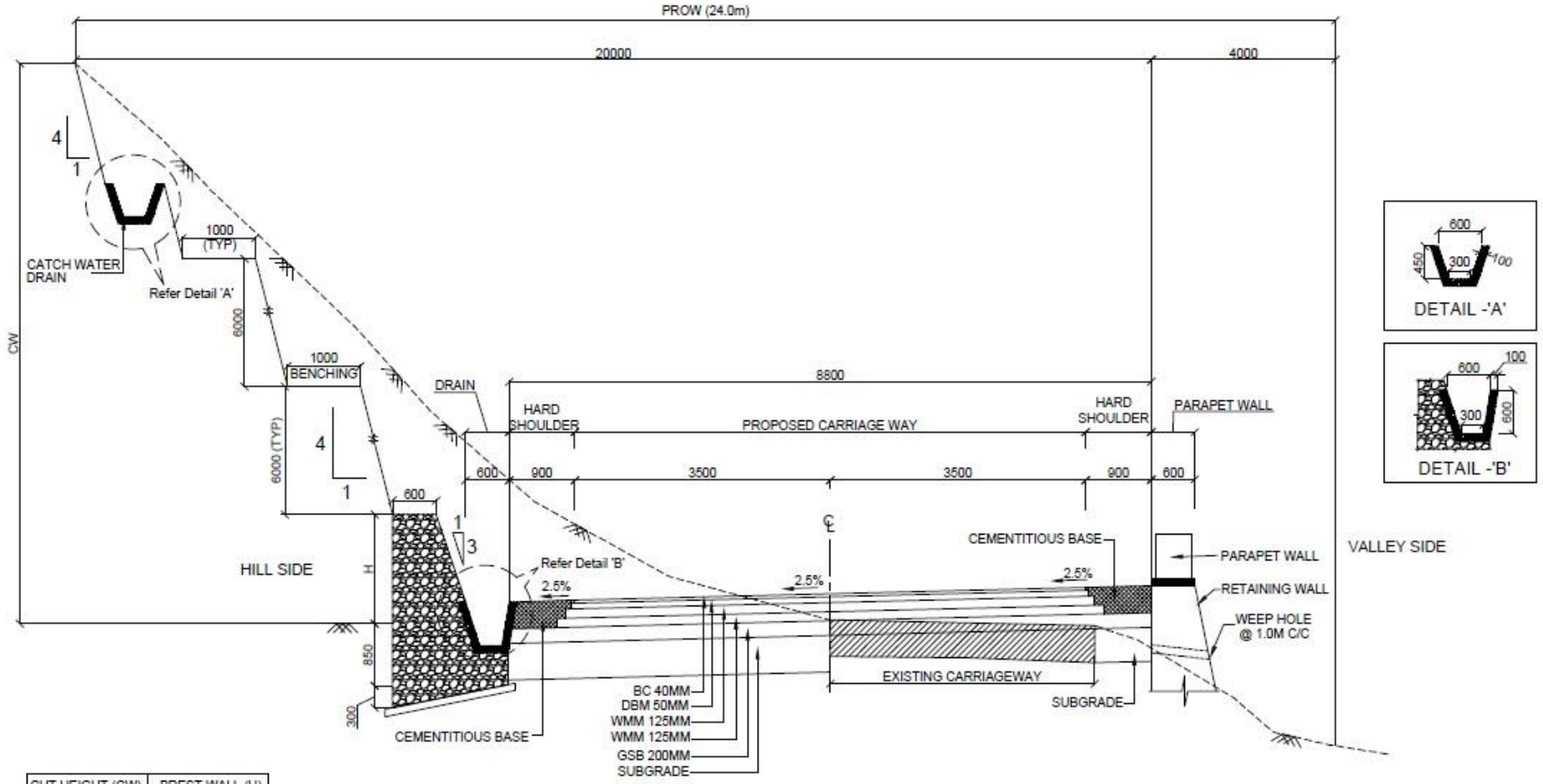
From (m)	To (m)	Length (m)	Descriptions	TCS Type
44400	44440	40	Typical Cross Section in Reconstruction of 2 lane with hardshoulder in rural areas with breast wall on hill side and retaining wall on valley side.	2
44440	45740	1300	Typical Cross Section in Reconstruction of 2 lane with hardshoulder in rural areas	3
45740	45800	60	Typical Cross Section in Reconstruction of 2 lane with hardshoulder in rural areas with breast wall on hill side and retaining wall on valley side.	2
45800	45950	150	Typical Cross Section in Reconstruction of 2 lane with hardshoulder in rural areas	3
45950	46000	50	Typical Cross Section in Reconstruction of 2 lane with hardshoulder in rural areas with breast wall on hill side and retaining wall on valley side.	2
46000	47130	1130	Typical Cross Section in Reconstruction of 2 lane with hardshoulder in rural areas	3
47130	47900	770	Typical Cross Section of 2- lane Widening in Built-up area	4
47900	51150	3250	Typical Cross Section in Reconstruction of 2 lane with hardshoulder in rural areas	3
51150	51200	50	Typical Cross Section in Reconstruction of 2 lane with hardshoulder in rural areas with breast wall on hill side and retaining wall on valley side.	2
51200	51300	100	Typical Cross Section in Reconstruction of 2 lane with hardshoulder in rural areas	3
51300	51340	40	Typical Cross Section in Reconstruction of 2 lane with hardshoulder in rural areas with breast wall on hill side and retaining wall on valley side.	2
51340	51500	160	Typical Cross Section in Reconstruction of 2 lane with hardshoulder in rural areas	3

The Typical cross sections (TCS) considered for the project road are shown in figures below:



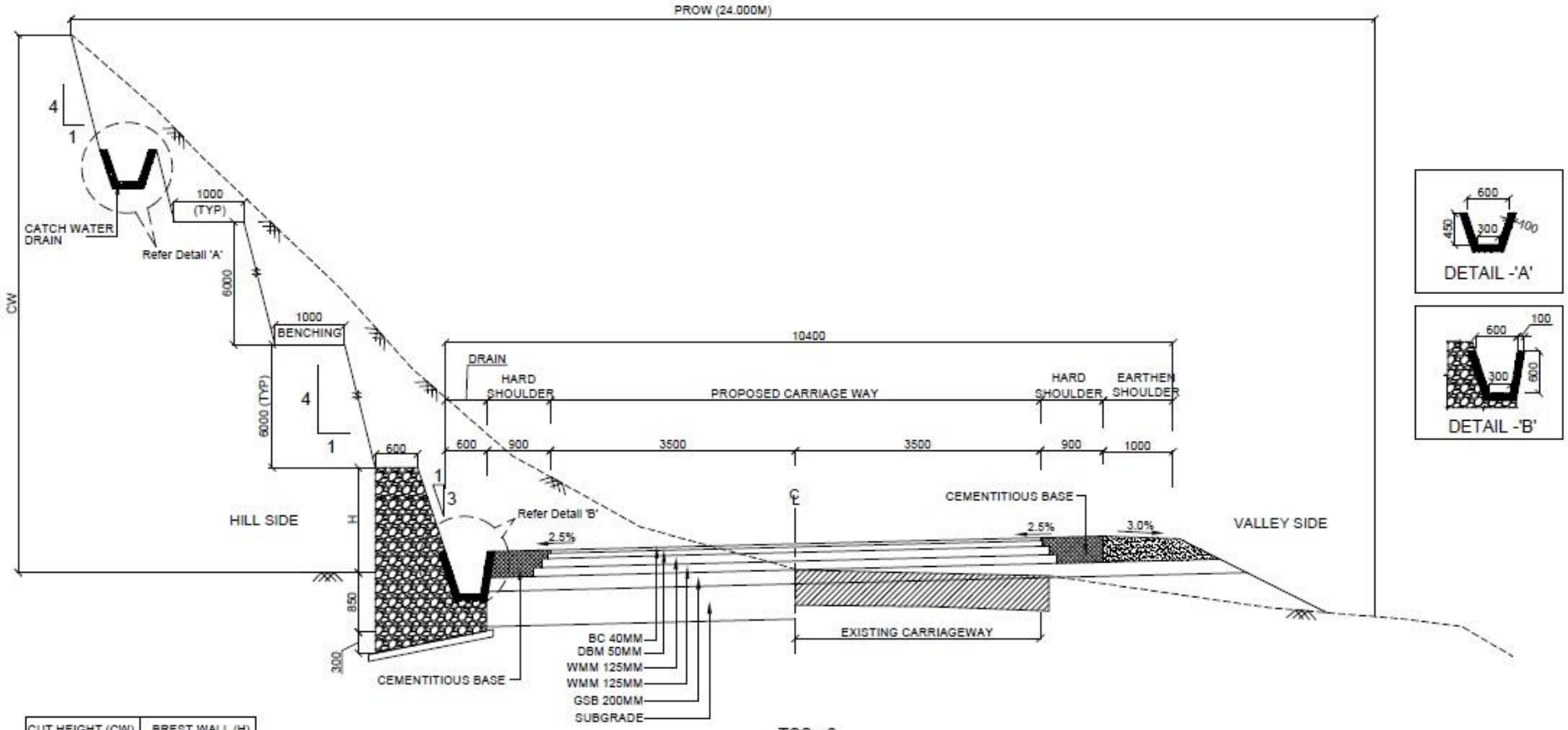
TCS - 1

TYPICAL CROSS SECTION IN RURAL AREA WITH RETAINING WALL BOTH SIDE



CUT HEIGHT (CW)	BREST WALL (H)
UPTO 3m	Nil
3m<CW<13.5m	1.5m
CW>13.5m	3.0m

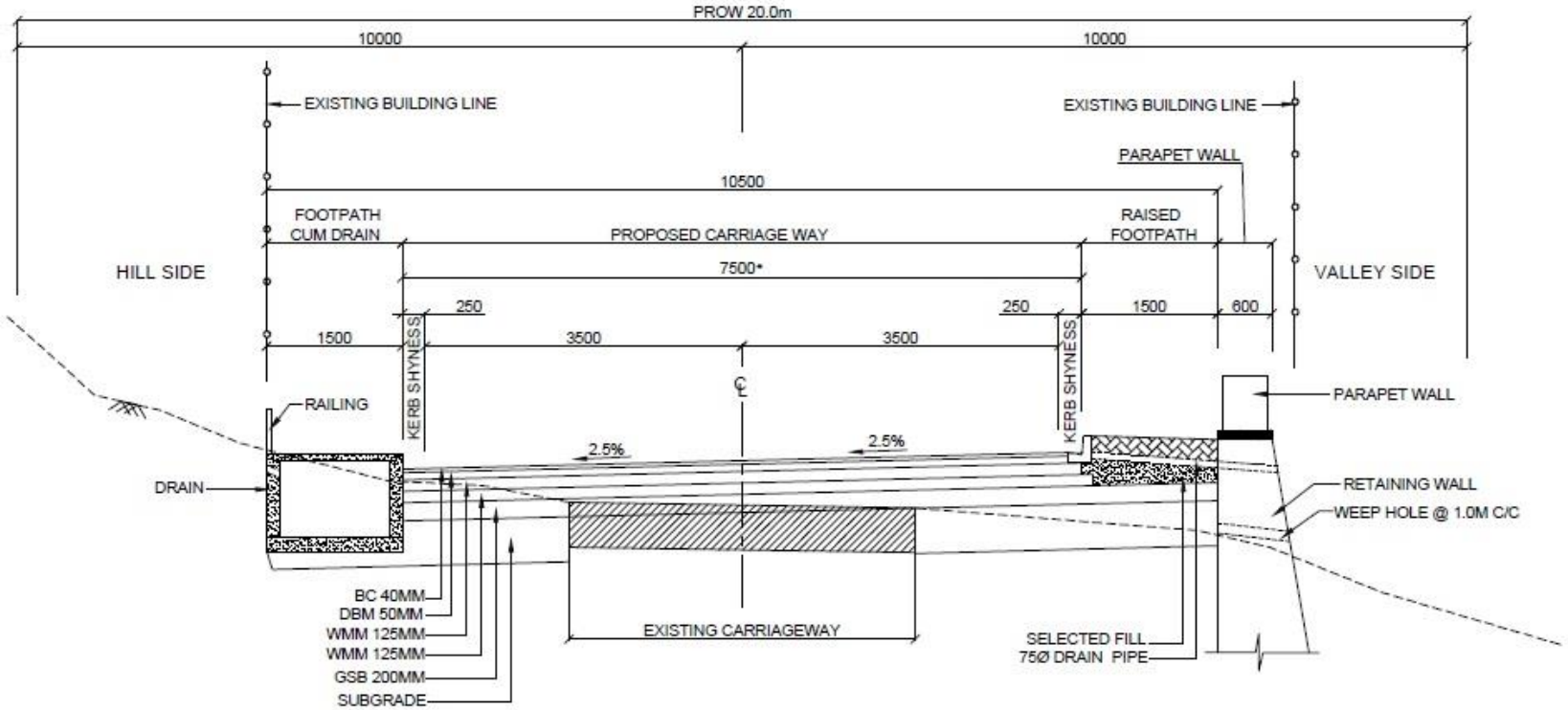
TCS - 2
TYPICAL CROSS SECTION RECONSTRUCTION / WIDENING OF 2 LANE WITH HARD SHOULDER IN RURAL AREA
(WITH BREST WALL ON HILL SIDE AND RETAINING WALL ON VALLEY SIDE)



CUT HEIGHT (CW)	BREST WALL (H)
UPTO 3m	Nil
3m<CW<13.5m	1.5m
CW>13.5m	3.0m

TCS - 3

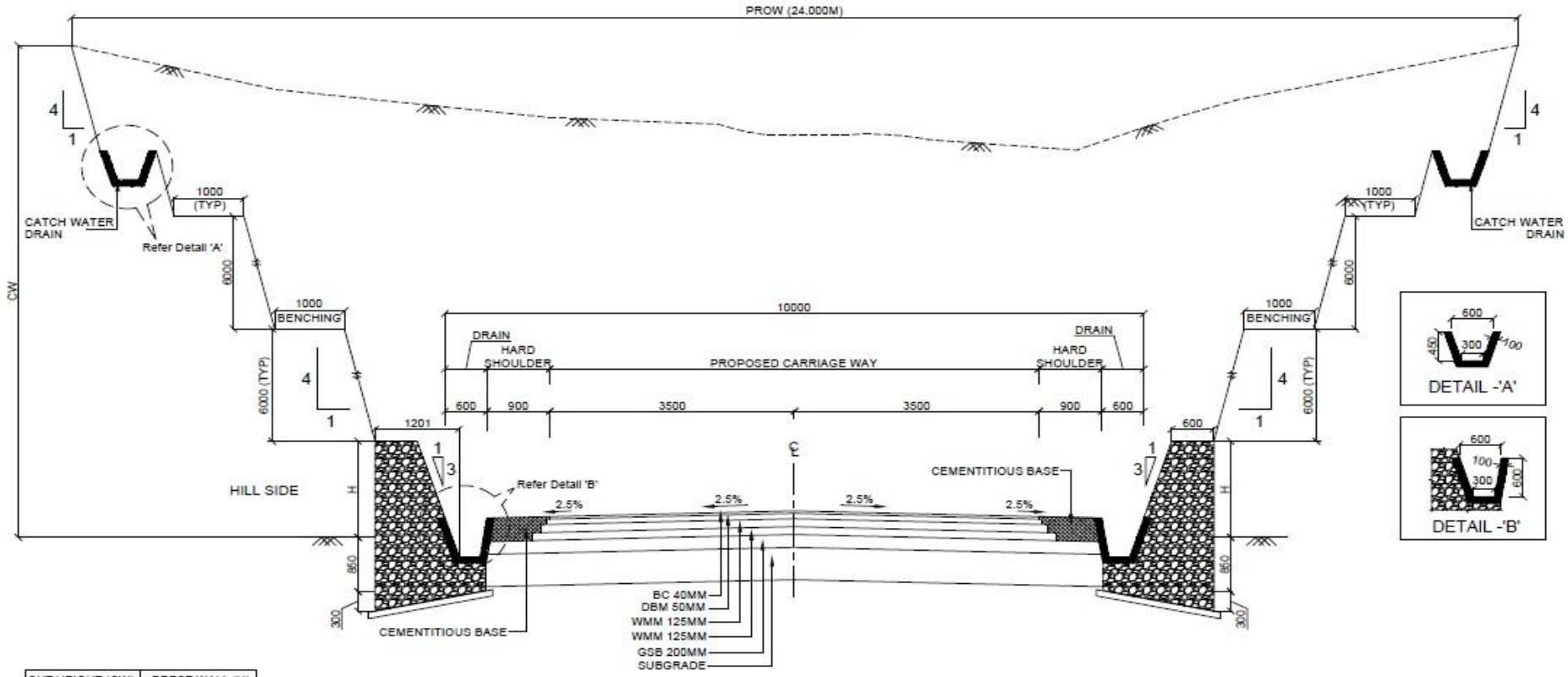
TYPICAL CROSS SECTION RECONSTRUCTION / WIDENING OF 2 LANE WITH HARD SHOULDER IN RURAL AREA
(WITH BREST WALL ON HILL SIDE AND NORMAL EMBANKMENT ON VALLEY SIDE)



TCS - 4

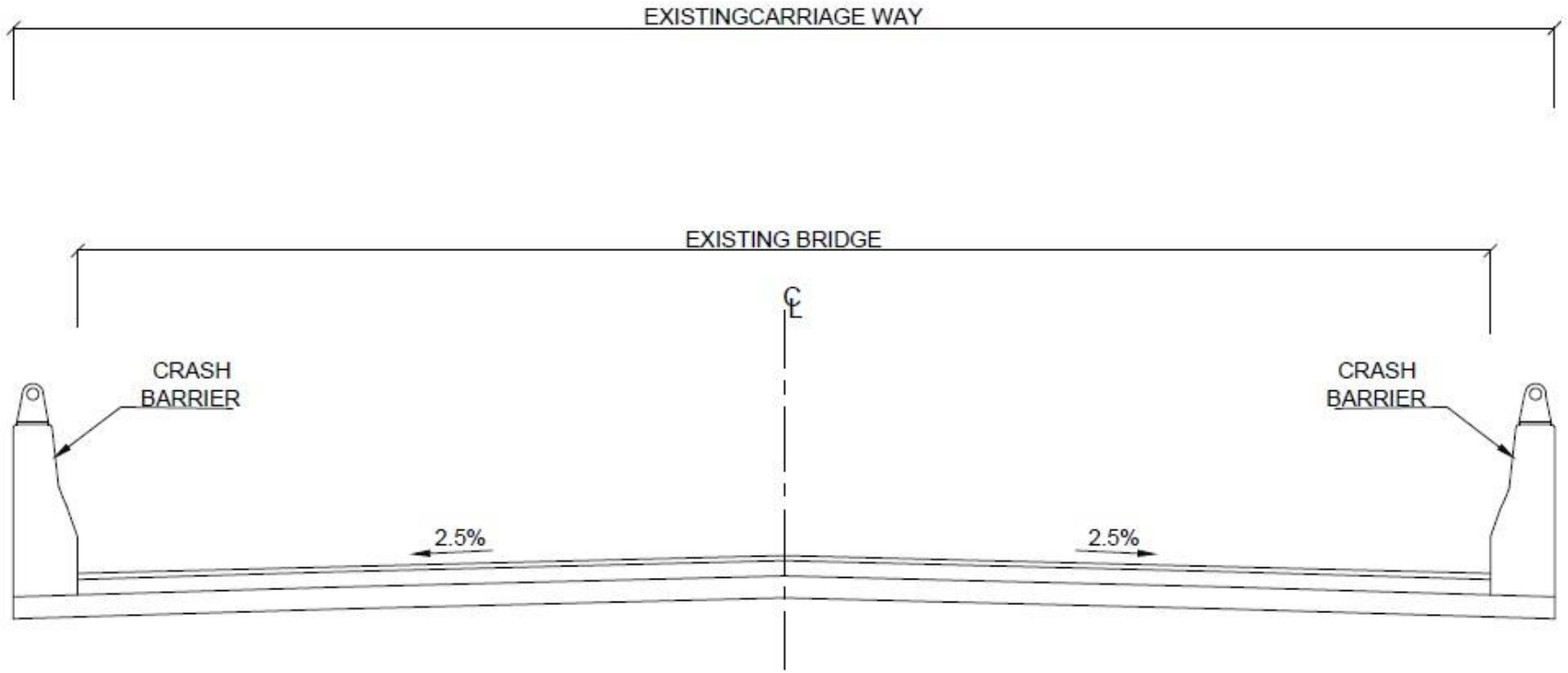
TYPICAL CROSS SECTION OF 2-LANE WIDENING IN BUILT-UP AREA (RECONSTRUCTION)

* IF WIDTH OF 7.5m IS NOT AVAILABLE INTERMEDIATE CARRIAGEWAY TO BE PROVIDED.



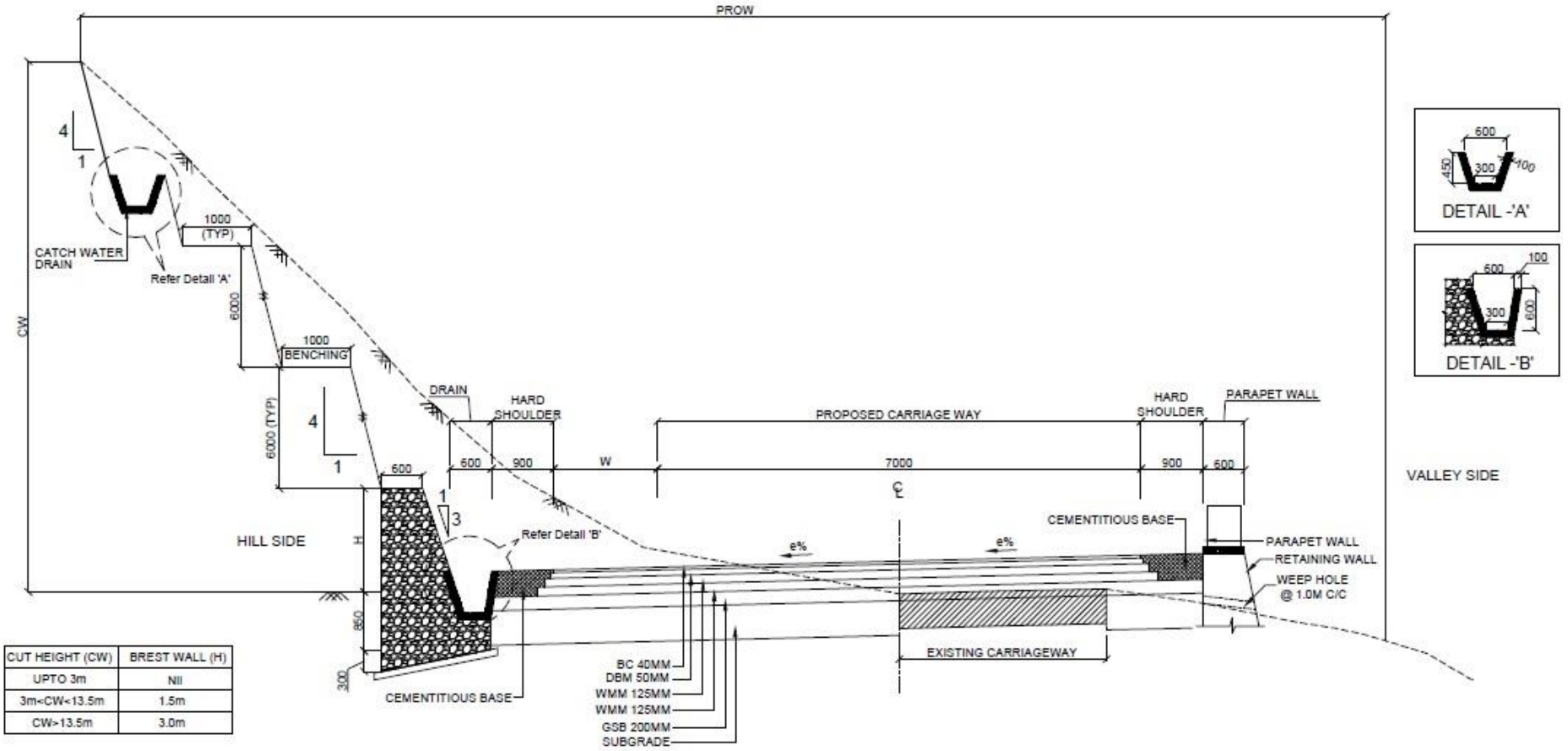
CUT HEIGHT (CW)	BREST WALL (H)
UPTO 3m	Nil
3m<CW<13.5m	1.5m
CW>13.5m	3.0m

TCS - 5
TYPICAL CROSS SECTION OF NEW CONSTRUCTION OF 2 LANE WITH HARD SHOULDER IN BOX CUTTING



TCS - 6

TYPICAL CROSS SECTION OF MINOR BRIDGE (RETAINED)



CUT HEIGHT (CW)	BREST WALL (H)
UPTO 3m	Nil
3m<CW<13.5m	1.5m
CW>13.5m	3.0m

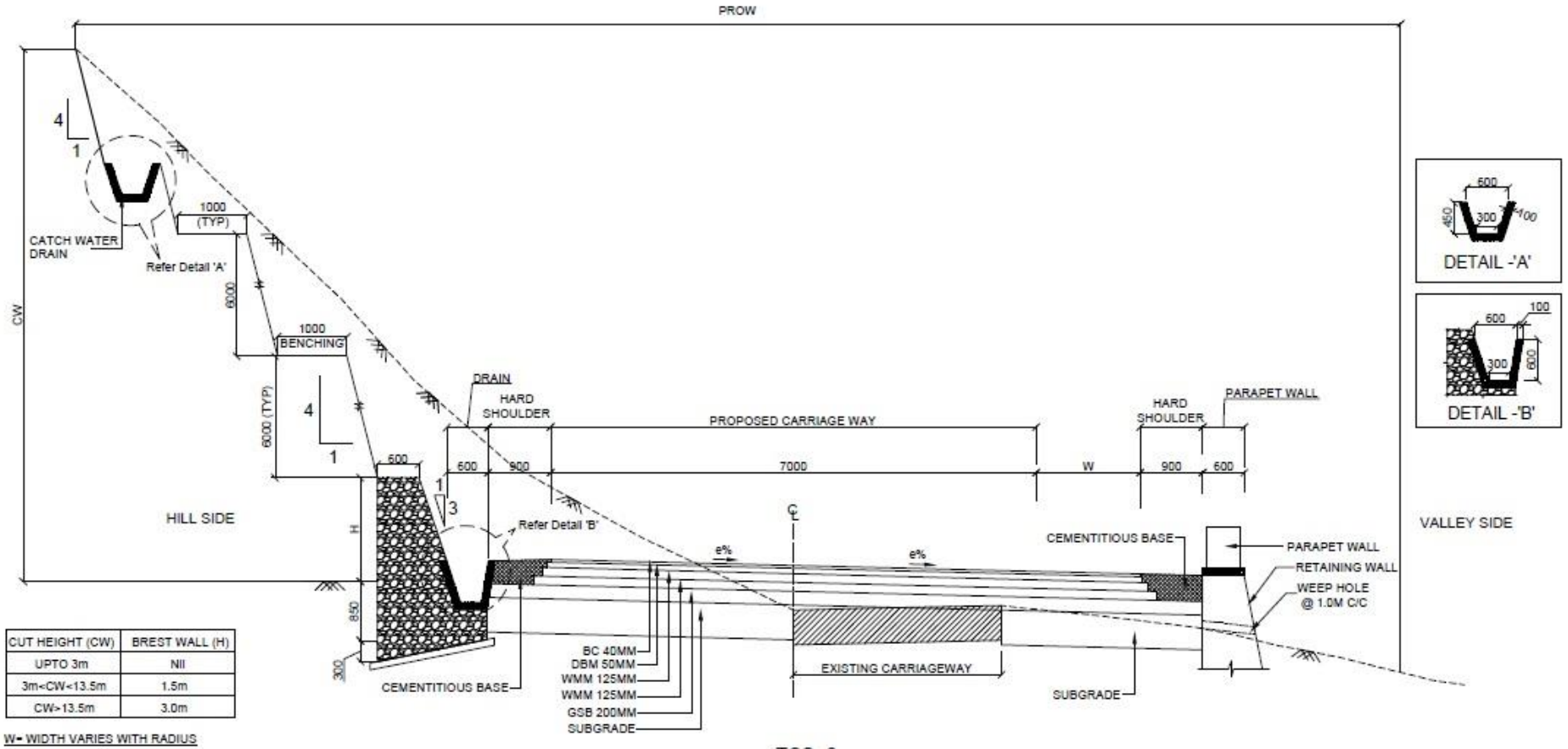
W= WIDTH VARIES WITH RADIUS

R	W
UPTO 20	1.5
21-40	1.5
41-60	1.2
61-100	0.9
101-300	0.6

TCS - 7

TYPICAL CROSS OF 2 LANE WIDENING AT EXTRA WIDENING & SUPER ELVATION (ON LHS CURVE)

NOTE:- HILL SIDE / VALLEY SIDE MAY CHANGE & LOCATION OF HILLSIDE AND VALLEY SIDE IS GIVEN IN TCS SCHEDULE



CUT HEIGHT (CW)	BREST WALL (H)
UPTO 3m	Nil
3m<CW<13.5m	1.5m
CW>13.5m	3.0m

W= WIDTH VARIES WITH RADIUS

R	W
UPTO 20	1.5
21-40	1.5
41-60	1.2
61-100	0.9
101-300	0.6

TCS -8

TYPICAL CROSS OF 2 LANE WIDENING AT EXTRA WIDENING & SUPER ELVATION (ON RHS CURVE)

NOTE:- HILL SIDE / VALLEY SIDE MAY CHANGE & LOCATION OF HILLSIDE AND VALLEY SIDE IS GIVEN IN TCS SCHEDULE

2.1.4 Alignment Design

Base plan of the proposed Project Highway showing all natural and manmade features has been prepared by using the available ground survey data. All features within a corridor width in a range of 40- 50m have been captured. This data has been processed using MX-Roads software to design the alignment. The following activities elucidate the preparation of base plans in more details:

- Format survey data to suit the requirements of Mx - Roads environment
- Downloaded the data into software
- Join the points with same description codes for all physical features like rivers, buildings, religious structures, shops, telephone, poles, electric poles, cross roads etc. within the above specified limits
- Establish break lines for proposed corridor features such as edge of the road, shoulder etc.
- Cross checked the prepared alignment plans by “walkover” surveys.
- Updated and finalized the alignment plans with additional survey data.

The entire geometric design has been based on the ground modelling by highway design software MX.

2.1.5 Horizontal Alignment

The horizontal alignment of the corridor has been designed for a speed of maximum 60 kmph and minimum of 30kmph except at hair pin bends where design speed is 20kmph. The corridor is fixed based on existing alignment, by minimum disturbance to habitation and efforts has been made, during design of horizontal alignment to keep it as fluent (higher radius) as possible.

Table 2-2: Horizontal Curve Details

HORIZONTAL DESIGN									
Sl. No.	Radius (m)	Start Chainage of		End Chainage of		HIP Chainage (m)	Design Speed, V (kmph)	Super elevation (%)	Hand of Curve
		Transition (m)	Curve (m)	Curve (m)	Transition (m)				
1	30	29645	29660	29674	29689	29660	30	5.93%	Left
2	30	29709	29724	29737	29752	29724	30	5.93%	Right
3	22	29757	29777	29814	29834	29777	20	7.00%	Left
4	70	29841	29856	29865	29880	29856	30	5.71%	Right
5	70	29882	29897	29907	29922	29897	30	5.71%	Left
6	80	29935	29950	29967	29982	29950	30	5.00%	Right
7	50	30023	30043	30048	30068	30043	30	7.00%	Right
8	20	30101	30121	30133	30153	30121	20	7.00%	Left
9	100	30159	30174	30206	30221	30174	35	5.44%	Right
10	300		30241	30306		30241	40	2.37%	Right
11	70	30336	30366	30381	30411	30366	40	7.00%	Right
12	25	30426	30446	30464	30484	30446	20	7.00%	Right
13	60	30487	30507	30530	30550	30507	30	6.67%	Left
14	40	30569	30589	30618	30638	30589	30	6.94%	Left
15	30	30653	30668	30672	30687	30668	30	5.93%	Right
16	30	30723	30753	30786	30816	30753	30	7.00%	Right
17	60	30859	30879	30892	30912	30879	30	6.67%	Right
18	50	30962	30982	30995	31015	30982	30	7.00%	Left
19	35	31056	31071	31075	31090	31071	30	5.08%	Left
20	20	31091	31111	31127	31147	31111	20	7.00%	Right
21	70	31148	31163	31226	31241	31163	30	5.71%	Left
22	20	31301	31321	31341	31361	31321	20	7.00%	Right
23	50	31362	31382	31390	31410	31382	30	7.00%	Left
24	30	31415	31430	31458	31473	31430	30	5.93%	Left
25	20	31489	31509	31515	31535	31509	20	7.00%	Right
26	35	31537	31552	31588	31603	31552	30	5.08%	Left

HORIZONTAL DESIGN									
Sl. No.	Radius (m)	Start Chainage of		End Chainage of		HIP Chainage (m)	Design Speed, V (kmph)	Super elevation (%)	Hand of Curve
		Transition (m)	Curve (m)	Curve (m)	Transition (m)				
27	20	31604	31624	31627	31647	31624	20	7.00%	Right
28	25	31655	31675	31705	31725	31675	20	7.00%	Left
29	60	31726	31746	31754	31774	31746	30	6.67%	Right
30	80	31802	31817	31828	31843	31817	30	5.00%	Right
31	35	31844	31859	31874	31889	31859	30	5.08%	Left
32	30	31918	31933	31947	31962	31933	30	5.93%	Left
33	50	31971	31991	32023	32043	31991	30	7.00%	Right
34	30	32088	32103	32108	32123	32103	30	5.93%	Left
35	40	32127	32147	32167	32187	32147	30	6.94%	Right
36	25	32187	32207	32210	32230	32207	20	7.00%	Left
37	25	32263	32283	32288	32308	32283	20	7.00%	Right
38	20	32308	32328	32345	32365	32328	20	7.00%	Left
39	20	32375	32395	32400	32420	32395	20	7.00%	Right
40	25	32424	32444	32474	32494	32444	20	7.00%	Left
41	20	32495	32515	32522	32542	32515	20	7.00%	Right
42	30	32543	32558	32574	32589	32558	30	5.93%	Left
43	45	32591	32606	32677	32692	32606	30	6.17%	Right
44	100	32758	32778	32832	32852	32778	40	7.00%	Right
45	40	32890	32910	32941	32961	32910	30	6.94%	Left
46	110	32964	32984	33023	33043	32984	40	6.46%	Right
47	60	33070	33090	33092	33112	33090	30	6.67%	Left
48	35	33117	33132	33214	33229	33132	30	5.08%	Right
49	200	33239	33249	33273	33283	33249	40	0.89%	Right
50	25	33287	33307	33319	33339	33307	20	7.00%	Left
51	300		33350	33411		33350	40	2.37%	Right
52	40	33418	33438	33445	33465	33438	30	6.94%	Right
53	20	33467	33487	33497	33517	33487	20	7.00%	Left

HORIZONTAL DESIGN									
Sl. No.	Radius (m)	Start Chainage of		End Chainage of		HIP Chainage (m)	Design Speed, V (kmph)	Super elevation (%)	Hand of Curve
		Transition (m)	Curve (m)	Curve (m)	Transition (m)				
54	25	33525	33545	33554	33574	33545	20	7.00%	Right
55	500		33608	33641		33608	50	2.22%	Right
56	35	33674	33699	33754	33779	33699	30	7.00%	Left
57	30	33838	33853	33868	33883	33853	30	5.93%	Right
58	50	33921	33941	34037	34057	33941	30	7.00%	Left
59	30	34066	34081	34105	34120	34081	30	5.93%	Right
60	60	34122	34137	34149	34164	34137	30	6.67%	Left
61	20	34191	34211	34225	34245	34211	20	7.00%	Right
62	110	34249	34269	34323	34343	34269	40	6.46%	Left
63	100	34348	34368	34383	34403	34368	40	7.00%	Right
64	70	34411	34426	34441	34456	34426	30	5.71%	Left
65	30	34457	34472	34493	34508	34472	30	5.93%	Right
66	30	34516	34531	34553	34568	34531	30	5.93%	Left
67	90	34580	34605	34636	34661	34605	40	7.00%	Right
68	100	34664	34684	34688	34708	34684	40	7.00%	Left
69	20	34718	34738	34768	34788	34738	20	7.00%	Left
70	30	34810	34825	34839	34854	34825	30	5.93%	Right
71	30	34863	34878	34888	34903	34878	30	5.93%	Left
72	20	34904	34924	34934	34954	34924	20	7.00%	Right
73	80	34963	34978	34982	34997	34978	30	5.00%	Left
74	50	35057	35077	35125	35145	35077	30	7.00%	Right
75	30	35156	35171	35178	35193	35171	30	5.93%	Right
76	50	35199	35219	35246	35266	35219	30	7.00%	Left
77	100	35266	35286	35298	35318	35286	40	7.00%	Right
78	200	35320	35340	35356	35376	35340	40	3.56%	Left
79	100	35386	35401	35429	35444	35401	35	5.44%	Left
80	30	35452	35467	35474	35489	35467	30	5.93%	Right

HORIZONTAL DESIGN									
Sl. No.	Radius (m)	Start Chainage of		End Chainage of		HIP Chainage (m)	Design Speed, V (kmph)	Super elevation (%)	Hand of Curve
		Transition (m)	Curve (m)	Curve (m)	Transition (m)				
81	25	35491	35511	35515	35535	35511	20	7.00%	Left
82	70	35538	35553	35567	35582	35553	30	5.71%	Right
83	40	35624	35639	35643	35658	35639	30	4.44%	Left
84	30	35660	35675	35691	35706	35675	30	5.93%	Right
85	80	35710	35725	35736	35751	35725	30	5.00%	Left
86	135	35773	35793	35795	35815	35793	40	5.27%	Left
87	70	35822	35837	35848	35863	35837	30	5.71%	Right
88	30	35866	35881	35894	35909	35881	30	5.93%	Left
89	30	35985	36000	36004	36019	36000	30	5.93%	Left
90	60	36020	36040	36041	36061	36040	30	6.67%	Right
91	25	36071	36091	36101	36121	36091	20	7.00%	Right
92	25	36165	36185	36200	36220	36185	20	7.00%	Left
93	60	36224	36234	36240	36250	36234	30	2.96%	Right
94	17	36254	36274	36298	36318	36274	20	7.00%	Left
95	20	36320	36340	36381	36401	36340	20	7.00%	Right
96	35	36499	36514	36530	36545	36514	30	5.08%	Right
97	40	36549	36569	36577	36597	36569	30	6.94%	Left
98	130	36630	36645	36786	36801	36645	40	5.47%	Left
99	90	36825	36850	36863	36888	36850	40	7.00%	Left
100	15	36941	36961	36967	36987	36961	20	7.00%	Left
101	30	37059	37074	37075	37090	37074	30	5.93%	Left
102	45	37098	37118	37162	37182	37118	30	7.00%	Right
103	300		37195	37260		37195	40	2.37%	Left
104	30	37281	37296	37316	37331	37296	30	5.93%	Left
105	30	37333	37348	37354	37369	37348	30	5.93%	Right
106	80	37383	37408	37425	37450	37408	40	7.00%	Left
107	200	37524	37564	37581	37621	37564	40	2.50%	Right

HORIZONTAL DESIGN									
Sl. No.	Radius (m)	Start Chainage of		End Chainage of		HIP Chainage (m)	Design Speed, V (kmph)	Super elevation (%)	Hand of Curve
		Transition (m)	Curve (m)	Curve (m)	Transition (m)				
108	40	37646	37666	37685	37705	37666	30	6.94%	Right
109	60	37711	37731	37773	37793	37731	30	6.67%	Left
110	35	37802	37817	37841	37856	37817	30	5.08%	Right
111	150	37861	37876	37928	37943	37876	40	4.74%	Left
112	30	37972	37987	38025	38040	37987	30	5.93%	Right
113	70	38049	38064	38083	38098	38064	30	5.71%	Left
114	20		38112	38143		38112	20	2.50%	Left
115	20		38199	38216		38199	20	2.50%	Left
116	30	38276	38291	38322	38337	38291	30	5.93%	Right
117	140	38342	38357	38396	38411	38357	40	5.08%	Right
118	80	38417	38442	38456	38481	38442	40	7.00%	Left
119	25	38499	38519	38522	38542	38519	20	7.00%	Left
120	40	38544	38559	38562	38577	38559	30	4.44%	Right
121	50	38631	38651	38679	38699	38651	30	7.00%	Left
122	40	38700	38720	38731	38751	38720	30	6.94%	Right
123	80	38757	38772	38793	38808	38772	30	5.00%	Left
124	60	38818	38838	38843	38863	38838	30	6.67%	Right
125	100	38869	38889	38936	38956	38889	40	7.00%	Left
126	15	38960	38980	38988	39008	38980	20	7.00%	Right
127	60	39011	39031	39046	39066	39031	30	6.67%	Left
128	35	39096	39121	39145	39170	39121	30	7.00%	Right
129	200	39192	39212	39220	39240	39212	40	3.56%	Left
130	85	39336	39361	39385	39410	39361	40	7.00%	Left
131	700		39497	39681		39497	50	2.50%	Right
132	100	39692	39712	39715	39735	39712	40	7.00%	Right
133	80	39740	39765	39767	39792	39765	40	7.00%	Left
134	70	39800	39815	39830	39845	39815	30	5.71%	Right

HORIZONTAL DESIGN									
Sl. No.	Radius (m)	Start Chainage of		End Chainage of		HIP Chainage (m)	Design Speed, V (kmph)	Super elevation (%)	Hand of Curve
		Transition (m)	Curve (m)	Curve (m)	Transition (m)				
135	20	39851	39871	39896	39916	39871	20	7.00%	Left
136	70	39934	39949	39965	39980	39949	30	5.71%	Left
137	70	40023	40038	40078	40093	40038	30	5.71%	Right
138	30	40106	40121	40126	40141	40121	30	5.93%	Left
139	35	40155	40180	40204	40229	40180	30	7.00%	Right
140	50	40257	40277	40283	40303	40277	30	7.00%	Left
141	70	40305	40320	40327	40342	40320	30	5.71%	Right
142	100	40403	40423	40436	40456	40423	40	7.00%	Right
143	70	40481	40496	40554	40569	40496	30	5.71%	Right
144	50	40572	40592	40604	40624	40592	30	7.00%	Left
145	60	40660	40680	40695	40715	40680	30	6.67%	Right
146	130	40803	40818	40867	40882	40818	40	5.47%	Right
147	40	40912	40932	40947	40967	40932	30	6.94%	Right
148	35	40967	40982	41028	41043	40982	30	5.08%	Left
149	50	41095	41115	41125	41145	41115	30	7.00%	Right
150	180		41226	41243		41226	30	2.50%	Left
151	35	41260	41275	41276	41291	41275	30	5.08%	Right
152	30	41292	41307	41318	41333	41307	30	5.93%	Left
153	25	41334	41354	41380	41400	41354	20	7.00%	Right
154	40	41407	41427	41429	41449	41427	30	6.94%	Left
155	70	41471	41486	41496	41511	41486	30	5.71%	Right
156	70	41514	41529	41545	41560	41529	30	5.71%	Left
157	70	41688	41703	41714	41729	41703	30	5.71%	Right
158	30	41739	41754	41789	41804	41754	30	5.93%	Left
159	40	41850	41875	41912	41937	41875	30	7.00%	Right
160	80	42039	42054	42077	42092	42054	30	5.00%	Left
161	300		42135	42175		42135	40	2.37%	Left

HORIZONTAL DESIGN									
Sl. No.	Radius (m)	Start Chainage of		End Chainage of		HIP Chainage (m)	Design Speed, V (kmph)	Super elevation (%)	Hand of Curve
		Transition (m)	Curve (m)	Curve (m)	Transition (m)				
162	60	42192	42207	42226	42241	42207	30	6.67%	Right
163	20	42246	42266	42307	42327	42266	20	7.00%	Right
164	50	42356	42376	42383	42403	42376	30	7.00%	Left
165	70	42416	42431	42442	42457	42431	30	5.71%	Right
166	40	42598	42618	42643	42663	42618	30	6.94%	Left
167	35	42761	42786	42817	42842	42786	30	7.00%	Right
168	50	42886	42906	42916	42936	42906	30	7.00%	Left
169	40	43006	43031	43043	43068	43031	30	7.00%	Left
170	60	43078	43098	43101	43121	43098	30	6.67%	Right
171	60	43123	43143	43153	43173	43143	30	6.67%	Left
172	15	43231	43251	43277	43297	43251	20	7.00%	Left
173	70	43362	43377	43388	43403	43377	30	5.71%	Right
174	70	43441	43456	43487	43502	43456	30	5.71%	Right
175	70	43515	43530	43574	43589	43530	30	5.71%	Right
176	130	43593	43608	43615	43630	43608	40	5.47%	Left
177	30	43667	43682	43697	43712	43682	30	5.93%	Left
178	50	43741	43756	43793	43808	43756	30	5.56%	Left
179	30	43811	43826	43842	43857	43826	30	5.93%	Right
180	70	43904	43919	43955	43970	43919	30	5.71%	Right
181	25	43988	44008	44013	44033	44008	20	7.00%	Left
182	25	44045	44065	44086	44106	44065	20	7.00%	Right
183	150	44154	44169	44254	44269	44169	40	4.74%	Left
184	50	44273	44293	44302	44322	44293	30	7.00%	Right
185	100	44328	44348	44396	44416	44348	40	7.00%	Left
186	100	44496	44511	44515	44530	44511	35	5.44%	Right
187	90	44538	44553	44575	44590	44553	35	6.05%	Left
188	30	44591	44606	44609	44624	44606	30	5.93%	Right

HORIZONTAL DESIGN									
Sl. No.	Radius (m)	Start Chainage of		End Chainage of		HIP Chainage (m)	Design Speed, V (kmph)	Super elevation (%)	Hand of Curve
		Transition (m)	Curve (m)	Curve (m)	Transition (m)				
189	30	44625	44640	44647	44662	44640	30	5.93%	Left
190	80	44682	44697	44806	44821	44697	30	5.00%	Right
191	25	44821	44841	44855	44875	44841	20	7.00%	Left
192	300		44913	44969		44913	40	2.37%	Left
193	60	44969	44984	45045	45060	44984	30	6.67%	Right
194	35	45089	45114	45134	45159	45114	30	7.00%	Left
195	40	45169	45189	45198	45218	45189	30	6.94%	Right
196	60	45222	45242	45252	45272	45242	30	6.67%	Left
197	20	45302	45322	45335	45355	45322	20	7.00%	Right
198	20	45442	45462	45477	45497	45462	20	7.00%	Left
199	40	45499	45514	45518	45533	45514	30	4.44%	Right
200	35	45575	45600	45607	45632	45600	30	7.00%	Right
201	300		45675	45721		45675	40	2.37%	Right
202	20	45730	45750	45769	45789	45750	20	7.00%	Left
203	30	45791	45806	45813	45828	45806	30	5.93%	Right
204	60	45843	45858	45876	45891	45858	30	6.67%	Left
205	25	45895	45915	45931	45951	45915	20	7.00%	Right
206	50	46053	46073	46080	46100	46073	30	7.00%	Left
207	55	46111	46126	46172	46187	46126	30	5.05%	Right
208	30	46190	46205	46224	46239	46205	30	5.93%	Left
209	60	46245	46260	46285	46300	46260	30	6.67%	Left
210	60	46306	46321	46326	46341	46321	30	6.67%	Right
211	80	46371	46396	46420	46445	46396	40	7.00%	Right
212	60	46544	46559	46578	46593	46559	30	6.67%	Left
213	40	46599	46624	46636	46661	46624	30	7.00%	Right
214	35	46697	46722	46751	46776	46722	30	7.00%	Left
215	50	46784	46804	46837	46857	46804	30	7.00%	Right

HORIZONTAL DESIGN									
Sl. No.	Radius (m)	Start Chainage of		End Chainage of		HIP Chainage (m)	Design Speed, V (kmph)	Super elevation (%)	Hand of Curve
		Transition (m)	Curve (m)	Curve (m)	Transition (m)				
216	500		46884	46931		46884	50	2.22%	Right
217	40	46971	46991	47005	47025	46991	30	6.94%	Left
218	20	47027	47047	47052	47072	47047	20	7.00%	Right
219	50	47074	47089	47095	47110	47089	30	5.56%	Left
220	40	47185	47210	47216	47241	47210	30	7.00%	Right
221	50	47284	47304	47331	47351	47304	30	7.00%	Right
222	25	47359	47379	47400	47420	47379	20	7.00%	Left
223	100	47421	47436	47438	47453	47436	35	5.44%	Right
224	70	47510	47540	47549	47579	47540	40	7.00%	Left
225	45	47581	47606	47609	47634	47606	30	2.50%	Right
226	100	47643	47663	47671	47691	47663	40	7.00%	Left
227	150	47714	47729	47747	47762	47729	40	4.74%	Right
228	40	47766	47791	47794	47819	47791	30	7.00%	Left
229	25	47887	47907	47920	47940	47907	20	7.00%	Left
230	25	47951	47971	47977	47997	47971	20	7.00%	Right
231	50	48035	48055	48066	48086	48055	30	7.00%	Right
232	55	48121	48136	48143	48158	48136	30	5.05%	Right
233	80	48166	48181	48194	48209	48181	30	5.00%	Left
234	35	48221	48246	48255	48280	48246	30	7.00%	Left
235	25	48283	48303	48327	48347	48303	20	7.00%	Right
236	40	48429	48454	48456	48481	48454	30	7.00%	Left
237	60	48493	48508	48536	48551	48508	30	6.67%	Left
238	30	48554	48569	48573	48588	48569	30	5.93%	Right
239	40	48591	48611	48618	48638	48611	30	6.94%	Left
240	65	48649	48669	48752	48772	48669	40	7.00%	Right
241	60	48781	48801	48813	48833	48801	30	6.67%	Left
242	220		48862	48935		48862	40	2.50%	Right

HORIZONTAL DESIGN									
Sl. No.	Radius (m)	Start Chainage of		End Chainage of		HIP Chainage (m)	Design Speed, V (kmph)	Super elevation (%)	Hand of Curve
		Transition (m)	Curve (m)	Curve (m)	Transition (m)				
243	30	48948	48963	49015	49030	48963	30	5.93%	Left
244	50	49072	49092	49097	49117	49092	30	7.00%	Left
245	70	49120	49135	49141	49156	49135	30	5.71%	Right
246	350		49172	49220		49172	40	2.50%	Left
247	50	49311	49331	49399	49419	49331	30	7.00%	Right
248	300		49522	49554		49522	40	2.37%	Left
249	30	49572	49587	49614	49629	49587	30	5.93%	Right
250	30	49631	49646	49648	49663	49646	30	5.93%	Left
251	60	49664	49684	49694	49714	49684	30	6.67%	Right
252	15		49717	49743		49717	20	2.50%	Left
253	80	49744	49759	49841	49856	49759	30	5.00%	Right
254	30	49859	49874	49881	49896	49874	30	5.93%	Left
255	50	49901	49921	49934	49954	49921	30	7.00%	Right
256	70	50061	50076	50092	50107	50076	30	5.71%	Right
257	30	50125	50140	50164	50179	50140	30	5.93%	Left
258	30	50184	50199	50200	50215	50199	30	5.93%	Right
259	180	50235	50250	50294	50309	50250	40	3.95%	Right
260	30	50322	50337	50349	50364	50337	30	5.93%	Left
261	60	50368	50383	50408	50423	50383	30	6.67%	Right
262	150	50483	50498	50519	50534	50498	40	4.74%	Right
263	20	50559	50579	50610	50630	50579	20	7.00%	Left
264	20	50659	50679	50704	50724	50679	20	7.00%	Right
265	130	50754	50769	50839	50854	50769	40	5.47%	Left
266	25	50868	50888	50893	50913	50888	20	7.00%	Left
267	25	50918	50938	50944	50964	50938	20	7.00%	Right
268	20	51007	51027	51044	51064	51027	20	7.00%	Left
269	25	51121	51141	51146	51166	51141	20	7.00%	Left

HORIZONTAL DESIGN									
Sl. No.	Radius (m)	Start Chainage of		End Chainage of		HIP Chainage (m)	Design Speed, V (kmph)	Super elevation (%)	Hand of Curve
		Transition (m)	Curve (m)	Curve (m)	Transition (m)				
270	15	51172	51202	51203	51233	51202	20	7.00%	Right
271	40	51239	51254	51341	51356	51254	30	4.44%	Left
272	15	51360	51390	51404		51390	20	2.50%	Right
273	70		51406	51447	51462	51406	30	2.50%	Left
274	40	51478	51503	51511		51503	30	2.50%	Right
275	100		51526	51537	51552	51526	30	2.50%	Left
276	100	51585	51600	51612		51600	30	2.50%	Left

2.1.6 Vertical Alignment / Gradient

The Vertical Alignment has been designed for minimum criterion of Stopping Sight distance as specified in IRC: SP 23. The existing ground profile shall be reviewed on the basis of profile, cross sections taken at regular intervals with the aid of triangulated Digital Terrain Model (DTM).

Table 2-3: Vertical Curve Details

Curve No.	IP		Type of Curve	Curve Length (m)	K Value	Start		End		Gradient	
	Chainage (m)	Level (m)				Chainage (m)	Level (m)	Chainage	Chainage (m)	Level (m)	Out
1	29751.5	1070.94	Hog	40	10.114	29731.5	1070.1	29771.5	1070.98	4.174	0.22
2	29800.8	1071.05	Sag	30	14.068	29785.8	1071.01	29815.8	1071.4	0.22	2.352
3	29900.5	1073.39	Hog	40	8.864	29880.5	1072.92	29920.5	1072.96	2.352	-2.161
4	30005.6	1071.12	Sag	30	17.101	29990.6	1071.45	30020.6	1071.06	-2.161	-0.406
5	30138.5	1070.58	Hog	60	9.145	30108.5	1070.7	30168.5	1068.49	-0.406	-6.967
6	30402.6	1052.18	Sag	30	11.272	30387.6	1053.23	30417.6	1051.54	-6.967	-4.306
7	30516	1047.3	Hog	30	35.167	30501	1047.94	30531	1046.52	-4.306	-5.159
8	30658	1039.97	Hog	30	66.685	30643	1040.75	30673	1039.13	-5.159	-5.609
9	30798.9	1032.07	Sag	40	8.07	30778.9	1033.19	30818.9	1031.94	-5.609	-0.652
10	30858.9	1031.68	Hog	30	23.149	30843.9	1031.78	30873.9	1031.39	-0.652	-1.948
11	31013.4	1028.67	Hog	40	9.03	30993.4	1029.06	31033.4	1027.4	-1.948	-6.378
12	31071.9	1024.94	Hog	30	42.257	31056.9	1025.9	31086.9	1023.88	-6.378	-7.088
13	31142.6	1019.92	Sag	30	37.779	31127.6	1020.99	31157.6	1018.98	-7.088	-6.294
14	31225	1014.74	Sag	30	10.215	31210	1015.69	31240	1014.24	-6.294	-3.357
15	31306.9	1011.99	Hog	40	9.13	31286.9	1012.66	31326.9	1010.44	-3.357	-7.738
16	31356	1008.2	Sag	40	8.482	31336	1009.74	31376	1007.59	-7.738	-3.023
17	31421.3	1006.22	Hog	40	10.888	31401.3	1006.83	31441.3	1004.88	-3.023	-6.696
18	31532.8	998.754	Sag	40	18.856	31512.8	1000.09	31552.8	997.839	-6.696	-4.575

Curve No.	IP		Type of Curve	Curve Length (m)	K Value	Start		End		Gradient	
	Chainage (m)	Level (m)				Chainage (m)	Level (m)	Chainage	Chainage (m)	Level (m)	Out
19	31603.7	995.509	Hog	30	25.209	31588.7	996.195	31618.7	994.644	-4.575	-5.765
20	31686.9	990.717	Sag	40	7.112	31666.9	991.87	31706.9	990.689	-5.765	-0.141
21	31730.1	990.656	Hog	40	10.655	31710.1	990.684	31750.1	989.877	-0.141	-3.895
22	31831	986.726	Hog	30	11.074	31816	987.31	31846	985.735	-3.895	-6.604
23	31917.3	981.03	Sag	40	8.162	31897.3	982.351	31937.3	980.689	-6.604	-1.704
24	31989	979.808	Hog	30	8.913	31974	980.064	32004	979.048	-1.704	-5.07
25	32139	972.205	Sag	30	11.236	32124	972.965	32154	971.845	-5.07	-2.4
26	32222.6	970.199	Hog	40	10.548	32202.6	970.678	32242.6	968.96	-2.4	-6.192
27	32310.6	964.751	Sag	40	7.83	32290.6	965.989	32330.6	964.534	-6.192	-1.083
28	32372.1	964.085	Hog	40	9.356	32352.1	964.301	32392.1	963.013	-1.083	-5.358
29	32432.9	960.826	Sag	40	18.917	32412.9	961.897	32452.9	960.177	-5.358	-3.244
30	32544.7	957.201	Hog	30	11.195	32529.7	957.688	32559.7	956.313	-3.244	-5.923
31	32609.6	953.356	Sag	30	7.433	32594.6	954.244	32624.6	953.073	-5.923	-1.887
32	32660.7	952.392	Hog	30	7.901	32645.7	952.675	32675.7	951.539	-1.887	-5.684
33	32806.8	944.087	Sag	30	15.324	32791.8	944.939	32821.8	943.528	-5.684	-3.727
34	32900.9	940.581	Hog	30	10.233	32885.9	941.14	32915.9	939.582	-3.727	-6.658
35	33115.3	926.3	Sag	40	8.161	33095.3	927.632	33135.3	925.949	-6.658	-1.757
36	33495.8	919.615	Sag	30	9.573	33480.8	919.878	33510.8	919.821	-1.757	1.377
37	33632.2	921.492	Hog	30	16.852	33617.2	921.286	33647.2	921.432	1.377	-0.403
38	33748.5	921.023	Hog	30	12.148	33733.5	921.084	33763.5	920.592	-0.403	-2.873
39	33971.7	914.611	Hog	30	18.152	33956.7	915.042	33986.7	913.932	-2.873	-4.525
40	34105	908.578	Sag	30	7.637	34090	909.257	34120	908.489	-4.525	-0.597
41	34191.3	908.063	Hog	30	22.15	34176.3	908.153	34206.3	907.77	-0.597	-1.952
42	34330	905.356	Hog	30	17.13	34315	905.649	34345	904.801	-1.952	-3.703
43	34404.3	902.606	Sag	30	8.804	34389.3	903.162	34419.3	902.562	-3.703	-0.295

Curve No.	IP		Type of Curve	Curve Length (m)	K Value	Start		End		Gradient	
	Chainage (m)	Level (m)				Chainage (m)	Level (m)	Chainage	Chainage (m)	Level (m)	Out
44	34479.5	902.384	Hog	30	10.489	34464.5	902.428	34494.5	901.91	-0.295	-3.156
45	34524.9	900.951	Sag	30	9.33	34509.9	901.424	34539.9	900.96	-3.156	0.06
46	34583.1	900.986	Hog	50	10.03	34558.1	900.971	34608.1	899.755	0.06	-4.925
47	34637.1	898.323	Sag	30	7.327	34622.1	899.062	34652.1	898.198	-4.925	-0.831
48	34780.3	897.134	Hog	30	29.431	34765.3	897.259	34795.3	896.856	-0.831	-1.85
49	34855.2	895.748	Sag	30	21.461	34840.2	896.026	34870.2	895.68	-1.85	-0.452
50	34953.4	895.304	Hog	40	10.836	34933.4	895.395	34973.4	894.475	-0.452	-4.144
51	35031.9	892.05	Sag	30	8.903	35016.9	892.672	35046.9	891.934	-4.144	-0.774
52	35150.8	891.13	Sag	30	31.106	35135.8	891.246	35165.8	891.158	-0.774	0.19
53	35232.3	891.285	Hog	30	20.174	35217.3	891.256	35247.3	891.09	0.19	-1.297
54	35381.4	889.351	Hog	30	29.513	35366.4	889.546	35396.4	889.004	-1.297	-2.313
55	35537.8	885.735	Hog	30	14.227	35522.8	886.082	35552.8	885.072	-2.313	-4.422
56	35635	881.434	Hog	30	11.334	35620	882.098	35650	880.374	-4.422	-7.069
57	35692.5	877.374	Sag	40	8.343	35672.5	878.787	35712.5	876.919	-7.069	-2.274
58	35760.3	875.831	Hog	30	11.067	35745.3	876.172	35775.3	875.083	-2.274	-4.985
59	35823.5	872.678	Sag	30	9.386	35808.5	873.426	35838.5	872.409	-4.985	-1.789
60	35902.4	871.268	Hog	30	15.236	35887.4	871.536	35917.4	870.704	-1.789	-3.758
61	36005.3	867.401	Hog	30	95.878	35990.3	867.965	36020.3	866.79	-3.758	-4.071
62	36153.2	861.379	Hog	30	32.742	36138.2	861.99	36168.2	860.631	-4.071	-4.987
63	36227.3	857.684	Hog	30	21.912	36212.3	858.432	36242.3	856.731	-4.987	-6.356
64	36522.9	838.893	Sag	30	14.678	36507.9	839.846	36537.9	838.246	-6.356	-4.312
65	36695.7	831.441	Hog	30	21.666	36680.7	832.088	36710.7	830.586	-4.312	-5.697
66	36905.9	819.468	Sag	130	21.677	36840.9	823.171	36970.9	819.663	-5.697	0.3
67	37094	820.032	Sag	60	7.792	37064	819.942	37124	822.432	0.3	8
68	37195.9	828.185	Hog	30	23.542	37180.9	826.985	37210.9	829.194	8	6.726

Curve No.	IP		Type of Curve	Curve Length (m)	K Value	Start		End		Gradient	
	Chainage (m)	Level (m)				Chainage (m)	Level (m)	Chainage	Chainage (m)	Level (m)	Out
69	37363.8	839.48	Hog	60	11.392	37333.8	837.462	37393.8	839.918	6.726	1.459
70	37451.3	840.756	Sag	40	9.528	37431.3	840.464	37471.3	841.887	1.459	5.657
71	37626	850.642	Sag	60	48.997	37596	848.945	37656	852.707	5.657	6.882
72	37725	857.452	Hog	40	9.189	37705	856.076	37745	857.958	6.882	2.529
73	37846.1	860.514	Sag	40	9.6	37826.1	860.008	37866.1	861.853	2.529	6.695
74	38019	872.095	Sag	30	32.477	38004	871.09	38034	873.238	6.695	7.619
75	38114.4	879.358	Hog	65	8.531	38081.9	876.882	38146.9	879.358	7.619	0
76	38205.1	879.358	Sag	50	7.143	38180.1	879.358	38230.1	881.108	0	7
77	38384	891.88	Hog	30	23.224	38369	890.83	38399	892.736	7	5.708
78	38544.7	901.053	Sag	30.249	23.417	38529.6	900.19	38559.9	902.112	5.708	7
79	38623.2	906.548	Hog	30	16.246	38608.2	905.498	38638.2	907.321	7	5.153
80	38720.2	911.548	Hog	30	12.183	38705.2	910.775	38735.2	911.952	5.153	2.691
81	38828.8	914.47	Sag	40	9.314	38808.8	913.932	38848.8	915.867	2.691	6.986
82	39046.4	929.669	Hog	80	15.081	39006.4	926.875	39086.4	930.341	6.986	1.681
83	39132.1	931.109	Sag	60	11.309	39102.1	930.605	39162.1	933.205	1.681	6.987
84	39409.3	950.475	Hog	100	55.28	39359.3	946.982	39459.3	953.064	6.987	5.178
85	39608.6	960.795	Sag	50	27.436	39583.6	959.501	39633.6	962.545	5.178	7
86	39830.3	976.314	Hog	200	66.467	39730.3	969.314	39930.3	980.305	7	3.991
87	40083.4	986.418	Sag	30	13.175	40068.4	985.819	40098.4	987.358	3.991	6.268
88	40264.6	997.774	Hog	30	34.838	40249.6	996.834	40279.6	998.585	6.268	5.407
89	40445.1	1007.53	Hog	120	15.221	40385.1	1004.29	40505.1	1006.04	5.407	-2.477
90	40606.4	1003.53	Sag	80	9.489	40566.4	1004.53	40646.4	1005.92	-2.477	5.954
91	40678.9	1007.85	Hog	40	9.13	40658.9	1006.66	40698.9	1008.16	5.954	1.572
92	40752	1009	Sag	50	13.295	40727	1008.61	40777	1010.33	1.572	5.333
93	40824.2	1012.85	Hog	40	10.327	40804.2	1011.79	40844.2	1013.14	5.333	1.46

Curve No.	IP		Type of Curve	Curve Length (m)	K Value	Start		End		Gradient	
	Chainage (m)	Level (m)				Chainage (m)	Level (m)	Chainage	Chainage (m)	Level (m)	Out
94	40895.7	1013.9	Sag	30	6.905	40880.7	1013.68	40910.7	1014.77	1.46	5.804
95	40946.4	1016.84	Hog	50	8.996	40921.4	1015.39	40971.4	1016.9	5.804	0.246
96	41041.3	1017.08	Sag	100	14.806	40991.3	1016.95	41091.3	1020.58	0.246	7
97	41141.3	1024.07	Hog	30	47.187	41126.3	1023.02	41156.3	1025.03	7	6.364
98	41469	1044.93	Hog	80	14.487	41429	1042.38	41509	1045.27	6.364	0.842
99	41622.2	1046.22	Sag	50	21.606	41597.2	1046.01	41647.2	1047.01	0.842	3.156
100	41768.5	1050.83	Sag	60	18.841	41738.5	1049.89	41798.5	1052.74	3.156	6.341
101	41892.5	1058.7	Hog	80	28.026	41852.5	1056.16	41932.5	1060.09	6.341	3.486
102	42096.2	1065.8	Sag	60	20.802	42066.2	1064.75	42126.2	1067.71	3.486	6.371
103	42431.8	1087.18	Hog	60	18.252	42401.8	1085.27	42461.8	1088.11	6.371	3.083
104	42662.9	1094.31	Sag	60	35.737	42632.9	1093.38	42692.9	1095.74	3.083	4.762
105	42920.5	1106.57	Hog	60	53.206	42890.5	1105.14	42950.5	1107.66	4.762	3.635
106	43067	1111.9	Sag	60	17.828	43037	1110.81	43097	1114	3.635	7
107	43240.6	1124.05	Hog	60	27.624	43210.6	1121.95	43270.6	1125.5	7	4.828
108	43465.9	1134.93	Sag	60	59.901	43435.9	1133.48	43495.9	1136.68	4.828	5.83
109	43696.2	1148.35	Hog	80	38.014	43656.2	1146.02	43736.2	1149.84	5.83	3.725
110	43893.3	1155.69	Sag	60	29.282	43863.3	1154.58	43923.3	1157.43	3.725	5.774
111	44156.6	1170.9	Hog	60	122.722	44126.6	1169.17	44186.6	1172.48	5.774	5.285
112	44335.2	1180.34	Hog	60	45.205	44305.2	1178.75	44365.2	1181.53	5.285	3.958
113	44520.8	1187.68	Sag	60	19.724	44490.8	1186.5	44550.8	1189.78	3.958	7
114	44648.4	1196.61	Hog	40	10.053	44628.4	1195.21	44668.4	1197.22	7	3.021
115	44699.8	1198.16	Sag	30	7.54	44684.8	1197.71	44714.8	1199.21	3.021	7
116	44841.9	1208.11	Hog	40	25.3	44821.9	1206.71	44861.9	1209.19	7	5.419
117	44970.4	1215.08	Sag	40	34.855	44950.4	1213.99	44990.4	1216.39	5.419	6.567
118	45111.9	1224.37	Hog	80	16.814	45071.9	1221.74	45151.9	1225.09	6.567	1.809

Curve No.	IP		Type of Curve	Curve Length (m)	K Value	Start		End		Gradient	
	Chainage (m)	Level (m)				Chainage (m)	Level (m)	Chainage	Chainage (m)	Level (m)	Out
119	45183.8	1225.67	Sag	40	8.578	45163.8	1225.31	45203.8	1226.96	1.809	6.472
120	45442.5	1242.41	Hog	80	9.657	45402.5	1239.82	45482.5	1241.68	6.472	-1.812
121	45547	1240.52	Sag	60	7.953	45517	1241.06	45577	1242.23	-1.812	5.732
122	45773.8	1253.52	Hog	40	20.276	45753.8	1252.37	45793.8	1254.27	5.732	3.759
123	45897.1	1258.15	Sag	30	13.528	45882.1	1257.59	45912.1	1259.05	3.759	5.977
124	46085.6	1269.42	Hog	50	16.617	46060.6	1267.92	46110.6	1270.16	5.977	2.968
125	46153.1	1271.42	Sag	30	7.676	46138.1	1270.98	46168.1	1272.45	2.968	6.876
126	46302.7	1281.71	Hog	40	9.535	46282.7	1280.34	46322.7	1282.25	6.876	2.681
127	46383.3	1283.87	Sag	40	9.258	46363.3	1283.34	46403.3	1285.27	2.681	7.002
128	46553.8	1295.82	Hog	40	16.472	46533.8	1294.42	46573.8	1296.73	7.002	4.574
129	46617.4	1298.72	Sag	30	12.405	46602.4	1298.03	46632.4	1299.77	4.574	6.992
130	46729.5	1306.56	Hog	30	12.058	46714.5	1305.51	46744.5	1307.24	6.992	4.504
131	46771.9	1308.47	Sag	30	12.025	46756.9	1307.79	46786.9	1309.52	4.504	6.999
132	46901.6	1317.55	Hog	100	109.554	46851.6	1314.05	46951.6	1320.59	6.999	6.086
133	47126.9	1331.26	Hog	30	17.45	47111.9	1330.35	47141.9	1331.91	6.086	4.367
134	47203.1	1334.59	Sag	30	11.902	47188.1	1333.93	47218.1	1335.62	4.367	6.887
135	47392.6	1347.64	Hog	30	10.739	47377.6	1346.61	47407.6	1348.25	6.887	4.094
136	47497.5	1351.94	Hog	40	11.489	47477.5	1351.12	47517.5	1352.06	4.094	0.612
137	47660.9	1352.94	Hog	50	9.844	47635.9	1352.78	47685.9	1351.82	0.612	-4.467
138	47810.7	1346.24	Sag	120	10.465	47750.7	1348.92	47870.7	1350.44	-4.467	7
139	47970.6	1357.43	Hog	30	11.135	47955.6	1356.38	47985.6	1358.08	7	4.306
140	48037.8	1360.33	Sag	30	11.262	48022.8	1359.68	48052.8	1361.37	4.306	6.97
141	48155.3	1368.52	Hog	30	12.779	48140.3	1367.47	48170.3	1369.21	6.97	4.622
142	48214.2	1371.24	Sag	30	12.616	48199.2	1370.55	48229.2	1372.29	4.622	7
143	48325.6	1379.04	Hog	60	20.196	48295.6	1376.94	48355.6	1380.24	7	4.029

Curve No.	IP		Type of Curve	Curve Length (m)	K Value	Start		End		Gradient	
	Chainage (m)	Level (m)				Chainage (m)	Level (m)	Chainage	Chainage (m)	Level (m)	Out
144	48427.2	1383.13	Sag	60	38.864	48397.2	1381.92	48457.2	1384.8	4.029	5.573
145	48515.8	1388.07	Hog	100	37.385	48465.8	1385.28	48565.8	1389.52	5.573	2.898
146	48604.5	1390.64	Sag	30	11.467	48589.5	1390.2	48619.5	1391.47	2.898	5.514
147	48872.8	1405.43	Sag	30	25.735	48857.8	1404.6	48887.8	1406.43	5.514	6.68
148	49011	1414.67	Hog	30	11.865	48996	1413.67	49026	1415.29	6.68	4.151
149	49075.6	1417.35	Sag	30	10.532	49060.6	1416.73	49090.6	1418.4	4.151	7
150	49326.6	1434.92	Hog	30	16.447	49311.6	1433.87	49341.6	1435.69	7	5.176
151	49400.3	1438.73	Sag	30	16.793	49385.3	1437.96	49415.3	1439.78	5.176	6.962
152	49539.1	1448.4	Hog	40	9.722	49519.1	1447	49559.1	1448.97	6.962	2.848
153	49594.8	1449.98	Sag	50	12.042	49569.8	1449.27	49619.8	1451.73	2.848	7
154	49807.7	1464.88	Hog	60	35.084	49777.7	1462.78	49837.7	1466.47	7	5.29
155	50046.9	1477.54	Sag	60	270.097	50016.9	1475.95	50076.9	1479.19	5.29	5.512
156	50209	1486.47	Hog	40	10.084	50189	1485.37	50229	1486.78	5.512	1.545
157	50317.8	1488.15	Sag	80	15.167	50277.8	1487.54	50357.8	1490.88	1.545	6.82
158	50720.5	1515.62	Hog	60	169.673	50690.5	1513.57	50750.5	1517.56	6.82	6.466
159	50932	1529.3	Hog	60	16.616	50902	1527.36	50962	1530.15	6.466	2.855
160	51069.1	1533.21	Sag	60	21.414	51039.1	1532.35	51099.1	1534.91	2.855	5.657
161	51208	1541.07	Hog	60	10.911	51178	1539.37	51238	1541.12	5.657	0.158
162	51305.2	1541.22	Sag	30	12.66	51290.2	1541.2	51320.2	1541.6	0.158	2.528
163	51373	1542.94	Hog	30	18.799	51358	1542.56	51388	1543.08	2.528	0.932
164	51443.9	1543.6	Sag	30	19.482	51428.9	1543.46	51458.9	1543.97	0.932	2.472

2.1.7 Protection Work:

In mountainous and steep terrain, the geometric of the road shall be such that it gives the optimized and safe solution. The protection work plays the vital role in such terrains. The Hill side of the road shall be provided with drain and breast wall upto 3m height. Above that cutting with a slope of 1 Horizontal to 4 verticals is provided upto 6m of height with benching of 1 m and consequently the slope of 1 horizontal to 4 verticals with benching is provided till it reaches the ground. On valley side retaining wall shall be provided with safety barrier in the form of parapet wall/ W- beam crash barrier.

Below are the details of retaining wall/ breast wall

Table 2-4: Retaining wall Details

TYPE OF PW	Type of Earthwork	HT (m)	LHS	RHS	TOTAL LENGTH (m)
			LEGTH (m)	LEGTH (m)	
RW	VALLEY PW	2-2.5	0	0	0
RW	VALLEY PW	2.5-3	40	0	40
RW	VALLEY PW	3-3.5	0	190	190
RW	VALLEY PW	3.5-4	0	0	0
RW	VALLEY PW	4-4.5	0	0	0
RW	VALLEY PW	4.5-5	110	0	110
RW	VALLEY PW	5-5.5	40	70	110
RW	VALLEY PW	5.5-6	70	0	70
RW	VALLEY PW	6-6.5	180	0	180
RW	VALLEY PW	6.5-7	100	0	100
RW	VALLEY PW	7-7.5	0	40	40
RW	VALLEY PW	7.5-8	60	0	60
RW	VALLEY PW	8-8.5	40	0	40
RW	VALLEY PW	8.5-9	50	40	90
RW	VALLEY PW	9-9.5	0	0	0
RW	VALLEY PW	9.5-10	0	0	0

Table 2-5: Breast wall Details

TYPE OF PW	Type of Earthwork	HT of BW(m)	LHS	RHS	TOTAL LENGTH (m)
			LEGTH (m)	LEGTH (m)	
BW	HILL PW	1.5	1490	9730	11220
BW	HILL PW	3	10	840	850

2.1.8 Radius of curves for 30 to 40KMPH design speed:

Following are the locations where design speed is between 30 to 40 KMPH. The speed cannot be improved because of terrain contrainst and huge quantity of protection work.

Table 2-6: locations where design speed is between 30 to 40 kmph

Chainage(m)	Radius(m)	Design Speed in KmPh	Hand of curve	Extra Widening (m)
29666.5225	30	30	Left	1.5
29730.3	30	30	Right	1.5
29860.3415	70	30	Right	0.9
29902.2585	70	30	Left	0.9
29958.4695	80	30	Right	0.9
30045.757	50	30	Right	1.2
30189.853	100	35	Right	0.9
30373.6685	70	40	Right	0.9
30518.171	60	30	Left	1.2
30603.505	40	30	Left	1.5
30669.882	30	30	Right	1.5
30769.563	30	30	Right	1.5
30885.209	60	30	Right	1.2
30988.427	50	30	Left	1.2
31072.8515	35	30	Left	1.5
31194.0325	70	30	Left	0.9
31385.8675	50	30	Left	1.2
31444.2825	30	30	Left	1.5
31569.9305	35	30	Left	1.5
31750.1275	60	30	Right	1.2
31822.6025	80	30	Right	0.9
31866.2105	35	30	Left	1.5
31940.016	30	30	Left	1.5
32007.093	50	30	Right	1.2
32105.753	30	30	Left	1.5
32156.837	40	30	Right	1.5
32566.205	30	30	Left	1.5
32641.5375	45	30	Right	1.2
32805.001	100	40	Right	0.9
32925.489	40	30	Left	1.5
33003.299	110	40	Right	0.6
33091.023	60	30	Left	1.2
33173.0655	35	30	Right	1.5
33260.6665	200	35	Right	0.6
33441.4385	40	30	Right	1.5
33726.4815	35	30	Left	1.5
33860.3925	30	30	Right	1.5
33988.7635	50	30	Left	1.2
34092.69	30	30	Right	1.5
34143.0205	60	30	Left	1.2
34296.1305	110	40	Left	0.6
34375.505	100	40	Right	0.9
34433.1945	70	30	Left	0.9
34482.533	30	30	Right	1.5
34542.168	30	30	Left	1.5
34620.662	90	40	Right	0.9

Chainage(m)	Radius(m)	Design Speed in KmPh	Hand of curve	Extra Widening (m)
34685.982	100	40	Left	0.9
34831.8365	30	30	Right	1.5
34883.135	30	30	Left	1.5
34980.386	80	30	Left	0.9
35101.1065	50	30	Right	1.2
35174.5845	30	30	Right	1.5
35232.1085	50	30	Left	1.2
35291.642	100	40	Right	0.9
35348.073	200	50	Left	0.6
35414.8395	100	35	Left	0.9
35470.51	30	30	Right	1.5
35560.072	70	30	Right	0.9
35640.9365	40	30	Left	1.5
35682.9025	30	30	Right	1.5
35730.026	80	30	Left	0.9
35794.0265	135	40	Left	0.6
35842.6195	70	30	Right	0.9
35887.8635	30	30	Left	1.5
36001.7775	30	30	Left	1.5
36040.637	60	30	Right	1.2
36237.1035	60	30	Right	1.2
36522.165	35	30	Right	1.5
36573.222	40	30	Left	1.5
36715.2845	130	40	Left	0.6
36856.682	90	40	Left	0.9
37074.294	30	30	Left	1.5
37139.899	45	30	Right	1.2
37306.0195	30	30	Left	1.5
37351.119	30	30	Right	1.5
37416.422	80	40	Left	0.9
37572.1075	200	50	Right	0.6
37675.6135	40	30	Right	1.5
37752.0455	60	30	Left	1.2
37828.9485	35	30	Right	1.5
37902.0925	150	40	Left	0.6
38005.8465	30	30	Right	1.5
38073.837	70	30	Left	0.9
38306.302	30	30	Right	1.5
38376.492	140	40	Right	0.6
38448.9165	80	40	Left	0.9
38560.905	40	30	Right	1.5
38664.7665	50	30	Left	1.2
38725.4045	40	30	Right	1.5
38782.299	80	30	Left	0.9
38840.5145	60	30	Right	1.2
38912.802	100	40	Left	0.9
39038.9155	60	30	Left	1.2
39133.259	35	30	Right	1.5

Chainage(m)	Radius(m)	Design Speed in KmPh	Hand of curve	Extra Widening (m)
39215.6555	200	50	Left	0.6
39372.9615	85	40	Left	0.9
39713.369	100	40	Right	0.9
39765.8315	80	40	Left	0.9
39822.1515	70	30	Right	0.9
39957.2975	70	30	Left	0.9
40057.806	70	30	Right	0.9
40123.157	30	30	Left	1.5
40192.24	35	30	Right	1.5
40279.6965	50	30	Left	1.2
40323.877	70	30	Right	0.9
40429.963	100	40	Right	0.9
40525.0325	70	30	Right	0.9
40598.08	50	30	Left	1.2
40687.383	60	30	Right	1.2
40842.3155	130	40	Right	0.6
40939.553	40	30	Right	1.5
41005.0575	35	30	Left	1.5
41119.8605	50	30	Right	1.2
41275.4015	35	30	Right	1.5
41312.6375	30	30	Left	1.5
41427.638	40	30	Left	1.5
41491.1345	70	30	Right	0.9
41536.9195	70	30	Left	0.9
41708.369	70	30	Right	0.9
41771.399	30	30	Left	1.5
41893.0995	40	30	Right	1.5
42065.344	80	30	Left	0.9
42216.754	60	30	Right	1.2
42379.4215	50	30	Left	1.2
42436.6075	70	30	Right	0.9
42630.7425	40	30	Left	1.5
42801.562	35	30	Right	1.5
42910.707	50	30	Left	1.2
43037.282	40	30	Left	1.5
43099.1315	60	30	Right	1.2
43148.0355	60	30	Left	1.2
43382.4395	70	30	Right	0.9
43471.811	70	30	Right	0.9
43551.866	70	30	Right	0.9
43611.2365	130	40	Left	0.6
43689.5105	30	30	Left	1.5
43774.3105	50	30	Left	1.2
43833.668	30	30	Right	1.5
43936.7325	70	30	Right	0.9
44211.452	150	40	Left	0.6
44297.8505	50	30	Right	1.2
44371.9925	100	40	Left	0.9

Chainage(m)	Radius(m)	Design Speed in KmPh	Hand of curve	Extra Widening (m)
44512.9975	100	35	Right	0.9
44563.734	90	35	Left	0.9
44607.5325	30	30	Right	1.5
44643.286	30	30	Left	1.5
44751.2115	80	30	Right	0.9
45014.4745	60	30	Right	1.2
45124.069	35	30	Left	1.5
45193.2725	40	30	Right	1.5
45246.6615	60	30	Left	1.2
45515.938	40	30	Right	1.5
45603.4425	35	30	Right	1.5
45809.574	30	30	Right	1.5
45867.0255	60	30	Left	1.2
46076.4055	50	30	Left	1.2
46149.0375	55	30	Right	1.2
46214.32	30	30	Left	1.5
46272.6485	60	30	Left	1.2
46323.6245	60	30	Right	1.2
46407.8595	80	40	Right	0.9
46568.5995	60	30	Left	1.2
46629.9755	40	30	Right	1.5
46736.3005	35	30	Left	1.5
46820.4645	50	30	Right	1.2
46998.041	40	30	Left	1.5
47092.313	50	30	Left	1.2
47213.25	40	30	Right	1.5
47317.4015	50	30	Right	1.2
47436.831	100	35	Right	0.9
47544.406	70	40	Left	0.9
47607.039	45	30	Right	1.2
47667.0545	100	40	Left	0.9
47738.088	150	40	Right	0.6
47792.9555	40	30	Left	1.5
48060.475	50	30	Right	1.2
48139.1935	55	30	Right	1.2
48187.084	80	30	Left	0.9
48250.6475	35	30	Left	1.5
48454.925	40	30	Left	1.5
48522.2565	60	30	Left	1.2
48570.6315	30	30	Right	1.5
48614.6175	40	30	Left	1.5
48710.3835	65	30	Right	0.9
48806.926	60	30	Left	1.2
48988.7	30	30	Left	1.5
49094.236	50	30	Left	1.2
49138.0915	70	30	Right	0.9
49364.994	50	30	Right	1.2
49600.568	30	30	Right	1.5

Chainage(m)	Radius(m)	Design Speed in KmPh	Hand of curve	Extra Widening (m)
49647.4595	30	30	Left	1.5
49688.8335	60	30	Right	1.2
49800.066	80	30	Right	0.9
49877.689	30	30	Left	1.5
49927.7535	50	30	Right	1.2
50084.056	70	30	Right	0.9
50151.9815	30	30	Left	1.5
50199.3945	30	30	Right	1.5
50271.7115	180	40	Right	0.6
50343.1075	30	30	Left	1.5
50395.157	60	30	Right	1.2
50508.2395	150	40	Right	0.6
50803.679	130	40	Left	0.6
51297.4115	40	30	Left	1.5
51507.078	40	30	Right	1.5

Table 2-7: locations where design speed is less than 30 kmph

Chainage(m)	Radius(m)	Design Speed in KmPh	Hand of curve	Extra Widening (m)
29795.299	22	20	Left	1.5
30126.7185	20	20	Left	1.5
30454.7345	25	20	Right	1.5
31118.725	20	20	Right	1.5
31331.2025	20	20	Right	1.5
31512.063	20	20	Right	1.5
31625.475	20	20	Right	1.5
31690.1655	25	20	Left	1.5
32208.379	25	20	Left	1.5
32285.2155	25	20	Right	1.5
32336.469	20	20	Left	1.5
32397.6735	20	20	Right	1.5
32458.7385	25	20	Left	1.5
32518.5625	20	20	Right	1.5
33312.9775	25	20	Left	1.5
33492.094	20	20	Left	1.5
33549.2365	25	20	Right	1.5
34217.943	20	20	Right	1.5
34752.868	20	20	Left	1.5
34929.3825	20	20	Right	1.5
35513.0945	25	20	Left	1.5
36095.6895	25	20	Right	1.5
36192.933	25	20	Left	1.5
36286.3015	17	20	Left	1.5
36360.22	20	20	Right	1.5
36964.1085	15	20	Left	1.5
38520.3625	25	20	Left	1.5
38984.0785	15	20	Right	1.5

39883.5495	**20**	**20**	**Left**	**1.5**
41366.7635	**25**	**20**	**Right**	**1.5**
42286.272	**20**	**20**	**Right**	**1.5**
43263.8555	**15**	**20**	**Left**	**1.5**
44010.5585	**25**	**20**	**Left**	**1.5**
44075.4865	**25**	**20**	**Right**	**1.5**
44847.796	**25**	**20**	**Left**	**1.5**
45328.4695	**20**	**20**	**Right**	**1.5**
45469.388	**20**	**20**	**Left**	**1.5**
45759.417	**20**	**20**	**Left**	**1.5**
45922.8685	**25**	**20**	**Right**	**1.5**
47049.443	**20**	**20**	**Right**	**1.5**
47389.4065	**25**	**20**	**Left**	**1.5**
47913.0735	**25**	**20**	**Left**	**1.5**
47973.795	**25**	**20**	**Right**	**1.5**
48314.9805	**25**	**20**	**Right**	**1.5**
50594.594	**20**	**20**	**Left**	**1.5**
50691.467	**20**	**20**	**Right**	**1.5**
50890.501	**25**	**20**	**Left**	**1.5**
50941.056	**25**	**20**	**Right**	**1.5**
51035.158	**20**	**20**	**Left**	**1.5**
51143.89	**25**	**20**	**Left**	**1.5**
51202.254	**15**	**20**	**Right**	**1.5**
51397.012	**15**	**20**	**Right**	**1.5**

2.1.9 Summary of extra widening

Extra Widening (m)	Length (m)
0.6	1286.117
0.9	3231.209
1.2	3006.389
1.5	7233.371
Total	**14757.09**

2.1.10 Locations of Hill and Valley

S. No.	(Design Chainage) Start	(Design Chainage) End	Length (m)	LHS	RHS
1	29600	30130	530	Hill	Valley
2	30130	42280	12150	Valley	Hill
3	42280	43260	980	Hill	Valley
4	43260	47580	4320	Valley	Hill
5	47580	47680	100	Hill	Valley
6	47680	47890	210	Valley	Hill
7	47890	51500	3610	Hill	Valley

2.1.11 Location of Parapet wall

Parapet wall are provided at retaining wall location and bridges. Following are the locations of parapet wall

Start Design Ch.	End Design Ch.	Length(m)
29600	31500	2000
36970	37001	31
37054	37090	37
38187	38200	14
39660	39700	40
40350	40440	90
40500	40600	100
40720	40790	70
41210	41250	40
42480	42520	40
43390	43430	40
44400	44440	40
45740	45800	60
45950	46000	50
47130	47900	770
51150	51200	50
51300	51340	40

2.1.12 Location of W- Beam crash Barrier

W- beam crash barrier are provided at all sharp curves and other than parapet location on valley side.

Following are the locations of W-Beam crash barrier

Start Design Ch.	End Design Ch.	Length(m)
31500	36920	5420
37001	37054	53
37090	38144	1054
38144	38187	43
38200	39660	1460
39700	40350	650
40440	40500	60
40600	40720	120
40790	41210	420
41250	42480	1230
42520	43270	750
43350	43390	40
43430	44400	970
44440	45740	1300
45800	45950	150
46000	47130	1130

Start Design Ch.	End Design Ch.	Length(m)
47900	51150	3250
51200	51300	100
51340	51500	160

2.1.13 Bus Shelter

The bus shelters are provided at following locations;

S.No.	Chainage	SIDE
1	30+060	LHS
2	30+232	RHS
3	30+643	LHS
4	30+830	RHS
5	31+653	RHS
6	31+800	RHS
7	32+521	LHS
8	32+700	RHS
9	40+392	LHS
10	40+580	RHS
11	47+272	LHS
12	47+464	RHS
13	49+503	LHS
14	49+658	RHS
15	50+968	LHS
16	51+084	RHS

2.1.14 Road Junctions

There are following junctions fall in the project highway which are are as follows:

There are no Major Junctions and Sixteen Minor Junctions as per details given in ***Table-2.8.***

Table 2-8: Major & Minor Juctions

S. No.	Location Existing (km)	Design Chainage (Ch.)	Type	Category	Side Road/(s) Leading Towards
1	31.015	30+135	T	Minor	Chakabama Military Station
2	31.590	30+700	T	Minor	BSF Camp
3	31.862	30+970	T	Minor	Road towards Kezoma Town
4	32.079	31+168	Y	Minor	Road towards Cimorb Public School
5	32.657	31+721	Y	Minor	To Forest

S. No.	Location Existing (km)	Design Chainage (Ch.)	Type	Category	Side Road/(s) Leading Towards
6	33.517	32+565	T	Minor	To Mitelephe
7	34.118	33+142	T	Minor	To Mitelephe
8	38.120	36+986	Y	Minor	Village Road
9	41.852	40+447	Y	Minor	British Project Road
10	44.737	43+250	T	Minor	Village Road
11	46.957	45+450	Y	Minor	Village Road
12	48.944	47+374	T	Minor	Village Road
13	51.254	49+600	Y	Minor	Kikruma Road
14	52.495	50+810	Y	Minor	Village Road
15	52.916	51+205	T	Minor	Village Road
16	53.092	51+385	T	Minor	Village Road

2.2 PAVEMENT DESIGNS

2.2.1 Introduction

The purpose of pavement design and option study is to make analysis of different pavement alternatives to provide a basis for selection of the most advantageous solution, considering all costs occurring during the life of the pavement viz. construction cost, road user cost and maintenance cost. Traffic surveys were conducted on the Project Highway to know the future traffic flow pattern. Traffic projection over the design period has been done using present traffic and secondary data. Detailed pavement investigations viz. inventory, visual condition survey, roughness survey, structural evaluation and soil surveys were also conducted.

Axle Load Survey was conducted at two locations on the Project Highway, in order to estimate Vehicle Damage Factor (VDF), for use in pavement design. Soil samples were collected at sub-grade level of existing pavement and tested to find the properties necessary for pavement design. Borrow areas were identified along the Project Highway and the samples were tested to ascertain the properties of soil to be used for the construction of sub grade for new pavement.

2.2.2 Flexible Pavement Design

Flexible pavement has been proposed for widening of main carriageway, proposed bypass and junctions.

The type and pavement structural layers proposed are as under:

The proposed flexible pavement for widening portion, new bypass/realignment sections and proposed service roads, consists of various layers such as Granular Sub base (GSB), Wet Mix Macadam (WMM), Bituminous Surfacing comprising Dense Bituminous Macadam (DBM) and Bituminous Concrete (BC).

Strengthening / improving riding quality of existing flexible pavement is to be achieved by providing an overlay which may consist of Dense Bituminous Macadam and/or Bituminous Concrete (BC) layer.

The design of Flexible pavement for widening of main carriageway, Junctions and proposed bypass sections have been carried out in accordance with IRC: 37-2012.

2.2.3 Design Life

Pavement design life is the period for which the initial design of pavement crust layers shall be carried out. Design life should not be referred as terminal stage of crust beyond which crust becomes unusable.

The flexible pavement design is to be carried out in accordance with IRC: 37-2012. As per clause 4.3.2 of IRC: 37-2012 a design life of 15 years has been considered for flexible pavement design. The base year of traffic estimation considered is 2016.

2.2.4 Design Traffic Loading

Base year traffic in terms of AADT, design period, traffic growth rates, vehicle damage factors (VDFs) and lane distribution factors (LDFs) are required to estimate the design traffic loading in terms of equivalent standard axles.

2.2.4.1 Traffic Homogeneous Sections

Based on the detailed reconnaissance of the project road for traffic intensity and composition, the project road has been considered as three traffic homogeneous section. The proposed traffic homogeneous section is given in **Table 2.9.**

Table 2-9: Traffic Homogeneous Sections

Section No.	Starting		Ending		Length
	Existing km	Place	Existing km	Place	(in km)
I	km 0.000	Merima	km 30.600	Chakhabama	30.60
II	km 30.600	Chakhabama	km 68.000	Pfutsero	37.40
III	km 68.000	Pfutsero	km 132.000	Jessami	64.00

2.2.4.2 Base Year Traffic (AADT)

The base year traffic has been assessed by carrying out traffic surveys. The detailed traffic surveys and analysis for the project road have been given in above chapters. For pavement design purpose, commercial vehicles of laden weight more than 3 tones have been considered. Such vehicles consisted of buses, LCVs, 2 Axle trucks, 3 Axle trucks and Multi Axle trucks. The summary of AADT of commercial vehicles considered for pavement design is given in **Table 2.10**.

Table 2-10: Summary of Commercial Vehicles (AADT)

Traffic Homogenous sections Km	LCV	2 Axle	3 Axle	Multi axle Vehicles	Buses	Total Commercial vehicle
7.880 to 30.600	25	31	0	0	9	65
30.600 to 68.000	30	40	0	0	9	79
68.000 to 132.000	27	26	0	0	7	60

Note: For this package-II, the traffic considered is the section from Km 30.600 to Km 68.000

2.2.4.3 Traffic Growth Rates

Traffic growth rates have been estimated based on elasticity method and the summary of obtained growth rates are given in **Table 2.11.** The detailed traffic growth calculations have been given in above chapters.

Table 2-11: Summary of Proposed Traffic Growth Rates

Vehicle type	2017-21	2022-26	2027-31	Beyond 2031
Bus	4.84	4.37	3.94	3.56
LCV	11.72	10.2	9.12	8.2
2AT	6.62	5.8	4.96	4.16
3Axle	5	5	5	5
MAV	5	5	5	5

Note: Minimum traffic growth rate of 5% has been considered for the pavement design purpose

2.2.4.4 Vehicle Damage Factors (VDFs)

The vehicle damage factor (VDF) is a multiplier to convert the number of commercial vehicles of different axle loads and axle configuration to the number of standard axle load repetitions. It is defined as the equivalent number of standard axles per commercial vehicle. Universally accepted standard axle load weighs 8,160 Kg. ESAL is determined by the relationships recommended in IRC: 37-2012 'guidelines for the design of Flexible Pavements'. An excerpt is presented here.

Single axle with single wheel on either side: Equivalency Factor = (Axle load in tones /6.6)^4
Single axle with dual wheels on either side: Equivalency Factor = (Axle load in tones /8.16)^4
Tandem axle with dual wheels on either side: Equivalency Factor = (Axle load in tones /15.10)^4
Tridem axles with dual wheels on either side: Equivalency Factor = (Axle load in tones /22.85)^4

The relationship is referred to as the 'Fourth Power Rule', which states that the damaging effect of an axle load increases as the fourth power of the weight of an axle. In order to convert axle loads from the survey data into ESAL, each axle of each category of vehicle is multiplied by the equivalency factor of that type of axle. The output is called the 'damage' caused by that particular axle on the pavement. Damages by all axles are then added to find the cumulative damage by that type of vehicle. The cumulative damage is divided by

the number of vehicles of that category surveyed to obtain the average damage, which is also called the Vehicle Damage Factor (VDF) of that category of vehicle.

$$VDF = \frac{\text{Cumulative Damage}}{\text{Sample Size}}$$

Detail VDF calculation is given in **Appendix-D 2 main report.** The summary of calculated and adopted VDF values is given in **Table 2.12**.

Table 2-12: Summary of Adopted Vehicle Damage Factors (VDFs)

Vehicle type	Calculated VDF values				Adopted VDF values
	Direction Location km 13.000		Direction Location km 107.000		
	Chanditala to Champadang	Champadanga to Chandital	Chanditala to Champadang	Champadanga to Chandital	
LCV	0.18	0.25	0.32	0.19	0.5
BUS	0.43	0.43	0.43	0.43	0.5
2 Axle	1.12	0.67	1.29	0.80	0.5

Adopted VDF value is as per Table no 4.2 of IRC 37-2012

2.2.4.5 Lane Distribution Factors

Lane distribution factors have been considered as per clause 4.5.1 of IRC: 37-2012 and the same are given in **Table 2.13.**

Table 2-13: Adopted Lane Distribution Factors (LDFs)

Sl. No	Description	Design Period		LDF Considered (%)
		From (Year)	To (Year)	
1	2 Lane Carriageway	2021	2035	50

2.2.4.6 Traffic Loading (Cumulative Million Standard Axles)

For flexible pavement design traffic loading in million standard axles (MSA) has been estimated for design life of 15 years (post construction).

The design traffic is considered in terms of the cumulative number of standard axles to be carried during the design life of the road. This can be computed using the following equation:

$$N = \frac{365*[(1+r)^n-1]*A*D*F}{r}$$

Where,

N = Cumulative number of standard axles to be catered for in the Design in terms of MSA

A = Initial traffic in the years of completion of construction in terms

of the number of commercial vehicles per day.
D = Lane distribution factor
F = Vehicle Damage Factor
n = Design life in years
r = Annual growth rate of commercial vehicles

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

$$A=P\ (1+r/100)x$$

Where,

P = Number of commercial vehicles as per count
x = Number of years between the count and the year of completion of construction.

The summary of obtained and adopted MSA is given in **Table 2.14;** the detailed MSA calculations are given as **Appendix-D 3 of main report.**

Table 2-14: Obtained and Adopted MSA for the Project Road

Traffic Homogenous sections Km		MSA Obtained	MSA Adopted	MSA as per 2-lane Manual
Existing (Km)	Design (Km)			
30.474 to 53.220	29.600 to 51.500	0.037	10	20*

* As per clause 5.4.1 of IRC: SP-73-2015 design traffic shall not be less than 20MSA

2.2.5 Design CBR

Effective design CBR of 8% is considered in pavment design.

2.2.6 Flexible Pavement Design for Widening/New Construction

The IRC method for pavement design is based on limiting the vertical compressive strain on top of sub-grade which results in permanent deformation of the pavement and the horizontal tensile strain at the bottom of the bituminous layer which results in cracking of the pavement. The relationships governing the above two pavement failure criteria are expressed as:

Rutting Model: The model considers the vertical strain in sub-grade as the only variable for rutting, which is a measure of bearing capacity of the sub-grade.

$N = 4.1656 \times 10^{-8} (1/\varepsilon_v)^{4.5337}$ - (80% Reliability Level)

$N = 1.41 \times 10^{-8} (1/\varepsilon_v)^{4.5337}$ - (For 90% Reliability Level)

Where,

N - Number of cumulative standard axles, and
ε_v - Vertical strain in the sub-grade

Fatigue Model: With every load repetition, the tensile strain developed at the bottom of the bituminous layer develops micro cracks, which go on widening and expanding till the load repetitions are large enough for the cracks to propagate to the surface over an area of the

surface that is unacceptable from the point of view of long term serviceability of the pavement. The phenomenon is called fatigue of the bituminous layer and the number of load repetitions in terms of standard axles that cause fatigue denotes the fatigue life of the pavement. Cracking in 20% area has been considered for traffic up to 30 MSA and 10% for traffic beyond that.

$N_f = 2.21 \times 10^{-4} (1/\varepsilon_t)^{3.89} * (1/MR)^{0.854}$ (80% Reliability)
$N_f = 0.711 \times 10^{-4} (1/\varepsilon_t)^{3.89} * (1/MR)^{0.854}$ (90% Reliability)

Where,

N_f = Fatigue life in number of standard axles
ε_t = Maximum tensile strain at the bottom of the bituminous layer, and
M_R = Resilient modulus of the bituminous layer

The mixes used in the pavement under study sections were generally designed for 4.5% air voids and bitumen content of 4.5% by weight of the mix (which in terms of volume would come to 11.5%). Hence introduced the C factor in fatigue models to take into account the effect of air voids (Va) and volume of bitumen (Vb), which is given by the following relationships;

C = 10M, and M=4.84(Vb/(Va+Vb)-0.69)

Corresponding to the values of Va and Bv as stated above the above equation for 80% reliability is as given below;

$Nf = 0.5161*C*10^{-4} (1/\varepsilon_t)^{3.89} * (1/M_R)^{0.854}$

The flexible pavement design has been carried out by using the principles of analytical design. Analytical design as per procedure given in the clause 9.1of IRC: 37-2012, thereby ensuring requisite structural layers.

The entire project stretch is considered in three homogeneous sections viz. Kohima to Nagaland Existing Chainage (Km 0.000 to Km 132.00) after considering the factors like traffic volume, Effective design CBR of 8% is considered for the purpose of pavement design for package-I of the project highway. The new 2 lanes and widening /up gradation sections are designed for maximum traffic of 10MSA.The proposed crust thickness for flexible pavement option is presented in **Table 2.15**.

Table 2-15: Proposed Flexible pavement design for Reconstruction, New Construction and Widening(10MSA)

Design Chainage (km)		Design Traffic (MSA)	CBR (%)	Proposed Flexible Pavement Thickness (mm)				Total (mm)
From	To			BC	DBM	WMM	GSB	
29.600	51.500	10	8	40	50	250	200	540

Table 2-16: Proposed Flexible pavement design for Reconstruction, New Construction and Widening (20MSA)

Design Chainage (km)		Design Traffic (MSA)	CBR (%)	Proposed Flexible Pavement Thickness (mm)				Total (mm)
From	To			BC	DBM	WMM	GSB	
29.600	51.500	20	8	40	80	250	200	570

Since very less commercial traffic is plying on the project highway which is 204 numbers in the year of 2017 and the projected would be 848 numbers in the year of 2035. Hence 10 MSA is adopted the pavement design.

2.2.7 Strengthening of Existing Pavement

Detailed pavement condition survey and pavement investigations have been carried out to assess the strength of the existing flexible pavement. Based on the observations from pavement condition/investigations, strengthening measures have been finalised.

Fresh BBD Survey has been carried out at as per the methodology discussed in chapter above and the detailed BBD analysis is given in **Appendix-D1 of main report.**

The Existing pavement condition is poor to very poor from Km 0.000 to Km 30.000 and from Km 30.000 to Km 132.000 is fair to poor. Existing crust composition is not having proper layers and the existing layer thicknesses are deficient and not confirm to the specifications. Further existing pavement is not having proper drainage layer. BBD survey has been carried out along the project road and the observed deflection values are significantly on higher side. Therefore, considering all these parameter the entire project road is recommended for reconstruction. Reconstruction is to be carried out as per the new pavement design.

2.2.8 Materials

All materials to be used in works shall be in conformity with the requirements laid down for relevant item in MORT&H Specifications, V Revision. If any material, which is not covered in MORT&H Specifications, is used, shall conform to IRC or relevant Indian or International Standards, provisions.