GREJ
ENGINEERS

1/9/2023

DESIGN BASIS REPORT

INTERNAL ROADS OF RESSING HEP

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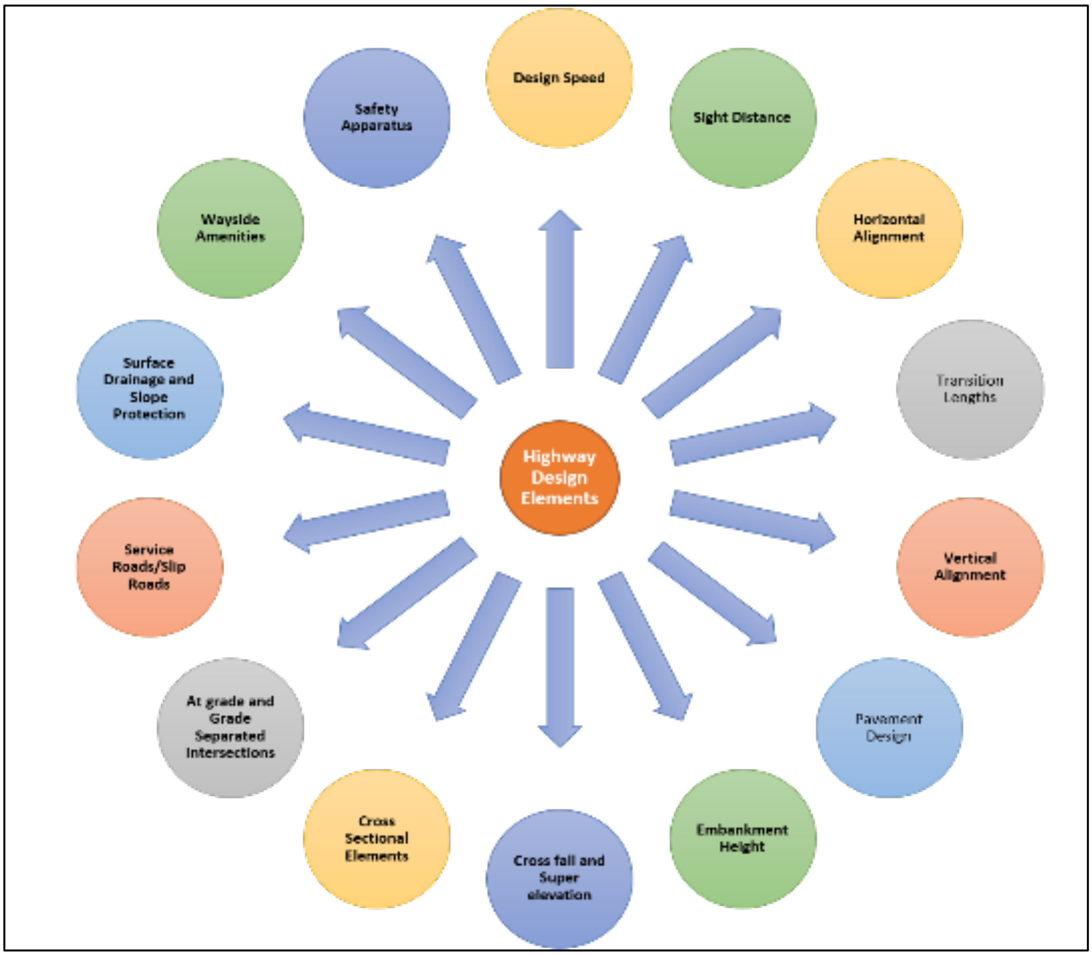
1 DESIGN BASIS, STANDARDS AND SPECIFICATIONS

1.1 General

This chapter describes the various design standards adopted to the design of road as per Indian standard configuration engineering design proposed for the project road.

For design of road elements like design speed, sight distance, geometry, pavement design etc. play a very important role. **Figure 1.1** shows graphical presentation of road design element.

Figure 1.1: Graphical Presentation of Road Design Elements



1.2 Various Design Components of Project Road

The basic data used for detail design of various components of the project road are indicated in **Table 1.1**, below

Table 1.1: Various Design Components

Sl. No.	Design Component	Basic Data for Design	Out come
1	Highway Geometric Design	Geometric design standards	Providing the Horizontal and vertical curves as per the IRC- SP 48 (Hill Road Manual).
2	Pavement design	As per IRC -SP 37-2018	Thickness and composition of pavement
3	Junctions	Design of junction as per IRC-SP 41	Design of junction
4	Roadside Drains	As per Available Data	Location, type and size of roadside drains to be provided
5	Design of culverts	Location marked in provided Survey	New culverts

1.3 Codes and Guidelines

The Consultant has referred to the latest IRC publications and MORT&H circulars regarding design standards for National Highways in India. The relevant design standards adopted for the design includes:

1.3.1 Codes Adopted for Roadway Design

Important codes for quick reference are mentioned below:

IRC Standards

IRC-SP

1) IRC: SP: 23-1993: - Vertical Curves for Highways
2) IRC: SP: 41-1994: - Design of at-grade intersection
3) IRC: SP: 42-2014: - Guidelines on Road Drainage
4) IRC: SP: 48-1998: - Hill Roads Manual

1.4 Design Speed and Terrain Classification

For geometric design of the highway, design speed is used as an index which links road function, traffic flow and terrain. An appropriate design speed should correspond to general topography and adjacent land use. The speed selected for design should also cater to travel needs and behavior of the road users.

Terrain is classified by the general slope of the ground across the road alignment. The terrain classification and definition as per IRC: SP: 48-1998 is presented in **Table 1.2**, below.

Table 1.2: Terrain classification

Nature of Terrain	% Cross Slope of the Country
Plain	0 to 10
Rolling	Greater than 10 up to 25
Mountainous	Greater than 25 up to 60
Steep	More than 60

The project road passes through **Mountainous / Steep terrain** and the design speed is adopted accordingly, as shown in **Table 1.3**, below.

Table 1.3: Design Speed

Description	IRC: SP:48-1998	Adopted for the Project Road
Ruling	40 km/hr.	40 km/hr.
Minimum	30 km/hr.	30 km/hr.

1.5 Sight Distance

Visibility is an important requirement for the safety of travel on roads. For this it is necessary that sight distance of adequate length is available in different situations, to permit drivers enough time and distance to control their vehicles so that chances of accidents are minimized. Sight distance is a direct function of the design speed. Sight distance corresponding to various design speeds are given below in **Table 1.4**.

Table 1.4: Sight Distance

Design Speed	Sight Distance	IRC: SP:48-	IRC:52-2001	IRC: SP:73-2015	Adopted for the Project Road
40 km/hr.	Stopping	45 m	45 m	45 m	-
30 km/hr.	Stopping	30 m	30 m	-	30 m

In general, the design would be done based on **Stopping Sight Distance**.

1.6 Horizontal Alignment

a) General

In a road alignment, changes in direction are often necessary due to restrictions imposed by topography, environmental and ecological qualities of areas, presence of monuments, places of worship, sites of structures and other considerations such as available land. For balance in highway design, all geometrical elements should be determined for consistent operation under the design speed in general. A horizontal alignment should be as smooth and consistent as possible with the surrounding topography. To achieve that, an appropriate blending with the natural contours is preferable to the one with long tangents through the terrain.

b) Horizontal Curve

The minimum horizontal curve radius is the limiting value of curvature for a given design speed and is determined based on from the maximum rate of super elevation and the side friction factor. The minimum ruling radii of horizontal curve adopted is given in **Table 1.5**, below:

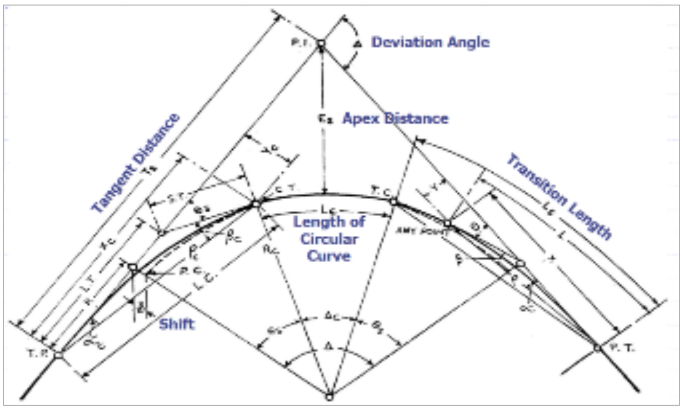
Table 1.5: Horizontal Radii Criteria

Description		IRC: SP: 48-1998	IRC:52: 2001	IRC: SP:73-	Adopted for the Project Road
Minimum Horizontal Curve Radius					
Areas not affected by Snow	Ruling (Design Speed – 40 km/hr.)	50 m	50 m	150 m*	50 m
	Abs. Min. (Design Speed – 30	30 m	30 m	75 m*	30 m
Snow bound areas	Ruling (Design Speed – 40	60 m	60 m	-	NA
	Abs. Min. (Design Speed – 30	33 m	33 m	-	NA

* No Separate value for snow bounds and not snows bound areas. Also, the values correspond to both mountainous and steep terrain.

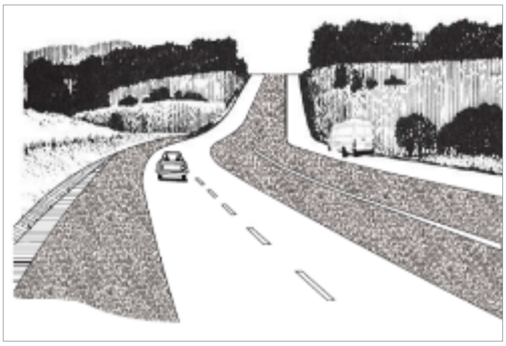
At the locations with constraints at existing alignment sections, absolute minimum radius may have to be proposed to accommodate within available roadway.

c) Transition (Spiral) Curves

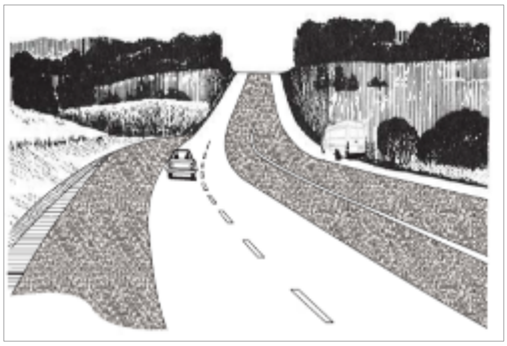


The purpose of a transition (spiral) curve is to provide a smooth and aesthetically pleasing transition from a tangent and a circular curve. In addition, the transition curves provide the necessary length for attainment of super-elevation runoff.

Transition curve length shall be provided as per Hill Road Manual, IRC: SP: 48-1998



Curve without Spiral Transition



Curve with Spiral Transition

Method 1: Rate of Change of centrifugal acceleration LS =	$\frac{0.02158 * V^3}{C * R}$
Method 2: Rate of Change of Super elevation LS =	$\frac{\frac{Cw}{2} * e_{prov} * Rate * 0.0635 * V^2}{R}$
Where, e = Super elevation CW /2= width of carriageway to be super elevated V = Design Speed R = Radius in m C = 80 / (75+V) subject to Max. 0.8 & Min. 0.5 Rate of Attainment i.e., 1in150 for Plain/Rolling LS = Length of Spiral to be provided (Maximum of Method 1 and 2)	

Maximum transition length achieved out of two methods as mentioned below shall be adopted

d) Super-elevation

Super-elevation is the transverse slope provided at horizontal curve to counteract the centrifugal force, by raising the outer edge of the pavement with respect to the inner edge, throughout the length of the horizontal curve. When the outer edge is raised, a component of the curve weight will be complimented in counteracting the effect of centrifugal force.

The super elevation will be restricted to a maximum of 5% if the radius is more than desirable minimum and it will be limited to 7 % if the radius is less than desirable minimum radius.

The super elevation shall be derived by the following method:

$$e = V^2/225R$$

Where,

e = super elevation in meter per meter

V = Speed in Km/hour

R = Radius in meter

The maximum super elevation values as suggested by the codes and the final value adopted is given below in **Table 1.6**.

Table 1.6: Super elevation Details

Description	IRC: SP: 48-1998	IRC:52: 2001	IRC: SP:73-2015	Adopted for the
Maximum in area not affected by snow	10%	7%	7% (No separate values given for snow bound and unbound areas), 5% for urban	10%
Maximum in snow bound Area	7%	7%		NA
Rate of change	1 in 60	1 in 60	1 in 60	1 in 60

The super elevation is attained from normal camber in two stages, as detailed below.

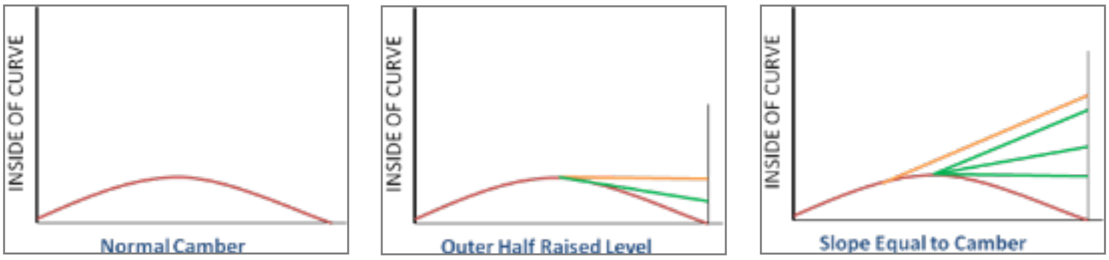
I. <u>First Stage</u>

The outer half of the camber is gradually raised until it is level and the outer half is in line with the inner half of the cambered surface.

II. Second Stage

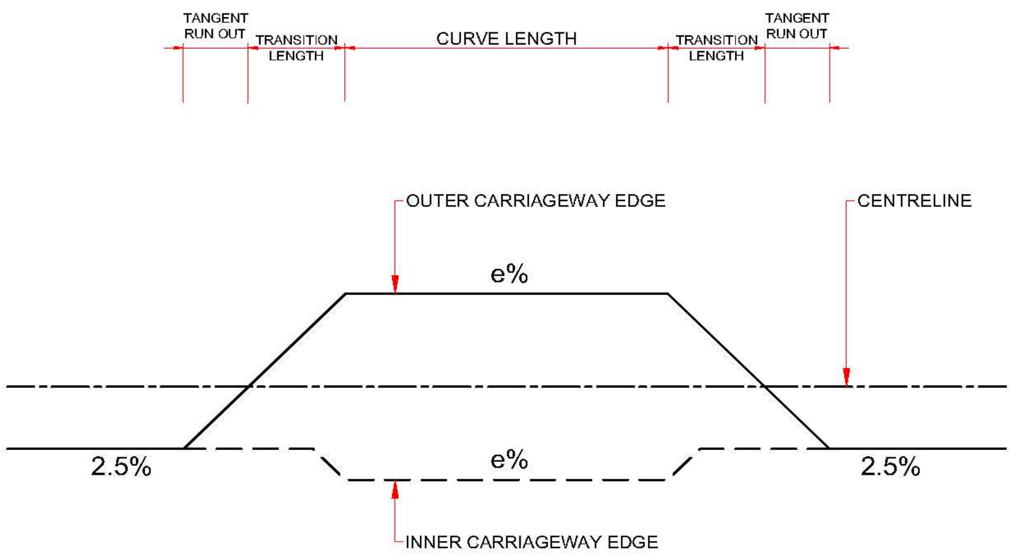
In the second stage one of the following methods may be adopted depending upon site conditions:

- Pavement Revolved about Centreline
- Pavement Revolved about inner Edge
- Pavement Revolved about Outer Edge



The Consultant proposes to adopt the method of attending super elevation through the revolution of pavement about centerline thus keeping the level of road centerline unchanged.

The schematic diagram of super elevation attainment, with one side camber is presented at **Figure 1.3**



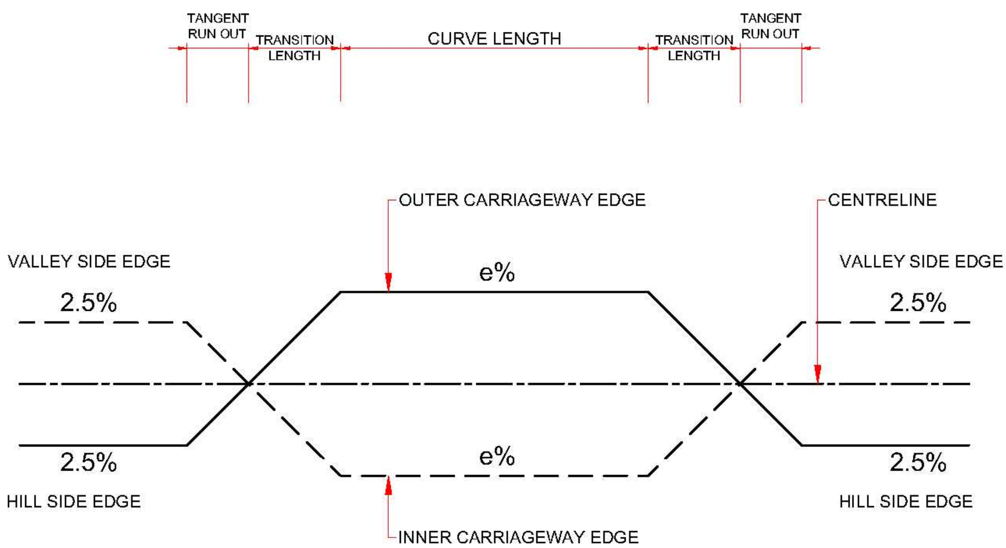


Figure 1.2: Super Elevation Attainment at one side camber sections

1.7 Vertical Alignment

a) General

The vertical alignment should produce a smooth longitudinal profile consistent with the standard of the road and the terrain. Wherever possible horizontal and vertical curvature should be so combined that the safety and operational efficiency of the road is enhanced.

b) Gradients

The gradient proposed for the project road is shown below in **Table 1.7**.

Table 1.7: Vertical Gradient

Description	IRC: SP: 48-1998	IRC:52: 2001	IRC: SP:73-2015	Adopted for Project Road
Ruling	6%	6%	6%	**6%**
Limiting	7% 7%	7% 7%	7% 7%	**7%** **7%**
Exceptional	8%	8%	-	**8%**

To ensure adequate drainage, roadways typically have a minimum longitudinal grade of 0.5% to 0.6%, depending on the terrain. The minimum longitudinal grades as per IRC: 73-1980 design standards are 0.5% for lined side ditches, and 1.0% for unlined side ditches. The AASHTO (2011) and TAC (1999) design guidelines recommend a minimum 0.5% longitudinal grades for highways. It is therefore, proposed to adopt a minimum of 0.5% longitudinal gradients as far as possible.

c) Vertical Curves

The length of a vertical curve is calculated using the following equation:

L = K x A,

Where L = Length of vertical curve in meters;

K = Coefficient, a measure of the flatness of a vertical curve; and

A = Algebraic difference of grade lines (%)

Table 1.8 shows the minimum K values adopted by the Consultant based on IRC guidelines.

Table 1.8: Adopted K Value for Vertical Curve

Design Speed (km/hr)	'K' value for summit curves		'K' value for valley curves	Minimum length of curve (m)
	Desirable (ISD)	Minimum (SSD)		
40	8.4	4.6	6.6	20
30	3.8	2	3.5	15

However as per IRC Length of Vertical curve should be calculated from both conditions as mentioned below.

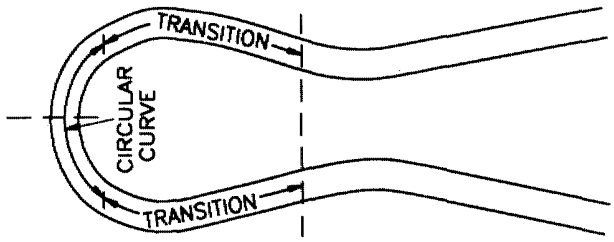
Length of Summit Curve	**Length of Valley Curve**
For L > SL = $NS^2/4.4$	For L > S L = $NS^2/(1.5+0.035S)$
For L < S L= 2S – 4.4/N	For L < S L = 2S – (1.5+0.035S)/N

Where L = Length of vertical curve in meters;

S = Sight Distance in meters

N = Algebraic difference of grade lines (%)

1.8 Hair Pin Bends



a. Minimum Design Speed - 20 kmph

b. Minimum Roadway width at apex - 11.5 m for double lane

c. Minimum radius of inner curve - 14.0 m

d. Minimum length of transition curve - 15.0 m

e. Gradient - Max. 1 in 40 (2.5%), Min. 1 in 200 (0.5%)

f. Super elevation - 1 in 10 (10%)

Inner and outer edges of the roadway will be concentric with respect to center line of the pavement. Where a number of hair-pin bends have to be introduced, a minimum intervening distance of 60 m will be provided between the successive bends to enable the driver to negotiate the alignment smoothly.

Widening of hair-pin bends subsequently is a difficult and costly process. Moreover, gradients become sharper as generally widening can be achieved only by cutting the hill side. These points are kept in view at the planning stage, especially if a series of hair-pin bends are involved.

a) Road Cross sectional details

Table 1.9: Road Cross Section

Description	IRC: SP:48-1998	IRC: 52:2001	IRC: SP:73-2015	Adopted for the Project Road
Lane width of single lane carriageway in hills	3.0 m	3.5 m	3.75 m	3.0 m
Lane width of Intermediate Lane carriageway in hills	-	-	-	-
Earthen Shoulder / Paved Shoulder	0.90 m on both sides	0.90 m on both sides	0 m on hill side; 1 m on valley side	-
Drain on Hill Side	0.6 m	-	-	0.6 m
Parapet on Valley Side	0.4 m	-	-	0.4 m
Drain cum Footpath in Urban Sections	-	-	-	-
Kerb Shyness in Urban Sections	-	-	-	-
Normal Camber	1.7 to 2.5%	2.0 to 2.5%	2.5% for bituminous; 2.0% for concrete	2.5% for bituminous; 2.0% for concrete

b) Embankment Slopes

The Consultant proposes to provide slopes of 11H:1V in Fill sections in accordance to the provision of IRC: SP:48-1998. The side slopes of cutting shall be provided in accordance with the nature of soil encountered and clause 7.4.1 of IRC: SP:48-1998.

c) Pavement Camber (Cross Fall)

A unidirectional cross fall towards hill side, for carriageway will be adopted, in the hilly stretches. In other sections, bidirectional cross fall for carriageway will be adopted. The cross fall for earthen shoulder will be 2.5%.

Earthen shoulder on the high side of super elevated portion will be provided with reverse slope from the super elevated carriageway portion. The effective difference between pavement cross fall and outside earthen shoulder cross fall (roll-over) will not exceed 8%.

1.8.1 Design Standards

The design standards to be followed for New Pavement Design and Pavement Strengthening are:

1. IRC: SP-73:2015: Manual of Specifications & Standards for Two Lane of Highways with paved shoulder
2. IRC: SP: 48-1998: Hill Roads Manual
3. IRC: 37-2018: Guidelines for the Design of Flexible Pavements,

1.8.2 Design Period

As per IRC:37-2018 "Guidelines for the Design of Flexible Pavements", for new pavement as well as overlay, 15 years design life is considered.

Calculation of Traffic is purely based on the assumption. Details are mentioned below.

Year Wise Traffic Volumes and MSA Projection - Based on IRC -37 2018					
Year	**single axle dual tyre**	**Tandem Axle Dual Tyre**	**Total AADT (two directional)**	**Design Lane MSA**	
VDF	**0.60**	**0.60**		**Yearly**	
Growth Rate	**0.00**	**0.00**		**MSA (LDF=1)**	
2022					
2023	50	30	80	8.0	8.0
2024	50	30	80	0.0	8.0
2025	50	30	80	0.0	8.0
2026	50	30	80	0.0	8.1
2027	50	30	80	0.0	8.1
2028	50	30	80	0.0	8.1
2029	50	30	80	0.0	8.1
2030	50	30	80	0.0	8.1
2031	50	30	80	0.0	8.1
2032	50	30	80	0.0	8.2
2033	50	30	80	0.0	8.2
2034	50	30	80	0.0	8.2
2035	50	30	80	0.0	8.2
2036	50	30	80	0.0	8.2
2037	50	30	80	0.0	8.2
2038	50	30	80	0.0	8.3
2039	50	30	80	0.0	8.3
2040	50	30	80	0.0	8.3
2041	50	30	80	0.0	8.3

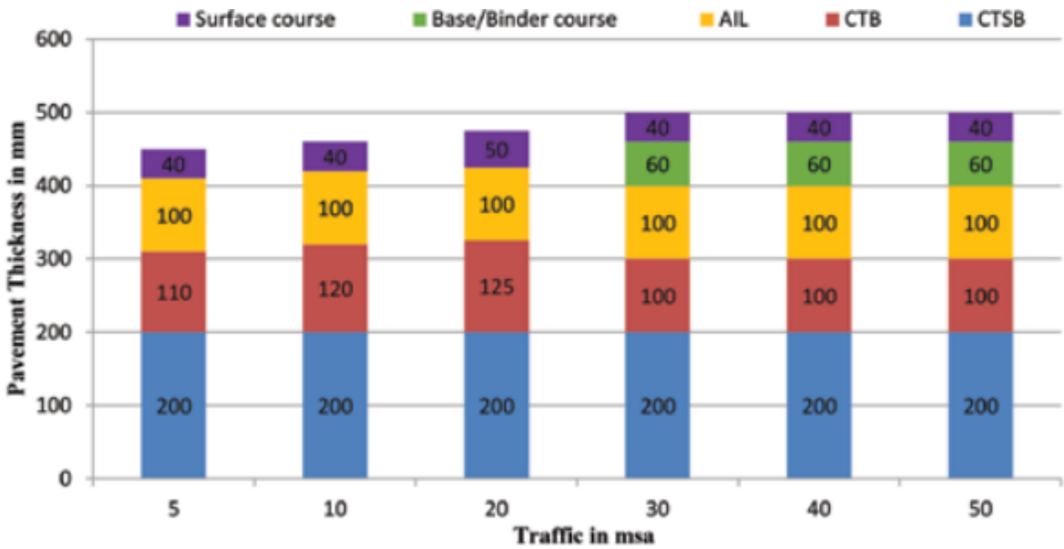
2042	50	30	80	0.0	8.3
2043	50	30	80	0.0	8.4

NOTE:-

1. **Sample Calculation which purely based on assumption related to traffic composition, Growth rate is represented above.**
2. **Assumptions to be validated with traffic studies.**

Based on the above traffic data table, we assumed the 10 MSA and 15% CBR (Due to good quality of rock available as per the information provided by Client).

As per IRC:37-2018 "Guidelines for the Design of Flexible Pavements", for new pavement. The proposed pavement is as-



However, most of the road are temporary road and will not be required after the construction of Dumping site etc. It is strongly recommended that the GSB will be 150 mm.

Standards for at-Grade Intersections-Turning, Merging Diverging

The standards proposed in IRC: SP:41-1994, "Guidelines for the Design of At-Grade Intersections in Rural and Urban Areas" will be applied.

1.9 Drainage in Rural and Urban Areas

1.9.1 Drainage along the road

References

- IRC SP:42-2014 – Guidelines on Road Drainage