Design of Flexible Pavement for NH – 7 of Nagpur-Hyderabad stretch (from km. 123+000 to km. 175+000)

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Abstract – NH-7 is an important road link connecting Varanasi in Uttar Pradesh with Kanyakumari at the southern tip of India. Originating at Uttar Pradesh, it traverses through states of Madhya Pradesh, Maharashtra, Andhra Pradesh, and Karnataka before terminating at Kanyakumari in Tamil Nadu. It traverses through major towns of Rewa, Nagpur, Adilabad, Hyderabad (state capital of Andhra Pradesh), and Bangalore (state capital of Karnataka). The 22 km long project road from km 153 to km 175 forms a part of the North-South corridor and is at the southern tip in the state of Maharashtra.The existing Road to a length of about 22 km has 2-lane bituminous carriageway, generally with 1.5- 2.5 wide earthen shoulders. There are 10 nos. of Minor bridges, 29 nos. of culverts and a 2-lane ROB. Under the project, the road will be widened to 4-lane divided carriageway with widening of all the structures. Provision of underpasses, service roads at built up locations, bus bays, road furniture and safety measures, are proposed for smooth flow of traffic through out the length of the project road.

Index Terms – Super elevation, initial traffic, Design traffic, Centrifugal acceleration.

1. INTRODUCTION

1.1. Horizontal Alignment

The horizontal alignment of a road usually compromises a series of straights (tangents) and circular curves which may or may not be connected by transition curves. The following section outlines design criteria which have been considered when developing the horizontal alignment.

Superelevation and side Friction details

Super elevation is the cross fall this is provided on the pavement on a horizontal curve in order to assist a vehicle to maintain a circular path, and partially compensate the centrifugal force. For normal values of super elevation, side friction and radius, the following formula is adopted

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

e = pavement superelevation

f = coefficient of side friction force developed between the vehicle tyres and the road pavement. This is taken as positive if the frictional force on the vehicle acts towards the centre of the curve.

R = curve radius (m)

Maximum side friction of 0.15 is adopted for the project road as per IRC: 73 Considering the high speed characteristics of the project road, the maximum superelevation is limited to 5 % .Superelevation has been developed by rotating the median edge.Minimum rate of change of superelevation is adopted as **1 m in 100 m**.Positioning of superelevation development in transitions is kept so that 0 % crossfall corresponds to the start of the transition and full superelevation for the curve (e %) is attained at the end of the transition. In circular curves, 2/3 of the superelevation is achieved on the tangent i.e. at the start of the curve 2/3 e% is achieved.

Table 1.1: Limiting Values for horizontal Elements

Terrain	Ruling (%)	Limiting (%)	Exceptional (%)
Plain & Rolling	3.3	5.0	6.7

1.2 Vertical Alignment

The vertical alignment has been designed to be generally compatible with the horizontal alignment and consistent with the topography to achieve a free flowing profile. For the rolling terrain of the project road, the following gradient standards as prescribed by IRC have been adopted.

Vertical Curves: Vertical curves have been designed to provide visibility corresponding to at least the safe stopping sight distance. For valley curves, the visibility corresponds to the sight distanceFor design control, the concept of ‘K’ value which is defined as the length of curve for one percent grade difference has been adopted. The ‘K’ values for plain and rolling terrain to satisfy the visibility requirements as per IRC: 73 are given in

2. DESIGN CALCULATIONS

ii) HIP Chainage 165+871

Design Parameters:

R = 2005 m

Δ = 4º47'53"

V = 100 kmph

Since radius is not less than 1800 m no super elevation is provided hence no transition is required.

a) Calculation of super elevation (e):

$$e = \frac{V^2}{225\,R} = \frac{100X100}{225\,X\,2005}$$

$$= 0.022$$

Hence, normal camber of 2.5 % can be adopted.

b) Features of the curve

Ts = R Tan Δ/2

Es = R Sec Δ/2 – R

L = RΔ

Δ = 0.721 rad

Therefore,

Ts = 2005 X Tan Δ/2

= 84.259 m

Lc = 2005 X 0.084

= 168.42 m

$$Es = 2005\ X\ Sec\ \frac{4^{O}47'53"}{2} - 2005$$

=1.77 m

ii)PVI Chainage 159+894(left median edge)

Design parameters

Grade in,N1 = -2.157 %

Grade out,N2 = 0.179 %

Grade difference, N = 2.337 %

Design speed ,V = 100 kmph

PVI Level = 238.791 m

Stopping Sight Distance = 180 m

Type of Curve :: Valley curve

Calculations:

Assuming L >SSD,

$$L = \frac{NS^2}{100(1.5+0.035S)}$$

$$= \frac{2.337\ X180^2}{100(1.5+0.035X180)}$$

= 97.075

Therefore, L < SSD

For L< SSD,

$$L = 2S - \frac{(1.5+0.035S)X100}{N}$$

$$= 360 - \frac{(1.5+0.035\ s)X100}{2.337}$$

= 26.238 m

Min curve length provided.

MIN Length of curve provided = 110 m

Chainage at start of curve=PVI chainage – L/2

=159894 – 110/2

=159839

Chainage at end of curve =PVI Chainage +L/2

=159894 +110/2

=159949

Level at start of Curve =Level of PVI – (N1/100)X L/2

=238.791-(-2.157/100)X110/2

=239.977 m

Level at end of curve =Level of PVI + (N2/100)X L/2

=238.791 + (0.179/100)X110/2

=238.889 m

Level of road at PVI =Level of PVI +NL/800

=238.791 + (2.337X110)/800

=239.112 m

3. PAVEMENT DESIGN

The design methodology adopted for the various cases are as follows:

- Strengthening Existing Pavement

  IRC: 81 using Benkelman Beam Deflections from control section testing. The results have been crosschecked by reverse CBR method (component analysis) and the need for minimum depth of bituminous layers to disperse the heavy axle loads without significant damage.

- New Flexible Pavement

  IRC: 37, adopting relevant traffic loading and subgrade strength parameters. Designs have also been prepared adopting AASHTO procedure for comparison of results and for finalisation of pavement composition using engineering judgment.

For the 4-laning projects, pavement design is carried out for smooth riding quality in the following cases,

- Strengthening the existing pavement through overlays
- New pavement for widening existing carriageway on existing formation for accommodating width for kerb shyness and paved shoulders or for symmetrical widening
- New pavement for new carriageway (eccentric widening)
- New pavement for service roads

3.1. Table 3.1:Design Traffic in terms of ESAL

Design of new flexible pavement applies to the new carriageway and widening of existing carriageway including paved shoulders. The methodology recommended in IRC: 37-2001 has been adopted, and the designs recommended based on best engineering judgment.

The new stretch has been designed based on IRC – 37 :2001 for which traffic upto 150 msa can be calculated.The present road has a design traffic about 58 msa for which CBR is taken as 8%.

Design Period	**ESAL (million)**
10 Years	36
15 Years	58
30 Years	174

i)Traffic Data Collection

The traffic data has been collected by manual counting of vehicles at a particular stretch and the initial traffic has been calculated.The initial data collected is around 3608 commercial vehicles per day in both the directions, in which 1804 cvpd in each direction

ii) Design factors

The various design factors that are applicable are vehicle damage factor,lane distribution factor and traffic growth rate and finally design life of pavement .The vehicle damage factor(F) is taken as 4.5 as the number of commercial vehicles got is more than 1500.

The design life of pavement(n) is considered to be 15 years after completion of construction. The lane distribution factor(D) is considered to be 75 % and directional distribution is considered to be 50 % .The traffic growth rate(r) is assumed to be 7.5 % as in case of a national highway having high growth rate.

All these factors and assumptions are made with reference from IRC – 37 :2001 .

Design traffic N $= 365 \text{ X } ((1+r)^n-1)/r \text{ X A X D X F}$

$= 365 \text{ X } ((1+0.075)^{15}-1)/0.075 \text{ X } 3608 \text{ X } 0.375 \text{ X } 4.5$

$= 615.93 \text{ X } 26.1 \text{ X } 3608$

$= 58001388.984$

$= 58 \text{ x}10^6$ sa

= 58 msa

For traffic of 58 msa and CBR value of 8 % ,then by IRC charts plate 2 the following crest thickness is adopted for the new pavement having a sub-grade thickness of 500 mm keeping constant.

Granular sub – base	=	200 mm
Wet mix macadam	=	250 mm
Dense Bituminous Macadam	=	110 mm
Bituminous course	=	50 mm

4. RESULTS AND DISCUSSIONS

Service Road

Design of pavement for service road has been carried out in accordance with IRC:37-2001 for a design period of 15 years. Traffic assumed for the same is 10% of the design traffic for main carriageway. Therefore, 10% of 58 million ESAL, i.e. 6 million ESAL is considered asdesign traffic for service road.

Based on IRC: 37-2001, for subgrade CBR of 8% (as subgrade will be constructed with borrow material), pavement composition for service roads has been worked out and indicated in **Table 4.13.**

Table 4.2:Pavement Composition for Service Road

S No.	Design Traffic	Subgrade CBR	Pavement Component	Thickness (mm)
1	6 million ESAL	8 %	SDBC	25
2			BM	75
3			WMM	250
4			GSB	150

5. CONCLUSION

1 The design is based on the peak hour flow of traffic and the design is carried out by the overall traffic summed up to the end of the day.

2 I.S. recommends for every 1000 pcu, the lane width should be 3.5 m, but the present pavement width is too less to meet the standards.

3 As the width of old pavement is of 7 m with an average of 2.0 m Earthern shoulder, the thesis recommends to widen the carriageway width to 4- lane divided carriage way as it is insufficient for traffic movement.

4 4.The thesis is designed as per both the guidelines of AASHTO and IRC. But due to the complicated design procedure and economic point of view,IRC recommended designs are suggested in the present project.

5 The thesis suggests to overlay the project stretch which is good in subgrade and older crest thickness and the remaining stretch of 22 km is made to reconstruct due to poor sub grade. This 22 km is made to design according to IRC-37 :2001 guidelines.

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