A Case Study on Curve Design for Improvements to Existing Master Plan Roads

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Abstract-The present case study deals with development of existing roads to master plan roads. The roads from NH-5 junction to kommadi village, NH-5 to Navodhaya School, are located in Visakhapatnam city in India. Particularly these areas are densely populated and occupied with housing units, schools and commercial buildings. As these roads could not meet the present & and future demand, new road proposals was put forward by Visakhapatnam development authority (VUDA) to widen the existing road to master plan road. The present condition of the road is in deteriorated state which is sacrificed and new pavement design is proposed according to IRC-37:2001 recommendations. The studies involves collection of details such as road width, gradient, deflection angle, length of curve and radius of curve and design them to the prescribed standards of IRC code. The curve parameters have been measured using theodolite by traversing along center line of the curve.

Index Terms—About four key words or phrases in alphabetical order, separated by commas.

I. INTRODUCTION

The geometric design of a highway deals with the dimensions and the layout of visible features of the highway such as alignment, sight distances and intersections. The road geometrics of highway should be designed to provide optimum efficiency in traffic operations with maximum safety at reasonable cost. The designer may be exposed to either planning of new highway network or improvement of existing highways to meet the requirements of the existing and the anticipated traffic. It is possible to design and construct the pavement of a road in stages; but it is very expensive and rather difficult to improve the geometric elements of a road in stages at a later date. Therefore it is important to plan and design the geometric features of the road during the initial alignment itself taking into consideration the future growth of traffic flow and possibility of the road being upgraded to a higher category or to a higher design speed at a later stage.

A horizontal curve is a curve in plan to provide change in direction to the center line of a road. The minimum radius of a horizontal curve depends on the permissible design speed for the road. The value of minimum radii for various categories of roads in different areas are recommended by the Indian Road Congress is given.

II. TYPES OF CURVES

The following types of horizontal curves are used in the alignment of highway:

A. Simple Curve

It is a circular curve which consists of a single arc of uniform radius

B. Compound Curve

This is the circular curve which is comprised of a series of two or more simple curves of different radii which turn in the same direction.

C. Reverse Curve

This is a circular curve consisting of two simple curves of same or different radii which turn in the opposite direction.

D. Transition Curve

A transition is the curve having a radius which decreases from infinity at the tangent point to a designed radius of the circular curve.
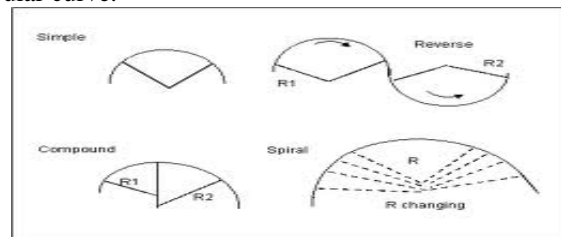

Fig. 1 Different types of Horizontal Curves

III. CURVES METHODOLOGY

The study involved collection of details of the existing road. The main features of the road such as road width, gradients, deflection angle of existing curves, length of curve, radius of curvature etc. The gradients of the existing road have been collected and the present longitudinal section of the road has been plotted. The curve parameters have been measured using theodolite by traversing along the center line of the curve for a length of 1.20km. The details so gathered are compared with the IRC specifications vide IRC 37-2001.The existing curves whose radius is less than permissible radius as prescribed in the IRC code have been studied so as to flatten further. However if the condition doesn't permit, an alternate alignment proposal for a patch shall be proposed at some locations. Further the existing condition of road, marking, cross drainage, road stability, safety features other miscellaneous parameters have been studied and necessary improvements have been The present roads comes under the category "Village and Other District Roads" and the carriage way width, shoulder width and total road way width are 3.75m, 2 X 1.0m and 5.75m respectively.

(A) Radius of the curve :

$$R = \frac{360° \times L}{D \times 6.285}$$

Where   L= length of arc

          D = deflection angle

(B) Super elevation : $e = \dfrac{V^2}{225R}$

Where   V= design speed in kmph

          R= radius of the curve

(1) If the calculated "e" value is less than 0.07, then the value so obtained is provided.

(2) If the value of "e" exceeds 0.07, then provide maximum super elevation equal to 0.07.

(C) Coefficient of friction : $F = \dfrac{V^2}{127R} - 0.07$

Where, V = design speed in kmph.,

          R = radius of the curve

(D) Extra Widening: $We = Wm + Wps$

$$= \frac{nl^2}{2R} + \frac{V}{9.5\sqrt{R}}$$

Where Wm = Mechanical Widening

        Wps = psychological Widening

        n = no. of lanes

        V = design speed kmph R = radius of curve

IV. DESIGN AND DRAWINGS OF PROPOSED CURVES

List of Curves: The list of curves and their parameters such as deflection angle, radius, direction, length etc., of widened roads from NH-5 to kommadhi village, yendada jn. To GITAM college, madhurawada jn. To bakanna palem have been measured, calculated and listed below with the help of theodolite. AutoCAD Drawings and the relations stated above and listed below.

The road from NH-5 to Kommadi Village (Surya Press) and NH 5 to Navodaya School Visakhapatnam city. Particularly this area's are densely populated and occupied with educational institutions, commercial buildings etc. As these roads could not meet the present and future demand, a proposal was put forward to carry out the improvements to this road under IRC recommendations.

Table 1: Curve Design of Road from Nh-5 to Kommadi Village (Surya Press)

S.No	Curve no	1	2	3
	Chainages	140 m to 260 m	870m to 1080 m	1490m to 1550m
1	Design speed in plain terrain for other district roads (V) in Kmph	65	65	40
2	Arc length (L) in m	118.92	204.05	56.42
3	Deflection angle Δ in radians	26.962	30.720	49.547
(A)	Radius of the curve (R) = $\frac{360L}{2\pi\Delta}$ (m)	253.00	381.00	65.00
(B)	Super elevation (e) = $\frac{v^2}{225R}$	0.07	0.049	0.07
(C)	Check for friction coefficient (F)= $\frac{v^2}{127R} - e$	0.061	0.017	0.124

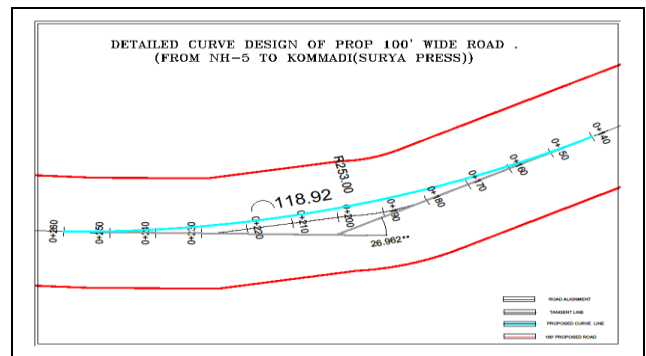|				
	Pavement width for two lanes (W) in m	7.5	7.5	7.5
4	No of Lanes (n)	2	2	2
5	Length of vehicle (l) in m	6	6	6
(D)	Extra widening(We = Wm + Ws)			
	Mechanical widening, Wm=(nl²/2R)	0.570	0.450	1.080
	Psychological widening, Ws=(V/9.5x√R)			
	Total pavement width on curve (W+We) in m	8.070	7.950	8.580
		8.000	8.000	9.000

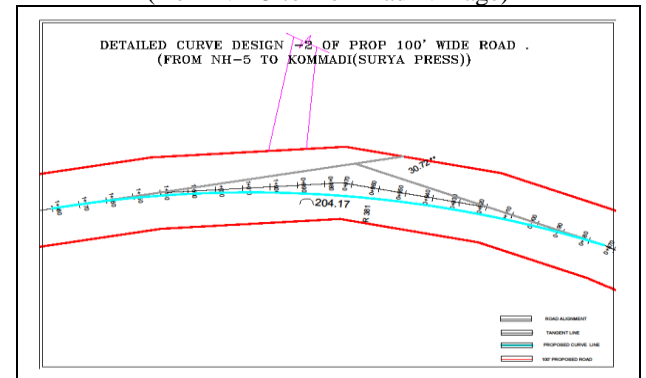Fig. 2: Detailed curve design at chainage 140 m to 260 m (from NH-5 to Kommadi Village)

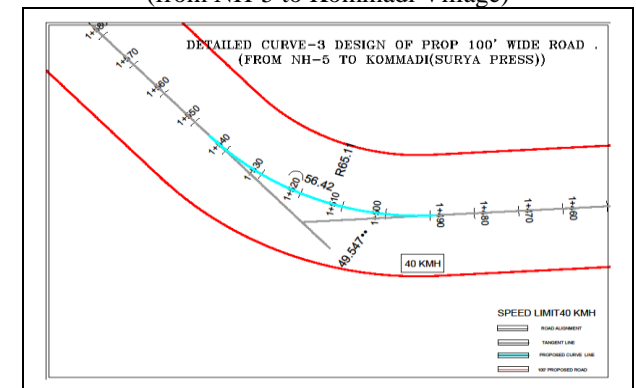Fig. 3: Detailed curve design at chainage 870 m to 1080 m (from NH-5 to Kommadi Village)

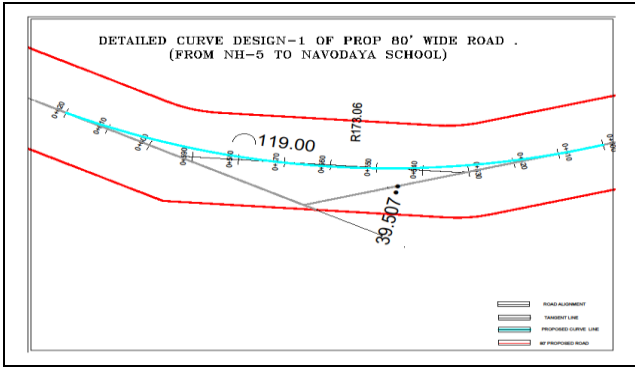Fig. 4: Detailed curve design at chainage 1490m to 1550m (from NH-5 to Kommadi Village)

Fig. 5: Detailed curve design at chainage 500m to 620m
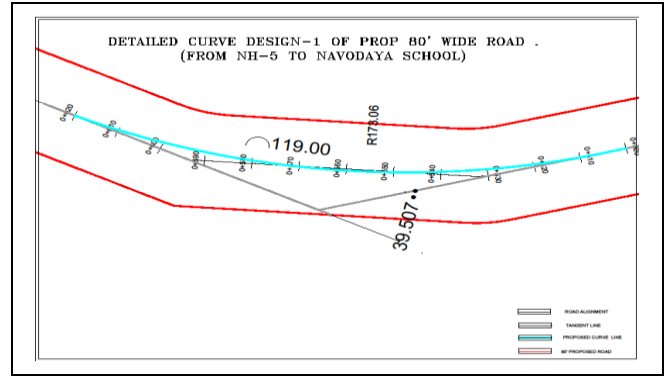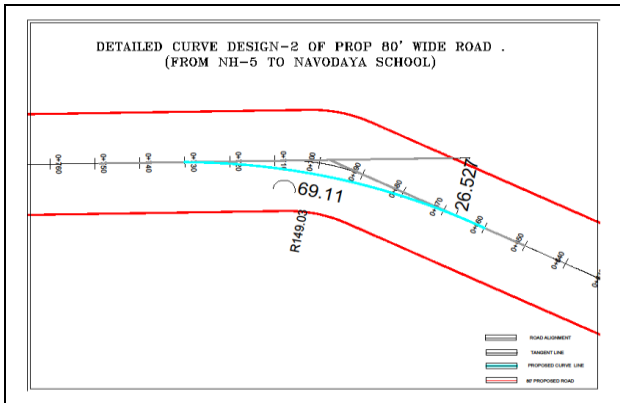(from NH-5 to Navodaya School)

Fig. 6: Detailed curve design at chainage 660m to 730m
(from NH-5 to Navodaya School)

Fig. 7: Detailed curve design at chainage 1220m to 1270m
(from NH-5 to Navodaya School)

Fig. 8: Detailed curve design at chainage 1270m to 1310m
(from NH-5 to Navodaya School)
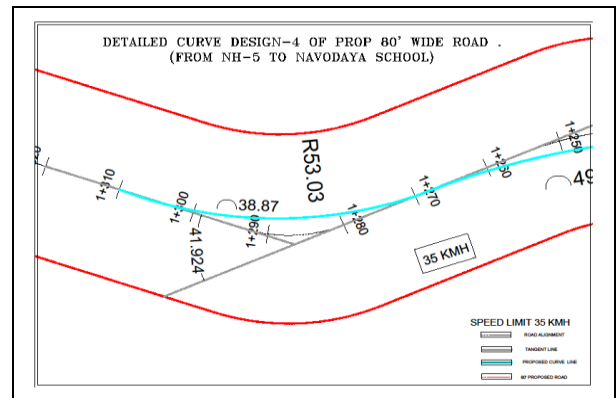

Fig. 9: Detailed curve design at chainage 2050m to 2120m
(from NH-5 to Navodaya School)

Table 2: Curve Design of Road from NH 5 to Navodaya School

S.No	Curve no	1	2	3	4	5
	CHAINAGES	500m to 620m	660m to 730m	1220m to 1270m	1270m to 1310m	2050m to 2120m
1	Design speed in plain terrain for other district roads (V) in Kmph	65	65	40	35	65
2	Arc length (L) in m	119	69.11	49.41	38.87	68.19
3	Deflection angle Δ in radians	39.507	26.527	28.026	41.924	23.138
(A)	Radius of the curve $(R) = \dfrac{360L}{2\pi\Delta}$ (m)	173.00	149.00	101.00	53.00	169.00
(B)	Super elevation (e) $=\dfrac{V^2}{225R}$	0.07	0.07	0.070	0.070	0.070
(C)	Check for friction coefficient $(F)=\dfrac{V^2}{127R} - e$	0.122	0.153	0.055	0.112	0.127
	Pavement width for two lanes (W) in m	7.5	7.5	7.5	7.5	7.5
4	No of Lanes (n)	2	2	2	2	2
5	Length of vehicle (l) in m	6	6	6	6	6
(D)	Extra widening(We = Wm + Ws) Mechanical widening, $W_m=(nl^2/2R)$ Psychological widening, $W_s=(V/9.5\times\sqrt{R})$	0.730	0.800	0.780	1.190	0.740
	Total pavement width on curve (W+We) in m	8.230	8.300	8.280	8.690	8.240
		8.200	8.300	8.300	9.000	8.000

V. CONCLUSIONS

1. Curves are provided according to the topography of the area to avoid excessive cutting and filling.
2. For all curves below the desirable standards, warning signs are proposed to restrict the speed of vehicles.
3. The road from NH-5 junction to kommadhi village at chainage- 140m to 260m is designed, with a design speed of 65kmph for a radius of 253m. From chainage- 870m to 1080m, with a design speed of 65kmph for a radius of 381.00m and from chainage- 1490m to 1550m, with a design speed restricted to 40kmph for a radius of 65.00m.

4. The road from NH-5 junction to Navodaya school at chainage- 660m to 730m is designed with a design speed of 65 kmph for a radius of 149.00m. from chainage- 1220m to 1270m, with a design speed restricted to 40kmph for a radius of 101.00m, from chainage- 1270m to 1310m, with a design speed restricted to 35 kmph for a radius of 53.00m and from chainage- 2050m to 2120m, with a design speed of 65kmph for a radius of 169.00m.

VI. ACKNOWLEDGMENT

REFERENCES

[1] Annette R. Hill, Andrew R. Dawson and Michael Mundy (2001) Utilisation of aggregate materials in road construction and bulk fill. Res. Cons. Recycling. 32(3), 305-320.
[2] Gopala Raju SSSV, Murali M and Rengaraju VR (2007) Reuse of polythyelene waste in road c onstruction. J. Environ. Sci. Engg. 49(1), 67-70.
[3] Ministry of Road Transport and Highways (MoRTH) (2002) Specification for roads and bridges. Indian roads congress publication.
[4] Pasetto M (2000) The re-utilisation of discarded building materials in cement-stabilised layers of road and airfield pavements. Waste Management Series. 1(1), 548-566.
[5] Gopala Raju SSSV., (2011), Vehicular Growth and Its Management in Visakhapatnam City Case Study, Indian Journal of Science and Technology, Vol. 4,No.8, pp 903-906.
[6] Bhuyan, P.K, 2002, Accidents Analysis on Two-Lane Roads, Unpublished Seminar Report, Department of Civil Engineering, Indian Institute of Technology Roorkee
[7] Jain, S.S., Parida, M., Chauhan, M.P.S. and Landge, V.S., 2004, Identification of Hazardous Locations on National Highways, International Conference on Transportation Systems Planning and Operation (TRANSPO 2004), Chennai.
[8] Gopala Raju SSSV., (2012), Identification of black spots and junction improvements in Visakhapatnam City, Indian Journal of Innovations and Development, Vol.1, No.6, pp.469-471.

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