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A Review of Literature on Geometric Design of Highway

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Abstract - *Geometric design of highway deals with designing of physical visible features of highway those comprise of cross-sectional elements, sight distances, alignment, curves, superelevation, and other allied features. India is one of the country having population increases progressively causes traffic volume more. In addition to that sanctioning of funds from government for transportation infrastructure development is not satisfactory. So that it is preferable to plan and design the geometric elements of the road during the initial alignment stage itself by considering future traffic growth. And it is very difficult to improve geometric elements after construction and cause to unwanted capital investment. This paper presents review on past work done on geometric design of highway and emphasises planning and designing of geometric features. Although there are number of factors influences on design of highway, but suitable geometric design having objective of giving optimum efficiency in traffic operation with contentment safety measures at reasonable cost.)*

Key Words: **Review, Geometric design, super elevation, cross-sectional elements, optimum efficiency.**

1. INTRODUCTION

Geometric design of highway deals with designing of physical visible features of highway those comprise of cross-sectional elements, sight distances, alignment, curves, super elevation, and other allied features. Here is a brief definition of some geometric elements.

Alignment: The alignment is the route of the road, defined as a series of horizontal tangents and curves.

Profile: The profile is the vertical aspect of the road, including crest and sag curves, and the straight grade lines connecting them.

Cross- section: The cross section shows the position and number of vehicle and bicycle lanes and sidewalks, along with their cross slope or banking. Cross sections also show drainage features, pavement structure and other items outside the category of geometric design.

Sight distance: Road geometry affects the sight distance available to the driver. Sight distance, in the context of road design, is defined as "the length of roadway ahead visible to the driver."

Cross slope: Cross slope describes the slope of a roadway perpendicular to the centreline. If a road were completely level, water would drain off it.

Crest curves: Crest vertical curves are curves which, when viewed from the side, are convex upwards. This includes vertical curves at hill crests, but it also includes locations where an uphill grade becomes less steep, or a downhill grade becomes steeper.

Superelevation: To counter-act the effect of centrifugal force and reduce the tendency of vehicle to overturn and to skid laterally outwards, pavement outer edge is raised with respect to inner edge. Thus, providing a transverse slope is known as Super elevation.

Horizontal curves: Horizontal curves are provided to change the direction of centre line of the road. When a vehicle negotiates a horizontal curve, centrifugal force acts outwards through centre of gravity of the vehicle which depends upon the radius of curve and speed of vehicle.

Transition curve: To enable gradual introduction of superelevation and the centrifugal force on a vehicle negotiating a horizontal curve avoiding sudden jerk on the vehicle, a transition curve is introduced whose radius reduces from infinity at tangent point to a designed radius of the circular curve

2. LITERATURE REVIEW

Hameed Aswad Mohammed (2013). He had stated that shoulder wider than 2.25m give additional safety. Average single vehicle accident rate for highway curves is about four times the Average single vehicle accident rate for highway tangents. Horizontal curves are more dangerous when combined with gradients and surfaces with low coefficient of friction. There is only a minor decrease in the speed adopted by drivers approaching curves of radii which are significantly less than the minimum radii specified for the design speed. Horizontal curves are more dangerous when combined with gradients and surfaces with low coefficient of friction. Horizontal curves have higher crash rates than straight sections of similar length and traffic composition. The difference becomes apparent at radii less than 1000m. the increase in crash rates becomes particularly significant at radii below 200m. small radius curves result in much shorter curve lengths and overall implications for crashes may not be as severe as would first appear.

Neeraj and S.S.Kazal (2015). They were presented formulas in pavement widening on horizontal curves. To prevent off tracking, extra widening of pavement is provided at horizontal curves which is called mechanical widening.

$$W_m = nl^2/2R$$

W_m is mechanical widening

"R" is mean radius of curve
"n" is number of lanes
"l" is length of wheel base

$$W_{ps} = v/(2.64\sqrt{R})$$

"v" is design speed in metre per second

Min-Wook Kang et al. (2013). A fuel consumption model is developed based on highway geometric characteristics like grades, length and location of crest& vertical curves, speed& road surface type& condition. The output of fuel consumption model is the amount of fuel consumed by the vehicle while it travels along a highway at cruising speed.

Fuel consumption model limitations:

- It is only for passenger car units. It will be update with consideration of other type of vehicles.
- It is does not yet consider the effect of intersections& junction points with existing roads.
- It is not suitable for vehicle travelling along highway curved sections where acceleration and deceleration are needed due to variety design speeds.

Asok Kumar et. al (2015). They stated that for designing geometric elements designing MX ROAD software is high design precision and saving time.

Vikas Golakoti (2015). His thesis includes geometric factors of road and data collection and analysis of geometric parameters. The aim of this study is to find the role of the geometric factors of road on accident rate in the case of plain terrain and also find the extent to which these factors affect the accident rate for rural areas. The study aims to find the impact of factors like extra widening, horizontal radius, sight distance, K-value, super elevation, horizontal arc length, vertical arc length, vertical gradient on the accident rate and aims to study the significant factors causing accidents and to find the values for future design of roads.

American Association of State Highway and Transport Officials (2005). This policy states standards for highway designing elements. In addition to that vertical clearance, cross-section, structural capacity of bridges and about tunnels.

Government of the People's Republic of Bangladesh Ministry of Communications Roads and Railways Division (2000). It states design standards for different road classifications, traffic volume and capacity, design speed, and sight distances along with design procedure.

Indian Road Congress 73:2005. It gives specifications of highway geometric elements, terrain classification, and design speed for different types of highways and design traffic and capacity.

United Nations Highway Safety Information System (1999) gives basic methodology involved the development of cross-sectional models. For each State, individual models predicting crash rate per kilometer for typical sections of two-lane, four-lane undivided, and four-lane divided (non-freeway) roadways were developed. Over-dispersed Poisson models were fitted to the data. Crash rate per kilometer differences between pairs of road classes were then calculated as a measure of safety effect.

Mohammad A. Hadi et al. (1994). They used negative binomial regression analysis to estimate the effect of cross-section design elements on total fatality and injury crash rates for various types of rural and urban highways at different traffic levels. The results show that depending on the highway type investigated increasing lane width, median width, inside shoulder width, are effective in reducing crashes.

Abo El-Hassan M. Rahil et al. (2014). They got three approaches to relate accident rate to geometric characteristics and traffic related explanatory variables: Multiple Linear regression, Poisson regression and Negative Binomial regression. Various models have been intensively tested and validated. The adjustment of the models is based on historical accident data and on the characteristics of experimental sections selected from the road network. For example, Multiple linear and Poisson regression were used. In order to estimate accident rates using traffic and geometric independent variables. Moreover, developed a model to identify the most significant traffic and geometric elements in predicting accident frequency. They used both the Poisson and negative binomial regression models. It should be pointed that, in using such models for future forecast one has to be careful as this entails extrapolating outside the range where the real observations were made. These models can be used for short-term forecast of 1–3 years. It is advisable that whenever data is available, these models should be updated through recalibration.

Matthew G. Karlaftis and Ioannis Golias (2001). They focused on relationship between rural road geometric characteristics, accident rates and their prediction, using a rigorous non-parametric statistical methodology known as hierarchical tree-based regression. Their goal is twofold; first, it develops a methodology that quantitatively assesses the effects of various highway geometric characteristics on accident rates and second, it provides a straightforward, yet fundamentally and mathematically sound way of predicting accident rates on rural roads. The results show that although the importance of isolated variables differs between two-lane and multilane roads, 'geometric design' variables and 'pavement condition' variables are the two most important factors affecting accident rates.

Ali Aram (2010). He had studied safety factors on horizontal curves of two lane highways and added that Horizontal curves have higher crash rates than straight sections of similar length and traffic composition; this difference becomes apparent at radii less than 1000 m. The increase in crash rates becomes particularly significant at radii below 200 m. Roadway and geometric features that influence safety at horizontal curve sections are:

- Traffic volume on the curve and traffic mix (such as the percentage of trucks)
- Curve features (such as degree of curve, curve length, superelevation, presence of transition curves)
- Cross sectional curve element (such as lane-width, shoulder width, shoulder type, shoulder slope)
- Curve section roadside hazard features (such as clear slope, rigidity, and types of obstacles)
- Stopping sight distance on curve (or at curve approach)
- Vertical alignment on horizontal curve
- Distance to adjacent curves
- Distance of curve to nearest intersection, driveway, etc.
- Pavement friction

Kay Fitzpatrick et al. (2008). The objective of their study was to develop Accident Modification Factors (AMFs) for median characteristics on urban and rural freeways and on rural multilane highways. A series of negative binomial regression models was used to determine the effects of independent variables on crashes. Variables considered in developing the base models included average daily traffic, left-shoulder width, barrier offset, median (with shoulder) width, and pole density. This approach for AMF development assumes that first each AMF is independent because the model parameters are assumed to be independent, and second the change in crash frequency is exponential. AMF equations were developed for urban and rural medians with rigid barriers, urban medians without barriers, and rural medians without barriers.

Manoj K.Jha and Paul Schonfeld (2004). They stated that Highway alignment optimization based on cost minimization requires comprehensive formulation of costs sensitive to alignment and development of efficient solution algorithms. in order to solve real-world problems, the optimization algorithms should work directly with a Geographic Information System (GIS) which stores relevant geographic information, such as land boundaries, environmentally sensitive regions, and topographic data. And presented a model for highway alignment optimization that integrates a GIS with genetic algorithms, examines the effects of various costs on alignment selection, and explores optimization in constrained spaces that realistically reflect the limits on road improvement projects.

3. CONCLUSIONS

After studied different sources and past work it should be stated some objectives of geometric design of highway given below

- Geometric design must be give optimum efficiency for traffic movement and safety purpose at reasonable cost.
- For every highway design, one can follow AASHTO and IRC guidelines primarily. A state highway specification comes secondary.
- MX Road software is the preferable and optimistic one for designing highway. So that it has default values for classification of factors influencing design of highway.
- Optimization of alignment could be done by Arc GIS software. So that cost of construction would be less.
- Extra care should be taken while designing super elevation (Min 4%- Max 10%) and pavement widening on horizontal curves.
- 2.25m wide shoulder gives extra safety and median width should be in between 0-6m to 1.2m.
- Proper sight distance and vertical alignment can consume less propulsive force leads to low fuel consumption.
- Horizontal curves at grade separation are more dangerous and causes 30% of accidents more.

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