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Two Lane Highway Consistency Based on Alignment Indices

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Abstract: Road fatalities are common and regular problem nowadays. These complex events associated with a variety of factors, like highway geometry, weather conditions, speed limits driver behavior, and human factors. Various highway geometric design consistency measures are alignment indices, driver workload, operating speed and vehicle stability. The safety assessment of highways has an important role in transportation engineering as the increased rate of accidents can be avoided by the consistent design of highway alignment .This paper is focusing on the influence of alignment indices in the accidents rate. This work put forward a methodology for evaluating two-lane rural highway consistency and safety through alignment index. The influence of this alignment index on accidents is quantified through mathematical models and certain criteria were developed to evaluate the level of safety. The results of this work may greatly influence the implementation of road safety measures and thereby safety on highways.

Keywords: Operating speed, Vehicle stability, Driver Workload, Alignment Indices

I. INTRODUCTION

Road fatalities are complex events occur on the road without any prior intensions and are associated with variety of factors like highway geometry, weather conditions, speed limits and human factors. As the number of accidents increasing day by day the design consistency evaluation is becoming more significant. Geometric design consistency is an important component in highway design and an important tool in evaluating road safety. Mainly design consistency depends on four factors. They are vehicle stability, operating speed, and driver work load and alignment indices. Alignment indices based consistency measurement method is a convenient method for evaluating the consistency of highways. This paper mainly concentrates in highway geometry and its effect on safety. Horizontal alignment in road design consists of straight sections of road, known as tangents, connected by circular horizontal curves. Circular curves are defined by radius and deflection angle.

II. BACKGROUND

The goal of transportation is generally stated as the safe and efficient movement of people and goods. To achieve this goal, designers use many tools and techniques. One technique used to improve safety on roadways is to examine the consistency of the design. Increased knowledge and experience have proved that a consistent highway design, which ensures soundly tuned successive elements, can produce harmonious, homogeneous driver performance and does not provoke unexpected events. In contrast, inconsistent roadway design can produce unexpected changes in dynamic and speed conditions, which may impose high workloads that can surprise the driver and lead to speed or path errors. These inconsistencies, which should be controlled by the engineer, can result in critical driving manoeuvres for motorists, which may increase the probability of an accident. It is now widely recognized that highway consistency analysis can evaluate the performance of the road in terms of safety by correlating it with accident risk. Various approaches based on geometric relation design, operating speed differential, driving performance, and human workload evaluation have been used to evaluate the design consistency of a road alignment. Among them, naturalistic driving data obtained by using instrumented vehicles is a promising technique that can provide information directly related to the driving task and performance.

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III. METHODOLOGY

A. Study Area Selection

The study area selected was part of three state highways in Kerala. The curves for the study are selected on some criteria's. A curve should lie in a minimum tangent length of 100m distance and the grade on the curves should be zero or nearer to zero. Radius of curve has greater importance on road safety. Accidents occur largely on sharp curves. Those curves which satisfy the requirements were selected. It is necessary to have maximum number of curves within shortest distance satisfying the requirements. Three study stretches were selected was:

- Kulapully to Perumbilavu (SH39,SH23-31KM)- 36 Curves
- Pannithadam to Ottupara (SH50-16KM)- 24 Curve
- Vazhakode to Pazhayannur (SH73-18KM)- 27 Curve

B. Data Collection

Mainly two types of data are collected for the study, Geometric data and accident data. The geometric data collected for this study included information about the horizontal curves. For a horizontal curve, the data obtained are Radius of the curve (R), length of the curve (LH), degree of curvature (D), deflection angle (Δ) and length of the preceding tangent section (PTL), width of the road, level Difference at midcurve, superelevation, sight distance etc.

Table:1 Summary of Geometric Details

	Radius Of Curve (M)	**Curve Length (M)**	**Deflection Angle (Deg)**	**Width of the Road (m)**	**Superelevaton (m)**	**Sight Distance**
Minimum	899.64	109.68	63	13.89	8.10	41.1
Maximum	18.33	15.39	5	4.93	0.02	10.8
Average	200.58	51.09	20.43	6.86	3.01	21.25
Standard deviation	166.55	20.50	12.70	1.11	2.25	7.77

Accidents are the measure of inconsistency in highways. Accident data are generally maintained by the Police Department. Accident data were recorded in the First Information Report and accident data for the past five years (2013, 2014, 2015, 2016 and 2017) were collected from the respective police stations of nearby area.

C. Data Analysis

Characters of a roadway segment's alignment that appear to have several conceptual advantages can be use in design consistency evaluations [8]. If logically formulated, they should be easy for designers to use, understand, and explain. Alignment indices should also attempt to express the interaction between the vertical and horizontal alignments that are not considered in current design studies. The initial step in determining alignment indices consisted of identifying all possible indices that could be useful for this research. Therefore, some of the alignment indices that had been used in other countries or proposed for use were included. Study stretches were divided into smaller sections for finding alignment indices. These indices were then examined for their applicability for use in design consistency. The study area is divided into various section based on some criteria's. One of the major reasons for accidents at horizontal curves is speed of the vehicles. The indices which are considered for this study are given in Table II. Traffic volume and speed are major influencing factors of alignment indices. In this study, the junctions are taken as the starting and end points of a road section were the traffic volumes and speeds are changed. Likewise, 33 sections were found out. Alignment indices of the 33 sections were found out. The accident data provided by the Police will not give the number of accidents that happened at exact location of geometric elements like curved sections. Analyzing these Indices with accidents, it is found that the elements with the value closer to unity are geometrically consistent and the elements which differ from unity leads to inconsistency.

Table: 2 Horizontal Alignment Indices

Average Radius	AR = ΣRi/n
Average Tangent Length	ATL = Σ(TL)i/n
Curvature Change Rate	CCR = ΣΔi/L

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Degree of Curvature	DC = Σ(DC)i/L
Curve Length: Roadway Length	CL:RL = Σ(CL)i/L
Average radius to Road length	(AR/L)
Radius: Average Radius	(R/AR)
Tangent Length: Average Tangent Length	(TL/ATL)

To explain relationship between various geometric as well as alignment indices parameters graphical plots has been plotted. Almost 50 scatter plots were plotted. It helps to know the relation which can be used for the development of safety models. The plots are drawn between the number of accidents and alignment indices which shows more correlation with the accident rate. The alignment indices like ATL, CL:RL, CL:TL shows a linear relationship with number of accidents. In this study, correlation of various alignment indices with number of minor accidents, major accidents, fatal accidents and total accident were considered. And it is found out that major accidents show more correlation with the alignment indices. From the preliminary analysis graphs it is clear that ATL is directly proportional to number of major accidents as shown in FIG.1. FIG.2 shows that ratio between curve length and road length is directly proportional to number of major accidents. Variation of major accidents with ratio of curve length and tangent length is shown in FIG.3. Cl:TL shows a inverse proportion, as this ratio increases, number of accidents decreases.

Table: 3 Summary Statistics of Alignment Indices

Sl.No.	Model based on	Model	R^2	RMS
1	Major Accidents	$Y = -49.38+60.02(CL:TL)^{0.1}-4.82(CL:RL)-0.106(AVG\ CL)$	0.504	5.18
2	Major Accidents	$Y = -61.02+72.16(CL:TL)^{0.1}-5.07(CL:RL)-0.001(AVG\ CL)^2$	0.495	5.21

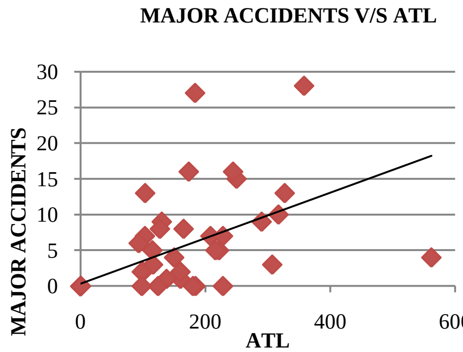

Fig.1 Number of major accidents v/s Average tangent length graph

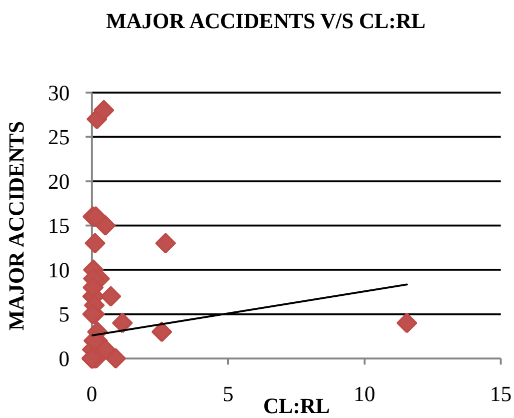

Fig.2 Number of Major accidents v/s CL:RL graph

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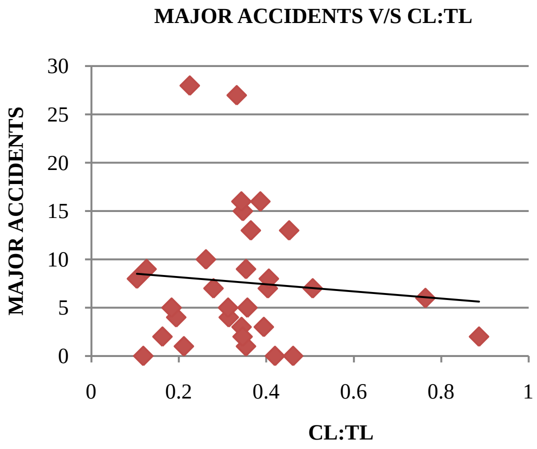

Fig.3 Number of Major accidents v/s CL:TL graph

D. Model Development

Horizontal alignment indices presented in TABLE III were used for this analysis. The Ratio of curve length to tangent length, Ratio of curve length to road length, Average curve length, Average Tangent Length are most influencing factors on the accidents on horizontal curves. The other geometric variables were found to be not influencing the accidents on state highways. With significant variables different trials of modeling were done. The dependent variables are Minor accidents, Major accidents, Fatal accidents, Total accidents and EPDO. Model which are relatively significant are given in TABLE IV. No significant model was obtained for minor, fatal and total accidents. As the number of data point are very less the coefficient of determination of the model are found less. Model validation is also conducted using 11 data points out of 33 data points. The validation results in root mean square error value within a range of 5.1 to 5.2.

Table: 4 Safety Evaluation Models

	AR	ATL	CCR	CL:RL	AR/L	AVG CL	AVG DA	AVG CL:TL
Minimum	29.21	93	4.17	0.01	0.01	0.01	11.25	0.10
Maximum	447.53	562	10262.01	11.55	5.96	88.66	58	0.88
Average	166.98	195.66	426.62	0.70	0.66	16.59	22.59	0.34
Standard deviation	103.74	99.26	1772.06	2.05	1.32	25.53	10.89	0.16

IV. CONCLUSION

- The Ratio of curve length to tangent length, Ratio of curve length to road length, Average curve length, Average Tangent Length, was found to be the most influencing variables on the accidents on horizontal curves have strong relations on accidents.
- The geometric design consistency evaluation of horizontal curves based on number of accidents and comparison of models of design consistency evaluation with respect to for the selected road sections were obtained.
- For poor sections some improvements have to be done in geometrical aspects to the road network. As we know every accident are not caused by geometric inconsistency there will be multi causal problems.

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V. FUTURE SCOPES

This analysis obtained can be used as a reference for any other type of road networks and for vertical curves in future and many other factors which influence accidents on curves are there to be checked more.

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