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Accident Prediction Model for Evaluating Safety of Horizontal Curves on Two-Lane Rural Highways

Swathy P Mohan[1], Jisha Akkara[2], Anitha Jacob[3]
[1]PG scholar, Dept. of Civil Engineering, Jyothi Engineering College, kerala, India
[2]Assistant Professor, Dept of Civil Engineering, Jyothi Engineering College, Kerala, India
[3]Lecturer, Dept. of Civil Engineering, Govt.Polytechnic College, Chelakkara, kerala, India

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ABSTRACT: **-** Safe and efficient movement of people and goods is stated as the goal of transportation. But accident statistics show that number of accidents is increasing in developing countries. In India, majority of the accidents are found to take place on highways passing through rural areas. Rural highways are characterized by a low traffic volume and hence, speed of the vehicles is mainly controlled by the geometry. Estimating the number of crashes that may result for a given highway design is a matter of great interest to the highway engineering community. A road crash prediction model can estimate the expected number of crashes that could result from a given highway design. The output of the work is to analyze the accident patterns on the horizontal curves on selected three road stretches, to develop an accident prediction model and to develop some evaluation criteria based on that. From the study it is found that the geometric parameters have significant influence on crashes on curves. An increase in the degree of curvature, level difference at midcurve, width of road showed an increase in the number of crashes. The skid number also showed a significant effect on crashes. The evaluation criteria was developed based on EPDO values to identify the low risk, medium risk, high risk curves.

KEYWORDS: Accident Prediction Model, Equivalent Property Damage Only Crashes, Linear Regression Model, Two-lane Rural Highways

I. INTRODUCTION

Every year the lives of roughly 1.35 million people are curtail as a results of a road traffic crash. Between 20 and 50 million more people suffer non-fatal injuries, with many incurring a disability as a result of their injury as per the WHO. Road traffic injuries cause considerable economic losses to individuals, their families, and to nations as an entire . These losses arise from the value of treatment also as lost productivity for those killed or disabled by their injuries, and for relations who got to take time off work or school to worry for the injured. Road traffic crashes cost most countries 3% of their gross domestic product. Even though several initiatives have been taken by the Police to enforce road discipline and enforcement of rules by Motor Vehicles Department, road accidents are increasing in our state. The increasing trend of traffic accidents may be a matter of great concern. The analysis of figures from 1980-81 onwards shows that an increase in the number of accidents was steady from 7,064 in 1980-81 to 20,900 in 1990-91 and 34,387 in 2000-01 and 35,282 in 2010-11 and 39,137 in 2015-16. In 2017-18, Kerala registered 38,734 accidents (106 per day).

Accidents due to KSRTC buses were 3 per day in 2017-18 and other bus were (8 per day). The number of two wheelers has increased from 65.77 lakh in 2017 to 77.97 lakh in 2018, recording average annual growth rate of 18.6 per cent. The number of traffic crashes involving two wheelers has increased from 41 per day in 2017 to 94 per day in 2018. Bike accidents account for nearly 55 per cent and Motor Cars for 21 per cent respectively of the total accidents reported in the State as per economic review 2018. As per records available with traffic police most of the accidents are attributable to the fault of drivers . However, deficiencies in road design, bad road conditions also affect motor vehicles . It is estimated that more than 50% of the total fatalities on rural highways can be attributed to the crashes that takes place on curved sections. Thus curved sections and the corresponding transition section represents the most critical locations while considering measures for improvement of highway safety. The accident prediction models can be used as a quantitative tool for the evaluation of the impact of design consistency on road safety.

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II. LITERATURE REVIEW

The common practice adopted for crash analysis is to use the linear and functional forms for regression modelling. Recently some new approaches are proposed, in whichnon-linear functions are adopted. Several studies havePoisson regression models were used in turn and were used in the development of the models. In the Highway Safety Manual (HSM), safety performance functions (SPFs) and crash modification factors (CMFs) are used to predict number of crashes in evaluating the safety effects of design and operational changes. Although the applicability of SPFs and CMFs may significantly vary by crash severity, the first release of the HSM focused on total crash counts, with only limited consideration of crash severity distributions.

[1] Jeffrey P Gooch and V VGayah (2018) used mixed effects negative binomial regression model for safety performance on both horizontal curves an tangents on two lane rural highways. Their major findings were that the highway safety manuals applies same SPF's to both tangent and curve sections and adjust the safety performance on curves using CMF's that account only for curve radius and length, The shape relationship between traffic volume and safety performance differs for both sections and applying a CMF to account for safety performance of horizontal curve does not reflect the differences,the study suggests that separate SPF should be developed and included in future editions of Highway Safety Manuals.

[2] C. Xin et al.(2018) used Conditional logistic regression where dependent variable is a binary variable to explore the effects of horizontal curve design features(curve radius and curve type) on the risk of single motor cycle crashes on RTU highways with matched casecontrol study. Sharp non reverse curve(<=1500 ft) showed riskiest curve design followed by sharp reverse and moderate curves(1500 ft<=R<=3000 ft).

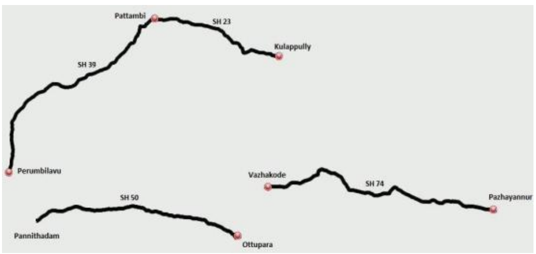
[3] In a study by K Al-Sahili, M Dwaikat(2018), The application of both Poisson and negative binomial regression techniques was investigatedNegative binomial model was selected which found to improve the over-dispersion of all models.

[4] S .Chen, Tariz Usman Saeed(2019) used Bivariate negative binomial models for casualty and non-casualty crashes and also analysed elasticity of crash frequency to the explanatory variables.

[5] Anitha Jacob and Anjaneyalu MVLR(2013) developed four regression models to represent the crash prediction on horizontal curves on two lane rural highways. They conducted an exhaustive study using data of more than 500 kilometers of National and State Highways of Kerala to bring out the influence of various roadway and traffic conditions on traffic safety. The models developed were multiple linear regression, poisson regression, negative binomial regression, and zero inflated poisson regression modeling. The idea of this study was to help practitioners by providing them with less expensive and more user-friendly model. Multiple linear regression model was found relatively simple in application but with less precision in prediction. They also found that Poisson regression model was better suited to predict crashes than other models even though the data contain some amount of dispersion. Shoulder width found to be more sensitive than carriage way width to the crash frequency in the sensitivity analysis.

III. METHODOLOGY AND DATA COLLECTION

The data collection included geometric data and crash data. The study stretch was identified and the variables that are to be collected were identified. The stretch having horizontal curves were taken and the criteria was that the curves should have a tangent length greater than 100 m. Three stretches were selected for the study in the state highway (SH 74, 77, 39 and 50) vazhakode-chelakkara-pazhayannurroute,kulappullypattambi-perumbilavu route , pannithadam-ottupara route.



STUDY STRETCHES

GEOMETRIC DATA COLLECTION

GPS survey of the study stretches were carried out to know the distance and along with the geometric features of the same such as the number of horizontal curves, number of intersections, tangent length etc. Global Positioning System; is a navigation and positional tool to collect spatial data. Total station survey was carried out to get the detailed geometric data of the identified study stretch . The collected geometric parameters were road width, shoulder width, length of tangent to the curve. Data from total station were later exported to

CAD software for generating plan and profile. Details like radius of curve, length of curve, rate of super elevation, gradient and tangent length were extracted from the drawings. For the purpose of measuring the stopping sight distance or visibility a head IRC has suggested to the height of eye level of driver 1.2 m and the height of the object 0.15m above the road surface. Hence the stopping sight distance is that minimum distance measured along the centre line of the inner curve at which an object of height 0.15m can be seen by a driver whose eye is at a height of 1.2m above the road surface. A special equipment was used for finding sight distance.

PAVEMENT SURFACE CONDITION

Pavement skid resistance has been recognized as the most important parameter in reducing traffic accidents especially in wet conditions. For safety enhancement of roads the knowledge of the friction coefficient and skid resistance is very valuable information .

Skid resistance is the force developed when a vehicle tyre is prevented from rotating slides along the pavement surface. Traffic accidents can be the result of a combination of many factors but one of the primary safety criterions for asphalt pavements is tire pavement interaction, and this is directly related to surface texture characteristics. A British Pendulum Tester was used to find out the skid resistance at each horizontal curves which included three trials at the super elevated curve portions. From the total observations , the mean value of skid number was found to be 42, the highest value being 51 and the lowest skid value obtained as 19.

CRASH DATA COLLECTION

Crash data were collected from the first investigation report (FIR) for the last 6 consecutive years (2013,2014,2015,2016,2017,2018). The police stations coming under the study stretches are wadakancherry, chalissery, pazhayanur, shornur, cheruthuruthy, pat- tambi, erumapetty, thrithala, kunnamkulam. Crashes recorded under the following sections were written down manually. Type of crash, date and time of occurrence, age of driver (accused) , type and number of vehicles involved in the crash , number of persons injured or dead , details of the victims or their relatives, location and exact crash spot noted out for IPC sections 337,338, and 304(A).

IV. PRELIMINARY ANALYSIS

A preliminary analysis of data will help to identify the relationship between dependent and independent variables in the data set. the variables are influential on dependent variable can be identified and their logical relationship can be recognized. Non-injury crash/ property damage only, evident injury crash (major and minor crash) , Fatal injury crash(death causing) crashes are expressed in terms of severity by a factor termed as equivalent property damage only (EPDO)crashes. Weightages was given to different types of crashes , Property damage only-1, Non-grievous crashes- 1, Grievous crashes -4, Fatal crashes -12. Scatter plot analysis were made for the EPDO and different parameters and for each vehicle type like two wheelers, three wheelers, light motor vehicles and heavy motor vehicles. The correlation of different variables to the dependent variables were identified for each type of vehicles.

EPDO	SIGNIFICANT VARIABLES
Two Wheeler	level difference(LD), degree of curvature ,skid number
Three Wheeler	level difference, super elevation, degree of curvature, skid number
LMV	skid number, degree of curvature, level difference, super elevation
HMV	superelevation, deflection angle, width of road, level difference

V. DEVELOPMENT OF SAFETY PREDICTION MODEL

LINEAR REGRESSION MODELLING

Linear regression analysis helps to predict the value of a variable based on the value of two or more other variables. The independent variables selected were geometric and pavement skid resistance and the dependent variable taken as EPDO. The SPSS software was used for modeling part. Of about 100 curves, 60 curves were taken for calibration purpose and the remaining curves were taken for validation purpose. After several trials the best regression models were identified with better coefficient of determination(R2) value and with least error.

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SL NO	TYPE OF VEHICLES	MODEL DEVELOPED	R2 VALUE
1.	Twowheeler	EPDO= -7.764+43.187LD^2-0.0014DC^2+0.335SN	0.802
2.	Threewheeler	-EPDO= 2.077+8.698LD^2+0.100DC^2+0.551SE+0.117 SN	0.652
3.	LMV	EPDO= 4.205+33.622LD^2-0.03DC^2+0.991SE+0.144SN	0.764
4.	HMV	EPDO= 2.925+99.27LD-0.061WR^2-0.110DA^2-9.035SE	0.813

MODEL VALIDATION
The difference between the predicted and observed were calculated at each curve. The error was calculated as difference between the observed value and predicted value. The mean standard error and the root mean square error have been computed.

• MSE = SSE÷n
[n= no: of samples]
• The root mean squared of error RMSE were calculated RMSE = √MSE

TYPE OF VEHICLES	MODEL DEVELOPED	RMSE	T VALUES
Two Wheeler	21.297+94.787LD^2 $-0.005DC^2$ $-0.279SN$	11.134	1.99,3.032,-2.01,-1.891
Three Wheeler	-13.879+0.339WR +0.009DA^2 $-0.08SN$	10.120	1.985,4.354,2.887
LMV	-4.650+96.435LD^2 $-0.02DC^2$ + 0.062SN	9.864	3.69,4.048,-1.884,2.03
HMV	-7.40+17.935LD -0..364WR^2 $-0.004DA^2$	6.242	-1.99,3.77,-2.41,2.15

VI. EVALUATION CRITERIA

EVALUATION PROCEDURE
For the purpose of evaluation, the number of crashes and thus the equivalent property damage only crashes due to two wheelers, three wheelers, light motor vehicles, heavy motor vehicles are considered. The rating of roads is carried out by finding the number of low risk, medium risk, high risk curves on each stretches.

CRASH RATING	CRITERIA
low risk	0<EPDO<8
medium risk	8<EPDO<20
high risk	EPDO>20

EVALUATION RESULTS
Evaluation of horizontal curves on the stretches was made by identifying the number of low risk, medium risk, high risk curves. By analyzing the results it was clear that kulappully-perumbivau route is having more number of high risk curves which have an EPDO value greater than or equal to 20, followed by vazhakodepazhayannur route. No high risk curves are identified on vellarkkad to ottupara route, but the medium risk curves are more on this route. Identifying and treating the high risk curves could improve the safety of these routes.

Stretch	Low risk	Medium risk	High risk
Kulappully to perumbilavu	28	2	5
Vellarkkad to ottupara	24	4	0
Vazhakode to pazhayannur	25	3	1

VII. CONCLUSION

The following general conclusions were developed based on the findings of the study: It was identified that accidents have more influence on geometric parameters since the R2 values of models are significant. The geometric parameters have good influence on the crashes. The geometrical details like horizontal profile of stretch, length of the stretch, degree of curvature, sight distance and level difference and also the pavement friction is too considered. Using the available crashes actual accident for every accident location is calculated. regression equation model is used to find out the predicted crash rate . The equation is developed using accident as dependent variable and degree of curvature, sight distance, level difference, radius of curvature, curve length, skid number as independent variables. The model developed is also used for the highways having conditions rather like the study and should facilitate to take right decision in the direction of accidents management i.e. to decide out and implement remedial measures in the view of traffic safety. For safety designation and specially, identification of dangerous zones in network by ranking the sites by their accident rates, the model is also very helpful.

It can be observed from the model developed for the geometrical details of the road to predict future crash rate that the relation between accident and degree of curvature , sight distance, curve length, radius of curvature, traffic volume, level difference all are positive. Considering two wheelers and light motor vehicles , the level difference at mid curve is more influential in creating the accidents. An small increase in the level difference may significantly affect their crash rate. Considering the heavy motor vehicles the width of road and deflection angle have major influence on the crashes. The increase in road width also shows an increase in the crashes due to heavy motor vehicles. This may be due to increased confidence of drivers at curves thereby overspeed . The accidents shows a negative correlation to the degree of curvature in the case of two wheelers and light motor vehicles. From the observed and predicted accidents it is observed that some of them are over predicted and some of them are under predicted. From the evaluation criteria developed it can be seen that kulappully-perumbilavu route consist of more number of high risk curves, which shows that crashes are continuously occurring throughout every year, than other two routes. Identifying and properly treating these curves can significantly improve the safety. The ottupara-pannithadam route contains the least high risk curves.

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REFERENCES

[1]. J. P. Gooch et al., “Safety Performance Functions for Horizontal Curves and Tangents on Two Lane ,Two Way Rural Roads”,*Journal of Accident Analysis and Prevention*, vol. 120 , pp. 28-37,2018

[2]. C. Xin et al., “Development of Crash Modification Factors of Horizontal Curve Design Features for Single-motorcycle Crashes on Rural Two Lane Highways”, Journal of Accident Analysis and Prevention,vol. 123, pp. 51-59, 2019.

[3]. Khaled Al-Sahili et al., “Modeling Geometric Design Consistency and Road Safety for Two-lane Rural Highways in the West Bank,Palestine”, Arabian Journal for Science and Engineering, 2018.

[4]. S. Chena, T. U. Saeed, “Safety Sensitivity to Roadway Characteristics: A Comparison Across Highway Classes”, Journal of Accident Analysis and Prevention, vol. 123,pp. 39-50, 2019.

[5]. Anitha Jacob, Anjaneyalu M,V,L.R , “Development of crash prediction models for two-lane rural highways using regression analysis”, Highway Research Journal, vol. 6, pp. 59-70, 2013

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Email id: ijaem.paper@gmail.com