Identifying Accident Prone Spot on Rural Highways - A Case Study of National Highway No 58

Vishrut Landge[1]. and A.K.Sharma[2].

Abstract—Identifying accident prone location (APL) on a highway has always been a challenge for traffic engineers. Several methods have been tried to detect the locations with high rate of accidents in order to reduce the accidents. Statistical methods are helpful in identifying the APL but fail to identify the cause behind it. For the corrective action it is important to know the cause of accident.

The present study aims to identify APL along the National Highway No 58 connecting New Delhi to Mana. The study is founded on the road accident data for the last three years. The criticality of each section for various configurations is arrived at based on the Babkov coefficient method. Multiple regression technique is used to pin down the influence of the traffic and geometric features responsible for accidents. Remedial measures are suggested depending on the identified factors governing safety of the location

Keywords—Accidents, Babkov method, modeling, negative binomial regression

I. Introduction

ROAD safety in India is a matter of great concern. Over the past decade, there has been an abnormal increase in the motor vehicle population and the consequent increase in the road accident fatalities and the injuries in India. It has been noticed that on an average 180 persons die and 900 are injured in the road accidents every day.[1] In the past 15 years the number of persons getting killed annually has increased by about 20 times.[1] Almost 25 percent of all deaths in the productive age group (18-65 years) are on account of road accident injuries. Also, the statistic shows that India's motor vehicle population is hardly 1% of the world yet 10% of the total fatalities occur on Indian roads. About 61% accidents occur due to heavy vehicles in the country. The road accidents are increasing rapidly on National Highways too.

The fatalities of road accidents have increased from 64,000 in year 1994 to 85,000 in year 2011. [2] National Highway carries 40% of goods traffic, State Highways carry 30% of goods traffic.[2]

[1]V.S.Landge is working at VNIT, Nagpur as Associate professor in Civil Engineering Department

[2]A.K.Sharma is working at Shri Ramdeobaba College of Engineering and Management, Nagpur , as Associate professor in Civil Engineering Department

The National Highways though contribute only 2% of the total road network, 25% of road accidents occur on them, out of which 34% lead to fatalities and 28% to serious injuries.[2]

II. Scope of the Study

In this study, the scope of work is to present the accident scenario on National Highway 58. Kilometer wise analysis of accident has been carried out using Babkov coefficient method to identify APL. Regression method is used to recognize the causes of accident and their relative contribution to accidents

III. Objective Of The Study

The objective of the study is to identify the accident black spot using both the, Babkov method and the police records and then carry out detailed micro level analysis at the identified location to identify the exact geometric and traffic parameters responsible for accidents and to suggest remedial measure based on the factors identified.

IV. Methodology

Step by step methodology adopted is as given below.

- Selection of the highway segment
- Data collection through field studies and surveys
- Accident data collection from the police stations
- Identification of APL using Babkov coefficient method
- Modeling the accident and the geometric features
- Interpretation of model results and suggestion of remedial measures

V. Babkov Coefficient Method

Babkov coefficient method is an empirical method of identifying sites with combination of geometric features that may lead to a hazardous location. [3]The method is geometry based and takes into consideration the geometric and traffic features to arrive at the potentially unsafe site.

Babkov coefficient is a product of the partial Bakkov coefficient as given below. The partial babkov coefficients are the figures associated with the geometric features having significant impact on safety. A location is considered as APL if the total babkov coefficient exceeds 25 for new highways and 15 for old the highways. [3]

$$(K) = (K1 \times K2 \times K3 \times K4 \ldots \times K14) \quad (1)$$

Where, K = Total Babkov coefficient K1 - K14 = Partial Babkov coefficients corresponding various traffic and geometric features After finding out the total coefficient for different sections of the road, linear charts were plotted between the total accident coefficients and chainage. Regressions analysis was carried out to identify the most significant parameters of the total parameters under consideration. Apart from other data such as road marking, lighting, traffic enforcement sign etc. was also collected. The accident data of the past three years from various police stations within the test section was also collected

VI. Data Analysis

The test section was divided into subsection of 200 m each. Geometry and traffic data was collected for each section. Babkov coefficient was calculated to identify the APL. [3] According to Babkov method a section can be categorized as black spot of the K value is more than 25, in case of new roads.[3] Since this road was upgraded from State Highway to National Highway around 2 years back it can be treated as new construction. A sample histogram sheet for kilometer location 177-178 near "Shani Dev Mandir" is shown below in Fig 1. Nine black spot were identifies using this technique is shown in table 1 below The police accident records too show high rate of accident on these spots.

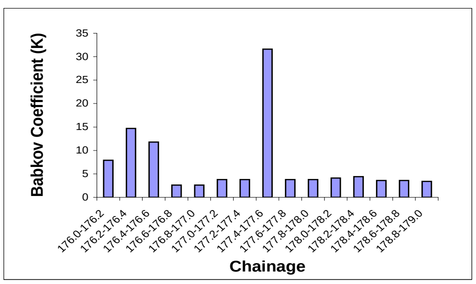

Fig 1 . Sample histogram sheet for 176-179 KM

TABLE I

S.No.	Chainage	Location Name
1.	177.4 – 177.6	Near Shani Dev Mandir
2.	191.6 – 191.8	Bahdrabad Mode
3.	193.4 – 193.6	Near Bahdrabad Degree College
4.	197.2 – 197.4	Near Jwalapur Byepass
5.	212.0 – 212.4	Near Motichur level crossing
6.	216.0 – 216.4	Near Hotel Midway
7.	218.2 – 218.4	Near Nepali Farm
8.	220.6 – 220.8	Near Shyampur Police Chowki
9.	225.0 – 225.2	Near Kale Ki Dhal

VII. Modeling For Causative Factors

Rate of fatality is very high on the said road. For fatal accidents, the police mention all the details very seriously. The life insurance agency also makes an independent investigation of fatal accident and hence the details are seldom missed. As such fatality rate per section per year was selected as a dependent variable for modeling.

$$FR = \frac{F \times 100{,}000{,}000}{ADT \times 365}$$

Where, FR = Fatality rate F = Fatal accidents per year per section ADT = Average daily traffic (vehicles per day)a detailed literature survey was undertaken to know the past efforts done in this area. It was found that the work done could be categorized broadly into the deterministic family of models and the stochastic family of model. Choice of the model is determined by the nature and quality of the variable and data.

Accidents being random and sporadic in nature stochastic models were selected. Since the data was over dispersed negative binomial model was opted.[4]

Out of the collected geometric and traffic parameters, following parameters with significant impact were selected for modeling purpose as independent variables.

Spot speed: speed and travel time are the most common indicator of the performance of a traffic facility. Spot speed is one of the major parameter that is used as an indicator of traffic performance. Spot speed of a location has considerable impact on the fatality rate.

Shoulder width: Shoulder provides an area along the highway for vehicle to stop, particularly during emergency. Slow moving vehicles, pedestrians can use the shoulder and keep the carriageway free for heavy and fast moving vehicles. A report by Zegeer et al. (1986) on the effect of cross-section for two-lane rural roads indicated that a paved shoulder widening of 2 feet per side reduces accidents by 16%.[5] Shoulder width has been a variable with significant influence on safe operations of traffic and hence selected as a variable.

Percentage of heavy vehicle: The highway No 58 carries mixed type of traffic. The traffic composition includes Heavy vehicles, passenger cars, Public vehicle, Non motorized vehicles and Animal drawn vehicles. The nature of accidents observed indicated involvement of heavy vehicles, hence selected as one of the parameters for modeling.

Output of the models developed using statistical software SPSS is as follows.

Form of the negative binomial regression model used.

$$p(Y=y_i) = \frac{\Gamma\left(\frac{1}{\alpha}+y_i\right)}{\Gamma\left(\frac{1}{\alpha}\right)\Gamma(y_i+1)}\left(\frac{1}{1+\alpha\mu_i}\right)^{\frac{1}{\alpha}}\left(\frac{\alpha\mu_i}{1+\alpha\mu_i}\right)^{y_i} \qquad y_i = 0, 1, 2\ldots$$

Where

$\mu_i = \quad v_i\left[e^{\sum_{j=1}^{k} x_{ij}\beta_j}\right]$ E(Yi)= i=1,2,3,…,n

And

$Var(Y_i) = \mu_i + \alpha\mu_i^2$ Where $\Gamma(.)$= Gamma function; α = rate of over dispersion.

VIII. Model Selection Criterion

Several permutation and combinations were tries to decide the best subset of independent variable to be included in crash model. Akaike's Information Criterion (AIC) was used to pick up the best combination. Akaike's information criterion is as given below. Best combination is the one with smaller value of ACI.

AIC= -2Log L +2K. ….Where Log L is the log likelihood; K is the number of estimated parameters [4],[8][9] A stepwise procedure was used to select the best model based on minimizing ACI value.

Individual parameters in the λ vector were tested to investigate null hypothesis. The method used was based on the standard error of coefficient, which is analogous to the t test used in conventional regression analysis.

$\chi^2 = b_i^2/(SE_i)^2$ ………

Where b_i is the estimate of β_j and SE_i is the standard error of coefficient Goodness of fit was measured using Pearson's Chi square static was. As elaborated in equation 9

$\chi^2 = \sum (Y_i - \lambda_i)^2 /(\lambda_i)^2$ ………..

The degree of freedom of this static is equal to the number of observation minus the total number of estimated parameters

MODEL 1

Fatality rate = 0.550 + 0.00014 Spot speed - 0.328 Shoulder width R-Sq = 53.0%

MODEL 2

Fatality rate = 0.428 - 0.327 Shoulder width + 0.0362 percentage Heavy Vehicles +0.0014 Volume R-Sq 83.0%

MODEL 3

Fatality rate = 0.275 - 0.334 Shoulder width + 0.013 Spot speed +0.0014 Volume R-Sq = 76.8%

Various combination of the variable were tried to assess their impact accurately. The above models have been selected. In all the models the shoulder width was proved to be the most important parameter The spot speed and the "volume of heavy vehicle" has more or less same effect on the rate of accidents. All the three combination of significant variables tried show a negative algebraic sign for shoulder width. The spot speed bears positive sign in all the built up models. Percentage heavy vehicle and volume shows positive sign indicating a positive impact on fatalities with increased Volume and percentage of heavy vehicles Models clearly bring out the role of variable like shoulder width, Percentage of heavy vehicles, spot speed and volume in safety of the selected sites.

Shoulder width bears a negative sign, leads to inference that more the shoulder width; less will be the accidents. Absence of sufficient shoulder width forces the slow moving and non motorized vehicles to use the pavement resulting in reducing the effective carriageway width available for fast moving vehicles.

Traffic volume and percentage of heavy vehicles are important parameters having significant impact on the fatalities. More traffic volume indicates more traffic exposure to the population residing nearby. As clearly pointed by the model more the volume more will be the fatalities. The nature of accidents in the area indicates heavy involvement of heavy vehicles in fatal accidents. The same is indicated by the model with positive algebraic sign. Spot speed bears a positive sign indicated that with increase in spot speed the fatal accidents will increase.

IX . Remedial Measures Based On The Models:

The models clearly bring out the role of the parameters in safety improvement. The objective suggestions for safety improvements are as follows. The suggestions are categorized as long term suggestions and instantly adoptable suggestions.

A. Long term suggestions

A separate lane for non motorized vehicles and animal drawn vehicle shall be provided along the National highway.

Shoulder width of 3 meters should be provided all along the highway on either side. The additional width is suggested (As per the model 2.5 meters is sufficient) keeping in view the future expansion.

B. Immediately applicable suggestions

Speed limits (of 60 Kmph) be imposed on the highway.

Levy of heavy fine is recommended for heavy vehicles violating the speed limits. As per the current rules a driver violating the speed limit is fined a meager amount of Rs 100 ($ 2.5) which is just 1 to 2.5 % of his monthly income.

Traffic warning signs be installed at every access point on either side.

Accident spot sign board be installed 100 m before every identified black spot

X. Conclusion

Babkov method is based on the geometric parameters it fails to explain the major factor responsible for accident. The aim of using modeling technique in accident analysis is to exactly point out the factors responsible for accidents and their interrelationship. Models built up in this study describe the situation and point a solution in a satisfactory way. Parameters like shoulder width, Sot speed and percentage of heavy vehicle are seen playing a major role in the rate of crashes. Measures to reduce the parameters indicated by positive sign will help reduce the fatal accidents

XI. Suggestions For Future Work

Accidents are a random event. Regression models employed assume the event to be normally distributed. This assumption however is not true. Hence it is recommended to employ stochastic techniques to model accidents. Stochastic techniques like Poisson regression and negative binomial regression model the accidents; assuming it as a random event.

Artificial Neural Network (ANN) is a new technique and can be effectively employed for accidents modeling. ANN does not assume any underlying principal of distribution. ANN could prove to be more effective tool.

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First author : **V.S.Landge**, born on 02-10-68, graduated from RKNEC, Nagpur (India) in 1991. He completed his post graduate studies in Transportation Engineering from BITS Pillani(Rajasthan, India) in 1993. He completed his Doctoral degree from IIT Roorkee(India) in 200 Presently working at VNIT, Nagpur as Associate professor in Civil Engineering Department. His main field of work has been traffic engineering particularly in the field of traffic Safety. He is a member of the State Technical Agency for Pradhan Mantri Gram Sadak Yojna for Vidarbha Region in India He has guided many undergraduate and post graduate dissertations.

Second author: **A.K.Sharma**, born on 28-12-64, graduated in civil Engineering from NIT Raipur (Chattisgarh,India) in 1987. He completed his post-graduate in Highway and Traffic Engineering from IIT Kharagpur (India) in 1989. Presently working at Shri Ramdeobaba College of Engineering and Management, Nagpur , as Associate professor in Civil Engineering Department. His main field of work has been pavement and traffic engineering. He has guided many undergradute and post graduate dissertations. Presently he is persuing his Doctoral research in the field of traffic safety