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Accident Analysis At The Black Spot: A Case Study

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Abstract*: Humans prefer comfort in every form. The same reason has prompted him to lay the roads and invent motor vehicles. This is the era we are seeing very huge number of vehicles on the roads. But to his dismay, with this comfortless, there came the problem of accidents due to increase in traffic volume. The increased human misery and serious economic loss caused by road accidents demand the attention of the society and call for the solution of this problem. The causes for accidents are many. It may be either due to the fault of the driver or vehicular defect, tough weather condition or due to improper road design and many more. Precisely, if accidents occur frequently at a particular road stretch then, the location is coined as Black Spot. In the present work, an attempt has been made to evaluate the effects of highway geometrics and speed parameters in increased accident rates at the black spot. The black spot of our interest is Busthenahalli bypass (spot-A) on National Highway-48 between Bangalore and Mangalore, Karnataka, India. The mixed traffic condition prevailing on the road and the inadequate geometric conditions on field create the problem of increased accident rates. The regression equation for the condition prevailing has been found for the location under consideration which represents the variation of accident rate with age of the driver, rise and fall, pavement width, Stopping Sight Distance for operating speed and regulating speed and Annual Daily Traffic(ADT).*

Keywords - *Accident rate, Black spot, Curve fitting, Geometric parameter, Regression analysis.*

I. Introduction

The spectacular increase in number of motor vehicles on road has created a major social problem-the loss of lives through road accidents. The appalling human misery and serious economic loss caused by road accidents demand the attention of the society and call for the solution of the problem. A multi-disciplinary approach is needed in understanding the problem and providing solution. Many features of highway affect the safety of vehicle and other road user, which leads to accidents and the improvements that may be desired. Based on the statistics, the traffic and highway engineer must devise ways to reduce accidents through better planning, design, construction and maintenance of traffic operation with appropriate regulatory measures. The accident situation is too more serious in India because of rapid growth of motor vehicles in the past few years and the inadequacy of many of our roads and streets to cope up with this traffic. It is estimated that the number of persons killed per 10,000 vehicles is 24.A recent Annual Accident Survey report of Hassan town highlights that Busthenahalli bypass(spot-A) of Hassan District, Karnataka, India i.e., between Bangalore-Mangalore, Karnataka as an accident-prone zone. The fatality rate of accidents are very much high over the years. The mixed traffic conditions prevailing on road, inadequate geometric conditions and attention of maintaining appropriate road geometric standards at the time of resurfacing maybe creating the problem in increasing accident rates. Here, an attempt has been made to analyze the impact of highway geometries and vehicular movement on the accident rate. The presently available geometric parameters are being compared with the present traffic conditions. The geometric elements evaluated are compared with the past geometric details and also with the geometric elements suggested by IRC. It gives an insight to the lapses in design for the existing condition on the field. Introduction of the paper should explain the nature of the problem, previous work, purpose, and the contribution of the paper. The contents of each section may be provided to understand easily about the paper.

II. Methodology

The test stretch under consideration, the independent variables like geometric parameters, age of driver, rise and fall, Annual Daily Traffic (ADT), SSD for operating speed, and SSD for regulating speed are evaluated. The accident data are collected from the records of Hassan City Police Station, Karnataka, India. After having the information individual relationship between accidents rates versus independent variables is established using ***"IBM SPSS Statistics 19"*** software. The relationship obtained between accident rate and each independent variable is nonlinear and they are initially linearized. Finally using all the variables multiple regression equation is developed and is presented. The validation of the model is carried out and tested for hypothesis to decide at what confidence of interval this equation can be used in the field. The analysis of accident statistics provides clues to the many factors that lead to the accidents and to improvements that may be desired. Accident data also supply valuable information to control, to regulate and manage the traffic more efficiently. Hence, based on these studies, the traffic engineer must devise ways to reduce accidents through better planning, design, construction, maintenance, traffic operation with timely regulation and management of traffic to ensure safety for the road users.

III. Statistical Alalysis And Results

3.1 Relationship between age of driver and accident severity.

The analysis is performed using the effective tool called Chi Square Test to compare the observed and expected value of the parameter under consideration and also to suggest that relationship established will be use full for prediction in future. The test helps in deciding the authenticity of observed and expected value. The observed value here is the information collected through the police records where through the objected data logic is derived and through logic, excepted values are evaluated.

TABLE I: Showing the Results Accident Rate Influencing the Age Group of Driver at Spot-A at 99.5% Confidence Interval

Year	$(\Psi)^2_{observed}$	$(\psi)^2_{tabled}$
2011	1.828	0.676
2012	1.740	0.676
2013	1.467	0.676
2014	0.527	0.676

The above results of table II helps in bringing the concurrency of expected and observed value. The above procedure includes testing of proportions with contingency tables and evaluating of goodness of fit. If chi-square observed is greater than Chi-Square expected, observed and expected values are in agreement. The closer the agreement suggests the hypothesis agrees to that level of confidence interval.

Here $(\psi)^2$ Observed is greater than $(\psi)^2$ tabled at 99.5% confidence interval in most of the cases at the spot-A and hence the hypothesis is true that accident severity is influencing the age of driver by applying a logic ratio and proportion technique.

3.2 Spot Speed Analysis at spot-A.

TABLE II: Showing the showing data for spot speed analysis results

Speed Range in kmph	Mid Speed in kmph	Frequency of Vehicles in PCU	Cumulative Frequency in PCU	% Cumulative Frequency
0--9	4.5	0	0	0
9--18	13.5	0	0	0
18--27	22.5	0	0	0
27--36	31.5	0	0	0
36--45	40.5	12.5	12.5	7.6687
45--54	49.5	34	46.5	28.527
54--63	58.5	32.5	79	48.466
63--72	67.5	31.5	110.5	67.791
72--81	76.5	21.5	132	80.981
81--90	85.5	17	149	91.411
90--99	94.5	8.5	157.5	96.625
99--108	103.5	4	161.5	99.079
108--117	112.5	1.5	163	100

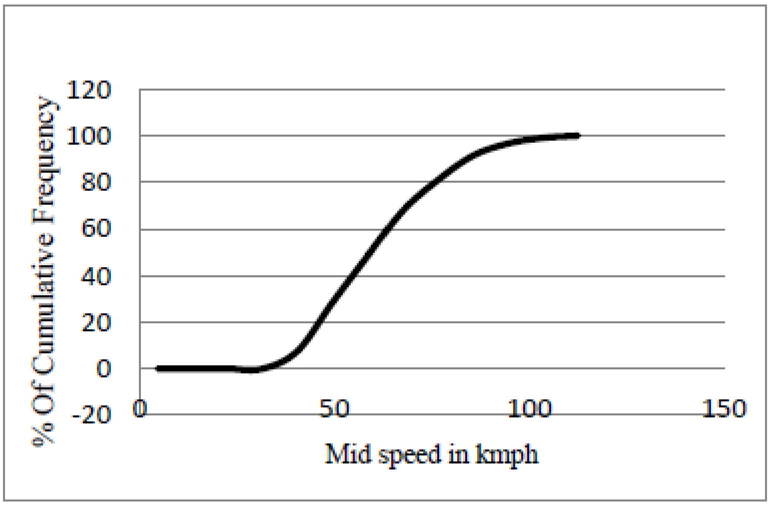

Fig. 1 Showing Variation of percentage of Cumulative Frequency with Mid Speed.

Following speed was obtained from the curve:

- Design speed(98th percentile) 99.54 kmph
- Upper speed limit(85th percentile) 83.83 kmph
- Medium speed(50th percentile) 59.21 kmph
- Lower speed limit (15th percentile) 43.65 kmph.

3.3 Regression model between accident rate and rise and fall.

TABLE III: Table showing regression models for accident rate versus rise at spot-a

Equation	Model Summary	
	R^2	F
Linear b_0+b_1x	0.954	185.255
Logarithmic $b_o\log(b_1x)$	0.863	56.462
Inverse $b_o*e^{(x\ln b_1)}$	0.710	22.062
Quadratic $b_o+b_1*x+b_2*x^2$	0.966	113.304
Cubic $b_o+b_1*x+b_2*x^2+b_3*x^3$	***0.989***	***204.949***
Compound $b_0(b_1^x)$	0.784	32.732
Power $b_o(x^{b1})$	0.617	14.490
Growth b_0e^x	0.784	32.732
Exponential b_0e^{b1x}	0.784	32.732
Logistic $1/(1+e^{-x})$ $x=b_0+b_1x$	0.784	32.732

From the model it is evident that the relationship between accident rate and rise is **cubic** in nature at Spot-A. It may appear that accident rate is having a direct impact on rise. As the rise increases the resistance to motion may increase and the tendency of the driver is to accelerate the vehicle. If the visibility problem is accumulated in the above section accident rate may increase. As R^2 value calculated is closer to unity, rise may have an impact in causing the accident in the location under consideration.

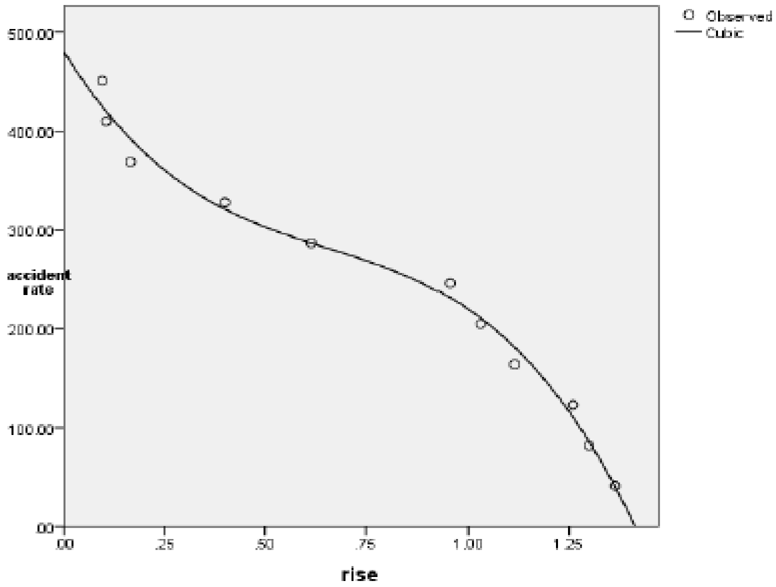

Fig. 2 Showing Variation of Accident rate versus Rise.

TABLE IV: Table showing regression models for accident rate versus fall at spot-A.

Equation	Model Summary	
	R^2	F
Linear b_0+b_1x	0.675	39.423
Quadratic $b_o+b_1*x+b_2*x^2$	***0.852***	***51.97***
Cubic $b_o+b_1*x+b_2*x^2+b_3*x^3$	0.852	32.723
Compound $b_0(b_1^x)$	0.405	12.936
Growth b_0e^x	0.405	12.936
Exponential b_0e^{b1x}	0.405	12.936
Logistic $1/(1+e^{-x})$ $x=b_0+b_1x$	0.405	12.936

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From the model it is evident that the relationship between accident rate and fall is **quadratic** in nature at Spot-A. It may appear that accident rate is having a direct impact on fall. As the fall increases the resistance to motion may increase and the tendency of the driver is to decelerate the vehicle. If the visibility problem is accumulated in the above section accident rate may increase. As R^2 value calculated is closer to unity, fall may have an impact in causing the accident in the location under consideration.

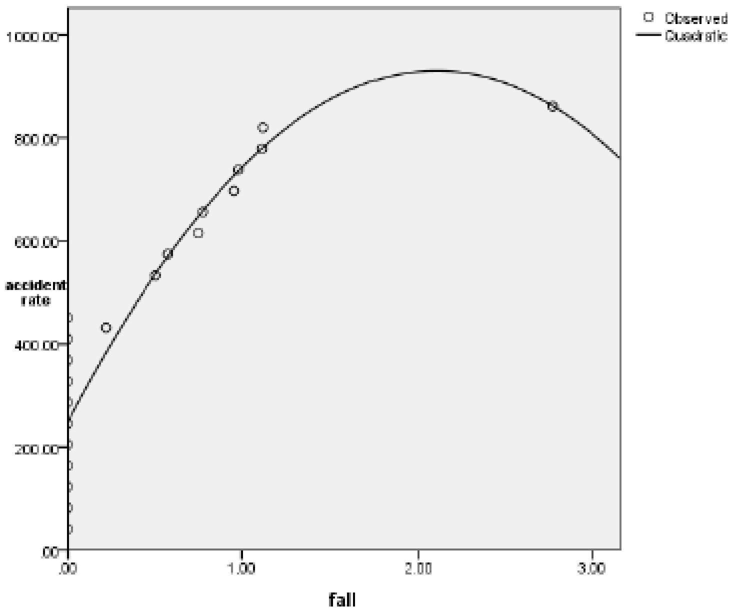

Fig. 3 Showing Variation of Accident rate versus Fall.

3.4 Regression model between accident rate and pavement width.

TABLE V: Table showing regression models for accident rate versus pavement width at spot-A.

Equation	**Model Summary**	
	$\mathbf{R^2}$	**F**
Linear b_0+b_1x	0.586	26.859
Inverse $b_o*e^{(xlnb_1)}$	***0.635***	***33.075***
Quadratic $b_o+b_1*x+b_2*x^2$	0.631	15.380
Cubic $b_o+b_1*x+b_2*x^2+b_3*x^3$	0.631	15.380
Compound $b_0(b_1^x)$	0.323	9.085
Power $b_o(x^{b1})$	0.346	10.071

The regression model developed between accident rate and pavement width evidently shows that the relationship is **inverse** in nature at the test location. As the width increases accident rate will be increased. It means increase in width increasing clear spacing of the vehicle thereby increasing the speed. Here the pavement width variable is having a positive effect on accident rate. Further, the constant value suggests that pavement width has insignificant effect on accident rate.

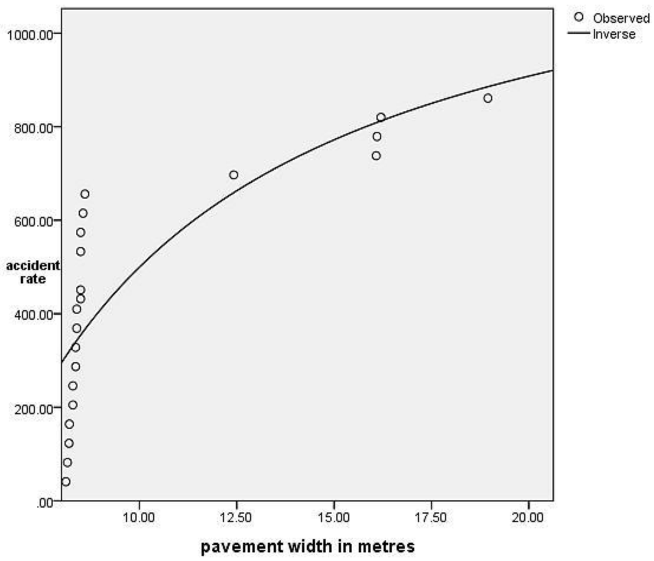

Fig. 4 Showing Variation of Accident rate versus Pavement width.

3.5 Regression model between accident rate and Annual Daily Traffic(ADT)

TABLE VI: Table showing regression models for accident rate versus ADT at spot A.

Equation	Model Summary	
	R^2	F
Linear b_0+b_1x	0.997	7155.485
Quadratic $b_o+b_1*x+b_2*x^2$	0.998	3604.919
Cubic $b_o+b_1*x+b_2*x^2+b_3*x^3$	0.998	2287.042
Compound $b_0(b_1^x)$	0.867	123.729
Power $b_o(x^{b1})$	***0.999***	***15800.154***
Logistic $1/(1+e^{-x})$ $x=b_0+b_1x$	0.867	123.729

A regression model has been developed between accident rate and ADT which evidently suggests that relationship follows **power** curve at the spot .From the model it appears that as ADT data value is less, accident rate will be less. This may be due to the increase in ADT data decreases the space gap distance and the speed of the vehicles travelling. Such non-uniform space gap distance and speed may lead to increase in accident at the location under consideration.

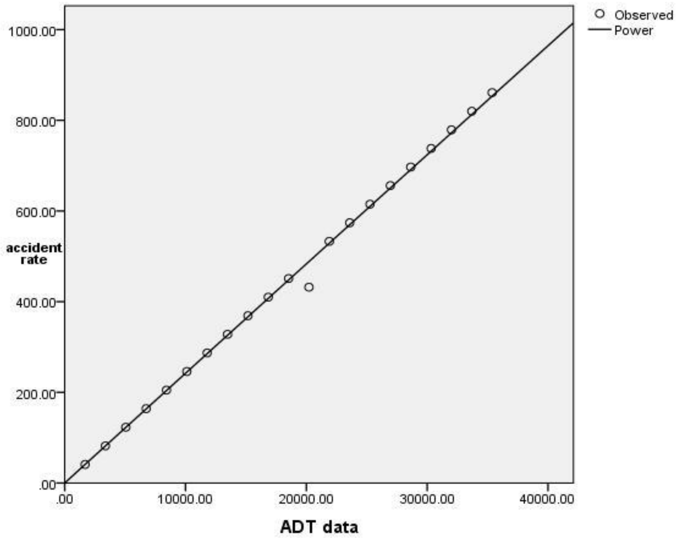

Fig. 5 Showing Variation of Accident rate versus Pavement width.

3.6 Regression model between accident rate and Regulating Speed.

TABLE VIII: Table showing regression models for accident rate versus regulating speed at spot-A.

Equation	Model Summary	
	R^2	F
Linear b_0+b_1x	0.997	7155.485
Logarithmic $b_o\log(b_1x)$	0.807	79.288
Quadratic $b_o+b_1*x+b_2*x^2$	**0.998**	**3604.919**
Cubic $b_o+b_1*x+b_2*x^2+b_3*x^3$	0.998	2287.042
Compound $b_0(b_1^x)$	0.867	123.729
Power $b_0(x^{b1})$	0.992	2459.840

A regression model has been developed between accident rate and regulating and operating speed which suggests that the relationship follows **Quadratic** nature at the test location. It means that the regulating speed can reduce the accident rate when implemented.

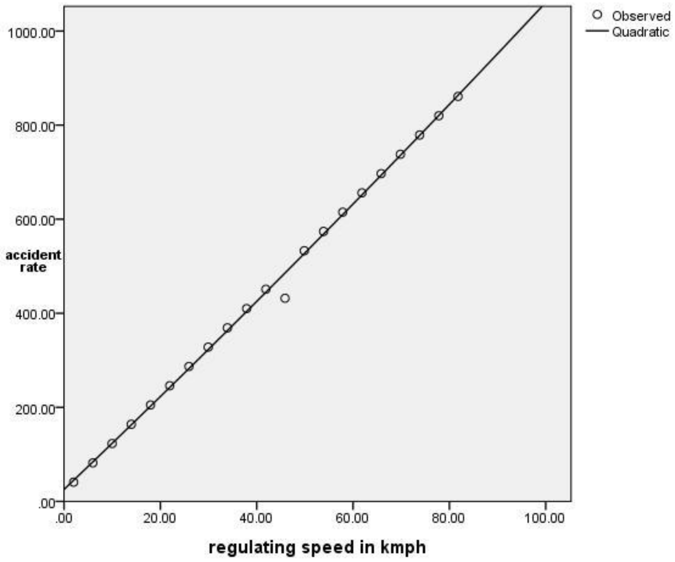

Fig. 7 Showing Variation of Accident rate versus regulating speed.

3.7 Regression model between accident rate and SSD for Regulating Speed.

TABLE IX: Table showing regression models for accident rate versus SSD for regulating speed at spot-A.

Equation	**Model Summary**	
	R^2	**F**
Linear b_0+b_1x	0.973	689.583
Quadratic $b_o+b_1*x+b_2*x^2$	0.996	2238.635
Cubic $\mathbf{b_o+b_1*x+b_2*x^2+b_3*x^3}$	**0.997**	**2144.481**
Compound $b_0(b_1^x)$	0.940	299.022
Power $b_o(x^{b1})$	0.620	31.037
Exponential b_0e^{b1x}	0.940	299.022

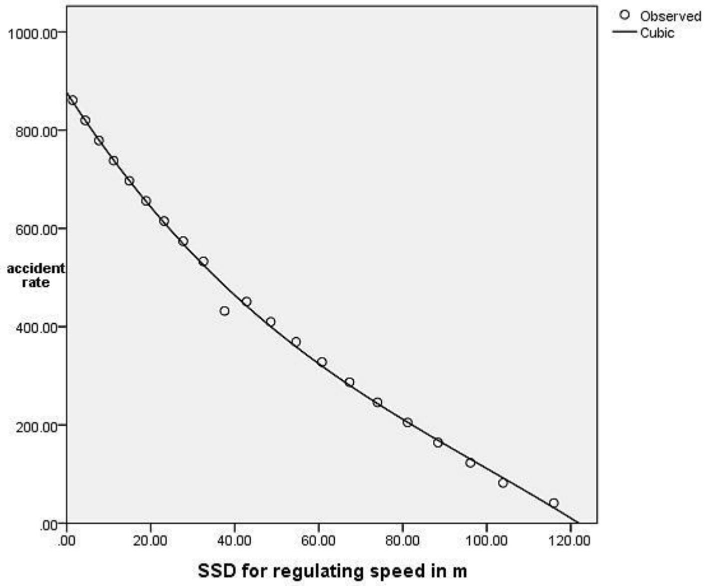

Fig. 8 Showing Variation of Accident rate versus SSD for regulating speed.

IV. Multiple Regresion Model

In the previous article individual relationship between accident rate and each variable contributing for accident are developed. In all the cases as the constant was varying which means that all the variables together contributing to cause accidents. The above aspect has initiated to Use ***"IBM SPSS Statistics 19"*** software to generate multiple linear regression models along with the results required for validation of the model in table. The model so developed as validated sequentially as explained below.

The multiple linear regression models for relationship between accident rate (Y) and pavement width (x_1), rise and fall (x_2), SSD for operating speed (x_3), ADT data (x_4) is:

$$\mathbf{Y = -\ 54.983 + 0.47\ X_1 + 3.113\ X_2 + 0.255\ X_3 + 0.026\ X_4}$$

4.1 Evaluation of Coefficient of correlation (R^2)

Using multiple linear regression models correlation co-efficient R^2 has been calculated which 0.998 for spot-A. Here R^2 is interpreted as the proportion of total variability. Since the model fits the data well, R^2 is closer to unity which implies that observed data and estimated value through the equation are closer to each other.

4.2 Evaluation of fitness of the data.

Even if data is well fitted, there may be violation of model assumption or model misspecification. To determine, if there is any serious violation of model assumption, residual plot study is carried out using multiple linear regression model. The standard residuals so calculated lies within + 2 to -2 there is no violation of model assumption and there is no model misspecification.

4.3 Evaluation of goodness of fit using standard static F-Test.

To check the authenticity of goodness of fit standard static F-test has been performed using multiple linear regression models by IBM SPSS Statistics 19. $\mathbf{F_{tabled}}$ is calculated which is 4.7.Here $\mathbf{F_{calculated}}$ is 1602.007. As $\mathbf{F_{calculated}}$ is greater than $\mathbf{F_{tabled}}$ at 99.9% level of confidence the goodness of fit condition is satisfied.

V. Conclusions

From the above project study carried out for spot-A, the following conclusions are arrived:

1. The age group of the driver is influencing in increasing the accident rate.
2. The increase in accident rate in the test may be due to rise and fall of the location.
3. Decrease in pavement width may be one of the reasons to increase the accident rate at the location under consideration.
4. Increase in operating speed may be causative for the increase in accident rate at the test location.
4. Especially at junctions because of the interference of the flow accident rate may be increased.
5. Increase in ADT especially in peak hour flow may be one of the reasons to increase accident rate.
6. The accident rate may be brought down if operating speed is limited to regulating speed.
8. Increase in road width at critical location under consideration may be the reason to increase accident rate.

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