Road Accident Preduction Modeling At Intersection

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Abstract- *The road traffic deaths and injuries are predicted to be the third largest contributor to the global burden of preventable death by 2020. Incidentally, India holds the dubious distinction of registering the highest number of road accidents in the world. According to the experts at the National Transportation Planning and Research Centre (NTPRC), the number of road accidents in India is three times higher than that prevailing in developed countries. The number of accidents for 1000 vehicles in India is as high as 35 while the figure ranges from 4 to 10 in developed countries.*

A brief analysis of the NCRB report points out that Andhra Pradesh is having the highest share of deaths due to road accidents (12%) followed by Maharashtra and Uttar Pradesh (11% each).

To regulate or reduce road accidents, identification of the accident prone locations and the factors to be evaluation is essential. For identification of accident prone zones and factors affecting accidents, the accident prediction models are developed. In the present study, the models at intersections are developed for accident rate with respective to intersection parameters for selected stretches on National Highway-9 and National Highway-7. The factors causing or influencing may be rectified and improvement can be done for prevention or reducing the accidents at intersections in the future improvements.

I. INTRODUCTION

Road accidents have been a major social problem in the developed and developing countries. In developing countries due to development in industrialization and urbanization with increase in the vehicular population there is no escape from accident hazard. Studies on road accident have indicated that accident rate in developing countries are high compared with those in developed countries.

Travel is an inherently risk activity, because movement creates kinetic energy, and if there is an accident or collision, the energy exchanges can cause damaging to both human and property.

GLOBAL SCENARIO OF ACCIDENTS

Road accidents kill 33 people every hour in southeast Asia and the highest number of these deaths are reported in India, as per World Health Organization (WHO) report. The survey was based on figures provided by 11 Southeast Asian countries. As many as 288,768 people were killed on the roads in the region and almost 73 percent of this burden belongs to India.

INDIAN SCENARIO

In India the road traffic, day by day is increasing is enormously. Incidentally, India holds the dubious distinction of registering the highest number of road accidents in the world. According to the experts at the National Transportation Planning and Research Centre (NTPRC) the number of road accidents in India is three times higher than that prevailing in developed countries. The number of accidents for 1000 vehicles in India is as high as 35 while the figure ranges from 4 to 10 in developed countries. According to the Ministry of Road Transport and Highways, Delhi the growth rate in total vehicles is 10%. The increase in mode wise vehicles from 1997 to 2004 is presented in Table The population according to 2007 statistics was 1,1,36,786,997. The total road network in India is 3,316,452 km. The Road accidents and the fatal accidents were 4,79219 and 1,14,444 for the year 2007

Motor vehicle registration in India

Year	MTW		Cars/Jeeps		Trucks		Buses	
	number	%	number	%	number	%	number	%
1997	25729	69	4672	13	2343	6	484	1.1
2004	51922	71	9451	13	3749	5	768	1.3
Growth/year(%)	10.6		10.6		6.9		6.8	

Year	Others		Total	
	number	%	number	%
1997	4104	11	37332	100
2004	6828	9	72718	100
Growth/year(%)	7.5		10	

(Source: Ministry of Road Transport and Highways, Delhi)

CAUSAL FACTORS FOR ROAD ACCIDENTS

Factors affecting road accidents are grouped into the following.

Vehicle Related Factors.
Road Related Factors.
Road User Related Factors.
Environmental Related Factors.

Vehicle Related Factors

Vehicle factors are fare less frequently the cause of accidents although they are influential in the nature and severity of resulting than either road user or environmental factors.

Visibility

The visibility of the road can be affected by the presence of any obstruction such as the framework of the cars etc.

Speed

The second highest accident-causing factor is the speed of the vehicle. The majority of accidents are caused in occasions such as speeding in the rain, going too fast on curves, high speeds in residential areas, speeding through school zones and speeding into a blind intersection.

Vehicle Lighting

For safe vehicle operation, a driver requires a clear view ahead, consistent with speed, and freedom from the glare.

Road Related Factors

Though the number of accidents in which the road factors are the direct cause is not very high. These have been found as contributory factors in large number of accidents including other elements of the overall road environment (e.g. pavement conditions, traffic and traffic regulation).

Shoulder Width and Shoulder Type

Insufficient lane and shoulder width decreases the opportunity for safe recovery when their vehicles runoff the road and reduces lateral separation between overtaking and meeting vehicle.

Bridge Width

Hazards associated with bridges can be significant. Road ways with narrow bridges reduce the opportunity for safe recovery by out of control vehicles and can result in end-of-bridge collision.

Horizontal curves

Accidents are more likely to occur on horizontal curves than on straight segments of roadway because of increased demands placed on the driver and the vehicle and because of the friction between tyres and pavement. The safety of an individual curve is influenced not only by the curve geometric characteristics, but also by the geometry of the adjacent highway segment.

Road User Related Factors

Psychological Factors of Road Users

The human being is the most sophisticated elements of the traffic equation. Both pedestrians and driver must be understood in human terms and not solely as a number in the column of statistics.

Impatience

Impatience of the driver in some cases is also considered to be dangerous in many cases. The impatience or anger is really a display of immaturity.

Drivers Characteristics

Main focus should be made on the driver himself as his physical, psychological and an emotional trait varies with every changing situation on the road.

Sex

Generally females are more attentive than their counterparts thus the probability of females involving in accidents is less than for males.

Training

It can be seen that systematic training of drivers has profound effect on their driving behavior and performance. Professional drivers of long distances haulage trucks and public transport buses, after receiving class room training and driving instructions are known to have inculcated good driving hobbies.

II. METHODS FOR IDENTIFYING ACCIDENTS

To ensure that safety objectives are met, a distinction must be made between: locations which are hazardous as identified based on accident experiences, and the locations and elements that are potentially hazardous due to their geometrics or physical features

Time Period and Segment Length Considerations

Accident based procedures are used to identify locations defined as hazardous based on past experience. These procedures involve the review and analysis of system wide accident information

To compare the accident experience of several locations fairly, the period of time over which accidents are counted and the length of road way section should ideally be the same at each location.

Analysis Period Considerations

- Accident data for the most recent 1 to 3-year period is normally used and is generally sufficient
- 2 or 3 year analysis periods are more appropriate at locations with low traffic volumes, where 1-year period may not provide sufficient information.

Analysis Roadway Length Considerations

The roadway network can be divided into spots and/or segments. Isolated curves, bridges, and intersections are examples of spot locations. Segments are typically defined by a particular length (e.g., 0.1 km, 0.15 km, 1.6 km, etc.) or as the section of highway between two defined spots. When selecting a length for spots or segments, the following points are considered:

- Segment (long roadway) lengths should be no shorter than the minimum distance used by police officers to describe an accident location. For example, if accidents are reported to the nearest 0.15 km, then the minimum segment length should be 0.15 km.
- For areas where accident reporting is subject to errors or less accuracy (i.e., rural areas or areas where field reference markers are far apart), longer segment lengths should be used for analysis purposes.

Methods for Identifying High Accident Locations

Methods for analyzing the hazardousness of locations include the following

- Spot map method
- Accident frequency method

Spot Map Method

The simplest method for identifying hazardous locations is to examine an accident spot map. The map will show the spots or segments having the greatest numbers of accidents.

Accident Frequency Method

The frequency method ranks locations by the number of accidents. The location with the highest number of accidents is ranked first, followed by the location with the second highest number of accidents, and so on. This method does not take into account the differing amounts of traffic at each location.

III. LITERATURE REVIEW

In this chapter, literature review related to road accident prediction models for estimating the safety of the signalized and unsignalised intersections is presented.

ACCIDENT PREDICTION MODELING TECHNIQUES

Multiple Linear Regression Model

Y be the number of accidents per year as dependent variable and X_1, X_2 and X_3 are the independent variables representing the traffic volume(AADT), length of the segment (km) and number of median openings per km respectively. Then the Multi Linear Regression model is in the form as follows

$$Y = D + AX_1 + BX_2 + CX_3$$

Where,

A,B,C = coefficients or proportions of the independent variables

D = model constant

GLIM Approach

The GLIM approach used here is based on the work of Hauer et al(1997) and Kulmala(1995). *Y* is assumed as random variable that describes the number of accidents at an intersection in a specific time period, and *y* is the observation of this variable during a period of time. The mean of *Y* is L, which can also be regarded as a random variable. Then for L=l, *Y* is Poisson distributed with parameter l. Because each site has its own regional characteristics with a unique mean accident frequency L, Hauer(1997) et al. have shown that, for an imaginary group of sites with similar characteristics, L follows a g distribution (with parameters k and k/μ), with a mean and variance of

$E(Y)=\mu;$

$Var(Y)= \mu + \mu^2/k$

Normal Regression

Let Y be the number of fatal, injury, property damage, or total accidents per year. The predictor variables considered are X_1, X_2, and X_3 denoting the SL, ADT, and VMT for each segment. In all the analyses, the variables X_1 and X_2 are assumed to be fixed and measured without any error. To fit the normal (N) regression, it is assumed that the data onY are normally distributed with mean μ_y = E(Y) and variance $\sigma_2 y = E(y - \mu_y)^2$.

The linear model is

$Y_i = \mu_y + e_i$

Luis F. Miranda-Moreno et al (2005) developed Alternative Risk Models for Ranking Locations for Safety Improvement. The authors compared the performance and practical implications of these models and ranking criteria when they are used for identifying hazardous locations. This research investigates the relative performance of three alternative models: the traditional negative binomial model, the heterogeneous negative binomial model, and the Poisson lognormal model.

Henry C. Brown et al(2005) considered the effects of access control on safety on urban arterial streets. Access control techniques are used to improve traffic performance and safety on highways. One important benefit of access control is improved safety. For a quantitative assessment of the benefits of access control on safety, impact models are needed to predict crash frequencies based on the geometric and access control characteristics of the segments. Theobjective of this research was to develop regression models to predictcrash frequencies on urban multilane arterial segments.

MODELS AT INTERSECTIONS

Andrew Vogt and Joe Bared (1998) developed accident models for two lane rural segments and intersections. The number of accidents along a highway segment or at an intersection is modeled as a random variable of Poisson type. Given a mean value for the number of intersections, assigning probabilities to each possible number of accidents.

$Y_m= \exp (a_0+a_1x_1+a_2x_2+a_3x_4\ldots\ldots\ldots a_nx_n)$

$= (\exp a_0) (\exp x_1)^a{}_1(\exp x_2)^a{}_2(\exp x_3)^a{}_3\ldots\ldots\ldots(\exp x_n)a_n$

Where,

y = proposed mean

x_1, x_2……. are the highway variables,

a_0, a_1………. are the intercept and the desired coefficients.

COMPARISION OF THE VARIOUS MODELING TECHNIQUES

In Multiple Linear Regression model, dependent variables are assumed to follow normal distribution and it is assumed that there is no relation between error and independent variable. MLR model can deduce the negative number that could not appear as the number of accident. The GLIM approach, assumes a non-normal error structure and the accidents are discrete and random. Normal Regression is assumed that the data on dependent variable is normally distributed with mean. The power function was applied to the entire data set as well as to the disaggregate groups of segments. The regression parameters of these models were estimated by the maximum-likelihood method.

SCOPE OF THE PRESENT STUDY

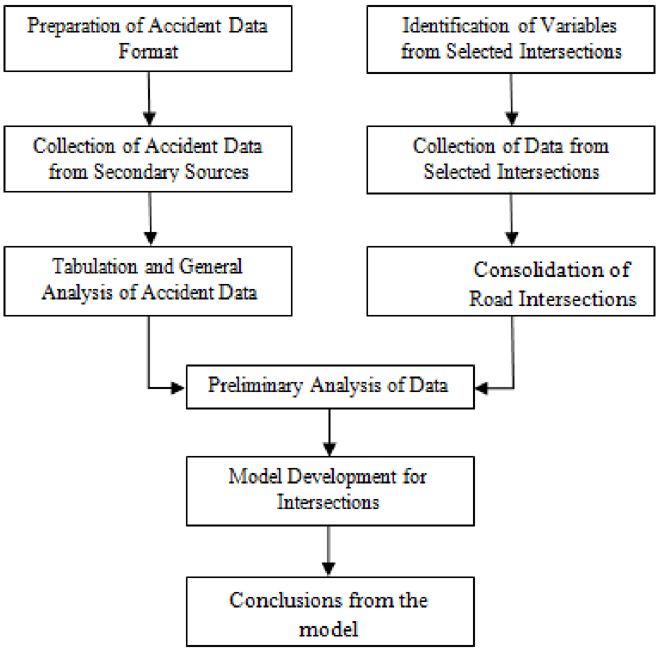
At intersections the accident influencing parameters such as traffic flow, turning radius, and type of intersection have to be analysed comprehensively for prevention or regulation of accidents.

SUMMARY

In this chapter various modeling techniques, accident prediction models, past experience and applicability and limitations are presented.

IV. METHODOLOGY

The intent of this chapter is to explain the procedure which is going to be adopted in this present study. A flow chart involving proposed methodology is shown in Figure.



Study Methodology

PREPARATION OF ACCIDENT DATA FORMAT

The First stage of the study includes preparation accident data format to collect the accident data from the police stations. The forms are prepared based on IRC: 53 – 1982.These forms if filled properly provide the necessary information of the location, type of area, Classification of the accident vehicles and others involved in the accident, etc. The formats of the forms have been designed to facilitate computer processing.

CONSOLIDATION OF ROAD INTERSECTIONS DATA

Data collected from the intersections are to be tabulated to use in the model development.

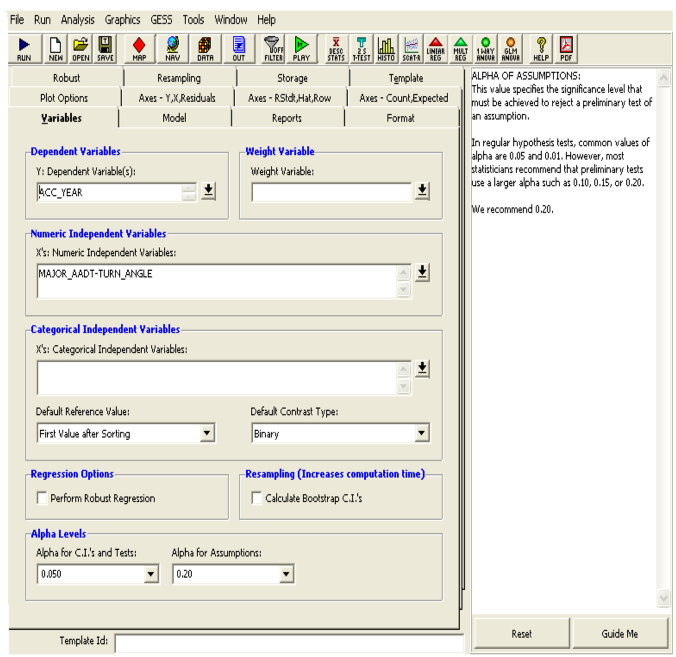
V. MODEL DEVELOPMENT

Curve fitting is a mathematical technique used to find an appropriate mathematical relationship between a dependent variable Y and a single independent variable X. NCSS is statistical analysis package. Using NCSS package, different curves will be fitted to test the relation between road intersection parameters and accident rate as obtained by Microsoft Excel.

NCSS is a comprehensive system for analyzing data. NCSS can take data from almost any type of file and use them to generate tabulated reports, charts and plots of distributions and trends, descriptive statistics, and complex statistical analyses

Figure 3.2 presents the NCSS input window through which the data has been entered. After giving the accident rate as the dependent variable and major road, minor road, turning traffic volume, pedestrian volume and other intersection parameters as the independent variables. By running the program the model and other correlations can be obtained.

For each model, regression coefficients, multiple R, R2, adjusted R2, Pseudo R2standard error of the estimate; analysis of variance table will be calculated. And the significance tests have to done for checking the consistency of fit for the model developed. Accidents at the intersections are the particular importance of this study. Relation between road intersection parameters and accidents will be known from scatter plots. A model based on the relation found earlier will be developed to find out the relationship between accident rates and intersection parameters. NCSS package will be used for model development.



NCSS software Input Window

VI. SUMMARY

In this chapter, the methodology of the dissertation work and statistical package NCSS discussed briefly. The details of various stages proposed for the present study are presented.

DATA COLLECTION AND PRELIMINARY ANALYSIS

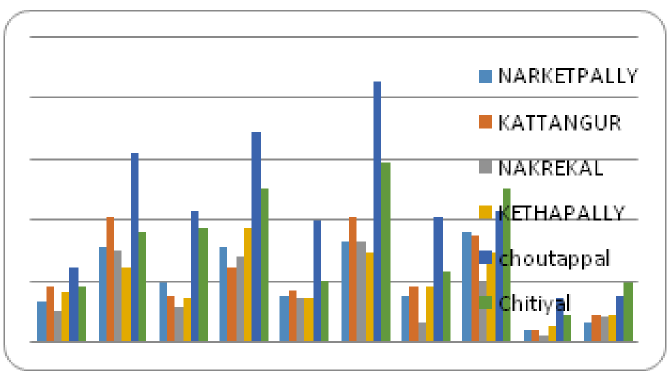
In this chapter data collection, analysis of accident data and intersection details of the study area is presented.
NH-9 starts at Pune and ends at Machilipatnamen route Hyderabad, Vijayawada, Pune and Sholarpur. The highway traverses a distance of about 841 km through the states of Maharashtra (336 km), Karnataka (75 km) and Andhra Pradesh (430 km).

ACCIDENT DATA COLLECTION FROM SECONDARY SOURCES

In India, police men are responsible for recording road accidents. The accident data was collected from concern police stations. The accident data in the year 2006 to 2010(April) and year 2002 to 2009 was collected from the police stations for stretch 1 and 2 and stretch 3 and 4 respectively.

Yearly Variation of Accidents During 2006 to 2010(April)

Total numbers of accidents registered along NH-9, police station wise are represented in for the stretch 1. Total 1539accidents were recorded during 2006 to 2010 (April), in these 519 were fatal accidents and 1020 were non fatal accidents. More number of accidents occurred in Choutappal and Chitiyal police station regions than remaining police station regions. The police station wise distributions of accidents are graphically presented in Figure.

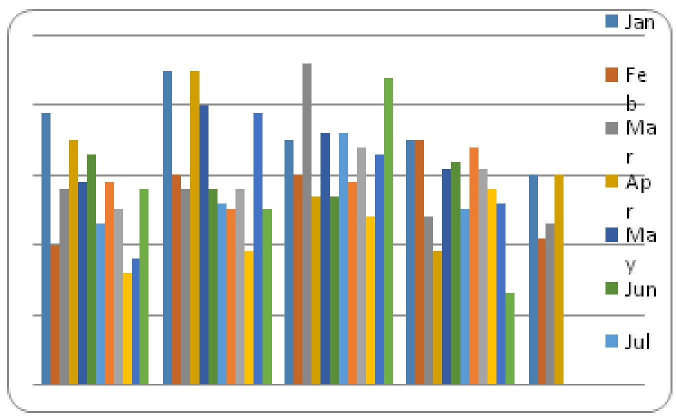


Monthly Variation of Accidents During 2006to 2010(April)

The analysis of month wise distribution of accidents indicates that most of the accidents were occurred in the months of January, April, and March. The Table. shows the distribution during the years from 2006 to 2010(April). Monthly distributions of accidents are graphically presented in Figure.

MONTH	YEAR					TOTAL	PERCENTAGE(%)
	2006	2007	2008	2009	2010		
JAN	39	45	35	35	30	**184**	**11.96**
FEB	20	30	30	35	21	136	8.84
MAR	28	28	46	24	23	**149**	**9.68**
APR	35	45	27	19	30	**156**	**10.14**
MAY	29	40	36	31	*	136	8.84
JUN	33	28	27	32	*	120	7.80
JUL	23	26	36	25	*	110	7.15
AUG	29	25	29	34	*	117	7.60
SEP	25	28	34	31	*	118	7.67
OCT	16	19	24	28	*	87	5.65
NOV	18	39	33	26	*	116	7.54
DEC	28	25	44	13	*	110	7.15
TOTAL	323	378	401	333	104	1539	**100**

(* implies data not available)



Month wise accidents during 2006-2010(April)

Type of Vehicles Involved in the Accident

The analysis about the type of accused vehicle and victim vehicles involved in the accident reveals that as much as 52% of accused vehicles are Trucks/Lorry/Tractor and 25% of Car/van/Jeep. As much as 25% of victims are two wheeler ridersand about 20% victims are pedestrians. The distribution of accused vehicles and victim is summarized in table and presented graphically in Figures 1 and 2

Number of Accused and Victim Vehicles involved in the accidents

VEHICLE TYPE	ACCUSED VEHICLE	VICTIM VEHICLE
2w	89	377
3w	98	164
lorry	782	272
car	372	180
bus	122	78
cycle	0	51
ADV	0	7
pedestrian	3	292
unknown	42	67

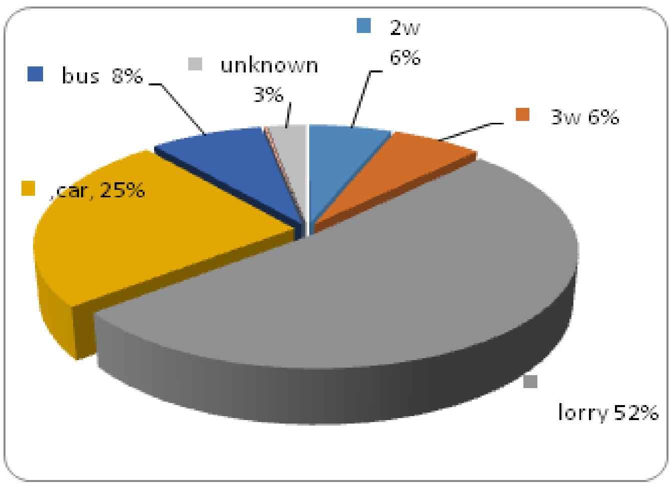


Figure-1

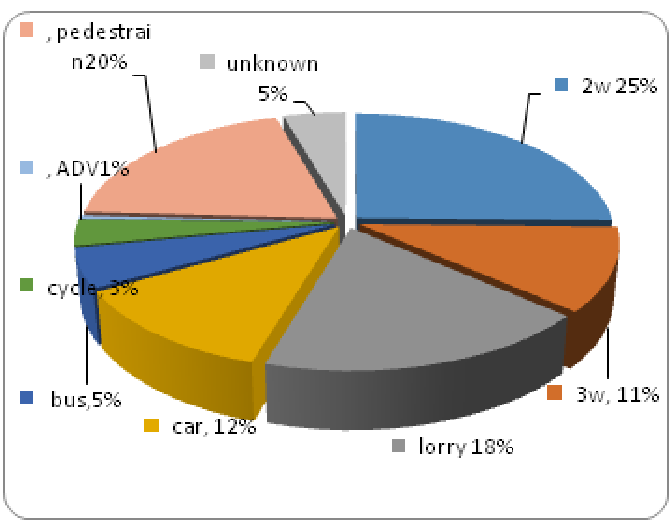


Figure-2

Figure 1: Composition of Accused vehicles involved in the accident

Figure 2: Composition of Victim vehicles involved in the accident

Nature of Accident Occurred

The rear end collision and head on collision are more due to misjudgment of speeds between following and opposing vehicles, as show in Table and Figure.

Nature of accidents occurred

NATURE OF ACCIDENT	NO.OF ACCIDENTS
overturning	68
Head on collision	658
Rear end collision	397
Collision brush	264
Right angled collision	7
Skidding	22
Right turn collision	5
Hit tree	28
Hit n run	85

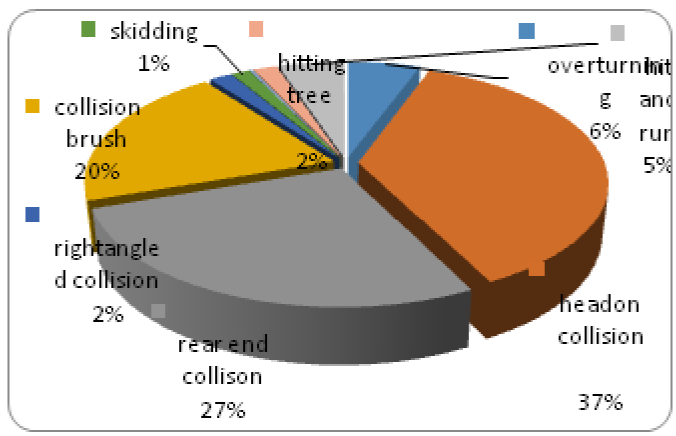


Figure: Nature of Accidents

RELATION OF ACCIDENT/YEAR WITH INTERSECTION PARAMETERS

An attempt has been made to develop the relationship between accidents and different intersection parameters using Microsoft Excel trend line approach.

Accident/Year Vs Major Road Volume

A scatter plot is drawn as shown in Figure4.24 between number of accidents peryrand major road volume on Y and X-axis respectively. From the Figure it is clear that the Acc/Yris varying linearly w.r.t Major road traffic volume.

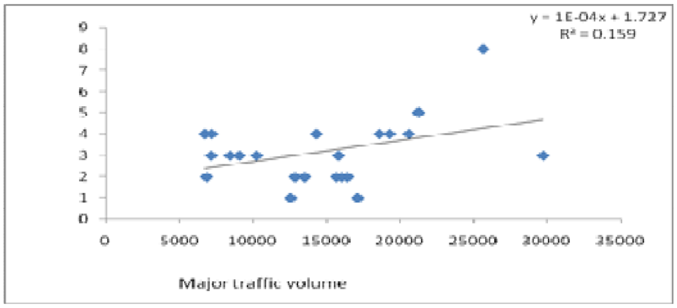
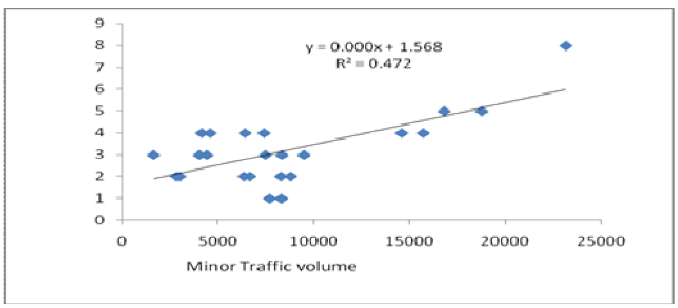


Figure: Acc/year as a function of Major road volume

Accident/3-Year Vs Minor Road Volume

A scatter plot is drawn as shown in Figure4.25 between number of accidents peryrand minor road volume on Y and X-axis respectively. From the Figure it is clear that the Acc/Yris varying linearly w.r.t Minor road traffic volume.



VII. COMPARISON OF MODELS

From the above trend line approach, the variation of accident rate with respective to intersection parameters is estimated. The major traffic volume, minor traffic volume, turning traffic volume, pedestrian volume and no of legs has linearly increasing relationship with the accident rate and having better R-Square value, which is logically true. The paved shoulder width, unpaved shoulder width is also increasing linearly but impact due less R-Square value.

VIII. CONCLUSION

The following conclusions are drawn from the present study

- Number of legs and turning radius are playing critical role for the accidents at intersections.
- Major traffic, Minor traffic, Turning traffic and Pedestrian volume are the major factors causing collisions.
- Approach width is also playing a critical role for intersection accidents.
- As the number of legs of intersection increases there is a increase in accident rate .

LIMITATIONS

The accidents data are taken from the FIR (First Information Index) in the police stations. The location of the accident occurred place is not mentioning properly in the FIR indices. So, it is difficult to find the exact location of the accident occurred chainage even though field visits done. If the exact location of accident occurred place known then the variation in road geometrics and traffic conditions can be found.

SCOPE FOR FURTHER STUDY

The present study can be further extended by considering sight distance and gap at the intersections.

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